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PRICLY PEAR AS STOCK FEED.

A Review of some Experiments in Queensland with Opuntia inermis (the Common Pest Pear).

By Frank Smith, B.Sc., F.I.C.

PRESIDENTIAL ADDRESS.

(Delivered before the Royal Society of Queensland, 30th March, 1921.)

FOREWORD.

In 1916-17 the author investigated the value as stock feed of the common pest pear (O. inermis) for the Queensland Government at Wallumbilla, Maranoa district. There was subsequently published by the Department of Agriculture a popular bulletin* in which the main conclusions of the investigation were set forth. Experimental data bearing on the value of the common pest pear have, however, not previously appeared.

The author is indebted to the Minister for Agriculture (Hon. W. N. Gillies) for permission to make the basis of this paper his technical manuscript dealing with the Wallumbilla experiments in possession of the department. The short description of the feeding trials is derived from, and the tabulated data upon which the conclusions here advanced are founded are reproduced by permission from the manuscript referred to.

INTRODUCTION.

The Prickly Pear Travelling Commission appointed by the Queensland Government to report on means of controlling the prickly-pear pest drew attention (7)† to the considerable use of opuntias as drought feeds and their systematic employment in productive rations for stock prevailing in various countries. In America and elsewhere the recognised value of opuntias had led to advocation of their cultivation as farm

* The Feeding of Prickly Pear to Stock (1918).
† The numerals in brackets refer to literature cited at the end of the paper.
crops. A leading recommendation of the Commission was that the utility as stock feeds of the prickly pears within the State should be investigated.

The principal naturalised opuntia of Queensland is *O. inermis*, a variety with few spines, though its abundant fine prickle necessitates preparation before feeding to stock. *O. inermis* was employed by the author in the trials with steers, dairy cows, and sheep here detailed. The trials with steers (1916) enabled a conclusion to be arrived at with regard to the wholesomeness and palatability of prickly pear, and were a useful preliminary to the work with dairy cows. The dairy herd experiments (1917) were designed to test the value of prickly pear as a roughage in rations for milk production. The sheep experimentation (1917) constitutes, it is believed, the first systematic trials of prickly pear with sheep recorded.

PART I.—PRICKLY PEAR IN THE RATIONS OF STEERS.

PLAN OF EXPERIMENT.

The animals employed in the experiments were eighteen mature steers, principally of Shorthorn and Hereford strains. The beasts were stall fed and kept in an enclosure bare of herbage. The prickly pear was harvested and passed through a power-driven Texan pear-slicer before feeding, but not otherwise prepared.

The main trials are described as maintenance trials, but, the rations providing generally nutriment in excess of that necessary to merely preserve body weight, they are such in the economic rather than the strict physiological sense. Two series were conducted, viz. —One in the winter season when a small amount of hay was provided as roughage in addition to prickly pear; the second in spring when, after recognition of the restriction by other feeds of the prickly pear consumed, the feeds supplementing prickly pear were limited to concentrates or legume hay for the supply of necessary protein.

The insufficiency of prickly pear alone for the maintenance of beasts was demonstrated in the first trials.

The recognition of the importance of palatability of a feed in its evaluation led to some study of the appetite displayed by experimental animals for prickly pear. The number of
individuals employed therein was small, but was considered sufficient to enable the factors by which appetite might be influenced to be well discerned.

The effect of administration of water to pear-fed animals was investigated during the second trials, when the progress of watered and unwatered animals was compared.

The continuance of prickly pear feeding for from seven to eight months provided ground for pronouncement on the effect of the feed on the health of animals, judged both by their obvious condition at the end of the feeding and by post mortem appearance.

**Maintenance Trials. Feeds Consumed Daily and Alteration of Body Weights.**

*First Trials (50-70 days).*—Four groups of animals were utilised, viz.:

1. Three animals received prickly pear alone;
2. Five animals received prickly pear with a little hay roughage;
3. Six prickly pear, a little hay, and meal;
4. Four prickly pear, hay, and legume hay. The prickly pear was of 86-87 per cent. water content, and as much was supplied as was eaten. The meal was linseed meal or coconut cake. The hay was wheaten and panicum hay, fed chaffed; the legume, chaffed lucerne hay. The data for the trials are given in Table 1.

*Second Trials (50-55 days).*—The disposition of the experimental animals was as follows:

1. Seven received prickly pear and chaffed lucerne hay;
2. Eleven received prickly pear and meal (either linseed meal, coconut cake, or maize germ-meal). As much prickly pear was given as was eaten, and no hay roughage was supplied. The prickly pear varied in water content from 82-86 per cent. The amount of meal or legume fed in both the first and second trials was made to provide protein at least adequate to the maintenance of the animals. The rations fed in the second trials and the gains made are summarised in Table 2.

The weights recorded are based on ten weighings on successive days about the initial and final days of the periods. The weighings were made immediately after the morning meal of prickly pear, and as they were obviously influenced by the amount of pear taken they were corrected accordingly, being brought to a basis of a sixty-pound prickly pear consumption. This method of correction would appear to be necessary where
there is variation in the amounts of roughage consumed daily, and is thought to be productive of as great accuracy as is commonly possible in this class of experiment.

**Table 1.—First Maintenance Trials. Feeds Daily, and Initial and Final Body Weights.**

<table>
<thead>
<tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prickly Pear</td>
<td>Hay</td>
</tr>
<tr>
<td>Prickly pear</td>
<td>7</td>
<td>50</td>
<td>54.8 Lb</td>
<td>Lb</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td></td>
<td>53.0 Lb</td>
<td>Lb</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td></td>
<td>50.5 Lb</td>
<td>Lb</td>
</tr>
<tr>
<td>Prickly pear and hay</td>
<td>5</td>
<td>65</td>
<td>49.8 Lb</td>
<td>7.38 Lb</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>65</td>
<td>42.0 Lb</td>
<td>8.31 Lb</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td>65</td>
<td>44.4 Lb</td>
<td>8.00 Lb</td>
</tr>
<tr>
<td>Prickly pear and meal</td>
<td>(with hay)</td>
<td>13</td>
<td>48.3 Lb</td>
<td>7.72 Lb</td>
</tr>
<tr>
<td></td>
<td>15</td>
<td>70</td>
<td>41.5 Lb</td>
<td>8.15 Lb</td>
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<tr>
<td></td>
<td>2</td>
<td>70</td>
<td>68.3 Lb</td>
<td>1.81 Lb</td>
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<td></td>
<td>4</td>
<td>70</td>
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<td>3.13 Lb</td>
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<td>8</td>
<td>70</td>
<td>72.5 Lb</td>
<td>1.56 Lb</td>
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<td>10</td>
<td>70</td>
<td>58.5 Lb</td>
<td>2.03 Lb</td>
</tr>
<tr>
<td></td>
<td>14</td>
<td>70</td>
<td>42.4 Lb</td>
<td>3.35 Lb</td>
</tr>
<tr>
<td>Prickly pear and legume</td>
<td>(with hay)</td>
<td>17</td>
<td>57.6 Lb</td>
<td>1.74 Lb</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>70</td>
<td>89.0 Lb</td>
<td>3.71 Lb</td>
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<td></td>
<td>3</td>
<td>70</td>
<td>60.8 Lb</td>
<td>3.31 Lb</td>
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<td></td>
<td>6</td>
<td>70</td>
<td>70.5 Lb</td>
<td>3.27 Lb</td>
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<tr>
<td></td>
<td>18</td>
<td>70</td>
<td>68.9 Lb</td>
<td>3.31 Lb</td>
</tr>
</tbody>
</table>

* Linseed meal.
† Coconut cake.

**Table 2.—Second Maintenance Trials. Feeds Daily, and Initial and Final Body Weights.**

<table>
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<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Prickly Pear</td>
<td>Lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal</td>
<td>2</td>
<td>50</td>
<td>67.9 Lb</td>
<td>3.00 Lb</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td>54.3 Lb</td>
<td>3.50 Lb</td>
</tr>
<tr>
<td></td>
<td>6*</td>
<td></td>
<td>78.7 Lb</td>
<td>2.00 Lb</td>
</tr>
<tr>
<td></td>
<td>10*</td>
<td></td>
<td>50.1 Lb</td>
<td>4.00 Lb</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td></td>
<td>62.6 Lb</td>
<td>2.50 Lb</td>
</tr>
<tr>
<td></td>
<td>13</td>
<td></td>
<td>63.8 Lb</td>
<td>2.00 Lb</td>
</tr>
<tr>
<td></td>
<td>14*</td>
<td></td>
<td>52.6 Lb</td>
<td>1.75 Lb</td>
</tr>
<tr>
<td></td>
<td>15*</td>
<td></td>
<td>54.2 Lb</td>
<td>2.50 Lb</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td></td>
<td>60.3 Lb</td>
<td>2.50 Lb</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td></td>
<td>58.1 Lb</td>
<td>2.25 Lb</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td></td>
<td>69.5 Lb</td>
<td>2.10* Lb</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
<td>1</td>
<td>50</td>
<td>73.7 Lb</td>
<td>3.00 Lb</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>71.0 Lb</td>
<td>3.00 Lb</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td></td>
<td>76.0 Lb</td>
<td>3.00 Lb</td>
</tr>
<tr>
<td></td>
<td>6*</td>
<td></td>
<td>74.4 Lb</td>
<td>3.00 Lb</td>
</tr>
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<td></td>
<td>7</td>
<td></td>
<td>70.0 Lb</td>
<td>3.00 Lb</td>
</tr>
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<td></td>
<td>9</td>
<td></td>
<td>71.4 Lb</td>
<td>3.00 Lb</td>
</tr>
<tr>
<td></td>
<td>11*</td>
<td></td>
<td>65.2 Lb</td>
<td>3.25 Lb</td>
</tr>
</tbody>
</table>

* Watered daily for 30 days.
† Linseed meal.
‡ Coconut cake.
§ Maize germ meal.
PRICKLY PEAR AS STOCK FEED.—SMITH.

MAINTENANCE TRIALS. NUTRITIVE VALUE OF FEEDS AND AVERAGE DAILY GAINS.

The net nutritive value of the feeds is computed in the starch equivalent system of Kellner (5). It was not possible to determine the digestibility of the prickly pear and other feeds by separate experiment. Therefore the digestibility coefficients adopted for prickly pear were those of American varieties (3, 9), the digestibility of prickly pear protein being taken as 71.6 per cent.*

<table>
<thead>
<tr>
<th>Table 3.—STARCH EQUIVALENTS AND DIGESTIBLE PROTEIN OF RATION DAILY, AND AVERAGE DAILY GAINS.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>GROUP</strong></td>
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<td>-----------</td>
</tr>
<tr>
<td><strong>FIRST TRIALS</strong></td>
</tr>
<tr>
<td>Prickly pear</td>
</tr>
<tr>
<td>Prickly pear and hay</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
</tr>
<tr>
<td>Prickly pear and lucerne (with hay)</td>
</tr>
<tr>
<td>Prickly pear and meal</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
</tr>
<tr>
<td><strong>SECOND TRIALS</strong></td>
</tr>
<tr>
<td>Prickly pear and meal</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
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<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
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<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
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<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
<tr>
<td>Prickly pear and meal (with hay)</td>
</tr>
<tr>
<td>Prickly pear and lucerne</td>
</tr>
</tbody>
</table>

* Watered daily for 30 days.

* Digestibility by pepsin in vitro 70-73 per cent.
The digestibility of the protein of the hays was determined by pepsin in vitro; the digestibility of the carbohydrates was arrived at according to Henneberg's rule* in preference to accepting the digestibility coefficients found for the varieties elsewhere. For the meals the digestibilities and starch equivalents were as given by Kellner. The starch equivalents of the prickly pear and hays were obtained from the starch values by deduction of -29 per cent. for each one per cent. of fibre (5).


The rations in the maintenance trials were generally sufficient for the production of small gains. The nutrients of the rations utilised for preservation of body weight can be deduced from the total nutrients by deduction of 3.0 lb. starch equivalent and -3 lb. protein for each one pound gained, these amounts being shown in feeding trials with oxen to be adequate for that amount of fattening increase (6). By this method the requirement of individual steers for strict maintenance in the first trials is found to range from 5.85 to 7.34 lb. starch equivalent, and from -44 to -74 lb. digestible protein daily. In the second trial the range was 5.50 to 7.43 lb. starch equivalent, and -43 to -69 lb. digestible protein. Per 1,000 lb. live weight the average daily maintenance requirement of steers shown in the first trials is 6.80 lb. starch equivalent and -62 lb. digestible protein; in the second trials 6.39 starch equivalent and -56 lb. digestible protein. The figures agree closely with the maintenance requirement for oxen of other fodders shown by various experiments—viz., 6.0 lb. starch equivalent and -61 lb. digestible protein (5). The inference is that prickly pear nutrients are well used in the maintenance of steers and for production of body weight increase.

The Appetite of Steers for Prickly Pear.

A study of the factors influencing the amounts of prickly pear eaten by steers was made partly during the maintenance trials and partly subsequent to them. The conclusions bearing upon the appetite of steers for prickly pear are dealt with in the following paragraphs:—

Prickly Pear as Sole Feed.—The amounts of succulent prickly pear eaten by three steers when the sole feed in a fifty-day trial ranged from 40 to 60 lb. per day. With three other steers in a ten-day trial the average daily consumption did not exceed 60 lb. per day. The starch equivalent of the average prickly pear ration slightly exceeded 40 lb.

Influence of Supplementary Feeds.—The effect of feeding protein supplying feeds in small amount is to increase the amount of prickly pear eaten by steers. Thus steer 16 when fed meal in the second maintenance trials ate 5.99 lb. starch equivalent prickly pear per day, as against 3.72 when pear was the sole feed. Steer 7 averaging 4.30 lb. starch equivalent when confined to prickly pear took 6.55 lb. when lucerne hay was also given. The feeding of meal increased the consumption of steer 12 from 4.24 to 5.64 lb. starch equivalent prickly pear. Supplementary feeds poor in protein do not similarly increase appetite for prickly pear. Steer 7 when fed millet hay equal in nutriment to the lucerne took only 3.90 lb. starch equivalent prickly pear; the appetite of steer 5 for prickly pear when lucerne was replaced by millet hay fell from 7.19 to 4.16 lb. starch equivalent.

Effect of Degree of Supplementation.—It was recognised early in the trials that increase in the amount of other feeds given decreased the amount of prickly pear eaten. Tables 4 and 5 show

Table 4.—Rations by Groups. Prickly Pear Variously Supplemented.

<table>
<thead>
<tr>
<th>Numbers of Animals</th>
<th>Supplement</th>
<th>Starch Equivalent per 1,000 lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td>5, 9, 11, 13, 15</td>
<td>Hay</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Suppl.</td>
</tr>
<tr>
<td></td>
<td>Lb.</td>
<td>Lb.</td>
</tr>
<tr>
<td>5, 9, 11, 13, 15</td>
<td>1.80</td>
<td>5.00</td>
</tr>
<tr>
<td></td>
<td>3.19</td>
<td>3.83</td>
</tr>
<tr>
<td></td>
<td>4.74</td>
<td>2.85</td>
</tr>
<tr>
<td>2, 4, 8, 10, 14, 17</td>
<td>Meal and hay</td>
<td>2.06</td>
</tr>
<tr>
<td></td>
<td>3.06</td>
<td>4.94</td>
</tr>
<tr>
<td>13, 6, 18</td>
<td>Lucerne and hay</td>
<td>1.40</td>
</tr>
<tr>
<td></td>
<td>2.33</td>
<td>5.30</td>
</tr>
<tr>
<td>2, 4, 8, 10</td>
<td>Meal</td>
<td>1.96</td>
</tr>
<tr>
<td></td>
<td>5.66</td>
<td>4.12</td>
</tr>
<tr>
<td>3, 5, 9, 11</td>
<td>Lucerne</td>
<td>1.32</td>
</tr>
<tr>
<td></td>
<td>3.40</td>
<td>5.03</td>
</tr>
</tbody>
</table>
the reduction of prickly pear nutrients used by experimental animals when the supplementary feeds were increased. All the rations are on the basis of consumption per 1,000 lb. live weight:—

**Table 5.—Individual Rations. Prickly Pear Variously Supplemented.**

<table>
<thead>
<tr>
<th>Number of Animal</th>
<th>Supplement</th>
<th>Starch Equivalent per 1,000 lb.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Supple-</td>
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<td></td>
<td></td>
<td>ment</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Lb.</td>
</tr>
<tr>
<td>2</td>
<td>Meal</td>
<td>1·70</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>5·64</td>
</tr>
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<td></td>
<td></td>
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<tr>
<td>8</td>
<td></td>
<td>5·76</td>
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<td>1·69</td>
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<td>5·58</td>
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<td>10</td>
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<td></td>
<td></td>
<td>5·63</td>
</tr>
<tr>
<td>3</td>
<td>Lucerne</td>
<td>1·31</td>
</tr>
<tr>
<td>5</td>
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<td>3·43</td>
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<tr>
<td>9</td>
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<td>1·31</td>
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<td>3·54</td>
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<td>1·30</td>
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<tr>
<td></td>
<td></td>
<td>3·16</td>
</tr>
</tbody>
</table>

The replacement of prickly pear is not, however, strictly proportional to the increased amounts of other feeds, and generally the total nutritive value is increased by more liberal feeding. The reduction in amount of prickly pear eaten is less with meals than with hays, due no doubt to the bulkier character of the latter. *The daily consumption per head of prickly pear by the steers when fed with minimum but sufficient quantity of other feeds ranged generally from 60 to 90 lb.*

**Effect of Succulence of Prickly Pear.**—The seasonal drying out of the prickly pear during the second maintenance trials was perceived to be accompanied by some alteration in the amounts consumed daily by experimental animals. In order to show the influence of the drying out of prickly pear on the amounts eaten by the steers, Table 6 has been prepared. The data are for thirteen animals over successive ten-day periods.
Table 6.—Variation in Consumption with Alteration in Water Content.

<table>
<thead>
<tr>
<th>Per Cent. Water</th>
<th>Prickly Pear (Lb.)</th>
<th>Dry Matter (Lb.)</th>
<th>Starch Equivalent (Lb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>85.14</td>
<td>66.9</td>
<td>9.96</td>
<td>5.94</td>
</tr>
<tr>
<td>84.35</td>
<td>64.6</td>
<td>10.06</td>
<td>6.04</td>
</tr>
<tr>
<td>82.42</td>
<td>61.8</td>
<td>10.20</td>
<td>6.18</td>
</tr>
<tr>
<td>85.04</td>
<td>59.6</td>
<td>10.47</td>
<td>6.20</td>
</tr>
<tr>
<td>85.75</td>
<td>64.2</td>
<td>9.60</td>
<td>5.84</td>
</tr>
<tr>
<td></td>
<td>68.0</td>
<td>9.70</td>
<td>5.88</td>
</tr>
</tbody>
</table>

With diminution in water content of prickly pear the amounts consumed are progressively diminished, but the amounts of dry matter ingested and nutrients utilised are slightly increased. The indication is that somewhat fuller employment of prickly pear will be made when the water content is below that of the highest succulence. Probably an upper limit would be reached, after which loss of succulence would render the plant less palatable to cattle.

Effect of Watering Cattle on Consumption of Prickly Pear.—Six of the steers were each given water on thirty consecutive days in the second maintenance trials. The giving of water had little effect on the appetite of the animals for prickly pear. Thus the average consumption during the days on which water was given was 6.02 starch equivalent, on the other days 6.42 starch equivalent. The remaining steers during the periods for which the comparison was made ate 6.33 and 6.35 starch equivalent of prickly pear.

Attempted Improvement of Palatability of Prickly Pear.—No method of feeding prickly pear—as feeding after boiling the joints, after singeing or roasting, or feeding salted or admixed with palatable meals—was found to increase the amounts eaten by the steers.


The water supplied by the succulent prickly pear was evidently sufficient for the steers in the winter season. During the first maintenance trials and thereafter for a total of 150 days, the animals had no other water supply than that furnished by the pear. In warmer weather during the second trials it
was deemed advisable to water the steers at least about each fifth day. Certain of the animals given water each day were found to drink from nil on cool days to 6 gallons per head during hot spells. The animals offered water at intervals drank freely.

As already shown, the administration of water has but little effect on the consumption of prickly pear by beasts. Nor is it apparent that watering is directly harmful. Although scouring was more marked in the case of the six steers given water daily for thirty days in the second maintenance trials, it was apparently in no way harmful, and these made body weight gains equal to those of the other animals. (See Tables 2 and 3.)

**Prickly Pear—Forest and Scrub Growth.**

The view has been held by some cattle-men that the prickly pear sheltered by scrubs is more valuable and nutritious than that occurring in open forest land. During the first maintenance trials the scrub form was for a period substituted for the ordinary forest growth. There was no indication that the experimental animals made any discrimination when both forms were placed before them in the feed-boxes. The two forms have practically the same composition, are apparently of equal feeding value, and were equally utilised in the feeding trials (Table 7):

<table>
<thead>
<tr>
<th>Table 7.—Forest and Scrub Prickly Pear.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Composition.</strong></td>
</tr>
<tr>
<td>Scrub</td>
</tr>
<tr>
<td>Forest</td>
</tr>
</tbody>
</table>

**Cow Pear.**

It is a matter of frequent observation that cattle agisted on prickly pear are accustomed to browse certain plants, commonly referred to as "cow pear," to the exclusion of those adjacent. It has been assumed that the preference is on account of distinguishing flavour or instinctive recognition of greater nutritive value. The preferred plant is recognised by
more observant stockmen by a more swarthy hue of the joints and by the bearing of few, aborted, or seedless fruits. The joints are thicker, inclining to club-like, are less acid, and have a slightly fruity odour when cut. Dr. White-Haney at the Dulacca Station (8) devoted some attention to plants apparently identical with those noticed, principally in the direction of establishing absence of fecundity in the flower. Dr. White-Haney did not, however, note the comparative absence of prickle which the author has observed to be a constant characteristic.

The relative palatability of ordinary and cow pear were tested by placing both forms, prepared by slicing, before the experimental animals. For a few days there was shown a distinct preference for the cow pear, due no doubt to appreciation of its lesser acidity after the ordinary form; thereafter the ordinary form appeared to be eaten with as much relish.

In Table 8 are compared the compositions of cow pear and ordinary prickly pear at the same season, and also the utilisation of each when fed over two periods to a group of animals in the second maintenance trials:

<table>
<thead>
<tr>
<th>COMPOSITION</th>
<th>UTILISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Water</td>
</tr>
<tr>
<td>Ordinary pear</td>
<td>87.25</td>
</tr>
<tr>
<td>Prickly pear</td>
<td>83.16</td>
</tr>
</tbody>
</table>

The higher utilisation shown for the cow pear may be attributed to its superior dryness. (See p. 9.) The preference shown for cow pear by cattle at pasture is, no doubt, due to the absence of prickliness, such prickles as is present being soft and downy in character. The ordinary form was equally acceptable when its abundant prickles was detached and abraded by passage through the cutter, or softened by the juice exuding from the sliced and pulped joints.

* Dr. White-Haney's "Abnormal form" also has a lower water content than ordinary prickly pear.
THE WHOLESOMENESS OF PRICKLY PEAR.

The good condition of the steers at the conclusion of seven to eight months' feeding was evidence that prickly pear is a wholesome cattle feed. Certain of the animals were slaughtered and made subject of post-mortem examination. The report (10) of the veterinary surgeon, Mr. A. McGown, M.R.C.V.S., states that the carcasses were well nourished and entirely healthy; flesh of good colour, nicely grained, and of good quality; fat evenly distributed, good clear white in colour and of good quality. Certain changes were evident in the alimentary canal—viz., some signs of occasional slight ulceration of tongue and fauces, roughened palate, and enlarged papillae both of cheek and rumen, thickened and toughened mucous membrane of certain organs.

The slight lesions described would have been caused by portions of spines included in the feed. They are accidental rather than necessary effects of the feeding of chopped *O. inermis*. Animals browsing the pest pear are apt, however, to sustain some injury from spines, as evidenced by spines occasionally found embedded in the tongue and the occurrence of abscess of the jaw and fauces. Cattle constrained by hunger to browse the prickly form of *O. inermis* may suffer from sore mouth to an extent preventing further feeding. The alterations noted in the post-mortem are ascribed to the prickle ingested and the nature of the feed.

Ranchers in Texas are reported to lose cattle from the effects of accumulation of prickly pear fibre in the stomachs (2). The condition is said never to occur from feeding chopped prickly pear, and is obviated by inclusion of a reasonable amount of other feed in the dietary. In local experience it would appear that fibre balls are but rarely encountered in slaughtered beasts. Cases of bloat are reported from America. Bloat could, no doubt, be caused by surfeit. The amount of *O. inermis* that steers are willing to eat appears, however, to be substantially lower than obtains with certain American species. Owing probably to the watery character of the feed and the low fibre content, rumination is restricted in animals receiving a high proportion of prickly pear in the dietary. The assertion that has been made that feeding on prickly pear unfit cattle for grass pasturage is, however, negatived by the fact that steers employed in the trials subsequently made good gains at grass and were eventually marketed in prime condition.
PRICKLY PEAR AS STOCK FEED.—SMITH.

The Utility and Limitations of Prickly Pear as a Roughage for Steers.

The trials here described demonstrate the ability of rations comprising a high proportion of prickly pear properly supplemented by other feeds to produce substantial gains in steers. Prickly pear is a satisfactory sole roughage fed with meals.

The insufficiency as a maintenance feed of prickly pear alone was shown in the first maintenance trials when three steers receiving it and no other feed rapidly lost weight, scoured badly, and exhibited stariness of coat and other signs of unthriftness. Steer No. 16, initially in rather low store condition, showed signs of weakness at the end of fifty days, when all three were given meal or lucerne in addition to prickly pear. Thereupon improvement in appearance and condition was soon noticed.

Animals receiving a medium allowance of ordinary hays, though maintaining body weight during sixty and sixty-five day periods, showed in dulness of coat sign of unthriftness attributable to improper rather than insufficient feed.

Besides its use as a maintenance feed and drought emergency fodder, the employment of prickly pear in rations for fattening steers is reported from Texas, cotton-seed meal being generally combined with it for the purpose. Griffiths (1) records good results with this ration at Encinal, Texas. Twenty-seven head fed chopped prickly pear, and consuming 96 lb. per head and about 4.4 lb. cotton-seed meal daily, averaged in gain 13 lb. per day. For this result the starch equivalent of the daily ration would have approached 12 lb., of which the prickly pear contributed 9 lb.

With *O. inermis* the highest ration, including medium allowance of meal, consumed by steers does not, as shown in the experimental part of this paper, much exceed 10 lb. starch equivalent, adequate only to production of 1 lb. fattening increase daily. It is also shown that increase of meal with the object of improving the ration would reduce the amount of prickly pear eaten, and the total nutritive value of the ration would not be increased proportionately to the added meal. A rate of fattening increase equal to that of the Texan experiments quoted could not, therefore, be procured except by including high amounts of meal in the feed, which would then comprise a comparatively low proportion of prickly pear.
The inferior utility for purposes of fattening that is shown for *O. inermis* might reasonably be attributed to a lower palatability to cattle than is possessed by the species employed in the Texan trials. The medium order of palatability demonstrated for it would indicate that the utility of the pest pear for beef cattle is as a maintenance feed rather than as a roughage in rations designed for economic productive purposes.

**Agistment Problems.**

There has been much variance of opinion among cattle-men as to the value of standing prickly pear in agistment, and considerable uncertainty has existed as to the factors contributing to the carrying capacity of prickly pear lands. It has been commonly held that prickly pear has been instrumental in drought in saving cattle not removed to more favoured regions for pasture, and that at all seasons dense prickly pear areas are capable of carrying and turning out a certain number of beasts in fat condition. It has also been claimed that cattle can exist for long periods or indefinitely with no other water supply than is provided by succulent prickly pear, and that access to water may be attended by harmful or even fatal results.

It is thought possible to obtain a solution of certain vexed questions in prickly pear agistment by application of the results of the feeding trials. It has been shown that the various forms of prickly pear differ but slightly in nutritive value and utility to the beast, save that the comparatively prickle-free form (cow pear) alone allows of free browsing. Prickly pear alone, chiefly due to poverty in protein, has been shown to be insufficient for the maintenance of cattle, which depends on provision of protein-supplying feeds as supplements to the prickly pear.

In many areas the deficiency of protein of prickly pear is made good by naturally occurring edible shrub. In the typical prickly pear scrubs of the Maranoa there were observed as many as thirty varieties of shrub or small tree recognised by consensus of reliable opinion as edible to cattle, though of varying palatability and protein content. The main factors in the carrying capacity of prickly pear areas are abundance of edible prickly pear ("cow pear") and sufficiency of protein-supplying edible shrub—conditions that no doubt characterise the best prickly pear scrubs. A combination of prickly pear
and lucerne hay in medium amount was shown in the trials to be capable of producing in steers increase exceeding $\frac{1}{2}$ lb. per day. A similar ration of prickly pear and edible shrub, which should be not infrequently obtainable in the scrubs, would, there appears every reason to assume, be productive of similar increase. The limitation of the prickly pear ration by the restricted appetite shown for it by steers would, however, generally limit the rate of fattening increase to a moderate figure, which, though attained in the earlier stages of fattening, would be insufficient to ultimately, in the most favourable circumstances, produce beasts of more than moderately fat or good store condition.

Accordingly as the edible pear is limited in amount or the edible shrub is insufficient, cattle will fail to do well. The prime beast occasionally reported would appear to be exceptional and to depend on utilisation of other and better grazing than prickly pear and shrub, or on a higher appetite for prickly pear than is shown by the average animal.

The appetite of steers for prickly pear is such as to enable their water requirements to be satisfied by the plant at least in cool weather. In hot seasons the highest degree of succulence may suffice, whereas in prolonged drought, owing to the drying out of the prickly pear, the holding of cattle on unwatered country is no doubt highly hazardous, and may entail heavy loss. The administration of water to prickly pear fed animals has been shown to be, per se, unharmful. Yet it would appear that close frequentation of water by cattle during very hot seasons might prove a disadvantage, owing to depletion of the edible prickly pear in the vicinity and eating out of edible shrub. The reported losses of prickly pear agisted cattle having access to water would seem to be accidental, due in drought to immoderate drinking of water induced by prolonged thirst, and would include animals that have perished after bogging at the margins of waterholes.

The appetite displayed by milking cows for prickly pear (see Part II.) would indicate that, if the supply of protein-rich shrub is abundant, cows will be maintained in milk sufficient for the nourishment of calves at foot. The very limited appetite of calves for prickly pear* would show that prickly pear and shrub browse, partly because of the inaccessibility of the

* The author's experiments with calves not here reported.
shrub, will not adequately provide for sustenance and growth of young stock, which, indeed, appears to be the experience of most cattle-men.

PART II.—PRICKLY PEAR FOR DAIRY HERDS.

Griffiths (2) records the regular use of prickly pear for dairy herds in Texas, and later (1) shows its suitability for roughage in a trial with two milk cows. In Sardinia employment in suitable rations is regarded as advantageous. More recently Woodward, Turner, and Griffiths (9), in a comprehensive trial at Brownsville, Texas, have demonstrated the possibility of using prickly pear in considerable proportion in rations for milk production. Locally, apart from a limited use of the boiled joints generally fed with bran or the enforced browsing of edible prickly pear in drought, the plant has not found any general use for dairy herds.

The utility of prickly pear as a feed for dairy cows depends fundamentally on the actual value of the prickly pear nutrients in the rations, but will be conditioned by such considerations as the cost of feeds, both relative and actual, with which it might be fed or replace in the ration. In this paper the value of the nutrients of prickly pear in milk production alone is discussed without reference to the economic side.

Plan of Experiment.

In the author's main experiments fifteen dairy cows were utilised—pure and grade Ayrshires, grade Shorthorns, and Jersey grade. Of these, seven were acquired in the district and were doubtless accustomed to prickly pear in the pasture. The plan was to compare prickly pear as a roughage feed, both as regards its efficiency in the ration and effect on the quality of the product, with a usual roughage, which in this case was mature Soudan grass (Sorghum var.) hay coarsely chaffed. The concentrates completing each ration were wheat-bran and linseed meal in equal quantities.

As it was evident from the work with steers that prickly pear was not a highly palatable feed, it appeared probable that enough would not be eaten by the cows, when liberally supplemented by meal, to constitute a ration adequate to high milk yields. Accordingly the trials were preceded by a
preliminary period, when all received a ration of meal and as much prickly pear as was eaten for long enough to allow the yields to recede to a level commensurate with the highest prickly pear ration that could be fed to each.

Three comparisons were made—viz., prickly pear alone vs. Soudan grass hay; prickly pear vs. prickly pear and hay; and prickly pear and hay vs. hay. In addition, two cows were fed prickly pear continuously. The comparisons were made during forty-day periods, the first ration being fed in two separate half periods of twenty days, the second in an interposed forty days. The cows were grouped and fed as shown in Table 9:

<table>
<thead>
<tr>
<th>No. of Cows</th>
<th>First Ration (20 days)</th>
<th>Second Ration (40 days)</th>
<th>First Ration (20 days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Prickly pear and meal</td>
<td>Hay and meal</td>
<td>Prickly pear and meal</td>
</tr>
<tr>
<td>5</td>
<td>Prickly pear and meal</td>
<td>Prickly pear and meal</td>
<td>Prickly pear and meal</td>
</tr>
<tr>
<td>3</td>
<td>Prickly pear, hay, and meal</td>
<td>Hay and meal</td>
<td>Prickly pear, hay, and meal</td>
</tr>
<tr>
<td>2</td>
<td>Prickly pear and meal continuously†</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Ten days' transition periods for changing feeds were allowed.
† Five months.

The prickly pear was of about 85 per cent. water content, and was prepared by passing through a Texan prickly pear slicer. Generally as much was fed as was eaten. In the second period as much hay was given as produced about the same body weight gains as were previously obtained with prickly pear. Allowance of meal was made to provide protein in accordance with the Haecker standard for milch cows' (4). The meal allowance was adjusted to the butter-fat yield every tenth day. The prickly pear and other feeds were regularly analysed. The digestibility coefficients of the feeds were obtained in the manner employed in the work with steers. The milk was weighed at each milking and analysed each alternate day during the periods. The fat content and specific gravity were determined and the solids-not-fat calculated by Richmond's formula. The initial and final body weights were each based on ten consecutive daily weighings, corrected as in the work with steers.
Milk Production, Feeds, and Body Weights.

Tables 10 and 11 give the data by groups relative to yields, feeds, and alterations in body weights.

Table 12 deals with the starch equivalents and content of digestible protein of the rations.

Table 10.—Group Yields of Milk, Butter-fat, and Solids-not-fat. Forty-day Periods.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1—</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10, 11, 12, 13, 14</td>
<td>Prickly pear and meal</td>
<td>3,447</td>
<td>145:27</td>
<td>4:21</td>
</tr>
<tr>
<td></td>
<td>Hay and meal</td>
<td>3,333½</td>
<td>162:54</td>
<td>4:57</td>
</tr>
<tr>
<td>Group 2—</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9, 16, 17, 18, 19</td>
<td>Prickly pear and meal</td>
<td>3,770½</td>
<td>152:43</td>
<td>4:03</td>
</tr>
<tr>
<td></td>
<td>Prickly pear, hay, and meal</td>
<td>3,920</td>
<td>168:82</td>
<td>4:31</td>
</tr>
<tr>
<td>Group 3—</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1, 4, 6</td>
<td>Prickly pear, hay, and meal</td>
<td>2,010½</td>
<td>80:73</td>
<td>4:01</td>
</tr>
<tr>
<td></td>
<td>Hay and meal</td>
<td>1,987</td>
<td>80:44</td>
<td>4:25</td>
</tr>
</tbody>
</table>

Table 11.—Group Rations and Gains in Body Weights. Forty-day Periods.

<table>
<thead>
<tr>
<th>Nos. of Cows.</th>
<th>Rations.</th>
<th>FEEDS CONSUMED.</th>
<th>Gains.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lb.</td>
<td>Lb.</td>
</tr>
<tr>
<td>Group 1—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10, 11, 12, 13, 14</td>
<td>Prickly pear and meal</td>
<td>12,498</td>
<td>1,676</td>
</tr>
<tr>
<td></td>
<td>Hay and meal</td>
<td>2,208</td>
<td>1,845</td>
</tr>
<tr>
<td>Group 2—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9, 16, 17, 18, 19</td>
<td>Prickly pear and meal</td>
<td>11,868</td>
<td>1,738</td>
</tr>
<tr>
<td></td>
<td>Prickly pear, hay, and meal</td>
<td>8,321</td>
<td>702</td>
</tr>
<tr>
<td>Group 3—</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1, 4, 6</td>
<td>Prickly pear, hay, and meal</td>
<td>3,283</td>
<td>561</td>
</tr>
<tr>
<td></td>
<td>Hay and meal</td>
<td>1,377</td>
<td>1,017</td>
</tr>
</tbody>
</table>

Comparing the yields, it is seen that prickly pear as the sole roughage produced more milk but less butter-fat than did the hay roughage.

The part roughage of prickly pear (prickly pear and hay) likewise produced more milk and less fat than the whole roughage of hay.

The part roughage of prickly pear produced more milk and more butter-fat than the whole prickly pear roughage.

Prickly pear reduced the fat percentage in the milk, but did not appreciably alter the content of solids-not-fat.
On the showing of Table 12, the hay rations supplied protein a little more liberally, but all the rations are comparable in this regard.

The Comparative Value in Milk Production of Prickly Pear and Soudan Grass Hay.

Woodward, Turner, and Griffiths estimated the relative values of prickly pear and sorghum hay for butter-fat production in rations producing approximately equal body-weight gains, disregarding the utilisation of portion of the ration for
production of body-weight increase. Their method was essentially to divide the weights or nutritive values of each feed by the weight of butter-fat produced. For the production of 1 lb. of butter-fat they were thus able to show in the various rations that a certain quantity of hay or prickly pear, proportional to their values for production, and equal quantities of grain were required.

By a similar method applied to the data for Groups 1 and 3 (Table 12), the author obtained the figures shown in Table 13:

<table>
<thead>
<tr>
<th>Ration</th>
<th>Prickly Pear</th>
<th>Hay</th>
<th>Meal</th>
<th>Gains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prickly pear and meal</td>
<td>7.32</td>
<td>Lb.</td>
<td>Lb.</td>
<td>27</td>
</tr>
<tr>
<td>Hay and meal</td>
<td></td>
<td>4.06</td>
<td>7.24</td>
<td>28</td>
</tr>
<tr>
<td>Group 3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prickly pear, hay, and meal</td>
<td>3.48</td>
<td>2.16</td>
<td>7.78</td>
<td>39</td>
</tr>
<tr>
<td>Hay and meal</td>
<td></td>
<td>4.90</td>
<td>7.67</td>
<td>44</td>
</tr>
</tbody>
</table>

It was thought, however, that the roughages could be better compared if the rations provided only for maintenance and milk-production without body-weight increase, and the figures were subsequently adjusted by subtraction from the nutrients of the roughage feeds of amounts adequate to the gains noted.* In addition, on the assumption that the nutrients of the hay and meal were of equal value in the rations, the slight inequalities of the quotients for meal have been smoothed out by conversion of the excess in one of the pair of meal quotients to hay nutrients. By this method of procedure there were obtained the following results, which are thought to be at least as accurate as those of Woodward, Turner, and Griffiths, viz.:

Prickly pear fed as sole roughage (high amounts), 7.32 lb. starch equivalent prickly pear = 3.90 lb. starch equivalent hay; or 1.88 lb. starch equivalent prickly pear = 1.00 lb. starch equivalent hay.

Prickly pear fed as part roughage with hay (medium amounts), 3.48 lb. starch equivalent prickly pear = 2.39 lb. starch equivalent hay; or 1.41 lb. starch equivalent prickly pear = 1.00 lb. starch equivalent hay.

* Viz., 3.0 starch equivalent for 1 lb. body-weight increase (6, p. 198).
On the basis of butter-fat production, Woodward, Turner, and Griffiths found that, for *O. gommei* and *O. cyanella*, one part digestible nutrients of sorghum hay equalled 1-4 parts digestible nutrients prickly pear when fed in medium amount; while when fed in high amount the value of the prickly pear was 33 per cent. lower.

As milk is generally valued as a commodity on butter-fat content, the butter-fat basis is no doubt the best on which to evaluate the feeds. If compared on the basis of milk produced, having no regard to fat content, the comparative values of prickly pear and hay will be slightly more favourable to prickly pear. In terms of weights of the feeds, 1 lb. of chaffed Soudan grass hay in rations for milk cows is equal in value to 5 to 6 lb. of succulent prickly pear (85 per cent. water content) when the prickly pear is fed in medium amount, and to 8 lb. when fed in high amounts.

**The Influence of Prickly Pear on Composition of Milk.**

Feeding prickly pear reduces the fat content of the milk; generally the higher the amount fed, the greater the reduction. (Table 10.) Table 14 gives the fat percentage of the milk of individual cows receiving various feeds in the course of the trials. Table 15 also shows the effect of prickly pear by comparing the fat content of the milk of individuals just before and after changes of roughages:

**Table 14.—Butter-fat in Milk of Individual Cows during Diverse Feeding.**

<table>
<thead>
<tr>
<th>Nos. of Cows</th>
<th>Ration.</th>
<th>Fat.</th>
<th>Ration.</th>
<th>Fat.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prickly pear and meal</td>
<td>Per cent.</td>
<td>Hay and meal</td>
<td>Per cent.</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>5-70</td>
<td></td>
<td>6-16</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>4-39</td>
<td></td>
<td>4-52</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>3-49</td>
<td></td>
<td>3-74</td>
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<tr>
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<td>4-15</td>
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<td>4-88</td>
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<tr>
<td>14</td>
<td></td>
<td>4-07</td>
<td></td>
<td>4-79</td>
</tr>
<tr>
<td>9</td>
<td>Prickly pear and meal</td>
<td>3-37</td>
<td>Prickly pear, hay, and meal</td>
<td>3-90</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>3-38</td>
<td></td>
<td>3-98</td>
</tr>
<tr>
<td>17</td>
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<td>5-34</td>
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<td>5-20</td>
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<td>18</td>
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<td>4-22</td>
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<td>4-14</td>
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<tr>
<td>19</td>
<td></td>
<td>4-06</td>
<td></td>
<td>4-34</td>
</tr>
<tr>
<td>1</td>
<td>Prickly pear, hay, and meal</td>
<td>4-17</td>
<td>Hay and meal</td>
<td>4-33</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>4-32</td>
<td></td>
<td>4-69</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>3-43</td>
<td></td>
<td>3-75</td>
</tr>
</tbody>
</table>
Table 15.—Fat Percentage in Milk for Ten-day Periods before and after Change of Roughage.

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>%</td>
<td></td>
<td>%</td>
</tr>
<tr>
<td>10</td>
<td>Prickly pear—hay</td>
<td>5.97-6.10</td>
<td>Hay—prickly pear</td>
<td>6.52-5.55</td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>4.14-4.90</td>
<td></td>
<td>5.68-4.99</td>
</tr>
<tr>
<td>12</td>
<td></td>
<td>3.58-3.68</td>
<td></td>
<td>3.98-3.75</td>
</tr>
<tr>
<td>13</td>
<td></td>
<td>3.85-4.76</td>
<td></td>
<td>5.01-4.52</td>
</tr>
<tr>
<td>14</td>
<td></td>
<td>4.18-4.97</td>
<td></td>
<td>4.85-4.18</td>
</tr>
<tr>
<td>9</td>
<td>Prickly pear—part prickly pear</td>
<td>2.95-3.94</td>
<td>Part prickly pear—prickly pear</td>
<td>4.15-3.91</td>
</tr>
<tr>
<td>16</td>
<td></td>
<td>3.05-3.94</td>
<td></td>
<td>4.03-3.94</td>
</tr>
<tr>
<td>17</td>
<td></td>
<td>4.22-5.02</td>
<td></td>
<td>5.48-5.90</td>
</tr>
<tr>
<td>18</td>
<td></td>
<td>3.89-4.03</td>
<td></td>
<td>4.18-4.66</td>
</tr>
<tr>
<td>19</td>
<td></td>
<td>4.01-4.62</td>
<td></td>
<td>4.64-4.43</td>
</tr>
<tr>
<td>1</td>
<td>Part prickly pear—hay</td>
<td>4.10-4.11</td>
<td>Hay—part prickly pear</td>
<td>4.12-4.02</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>4.44-4.77</td>
<td></td>
<td>4.80-4.46</td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>3.18-3.67</td>
<td></td>
<td>3.93-2.93</td>
</tr>
</tbody>
</table>

A similar reduction of butter-fat content was shown to attend the feeding of prickly pear in the Brownsville trials (9).

As already shown, the inclusion of prickly pear in the ration of dairy cows does not influence the percentage of solids-not-fat of the milk.

**The Influence of Prickly Pear on the Quality of the Product.**

No characteristic flavour was found to be imparted to the milk of the cows by feeding prickly pear. Tested for keeping properties in comparison with milk produced on hay roughage, no distinction could be drawn with regard to the rate or condition of souring of the samples. The cream from the milk of prickly pear fed cows could be churned without difficulty. The butter, in contrast to the highly coloured product obtained by Woodward, Turner, and Griffiths, was paler than that produced on the hay roughage. It was judged by the Government dairy expert to be not inferior to the butter produced by hay fed cows.

The milk of prickly pear fed cows seemed to be entirely suitable for cheesemaking. The time of coagulation was normal, and the curd displayed no property that would be unfavourable to manufacture.

**The Suitability of Prickly Pear as a Roughage for Dairy Cows.**

Prickly pear is an entirely wholesome roughage for dairy cows, and can be safely fed for considerable periods. All the
cows increased in weight during the trials, and were in satisfactory condition at the conclusion. Cows 5 and 15 received a ration of prickly pear and meal continuously for 140 days. Cow 5 averaged 24½ lb. milk per day at the beginning, and finally 9 lb. per day; during the period she yielded 1,926½ lb. of milk, containing 77-26 lb. of butter-fat. Cow 15 gave 2,634½ lb. of milk and 96-67 lb. of butter-fat; at the beginning her yield was 26½ lb. of milk per day, and finally 17 lb. Both increased in weight during the period.

Three other cows which were advanced in calf dried off early and were each given 2 to 3 lb. meal per day with 70 to 80 lb. of prickly pear. They remained in excellent condition and subsequently gave birth to well-formed and vigorous calves.

The amount of succulent prickly pear eaten by cows receiving a liberal allowance of meal was about 60 lb. per day. The appetite of dairy cows for prickly pear is somewhat better than that of steers, and is better maintained when other feeds are liberally supplied. Nevertheless, as with steers, when the amounts of supplementary feeds are increased the amount of prickly pear consumed, even when the total feed given is still below the capacity of the cow, is progressively diminished.

This fact, evidence of at most medium palatability of prickly pear, in conjunction with the inferior value of prickly pear nutrients for milk production, would render prickly pear rations, employing prickly pear in high or medium amounts, inadequate to maintain the full milk supply of high-yielding cows. When amounts of meal are given to provide for high milk yield, the amount of prickly pear taken will be small, and the total ration inadequate to the yield. It is thought that prickly pear and meal rations, containing prickly pear as the sole roughage or in such amounts as might be fed with a part roughage of hay, will not generally provide for yields of more than 2½ gallons of milk per day. The supplementation of prickly pear with legume hay in lieu of meal will, on account of greater restriction of appetite for prickly pear due to the bulkier feed, provide only for a lower level of milk yield.

Owing to the greater reduction of butter-fat and depression of milk yield produced by feeding in high amount and as the sole roughage, it would be better to make the prickly pear part of the roughage ration with hay. So fed, prickly pear
appreciably increases the milk yield as compared with an entire hay roughage. Under circumstances where the accompanying depression of butter-fat content is not important, the inclusion of the succulent in the dietary of medium-yielding dairy cows would be an advantage.

PART III.—PRICKLY PEAR IN THE MAINTENANCE OF SHEEP.

Cacti, cut by the machettes of ranchmen, in conjunction with browse afforded by edible bush, are reported to be serviceable as a drought feed for sheep in Texas, while the succulence of the plants in the Mexican desert is said to enable flocks to remain as long as sixty days unwatered (2). Locally O. inermis in pasture has been regarded as of no value as sheep feed, the animals either being injured by the prickle or becoming addicted to fruit-eating with fatal results. The object of the experimentation with sheep was to determine the value of prickly pear as a maintenance feed when fed after preparation.

Experimental.

The sheep utilised were lightly woolled store six-tooth ewes, crossbreds or merinos. The prickly pear was of 83-85 per cent. water content, sliced by machine and further finely minced by hand implements. The prickly pear was variously supplemented. The arrangement of the experiment is shown in Table 16:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Duration</th>
<th>Number of Sheep</th>
<th>Supplementary Feeds, Lb. per head daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 days</td>
<td>20</td>
<td>Nil</td>
</tr>
<tr>
<td>2</td>
<td>60 days</td>
<td>8</td>
<td>-64 lb. wheat bran</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td>10</td>
<td>-30 lb. linseed meal</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>10</td>
<td>-80 lb. chaffed hay</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td>9</td>
<td>-33 lb. linseed meal</td>
</tr>
<tr>
<td>6-10</td>
<td>70 days</td>
<td>7-10</td>
<td>-47-55 lb. chaffed hay, -09-11 lb. blood meal</td>
</tr>
</tbody>
</table>

The total time for which the sheep were fed prickly pear was five months.

The sheep were fed by groups in wooden troughs, and no other feed was available than was given. The animals were
provided with salt and sulphate of iron licks. The average amounts of prickly pear eaten per head daily, the nutrients of the rations, and the daily gains recorded in the experiments are given in Table 17:

<table>
<thead>
<tr>
<th>Experiment</th>
<th>Prickly Pear. Average per Head daily</th>
<th>Starch Equivalent</th>
<th>Average Body Weights.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3.82 Lb.</td>
<td>0.31 Lb.</td>
<td>3.11 Lb.</td>
</tr>
<tr>
<td>2</td>
<td>3.10 Lb.</td>
<td>0.26 Lb.</td>
<td>0.57 Lb.</td>
</tr>
<tr>
<td>3</td>
<td>2.91 Lb.</td>
<td>0.25 Lb.</td>
<td>0.49 Lb.</td>
</tr>
<tr>
<td>4</td>
<td>3.21 Lb.</td>
<td>0.26 Lb.</td>
<td>0.57 Lb.</td>
</tr>
<tr>
<td>5</td>
<td>3.70 Lb.</td>
<td>0.30 Lb.</td>
<td>0.56 Lb.</td>
</tr>
<tr>
<td>6</td>
<td>2.08 Lb.</td>
<td>0.17 Lb.</td>
<td>0.43 Lb.</td>
</tr>
<tr>
<td>7</td>
<td>1.80 Lb.</td>
<td>0.15 Lb.</td>
<td>0.41 Lb.</td>
</tr>
<tr>
<td>8</td>
<td>2.64 Lb.</td>
<td>0.22 Lb.</td>
<td>0.46 Lb.</td>
</tr>
<tr>
<td>9</td>
<td>2.10 Lb.</td>
<td>0.18 Lb.</td>
<td>0.44 Lb.</td>
</tr>
<tr>
<td>10</td>
<td>2.80 Lb.</td>
<td>0.24 Lb.</td>
<td>0.46 Lb.</td>
</tr>
</tbody>
</table>

The amount of digestible protein in the average prickly pear ration in Experiment 1 was -0.01 lb.; the amounts in Experiments 2 to 5 ranged from -0.05 to -0.09 lb.; in Experiments 6 to 10, -0.09 lb. The gains shown are the averages in the groups; at the same time it was apparent that some sheep did better than others. The differences would be accounted for by differences in appetite for prickly pear. Two sheep in Experiment 2 and one in Experiment 3 ate so little prickly pear that it was necessary to remove them to other feed.

The proportion of the total nutrients furnished by prickly pear in Experiments 2 to 5 was about 50 per cent.; in Experiments 6 to 10, 40 to 50 per cent.

The average rations in Experiments 2 to 5 were sufficient to enable the sheep to maintain their condition. In Experiments 6 to 10 the sheep did less well owing to the lower appetite displayed for prickly pear.

**The Appetite of Sheep for Prickly Pear.**

Prickly pear is indifferently palatable to sheep. It was found that as the amounts of supplementary feeds were increased the amount of prickly pear consumed was pro-
gressively decreased, and when about 7 lb. starch equivalent was given per sheep in the form of other feeds practically no prickly pear was eaten.

Watering inhibits the consumption of prickly pear by sheep. In Experiments 1 to 5 in winter it was not deemed necessary to water the sheep, save at infrequent intervals, and the prickly pear eaten was higher than in the later experiments, during which warmer weather necessitated watering at least each fifth day. On days on which water was given the sheep ate less prickly pear. The average prickly pear consumption per head on days on which the sheep had no water was -28 lb. starch equivalent; when water was given, it receded to -14 lb.

The Limited Utility of Prickly Pear as Sheep Feed.

The indifferent palatability of prickly pear will limit its usefulness to that of an emergency drought fodder for the maintenance of mature sheep; for which purpose it will be a safe and economical feed and may compose up to 50 per cent. of balanced rations, in which it is included. The failure noted of a few sheep to subsist thereon does not affect the general conclusion as to the utility of prickly pear for maintenance; and even the reduced rations, due to occasional watering in warmer seasons, would enable the animals to subsist, or preserve a lean condition, over considerable periods. It will be evident that, for the best results with prickly pear, sheep should be given water as infrequently as the season permits.

The author is of opinion that prickly pear where it occurs might advantageously be made a portion of a drought ration with the edible shrub commonly cut for sheep. The succulence of the plants would tend to conserve water supplies, and would provide a corrective to the fibrous and astringent foliage which may be productive of impaction and losses from this cause.

Prickly pear is not sufficiently palatable to be included in rations designed for fattening or adequate to the maintenance of milk yield of ewes with lambs at foot.

A separate trial showed prickly pear to have no utility as a feed for lambs. The animals ate little, and, when supplied liberally with other feeds, refused prickly pear altogether.
SUMMARY AND CONCLUSIONS.

The prickly pear employed in trials with steers, dairy cows, and sheep was *O. inermis*, a prickly but comparatively spineless species. It was fed after slicing, and no other preparation was necessary.

Prickly pear is a wholesome cattle feed, but alone will not enable cattle to subsist for more than limited periods.

Prickly pear is not highly palatable to steers. With minimum amounts of meals or legume hay, however, steers will generally eat enough to obtain a total ration somewhat more than sufficient for maintenance.

The almost medium palatability of prickly pear will make it useful chiefly in maintenance rations. On account of the little appetite shown for prickly pear when supplementary feeds are given liberally, economic fattening of steers would not be possible on rations employing prickly pear.

No form of prickly pear is markedly more nutritious or palatable than others.

The requirements for the thrift of cattle at prickly pear agistment are edible prickly pear—the form free from prickle—and edible shrub. The best browse afforded by prickly pear and shrub will generally provide only for the turning out of cattle in at most good store condition.

The succulence of prickly pear will satisfy the water requirements of cattle in cool seasons. In drought during hot weather water supplies will be necessary.

Prickly pear is not highly palatable to dairy cows.

Feeding prickly pear reduces the yield of butter-fat and the percentage of butter-fat in the milk. The higher the amount of prickly pear fed in the ration, the greater the reduction. The content of solids-not-fat in the milk is not affected by feeding prickly pear.

Feeding prickly pear slightly increases the milk yield. The increase is more marked when prickly pear is fed in medium amounts than when it constitutes the sole roughage.

The nutrients of prickly pear have less value in milk production than have the nutrients of hay.
Compared with succulent prickly pear, 1 lb. of Soudan grass (Sorghum var.) hay was equal to 5 to 6 lb. of prickly pear when the prickly pear was fed in medium amount, and to 8 lb. of prickly pear when given in high amount. It will be better to feed prickly pear as part roughage with hay than as the sole roughage and in high amount. Where reduction of butter-fat is not important, prickly pear would be useful as a succulent in the dietary of milch cows.

Owing to reduction of the amount eaten through feeding high amounts of supplementary feeds, it will not be possible to include prickly pear in high or medium amount in the rations of more than medium-yielding cows.

The butter produced by prickly pear fed cows is pale in colour. The milk is suitable for cheesemaking.

Prickly pear can well constitute the bulk of the ration of dry cows.

It is thought that O. inermis is less palatable to cattle than some other species.

Prickly pear is indifferently palatable to sheep. It can be fed finely cut without ill effect.

With small amounts of other feeds enough prickly pear is generally eaten to constitute a ration that is barely sufficient to maintain the sheep.

The succulence of prickly pear will supply sheep with sufficient water in cool weather. The appetite of sheep for prickly pear is diminished when water is given. For the best results the animals should be watered only as made imperative by the season.

The utility of prickly pear for sheep is solely as a roughage in rations for maintenance. It will have no value in sheep-raising.
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THE PHYLOGENETIC SIGNIFICANCE OF THE PREHALLUX AND PRE-POLLEX: A THEORY.

By C. D. Gillies, M.Sc., and P. W. Hopkins, M.C.

(Plate I.)

(Read before the Royal Society of Queensland, 27th June, 1921.)

One of the most conspicuous discontinuities in the accepted evolutionary scheme of the Tetrapodal Vertebrata lies between the Fish on one hand and the Amphibia on the other; this hiatus is accentuated by the almost dramatic appearance of the pentadactyl limb, or cheiropterygium, in its typical form in the earliest known Tetrapoda, i.e. the Stegocephalia, and, to add to the obscurity, embryology has thrown but little illumination upon the derivation of the appendage from the Fish limb or ichthyopterygium.

Those fish which are regarded as being nearest the Tetrapoda, such as the Dipnoi and Crossopterygii, possess pelvic and pectoral appendages typically piscine, whereas the most primitive Amphibia are provided with limbs constructed upon the pentadactyl plan, in common with the higher Tetrapoda. Omitting the girdle, the cheiropterygium in its typical form is usually resolved into five parts, viz.:

(a) A proximal single long bone (e.g. femur);
(b) A set of two long bones (e.g. tibia and fibula), which articulate with
(c) A series of small bones (e.g. tarsalia), followed by
(d) A set of five small elongated bones (e.g. metatarsals), supporting
(e) Phalanges of the digits.

For a considerable period all the metacarpals and metatarsals were regarded as being serially homologous in each instance, but it has been subsequently shown that the so-called first metacarpal and metatarsal are both homologous with phalanges. This being so, the question suggests itself, What has happened to the true first metacarpal and metatarsal? The fate of these structures has engaged our attention for some time and, as a result, in this paper is presented a theory which we hope will satisfactorily explain the disappearance of these bones.

So far as we can ascertain from the available literature we believe that we have not been anticipated in our views.
THE PHALANGEAL AFFINITIES OF THE FIRST “METACARPAL” AND “METATARSAL.”

In the ontogeny of the human metacarpus and metatarsus, it is found that each bone arises from two centres, a primary and a secondary. From the first develops the corpus or body of the bone, while from the second arises the epiphysis. In regard to the second-fifth metacarpals and metatarsals, the epiphysis is situated distally, but in the case of the first metacarpal and metatarsal the epiphysis is proximal—a feature characteristic of the phalanges. In addition to the method of ossification there is the nature of the vascular supply. The nutrient canal in both the phalanges and the first metacarpal and metatarsal is directed towards the capitulum or “runs from the elbow”; this is the reverse of that which occurs in the remaining metacarpals and metatarsals.

After taking everything into consideration, the “metacarpal” and “metatarsal” of the thumb and big toe, respectively, show such convincing phalangeal affinities that they are now almost universally regarded by anatomists as being homologous with phalanges, but on account of their analogy with the series associated with them, as well as for convenience, their names have not been changed.

The theories relating to the subject may be grouped under three headings as follows:

(a) Three phalanges present, metacarpal (or metatarsal) absent;

(b) Two phalanges present, metacarpal (or metatarsal) present;

(c) Two phalanges present, proximal component a phalango-metacarpal (or phalango-metatarsal).

Of these the first is the most generally accepted and it is the one supported by the authors. With reference to (b) and (c), G. M. Humphrey, in 1858, practically combined these two views, as he regarded the bone in the hand articulating with the multangulum majus (trapezius) as intermediate between a phalanx and a metacarpal, but on the whole he considered that it showed more affinities with the latter; furthermore he was of the opinion that the missing phalanx is the second.

Wood-Jones (1920) favours the theory of regarding the first element of the first digit as the metacarpal or metatarsal, the second as the first phalanx, and the third as the fused second and third phalanges.
The validity of the epiphyseal argument has been questioned by Allen Thomson (1868, pp. 133-144), who pointed out that the absence of a distal epiphysis in the first "metacarpal" and "metatarsal" is not constant, as there is an occasional appearance of an accessory distal epiphysis in both these bones in man, and to a lesser degree accessory epiphyses may be present in the remaining metacarpals and metatarsals. Thomson showed that these accessory epiphyses are normal in some animals, and are much better developed than in the case of man, viz.:

(a) Distal and proximal epiphyses to all metacarpals and metatarsals, e.g. Ornithorynchus;
(b) Distal and proximal epiphyses in metatarsals, e.g. seal;
(c) Distal and proximal epiphyses to first metacarpal and metatarsal, e.g. koala;
(d) Distal and proximal epiphyses to first metacarpal and metatarsal as an occasional variation, e.g. man.

Thomson summarised the position in a footnote (ibid., p. 143) as follows:—"These observations are interesting when taken along with those that I have recorded on the seal, as confirming the view of the inconstancy of the absence of a distal epiphysis in the first metacarpal or metatarsal bone, and in showing that we must distrust the position of the epiphyses to these bones as the ground of a homological distinction."

Even after rejecting the epiphyseal argument as invalid, in view of Thomson's statements, the nutrient canal has still to be explained. In this worker's paper (ibid., p. 144, fig. 2-4) these are figured antero-posterior longitudinal sections of the first and second digits of the hand and foot of a child seven years of age. Each of the metacarpals and metatarsals possesses both proximal and distal epiphyses, but in regard to the nutrient foramina the direction of the canal—as indicated by bristles—in the first metacarpal and metatarsal is normal, i.e. towards the head of the bone in the typical phalangeal manner; in the case of the other two bones, the direction of the canal conforms to the true metacarpal and metatarsal type.

Broome (Anat. Anz. 28) favours the view that the proximal position of the epiphysis in the first metacarpal is correlated with the great mobility of the first carpo-metacarpal articulation, i.e. the resemblance to the phalanges is due to convergence.
THE PREPOLLEX AND PREHALLUX.

These terms were given by Bardeleben, in 1885, to accessory bones on the medial side of the carpus and tarsus respectively, which either had previously been regarded as sesamoids or were quite unknown; the terms were first applied to the Mammalia, but it was subsequently shown that they also occurred in the Reptilia and Amphibia. Bardeleben stated (1889, p. 256) that these structures are found in certain members of those orders of Mammalia provided with five functional digits, viz., Marsupialia, Edentata, Rodentia, Insectivora, Carnivora, and Primates. It is of interest to note that Thomson (ibid., p. 139) stated that in those animals having fewer than five digits (e.g. pig and ruminants) only distal epiphyses are present in the metacarpals and metatarsals.

Bardeleben regarded the prepollex and prehallux as representing a degenerate sixth digit in the manus and pes respectively; he also believed that the pisiform and the tuberositas calcanei represented a seventh digit, thus advocating heptadactyly for the cheiropterygium. Gegenbaur attacked these views, which resulted in Bardeleben re-examining his theory, but he re-affirmed it unchanged. Theories relating to hexadactyly and heptadactyly have never received much support, which largely explains their comparative obscurity. Notwithstanding this, however, it is probable that, in the evolution of the cheiropterygium from the ichthyopterygium, polydactyly was characteristic of the early stages, but the pentadactyl scheme must have become stereotyped very early in the history of the Tetrapoda, as at present there is not sufficient evidence to make ancestral polydactyly more than an hypothesis. Baur (1896, p. 669), in commenting on the subject, remarked: "It is the general opinion that the ancestry of the vertebrates with a cheiropterygium had numerous digits, and there was considerable talk of an original hexa- or heptadactylism. No support to this view is given by the Stegocephalia: here we never have more than five digits, very often only four, and entirely limbless forms are found even in the Carboniferous."

Again, Beddard (1902) is not a supporter of polydactyly, as he regarded the prepollex and prehallux as accessory ossifications. Bardeleben (1889) described a nail associated with the prepollex of the Cape jumping hare (*Pedetes capensis*), and used the fact of the presence of such a structure with the prepollex and prehallux as an important argument in favour
of his theory, but Beddard (ibid.) showed that it loses weight when it is remembered that the marsupial genus *Onychogale*, or nail-tailed wallaby, possesses a nail-like appendage on the extremity of its tail; the lion is also similarly provided.

As mentioned above, Palaeontology does not support the theory of polydactyly, as the Stegocephali hitherto discovered are never provided with more than five digits to the pes or manus, and furthermore some of them may even be apodous. In this connection Wood-Jones (1920, p. 16) states: "It is true that Palaeontology has proved that the digitate limb may possess more than five digits, but that is a very different thing from demonstrating that any number greater than five represents a basal or primitive condition, for it is possible that the increased number might be due to a secondary specialisation."

Embryology is equally silent. In the development of the Amniote limb, never more than five digits have been observed in normal cases, and all the digits appear simultaneously. Frequently more digits are present in the embryo than in the adult, as, for example, in the Aves a rudiment of the fifth toe may arise in the embryo, but it degenerates later and is absent in the adult; this, of course, being in accordance with the Law of Recapitulation. In the tailed Amphibia the development of the digits proceeds in a different manner, the process being one of budding. The first to appear are the first and second digits, then the third, fourth, and fifth in order; and according to Baur there are never more digits in the embryo than in the adult. Graham Kerr also states that there is a tendency for the digits of Amphibia to develop in regular sequence according to the number of digits in the adult. On the other hand, it must be mentioned that Bardeleben (ibid., p. 256), stated that Kehrre maintains there is evidence for believing heptadactyly occurs in the Urodela.

In the Reptilia the prepollex and prehallux do not appear to be well represented, but in the Amphibia Anura the prehallux is quite a conspicuous structure.

**The Prepollex and Prehallux as the Missing Component in the Pollex and Hallux Respectively.**

Baur has suggested (1896, p. 669) that the prepollex and prehallux are of secondary origin, but, as Comparative Anatomy, Palaeontology, and Embryology do not support theories of
primitive hexadactyly or heptadactyly within known geological times, it does not appear tenable to regard either of these bones as accessory digits. Again, there is not a tendency for the addition of digits; on the contrary, there is a pronounced movement towards reduction, and Flower (1885, p. 283) has summarised the manner of reduction as follows:—When one digit is lost, it is usually the first, then follows the fifth; the third is always retained though either two or four or both of these digits may be absent.

Graham Kerr (1919, p. 453), in commenting upon the cheiropterygium, considers that there is greater anatomical efficiency in the possession of a central digit supported on each side by another digit; and possibly the presence of an additional digit outside these again is a further advantage. This then implies that the third digit is the most essential of the series, a conclusion quite in accord with Flower's Law of Digital Reduction.

As nature seems so insistent upon the expression of symmetry, to obtain this state of affairs with a six digital manus or pes it would necessitate shifting the axis of symmetry from the third digit to the interval between the third and fourth. This may appear to be the case in regard to the Artiodactyle Ungulates (e.g. pig), but when the carpus and tarsus are considered it will be seen that the symmetry of the appendage is fundamentally of the pentadactyl type, and that the shifting of the symmetry of the digits to the interval between the third and fourth is quite secondary, and only applies to the digits themselves.

With reference to the Anuran prehallux, Gadow (1901, p. 20) states that there are "five toes and the rudiment of a sixth digit, the so-called prehallux, which consists of two to four pieces, including the one representing the metatarsal. This prehallux as a vestige of a once better developed digit is exactly like the elements on the radial side of the wrist which, we are certain, are the elements of a once complete finger, the pollex. The only weighty difficulty against its interpretation as a prehallux lies in the fact that hitherto no six-toed Stegocephali have been found, but the fact that none are known with more than four fingers could be used as an argument against there being a pollex in recent Anura with just as good reason."
Gadow’s argument with reference to the pollex and four-fingered Stegocephali is invalid, for five-fingered forms are known, e.g. *Keraterpeton crassum* (Zittel, 1902, p. 127) has five digits in both manus and pes.

Beddard’s suggestion regarding the prepollex and prehallux as being accessory ossifications cannot apply to the Anura, as such ossifications are not at all typical of the Amphibia. The most characteristic accessory ossification in the Tetrapoda is the pisiform of the carpus—a bone which does not typically appear until the Reptilia are reached.

In connection with this paper, we examined, by means of X rays, the pes of the following Anura:—*Adelotis brevis*, *Hyla caerulea*, *H. peronii*, *Limnodynastes tasmaniensis*, *Notaden bennetti*, and *Rana papua*. From the plate it will be observed that there is no trace of the prehallux in *H. peronii*, *N. bennetti*, and *R. papua*, while in the remaining species a prehallux is present lying on the medial side of the pes near the tarso-metatarsal articulation: in *A. brevis* and *H. caerulea* it consists of two components and maybe in *L. tasmaniensis* also, though in regard to the latter the prehallux may prove to be only a single bone.

In most textbooks it is usually stated that the prehallux of the Anura consists of three or four pieces, of which the proximal member represents the metacarpal, and the remaining segments, the phalanges.

After carefully considering the data we advance the theory, that the prepollex and prehallux are the degenerate remnants of the true first metacarpal and metatarsal of the manus and pes respectively. We also regard the frequent occurrence of the prehallux in the Anura as a point of conciliance in favour of our theory, for by the Law of Recapitulation traces of the missing first metatarsal (and metacarpal) might be expected to occur in the Amphibia, which are almost universally considered to be the parent stock of the Tetrapoda. We consider that the pentadactyly condition became stereotyped very early in the history of the Tetrapoda, and that in these early forms all the digits were provided with true metacarpals or metatarsals as the case may be (see Fig. C). It is interesting to note that Bateson (1894) mentions a number of cases of variations in the human hand in which the thumb is provided with three phalanges—a condition which may be regarded as a reversion to the primitive type. Furthermore, it is significant
SIGNIFICANCE OF PREHALLUX AND PREPOLLEX.

PLATE I.

A. Rana papua. B. Hyla caerulea. C. Limnodynastes tasmaniensis.


Radiographs of the Anuran Pes.

Diagrams illustrating the fate of the first Metacarpal and Metatarsal according to the Prehallux Theory.

A, B. Hypothetical hepta- and hexadactyle stages, of which A is more primitive than B. Probably, in each instance, some of the digits were provided with more than three phalanges.

C. Primitive pentadactyl condition.

D. Metacarpal (or metatarsal) of first digit displaced = prepollex (or prehallux).

E. Typical pentadactyl manus (or pes).

mc 1. First metacarpal or metatarsal. In D it represents the prepollex or prehallux.

ph 1, ph 2, ph 3, First, second, and third phalanges respectively.
that, though an accessory phalanx may occasionally occur in the thumb, the number of phalanges in the fingers, on the whole, is remarkably constant.

Later, in the course of evolution, the true first metacarpal and metatarsal became displaced and subsequently disappeared in the great majority of Tetrapoda. Its occurrence in the Amphibia is therefore correlated with the lowly position of the group, while its appearance in animals such as *Talpa* and *Pedetes* may either be due to persistence or atavism. The multiple condition of the Anuran prehallux we regard as the result of fragmentation consequent upon the degeneracy of the structure and the mobility of the pes.

**RECAPITULATION.**

After examining the available literature, and from a consideration of the material investigated, we summarise as follows:

(a) The first metacarpal and metatarsal of the manus and pes are serially homologous with phalanges.

(b) In spite of the fact that the epiphyseal argument in favour of the phalangeal nature of the first metacarpal and metatarsal loses weight on account of the normal presence of distal and proximal epiphyses to these bones in certain animals, e.g. Koala, we consider sufficient evidence still remains to regard the first metacarpal and metatarsal as phalanges.

(c) Heptadactyly and hexadactyly, which probably may have occurred in the earliest Tetrapoda, cannot be regarded at present as more than philosophical speculations; pentadactyly appears to be firmly established throughout the known Tetrapoda, both living and extinct.

(d) The prepollex and prehallux are regarded by the authors as representing the missing first metacarpal and metatarsal respectively.

**ACKNOWLEDGMENTS.**

In conclusion, we desire to express our indebtedness to Professor R. Berry, University of Melbourne, for his sympathetic interest and advice; also to Mr. H. A. Longman, F.L.S., Director of the Queensland Museum, for the use of valuable material; and to Mr. W. M. Tanner, Brisbane, who generously undertook the preparation of the X-ray photographs used in this investigation.
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### ACACIAS OF SOUTH-EAST QUEENSLAND.

By John Shirley, D.Sc., and C. A. Lambert.

(Plates II-VI.)

(Read before the Royal Society of Queensland, 27th June, 1921.)

1.—INTRODUCTION.

To the Australian, the native wattles, forming his national emblem, possess a sentimental interest. To the general botanist they are none the less interesting, presenting striking peculiarities in their adaptation to climate. Many species use their flattened leafstalks or phyllodes to play the part of leaves after the seedling stage is passed, and these phyllodes bear stomata in almost equal number on both surfaces. The colour attraction for insects is found in the filaments of the stamens and not in the petals. The stamens may have eight spherical chambers for the protection of pollen, instead of the four usually present in flowering plants; and there are no arrangements for protecting the pollen from rain or dew. Another peculiarity is the propagation of many species by means of root-cuttings.

2.—REVIEW.

The following are the common wattles in S.E. Queensland:

<table>
<thead>
<tr>
<th>No.</th>
<th>Series.</th>
<th>Scientific Name.</th>
<th>Local Name.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Uninerves—</td>
<td>Acacia—</td>
<td>Transverse-veined wattle</td>
</tr>
<tr>
<td>2</td>
<td>Brevifoliate</td>
<td>plagiophylla F.v.M.</td>
<td>Feather-veined wattle</td>
</tr>
<tr>
<td>3</td>
<td>Racemose</td>
<td>penninervis Sieb.</td>
<td>Burra</td>
</tr>
<tr>
<td>4</td>
<td>Racemose</td>
<td>falcata Willd.</td>
<td>Sweet-scented wattle</td>
</tr>
<tr>
<td>5</td>
<td>Racemose</td>
<td>suaveolens Willd.</td>
<td>Creekside wattle</td>
</tr>
<tr>
<td>6</td>
<td>Plurinervi—</td>
<td>fimbriata A. Cunn.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Triangular</td>
<td>amblygona A. Cunn.</td>
<td>Obtuse-angled wattle</td>
</tr>
<tr>
<td>8</td>
<td>Nervosa</td>
<td>implexa Benth.</td>
<td>Curly-fruit wattle</td>
</tr>
<tr>
<td>9</td>
<td>Nervosa—</td>
<td>complanata A. Cunn.</td>
<td>Winged wattle</td>
</tr>
<tr>
<td>10</td>
<td>Juliflora</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Tetramera</td>
<td>longifolia Willd.</td>
<td>Toowoomba wattle</td>
</tr>
<tr>
<td>12</td>
<td>Falcata</td>
<td>maideni F.v.M.</td>
<td>Maiden's wattle</td>
</tr>
<tr>
<td>13</td>
<td>Falcata</td>
<td>glaucescens Willd.</td>
<td>Rosewood wattle</td>
</tr>
<tr>
<td>14</td>
<td>Falcata</td>
<td>cunninghamii Hook.</td>
<td>Black wattle</td>
</tr>
<tr>
<td>15</td>
<td>Falcata</td>
<td>walcocarpa A. Cunn.</td>
<td>Hickory wattle</td>
</tr>
<tr>
<td>16</td>
<td>Dimidiata</td>
<td>cincinnata F.v.M.</td>
<td>Island wattle</td>
</tr>
<tr>
<td>17</td>
<td>Bipinnata</td>
<td>decurrens Willd.</td>
<td>Green wattle</td>
</tr>
</tbody>
</table>
Less common, or more local, are *A. pugioniformis* Wendl., *A. hispida* Willd., *A. amoena* Wendl., *A. adunca* A. Cunn., *A. podalyriaefolia* A. Cunn., *A. elongata* Sieb., &c., &c. The anatomical details, given in this paper, are restricted to Nos. 2, 5, 6, 7, 10, 12, 13, and 14.

3.—GENERAL NOTES.

I.—*Acacia amblygona* A. Cunn. is found in undulating country, and on the foothills of ranges, both in coastal and inland districts. Near Brisbane its height is seldom more than 3 or 4 feet. Its branches are terete and pubescent, and the phyllodes are 3-4 lines by 1½ to 3 lines and almost triangular. The pods are linear, somewhat curved, and 1½-2 lines broad. They are slightly contracted between the seeds. It is figured in Mueller's Australian Acacias, decade 7, plate 3. It has been reported from Eidsvold, Miles, and Chinchilla.

II.—*Acacia aulacocarpa* A. Cunn. is known in South-eastern Queensland as the hickory wattle, as its young stems were formerly used as handles for the whips of bullock-drivers. It is found along the eastern coast of Queensland from the Tweed River to Bowen and Lizard Island,¹ and inland through the Suttor Desert² to tropical West Australia.³ Its phyllodes are similar in general appearance to those of *A. cunninghamii* Hook., from which they can be distinguished, under the lens, by their freedom from anastomoses in the veins, and by their faintly glaucous surface. The pods are 2-3½ inches long and ½ inch broad, the outer surface marked by oblique furrows, from which the specific name is derived. *Acacia aulacocarpa* grows in communities, forming wattle scrubs, and reaches in S. E. Queensland a height of 20 to 30 feet. It is figured in Mueller's Aust. Ac., dec. 9, pl. 9; and in Maiden's Forest Flora, vol. 3, pl. 103.

III.—*Acacia cincinnata* F.v.M.⁴ In the Flora Australiensis this wattle was reported as from "Rockingham Bay and several other localities in tropical Queensland," a statement repeated in Bailey's Queensland Flora, vol. ii, p. 513. Unfortunately Bailey seldom added to the localities given in the Flora. Cambage (Proc. Roy. Soc. N.S.W., vol. 49, p. 396)

¹ Maiden, Tropical Acacias of Queensland, p. 45.
² Maiden, Flora of Northern Territory, p. 327.
³ Maiden, Notes on Tropical West Australian Acacias, p. 111.
⁴ White, Queensland Naturalist, April 1917, p. 65.
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PLATE II.

Fig. 1.—*A. amblygona*, T.S., x 25.

a. Pith.  
b. Leaf trace.  
c. Secondary wood.  
d. Bast.  
e. Phelloderm.

Fig. 2.—*A. amblygona*, L.T.S., x 200.

a. Wood fibres.  
b. Medullary ray.  
c. Tracheides.
Fig. 1.—A. cunninghamii, T.S., x 40.

a. Pith.  
b. Secondary wood.  
c. Bast.  
d. Phelloderm.  
e. Cork.

Fig. 2.—A. cunninghamii, L.T.S., x 200.

a. Wood fibres.  
b. Medullary ray.  
c. Dotted vessel.
gives Kuranda to Almaden in the Cairns hinterland as additional habitats. Recently it has been found on Bribie Island at the northern end of Moreton Bay, growing in swampy ground, and forming tall trees 40 to 50 feet high. Fortunately it was found in fruit, and the curious spirally curled pods were confirmative of its determination. The bark is dark, and at first sight suggests an ironbark eucalypt. This species is figured in Mueller's Aust. Ac., dec. 9, pl. 6. Along the tropical coast it is called the island wattle.

IV.—Acacia cunninghamii Hook. was formerly known round Moreton Bay as the black wattle. It grows in the same situations as A. aulacocarpa, which it often closely resembles in height and phyllodes. When in fruit it can easily be distinguished by its much narrower pods; when without fruit it can be separated from its ally by the frequent anastomoses of the veins of the phyllodes, and by the triangular outline shown in a cross-section of the young twigs.

V.—Acacia fimbriata A. Cunn. is known as the creek-side and flax-leaved wattle, and loves the sides of streams and the borders of marshes, being found in coastal country from Brisbane to Broadsound. It was formerly known and distributed in Queensland as Acacia linifolia Willd., from which Mr. J. H. Maiden has shown that it must be specifically separated. The main differences are in the phyllodes, which in A. fimbriata are larger, broader, and fringed along the margins with minute cilia. Mr. Maiden has suggested the vernacular name of fringed wattle, leaving that of flax-leaved wattle to the true A. linifolia. This species is figured in Forest Flora, vol. v, pl. 157. It is a tall shrub or small tree, seldom reaching 20 feet in height.

VI.—Acacia implexa Benth. is found in Queensland from the Brisbane to the Burnett River along the coast, and inland to the valley of the Dawson, the great southern tributary of the Fitzroy. In S.E. Queensland it is typically a mountain species, and is specially characteristic of such basaltic masses as Tambourine, Beech Mountain, and Springbrook. It forms trees reaching 30 or 40 feet or more. The linear pods, not more than 3 lines broad when ripe, form a twisted and curled-up mass, hence the specific name. It is figured in Mueller's Aust. Ac., dec. 8, pl. 2; and in Maiden's Forest Flora, vol. v, pl.

It is known as the mountain wattle and curly-fruited wattle among bushmen and selectors. The flowers are usually of a very pale yellow colour.

VII.—Acacia maidenii F.v.M. is a common wattle in sandy country near Brisbane. A fine specimen in the Botanic Gardens, Brisbane, is probably a survival from the old river scrub in that locality. When young its phyllodes are often mistaken for those of Acacia longifolia Willd. The flowers are in nearly sessile spikes, solitary or two or three together, and are pale yellow or almost white. The pods are narrow and twisted, and may be mistaken for those of A. implexa. The flowers closely resemble those of Acacia longifolia, from which Maiden's wattle may be separated by not possessing the white bract at the base of each flower, as in longifolia. At times the similarity between the phyllodes of A. implexa and A. maidenii is extremely close. No common name is used for this tree in Southern Queensland. It is seldom found more than 20 feet in height; it is figured in Maiden's Forest Flora, vol. vi, pl. 220.

VIII.—Acacia penninervis Sieb., the feather-veined wattle, is extremely common in the low-lying coastal country of S.E. Queensland. It is easily recognisable by its pinnately veined phyllodes, the edges thickened, and usually showing a marginal gland below the middle. Each globular capitulum contains about 20 flowers, the calyx truncate, the petals smooth. It extends from Point Danger to Roma and Mitchell, beyond which to the north and west it seems to be replaced by its ally A. bancrofti Maiden. It is figured in Maiden's Forest Flora, vol. iii, pl. 91, 92.

4.—HISTOLOGY OF STEMS.

I.—Acacia amblygona A. Cunn., transverse section of twig in its third year. (Plate II.) The pith shows large polygonal cells, in transverse section, six- or seven-sided, 20-26 μ in diameter, some having lost their protoplasmic contents, others filled with starch grains, showing radiate arrangement. The medullary rays, coloured by methylene blue, show very plainly, and the cells are large for the Acacia family, measuring 14-20 μ. Through the wood of the first and second years they are in single rank, in the third year's wood they may be in double or treble rows. The vessels of the xylem are smaller
ACACIAS OF SOUTH-EAST QUEENSLAND.

PLATE IV.

Fig. 1.—*A. linifolia*, T.S., x 25.

Pith in centre.  
*b*. Leaf trace.  
*c*. Secondary wood.  
*d*. Bast.  
*e*. Phelloderm.

Fig. 2.—*A. linifolia*, L.T.S., x 200.

*a*. Tracheides.  
*b*. Wood fibres.  
*c*. Medullary ray.
than usual, ranging from 30-57 μ in diameter; in all other wattle stems sectioned, the vessels reach usually twice these dimensions. The sieve tubes show the same peculiarity, being decidedly narrow in transverse section. The stem is strengthened by old strands of hard bast, pushed out towards the circumference, to form sclerenchymatous strengthening bands, like the steel laths of reinforced concrete. The phelloderm takes the methylene blue stain very deeply, as does the live cork; between the two is seen the almost unstained phellogen, some of the cells undergoing mitotic division.

In the tangential longitudinal section the same structures are seen, small reticulated vessels and tracheides prevailing throughout a great portion of the xylem, with larger dotted vessels in the sapwood.

II.—*Acacia fimbriata* A. Cunn. and *A. linifolia* Willd. (Plate IV.) No support is given to a separation of these two wattles by a study of their internal structure. The supply and arrangement of the vessels of the xylem agree in both forms; the medullary rays are similarly strongly marked, the pith is larger in area, relative to the wood, than in many allied species, and in tangential section the medullary rays show both in xylem and phloem a single row of elongated oval cells. In the deeper layers of the cortex, strands of sclerenchyma are noted, the cavities of the cells almost obliterated by the addition of layers to the cell-walls. Occasionally these strands invade the outer layers of the alburnum. The larger vessels and tracheides are pitted ones; reticulated vessels are far less numerous than in *A. amblygona*.

In the medullary rays, when passing through the phloem, the cells are shortest in the direction of the ray, the transverse diameter being much enlarged.

III.—*Acacia aulacocarpa* A. Cunn., *A. cincinnata* F.v.M., and *A. cunninghamii* Hook. (Plate III.) These all belong to Juliflore, and the first and third species have many features in common. In the transverse section of a young twig, the triangular outline at once distinguishes *A. cunninghamii*, but this means of identification is lost in older branches. Vessels of the xylem of *A. cunninghamii* range from 70 μ to 140 μ and are the broadest of any acacia examined; in *A. aulacocarpa* they vary from 30 μ to 105 μ; and in *A. cincinnata* have about the same limits. In the first year's stem of *cunninghamii,*
triangular in outline, the epidermis is well shown, the outer walls so strengthened with cutin as to form half the radial diameter of each cell. A circle of sclerenchyma lies between the phelloderm and the phloem, lying in a series of curves round the vascular bundles, with larger thick-walled cells where two curves meet, some of which have the diameter of vessels. In older sections of 4-5 years, the vessels have their greatest diameter parallel to the circumference, and the lines of wood-cells are much distorted around vessels and near the outer portions of the xylem. The pith-cells are full of starch grains, and a few contain tabulate crystals. In tangential longitudinal section both aulacocarpá and cunninghamii show the cells of the medullary rays in uniseriate arrangement; in the former the ray sections are 210-225 μ by 9-12 μ; in the latter 110-210 μ by 10 μ. A. cincinnata shows alternating layers of hard and soft bast in the phloem, but otherwise its histology is that already described for aulacocarpa.

In cunninghamii the pith cells are large, filled with starch, often elongated in a radial direction and bounded by a wavy outline of protoxylem. The primary medullary rays are strongly marked, and are formed of cells of considerable radial diameter.

Neither endodermis nor pericycle is clearly shown in any member of this group.

IV.—Acacia penninervis Sieb., in transverse section, is remarkable for the numerous broken concentric rings of sclerenchyma or hard bast in the phloem, and for the thickness of the bast layer. The vessels vary in diameter from 43 μ to 105 μ. The wood-cells produced in autumn have their walls much thickened, and each annual zone is thus made to add to the strength and elasticity of the stem. Dotted tracheides are more than usually numerous.

Passing through the phloem, the cells of the medullary rays remain uniseriate, but acquire a greater transverse diameter, and are plainly seen in the more internal masses of sclerenchyma. In tangential section they measure 103-220 μ by 6-17 μ. In the phelloderm, at intervals, the large cells are seen to be placed with the long axis directed radially; in other parts of the inner cortex the longitudinal axis of each cell of this inner layer is vertical. These cells retain their protoplasm, and have a rather narrowly elliptical nucleus. (Plate VI.)
Fig. 1.—*A. maideni*, T.S., x 35.

a. Pith.  
b. Vessel.  
c. Secondary wood.  
d. Cambium.  
e. Bast.  
f. Phelloderm.  
g. Cork.

Fig. 2.—*A. maideni*, L.T.S., x 200.

a. Wood fibres.  
b. Tracheides.  
c. Medullary ray.
ACACIAS OF SOUTH EAST QUEENSLAND.

PLATE VI.

Fig. 1.—A. penninervis, T.S., x 25.


Fig. 2.—A. penninervis, L.T.S., x 200.

V.—*Acacia maidenii* F.v.M. differs radically in its histology from all other species examined. The vessels of the xylem are few and small, and in young stems all are elongated in a radial direction. The medullary rays are narrow and drawn out radially, and the cells of the wood parenchyma are less thick-walled than usual. Much of the water and dissolved minerals of the ascending sap must pass by osmosis through the wood-cells of the alburnum.

Passing through the phloem the medullary rays take a very wavy course. In tangential section they measure 110-285 μ by 8 to 12 μ. The pith is of the usual structure and contains a few idioblasts. Strands of sclerenchyma are found in the cortex, but this tissue is not as strongly developed as in any of other acacias examined. Surrounding the vessels of the xylem the wood-cells are larger and their rows more irregularly constituted (tangential section) than elsewhere. In the cells of the cortex numerous tabulate crystals were noted. (Plate V.)

VI.—*Acacia implexa* Benth. The young stem of *implexa* 1-2 years old shows the layer of epidermal cells with their external thickening of cutin. The pith and xylem are of the ordinary type, but the phloem is mainly of soft bast, and the sclerenchyma is only moderately developed. In all other respects it agrees with the characteristics already laid down.
NEW AND LITTLE-KNOWN SARCO-PHAGID FLIES FROM SOUTHEASTERN QUEENSLAND.

By Professor T. Harvey Johnston, M.A., D.Sc., and O. W. Tiegels, M.Sc., Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Twenty-six Figures.)

(Read before the Royal Society of Queensland, 27th June, 1921.)

The sheep maggot-fly problem in Eastern Australia has led to a considerable amount of attention being paid to certain blowflies, especially in New South Wales where Mr. W. W. Froggatt has been investigating them. However, apart from some references to a few species, e.g. Sarcophaga aurifrons, very little notice has been taken of the Sarcophagidae for many years past. In fact there is not an adequate account of even one of the flesh flies as yet recorded from the Commonwealth. Only two species from Australia have been figured, viz., S. aurifrons by Froggatt and S. pachytii by Olliff. The family has, then, been almost entirely neglected, this inattention to such a common group of large blowflies being no doubt due to the difficulty experienced by collectors and workers in differentiating the various forms. Commonly Sarcophagid specific characters are far from being obvious, and as a rule it is necessary to study the male copulatory organs in order to differentiate between species which otherwise are very similar. It is extremely difficult to allot female specimens to their species as they much more closely resemble one another than do the males of different species. In order to obtain the two sexes we have bred out specimens from larvae deposited by captured gravid females. As regards certain of those dealt with by us we have examined only males which were captured, and in such cases the female is still unknown.

The senior author, while on a recent visit to U.S.A. and England, took the opportunity to submit some Queensland Sarcophagids to Dr. J. M. Aldrich, of the National Museum, Washington D.C., and Major E. Austen, D.S.O., of the British Museum. To those two authorities on Diptera we are indebted.
for certain identifications referred to later on. Dr. Aldrich also kindly allowed us to make use of the card catalogue of those recorded from Australia, the catalogue being the work of Dr. C. H. Townsend.

The first author to deal with any Australian Sarcophagidae was Robineau-Desvoidy, who in 1830 published descriptions of five species from Sydney, viz., (1) *S. depressa*, (2) *S. peregrina*, (3) *S. subrotunda*, (4) *S. rapida*, and (5) *S. musca*, all under the generic name *Myophora*. We have not been able to consult his "Essai," but, thanks to Mr. W. A. Rainbow, Australian Museum, Sydney, we have seen figures of *S. musca* published by Guerin-Meneville, whose specimens came from New Guinea. The text relating to the work (Zoology, Voyage of the "Coquille") was not available, but Figure 4 suggests a *Sarcophaga*; the drawing of a front view of the head and face, however, shows marked differences from the *Sarcophaga* type, e.g. the sketch shows the presence of a fully plumose arista, prominent first antennal joint, an atypical number and arrangement of the bristles. If the figure be incorrectly drawn, then it is possible that *S. musca* may be that described later by Walker as *S. irrequieta*, since small underfed specimens of the latter commonly resemble *Musca domestica* at first sight in regard to size and colouration. In all probability the remaining four, if recognisable, will be found to be common forms in the vicinity of Sydney (*S. miser* being one for example), and some of the species described in this paper may be synonyms.

A little later Macquart (1846, 1855) described three from the east coast of Australia, viz., (6) *S. aurifrons*, (7) *S. flavifemorata*, and (8) *S. ruficornis*. The last-mentioned specific name is not available, having been preoccupied by *S. ruficornis* (Fabr.) from East India. No. 7 we do not know. *S. aurifrons* is the name given in Australia to a certain type of blowfly, but as a result of our observations we find that probably ten or twelve Brisbane species could be included under the description. As we have not access to Macquart's type, we have fixed his name on a particular species based on specimens collected in Brisbane by Mr. Froggatt many years ago and forwarded to Washington D.C. for determination by Coquillet, who labelled some as *S. aurifrons* Macq. and others as *S. frontalis* Thoms. Through the kindness of Mr. Froggatt we have been able to examine the determined specimens.
Brauer and Bergenstamm (1891) used the name *S. aurifera* Macq. but we suspect it to be an error for *S. aurifrons*. At any rate it is a mere *nomen nudum* as used by these two authors.

Walker (1849) added the names of four species to the list, viz., (9) *S. impatiens*, (10) *S. misera*, (11) *S. irrequieta*, and (12) *S. prædatrix*. The type specimens of all four species are in the British Museum and are females labelled as having been collected in Sydney, New Holland, Houtman's Abrolhos (West Australia), and Port Essington (Northern Territory) respectively. We are now able to give full accounts of the first three of Walker's species, but the fourth is not represented in our collection.

Thomson in 1868 described two Sarcophagids collected by the "Eugenie" naturalists in Sydney, viz., (13) *S. ochri-palpis* and (14) *S. pallichrus*. The former was stated to be near *S. aurata*, a species described by Macquart (locality, ?Oceania); but we have regarded it as a synonym of *S. irrequieta*. *S. pallichrus*, which Van der Wulp placed tentatively in his genus *Sarcophagula* (1887), is not represented in our collection.

There do not appear to be any more references to the group until 1891, when Olliff and Skuse named two parasites of grasshoppers as (15) *Tachina oedipoda* and (16) *Masicera pachytili* respectively. Olliff referred to the latter and published a figure of it (1891a), the illustration being republished by Mackinnon (1920). The species was subsequently stated by Froggatt (1905, 1907) to be a *Sarcophaga*. *Tachina oedipoda* is a *nomen nudum* as far as Olliff- (1891b) is concerned, but Froggatt (1905, 1907) has reported it to be a *Sarcophaga*, closely related to *S. aurifrons*. The status of these two flies bred from locusts can only be determined by an examination of the type material.

Certain specimens collected in Brisbane and forwarded by Mr. Froggatt (1907) to Coquillet for determination were reported to be (17) *S. frontalis*. Owing to Mr. Froggatt's kindness we have been able to synonymise Thomson's species with Walker's *S. misera*. Besides, the name *frontalis* is pre-occupied, having been employed by Doleschall in 1858.

Information relating to *S. aurifrons* was published by Mr. Froggatt in 1905, 1907, and in 1915.
The last Australian Sarcophaga to be described was (18) *S. froggatti* Taylor, 1917. Thanks to Mr. G. F. Hill, of the Australian Tropical Institute, we have been able to give an account of this fly.

Thus, of the eighteen species recorded to date, no less than eleven (including one with a preoccupied name) are still imperfectly known, many of them being quite unrecognisable from the scanty descriptions. Five are fully described (both sexes) in our paper, and two have been reduced to synonyms. To the list we add fifteen new and one previously known species, giving a description of both sexes in the case of eight new ones, and of the male only in the remaining seven.

We have compared our specimens with the accounts of various Sarcophagas from New Guinea, Southern Asia, the East Indies, and the Pacific Islands, as given by Walker (1856-1865), Macquart, Thomson, and Parker. Unfortunately many of the descriptions published by Macquart and Walker are so general or so scanty as to be of very little value for comparative purposes. The following species, however, may be definitely excluded from synonymy with the species referred to in this paper: — *S. ruficornis* Fabr. (India and Philippines); *S. orientalis* Parker, *S. crinita* Parker, *S. harpax* Pand. (all from Philippines); *S. perpusilla* Walker (New Guinea); *S. robusta* Aldrich, *S. haemorrhoidalis* Fallen, *S. barbata* Thomson, *S. pallinervis* Thomson (all from Hawaii); and the following described by Walker from the East Indies: *S. aliena*, *S. indicata*, *S. invaria*, *S. mendax*, *S. inextricata*, and *S. brevis*.

Acknowledgments are gratefully made to Dr. Aldrich (U.S. National Museum), Major E. Austen (British Museum), Messrs. W. W. Froggatt (Government Entomologist, Sydney), H. Tryon (Government Entomologist, Brisbane), and G. F. Hill (Tropical Institute, Townsville, N.Q.), as well as Dr. T. L. and Miss M. J. Bancroft (Eidsvold, Q.), for assistance in regard to material; also Messrs. H. A. Longman, Director of the Queensland Museum, and W. A. Rainbow and A. Musgrave, of the Australian Museum, Sydney, for assistance in regard to literature.

Types, both holotypes and allotypes, will be deposited in the Queensland Museum, Brisbane. Paratypes will, if sufficient be available, be distributed to other museums such as the Australian Museum, Sydney, British Museum, and U.S. National Museum.
Although twenty-one species are described in this paper, all but one (*Helicobia australis*) fall within the limits of the genus *Sarcophaga* as ordinarily accepted. One species, *S.* (*Para*- *sarcophaga*) *omega*, probably represents a new generic type but we have contented ourselves with the erection of a subgenus. Of the remaining nineteen species, the first four described—*S.* *impatiens*, *S.* *tryoni*, *S.* *alpha*, and *S.* *beta*—are very large flies with bright golden colouration on the head and thorax. The females, as far as known, possess scutellar apical bristles. Probably *S.* *gamma* belongs to this group but it is more greyish in general appearance. *S.* *delta* constitutes a group by itself; *S.* *irrequieta* and *S.* *eta* another small group of medium-sized greyish flies; *S.* *misera* and *S.* *dux* a fourth group. All the others, excepting perhaps *S.* *bancrofti*, are very similar in size and general colouration and constitute an *aurifrons* group.

We have not attempted to describe any species of which only the female is represented in our collection.

1. *Helicobia australis* n. sp. (Fig. 24).

In general appearance a small rather slender grey fly, 5 mm. in length and only about 1·2 mm. in breadth.

**Male.**—*Head.*—Front fairly prominent; at its narrowest about half the width of eye. Eyes red-brown. Parafrontals, checks, and back of head silvery, ferruginous in certain lights. Frontal stripe very dark chocolate, a little wider than parafrontals; mesofacial plates a pale fawn colour. First antennal joint inconspicuous; second large, very dark brown and with a silvery bloom; third less than twice the length of second, silvery. A row of eight frontals beside frontal stripe. Proboscis dark brown externally, much paler on internal (anterior) part; palps black; vibrissa inserted close to oral margin; four facials and three peristomials present. Verticals large, lateral verticals absent. Two rows of black bristles behind eyes, upper row the more complete. Silvery hairs clothe the back of the head, becoming longer but more sparse below; cheeks with black bristles.

Thorax as wide as head, and of a silvery grey colour. The usual three longitudinal lines are present, but are rather irregular and all extend on to scutellum, where the lateral ones are only faintly indicated. Thorax deep grey laterally and ventrally. Anterior spiracle very small, clothed with brown hairs.
The last two pairs of anterior acrostichals feebly developed; prescutellar acrostichals moderately strong. Apical scutellars present. Dorsocentrals remarkably well developed; the last two pairs as usual much the largest, the more anterior ones considerably larger than the prescutellar acrostichals. Two intra-alars present; three humerals; two post-humerals, of which the anterior is the larger.

Wings.—In the wing the first longitudinal vein is hairy, thus placing the species in the genus Helicobia.

Legs black; first femur not hairy, tibia shorter than tarsus; second and third legs not hairy, second femur without “comb,” tarsus longer than tibia; third tibia about as long as tarsus.

Abdomen about as long as thorax, oval; covered with short reclinate bristles above, slightly hairy below; provided postero-ventrally with a few rather long bristles. First segment of hypopygium greyish; second segment very dark shiny brown, hairy, tipped dorsally with light brown. Forceps relatively very large, shiny black, sharply pointed, and exceedingly hairy. Accessory plate somewhat semicircular, hairy. Penis fairly heavily chitinised, bearing posteriorly two long, prominent, ventrally directed processes, as figured (Fig. 24).

Described from two males, bred from decaying meat in Brisbane. *H. australis* is the first representative of the genus to be recorded from Australasia.

2. *Sarcophaga impatiens* Walker 1849 (Figs. 18, 19).

In general appearance a large golden and black fly, the male measuring about 14 mm.; the female somewhat shorter, about 12 mm. long, and much more thick-set.

Male.—*Head.*—A little narrower than widest part of thorax. Front not very prominent; about three-fifths the width of eyes. Frontal stripe very dark chocolate brown. Mesofacial plates a rich golden colour, borders tinged with black. Parafacial plates golden, with dark reflections; cheeks bright golden. Eyes red-brown. Proboscis black and brown, with golden hairs; palps black. Back of head golden, with a single row of short black bristles behind eyes. Hairs below these golden, becoming very long and bright golden on cheeks.

First antennal joint very small; second large and very dark brown, third over thrice the length of second, dark
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ferruginous. The second joint bears a prominent bristle. A row of thirteen frontal bristles present. Vibrisae inserted well above oral margin. Seven facial and five long peristomial bristles present. Lateral vertices inconspicuous.

Thorax golden, with the usual three longitudinal stripes, the middle one alone extending on to scutellum. Sides and ventral surface of thorax golden. Anterior acrostichals present, but very feebly developed. Of the posterior acrostichals only the prescutellar represented; these are moderately strong. Row of dorsocentrals complete; last in row very large. Scutellar apicals present. Anterior intra-alar bristle about as large as prescutellar acrostichal. Humeral bristle large but not extending beyond pronotum. Anterior spiracle dark chocolate coloured, protected by a heavy growth of short golden hairs.

Legs black and grey. First femur tinged with gold; hairy. Second femur hairy, but not heavily so; last tibia hairy. Pulvilli dark brown, fringed with silvery hairs.

Abdomen in male a little longer than thorax, conical; silvery with the usual black and silvery markings, and frequently tinged with gold. Median dorsal black stripe not extending on to last segment. Abdomen hairy beneath. First segment of hypopygium brown, anterior portion almost greyish; second, dark shining brown, almost black, the whole provided with long curly black hairs. Forceps angular and fairly sharp-pointed, the upper half provided with a number of short anteriorly directed bristles, and with long black hairs. Accessory plates dark brown, hairy. Claspers dark brown, almost black; the anterior pair especially strong, due to a great thickening of the lower two-thirds. First joint of penis dark brown; second dark brown, black in parts, bordered with white antero-ventrally, and provided with hooks and chitinous processes, as figured (Fig. 19).

Female.—This differs from the male in the following important characters:—Front slightly more prominent than in male; about five-sixths the width of eyes. Eleven frontal bristles beside the frontal stripe, and three beside eye; these latter extremely large, even more so than in S. tryoni; practically only in this respect can the two females be distinguished. Lateral vertices very large. Scutellar apical bristles present, but small and fairly close together. First femur clothed with short hairs ventrally; longitudinal row of bristles very well
developed. Second femur hairless; a "comb" not differentiated. Neither last femur nor tibia hairy. Abdomen oval, shorter and broader than thorax.

Bred from bad meat. This species is very common around Brisbane, especially during early autumn.

A female was kindly identified for us by Mr. E. E. Austen of the British Museum, by comparison with Walker's type (a female) in that collection, described from New Holland. A comparison of our bred females with this form allowed us to determine the hitherto undescribed male. Walker's type is labelled as having come from Sydney. Others in the British Museum have been collected in Tasmania, South Queensland, North Queensland (Stannary Hills, Coll. Dr. Bancroft), and New Hebrides; all determined by Mr. Austen.

3. Sarcophaga tryoni n. sp. (Figs. 9, 10).

Syn.: S. frontalis (in part) of Australian authors.

In general appearance bright gold and black. A large Sarcophaga. the males measuring about 17 mm. in length, though some may be as small as 11 mm. Female considerably shorter, measuring about 12 or 13 mm.

Male.—Head.—Parafrontals bright gold, with dark reflections. Back of head and cheeks bright gold. Width of front about half that of eyes. Frontal stripe black, about as wide as parafrontals. Mesofacial plate very pale golden, borders tinged with black. First antennal joint very small, dark brown; second much larger, almost black; third joint nearly four times the length of second, ferruginous. A row of eleven frontal bristles present. Verticals large, lateral verticals very small. Epistome prominent, tinged with pink; proboscis black, with golden hairs. Vibrissæ large. About seven small facial bristles present; twelve peristomials. One row of black bristles behind eyes; back of head provided with short golden hairs, forming a beard-like growth on cheeks.

Thorax varying from bright gold to almost ashy colour, and with the usual three black longitudinal stripes, the middle one alone extending on to scutellum. Sides of thorax grey, tinged with gold. Anterior spiracle with a strong growth of short golden and silvery hairs.
Anterior acrostichals present, but only posterior pair well
developed. Prescutellar acrostichals extend almost to end of
scutellum. Dorsocentrals complete; posterior pair extending
just beyond scutellum. Three humerals, the lowest reaching
about three-quarters of the distance to mesonotum. Anterior
intra-alars extremely weak. Scutellar apicals present.

Legs black and grey. Anterior femora tinged with gold.
Rows of bristles complete, but not hairy. Second femur with
short growth of hairs proximo-ventrally; "comb" developed.
Third femur with beard-like growth of hairs; third tibia very
hairy. Pulvilli dark brown, with silvery borders.

Abdomen a little broader than thorax. Silvery, with very
faint gold reflections; the usual black markings present. The
 longitudinal black line hardly visible on last segment. Dorsal
surface with short black reclinate bristles; ventral side hairy,
especially posteriorly. Hypopygium fairly prominent, dark
brown, almost black, very hairy. Accessory plate brown,
hairy. Forceps dark brown; not smooth; angular; upper
part hairy; ventral portion bare; tip not very sharp. Claspers
reddish brown. Distal joint of penis divided into anterior
and posterior parts, the colour of different portions varying
from white to black, according to the degree of chitinisation;
the posterior division provided with four short sharp spines
(Figs. 9, 10).

Female.—This differs from the male in the following
important characters:—It has the shorter, more thick-set
appearance typical of females. Colouration identical. Front
at narrowest point as wide as eye. Third antennal joint
scarcely three times the length of second. Arista slightly
more plumose than in male. Frontal stripe a little narrower
than parafrontals. Ten bristles in inner frontal row; three
very large ones comprising the outer frontal row; the lowest
reaching not quite to the base of the antenna. Lateral verticals
absent. Thoracic chaetotaxy as in male. Scutellar apicals
present, but a little closer together than in male, and situated,
not lateral to, but behind, the scutellar extension of the median
longitudinal black stripe. Anterior femur very faintly hairy.
Second femur not hairy, no "comb" developed. Third femur
and tibia without hair. Abdomen a little shorter than thorax;
oval. Longitudinal black stripe definite on last segment.

Bred from bad meat. This species, with which we have
much pleasure in associating the name of Mr. Henry Tryon,
the veteran Queensland Entomologist, is common around Brisbane, especially in March.

*S. tryoni* is without doubt one of the several species formerly included by Australian entomologists under the name of *S. frontalis*.

4. *Sarcophaga alpha* n. sp. (Fig. 21).

In general appearance a large brilliant gold-and-black insect, the male measuring about 15 mm. in length.

**Male.**—*Head.*—Parafrontals bright gold, with dark reflections. Cheeks and back of head bright gold. Frontal stripe almost black; a little wider than the parafrontals. Front rather projecting and about three-quarters the width of the eyes. Eyes reddish brown. First antennal joint small; second much larger, black; third about three times the length of second, ferruginous, and with a silvery bloom. Arista about half as long again as antenna, very strongly plumose. Mesofacial plates golden, bordered with black. Proboscis black, with pale-gold hairs; palps black. Epistome prominent.

A row of eleven frontal bristles present; vibrissae inserted somewhat above the oral margin. Five large and numerous smaller facial bristles; thirteen large epistomials. Verticals very large; lateral verticals medium-sized. A single row of black bristles behind eyes. Back of head provided with golden hairs, which become very long on cheeks.

**Thorax** golden, with three longitudinal black lines, of which the middle one extends on to the scutellum. Sides of thorax golden, with black markings; ventral side grey. Anterior spiracle black, with a few golden hairs.

Anterior acrostichals present, but small. Of the posterior acrostichals only the prescutellar occur. DorsocentraIs present; last two larger; last very large. First humeral bristle as large as first dorsocentral; last humeral not extending to the mesonotum. Scutellar apicals present.

**Legs** black, tinged with grey. Femur of first leg tinged with gold; dorsal and ventral longitudinal rows of bristles very well developed; very hairy. Second femur hairy on the proximal ventral side, but not markedly so; "comb" differentiated. Third femur very hairy. Third tibia very hairy; second hairy on ventral distal portion; first not hairy. Third tarsus a little longer than tibia. Pulvilli very dark brown, borders silvery.
Abdomen about as broad as thorax but considerably longer, measuring 8 mm.; pale golden, with the usual black markings. The dorsal black line complete. Dorsal surface covered with very short black reclinate bristles. Ventral surface slightly hairy, especially on last segment. Hypopygium large, shiny black, hairy. Forceps shiny black, and very definitely angular; lower arm of the angle bare, upper arm hairy; at the angle a number of short hairs and short blunt bristles. Accessory plate very dark brown, hairy. The posterior clasper is remarkable, in that it is provided with three prongs.

The penis closely resembles that of S. crinita from the Philippines, described and figured by Parker (1917). The upper joint is very dark brown, in places shining black. The lower is heavily chitinised on its proximal side, and from this are given off two anteriorly projecting curved shiny black hooks, supported dorsally and ventrally by a pair of large, but not heavily chitinised, "sheaths" (Fig. 21).

Described from two males caught around bad meat in Brisbane.

5. Sarcophaga beta n. sp. (Fig. 6).

In general appearance a large golden insect; smaller specimens not unlike S. aurifrons Meq. Length 11 to 14 mm.

Male.—Head.—Front slightly prominent, about half the width of eyes. Eyes dark red-brown, rather flat in front. Frontal stripe nearly black, as wide as parafrotentials. Parafrontals, genæ, and occiput bright golden. Mesofacial plates golden, borders tinged with silver. First antennal joint inconspicuous, second large and very dark ferruginous, third less than thrice the length of second and of a deep fawny colour. Epistome not very conspicuous. Vibrissæ large, inserted well above oral margin; seven facials present, eight peristomials; thirteen pairs of frontals beside frontal stripe; verticals fairly large, lateral verticals absent. A single row of black bristles behind eyes; occiput covered with weak golden hairs, which form a bright-gold beard-like growth on the posterior parts of the genæ; anterior part of genæ with shorter bright-golden hairs. Proboscis typical.

Thorax golden, with the usual black stripe, the median one alone extending on to scutellum; sides golden; under
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Side greyish. Three humerals present; the last two pairs of anterior acrostichals feebly represented. Of the posterior set, only the prescutellars are developed. Dorsocentral row complete; two intra-alars present. Anterior spiracle with light-brown hair.

Legs black and grey. First femur hairy; the longitudinal rows of bristles very completely developed; tibia longer than tarsus. Second femur hairy proximo-ventrally; a "comb" differentiated; tibia extremely hairy. Third femur very hairy; tibia moderately so.

Abdomen with usual black and white markings, the median black line extending faintly on to last segment. Covered above with short reclinate bristles, below rather hairy.

First segment of hypopygium brown, slightly pollinose; second shiny, almost black, hairy. Forceps shiny black, sculptured externally; approximated for about two-fifths their length, sharply pointed, angular in lateral view, the upper arm only being hairy. Accessory plates somewhat oval in shape, dark brown, with long hairs. Claspers very dark brown; posterior clasper very broad; the anterior clasper with two strong processes. The anterior part of the membrane surrounding the base of the penis also develops a short, blunt, yellowish process. Distal joint of penis fairly heavily chitinised. It is of the S. crinita type, as figured by Parker (1917), and consists of a posterior sheath, which lodges the base of a pair of strong processes, serrated anteriorly, and tipped with white. Anterior to the sheath is a movable hook-like structure, bearing in front a strongly serrated membrane, greyish in colour. The whole copulatory organ very closely resembles that of S. delta.

Female.—This differs from the male in the following characters:—Eyes rather flat in front, giving the front a rather prominent appearance. Front about three-fifths the eye-width. A row of nine frontals beside frontal stripe, and three larger ones immediately beside eyes. Lateral verticals present and well developed. Thoracic chaetotaxy as in male, except that apical scutellars are rather weaker. First femur moderately hairy, tibia slightly longer than tarsus. Second and third femora and tibiae hairless. No "comb" on second femur.

Described from two males and two females bred from decaying meat in Brisbane, February 1921.
6. *Sarcophaga gamma* n. sp. (Fig. 15).

In general appearance a medium-sized fly, about 13 mm. in length, and of a faintly golden greyish colour.

**Male.**—**Head.**—Front not very prominent; about three-quarters the width of the eye. Frontal stripe very dark chocolate brown, nearly black; almost twice the width of the parafrontals at their narrowest point. Parafrontals, genæ, and occiput bright golden. First antennal segment more conspicuous than usual; second large, very dark brown; third a dark fawn colour and about twice the length of second. Frontal field pale golden, borders dark; epistome not prominent. Proboscis and palps as usual. Eyes dark red-brown. Nine frontals. Verticals moderately developed; lateral verticals small. Vibrissæ inserted well above the oral margin. Four facials and twelve peristomials present. A single row of short black bristles behind eyes; hairs below this short and golden, becoming longer below on the genæ; those on anterior part of genæ shorter.

**Thorax** grey, tinged with gold. The usual three black lines present; the median extending on to scutellum where the laterals are only indistinctly represented. Under side grey; sides grey, tinged with gold. Of the acrostichals only the prescutellar are present, and these are but very faintly developed. Dorsocentral row complete. Apical scutellars present; anterior intra-alars exceedingly weak. Anterior spiracle with pale-golden hairs.

**Legs** grey and black. First femur with just a tinge of gold, slightly hairy; longitudinal rows of bristles very complete. Second femur hairy proximo-ventrally, with a well-defined "comb" distally; tibia longer than tarsus. Third femur hairy; tibia heavily clad with short hairs.

**Abdomen** covered dorsally with short reclinate bristles; hairy beneath. Conical in general shape, and a little longer than thorax. With the usual black and white markings; the dorsal black line extending on to last segment.

First segment of hypopygium silvery; second half the length of first, nearly black and shiny, hairy. Accessory plates triangular, brown, hairy. Forceps very well developed, shiny black, approximated for over half their length; tips bare, remainder very hairy. Claspers simple; dark shining black. First joint of penis very dark brown; second dark
SARCOPHAGID FLIES FROM SOUTH-EASTERN QUEENSLAND.

12.  
13.  
11.  
10.  
14.
brown and shiny black, in places white. The distal portion is divided into two parts, of curious appearance, as figured (Fig. 15).

Described from two males captured around 'decaying meat in Brisbane, April 1921.

7. *Sarcophaga delta* n. sp. (Fig. 13).

In general appearance a large grey fly, about 15 mm. in length.

**Male.**—*Head.*—Front slightly prominent, about two-fifths the width of eye. Frontal stripe very dark chocolate, rather narrower than parafrontals, which are pale golden, and rather more heavily pollinose than usual; genæ rather brighter golden; occiput silvery with pale-golden tint. Mesofacial plates silvery, with somewhat darker borders; ptininal suture fairly distinct throughout life. First antennal joint rather more prominent than usual; second large and nearly black; third a fawn colour, and about thrice the length of the second. A row of ten frontals beside frontal stripe; eight facials, and fourteen peristomials, some of the latter exceedingly large. Verticals present; lateral verticals present, but very weak. A single row of black bristles behind eyes. Back of head heavily clad with pale-golden hairs, developing into a beard-like growth postero-ventrally, and much shorter on the anterior part of the genæ. Proboscis as usual, palps black.

**Thorax.**—This is of a deep grey, with the usual black longitudinal marks, the middle one alone extending on to scutellum. Lateral and vertical parts grey. Anterior spiracle heavily coated with short brown hairs. Shoulder armed with moderately long black bristles. Anterior acrostichals all present, though very weak, posterior pair rather stronger than the others. Of the posterior row, only the prescutellars are present; these are very strongly developed. Apical scutellars very long. Dorsocentral row complete. There is an indication of a third intra-alar.

**Legs** black and grey. First femur slightly hairy, tibia longer than tarsus. Second femur slightly hairy proximo-ventrally, a "comb" differentiated; tibia hairy. Third tibia hairy; of a dark-brown colour.

**Abdomen** a deep grey with the median longitudinal deep-brown line feebly developed, and not distinctly visible on
last segment. Segments very faintly tinged with deep brown. Covered dorsally with short, black, reclinate bristles; slightly hairy ventrally, on all except last segment, which is very hairy.

First segment of hypopygium pale brown anteriorly, nearly black posteriorly, hairy; second segment shiny black and only very lightly hairy. Forceps very long, deep brown above, black below and slightly angular; not very sharply pointed. "Angle" armed with short black bristles; claspers dark shiny brown; the anterior clasper with two prongs. The penis shows a remarkable resemblance to that of Sarcophaga beta, which is in every other respect a quite distinct fly. The large anterior "hook" is present, but rather more slender; the pair of ventrally directed prongs also present, but not serrated anteriorly.

Described from one male captured by Mr. H. Jarvis on flowers in Brisbane, and kindly donated by Mr. Tryon.

8. Sarcophaga irrequieta Walker 1849 (Figs. 1, 2, 3).

Syns.: S. ochriptalpis Thomson 1868.
S. frontalis Johnston and Bancroft 1920.

In general appearance an ashy coloured fly, about 11 to 12 mm. long, though at times much smaller (7 mm.).

Male.—Head.—Parafrontals silvery with dark reflections, and very faintly tinged with gold. Front at narrowest part about one-fifth the width of head. Frontal stripe almost black, one and a-half times the width of parafrontals. Meso-facials faintly golden in the middle, more silvery at sides. First antennal joint small; second large and black; third over thrice the length of second, ferruginous, with faint silvery bloom. Arista plumose for over half its length and considerably longer than the three antennal joints combined. Eyes dark red-brown, the anterior facets larger than the posterior. Back of head dark grey, faintly tinged with gold immediately behind the eyes; cheeks lighter grey, gradually merging into the colour of the parafrontals. Proboscis dark brown, almost black, clothed with long golden hairs. Palps varying from ferruginous to almost black. Vibrissae long, inserted close to the oral margin. About ten moderately large facial bristles present. About ten rather long epistomials. Cheeks covered with short black bristles. A single row of twelve frontal
bristles. Lateral verticals very small. Three rows of black bristles behind eyes. Hairs, behind these, short and golden. Genæ provided with very long silvery hairs.

Thorax grey, faintly tinged with gold, especially around sides; frequently the thorax is quite grey. Three fairly regular longitudinal stripes present, of which the middle one alone extends on to the scutellum. Anterior spiracles dark chocolate in colour, covered with short silvery hairs. Ventral side of thorax greyish, provided with short black bristles; median ventral plates pink. Three humeral bristles present, of which the lowest two are rather large, and much larger than the first. Of the acrostichals, only the prescutellar pair is present. Anterior dorsocentrals rather weak. First posterior dorsocentral very weak; second a little larger, third much larger, fourth extending well beyond scutellum. First intralar very small, second very large. Apical scutellar bristles present.

Legs.—Coxæ dark grey, well armed with bristles. Femora black and grey, often faintly tinged with gold. First femur slightly hairy on its proximal ventral side; second femur more hairy, median ventral bristles differentiated into a "comb"; third femur hairy on median ventral side. Pulvilli dark brown, fringed with very minute silvery hairs.

Abdomen greyish gold in appearance, with the ordinary black markings. Upper surface covered with short reclinate bristles; ventral side hairy.

Hypopygium shining black, hairy, and not visible from above. Forceps shiny black, sculptured, dark brown on inner surface. Accessory plates brown, hairy, but not markedly so. Claspers heavily chitinised, shiny black.

The first joint of the penis is dark brown; the second forms a highly chitinised structure almost uniformly black. Viewed ventrally (Figs. 1, 2) it is triangular in shape, the apex of triangle pointing backwards. The organ is provided with two pairs of downwardly, outwardly, and ventrally projecting pale-brown chitinous processes, and with a pair of very heavily chitinised triangular, somewhat rounded masses, highly serrated on their anterior surface, giving the whole organ a remarkable appearance in lateral view (Fig. 3). In ventral view there can be seen two pale-yellow inwardly projecting chitinous pieces given off from the more anterior part of the triangle.
Female.—This differs from the male in the following characters:—Front less than one-third width of head. A row of eleven frontals beside the frontal stripe, three others immediately beside the eye, and converging above on to the first row. Lateral verticils nearly as large as verticils. Scutellar apicals absent. Legs not hairy. Anterior femur with very complete ventral row of bristles; only slightly hairy. In the second femur, the median ventral row is poorly developed; no “comb” is differentiated. Third femur not hairy. Pulvilli in the form of short tubes. Abdomen a little longer than thorax; oval. Sometimes grey, at other times distinctly golden. Ordinary black markings present. A black stripe, sometimes very distinct, runs down the middle of the abdomen. Dorsal surface with small reclinate bristles; ventral surface hairy, especially posteriorly.

This species appears to be identical with S. ochripalpis Thomson 1868, originally described from Sydney. We have suggested that S. irrequieta may perhaps be synonymous with S. musca described many years earlier by Robineau-Desvoidy (1830). Walker’s type specimen, a female, came from the Houtman’s Abrolhos, off the coast of West Australia. Our material was bred from decaying meat in Brisbane.

9. Sarcophaga eta n. sp. (Fig. 14).

In general appearance a medium-sized fly, about 11 mm. in length and closely resembling S. irrequieta Walker.

Male.—Head.—Front a little prominent, about half the width of eyes. Frontal stripe very dark brown, a little wider than parafrontals. The latter silvery, tinged faintly with gold; checks a little paler. Rear of head faintly golden, almost silvery. Mesofacial plates silvery, tinged with gold; borders blackish. Eyes red-brown. First antennal joint longer than usual, easily visible; second more slender and longer than usual, nearly black; third joint less than twice length of second. Arista plumose but not very strongly so. Proboscis dark brown; palps very dark ferruginous, almost black. The ptinal suture remains very distinct throughout life. A row of nine frontals beside the frontal stripe. Vibrissae inserted just above oral margin. Five rather small facials present; peristomialia eight in number, not very large. Cheeks provided with small black bristles. Two rows of black bristles behind eyes, the upper the more complete. Back of head covered
with short silvery hairs, which become longer on cheeks, but do not develop into a strong beard-like growth. Vertical bristle large; lateral vertical very small.

Thorax grey, with three longitudinal black lines, of which the middle one alone extends on to scutellum. Tip of scutellum faintly golden. Lateral and vertical parts of thorax grey. Of the acrostichals, only the prescutellar pair is present. Dorsocentrals complete, the last pair just extending beyond scutellum. Three well-developed humerals present. Apical scutellar bristle present. Anterior spiracle dark chocolate colour, with brown hairs.

Legs black and grey. First femur slightly hairy proximally; ventral longitudinal row of bristles very complete; first tarsus not longer than tibia. Second femur slightly hairy on proximal ventral half, "comb" developed; second tibia hairy; tarsus a little longer than tibia. Third tibia hairy; tarsus nearly as long as tibia. Pulvilli brown, fringed with delicate silver hairs.

Abdomen a little longer than thorax, with the usual black and silvery markings, the middle black line not definite on last segment. Short black reclinate bristles above, hairy beneath. Hypopygium almost black, shiny, very hairy. Forceps fairly straight, provided with a heavy growth of short hairs on its upper half. Posterior connecting membrane very feebly developed, though the forceps are approximated for about two-thirds their length. Accessory plates triangular, very dark brown, hairy; claspers shiny black. The penis is probably to be regarded as of a much modified tuberosa type; the posterior ventral spine being present and the anteriorly projecting chitinous bars represented by a pair of somewhat slender, curved, non-bifurcated pieces of chitin. Foliaceous chitin masses resembling those of S. misera var. dux are present, but are produced ventrally each into a long brown chitinous process.

Female.—This differs from the male in the following important characters:—Front slightly wider than eyes; an inner row of nine frontal bristles present, an outer of three, of which the lowest is very large. Scutellum more abbreviated than in male. Thoracic chaetotaxy as in male, except that last pair of posterior dorsocentrals extend well beyond scutellum. Scutellar apicals absent.
Legs.—First femur not hairy; second and third femora and tibiae devoid of hair, no “comb” on second femur. Abdomen shorter than in male, oval; the middle black line extending on to last segment.

Described from specimens bred by Mr. Henry Tryon from fish; in Brisbane. We have also collected one male attracted to bad meat in Brisbane.

10. Sarcophaga misera Walker 1849 (Fig. 22).

Syns.: S. frontalis Thomson 1868.
S. frontalis (in part) Froggatt 1907.
S. frontalis Tryon 1917.
S. misera Cleland 1912, 1913.
S. misera Johnston and Bancroft 1920 (a and b).

A moderate-sized fly, approximately 12 mm. in length, though some specimens may be as small as 7 mm.

Mæle.—Head.—Parafrontals pale golden, somewhat darkly tinged. Breadth of front at narrowest point about one-fifth width of head; cheek height one third that of eye. Eyes dark red-brown. Frontal stripe dark brown, almost black. First antennal segment inconspicuous; second large and black; third black, tinged with grey, and about twice the length of the second. Arista plumose for over half its length. One row of black chaetae behind eyes. Bristles below these irregular, dark, merging into longer golden hairs on genæ. Anterior part of cheek provided with long black chaetae. First segment of proboscis black, tinged with silver and pink; second segment shiny black; hairs of proboscis dark golden. Palps varying from brown to almost black. Lateral verticals absent. Vibrissæ inserted just above the oral margin. A single row of ten frontal bristles present, reaching down below the insertion of antenna.

Thorax greyish, tinged with gold; sometimes rather bright gold in appearance. Three dark irregular longitudinal stripes, extending on to the scutellum. Thorax at wing insertion pinkish. Bristles on thorax rather short, reclinate. Three humeral bristles present, of which the lowest is the longest. Anterior acrostichals absent. Three anterior dorso-centrals present, but very short. Outer presutural very large.
inner very weak. Four posterior dorsocentrals, first short, second a little longer, third much longer, fourth extending well beyond scutellum. Scutellar apical present. Three (at times five) sternopleurals. Ventral side of thorax silvery, sometimes tinged strongly with gold. Clothed with short black bristles, but not thickly.

*Legs* black, tinged with grey. Second and third coxae tinged with silver and pink. Coxae strongly armed with reclinate bristles. Proximal end of first femur with a small number of rather short hairs; second femur provided on its lower proximal half with a beard-like growth of very long hairs, while extending from the hairs to the top of the femur on its posterior part is a row of short stout bristles, about ten in number, forming a "comb." Tarsi not shorter than tibiae; pulvilli large, black, fringed with minute white hairs.

*Abdomen* black and silvery, clothed above with short reclinate bristles, beneath with longer hairs. Second segment without marginals; third with two; complete row on fourth.

Hypopygium black, not very prominent. Forceps black. Hypopygium and upper part of forceps provided with long curly hairs, which gradually shorten on the forceps; the tip of the latter bare. Prongs of forceps connected for varying distances by membrane. Copulatory organs of *tuberosa* type. Claspers dark brown. Accessory plates almost black, hairy. First joint of penis black, heavily chitinised; second joint somewhat triangular, the posterior end produced into a short sharp point, and bearing two large forwardly projecting prongs slightly bifurcated anteriorly; the whole dark brown, except in the most heavily chitinised parts, which are black. Between the anteriorly projecting chitinous pieces is a pair of pale-yellow serrated chitinous processes. The anterior portion of the penis is whitish.

**Female.**—The female is usually a little larger than the male, especially, of course, in the abdominal region.

Front about one-third the width of head. Frontal bristles in two rows; one beside the eye, consisting of four bristles; the other situated along the frontal stripe and composed of ten bristles. Scutellar apicals absent. Anterior femur slightly hairy, others not so; the ventral row of bristles of the second femur complete, i.e. no "comb" is differentiated. Third coxa bears a short apical bristle.
SARCOPHAGID FLIES FROM SOUTH-EASTERN QUEENSLAND.
Abdomen oval; genital segments are not visible from above. First ventral plate short but wide, second longer but narrower and bearing ten bristles, third still narrower with four bristles, fourth very narrow, fifth and sixth very narrow and fused.

Our specimens were bred from bad meat in Brisbane and horse dung in Eidsvold.

This species was first described by Walker (1849, p. 829), the type in the British Museum being a female from "New Holland." That institution also has specimens sent by Dr. Bancroft from the Burnett River. Mr. E. E. Austen, of the British Museum, has identified for us, by comparison with Walker's type, some females which are co-specific with other females common in Brisbane, while males have been obtained by breeding.

Mr. W. W. Froggatt, of Sydney, has kindly allowed us to examine a specimen collected at North Pine, near Brisbane, originally determined for him by Coquillet as *S. frontalis*, and referred to by him under this name (Froggatt, 1907, p. 315). It has been found specifically identical with *S. misera*. Johnston and Bancroft (1920, p. 75) have already referred to the presence of this species (Burnett River and Brisbane), while Cleland (1912, p. 150; 1913, p. 567) reported its occurrence in Sydney and Adelaide. Walker in his original description mentioned its presence in West Australia. Mr. Tryon (1917, p. 53) has referred to *S. frontalis* as one of the Queensland sheep maggot-flies. It seems to occur, then, over the whole of Australia.

11. *S. misera* Walker var. *dux* Thomson 1868 (Fig. 23).

*Syns.*: *S. dux* Thomson 1868.

*S. frontalis* (in part) Froggatt 1907.

*S. subtuberosa* Parker 1917.

Among the male *Sarcophagas* captured around carrion in Brisbane are a few which are in every way identical with the males of *S. misera* except for small differences in the structure of the penis. In these forms the anteriorly projecting bifurcated chitinous bars at the termination of the organ are considerably shorter and stouter, whereas the chitinous mass above these is much weaker, and even foliaceous in appearance.

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1 Thomson's specific name was already preoccupied, *S. frontalis* having been given to a fly from Amboina by Doleschall in 1858.
SARCOPHAGID FLIES FROM SOUTH-EASTERN QUEENSLAND. 71

(Fig. 23). One of these males was submitted to Dr. J. M. Aldrich of the United States National Museum, who determined it as *S. dux* Thomson. These males cannot be distinguished from *S. subtuberosa*, described from the Philippines and Guam by Parker (1917). In a note to Dr. E. W. Ferguson of the Health Department, Sydney, Dr. Parker referred to the latter species as being synonymous with *S. dux* Thomson. A female specimen of *S. dux* from Honolulu, kindly lent us by Mr. Henry Tryon, is indistinguishable from females determined by E. E. Austen as *S. misera*. These forms agree so closely with Walker's species that the differences are sufficiently recognised by placing the flies under the name *S. misera* var. *dux*.

The distribution of this variety is very wide. Thomson described his material from Honolulu, where its presence has also been referred to by Grimshaw and by Timberlake (1917). Parker's specimens came from the Philippines and Guam; ours were captured in Brisbane. This variety is one which has no doubt been included under *S. frontalis* by Australian authors, and is probably common in New South Wales.

12. *Sarcophaga aurifrons* Macquart 1846 (nec Doleschall 1858) (Fig. 4).

Syns.: *S. aurifera* Brauer and Bergenstamm.
*S. aurifrons* Froggatt 1905, 1907, 1915.
*S. aurifrons* Tryon 1917.
*S. aurifrons* Johnston and Bancroft 1920.
*S. aurifrons* Mackinnon 1920.

In general appearance a medium-sized greyish golden fly, about 10 mm. in length.

M A L E.—There is considerable variation in the shape of the head. In some specimens the eyes are either flat in front or (sometimes) slightly bent inwards giving the small frons a very prominent appearance. In each form the frons at its narrowest point is about one-third the width of eyes; while the frontal stripe is wide below, then becoming exceedingly narrow (less than half the width of parafrontals), widening again in the region of the ocelli. In other specimens the eyes are more projecting, the front proportionally less prominent, and the frontal stripe about two-thirds the width of an eye. The two types may occur among forms bred from the same parent. Eyes very dark red-brown. Parafrontals bright
golden, with dark reflections; genæ paler gold provided with black bristles. Occiput bright golden. Mesofacial plates very pale gold, almost silvery, with dark borders.

First antennal segment moderately conspicuous, black; second large, black, with silvery bloom; third less than twice the length of second, ferruginous, with silvery bloom. Vibrissa inserted close to oral margin; four small facial bristles; seven or eight epistomials. A row of nine frontals present. Verticals moderately large, lateral verticals inconspicuous. Three rows of black bristles behind eyes; genæ with short golden hairs posteriorly, longer below, but never forming a beard-like growth.

Thorax greyish gold above, brighter gold on sides, grey beneath. Dorsal surface with the three usual longitudinal stripes of which the middle one alone extends on to scutellum. Anterior spiracle dark chocolate, well provided with yellowish silvery hairs. Of the acrostichals only the prescutellar pair present. The row of dorsocentrals is complete, the posterior pair extending well beyond the scutellum. Anterior intraalar very weak. Upper humeral very weak. Scutellar apicals small. Halteres brown.

Legs black and grey. First femur very faintly tinged with gold; longitudinal rows of bristles complete; not hairy; tibia a little longer than tarsus. Second femur not hairy; a "comb" of eight bristles differentiated; second tibia hairless, and much longer than tarsus. Third femur very faintly hairy; tibia a little longer than tarsus, hairless.

Abdomen somewhat shorter than thorax, with the usual black and silvery markings, the silvery predominating. The median longitudinal stripe does not extend on to the last segment. Hypopygium not visible from above; very dark shining brown, almost black, and provided with rather short black hairs. Forceps slightly curved, sharply pointed, shiny black, hairy; posterior two-thirds bare. Claspers dark shiny black. The penis is a very complex organ; first joint shiny black; the second very strongly chitinised and provided with several complex white or brown chitin pieces (Fig. 4).

Female.—This closely resembles the male in general appearance and body proportions. Frons a little broader than width of eye. Frontal stripe about the width of parafrontals. Outer row of three frontal bristles well developed. Thoracic
chætotaxy as in male except that the apical scutellars are absent. The second femur does not develop a “comb.” Posterior trochanter with apical bristle. Abdomen a little more rounded than in male; the dorsal longitudinal line extends on to last segment.

Our specimens were bred from bad meat in Brisbane in November 1920.

Mr. W. W. Froggatt kindly allowed us to examine a female fly from the Brisbane district, determined for him by Coquillet as S. aurifrons Macquart. This female could be identified specifically with others which we have bred (along with the males) from bad meat. As these flies did not differ in any way from the scanty description given by Macquart, we have accepted them as belonging to this species, hoping, by giving an account of the male copulatory organs, to remove the confusion which appears to prevail regarding this fly. Macquart’s account could cover several species, and an examination of his type, if in existence, would be necessary to settle which, if any, of the many related forms herein described actually represents his species. Failing that, the above account will stand as valid for the species.

This fly is generally regarded as one of the sheep maggot-flies of N.S.W. and Queensland (Tryon 1917, p. 53). Macquart mentioned as localities “New Holland” and Tasmania. It is not very common about Brisbane. Mr. W. W. Froggatt has given a coloured figure and a short account (1905 ; 1907 ; 1915, p. 29, fig. 4). Mackinnon (1920, p. 553) has also published a figure.

In 1838, Doleschall described a different fly from Amboina as S. aurifrons n. sp., but as the specific name was already preoccupied his species might be renamed S. doleschalli.

13. Sarcophaga froggatti Taylor 1917 (Fig. 12).

Syns.: S. knahi Parker 1917.

S. aurifrons (in part) of Australian authors.

General appearance grey and golden. A medium-sized fly, varying from 6 to 11 mm. in length.

Male.—Head.—Front a little less than half the width of eyes. Parafrontals bright golden. Mesofacial plates pale golden, borders faintly tinged with brown. Cheeks and genæ
golden. Frontal stripe ferruginous, with a faint silvery brown. First antennal segment short and black; second much larger, black, with a ferruginous tinge, and silvery bloom; third joint about twice the length of the second. Arista dark brown at base, remainder light brown; strongly plumose for over half its length. Eyes reddish brown. Epistome prominent and silvery. A single row of black bristles behind eyes; bristles behind these weak and golden, becoming very long below. Cheeks provided with short golden hairs. A row of nine frontal bristles present. Lateral verticals present, but not very large. Four very weak facial bristles, also eight somewhat larger epistomials.

*Thorax* somewhat ashy coloured above, tinged with gold. Longitudinal stripes irregular, the middle one alone extending on to the scutellum. Ventral side of thorax greyish, with golden areas. Anterior spiracle brown, clothed with golden hairs.

Of the acrostichals only the prescutellar pair present. Anterior dorsocentrals weak, first posterior weak, second weak, third considerably larger, fourth very large. Three humerals present, of which the lowest is very large, extending beyond the pronotum. Scutellar apicals very large. Anterior intral-alar bristle as large as first anterior dorsocentral.

*Legs* dark grey, tinged with silver. Inner side of coxae grey, armed with long reclinate bristles, outer side dark, ferruginous. First femur hairy on ventral side, but not markedly so. Second femur a little hairy proximally, mid-ventral row of bristles developed into a "comb." Third femur strongly hairy. Third tibia very hairy. Pulvilli brown.

*Abdomen* silvery with ordinary dark-grey markings, provided above with short reclinate bristles, below with long hairs. Hypopygium very dark brown, almost black, very hairy. Forceps brown above, black below, hairy, tips bare; connecting membrane poorly developed. Accessory plates dark brown, provided with long thin hairs. Claspers shiny black.

The penis is of the *tuberosa* type; the chitinisation being not markedly heavy, so that the greater part of the organ is brown, not black. It is somewhat triangular in shape, the posterior ventral corner giving off a very short blunt process,
from which a pair of yellowish "scythe-like" processes run forwards and meet. Immediately above this there is a complicated but rather weak mass of chitinised tissue (Fig. 12).

**Female.**—The female differs from the male in the following characters:—Front equal to width of eyes. Lateral ventral bristles almost as large as verticals. Eight frontal bristles beside frontal stripe; three others converging upon these beside the eye. Lowest humeral bristle does not extend to mesonotum. Femora not markedly hairy; no "comb" developed on second femur; posterior tibia hairless. Abdomen a little shorter but broader than thorax; oval in shape, and with the usual black and grey markings.

A male of this fly was submitted to Dr. Aldrich, who determined it, by an examination of the male genitalia, as *S. knabi* Parker 1917. Mr. G. F. Hill of the Tropical Institute, Townsville, kindly sent us some specimens which he found to be co-specific with Taylor’s type in the Institute Collection. A comparison of the male genitalia of these forms, with the specimen which Dr. Aldrich determined as *S. knabi*, shows the two to be specifically identical, and to agree entirely, also, with *S. knabi* as described by Parker. *S. froggatti* Taylor and *S. knabi* Parker are therefore synonymous, the former having a few months’ priority. Townsend (1917, p. 191) created a genus *Glaucosarcophaga* with *S. knabi* as type. If the genus be accepted then the correct name of the type is *G. froggatti*.

This fly has a very wide range. Taylor’s material came from Winton (Central Queensland); our own is from Brisbane; Dr. Parker’s specimens were collected in the Philippine Islands.

14. *Sarcophaga zeta* n. sp. (Fig. 20).

General appearance closely resembling *S. aurifrons* Macq. Length 12 mm.

**Male.**—*Head.*—Front not very prominent; at its narrowest about two-fifths the eye-width. Frontal stripe very dark brown, almost black, equal in width to the parafrontals. The latter bright gold, with dark reflections; genae a little paler golden. Eyes dark red-brown. Mesofacial plates bright golden, borders very faintly tinged with black; back of head golden. Epistome prominent, pinkish. First antennal joint
inconspicuous; second much larger, nearly black; third ferruginous, with silvery bloom, and thrice the length of second. A row of fourteen frontal bristles present; seven facials; nine epistomials. Proboscis black, with golden hairs; palps almost black. A single row of black bristles behind eyes; hairs on back of head golden; hairs on genæ pale gold, and moderately long. Verticals present, but not very large; lateral verticals absent.

Thorax pale golden, with three longitudinal black stripes of which the middle one extends as a faint indication on the scutellum. Scutellum distinctly grey. Sides of thorax pale gold and silvery; ventral side grey. Last pair of anterior acrostichals present; prescutellar acrostichals well developed. Dorsocentral row complete, the last two larger than others; three humerals well developed, the lowest not extending to mesonotum. Anterior intra-alar slightly larger than usual. Scutellar apicals well developed.

Legs black and grey. First femur golden on ventral side; longitudinal row of bristles complete; femur moderately hairy. Second femur with a well-developed "comb," only very slightly hairy; second tibia not hairy. Third femur only faintly golden on under side, and lightly clothed with short hairs.

Abdomen silvery and black, as usual; very hairy on ventral surface. Hypopygium very dark brown almost black, less hairy than usual. Forceps, when viewed externally, shiny black, slightly sculptured and angular, but when viewed internally they appear dark brown. They are closely approximated for over half their length, but no connecting membrane is developed. At the angle are about ten short, stout, black bristles. The upper portion is hairy. Accessory plates brown and provided with only short hairs. Claspers brown at base, shiny black towards tips. Posterior clasper long and blunt; the anterior bifurcate. The connecting membrane immediately surrounding the penis develops a small "clasper-like" process antero-ventrally. First joint of penis dark brown; the second joint considerably simpler in structure than in the other forms examined by us, almost black in colour, and provided distally with a pair of medium-sized recurved hooks (Fig. 20).

Described from one male captured on bad meat in Brisbane.
15. **Sarcophaga theta** n. sp. (Fig. 5).

General appearance very like *S. aurifrons*. Length 9 to 12 mm.

**Male.**—**Head.**—Front fairly prominent, about half the width of eye. Frontal stripe nearly black, a little wider than parafrontals. Parafrontals, genæ, and back of head bright golden; mesofacial plates silvery with golden tinge and darker borders. Epistome fairly prominent, tinged with pink. First antennal segment very small; second shorter than usual and nearly black; third well over thrice the length of second, and of a very dark brown colour. Eyes red-brown. Proboscis and palps as usual. Eleven frontals beside frontal stripe; vibrissæ rather shorter than usual. Five facials, seven peristomials. Verticals present, lateral verticals absent. A single row of short black bristles behind eyes; back of head clothed with short pale-golden hairs, developing into a beard-like growth on the lower part of the genæ, but rather sparse and short on the anterior portion of the latter.

**Thorax** a pale-golden colour, with the usual three longitudinal black stripes, the middle one plainly visible on the scutellum, the lateral two only very faintly so. Sides of thorax golden; under side grey. Anterior spiracle provided with yellow hairs.

Of the anterior acrostichals only the posterior pair present, though but very weak; posterior acrostichals entirely absent. Dorsocentral row complete, the last pair extending just to the tip of scutellum. Two intra-alars, also apical scutellars, present.

**Legs** black and grey. First femur golden below and lightly hairy proximo-ventrally; tibia longer than tarsus. Second femur not hairy; a "comb" not definitely differentiated; tibia hairless. Third femur hairless, tibia strongly hairy.

**Abdomen** with the usual black and grey markings. The median longitudinal black row prominent anteriorly; extending only faintly on to the last segment. Abdomen with short black reclinate bristles above, hairy beneath. First segment of hypopygium silvery pollinose; second nearly black, shiny and very hairy. Forceps shiny black, a little sculptured, approximated posteriorly for about three-fifths their length; straight almost to the tips which are fairly sharply bent,
pointed and bare; the remainder strongly hairy. Accessory plates very large, dark brown and hairy. Claspers shiny black. First segment of penis brown; second more heavily chitinised, black, in parts brown, the outer portions yellowish or whitish. It is a relatively simple organ with a pair of short forwardly directed ventral processes, and a large irregular chitinous mass above and anterior to these (Fig. 5).

**Female.**—This differs from the male in the following characters:—Front about as wide as eyes. Lateral verticals well developed. A row of eight frontals beside frontal stripe, and three larger ones beside eye. Scutellum slightly more abbreviated than in male. Thoracic chaetotaxy as in male, except that the apical scutellars are absent. Thorax moderately hairy beneath. First leg not hairy; the second femur is remarkable in that it has a well-developed "comb" of eight bristles, such a structure being here confined to the female, whereas normally it occurs only in the male. Third tibia not hairy. Abdomen a little more rounded than in male. Dorsal longitudinal line extends definitely on to last segment.

Described from a number of males and females bred from decaying meat in Brisbane in September 1920.

16. *Sarcophaga iota* n. sp. (Fig. 11).

In general appearance a medium-sized greyish-gold fly; length of the male about 12 mm., while the female is usually from 9 to 10 mm.

**Male.**—*Head.*—Front prominent; over half the eye-width. Frontal stripe nearly black, and slightly less than width of parafrontals. Parafrontals golden, almost brassy in colour; genae approximately the same colour as parafrontals. Meso-facial plate silvery, with dark borders. First antennal joint inconspicuous; second moderately large, black; third black, and about four times the length of second. Back of head golden. Proboscis dark brown, almost black, and provided with long dark-brown hairs; palps very dark brown; epistome very faintly pink, not prominent. A single row of black bristles behind eyes; hairs below these golden, short, developing into a beard-like growth ventrally; anterior part of genæ with shorter golden hairs. Verticals present; lateral verticals absent. A row of frontals beside frontal stripe. Vibrissæ not very large.
Thorax greyish gold, with the usual black longitudinal stripes, the middle one alone extending on to scutellum; sides of thorax grey and gold; ventral side grey. Anterior spiracle dark chocolate brown, provided with brown hairs. Of the anterior acrostichals only the last two pairs are present; of the posterior, only the prescutellar; which are very strong, reaching nearly to the tip of scutellum. Apical scutellars present. Three intra-alar bristles present. Posterior pair of dorsocentrals reach far beyond scutellum.

Legs black and grey. First femur golden below, clothed with short hairs, tibia a little longer than tarsus. Second femur not hairy; a "comb" differentiated; tibia a little longer than tarsus. Third femur lightly hairy; tibia longer than tarsus and not markedly hairy.

Abdomen with the usual black and white markings; with short reclinate bristles dorsally, and a long beard-like growth of hairs ventrally. In the hypopygium the first segment is silvery pollinose, the second almost black and provided with long hairs. Forceps approximated for about two-thirds their length; angular in side view, ending in a sharp point; tip black and bare; upper portion slightly hairy, and dark shiny brown. Accessory plate brown, rounded, and moderately hairy. Claspers very dark brown. First joint of penis brown; second more heavily chitinised, black and dark brown, provided ventrally with a pair of hook-shaped, foliaceous processes, tipped ventrally with white (Fig. 11).

Female.—This differs from the male in the following characters:—It is shorter than the male, measuring about 9 to 10 mm.; one female reached only 7 mm. Front as wide as eyes. Lateral verticals very well developed. A row of seven frontal bristles beside the frontal stripe, and three large bristles beside eye. Scutellum much abbreviated, almost flat, whereas in the male it is strongly convex. Thoracic chaetotaxy as in male; i.e. two anterior acrostichals, three intra-alars, but no apical scutellars. Tibiae and femora all hairless. No "comb" on second femur. Abdomen very rounded; hairy, but not markedly so beanceth; median dorsal black line extends on to last segment.

Bred from decomposing meat in Brisbane, October 1920.
17. Sarcophaga kappa n. sp. (Fig. 7).

General appearance like *S. aurifrons* Meq. Length 12 mm.

**Male.**—**Head.**—Front not prominent; about two-fifths the width of eye. Eyes dark red-brown; frontal stripe very dark chocolate brown, and slightly broader than parafrontals at their narrowest. Parafrontals, genæ, and back of head golden, the latter very faintly tinged with dark. Genæ distinctly paler than parafrontals. Proboscis nearly black with brown hairs; palps very dark brown. Mesofacial plates faintly golden, more greyish at sides; epistome pinkish, not very prominent. First antennal joint inconspicuous; second black, tinged with silver, and a little smaller than usual; third joint rather over four times the length of second, and of a beautiful fawn colour. A row of twelve frontal bristles present. Verticals large; lateral verticals absent. Seven facials and eleven peristomials. A single row of black cilia behind eyes; hairs below these short and golden, developed into a beard-like growth below; hairs on anterior part of cheek shorter and golden.

**Thorax** pale golden, with the usual three regular longitudinal black stripes, the middle one extending on to the scutellum, the laterals represented each by a pale-brown discolouration. Sides golden; ventral portion grey. Of the anterior acrostichals only the posterior pair is developed; of the posterior set only the prescutellars, and these are considerably weaker than the anterior intra-alar. Scutellar apicals present; also three humerals, the lowest not reaching to the mesonotum. Dorsocentral row normal, the last pair (prescutellar) reaching just beyond scutellum.

**Legs** black, femora tinged with grey. First femur hairy, tibia slightly longer than tarsus. Second femur hairy proximo-ventrally, a "comb" developed distally; tibia longer than tarsus and not hairy. Posterior femur and tibia hairy.

**Abdomen** as long as thorax, conical, with the usual black and white markings, the median black line extending on to last segment; hairy below. First genital segment grey and pollinose; second dark brown, almost black, hairy. Accessory plates dark brown with long hairs. Forceps shiny black, curved; tips bare, remainder hairy, especially proximally. Claspers very dark brown, and articulating with one another basally. First joint of penis dark brown; the greater part
of the second black, with parts a lighter brown and parts whitish. From the ventral side are given off a number of irregularly shaped, somewhat foliaceous processes fringed with short whitish hairs. The penis is provided laterally with two strong black hooks, closely resembling claspers (Fig. 7).

**Female.**—This differs from the male in the following important characters:—Front about four fifths the width of eyes; parafrontals nearly twice the width of frontal stripe. Lateral verticals very well developed. Nine frontal bristles beside the frontal stripe; three which are much larger beside the eye. Thoracic chaetotaxy as in male, except that the prescutellar acrostichals are slightly larger in the female, and the scutellar apicals absent. First femur not hairy. Second and third tarsi and tibiae without hair. Abdomen more rounded than in male, and with the usual markings, the median black line extending on to the last segment.

Described from several males and females bred from bad meat in Brisbane.

**18. Sarcophaga omikron** n. sp. (Fig. 16).

General appearance closely resembling *S. aurifrons*. Length 10 to 12 mm.

**Male.**—*Head.*—Front moderately prominent, a little less than half the width of eye; eyes brown. Frontal stripe black, a little narrower than parafrontals. Parafrontals, genae, and occiput bright golden; mesofacial plates silvery, faintly tinged with gold. Epistome inconspicuous; first antennal joint invisible; second large, black, coated with silvery hairs; third joint silvery, about thrice the length of second. Arista shorter than usual, measuring only about six-fifths the length of the antennal joints combined. A row of twelve frontals beside frontal stripe; at the upper end of this row, below the ocelli, are five other bristles, one outside the row, the others internal to it. Vibrissa inserted fairly close to oral margin. About twelve facials and eight peristomials present. Verticals not very strongly developed; a single row of short black bristles behind eyes; occiput covered by short golden hairs which become longer below on the genæ, but shorter again more anteriorly.

*Thorax* rather bright golden, with the longitudinal jet-black stripes much darker than usual; the middle one alone has a
very prominent extension on to the scutellum. Sides grey and gold; ventral side grey; both provided with patches of long golden hairs. Shoulders with short black bristles and long golden hairs. Anterior spiracle dark chocolate, and provided with a heavy coat of short brown hairs.

Of the anterior acrostichals, only the posterior pair present, rather long but slender; of the posterior set, only the pre-scutellars. Scutellar apicals present; dorsocentral row complete, the last pair very long, the second shorter, but much stronger than those anterior to them. Two intra-alars.

Legs grey and black. The first femur bright golden beneath, and clothed with short hairs; longitudinal rows of bristles very complete. Second femur hairy proximo-ventrally; distally a "comb" is differentiated; tibia hairless, and considerably longer than tarsus. Third femur heavily clad with short hairs; distal two-thirds of tibia very hairy; distal third free; tibia longer than tarsus.

Abdomen about as long as thorax; conical, with the usual black and white markings; the dorsal longitudinal black line extends faintly on to last segment. Covered dorsally with short black reclinate bristles; hairy beneath. Hypopygium visible dorsally; first segment silvery pollinose, second shiny black and hairy. Forceps shiny black, curved, sharply pointed; tips bare, rest hairy. Accessory plates brown, hairy. Claspers simple; shiny black. The penis is a very stout organ, brown in colour, slightly pollinose, and developed distally into a short stout hook, as figured (Fig. 16).

Female.—This differs from the male in the following characters:—Frontal stripe about four-fifths the width of eye. A row of nine frontal bristles beside frontal stripe, a second row of three large bristles immediately beside the eye. Lateral verticals prominent. Thoracic chaetotaxy as in male, except that the scutellar apicals are absent. Scutellum considerably more rounded than in male. First femur only slightly golden, not hairy; tibia about as long as tarsus. Second and third tibiae and femora hairless; no "comb" on second femur. Abdomen rounded, much shorter than thorax; covered dorsally with short reclinate bristles; longitudinal black line faintly visible on last segment. Ventral side scarcely hairy.

Described from specimens bred from wool by Mr. Henry
19. *Sarcophaga sigma* n. sp. (Fig. 17).

General appearance closely resembling *S. aurifrons*.

**Male.—Head.**—Eyes dark red-brown, and very flat in front, giving the front a very prominent appearance. Parafrontals gold with dark reflections. Front half as wide as eyes; frontal stripe nearly black, a little wider than parafrontals. Genae golden with a rather brassy tint. Occiput golden. Mesofacials silvery; epistome fairly prominent. First antennal segment not very conspicuous; second large, nearly black; third about twice length of second, nearly black. A row of twelve frontals beside frontal stripe. Verticals present; lateral verticals rather well developed. Eight peristomials and seven facials present. Three rows of short black bristles behind eyes; the first row much more regular and complete than the others. Hairs below these short and silvery, developing into a beard-like growth below. Anterior part of gêna with black bristles.

**Thorax** golden grey with the usual black longitudinal stripes, only the middle one extending prominently on to the scutellum. Sides grey, tinged with golden, under side grey; anterior spiracle with brown hairs. Of the acrostichals only the prescutellar pair present, though very weakly developed; three intra-alaris; dorsocentral row complete; apical scutellars present; lowest humeral very large, extending just on to the mesonotum.

**Legs** black and grey. First femur tinged with gold ventrally, not hairy; tibia longer than tarsus. Second femur with a "comb," hairy proximo-ventrally. Third femur only slightly hairy; tibia not hairy.

**Abdomen** conical, shorter than thorax, with the usual black and white markings. Dorsal median line wide, but irregular, not extending on to last segment. Covered dorsally with short black reclinate bristles; hairy ventrally. Last segment of hypopygium shiny black, hairy; forceps fairly straight, bare at tips, hairy above. Accessory plate dark brown, hairy. Claspers dark shiny black. The penis is a heavily chitinised structure; the last segment nearly black, and divided distally into two parts, as figured (Fig. 17). The
Sarcophagid Flies from South-Eastern Queensland. 85

Posterior portion bears a long thin bent chitinous process; while laterally there is a curious tube-like structure of a pale-brown colour.

Female.—This differs from the male in the following characters:—Front about four-fifths the eye-width. A row of eight frontals beside the frontal stripe, and three large bristles beside the eye; lateral verticals well developed. Three rows of black bristles behind eyes; the first row well developed; the second irregular; the third very incomplete. Thoracic chaetotaxy as in male, except that the apical scutellars are absent. Legs as in male except that the second femur is not hairy and no "comb" develops; third femur not hairy. Abdomen more rounded than in male; very slightly hairy beneath, and then only posteriorly.

Described from a number of males and females bred from decaying meat in Brisbane in December 1920.

20. Sarcophaga bancrofti n. sp. (Fig. 8).

In general appearance a rather small form, measuring about 7 mm. in length.

Male.—Head.—Front prominent; less than one-third the width of eye. Eye reddish yellow. Frontal stripe very dark chocolate, wide below, but narrowing off towards the ocelli. Parafrontals pale golden above and beside the frontal stripe, the remainder silvery and heavily pollinose. Mesofacial plates a beautiful dark ferruginous colour; genae and meta-cephalon bright golden. The three antennal joints of a brilliant ochre; first joint clearly visible; second usual size; third over twice the length of second. Arista plumose for well over half its length, and not very much longer than the three antennal joints combined. Vibrissæ inserted close to oral margin. Six facials, eight peristomials, and a row of ten frontals present. Verticals not very strongly developed. Two rows of black bristles behind eyes; the lower row rather incomplete. Back of head coated with silvery hairs, which become longer below, but do not develop into a beard-like growth. Cheeks coated with black bristles. Proboscis as usual; palps like antennæ.

Thorax golden with the usual longitudinal black stripes, which do not extend on to scutellum. Lateral and ventral
parts grey. Anterior spiracle very small, clad with hairs which have a pinky tinge. Of the anterior acrostichals, only the posterior pair present; of the posterior acrostichals only the prescutellar occur and are rather well developed. Scutellar apicals present. Dorsocentral row complete. Four humeral bristles; anterior post-humeral does not reach beyond pronotum; second post-humeral a little smaller than first.

Legs black and grey. First femur not hairy, tarsus somewhat longer than tibia. Second femur not hairy, "comb" not clearly differentiated; tibia not hairy, longer than tarsus. Last leg not hairy. Pulvilli dark brown, fringed with silver.

Abdomen long and conical; the large anterior segment with a median triangular black patch; grey laterally, bordered with black; other segments with an indefinite black line along the back, dark brown beside this, bordered with a pair of anterior white and posterior black patches in each segment. Covered dorsally with short reclinate bristles; not hairy below, but clothed with short weak bristles.

First segment of hypopygium black, with faint silvery bloom; second segment black, very faintly ridged, and very slightly hairy. Forceps black; lightly hairy; rather thin and weak; not sharply pointed. Accessory plate somewhat triangular, hairy. Claspers dark shiny black, simple, the anterior pair larger than the posterior. The penis is a heavily chitinised structure; first joint shiny black, white ventrally; second joint nearly square in side view, provided anteriorly with a stout rather sharp hook, and posteriorly with a pair of yellowish brown processes (Fig. 8).

Described from a male caught in open forest country in Queensland National Park, in January 1921. The species is dedicated to Dr. T. L. Bancroft and his daughter M. J. Bancroft, Eidsvold, who have assisted us so freely in regard to material.

21. Sarcophaga (Parasarcophaga) omega new subgen., n. sp. (Figs. 25, 26).

Male.—Head (Fig. 26).—Front exceedingly prominent. Frontal stripe about thrice the width of the parafrontals, and pitchy black in colour, a little folded, and very minutely punctate. In the region of the ocelli it narrows; but below it widens out, developing into a pair of prominent folded exces-
Sarcophagid flies from south-eastern Queensland.

87 censes, which protrude well in front of the antennae, surround the mesofacial plate, and gradually die out at the oral margin. Front slightly under three-fifths the width of eye; genæ, metacephalon, and parafrontals brightly golden pollinose. First antennal joint concealed; second rather large, pitchy black, slightly punctate, with a few small bristles; third joint black, with a very faint silvery bloom, and about two and a half times the length of second. Mesofacial plate golden, with darker borders. Cheek height about two-fifths that of eye. Eye rather small, dark red-brown. A single row of ten rather small frontal bristles present; verticals large; lateral verticals absent. A single row of black bristles behind eyes; metacephalon covered with short pale-golden hairs, growing much longer below on the genæ; anterior part of genæ lightly clothed with pale-golden hairs. Proboscis and palps as usual.

Thorax at its broadest about the width of the head; colour rather ashy, faintly golden, with the usual three very dark brown longitudinal stripes, the middle one alone extending on to scutellum. Anterior spiracle large and clothed with pale-golden hairs. Sides grey and golden; under side grey and golden, the former predominating. Of the anterior acrostichals only the posterior pair is well developed; of the posterior set, only the prescutellars are differentiated, being rather large. Dorsocentral row normal; apical scutellars well developed; two intra-alars present. Three humerals, the lowest extending just beyond pronotum; a single post-humeral.

Legs black and grey. First femur golden beneath; longitudinal rows of bristles complete; femur only very slightly hairy proximo-ventrally; tibia not hairy. Second femur clothed with short hairs proximo-ventrally; a well-defined “comb” present; tibia longer than tarsus. Last femur heavily clothed with short hairs; distal two-thirds of tibia hairy; tibia longer than tarsus.

Abdomen conical and rather longer than thorax, with the usual black and white markings, the longitudinal black line not extending on to last segment. Upper surface with short reclinate bristles; lower surface moderately hairy.

First segment of hypopygium black, faintly golden pollinose, hairy; second segment rather small, shiny black, very hairy. Forceps shiny black or very dark brown, faintly sculptured, sharply pointed, hairy; upper half approximated,
points converging towards each other. A moderately developed connecting membrane present. Accessory plate brown, hairy. First joint of penis dark brown; second somewhat like that of *Sarcophaga froggatti*, though more elongated.

Described from one male, caught on decaying meat in Brisbane, April 1921.

This species is distinguished from all other Sarcophagids known to us by the above-mentioned very prominent excrescences on the head. As all the remaining external characters are of the ordinary *Sarcophaga* type, we are placing this form in a new subgenus *Parasarcophaga* which may be provisionally diagnosed as follows:—*Male*: General characters as in *Sarcophaga*; but frontal stripe about three times the width of the parafrontals whereas in the males of *Sarcophaga* it is seldom more than twice; frontal stripe developed into a very large lobed prominence forming an arch around the mesofacial plate. Type species, *Parasarcophaga omega*.

**LIST OF FIGURES.**

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THE MAGNIFICENT SPIDER: DICTOSTICHUS MAGNIFICUS RAINBOW.

Notes on Cocoon Spinning and Method of Catching Prey.

By Heber A. Longman, F.L.S.

(Plates VII and VIII.)

(Read before the Royal Society of Queensland, 25th July, 1921.)

The following observations are the result of several months of study of the "Magnificent Spider," Dicrostichus magnificus, specimens of which have been transferred to my garden in Brisbane. The so-called cocoons or egg-bags of this spider are such remarkable objects that they are frequently brought to the Queensland Museum. The children call them "cow's teats." As the spiders are practically stationary in the adult stage, they can be studied at leisure if established in a garden. Apparently no observations have been previously made on the spinning of the large cocoons, or on the remarkable way in which these spiders catch their prey, as described in this paper.

The adult female of Dicrostichus magnificus is a very large and handsome spider. A detailed description was given by Rainbow (1), and need not be repeated here, in view of my illustrations.

The abdomen is cream-coloured above, with darker vermiculations and a mosaic of fourteen salmon-pink spots on the front edge; the two prominent tubercles are yellowish. The dainty little turret on the cephalo-thorax, forming Simon's generic character (2), has an alabaster base, and the wine-coloured turret itself supports two pairs of eyes.

Although the locality for Rainbow's type was Mount Kembla, N.S.W., there appear to be no special distinctions in our Queensland specimens.

Apparently the different species of Dicrostichus manufacture distinct types of cocoons, but the contours of those associated with D. magnificus vary considerably. Rainbow figured cocoons with a very blunt terminal portion or tail.
In a series of seven in the same bunch in the Queensland Museum, much variation is to be noted. As may be seen from the illustrations, the cocoons are more or less elongate-fusiform. Saville Kent illustrated a similar cocoon (unnamed) in Chromo Plate IX. "The Naturalist in Australia," 1897.

The cocoons made by the specimen in my garden showed variations ranging from 3 to 4 in. in length, the maximum diameter being about an inch. In a cocoon 4 in. long, the peduncle occupied about one quarter of the total length, and the tail or terminal portion also about one quarter, this being the most variable part.

The inner cocoon hangs centrally in the upper half of the outer envelope, being elegantly pear-shaped, with the globular end downwards. Between the two envelopes when the cocoon is opened will be found a loose packing of delicate silk, which doubtless forms a valuable elastic medium, protecting the inner cocoon with its precious freight of eggs. The texture of the inner cocoon is similar to fine rice-paper, and it is much whiter in colour than the other. Within there is a quantity of fine, loose silk surrounding the eggs. The contents of an injured cocoon were counted, over 600 eggs being present. Taking five cocoons as the average, each spider lays in a season about 3,000 eggs.

Our spider made its home in a rose-bush. By binding a number of leaves together it formed a large retreat or nest, which it completely lined inside with silk webbing. During the daytime it was invariably to be discovered in this retreat with its head turned away from the opening. An angle between two branches formed an appropriate setting for the series of cocoons to be spun. The shelter of the foliage was increased by a small leafy branch, placed in position by my wife, which the spider promptly made use of the next night and secured by silken strands. A fallen rose-petal was also worked by the spinner into its bower.

Two cocoons were spun in the earlier months of the year, but no notes were then taken. Subsequently our interest was so aroused that each night, so far as possible, the spider was watched, for we were determined to see the wondrous spinner at work. With the third cocoon we were unlucky, for it was spun during our absence on the night of 31st March, shortly after the full moon.
On the 7th April there was a domestic tragedy, for a large immature Orthopteron, noted by Mr. H. Hacker as belonging to the family Gryllacridae (locally called "a cricket"), was discovered eating the eggs from the third cocoon. It had torn away both envelopes and had also broken the top part of the second cocoon. The spider was hanging close by, apparently quite unable to protect its eggs.

**Balooning.**—On the 16th April, a fine moonlight night, tiny spiderlings (about 2 mm. in diameter) were found to be emerging from the first cocoon through a hole in the upper part which was just large enough to enable them to struggle through. When they emerged they climbed to the top and on to the surrounding leaves and roses. Spinning fine threads which floated away on a gentle breeze, they were seen ballooning through the air to start life on their own account. Often the tiny threads would get entangled and three or four spiderlings would form a little constellation among the leaves. For the next four days these small adventurers were still emerging, mostly at night. Some were noticed to float up almost vertically. Two or three were located on the upper branches of shrubs on the other side of the garden, but all were eventually lost sight of, probably being devoured by the omnivorous sparrows. What number, if any, of these tiny aeronauts survived, I dare not suggest. My observations on isolated cocoons show that the spiderlings are able to penetrate the tough outer envelope of the cocoon and escape without any assistance from the mother. Examination of cocoons from which the spiderlings had all emerged showed that they contained the débris of initial ecdyses.

**Spinning the Cocoon.**—On the night of 21st April our persistent watching and waiting were rewarded. Shortly after sunset the spider was noticed to be busy, and quite a different creature from the almost motionless object of previous nights. She had chosen a perfect moonlight night for her toil. At first her object was not apparent, for she was at work among the supporting strands near the old cocoons. By letting herself down she spun a strand, up which she then climbed, taking it with her and attaching the line horizontally. She repeated this until many supports were formed for the dainty home of the new brood. Then the spider slowly spun a vertical strand by letting herself down from the upper supports. Although thin, this strand was, as will be
subsequently shown, of surprising toughness. At the end of this line she was suspended, and at 8.30 we noticed that the great work of spinning the cocoon was actually commenced. A tiny sheet of web was spun out from the end of the central strand. At 9 o'clock this was apparent as a little oval tent over the spider's back, to which she, ever spinning, added to the circumference. In weaving this ever-growing sheet, she twisted from side to side, the central strand rotating at her will through two-thirds of a circle, and then returning. At 9.30 the spider was half enveloped in a filmy cloud, as it appeared in the moonlight, and the sheet was being gathered into a bag. Into this bag the eggs were then laid with marvellous quickness, the whole operation taking but a few minutes. The eggs formed a glistening, globular mass about three-eighths of an inch in diameter, and this could be easily seen through the substance of the inner cocoon. During the process the spider's abdomen was inside the opening in the bag. Immediately afterwards, the mother was seen to have lost her great bulk, and the abdomen appeared to be wrinkled. At 9.45 the spider was hard at work filling the slit in the bag through which the eggs had been laid. Did she leave a weak place for the exit of the young, one wonders? At 10.30 the inner capsule was finely woven over and complete.

For the next hour the spider was unceasingly engaged in building up a fluffy packing around and below the inner cocoon. In this particular instance, quite a long tail, or apical portion, was spun, but the work on this part varies considerably in different egg-bags, and is probably dependent on the immediate surroundings of the cocoons. This fluffy packing is built up until its contours take the final shape of the cocoon.

The colossal task of weaving the large outer capsule was then commenced. This is by far the most arduous portion of all the mother's labour. The outer envelope has to be made strong enough to protect the precious inner cocoon from the weather, from friction when blown against leaves and branches, from the attacks of predaceous insects, and from the ovipositors of parasitical insects. Under magnification, its finished texture is seen to be very closely woven, and the final result is a tough material, not easily torn or penetrated.

During the long process of spinning this outer envelope, the spider worked from top to bottom, head downwards,
and then from bottom to top, on the other side, head upwards. It supported itself by gripping the cocoon with its legs meanwhile. Against the light the minute silk threads issuing from the spinnerets could be seen as a shining band of conjoined lines. The legs were in no way used to manipulate the threads, but the body was moved up and down, up and down, making a stroke of about three-eighths of an inch. One touch of the protruding spinnerets on the cocoon sufficed to attach the strands. The spider moved with surprising quickness, its spinning stroke varying from about 60 to 80 spins per minute. During its journey up and down the capsule 260 spinning movements were counted, and this represented but a single narrow sector of the whole circumference. Some idea of the energy expended by the toiling mother in her great work may be gauged from these figures, and one wonders at the strength of the muscles which move the abdomen. With haste and without rest, the process was continued, and at midnight the cocoon had attained its final contours. The spinning on the outer surface then reached a finer stage, and the glossy waterproofing was being done. Instead of working in vertical lines, the threads were attached from side to side as the spider made its way down and then up the capsule. This lateral movement was very noticeable, and the resultant spinning added to the toughness of the material, giving a criss-cross weaving. The whole surface of the cocoon had been woven over many times.

By 1 o'clock the capsule was smooth and glossy, but the spider was still working up and down, making short spins from its apparently inexhaustible reservoirs, the threads being attached by lateral movements of the abdomen.

During the whole process up to this time, the spider and cocoon were suspended by the tiny vertical cable which appeared to be perilously slender, and which swayed with every movement of the spinning mother. At 1.30 the spider was working at the upper half of the cocoon, which it cleverly rotated through three-quarters of a circle as it spun, moving the cocoon instead of its abdomen. At 1.45 it commenced to strengthen the slender supporting strand, somewhat to the relief of the weary though keenly interested watchers. For the next half-hour it worked at this peduncle, moving up and down and occasionally partly rotating it, getting a criss-cross effect with its weaving. It also climbed several times up among the supporting horizontal strands adding to the attachments.
At 2.30 it was still working at the peduncle, occasionally finishing off its spins near to the centre of the cocoon. The peduncle of the cocoon was now nearly one-eighth of an inch in diameter, and this was slightly expanded again at the very top, where attachments were made.

At 2.45 the spider stopped spinning for the first time during the whole process, so far as we could see from our almost continuous observations. She rested on the peduncle for about ten minutes, and then she proceeded to test the supporting strands, adding several to the surrounding leaves and twigs. This work was continued until 3.20. Lines were taken far back among the surrounding leaves and these were bound together, as though the spinner were aware that they might otherwise fall off and imperil the whole structure. Possibly this extra work was necessary because the cocoons were hanging with plenty of space between the angle of the two branches. Attachments were made to the top and to lower portions of the peduncle, so that the cocoon could safely swing in the wind without breaking a thread. Like a skilled engineer, the spinner went carefully over her work, testing, adding, strengthening, as though determined to make it as secure as was spiderly possible. For short periods she remained quiescent, but it was not until 4 o'clock that she was fully satisfied and moved slowly along her lines to the cozy retreat.

It is astonishing to see the powers and the limitations of instinct. This skilful spinner had apparently neither the art nor the inclination to mend the rent in her cocoon when it was torn by the Gryllacridid.

Probably her far-off ancestors were content to spin a simple cocoon with but one envelope. And even with the double shield but few of these spiders survive, for they do not appear to be very common. Nature is ever prodigal with her resources, and it may be that, of all the progeny of this night of spinning under the moon, but one or two will survive the perils of ballooning when they emerge on their fearless flight.

The fifth cocoon was spun on 7th May, fifteen days afterwards, on a dark, moonless night. The sixth was made on 23rd May in threatening weather, the spider apparently hesitating until after 10 o'clock whether or not to spin. On 14th June the seventh and last cocoon of the season was made, this being only two-thirds the size of the others.
Cocoons of Dicrostichus magnifica.
Spiderlings from the cocoon made on the 21st April did not emerge until the 25th July.

Remarkable Method of Catching Prey.—Rainbow referred to the retitelarian nature of the web of this spider (3), but my observations definitely show that Dicrostichus magnificus does not catch its prey in a web, at any rate in the cocoon-making season. Except for the many supporting strands for the cocoons, and the simple lines by which it suspends itself, which are also connected with the closely woven retreat, no other web is spun. None of these lines are sticky and no insect can be caught on them. There is no web entanglement to trap the moths on which it feeds. Shortly after sunset, the spider hangs suspended on a more or less horizontal line near to its cocoons. My wife and I repeatedly found it sucking a common species of Noctuid moth (Remigra frugalis Fabr.) which it had secured in some mysterious way. Close and persistent watching through many nights revealed the remarkable method by which it caught them. From its slender bridge it would spin a filament, usually about one and a-half inches in length, which was suspended downwards; on the end of this was a globule of very viscid matter, a little larger than the head of an ordinary pin, occasionally with several smaller globules above. This filament was held out by one of the front legs, the miniature apparatus bearing a quaint resemblance to a fisherman’s rod and line. On the approach of a moth, the spider whirls the filament and globule with surprising speed, and this is undoubtedly the way in which it secures its prey. The moths are unquestionably attracted to an effective extent by the spider, whether by scent or by its colour we cannot say. We certainly could not distinguish the slightest odour. But the fact remains that night after night one or two moths would flutter up and be caught. Other moths near by seemed to be indifferent, but two were often secured in the space of an hour, one of which would be packed away on the line to be sucked later. The spectacle of the moth fluttering up to the spider, sometimes two or even three times before it was caught, is one of the most interesting little processes which the writer has ever witnessed in natural history. The supposed desire of the moth for the star is a poet’s fancy, but the attraction of the moth to the Dicrostichus, although mysterious, can be seen by any patient watcher.

The globule is composed of most tenacious material, and quite large leaves can be suspended on it by a mere touch.
The spider can be artificially fed by holding a moth to the hanging globule, to which it can be transfixed by the slightest contact. Occasionally the filament and globule will be drawn up and another manufactured. The spider will ignore a moth which is artificially placed along its lines, and apparently its one method of catching them is by the filament and globule. The moth is as helpless when touched by the globule as is a fly on fly-paper. When the insect is secured on the sticky globule it is pulled up, and apparently killed by an injection of venom; it is then neatly bound in a little bundle, leisurely placed in line with the spider's head and there held and sucked, the wings being ultimately discarded.

Probably the study of allied species will reveal other stages in the evolution of this curious habit. Celenia excavata, which makes small spherical cocoons, is also without a web.

LITERATURE CITED.


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(Plates IX. and X.)

(Read before the Royal Society of Queensland, 25th July, 1921.)

Sheep maggot-flies are amongst the commonest and most widely spread insects in Australia. When one takes into consideration the extensive degree of parasitism exhibited by Hymenoptera upon other insects, it might reasonably be expected that numerous species would be found which depend for their existence on this abundant food supply. A number of such wasps have actually been discovered in Australia, mainly by Mr. W. W. Froggatt, of Sydney. In the present paper three other primary parasites of sheep blowflies are recorded. Careful search would, no doubt, reveal the presence of other species.

The forms hitherto recorded are—(1) Nasonia brevicornis Ashmead; (2) Dirhinus sarcophage Froggatt; (3) Chalcis calliphorae Froggatt; (4) Hemileucaomyia abrupta Dodd. The following forms in addition to Nos. 1, 2, and 3 have been found parasitizing either the larvae or the pupae of blowflies in Brisbane under natural conditions:—(5) Spalangia muscifurum Richardson; (6) an Encyrtid wasp, for which the name Australencyrtus giraulti, n. gen., n. sp., is proposed; (7) and a Proctotrypid (Diapriid) wasp, apparently also new, for which we propose the name Paraspidomicrus froggatti, n. gen., n. sp. (8) An eighth species, Pachycrepoides dubius Ashmead, has been recorded by Girault, from North Queensland, where no doubt it parasitizes Muscoid flies, as elsewhere. (9) Probably Chalcis dipterophaga Girault & Dodd is a parasite of blowflies.

In the present paper we give (A) an account of the biology of some of these forms, together with some general remarks on each species: (B) a discussion of the rôle they can be made to play in the control of the sheep flies; (C) a description of two apparently new wasp parasites of Australian blowflies.

Some information relating to these hymenopterous parasites of flies has been recently published by one of us (Johnston, 1921).
A.—OBSERVATIONS ON THE BIOLOGY OF THE CHALCID PARASITES OF AUSTRALIAN SHEEP BLOWFLIES.

The chalcid wasps that parasitize sheep maggot-flies may be divided into two groups according as they attack the pupa or larva. Egg parasites have not yet been discovered. To the former group belong *Nasonia brevicornis*, *Paraspilomicrus froggatti*, *Spalangia muscidarum*, *Dirhinus sarcophagae*, *Pachycrepoideus dubius*, and *Hemilexomyia abrupta*; to the latter group, *Chalcis dipterophaga*, *Chalcis calliphorae*, and *Australencyrtus giraulti*.

1. *Nasonia brevicornis* Ashmead. (Figs. 5, 6, 7, 20, 21, 22, 27-33.)

A full description of this species was given by Girault and Sanders (1909-1916). Its presence in Australia was detected by Girault in October, 1911; two years later it was found by Mr. Froggatt in N.S.W. and by Mr. E. Jarvis in Longreach, Central Queensland.

The wasp occurs very commonly in Brisbane, and can generally be easily attracted by exposing decaying meat. Careful observations on its life-history have been carried out by W. W. Froggatt and T. McCarthy (1914, 1915), as well as by J. L. Froggatt (1919). A more complete account which includes the observations of these authors has been given by Altson (1920). Graham-Smith (1919) also refers to this insect in his work on the parasites of common house-flies. (See also Johnston and Bancroft, 1920; Johnston, 1920.)

In the following account, therefore, only a very brief summary of published observations, supplemented by others of our own, will be given.

Length of Life-cycle.—Various observers have obtained varying results; Girault and Sanders give 15-22½ days, according to the season, in America; W. W. Froggatt and McCarthy 11 to 15, and J. L. Froggatt gives 11-14 days, in N.S.W. In Brisbane, during November, the total period was found by us to vary from 11 to 14 or even as much as 16 days, while in January and February it occupied about 14 days. Altson found that under laboratory conditions with a mean temperature of 20° C. it averaged 21 days in London.

Oviposition.—The wasps are readily attracted to carrion,
and are frequently seen sitting on the breeding-jars, or walking over the soil in search of pupæ. When a suitable pupa is found the wasp walks over it, testing the shell with its antennæ, and when a favourable spot has been found inserts its ovipositor (figs. 5, 6, 7), taking up the curious attitudes that have been described by various workers. During the process of piercing the pupal shell an oily fluid is seen running down the ovipositor, evidently acting as a lubricant. During oviposition, which lasts from a few minutes to a quarter of an hour (or even 25 minutes, Froggatt and McCarthy; 30 minutes, Altson), a number of eggs, generally about 15 to 20, but sometimes only one or two, are deposited on the surface of the developing fly (fig. 29). On several occasions it was observed that, although the ovipositor had been inserted for quite a long time, no eggs were deposited. The ovipositor is a moderately long structure, and, as it is inserted to its full length, the wasp places the eggs in clusters, sometimes at a considerable distance from the puncture.

Egg (fig. 27).—The egg is whitish and somewhat transparent, measuring, when freshly laid, about 0.32 mm. in length by 0.08 to 0.12 mm. in breadth. It appears to contain a small amount of yolk. During development the egg frequently lengthens a little. The duration of the egg period is exceedingly important economically (as will be described more fully below), and, according to published observations, varies from 30 to 74 hours. The time in Brisbane in midsummer was found to be 40 hours.

Larva.—This, on hatching, is a small whitish maggot about 0.3 mm. long, which maintains the same general appearance throughout larval life. The larvae do not appear to move far from their original source of attachment, but can be seen clustered together where the eggs were originally placed (fig. 20). Here they appear to remain throughout the feeding period, which is about 4½ to 5 days (7 to 10 in London, Altson). The three instars are easily recognisable by the structure of the jaws, which in the first instar are long, slender, slightly curved, stylet-like structures, serving to penetrate the epidermis of the developing fly (fig. 30). The larva of the second instar is much larger than that in the first stage (fig. 31); the jaws are more powerful, and the whole larva appears much more heavily chitinised (fig. 32). The jaws of the larva
in its third instar are quite different, being much sharper piercing structures, transversely arranged (fig. 33). The fully grown larva varies in length from 1.3 to 2.4 mm.

Feeding takes place by the suctorial action of the mouth applied to the original puncture. Two sets of larval muscles appear to take part in this, a sphincter set surrounding the end of the head and evidently serving to protrude the pharynx, and a retractor set inserted into the pharynx and serving to withdraw it (fig. 32). During the feeding stage the intestine remains closed distally. The larva then undergoes a resting period (propupal stage) at the end of which it empties the intestine, the larva (fig. 21) changing from dirty grey to pure white. After about 22 hours it moults, and a whitish pupa appears, about 1.5 mm. in length (fig. 22). About two days later the eyes turn reddish, on the next day they are bright red; on the following day the anterior half of the pupa turns black, and on the last day the mature wasp may be seen, within the pupal skin. The whole pupal period lasts about six days in Brisbane (five in N.S.W. according to Froggatt and McCarthy). Altson states that in London the period of development of the larva occupies 7 to 10 days from the time of hatching, with a propupal stage of 1 to 3 days, the pupal stage being 8 to 12 days (1920, pp. 219, 220). Girault and Sanders give 9 days as an average (U.S.A., springtime).

The males generally hatch first and can be seen on or near the fly-pupa, waiting for the females to emerge. Fertilisation takes place immediately, and in about six hours (3 to 24, Girault and Sanders) the females are ready for laying. Unfertilised females also oviposit quite readily, the offspring being entirely males. The females will oviposit for about three weeks. Observations by Girault and Sanders and by Froggatt and McCarthy show that on an average one female may deposit 113 eggs, but unfortunately she distributes them only amongst 17 to 20 pupae (on an average) so that her destructive action is considerably limited. The wasp thrives fairly well in the Australian climate, and has established itself over wide areas of N.S.W. and Queensland. Froggatt and McCarthy (1914) mentioned the following blowflies as hosts:—Calliphora villosa (= Neopollenia stygia), C. oceanic (= Paracalliphora augur), C. erythrocephala, and C. ruficacies. J. L. Froggatt (1919) added to the list Lucilia sericata, Sarcophaga aurifrons, Ophyra nigra, and Pycnosoma varipes, the last-named two being
Fig. 1. Australencyrtus giraulti ovipositing in maggot; 2, Dirhinus sarcophaga ovipositing in pupa; 3, Spulangiia muscidarum (from Burnett River); 4, Paraspilomicrus froggatti.
less readily selected by the chalcid for parasitism than the others mentioned. Johnston and Bancroft (1920) added Musca domestica, M. velutissima, M. hilli, and M. terre-reginae. Altson (1920) gives a list of British hosts. No less than eight species of flies (Musca domestica and seven blowflies) are mentioned by Girault and Sanders as capable of becoming parasitized by Nasonia. We have found the wasp able to parasitize, in addition, the pupae of the various species of Sarcophaga recently described by us as breeding in carrion (S. aurifrons, S. impatiens, S. irrequieta, S. misera, etc.)

(Figs. 4, 7, 8, 18, 19.)

This Proctotrypid was first obtained from naturally infected Lucilia pupae in November, 1920. A number of wasps (eight altogether) were bred from a single pupa.

Fertilisation takes place soon after hatching. The male sits upon the female, the long antennae intertwining and undergoing a short vibration every few seconds, producing a most ludicrous effect. During oviposition the wasp adopts a curious arched attitude (fig. 8), the egg-laying process lasting about ten minutes. No developmental stages have been observed by us.

This wasp was seen around Brisbane in October and November, 1920, and again in April, 1921, but never commonly. A description of this apparently new genus and species is given at the end of this paper.

3. Spalangia muscidarum Richardson. (Fig. 3.)

This wasp was first recorded from Australia by Johnston and Bancroft (1920), who found it parasitizing various flies (Musca spp. and Stomoxys calcitrans) in Eidsvold, Burnett River, Queensland. They stated that in captivity females would parasitize Pycnosoma rufifacies, P. varipes, Paracalliphora augur, Chrysomyia dux, Sarcophaga spp., as well as other sheep and carrion flies. We have also seen a number of these wasps bred from Lucilia pupae from Roma, by Mr. F. Taylor; also some in the U.S. National Museum, Washington, bred from Musca domestica in Adelaide and forwarded by Mr. A. M. Lea. During February this wasp appeared attacking the large golden species of Sarcophaga (S. impatiens, etc.) in Brisbane. It is, then, one of the natural enemies of sheep maggot-flies.

The total period from egg deposition to the emergence of the wasp was 21 to 28 days during midsummer, and never more than one wasp developed from a single pupa (Johnston and Bancroft, 1920). With *Sarcophaga impatiens* during February the period varied considerably, being between 23 and 30 days; and no more than one wasp appeared from even these large pupae.

This chalcid appears to be widely distributed over Southern Queensland, though probably not common.

4. *Dirhinus sarcophagæ* Froggatt. (Figs. 2, 10, 23, 24, 34.)

This wasp was first described and figured by Froggatt (1919), who bred it from pupae of *Sarcophaga aurifrons* Macq. It occurs also in Brisbane and is most common about February. It will parasitize any of the common sheep-fly pupae, *Pycnosoma* (both species), *Lucilia* spp., and *Sarcophaga* spp. being readily attacked. During oviposition the wasp assumes a most remarkable, uncouth attitude (fig. 2), remaining in this position for about fifteen minutes, and seems oblivious to everything going on around it, so that the pupa with the parasitizing wasp can readily be lifted without disturbing the latter. After oviposition is completed the wasp settles on the pupa in a crouching attitude for a long time, and then wanders off, usually to attack another.

The egg measures -68 mm in length and -17 in breadth (fig. 34). The egg period has not been observed. The maggot is a large whitish legless creature (fig. 23; Froggatt, 1919, p. 854, fig. 1) which feeds on the outside of the fly-nymph just as *Nasonia* does. It measure from 3 to 4 mm. in length.

The third instar does not appear to possess jaws. Its head is a curious structure and is provided with two prominent lips (fig. 10), the action of which causes the liquid contents of the disintegrating fly larva to flow into the mouth. The larvae appear to be predaceous; for on several occasions two larvae were found within a fly-pupa, yet not more than one wasp was observed to emerge from each fly-pupa. The wasp-pupa is a large white creature (fig. 24), with the characteristic *Dirhinus* appearance. The pupal period has not been determined but it is more than 7 days. The total period from oviposition to emergence during November, 1920, was found to be 25 days; but during January, 1921, as much as 28 days.
Mr. Froggatt regards this wasp as being capable of digging well beneath the soil in search of *Sarcophaga* pupae. This is probably not the case. Sarcophagid flies pupate just as frequently on the surface of the soil as do the other carrion-flies, and it is doubtful whether the wasp would trouble to attack those beneath the surface of the soil, when there are more accessible pupae available. On one occasion this alleged habit was tested. Soil containing pupated larvae was put into a bottle, together with a female *Dirhinus*; she could easily have reached them by a little digging (the soil being about one inch in depth), but took no notice whatever of the buried pupae, and after a few hours' captivity spent all her time in trying to escape.

5. *Pachycrepoideus dubius* Ashmead.

This wasp was first described from U.S.A., where it parasitizes the house-fly. It has been recorded by Girault from Northern Queensland, but nothing further is known about it in this country. Undoubtedly it attacks various flies occurring in that locality.


This Diapriid wasp was first described and figured by W. W. and J. L. Froggatt (1917, pp. 32-33) as being bred from a blowfly (? *Ophyra nigra*), and from *Musca domestica* (1918, p. 18) near Hay, N.S.W. It was more fully described and named by Dodd (1920, p. 421) under the above designation. The latter author reported it as a parasite of *Ophyra nigra* and *Calliphora villosa* (i.e. *Neopollenia stygia*) in N.S.W. (Froggatt collection). It has not been found in Brisbane.

7. *Chalcis calliphorae* Froggatt.2

This fairly large insect was described by Froggatt (1916, p. 506; 1917, p. 30) from Hay district, N.S.W., as a black wasp about the size of a small housefly, with reddish-yellow antennae, oval shining red-brown abdomen, and with thickened hind femora. This chalcid, which breeds readily in captivity, attacks blowfly larvae and does not prevent their pupation before destruction occurs.

2 D. Miller (N. Z. Jour. Agric., 22 June, 1921) states that large numbers of this parasite, obtained from Australia, were liberated in New Zealand two years ago, but that no definite results have yet been attained.
Figs. 5-7. stages in oviposition (Nasonia brevicornis). 5, commencement of insertion of ovipositor; 6, ovipositor fully inserted; 7, oviposition completed, wasp licking up fluid from puncture; 8, Paraspilomicrus ovipositing in pupa; 9, head of larva of Austr. giraulti, showing suctorial apparatus, etc. (s.m., sphincter muscle; r.m., retractor musculature; i., intestine; br., brain; n.g., first nerve ganglion; j., jaw); 10, head of larva of Dirhinus sarcophage (f.b., fat body).
8. Chalcis dipterophaga Girault and Dodd.

Syn.: C. calliphorae Johnston 1921 (from Brisbane).

This rather large wasp, which seems to differ from C. calliphorae only in the lighter colouration of the antennae and abdomen, was found on one occasion in Brisbane to be attracted to blowfly maggots. There is little doubt that the species is a parasite of the latter. Girault (1915) reported that this Chalcid was bred from dipterous puparia in North Queensland.


(Figs. 1, 9, 11-17, 25-26.)

This Encyrtid wasp, of which a description is given at the end of the paper, was first discovered attacking sheepfly maggots in Brisbane in October, 1920. It was soon found that it could be bred with comparative ease and in large numbers. On one occasion many thousand individuals were obtained after several generations from a single female. During February, 1921, the wasp was again seen in the open, while during April it was quite common around decaying meat. A few specimens were seen during July, 1921.

The female attacks all the common sheep blowflies in their larval state, seeming to prefer smooth maggots (Chrysomyia dux, Lucilia spp., Paracalliphora augur), but will quite readily attack the "hairy" Pycnosoma larvae (P. rufifacies and P. varipes) as well as those of the thick-skinned Sarcophaga spp. The wasps are exceedingly active, especially the females, which settle on any part of the maggots (fig. 1), and immediately begin to oviposit after showing great dexterity in clinging to the maggot as the latter crawls or wriggles. As a rule they do not appear to hurt the maggot in any way during the operation, though sometimes the latter is seen to writhe a little, no doubt when the ovipositor happens to injure a nerve.

Under artificial conditions numerous wasps commonly attack a maggot at once. When some decaying meat is exposed these wasps can often be seen close to the living maggots, and they will even attempt to parasitize those which are wriggling about immediately beneath the soil. Oviposition lasts from a quarter to half a minute, but at times when the maggot is quiet it will take considerably longer. Usually about seven eggs appear to be laid at each act of oviposition. Sometimes as many as twenty-nine wasps emerge from a pupa (artificially infected, probably by several wasps), the insects
being then considerably smaller than usual. If pupae be too heavily parasitized, then neither wasps nor flies emerge. The following numbers were obtained from six artificially infected fly-pupae, kept under observation: 29, 26, 22, 14, 11, 10.

The freshly laid egg is rather long and somewhat irregularly shaped, measuring -208 mm. in length and -076 mm. in breadth. A small clear area can be seen at one end of the otherwise granular protoplasm; and it is here that the egg membrane possesses a micropyle (fig. 16). The egg soon begins to segment by the usual peripheral segmentation method characteristic of insects. After 24 hours it is in a high state of segmentation and the developing embryo can be seen in the middle (fig. 17). The egg has by this time contracted considerably, measuring only -164 mm. in length by -072 mm. in breadth. Hatching appears to take place in about 48 hours, but this statement is made with considerable reserve.

The larva is of the usual 14-segmented type, the nine spiracles together with the tracheae being very evident (fig. 25). Feeding appears to take place much in the same way as in Nasonia, that is, by a suctorial action produced by the alternate action of protrusive (sphincter) and retractile buccal muscles (fig. 9). A pair of chitinous jaws, resembling those of the third instar of Nasonia, are present. The midgut does not communicate with the rectum until the end of the feeding stage, when, probably after a period of resting, defaecation takes place, and then after about one day the larva molts and a pupa appears (fig. 26).

The pupa is at first white in colour; after a few days the eyes redden and then the whole pupa darkens and gradually develops into the adult. The full period, from oviposition to emergence of the adult, occupies about 20 days in midsummer. In October it was found to be 25 days, in February 21, in May as much as 28 or even 30 days, the time gradually lengthening between February and May as the weather became cooler. In June and July it occupied approximately six weeks.

It was found that when wasps which had just emerged from the fly-pupa were isolated they would parasitize maggots as usual, and further that the offspring consisted of males and females in the normal proportion, which we have ascertained to be about 3:7. It must, therefore, be inferred that
Figs. 11-17, *Australencyrtus giraulti*. 11, adult female; 12, antennæ of male and female; 13, head, face-view; 14, mandible; 15, wings of female; 16, freshly deposited egg, taken from larva of *Sarcophaga*; 17, egg 24 hours old.

Figs. 18, 19, *Paraspilomicrus froggatti*. 18, antennæ of male and female; 19, fore wing.
fertilisation actually took place before the wasps had emerged from the fly puparium. If this method alone took place in nature then the only opportunity for true interbreeding instead of inbreeding would occur when two females chanced to parasitize the same maggot. Copulation has been observed to take place immediately after emergence, the act occupying about a quarter of a minute.

The wasp is an exceedingly active little creature, and is easily distinguished from *Nasonia* by the brown colour of the under side, as well as by its much greater activity often manifested by leaping movements. It does not appear to live very well in close captivity, where our method adopted in keeping them has been merely to place them in glass tubes and provide them with a little diluted honey. Under these conditions they began to die on about the third day, and we have not kept them alive longer than seven days.

B.—THE ECONOMIC SIGNIFICANCE OF THESE CHALCID PARASITES.

The extent to which a species of parasite is capable of destroying or checking the numbers of its host species depends on numerous factors, all of which must be taken into account, yet which it is often exceedingly difficult to estimate, even roughly. These factors, in the case of the parasites of Australian sheep-flies, are very complex.

The most important of these factors is the accessibility of the host species to the parasite. If the parasite has relatively little opportunity of access, it cannot do much harm to the species as a whole. It may destroy large numbers of specimens of its host species, but the really important question, from an economic standpoint, is the ratio of the number destroyed to the number not available for attack. The relative importance of this factor will depend, therefore, partly on the habits of the host species and partly on that of the parasite. Unfortunately these habits are but scantily known at present.

A second important factor will be the capacity of the parasite for inhabiting a certain locality in sufficient numbers. This will depend partly on the presence or absence of necessary food or of enemies, and partly on climatic conditions.

A third important factor, and one which it is impossible to estimate in the laboratory, may be stated as follows:—Given
that a parasite will readily attack its host under laboratory conditions, will it do so on an extended scale where its host is accessible in large numbers? For example, Australencyrtus giraulti will attack maggots with great avidity in the laboratory, but it is not known whether it would do so if given the same opportunity on a large scale in nature. The only way to test this would be to liberate the parasite in numbers in a given district and see if it would establish itself.

If any one of the factors be continuously unfavourable, then the parasite cannot be of any very great importance. If finally the parasite is to eradicate the host, not only would all these conditions have to be very favourable, but a fourth factor would have to be taken into account, i.e. the relative rate of breeding of host species and parasites. It will now be necessary to examine the effect of chalcid wasps on sheep-flies along these lines.

An immense amount of material for parasitizing is constantly available to these wasps; it follows, obviously, that any parasite which is not common can destroy only a very small percentage of the available larvae or pupae; if the available material, however great in amount, is small compared with what is not available, the economic importance of the parasite is practically nil. It seems, as will be shown below, that such is the case with those wasps which attack the fly-pupae; and such forms as Dirhinus sarcophagy, Hemilexomyia abrupta, Pachycrepoides dubius, and Paraspilomicrus froggatti must be regarded as nothing more than entomologically interesting. Their scarcity probably depends on the unfavourable nature of the third factor, possibly also on the presence of enemies, or on poor food supply.

Spalangia muscidarum has been recorded as parasitizing various Muscid flies to a great extent in Eidsvold; it was also occasionally found destroying blowflies in Roma and in Brisbane, but there is as yet no evidence to show that it is of any more practical use against the sheep maggot-fly pest than such a form as Dirhinus sarcophagy.

Of Nasonia brevicornis much has been hoped; by some it has been regarded as the ultimate means of actually eradicating, or at any rate controlling, the blowfly. Taking into consideration the above general remarks, it will be seen that these claims are founded on no very firm evidence. Even
assuming that all the other factors are favourable (which is, however, not the case) it is evident that Nasonia cannot possibly act as an efficient control, since the blowflies breed not only faster but also more numerously. Suppose, for example, we liberated a single female Nasonia and a single gravid female blowfly, e.g. Pycnosoma, in a certain district in which neither occurred. The blowfly would lay about 250 eggs, all of which, it may be assumed, would possibly produce adults. Now Nasonia would parasitize these pupae to such an extent that about 113 offspring would be produced by it—not at the expense of 113 blowflies however, but of only about 17 to 20, as already mentioned. Nasonia, in fact, would be a much more useful insect if it laid only one egg per pupa. Hence after the very first generation we would have 113 chalcids and about 230 blowflies; after the next few generations the difference would become very great, and if the flies had no other enemies they would soon overrun the country. Even if we contrast the period (a) which elapses between the deposition of eggs by the chalcid and oviposition by the females which emerge from such eggs (oviposition occurring within a few hours after emergence), with (b) that occupied by Pycnosoma from its deposition as an egg until the resulting female is capable of ovipositing, it appears that the above result will not be materially affected: since (a) the wasp period referred to, during midsummer in Brisbane, is about 14 days, whereas (b) in the case of the blowfly it is from 14 to 16 days distributed as follows—about 9 to 10 days in the immature stages (egg, larva, and pupa) and about 5 to 6 days after emergence before egg-laying takes place. As an effective control, then, Nasonia is of little value. To what extent, then, does it act as a check? This depends entirely upon the ratio of the number of pupae to which it has access, to the number of those which it cannot harm. Simple experiments, such as enclosing a number of these chalcids in a jar in the bottom of which was a thin layer of soil containing pupae, showed definitely that the wasps would not dig into the ground. It is necessary, therefore, to inquire as to the proportion of pupae lying on the soil to those below it. The following simple experiments were carried out during the summer of 1920-21 in Brisbane, but it should be carefully noted that they were performed partly under laboratory conditions and partly under natural local conditions, but not under sheep-district conditions. It is reasonable to assume, therefore, that similar
Figs. 20-22. *Nasonia brevicornis*. 20, blowfly nymph (*Lucilia*) showing clusters of *Nasonia* larvae two days old; 21, larva in "grey stage"; 22, pupa.—Figs. 23, 24, *Dirhinus sarcophagus*. 23, larva, seven days old, ventral view; 24, pupa, dorsal view.—Figs. 25, 26, *Australencyrtus giraulti*. 25, larva, lateral view, showing respiratory system; 26, pupa.
Figs. 27-33, *Nasonia brevicornis*. 27, freshly deposited egg; 28, 18-hour embryo—note head, intestine, and anus; 29, blowfly pupa with a cluster of *Nasonia* eggs; 30, head-end of larva in first instar, ventral view showing jaws; 31, larva, three days after its deposition as an egg, second instar, showing respiratory system; 32, head of larva figured in fig. 31, showing jaws (*j*), antennae (*a*), buccal cavity (*b.c*), salivary duct (*s.d*), sphincter muscle (*s.m*), and retractor muscle (*r.m*); 33, jaw of larva in third instar.—Fig. 34, egg of *Dirhinus sarcophagae* from uterus of parent.
results will not necessarily be obtained in our Western areas as in Brisbane. It might be expected, for example, that maggots would pupate to a much larger extent in the wool, and beneath the carcass of a dead sheep (where they would be accessible to the chalcid), than they would in less protected places, such as under a piece of dry meat. Experiments carried out with rather large surfaces, such as sheep's heads split down the centre to produce greater areas for protection, indicate that this does not make much difference. In view of the unfavourable results to be described, obtained locally with *Nasonia*, it seems at least worth while to repeat the experiments with various species of larvae under sheep-country conditions during different portions of the year.

In January, 1921 (i.e. during the hottest part of the year), *Lucilia sericata* and *Sarcophaga* spp. were allowed to infect meat placed on dry soil. The experiment was carried out in the shade. After the maggots had ceased feeding the meat had to a great extent disappeared, only the fibrous portion remaining and producing an excellent shelter for pupating maggots. Different layers of the underlying soil were then removed and the pupae in each layer counted, the following results being obtained:

<table>
<thead>
<tr>
<th>Number of pupae</th>
<th><em>L. sericata</em></th>
<th><em>Sarcophaga</em> spp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>On surface or partly exposed</td>
<td>105</td>
<td>2</td>
</tr>
<tr>
<td>To depth of $\frac{3}{4}$ in.</td>
<td>663</td>
<td>14</td>
</tr>
<tr>
<td>From $\frac{3}{4}$ to $2\frac{1}{2}$ in.</td>
<td>1,403</td>
<td>47</td>
</tr>
<tr>
<td>From $2\frac{1}{2}$ to $3\frac{1}{2}$ in.</td>
<td>172</td>
<td>4</td>
</tr>
<tr>
<td>From $3\frac{1}{2}$ to 5 in.</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>From 5 to 6 in.</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Percentage on surface</td>
<td>43.7</td>
<td>3</td>
</tr>
</tbody>
</table>

¹ J. L. Froggatt (1919, p. 260) has stated that it is generally amongst the pupae of *P. ruficacies* and to a less extent *P. varipes* that *Nasonia* is actually found to work in the field, this being due largely to the habits of the larvae of these particular species, which usually pupate under the edge of the carcass remains or on the bones, wool, etc., instead of crawling away as the maggots of other blowflies do.
During February a sheep’s head, split down the middle, was put into a box of dry soil, and infested entirely with *Pycnosoma rufifacies* and *P. varipes*. After about six days, the head was lifted and about 100 blowfly pupae counted; as the experiment was intended for other purposes (as described below) the pupae beneath the soil were not counted, but it is significant that after several days thousands of *Pycnosomas* hatched, the bottom of a box. 2 ft. by 1½ ft., being literally green with them.

In April results were obtained which seem to show the effect of heavy rain on pupation. The sheep’s heads were placed in a box, and became duly infested with *Ophyra nigra*, *Sarcophaga* spp., *Pycnosoma rufifacies*, and *Lucilia sericata*. Heavy rain fell, the whole contents of the box becoming thoroughly wet. One portion of the box was more wet than the remainder; it contained no pupae. No pupae occurred on the surface anywhere in the box, but were all found at a depth of from ¾ to 1 inch below the surface where the soil was least wet. Below this the soil was wetter, and only six pupae were discovered in it, but in the relatively drier region above this level several hundred were counted. As several thousand pupae had been expected a search was made in the soil surrounding the box, and as a result great accumulations of pupae of all the species were found *buried in the soil to the depth of one inch* under sheltering boards close beside the box. Unprotected soil to a distance of 5 feet from the box was examined and showed the presence of numerous fly-pupae. It would seem, therefore, that during rainy weather the conditions for *Nasonia* are even more unfavourable, since, though the maggots do not bury themselves so far down in the soil, *none pupate on the surface*. If these experiments are confirmed under sheep-country conditions, then this chalcid cannot be regarded as even a serious check on the spread of sheep blowflies.

These experiments do not take account of another serious deficiency on the part of *Nasonia*, viz., the alleged inactivity of the parasite at the very time that the flies are at their worst (Report of Blowfly Committee, Institute of Science and Industry, December, 1920).² Possibly this is accounted for by

²As this pamphlet is not readily available to workers, we deem it advisable to republish the statements relating to the work of *Nasonia* at Mr. W. Russell’s sheep station, Dalmally, near Roma, Queensland:—

“As occasionally over 80 per cent. of the blowfly pupae are found to be
the following facts:—Increased fly activity generally means a decrease in the length of the life-cycle (especially the immature stages, owing to favourable conditions of temperature and moisture) and incidentally of the pupal period. For *Pycnosoma rufiacies* and *P. varipes* this latter period is $4\frac{1}{2}$ days during the summer months, becoming as low as 3 days (on an average 4 days) during the most favourable weather (February). The egg period of *Nasonia* in Brisbane during this time is 40 hours. It follows that, of these 3 or 4 days which the fly passes in the pupal stage and during which the chalcid can act against the fly, nearly two days are occupied in the hatching of the parasite’s egg. Hence, unless the pupae are attacked within 24 to 30 hours after pupation, they are practically safe from destruction by *Nasonia*; indeed, we have the paradoxical conception of the pupae of *Pycnosoma*, during this period, acting as a most efficient chalcid-destroyer—in other words, as a “*Nasonia-trap,*” in that at least half the chalcid eggs deposited must be wasted, unless, of course, the wasp will instinctively refuse to oviposit in advanced pupae. The immunity of *Pycnosoma* to *Nasonia* attack was exhibited by the following experiment, carried out in February, 1921, when *Pycnosoma* spp. are the dominating blowflies in Brisbane. A split sheep’s head was placed in a box of soil and allowed to

3 J. F. Illingworth in an article, “The Australian Sheep Fly in Hawaii” (Proc. Ent. Soc. Hawaii, 1917 (1918), 3. p. 429; Abstr. in Rev. Appl. Ent., B., 6. p. 163) referred to the rapid development there during July. A dead animal was exposed on 16th July, larvae hatched out next morning, and three days later entered the soil to pupate, the pupal stage occupying about six days.

4 Altson (1920, p. 224) states that *Nasonia* shows preference for pupae between 24 and 72 hours old for oviposition. We have found that the wasp will readily oviposit in living blowfly pupae of any age.
become heavily infested with these two species. When the maggots had begun to pupate the box was closed by a "wasp-proof" gauze, and 250 Nasonia liberates were placed in the box. The wasps could perhaps scarcely have had a better opportunity for demonstrating their action on pupae buried in the soil, as well as on recently pupated Pycnosoma pupae. As stated above, about a hundred pupae were found beneath the sheep's head, but the result of the experiment showed that several thousand had entered the soil. Pycnosomas hatched in due course in immense numbers. Thirteen days later twelve Nasonia hatched, probably all from one unfortunate pupa! Here, under the best conditions, except that they were in captivity (which does not seem to make much difference with Nasonia), the wasps were helpless in the face of a reduced pupal period on the part of their host-fly. It is at least possible that these facts will account for the field observations above quoted.

If these laboratory experiments can be confirmed in the field, it is evident that little can be hoped from such wasps as oviposit in pupae. Parasites which attack the larvae should be much more useful, since they can obtain access to all the individuals that the former class can, as well as many that the former cannot. To this group belong Chalcis spp. and Australencyrtus giraulti. The former can probably be dismissed on account of their rarity, though of course they might be bred up in the laboratory. The latter is more hopeful, as it appears to be fairly common in Brisbane and breeds very easily, but has, unfortunately, a rather long developmental period. The first factor, namely, access to its host, is very favourable; of the others, however, nothing is known, and it might turn out quite useless in the field. We hope to distribute a large number later in the year in the hope that this Encyrtid may be of some use.

To this latter group of maggot attackers belongs also an English Braconid species, Ilyia maducator. This has all the advantages possessed by the above-mentioned maggot-parasitizing wasps, and has also the additional qualification of laying a very large number of eggs and distributing them among an equal number of maggots. A wasp living under English conditions might be unable to exist in the Australian climate; but, on the other hand, it might be stimulated to greater activity, and it is certainly a parasite well worth
attempting to introduce into Australia provided that it is not already known to parasitize useful insects (Graham-Smith, 1916, 1919; Johnston and Bancroft, 1920; Altson, 1920).

Table showing Parasites and Hosts in Australia.

The following table may be of interest. It is not unlikely that all the parasites mentioned may prove to be able to attack all the species of flies in the list. The introduced English blowfly, *Calliphora erythrocephala*, does not occur in Queensland as far as we are aware, though Froggatt has reported its presence in Sydney.

<table>
<thead>
<tr>
<th>Australian Muscoid Flies</th>
<th>Parasites.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chrysomyia ruficases⁵</td>
</tr>
<tr>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

C.—DESCRIPTIONS OF NEW HYMENOPTEROUS PARASITES OF AUSTRALIAN BLOWFLIES.

Australencyrtus giraulti n. gen., n. sp. (Encyrtidae).

(Figs. 1, 9, 11-17, 25, 26.)

Description of Female.

Length of moderate-sized specimens 1.6 to 1.92 mm. Small individuals may be much shorter, measuring little over

⁵ The first two species are referred to in the rest of this paper under the genus *Pyenosoma* as they are generally known by such name in Australia. According to a recent remark by Mr. W. W. Froggatt, the correct name for *C. ruficases* is *C. albiceps* Wied. (P.L.S., N.S.W., 1920, p. 472).
1·2 mm. in length. All measurements given below refer to a large form 1·8 mm. long. The wasp is easily recognised by its shiny-black upper surface and pale-brown under surface (figs. 1, 11).

**Head** (fig. 13).—Height 6 mm.; breadth 5 mm.; length 32 mm. Depth of eyes about half that of head. Distance of ventral portion of eyes to mouth twice that of dorsal part to vertex. Head shiny black with very faint reticulate pattern; the numerous bristles generally lodged in small depressions. Ocelli large and prominent, nearer to eyes than to one another. Frons with a deep depression. Clypeus gently convex. Insertion of antennae on a level with lowest part of eyes, their distance from one another equal to their distance from the eyes.

Eyes bare; about fourteen bristles immediately around orbit; two vertical bristles in line with posterior ocelli. Front with about fifty other bristles.

Mandibles shiny black, long (216 mm.) and prominent. tridentate, the anterior tooth very small; the middle one larger and prominent, the lowest somewhat smaller; all very obtuse (fig. 14). Mandibles provided with twelve bristles. Maxilla short, foliaceous, covered with about twenty hairs on upper surface. Palps pale brown, long and prominent, last joint especially large. Submentum not prominent; the mentum somewhat triangular and provided with a row of short bristles. Labial palps rather small, with three joints of which the second is the smallest. Mentum with prominent but short ridges.

Length of antennae 88 mm.; maximum breadth 0·06 mm. Ten joints including ring-joint. Scape slender, about 25 mm. in length, slightly broader at tip than at base, moderately bristly, brown. Pedicel about one-third length of scape, very conical. Ring-joint very indistinct, about 0·02 mm. long. The following six joints very dark brown and heavily clad with short bristles; the proximal one oval, the others gradually shortening, the most distal dome-shaped. Club 3-jointed. 16 mm. in length (fig. 12).

"**Thorax.**"—Shiny black above, light brown below: pronotum prominent, length about half that of head; with delicate transverse striations. Mesothorax about thrice the length of pronotum; as the anterior part of the pronotum projects into the posterior concavity of head, and also is longer at the sides than dorsally, the mesothorax appears, in dorsal
view, nearly six times the length of the pronotum. Scutellum very prominent, about two-thirds the length of scutum. Scutum distinctly ridged; pronotum faintly striated; scutellum smooth. In the middle of the scutellum on either side of the mid-line, the chitinous plate has a pair of small circular holes. The ventral side of thorax light brown, shiny. From the postero-ventral region of the pronotum a thin plate, pale brown in colour and rather transparent, is given off backwardly, reaching so far back as to overlap the tegulae ventrally. Probably the anterior spiracle lies beneath this plate; a similar structure is developed along the whole of the ventral portion of the mesonotum, and overlaps a portion of the last coxa; it is light brown in colour, much stronger than the similar extension from the pronotum, and appears to be hollow. The second spiracle is probably hidden beneath this structure. From the metathorax a similar overlapping structure is developed, but it is much smaller. Immediately behind it lies the third spiracle; just above it is a small cluster of silvery hairs. Pronotum with a row of 18 short (9 and 9), scutum with 56 (28-28) rather long bristles; scutellum with 22 (11-11) moderately long bristles on anterior half, a pair on the border, three-quarters the distance to distal end, and a pair of rather long scutellar apicals. Tegulae each with three bristles.

Legs brown.—First leg: Coxa largest, powerful; breadth half the length; thirteen bristles externally, and two rows of small bristles on posterior (inner) margin. Trochanter half the length of coxa; double-jointed; hairless. Femur rather short, twice the length of coxa and thick-set; with four rows of moderately long bristles. Tibia one and a half times the length of coxa, slightly broader distally than proximally; spur as long as that of second leg, but considerably weaker, with five rows of moderately long bristles. Tarsus nearly as long as femur, the five joints very hairy; claws not markedly large.—Second leg: Coxa longer but less stout than in first leg; provided with six longitudinal rows of bristles. Trochanter long, double-jointed, hairless. Femur as long as first femur, but rather weaker; with six longitudinal rows of bristles. Tibia long (56 mm.), thinner than femur; with five rows of bristles, the enlarged tibial spur very faintly serrated at its inner distal end. First tarsal joint much elongated; claws small.—Third leg: Coxa exceedingly stout, a little longer than broad, with a faint reticulation; six rows of short bristles.
Trochanter single-jointed and with five rows of bristles. Femur about as long as first, but bulging strongly in middle, with six rows of bristles. Tibia a little shorter than second; bristly; first tibial joint much elongated, claws small.

Wings (fig. 15).—Fore wings: Length 1.44 mm., breadth .77 mm. Submarginal: marginal: post-marginal: stigmal = 37:5:6:8. Length of submarginal .59 mm. Submarginal with fourteen large bristles, those in middle of vein the largest. Marginal and post-marginal with three rows of rather shorter bristles. Stigmal with eight bristles; its termination broadened, angular, hooked and bluntly pointed, 4-punctate as figured. Anterior border strongly ciliated. Whole wing ciliated, except posterior border and a small area anterior to this.—Hind wings: Length .96 mm., breadth .32 mm. The distal marginal part of the wing-vein .3 mm. long; the distal submarginal portion very slightly longer and rather transparent, and with two punctures. A row of eleven bristles immediately anterior to it. Wing ciliated, except for a clear area at base of wing.

Abdomen shining black, marked with a delicate reticulum. Rather broader than thorax, and dorsoventrally compressed. First tergite as long as the next two together. Second, third, and fourth tergites all about equal in length. Fifth rather longer, and partly overlapping the more anterior ones, being very concave in dorsal view. First tergite with five pairs of bristles laterally; sternum with very numerous short bristles, and three pairs of longer bristles posteriorly. Second tergite with a transverse row of seven moderately large bristles on either side; five pairs on sternum. Third tergite with a transverse row of seven bristles on either side and a very long bristle laterally; three pairs on sternum. Fourth tergite with a row of six bristles on either side; sternum with a group of eight pairs. The fifth tergite very bristly; anteriorly a row of four bristles on either side; posterior to these a row of five larger bristles; a marginal row of twelve bristles on either side; the most anterior part of the tergite with a small rounded thickened chitinous area bearing five large bristles. Sternum with five pairs of bristles. The termination of the ovipositor provided with a marginal row of ten bristles. Point of ovipositor sharp; no serrations present; length .45 mm.; free posterior part of sheath .16 mm.
Description of Male.

The male closely resembles the female in general appearance and size. It differs in the following characters:

Length of antenna (fig. 12) greater, being about 1.2 mm.; scape very slightly shorter than in female, measuring about 0.24 mm. in length; next joint, corresponding to the pedicel, very short, 0.08 mm. in length; third joint 0.16 mm. in length. The following seven joints about equal in length, measuring 0.096 mm.; the most distal joint not club-shaped, but somewhat conical with apex of cone distally, without any sign of division into three parts such as occurs in female. Length of mandibles about the same as in female; teeth slightly more acute.

Thorax as in female. First coxa shaped as in female; seven large marginal bristles, ten smaller externally, numerous minute bristles internally. Trochanter single-jointed, two bristles on dorsal distal end. Femur with three rows of bristles, and an indication of a fourth row. Second trochanter very short, single-jointed, hairless. Bristles of second femur weak. Tibial spur weaker than in female.

Wings as in female, except that the stigmal vein is very slightly shorter, the termination a little more hammer-shaped. Size exactly as in female.

The third abdominal segment bears ventro-laterally a very long bristle, even longer than in female. The penis is rather long, about equal in length to the terminal part of the ovipositor of female.

The biology of this little wasp has been described in an earlier part of this paper, the various immature stages being figured (figs. 9, 16, 17, 25, 26).

Systematically the insect belongs to the Chalcidoid family Encyrtidae, sub-family Encyrtinae, tribe Mirini of Ashmead, or Encyrtini (as considered by Girault, 1915). It does not fall into any of the genera as given in either Ashmead's or Girault's keys. We therefore propose to establish for its reception a new genus, Australencyrtus, with A. giraulti as type. Mr. A. A. Girault, the well-known authority on chalcid wasps, informs us that it comes near Perkins's genus Echthrogramartopus. It differs from that genus, however, chiefly in that the club is distinctly shorter than the funicle; the frontal region between
the eyes is considerably wider than the width of eyes, and the scutellum is not sculptured; while the post-marginal vein is very slightly shorter than stigmal.

Type specimens (allotype and holotype) deposited in the Queensland Museum, Brisbane. Bred from various blowfly pupae in Brisbane.

**Paraspilomicrus froggatti** n. gen., n. sp. (Proctotrupoidea—Family Diapriidae). (Figs. 4, 8, 18, 19.)

**Description of Male.**

Length 1·7 mm. (excluding antennæ); shining black.

*Head.*—Length 0·34 mm.; height 0·45 mm.; breadth 0·37 mm. Frons not protruding in front of eye. Eye rather small, bare, distant its own height from mouth; depth less than half the height of head. Ocelli very prominent, as near to each other as to eyes. Head smooth, shiny black, without pattern, with numerous short bristles. Antennæ (fig. 18) inserted on a marked prominence; very long (1·15 mm.), consisting of thirteen joints; scape 0·32 mm. long; pedicel and next two joints about equal (0·08 mm.); remaining joints shorter, broader, and rounded, last elongated and conical, the whole covered with numerous rather short bristles. Palps long, brown, terminal segments slightly longer than sub-terminal; both bearing six setæ.

*Thorax.*—Length two and a half times the breadth. Tegulae very prominent, forming large angular prominences at sides. Pronotal neck short, with longitudinal shallow excavations; pronotum itself hardly visible from above. Scutum smooth, shiny black, without any pattern; parapsidal furrows very prominent; rather wider than long; with a small number of moderately long, brown reclinate bristles, developing into a more pronounced growth laterally just behind pronotum. Scutellum four-fifths length of scutum, with a light growth of hairs; a pair of large square depressions on either side of mid-line, just behind scutum; and a transverse row of nine small rounded depressions crossing the scutellum two-thirds the distance from anterior end. Behind these, a row of four larger rectangular depressions. Epinotum with a complete median longitudinal carina; with four irregular ridged depressions laterally. Petiole with a complete median carina and two pairs of longitudinal depressions on either side, more
distinct in anterior half; provided laterally with rather long, somewhat curled hairs. Epinotum sculptured laterally and with a growth of short silvery hairs. Scutum and scutellum quite bare and smooth at sides. Pronotum with a growth of hairs laterally along posterior margin. Thorax lightly hairy beneath.

*Paraspilomierus froggatti.*


_Epn._, epinotum; _pet._, petiole; _sct._, scutum; _scel._, scutellum; _tg._, tegula. Shaded portions represent depressions. Only first joint of antenna (a) showing in Fig. A.

*Legs.*—Coxæ dark brown, hairy, short and stout, especially the third. Second coxa weaker than the others. Trochanters very long and slender. Femora long, hairy; proximal half narrow, distal half expanded to become markedly club-shaped; proximal portion light brown, distal very dark brown, nearly black. First and second tibiae rather shorter, dark brown, hairy, provided distally with two moderately long setæ; last tibia considerably longer, and with a distinct tibial spur. Tarsi five-jointed, moderately long; last very long; all hairy, but not markedly so; claws short.

*Wings.*—Length of fore wing (fig. 19) 1.6 mm.; breadth 0.64 mm.; submarginal vein 0.64 mm. long; marginal vein very thick and short, 0.064 mm. long, with six long bristles;
stigmal vein very short (0.24 mm.), 4-punctate, and with one long bristle. Rest of venation very poorly developed. Heavily ciliated especially posteriorly; on proximal part the ciliation is very sparse. Length of posterior wing 96 mm.

Abdomen.—Epinotum and petiole described in connection with thorax. Rest of abdomen long and slender, about as long as thorax, with scattered hairs ventrally and post-dorsally: smooth and shiny black; termination sharply pointed.

Description of Female. (Fig. 8.)

This closely resembles the male, the most pronounced differences being in regard to the antennæ. Scape, pedicel, and next joint similar to those of male. The following two joints considerably smaller than in female, equal in size, rounded: the remaining joints gradually becoming longer and broader: terminal joint conical giving the whole antenna a slightly club-shaped appearance.

Systematic Position.—It has been considered necessary to erect for the reception of this species a new genus near Hemilexis Foerster, Spilomicrus Westwood, and Hemilecomyia Dodd. The name Paraspilomicrus is proposed.

Generic Characters.—Antennæ 13-jointed; scape unarmed; antenna in female somewhat club-shaped, last joint short and conical. Head not punctate, smooth; no ridges on temples; pronotum short; mesonotum slightly convex laterally, smooth; not ridged. Scutellum with two small prominent basal depressions, and laterally from each a larger shallow indistinct depression. Two transverse rows of small depressions towards posterior end of scutellum. Petiole about twice as long as broad; the large abdominal segment overlaps petiole dorsally, abdomen somewhat pointed, not truncate. Fore wing with pronounced submarginal vein; marginal vein thick and short, about twice as long as thick. Stigmal vein very short, punctate. rest of venation practically obsolete. Type: Paraspilomicrus froggatti Johnston and Tieg, 1921.

The specific name is intended as a tribute to Mr. W. W. Froggatt, Government Entomologist of New South Wales, who has done so much to increase our knowledge of sheep maggot-fly parasites.

Bred from pupæ of Lucilia spp., Brisbane, November, 1920. Holotype and allotype have been deposited in the Queensland Museum, Brisbane.
SUMMARY.

In the present paper three new primary hymenopterous parasites of sheep maggot-flies are recorded,—Spalangia muscidarum Richardson, Paraspilomicrus froggatti n. gen., n. sp., and Australencyrtus giraulti n. gen., n. sp.—and a few observations on the life-history of these and certain others are recorded.

As a result of a short investigation regarding the habits of these wasps and their hosts, it appears likely (from laboratory experiments only, however) that the value of some of these, especially Nasonia brevicornis, has been greatly over-estimated.

In conclusion, reasons are given for the advisability of the introduction of the well-known English sheep-fly parasite, Alysia manducator.
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SYDNEY B. J SKEITCHLY (In 1877 and in 1921).
GLACIAL MAN:
MY PART IN HIS DISCOVERY.

By Sydney B. J. Skertchly,
Late of H. M. Geological Survey of England, Past President.

(Delivered before the Royal Society of Queensland, 27th April, 1921.)

INTRODUCTORY.

It is quite appropriate that I should address you on the subject of the Antiquity of Man. Me voilà!

My discovery of the remains of glacial man was no fortuitous accident, but the culmination of a long and strict training. If like my predecessor the late Mr. Jack Horner I put in my thumb and pulled out a plum, it was not that I had stumbled upon the pastry, but that I had studied the ways of the cook, and knew where she got her raw material.

My very earliest memory is a distinct vision of a joyful moment in a gravel-pit. Amid vague, dark-flitting surroundings my mind’s eye still pictures a long garden, quite without detail; but clear and bright, a beacon in the gloom, comes the remembrance and the smell of enchanting red-brown gravel stones that my infant fingers fondled. Always clumsy, I was constantly being picked up with abraded kneecaps and os frontalis; my earliest ailment was gravel-rash. I am gravel-rash still. Gravel has yielded me my choicest quarry in each of the globe’s four quarters, and as the sands of life run out, to gravel I still turn unsated, for Australia’s river-banks are yielding me treasures valuable as those of Europe and America, and equally despised, for, though I have been telling you about them for five years, not a single one of you has had the curiosity to take a three hours’ journey to see the evidence. It may please you to know the Nerang River is sick with waiting and is rapidly erasing the writing on the wall you would not read.

About my ninth year we removed to Ashby-de-la-Zouch, famed in “Ivanhoe,” near which my father was establishing
encaustic and mosaic tile-works. Here he realised my uncanny faculty for nosing out the boundaries of clay-beds, and from that time, he a man of learning and originality, fostered my peculiarity, initiating me in many a ramble into the mysteries of vegetable physiology and insect lore, training me to use the microscope, and to handle mathematical and optical instruments familiarly.

My first teacher in geology was Ralph Tate, who died not long since Professor of Geology in the University of Adelaide; but my real teacher was Sir A. C. Ramsay, for many years afterwards my chief on the Geological Survey of England. Huxley built up my biology, and, I think, never quite forgave me for eschewing Natural History for my first love, Geology. Prof. Partridge kept my human anatomy bright. Dr. Duncan lured me with corals, and delighted me by allowing me to help name some of Darwin's corals from the "Beagle" voyage. Bates, an old family friend, had come back from the Amazons, and to his dying day never realised that I had grown up and could walk upright. Faraday used to visit my father. All my days were spent with scientists, artists, poets, and (for my sins) politicians. What a childhood it was!

But the crux of my life was my connection with the Tylor brothers, Alfred and Edward. The North London Railway had run a line through the contorted gravels of Hackney Downs. Here to my delight I found not only Mammoth bones and Urus but a rich deposit of freshwater shells. I carefully drew the section, collected and named the shells. But one puzzled me. It was a stranger, and I dared to hope it might be Cyrena fluminalis, not now living nearer than the Nile (where to my delight I afterwards found it) but known in a few of the older pleistocene beds of England and France. I see, in the mind's eye, a timid lad of thirteen with a box of shells, knocking quietly at a door in Paradise Row, Stoke Newington, having screwed his courage to call uninvited upon the rich Quaker geologist who lived there. I was ushered into a fascinating room, half library and half museum, and tremblingly awaited the coming of the great man. He looked at my shells and took me right into his warm heart. He was my true father in science; his house in town and country was my second home, and afterwards my only one; and till I dropped a few gravel pebbles on his coffin, his love and wisdom were my pride and stay. As an engineer he drilled me into
accuracy of measurements of distances, depths, and angles. A section to him was no sketch unconsciously modified to tally with hypothesis: it must be a portrait. This lesson has stayed with me. In that study, that eventful night, I saw my first paleolithic implement (exhibited). Tylor taught me to use theodolite, level, and clinometer; his books and specimens were at my disposal, and patiently he led me over all the pleistocene and recent beds of the Thames valley, and these and those of Northern France I carefully examined, levelled for him or with him. Alfred Tylor was both geologist and anthropologist, but the lustre of Sir Edward his younger brother’s name has overshadowed the fame of the greater Alfred. Only in one way, save in love, could I recompense him: I dedicated my "Physical System of the Universe" to him, and, good simple soul, he used to carry a copy of it about with him and show folks the title-page; and when Darwin and Wallace wrote congratulating me he was if possible more pleased than I was. For more than two-score years the winds have sung a requiem through the oak-leaves over his grave, and I have grown old and widowed; but in dreams each night as I press my lonely pillow, two faces come to me, my sweet wife’s and Alfred Tylor’s, and when in the not distant years I too am but a shade I fain would that some of my friends may carry kindly memories of me, if but in dreams.

Largely through Alfred Tylor’s influence I had the inestimable advantage of spending a year as Librarian and Diagram-maker at the Geological Society. Here I made the acquaintance of the great founders of Geology—Sedgwick—Phillips, Murchison, and above all of Sir Charles Lyell, the true father of modern geology, the founder of the Tertiary system, the great expounder of the action of existing forces, the inspirer of Darwin. Lyell was very good to me, and used to come, ask in his inimitably modest way if I could spare a little time for a chat! Fancy it! Spare time! I could have sat at his feet a lifetime. He used to tell me all his early struggles to drive out the perniciously convenient cataclysms and convulsions of nature that accounted so easily for cliff and gorge and contorted rock. His philosophical brain poured out to me of its vast stores, and warned me of many pitfalls, many a cul-de-sac in reasoning. To Lyell, next to Alfred Tylor, I am in grateful bondage still: they can never be repaid.

At the Geological Society I acquired a thorough knowledge
of the literature of geology in most of the European languages, and all the while was working hard with Huxley at biology. Never very strong, my strength began to fail, for I was working double tides, grudging every hour of sleep. So when I was offered the post, vacated by Clement (afterwards Sir Clement) le Neve Foster, of assistant geologist to Ismail Pasha, Khedive of Egypt, inclination and health caused me to accept at once, and so good-bye to all hopes of a School of Mines diploma: I did not care to grow learned by "degrees" when I could acquire knowledge in the bulk, and on Christmas Day, 1869, I landed in Alexandria with H. Bauerman as chief and John Keast Lord as naturalist.

How gladly would I here tell of the glamour of Egypt. He who quaffs the waters of Old Nilus shall long therefor for ever, said Herodotus; and it is true, for from that day to this my love of Egyptology has known no abatement. In the old-fashioned sloop-of-war "Tor" we visited every headland and bay on the Red Sea coast, from old forgotten Berenice the Roman port for their emerald mines and porphyry quarries, to beyond Bab-el-Mandeb where at Zeyla the raised coral reefs, far inland, shine like silver diadems on the dusky basalt brows of Ethiopia. We made extensive journeys inland by camel and on horseback into Nubia and Abyssinia. In Egypt I found neolithic stone implements, in Nubia stone-circles perch halfway up the mountain-side on tiny plateaus, and in some of the wadies both in Abyssinia and Arabia I found palæolithic implements that my colleagues laughed at.

In long camel-rides across the desert I had unique opportunities of studying the action of blown sand, but my glory was the Red Sea coast which I knew from end to end along the African and on many parts of the Asiatic shores. This great rift valley was to me one splendidly clear section 1,500 miles long, the story of whose rises and falls was written in white coral upon dark rock. It is one vast fold, depressed in the middle, elevated at the Suez and Somali ends, the latter being the highest part. Atoll and barrier and fringing and raised reef tell the story graphically—the raised reefs off Shadwan in the north make a white streak on the black diorites, it sinks to sea-level as you go south and the barrier reefs stretch outwards into the sea, till in the central depression the Dahlac Isles lie as atoll jewels under the burning skies. Southwards the raised reefs come on again and reach their
highest point south of Bab-el-Mandeb. It was a glorious confirmation of Lyell's views, which led to Darwin's theory and confirmed its general truth. My letters to Darwin on this quite new evidence gratified him and led to a long friendship.

Returning to Cairo Sir Samuel Baker asked me to take a branch of his Soudan expedition (viéd Sowakim) to Berber across the desert, as I was acquainted with some of the way and the natives knew me. This was a thing after my own heart, but family matters called me home, and my friend Higgin-bottom, an engineer, gladly accepted the post and, alas, died en route. I left Egypt with profound regret, but carried with me the memory of two grand sections, the Great Rift Valley, and the Suez Canal, then being dug, and along much of whose bed I have walked.

Returning to England I at once joined the Geological Survey, and to Ramsay's joy selected the Fenland for my field of work, as it was the most extensive area of newer rocks in the kingdom, and being supposed to be a compost of gravel, bog, and ague, no one had volunteered to survey it, nor had our good chief the temerity to order any of his men into its (reputed) wastes. Here I spent four happy years at my favourite study of recent geology, gaining a thorough acquaintance with what might be called the neolithic series. In the fens I met my first master in working flint. It was that unmitigated scamp Flint Jack, an expert whose forgeries are in every museum and well-nigh every private collection from John o'Groats to Land's End. I last saw him in Piccadilly garbed in a rusty brown coat as appropriately as a hedgehog in lace. He told me with tears how in his old age he had repented him of the evil that he had done, and was going to an honoured grave as an honest man in constant employment—making Egyptian antiquities for the trade. He was an irreclaimable rascal, but oh! he was an expert in flint.

By this time surely I was peculiarly fitted for the task that all unknown lay before me. The two Tylors and Lyell had trained and moulded my strange taste for Post-Tertiary geology; travel had widened my outlook; four years steady work in the fens had given me experience, and I was now ready for what I may perhaps not immodestly term my great work. Certainly no living being had my special training, and the difficulty of interpreting the evidence is shown by the fact that it has taken forty years for geologists and
anthropologists to reach the point I had arrived at in 1878, forty-three years ago, when I made my first announcement of my discoveries in Nature, vol. xvi, pp. 142, 163.

Having finished my Memoir of the Fens I went up to Brandon in Suffolk on its borders, a place already renowned for the paleolithic and neolithic implements its neighbourhood had yielded. It is now necessary to state briefly the condition of public and scientific opinion in those days.

PUBLIC OPINION, LAY AND SCIENTIFIC.

The mild and friendly criticism which to-day does duty for the old odiun theologicum is hardly generically homologous with the triumphant venomous outpourings against science in general and geology in particular that in my young days did duty for orthodoxy. Even at the social board a grim silence fell if anyone rashly uttered the word "Evolution." In 1872 I published my little Manual of Physical Geography, with which the vice-president of the Royal Geographical Society was pleased to be pleased. He was a merchant in a large way, and ordered some hundred copies to gratify Tylor and do me a good turn. But finding something about evolution at the end of it he countermanded the order. No wonder Darwin wrote to Hooker, "I begin to think every man is a fool who writes a book." You smile at this, but I didn't at the time, but to understand my position it is incumbent that you realise the atmosphere of the seventies.

In the geological world things were as follows:—The Geological Survey began its work in Cornwall and South Wales, where the pleistocene beds cover but a small area; and as nobody took much interest in them—save in the tin gravels—they were generally ignored on the maps, and all of them, sands, gravels, and clays, lumped together under the comprehensive term "Drift." Hence the implements from the gravels were called "drift implements." As the survey extended northwards these drift-beds took up greater and greater space, till by the time we were fairly among the glacial beds they occupied pretty well as much ground as those euphemistically called "solid" beds. Still we were expected to ignore them, consequently maps were issued with dotted boundaries where the solid beds ran under the drifts, till finally some of the maps showed limestones and sandstones
where no human eye could see anything but boulder-clay, save stones from the bottoms of wells. Then we field-men protested, and the mapping of the so-called superficial beds was seriously taken up. Even then two sets of maps were issued, the one showing the solid geology, the other drift maps. At last when, as in Rutland, the drift occupied 90 per cent. of the ground this ridiculous division was finally abandoned, and now all our Geological Survey maps show all the beds that appear on the surface.

Louis Agassiz had demonstrated the former existence of a glacial epoch, and we all thought the ice had come on gradually, culminated, and passed slowly away. But we who had to deal with the beds in our daily work soon found this simple, free-and-easy theory would not work. All boulder-clay was not mere iceberg droppings; most of it was the ground-moraines of land ice—of glaciers. Moreover, there turned out to be not one but several boulder-clays, showing that the Great Ice Age, as James Geikie felicitously dubbed it, was a complex era of alternate cold glacial and comparatively warm interglacial periods. Great was the controversy over this; the older men strenuously insisting that the Glacial Epoch, like the first French Republic, was one and indivisible. In Scotland, among the doughtiest champions of the new views were James Geikie and your old acquaintance Robert Logan Jack—whom you see I have known for over forty years. In England, Searles-Wood junior and F. W. Harmer had insisted on a similar state of things in East Anglia, and I soon found the same true of the midland counties; and a pretty tough fight we had to get our official heads to come round to our views. Anyhow I convinced Sir A. C. Ramsay, as you will see in his Geology of Great Britain.

In 1874 James Geikie published his "Great Ice Age," which practically settled the question, at least for us field geologists who were daily mapping the beds. Meanwhile I had gone to Brandon and had arrived at conclusions curiously like Geikie's, even to discovering a new series of interglacial beds, in fragments, but unmistakable, to which I gave the name of Brandon Beds. Also I had found that the chief boulder-clay differed in constituent matter according to the beds it passed over. From the nature of things this was much clearer in England than in Scotland. I wrote to Geikie, who
at once came to Brandon to see my evidence, and I showed him glacial clay that was pretty nearly all chalk, much to his surprise and delight. Amund Helland, the Norwegian geologist, had recently returned from Greenland, where a study of the ice had converted him to Geikie's views, and as soon as he heard of my work he hurried to England and a glorious time we had together before I packed him off to Geikie in Scotland. Then Geikie and I spent part of a summer in the Outer Hebrides working out their glacial history. Meanwhile a second edition of the "Great Ice Age" was called for and I wrote the better part of two chapters for it. Just as it was about to be issued I found my first implement in my Brandon Beds, sent Geikie the glad news, and he was able to note the fact in his preface.

As regards man's remains the case stood thus:—M. Boucher de Perthes had discovered what he believed to be flint tools in the gravels of the Somme associated with the remains of extinct animals, the mammoth, woolly rhinoceros, &c. Great was the stir, great the indignation at presuming to aver that man was more than 5,000 years old. The thing was impossible, impious, and patently absurd. No mention of such a thing occurred in any Hebrew or Greek text or in any of the commentaries, and this pithy and conclusive reasoning settled the matter. It was one of those knock-down blows that convince everybody but the person aimed at. A commission containing Lyell, Prestwich, Lubbock, Tylor, and others went over to Abbeville and Amiens, looked into the matter, were convinced, and from that time no geologist doubts man's contemporancy with the mammoth. Here is one of the original Abbeville implements from Tylor's collection. It dates from about three years before I knew him (exhibited).

Then my good old Quaker friend William Pengelly was making similar finds in Kent's Cavern, Torquay, and soon a perfect rage for cave-hunting set in, in which my colleague Boyd Dawkins distinguished himself. Edward Tylor some years before had gone to the West Indies for health's sake, and in Havanah met Mr. Christy the rich London hatter, who was then making his unrivalled anthropological collection. The two went to Mexico to study its antiquities, and this made Edward Tylor an anthropologist whose name is now familiar in our mouths as household words. Among the things Tylor elucidated was the origin of certain strange fluted stones, which
he showed to be the cores from which the flakes for making spear and arrow heads were struck. I have the original obsidian core that led him to the solution (exhibited). John Evans—
the Sir John of later date—collected stone and bronze tools assiduously, and had produced his great work on the Stone Implements of Great Britain. It is a splendid catalogue, but he was not much of a geologist. Sir John Lubbock, afterwards Lord Avebury, did us the incomparable service of inventing the terms "Neolithic" and "Palæolithic" for the two classes, polished stones, &c., as contrasted with the older, ruder, unground weapons till then known as drift implements, and he was the first not only to insist on the difference of their ages, but to show that even the drift implements of the gravel were not all of one age. Then Mr. Christy financed M. Lartet and others to work out the caves of Dordogne, which yielded among other treasures the now celebrated contemporary portrait of the mammoth engraved on his own tusk.

This then was the state of affairs:—James Geikie and I were up against three problems whose inertia was immense. Of course others were in the fray, especially Searles-Wood junior and F. W. Harmer in East Anglia, but I think we two stood most of the blows. Naturally I got a double share, for I had committed the enormity of slighting Bishop Ussher's chronology, and I assure you the Authorised Edition has the ballistic power of a siege-gun, especially when propelled by Calvanistic cordite. The battle raged on three fronts—the theological, the interglacial, and the Adamic, if I may so put my particular field of action. I should like to give due credit to others who were in the fray—Mortillet, Rutimeyer, Tideman, and many another veteran—but this is not a treatise, 'tis but a bit of personal reminiscence.

As regards the relics of man, the gravels of France and England had yielded bounteous spoil of implements; a memorable visit of English geologists to the Somme had formally received the outcast haches de silex of M. Boucher de Perthes within the pale of humanity; here is one of the tools brought back by A. Tylor from that memorable meeting. Caves were yielding up their treasures, and the great fact of man's contemporaneity with animals now extinct could never more be doubted. Sir John Lubbock was among the first to stress the fact that even in the gravels there was evidence of at least two distinct periods, one pertaining to a colder, the other to a warmer, climatic condition.

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But everyone thought these things were post-glacial, and
the orthodox ghost of good Bishop Ussher was not perturbed.

BRANDON.

I chose Brandon for my headquarters for anthropological
reasons; it was the centre of an area brimmed to overflow in
stepping-stones of our dead selves, from tumuli where bronze
fibula lay cheek by jowl with flint arrow-head and polished
celt, to old mines wherein the early knapper had quarried black
flint with deer-horn pick; and the gravels of the river-banks
were deposit-banks of palæolithic riches. Moreover it was the
only surviving seat of the gun-flint makers, who still send these
quaint survivals, weekly, by tens of thousands, to the Arctic
wilds of Siberia and Russia and the Hudson’s Bay Territory,
for the fur-hunters whose warmly gloved fingers could not
manipulate the tiny percussion cap. Canon Grenwell had
opened a few of the ancient flint-mines at Grime’s Graves, and
in a fine paper had dropped the seed of a pregnant idea that
the modern gun-flint industry might be the lineal descendant
of the neolithic flint trade.

I received official permission to devote as much time as
was needed to work out the story of this dying industry.

I became a flint-knapper and my siliceous education as a
workman was complete. I became partner in a gun-flint shop
and flint mine. The result was I was able to prove that the
gun-flint trade was the oldest in Europe, with continuity from
then backwards at least to neolithic times, for I learn that since
my time it has been thought the Grime’s Graves pits are late
palæolithic. I showed that all the knapper’s tools were but
iron and steel replicas of the stone and bone implements of
eal: that even some of the words of the lost language were in
daily use, and that the knapper himself belonged to the neolithic
type; not only his tools but his body was age-old.

Meanwhile mapping went on, and I very soon became
convinced that the palæolithic implements I found in plenty
were not all of the same age, that some indeed were derived
from older deposits, as you may get Coralline Cragshells in
the Red Crag.

James Geikie had thrown out the bold suggestion that the
river-gravels with palæolithic implements pertained to glacial
times: his argument being that their northern limit coincided
pretty closely with the southern limit of the later boulder-
clays, and were entirely missing from the area that had been ice-worn in the later cold spells, though the caves (as in Yorkshire), protected from the ice, yielded these tools not rarely. This was my nest-egg, upon which I brooded, and from which I hatched my own poor, pestered pullet. If, I argued, the crude man of the crude weapon followed up retreating ice and retreating reindeer he was the original cold-foot, but a plucky fighting-man. He must have gloried in the brave north wind which hardened his thews and kept him fit—he was of a race apart. The man who kept behind him on the warm plains and plateaus where

They say the Lion and the Lizard keep
The Courts where Jamshyd gloried and drank deep

must have been of other blood. Man in deed and in truth had even thus early segregated into diverse types. And so I set me to track him down.

For the glacial theory I then drove in my wedge showing that the Boulder Clay which marked the crest of the ice-wave, when glittering ice-pinnacles o’ertopped the vales of Thames and Severn, had not only gathered where it had not strawed, but oft-times and in divers places had strawed not far from where it had gathered—that the material filched from the blue-black Kimeridge Clay was carried unsullied forward onto the lighter blue Oxford Clay, and so on. No iceberg ever calved at the back of the North Wind knew enough geology to return its collection of rocks to their parent bed. The Chalky Boulder Clay got chalkier and chalkier as it spread over cretaceous East Anglia, till some of it held foreign matter in the scant percentage of the beastly powder of my childhood, *hydrargerum cum creta*.

It became clear that in pre-glacial times the chalk plateau around Brandon was, as might be expected, furrowed by brook and river, and then buried beneath the burden of the great ice rock-grinder. Then rain and frost and snow set to work to clean the plateau up again, and now only patches of glacial clay remain to witness of the days gone by. Some of these patches lay in hollows in the Chalk, and to my supreme delight beneath this Chalky Boulder Clay I found the shattered fragments of beds of sand and gravel and clay, clearly of fluviatile origin, obviously older than the glacial clay. They were the long-desired evidence of interglacial strata older than the climax of the Great Ice Age, and I named them the Brandon Beds.
Very soon after my fondest hopes were realised, and my Brandon Beds gave up their choicest secret—flint implements. I waited till I had got them in more than one locality—and they were as scarce as they were precious. I had of course notified my chiefs—they were not overwhelmingly congratulatory, and I don't think ever really convinced, though they were very nice to me, and allowed me to insert a meagre Bowdlerised edition of my views, in my official Report on the Gun-flint Industry.

Naturally the news created a sensation. Geologists were asked to gulp at least three heresies in one bolus. First, the Glacial Epoch was to be taken in three courses. Second, the salt of the Chalky Boulder Clay had lost its savour and was vapid freshwater stuff. Thirdly, that man went a hunting during fits of interglacial mildness between the cold chill working hours of glaciation.

Prof. T. McK. Hughes had left the Geological Survey and ascended the throne of Sedgwick at Cambridge. It was his delight, not once or twice in my poor Brandon story, to come down in full panoply of professorial dignity, with a tail of glorious undergrads, howk me out and go over the ground with me, and egg me on to expound, while he stood by mute. Then would he strip his sleeves, and standing on the Brandon Beds prove they were not there. He showed how my poor Boulder Clay was nought but solid chalk, and in fine demonstrated that I didn't understand geology but he did. Among those who listened and profited by this wisdom was the present Professor Marr, his successor (who has just exhumed me from oblivion), as he reminds me in a letter just to hand.

I valiantly bearded the Cambridge lions in their den, and at the Philosophical Society meekly suggested that the genesis of man and man in Genesis were not convertible terms. After being soothed by the strains of a paper on Smith's function in a rectangular parallelepipedon I was called on. It was Hughes's hour of triumph, and he was glad he had been born. In presence of megaspores of dons, he got me down and rolled on me, he took me in his teeth and mangled me, and then flinging my remains onto a cane-bottomed chair, sat down panting but proud. One man alone had arnica for me—the Rev. Osmond Fisher, our greatest mathematical geologist, who had been over the evidence with me, and whose guest I was. A truly
great man, he went west but a few years since, having spent nearly a century benefiting the earth with his profound originality. He took casts of my implements, and I suppose they still exist. Dear old friend, the storm that raged never shook your faith in my work—for you knew. To him I owe my introduction to T. Belt. We all three went over the ground together and Belt was satisfied. Alas! he died shortly after, I believe in Nova Scotia.

The Sheffield meeting of the British Association was at hand, and my friend E. B. Tylor (not then knighted) was president of the Anthropological Section, then new, much neglected, and a little feared. By this time I had begun to wish my silvern speech had been coined into golden silence, and I intended to adopt the tactics of Brer Rabbit, but Tylor wouldn't have it. "You see, Skertchly," he placidly remarked, "neither I nor anybody else cares one spangled sequin about your views, but you will be an attraction and there's sure to be a row, and the Anthropological Section will get into the limelight." So I was offered up, and there was a row. Evans, Huxley, Newton (not the gravitation maker but the bird man), and all the other magnates whose words decided whether a thing was true and respectable, true and naughty, or neither clubbed me as if each had inherited Thor's hammer. But I was never without one champion, and Sir John Lubbock stood up for me like—well, like Lord Avebury. Afterwards public opinion was too much for him, and he more than half recanted in Prehistoric Times.

Next came the meeting of the "Americanists" at Brussels. Evans, Lubbock, and I were selected to represent England. Lubbock was called to the South of France suddenly and couldn't come; Evans didn't come, I don't know why; and I stood there alone to represent Britannia, armed with a stone axe instead of a trident. I read a paper correlating the American and European old stone tools, and did it in my own hardened way. All the fine naturalists of Europe and some of the Americans were there. Again I had a solitary champion in that splendid fighter the Abbé Rénard, then holding a chair at Louvain.

A very serious accident caused me to leave the Geological Survey, and for months I was forbidden to read. For some time my wife and I wandered over France and Italy, and
I laid in new supplies of Tertiary and Post-Tertiary lore. Returning to England I found Lord Goschen had inaugurated the University Extension scheme, and I became one of the first lecturers. The London Institution asked me to lecture on Man, and I gave the first course of lectures ever delivered in London upon that subject at the famous institution in Finsbury Square. I also gave courses on Anthropology for the University Extension, naturally setting forth my views.

Then came the death of my beloved Alfred Tylor, and there was now nothing to keep me in England. I went to America and after many days read the story of pre-glacial man in California, as you may see in the Journal of the Anthropological Society for 1888, and a stone mortar from those old gravels of Butte County that I brought home is in the British Museum. The paper (read in my absence abroad) attracted but little attention, though S. Laing commented on it favourably in one of his thoughtful and delightful books. Even my friend Alfred Russel Wallace seemed oblivious of it, for he wrote to me that the remarks in his Darwinism were from his own observation—years after my visit. My American friend shared the fate of its English co-sinner.

The evidence I relied upon in America was entirely geological—a fact I must dwell upon more particularly further on. The artifacts were chiefly stone mortars, and they had been known since about 1849. The American geological mind was revolving in a sort of "Californian wheel" which went round and round to this sort of reasoning: The mortars are of human origin, therefore the gravels are Post-Tertiary; the flora in the gravels is Pliocene, therefore the gravels are Tertiary: clearly the gravels cannot be both; clearly we cannot ignore the 300 artifacts that had turned up by 1888, and as the genesis of man is proved in Genesis, it is preferable to abolish the Pliocene plants and the 100 feet of overlying basalt and let Bishop Ussher be true and fossils and mortars (having no souls to be lost) be post-tertiaried into respectability. Faith was removing mountains.

An opportunity of visiting Borneo having arisen I eagerly embraced it. From the time when in the lecture theatre of the School of Mines (then in our Geological Survey building in Jermyn street, London) I had followed with keen delight Huxley's masterly description of the Neanderthal and other
old skulls, I had been disposed (unorthodoxly) to think man was of more than one race even when we first come upon his relics; and I had grown more and more to place weight upon the view many held, that as West Africa was the home alike of the black negro and the black gorilla, just as the Islands of the Sun were the abode of the brown orang-utan and the brown Malay, those parts might be "centres of origin." So I fondly hoped it might fall to me to unearth glacial man in Asia as I had done in Europe and America. But neither gravel nor cave in Borneo or other island in the Archipelago had any message for me. Far up the Kinabatangan River I found this (exhibited) the only old stone implement that rewarded me. It is old, almost certainly prehistoric so far as the Dyak race is concerned, but whether it be coeval with our neolithic or paleolithic, or still newer, there was not a particle of geological evidence to prove. It was reserved, as you know, for M. Dubois to exhume the much-debated Pithecanthropus—the man-monkey, or the monkey-man. The fight on this point has raged fiercely, and the fray has not yet come even to an armistice; but this I know, that if M. Dubois be lucky enough to catch a live one he will be puzzled whether to take it to the Zoo or the Sunday-school.

From Borneo I went to China, always in quest of the glacial sangreal, and travelled mony a weary fit over gravel and loess, in the vain pilgrimage. The China-Japan war sent me to Australia, for Othello's occupation was gone from the land of Confucius, and unless my old pupil Sun-yat-sen, elected President of China, should lure me from this newest to that quasi-oldest civilisation, here I shall come to rest. What I have done in Queensland to elucidate our ill-used cousin Black-fellow's history I have already hinted at.

THE NATURE OF THE EVIDENCE.

Let me now expound in some detail the nature of the evidence; and permit me once again to emphasize that the pre-glacial, inter-glacial, glacial, or post-glacial antiquity of man depends upon geological evidence, and upon nothing else. The characters of the bones and implements, the associated fauna and flora, have nothing whatever to do with the question. If the beds be, say, inter-glacial so must be the associated animal and vegetable remains; they sink or swim together. Yet this axiom was, by most, overlooked.
Put plainly the case was this:—I asserted three things: first that the Brandon Beds lay beneath the Chalky Boulder Clay, and were consequently anterior to the culmination of the Glacial Period; secondly that the said Chalky Boulder Clay was the product of land ice and not of floating icebergs; thirdly that the Brandon Beds contained remains of man in the flint implements I obtained in several, and the broken bones and old hearth I found in one place. I may here add that I found what I believed to be the site of an old tool factory of this age, and Professor Marr writes me that a party of (now penitent) geologists have recently spent some days in detailed examination of the locality, and their results confirm my views. It did not take ten minutes to refute them forty years ago!

Looking back to those early days I now feel sure that I was at that time the only man alive who could have deciphered the evidence. I am too old (and too far away) to be suspected of immodesty in so saying, but if you recall my very peculiar and special training you will see why I make the statement, and also the reason why I have burdened this paper with so many reminiscences. It is not I but the ferment I set up that matters: I was only the unrecognised enzyme.

It might seem a perfectly easy elementary problem to prove that one bed lay atop of another when they were before your eyes. But it wasn’t. Whitaker and Hughes and Harmer (to cite a few) were competent field geologists and skilful mappers of beds, of wide experience, yet they failed to read the sections aright; and if they were nonplussed what was the fate of those whose scientific profundity would not enable them to distinguish between a cryptogram and a cryptogram?

Take the above three friends of mine. How came it that they failed to recognise my Boulder Clay in many cases—they who had mapped so much of it? It was largely owing to the reflex of the misleading theory of the marine origin of the boulder-clay. Clearly icebergs must in their melting moments shed their dry tears indiscriminately; the seeds of future marine boulder-clays (to change the metaphor) must fall, some upon good soil, some upon stony ground, and some by the wayside; there could be no connection between the stones in the clay and the rocks upon which they fell, if the berg were travelling high up above the outcrops of different kinds of rock. “Chalk to chalk” was not written in the iceberg’s burial service.
Now I found that, though most of the boulder-clay (where thick) was made up of the detritus of distant rocks, much of the lower part was largely composed of fragments of the local rocks. This is exactly what must be the case if the ice were grinding over the surface of the ground, and precisely what could not possibly occur if the ice were simply floating over it. This my critics had not yet realised. The evidence was further obscured by the soluble character of chalk. It is fairly soft and takes glacial striae beautifully, but, alas, carbon dioxide dissolved in rain-water has no reverence for geological records but avidly neutralises the acidity it suffers from by impartially absorbing chalk whether in glacial beds or in the parent rock. We folk got to recognise these well-licked relics of the boulder-clay even when they got into post-glacial gravels. In certain lights you could faintly trace the relics of the old striae; these chalk pebbles had become palimpsests which you could decipher if you knew the language; A. C. Ramsay used to call them ghosts. Finally these chalk errants lost every trace of their glacial travels.

I found that over a good deal of Norfolk and Suffolk—chalk country—the Chalky Boulder Clay was often much more chalk than clay, more especially at its base. Over the area round Brandon in both counties the boulder-clay has been almost completely removed, but I found its remains preserved in hollows in the chalk surface, sometimes but a trace being left which one had well-nigh to accept by faith and not by sight. It was this very chalky, much denuded, badly dissolved clay that I offered them as the real article; naturally they would not have it at any cost. But where, as at Culford, the boulder-clay was thick and unmistakable they accepted it and the Brandon Beds unconditionally. But the flint tools in the latter—well, they had to be explained away if they could not be explained. They were too few (at Culford two flakes only) to found such startling theory upon. They must have got in by accident; perhaps after all they were not really of man's handicraft. Short of deliberately accusing me of fabrication (in a double sense) they went through every conceivable logical contortion to obliterate their existence.

The Brandon Beds are a set of gravels, sands, loams, and clays, the most characteristic being pale-coloured, fine-grained loams, which, being suitable for brick-making in this clayless area, have been sought out and utilised. For the most part
they lie in small hollows in the chalk plain, and may attain a thickness of fifty feet, but are generally much thinner. They seldom cover more than a few square rods in area. They are usually finely bedded, but the bedding-planes now lie at any angle or may even be contorted. This is due partly to their porosity enhancing the rate of solution of the underlying chalk, which, wasting more quickly than that around, lets the Brandon Beds gradually down into a cup-shaped hollow. This is action from below. From above they have been tilted or contorted by the moving ice, which in places has protruded tongues of boulder-clay into or even beneath them. Often the ice has overridden without disturbing them, just as one may see a modern glacier do, which is nevertheless ploughing up the rocks hard by. The effects of these two opposite disturbing influences must be carefully disentangled if one is to read the record faithfully.

They are sometimes covered with several feet of typical boulder-clay, as at Culford, but generally the glacial overburden is thin, and often as at Broomhill only a trace is left, hard to make out; sometimes the boulder-clay has been completely worn away. But the Brandon Beds are invariably associated with the Chalky Boulder Clay, and even where they now lie uncovered it can always be proved that boulder-clay once overlaid them. The boulder-clay itself, over the chalk plain, lies preserved in just the same kind of hollows eaten into the chalk as do the implement-yielding loams and gravels. This curiously intimate association of isolated patches of the two deposits ("inliers" we call them) is the key to the problem.

STONES V. BONES.

Another objection was extracted from the stones themselves. See, they said, they agree not inter se; they are obviously of different types! Types! what had I to do with types? I was no typist, only a stenographer of facts. I only had one point to make, that these implements were older than the boulder-clay. Still, in a way, they had right on their side. Take these four specimens (exhibited) for example. This very crude flint they would now, I presume, call an eolith, of which more anon. This rolled, worn, rusty tool I suppose the French would dub a coup-de-poing of, say, Acheulian age. This beautiful pointed implement, finely flaked all over, would be unhesitatingly assigned to the
Magdalenian Age; but this ruddy tool, sharp almost as the day it was wrought, would puzzle them. I never saw one like it, and I know why; it happened to be a bit of "floor-stone" of good texture, but with what we knappers call a "wring" in it: it wouldn't, couldn't flake straight; the flakes would take on a curve, and so it has an individuality, it is a type unto itself. I found it in tough clay (hence the sharpness of its edges) near West Stow in the only hearth of this date I ever came across. It was associated with quantities of broken, pounded-up bones. I think its maker fashioned it sitting by the camp-fire into which it accidentally fell, which accounts for its burnt, red hue, and partly for its sharpness, for it has hardly been used.

"Now," said the type-founders, "riddle me this riddle. How can these four distinct types come out of beds of the same age?" Well that was no business of mine: I was satisfied they did. Still I proffered two explanations, either or both of which may be true. First, I couldn't picture a race all of whose members were equally skilful handcraftsmen, and moreover with only a single idea in their capacious brain-cases. There must have been clumsy boys and clever boys; and surely they had more than one use for tools—big, simple implements for rough work, more delicate ones for fancy work. You can buy a half-crown Waterbury and a hundred-guinea English lever in the same shop; and in the Outer Hebrides James Geikie and I watched a fine old grandmother at her spinning wheel in a cot of neolithic architecture and furnishing, while her bonny grand-daughter, a real Princess of Thule, sat using a Singer sewing-machine.

Types had no charm for me then. We had too few specimens to found classifications upon. Classifications are apt to be rather the needs of the museum than the necessities of history; sometimes the classification is more curious than the curiosity it labels. Hear what comfortable words a wise man utters in the year of grace one thousand nine hundred and eleven: "The value of stone implements in deciding upon the age of deposits (whether in caves or elsewhere) depends upon the intimacy of the relation existing between various forms of implement and strata of different age. How close that intimacy really is, has been debated often and at great length. Opinions are still at variance in regard to details, but as to certain main points, no doubt remains." I might quote
other authors to the same effect, but I gladly cite the above from Dr. W. L. H. Duckworth's "Prehistoric Man" for the kindly manner in which he has gathered the bread I cast upon the waters so long ago, and with friendly hand laid it, as he thought, upon my grave. I could not relegate him to the indignity of a footnote as if my gratitude, like Milton's land of no free-will, showed

"Only what one needs must do, not what one would."

I mentioned eoliths awhile back. Well, I found them by scores, and I will venture to pick out blindfold any worked flint or chert or bit of quartzite from naturally fractured stones, as long as my thumb has a tactile corpuscle left in working order.

Now as to Bones. As I had only stones to show, my critics demanded bones. Bones are so much more satisfactory than stones, they said in England then as they say in Queensland to-day. I hadn't any human bones to show; I didn't stock the Brandon Beds or I'd have had a good supply, enough to go all round. It looked as if my osteological friends had taken the motto De mortuis nil nisi bonum, and rendered it—De mortuis, concerning Prehistoric Man; nil, you can know nothing; nisi bonum, unless you've got his bones.

Besides, had the Brandon Beds been as full of bones as a glue-maker's yard it wouldn't have mattered to me; it would miss my point entirely; it would do nothing to settling the question of the age of the tool-bearing beds—folks would never grapple this, the important question.

Then as to types—as to races. With the memory of the Neanderthal and other palaeolithic finds such as the rich stores of La Madeline, which I discussed with Lartet, I was strongly of opinion that in palaeolithic as in modern times more than one human race was playing its part on earth. But with the race question I had no personal connection. Racial characters must be worked out in museums, and I was a field man. It was the history, not the genealogy, of man that was my métier. Indeed the very first attempt at dividing the palaeolithic age into stages was published by me in my book on the Fenland in 1878, and repeated in my official work on Gun-flints the following year. This was an additional crime; nevertheless, though this primitive effort had, naturally, many flaws in detail, succeeding research has confirmed my main contention; and
now, so far from there being a Palæolithic Man, anatomists are making of him almost as many races or subspecies or even species as there are skeletons, and they are still undecided as to the exact age of most of them. I assert now, as I did then, that bones of themselves tell us nothing of their date but only of their race, and an old race may exist to-day. On the Labrador coast you can knock fossil Lingulellas out of Cambrian rocks, and dig their living descendants from the mud at the cliff-foot. Our dear friend Pithecanthropus may be Pliocene or Pleistocene; he might be alive to-day, but his mere bones would not tell us when he lived—the rocks are the only true timekeepers.

However, if I failed to deliver human bones, I sent to the Geological Survey Office a good-sized hamper full of bone fragments from the hearth at West Stow above mentioned. They were mostly quite small bits, but I recognised a few teeth of oxen and deer. Huxley, who was our palæontologist, took but the palest interest in them, but he reported officially that they were mostly too fragmentary for identification, though Cervus elaphas seemed to be among them. I mentioned this at the Cambridge Philosophical Society and it proved a bonne bouche to Hughes, who after tearing it to bits proceeded to pick my bones in great style. Did I not know that Cervus elaphas was late Pleistocene? If that deer-tooth came out of the Brandon Beds it settled the whole matter; they were demonstrably post-glacial. And the congregation (save Osmund Fisher) chanted "Amen." What a strained effort my reply seemed! I pleaded that I didn't find the label but only the specimen; that I only said the beast from whose jaw the tooth was extracted lived pretty near where he was buried; that Huxley only erected the tombstone and if he cut the wrong name on it the corpse wasn't altered thereby; finally that, if Huxley as dentist had got his patient's name right in his books, it proved the elaphas family more aristocratically connected than was suspected, that elaphas belonged to a county family and was not of clodhopper blood. It was of no avail, but the anecdote points a moral and adorns this tale: it shows that if anatomy be not tempered with geology bones become shillelaghs for decorous Donnybrooks.

Permit me here to put in a little moral on my own account. Remember that my finds were made in the course of my daily work, and that I could spare only too little time over each section, seeing that the powers (not the Geological Survey
powers) who paid us could only appreciate area. My own chiefs were very lenient with me; they sympathised, but not to the extent of letting me spend a few pounds in clearing sections. It was the same with the visiting public; a party of about fifty from Norwich argued a whole afternoon about the interpretation of my Brandon Bed tool factory, but were not game to ante-up a shilling a head to do some digging and settle the point. This year Professor Marr and some friends, he tells me, have put in a week's hard work there and find I was not very far out.

* * * * * * * *

Forty years have passed. Eoliths have come to their own. Man has been tracked far beyond the glacial period, at least to the times of the Red Crag. He proves to be of several races. And I think it is also certain that though a race may become modified it seldom, if ever, dies out. All the points I claimed have proven to be points of light.

I believe man developed very rapidly, but only after he had learned to utilise fire. That this occurred in a cold region. It provided him with warmth and later with cooked food. But chiefly it gave him leisure, it doubled his life, and sundown no longer meant the close of a working day. How the leisure hours by the camp-fire split his genio-hyoglossus muscle, as boys used to split starlings' tongues, to make him talk, I will tell, with other heresies, unless the clock strikes ere I overcome my repugnance to ink, and will again do the penance of the pen.

Then, too, I believe man very early branched into two and only two sections—the Negro, and the rest. The Negro took as blind a path as my old acquaintance Orang Utan, and can no more advance than he can. To say he has never had a chance, that he has always been downtrodden, is sentimental flapdoodle. He has been on earth as long as we have; he was in contact with civilisation thousands of years before we were; in fine, he had a better chance than we had. He is what he is because he is what he is.

I think it certain that white races may gradually enlarge their borders successfully; they cannot emigrate to distant lands and permanently occupy them. The White Man cannot live in the United States or in Australia without transfusion of blood from the homeland.
I can see no, or very little, proof that man has increased in brain-power since palæolithic times; he has simply a bigger stock of knowledge—he knows more, he is not wiser.

I am deeply grateful to you good Queenslander for your kindly forbearance to-night. It may seem to have been a night of amazing indiscretion: that this being the Royal Society, and I an old President of yours, should have made my discourse dry. I must only plead the qualities of old wine—the best champagne is dry.

And now to look forward. I see, as Charon shuts off petrol nearing the jetty on the far side of the dark waters, Professor Thomas McKenny Hughes clear-cut against the western sky-line, atop of a high-level gravel escarpment of the Styx River, stretching out a hand to me. I hear his cry of welcome, and as I step ashore he whelms me with confetti made of torn fragments of his contra-Skertchly papers, and as we link arms he murmurs, "Come to the Mammoth and have tiffin with me, and meet your old friend *Homo Brandonbedensis*; he is a Pal of mine."
Contributions to the Queensland Flora.


(Read before the Royal Society of Queensland, 26th Sept., 1921.)

Since the publication of the "Queensland Flora" by the late F. M. Bailey, that author published various papers entitled "Contributions to the Queensland Flora," in the pages of the "Queensland Agricultural Journal" and as Botany Bulletins of the Department of Agriculture and Stock. Since his death in 1915, contributions to the flora of the State from the pens of J. F. Bailey and the present authors have appeared in the form of Botany Bulletins of the Queensland Department of Agriculture and Stock. Circumstances at present make it unlikely that any further Botany Bulletins will be issued for some time to come, and the present paper is the first of a series which we hope to publish in these Proceedings. It contains descriptions of new species, records of plants not previously found or recognised in the State, and critical notes on other species. Much of the material has come to hand through collections received for identification from correspondents in different parts of the State.

Order STERCULIACEÆ.

Sterculia quadrifida R. Br. The underside of leaves often pubescent with stellate hairs, or velvety tomentose with stellate and simple hairs intermixed.

In the description in the "Queensland Flora," i, 136, and in previous publications, the leaves are described as glabrous on both sides, but we recently received from the Rev. N. Michael some specimens collected at Mount Julian, Proserpine district, with the leaves decidedly velvety pubescent underneath, and on looking through the material in the Queensland Herbarium several specimens were noticed with the leaves bearing numerous and fairly crowded hairs approaching those of the Mount Julian specimens.
CONTRIBUTIONS TO THE QUEENSLAND FLORA.

ORDER RHAMNACEÆ.

CRYPTANDRA Sm.

C. armata sp. nov. (Text-fig. 1.)

Frutex, ramulis spinescentibus novellis puberulis; foliis glabris lanceolatis vel oblongo-linearibus vel fere teretibus marginibus revolutis 3-5 mm. longis; floribus breviter pedicellatis lateralibus, solitariis vel breviter racemosis; bracteis rotundatis marginibus ciliolatis; calycibus extus sericeopubescentibus, urceolatis 5-6 mm. longis, lobis triangularibus tubo tripto brevioribus; petalis cucullatis; antheris inclusis cordatis, filamentis liberis; ovario dense pubescente, stylo glabro.

A thorny shrub. Young branchlets finely pubescent. Thorns 3-5 lines (6-10 mm.) long. Leaves clustered at the base or scattered in the lower part of the horizontally spreading, pungent thorns, oblong-lanceolate, oblong-linear or almost terete, with closely revolute margins, curved in the dried specimens, 1½-2½ lines (3-5 mm.) long. Flowers on very short pubescent pedicels arising laterally from the thorns, single or very shortly racemose. Imbricate brown bracts broad and rounded, with minutely ciliate margins, less than 1 line (2 mm.)
in length. Calyx silky pubescent outside, broadly urceolate, 2½-3 lines (5-6 mm.) long, lobes triangular, about one-third of the total length of the calyx. Petals slightly protruding from the sinuses of the calyx, white, minute and hood-shaped, the enclosed anthers on very short free filaments, broad, cordate and dorsifixed. Ovary adnate by its broad base only, the free part densely pubescent, convex or broadly conical, obscurely flanged towards the base or the disk inconspicuous. Style glabrous and slender, about 1½ line (3 mm.) long; stigma truncate.

Hab.: Barakula, a few miles north of Chinchilla, J. E. Young.

The rigid and pungent thorns of this species are like those of *C. spinescens* Sieb., to which it is allied. From that species, however, it is distinguished by its larger, urceolate, non-stipitate calyx-tube and its conical ovary adnate by its broad base only. From the various forms of *C. amara* Sm. it can be distinguished by its very thorny branches and lateral flowers often solitary and its urceolate calyx-tube.

**Order SAPINDACEÆ.**

**Ratonia punctulata** F.v.M. Hitherto the flowers of this species were unknown. Following is a description of them:—Panicles in the upper axils, shorter than the leaves, narrow and raceme-like or with a few slender raceme-like branches, rhachis slender. Flowers pedicellate, about 2 lines (4 mm.) in diameter. Calyx divided to the base; lobes 5, glabrous, imbricate, one or two outer ones smaller than the others, orbicular, concave, with hyaline margins, about 1 line (2 mm.) in diameter. Petals only one or two in each flower examined, opposite to the smaller calyx-lobes, glabrous, cream-coloured, orbicular, about 1 line (2 mm.) in diameter. Stamens 8, about 1 line (2 mm.) long; anthers glabrous, cordate-ovate; filaments broad, ciliate, slightly longer than the anthers. Ovary glabrous or slightly pubescent, ovate or obscurely trigonous, tapering into a short style.

Hab.: Gregory River, near Mount Dryander, Proserpine district, Rev. N. Michael (flowering specimens).

**Order LEGUMINOSÆ.**

**Burtonia foliolosa** Benth. Fruiting specimens of this plant were previously unknown. The following description has been drawn up from material recently received:—Pod obliquely globular, compressed, 2½ lines (5 mm.) in diameter. Each pod generally contains 2 globose seeds, about ½ line (1 mm.) in diameter, borne on a funicle about 1 line (2 mm.) long.
Hab.: Between Blackall and Jericho, Central Queensland. D. W. Gaulrodger.

Desmodium triflorum DC. Prodr. ii, 334. Not previously recorded for the State.

Hab.: Kelsey Creek, near Proserpine, Rev. N. Michael; Enoggera Creek and Toowong, Brisbane district, F. M. Bailey.

Distribution: Cosmopolitan in the tropics.

Order MYRTACEAE.

KUNZEA Reichb.

K. flavescens sp. nov.

Frutex, ramulis novellis pubescentibus; foliis alternis oblanceolatis vel obovatis, mucronulatis vel acutis, supra glabris, subtus aliquando puberulis; inflorescentiis terminalibus capitatis vel subspicatis; bracteis bracteolisque orbicularibus concavis extus pubescentibus; floribus subsessilibus; calyce campanulato, extus dense pubescente, lobis lanceolatis: petalis albis orbicularibus glabris; ovario triloculato.

A shrub, the young shoots, branchlets, and calyces pubescent. Branchlets terete. Leaves rather crowded, alternate, very shortly petiolate, oblanceolate or obovate, mucronulate or acute, glabrous above, sometimes very minutely pubescent on the under side, venation obscure or occasionally the midrib and sometimes a longitudinal nerve on each side of it visible; 2-4 lines (4-8 mm.) long, 2-3 times as long as broad. Inflorescence terminal, capitate or shortly spicate about ½ in. (1-3 cm.) in diameter. Bracts and bracteoles similar, orbicular, concave, pubescent outside, over 1 line (2 mm.) in diameter. Flowers subsessile. Calyx campanulate, densely pubescent outside; tube nearly 2 lines (4 mm.) long; lobes 5, lanceolate, about half as long as the tube. Petals 5, white, orbicular, glabrous, nearly 1 line (2 mm.) in diameter. Stamens indefinite; filaments slender, nearly 2 lines (4 mm.) long; anthers minute. Ovary filling the lower part of the calyx-tube, 3-celled, with a single ovule in each cell; style 2 lines (4 mm.) long; stigma flat, orbicular.

Hab.: Crow's Nest, Darling Downs. Dr. F. Hamilton Kenny.

K. Cambagei Maid. & Betche, a New, South Wales species, is closely allied to this species, but is distinguished by its lateral and smaller inflorescence, smaller leaves (4-5 mm. long), narrow bracteoles, and 2-celled ovary.
Order RUBIACEÆ.

DENTELLA, Forst.

D. minutissima sp. nov.

Herba minutissima subcarnosa, foliis petiolatis minutis oppositi: ovatis vel orbicularibus 0.5-1 mm. longis, marginibus pilis albis hyalinis obsitis; floribus solitariis sessilibus: calycis tubo globoso setis hyalinis minutis obsitis, limbo 5-lobato; corollae tubo cylindrico 5-lobatis, lobis ovatis obtusis; staminibus subincluis; capsulis globosis vel ovalibus setis hyalinis obsitis; seminibus angulatis minute punctulatis.

A small fleshy herb creeping in mud and rooting at the nodes, forming a dense, green, carpet-like covering on the soil, all its parts thinly sprinkled with minute hyaline setae. Leaves minute, opposite, fleshy, ovate or orbicular, obtuse, 0.5-1 mm. long, on petioles of 0.5-1 mm. long. Flowers sessile, solitary in the axils, 3-4 lines (6-8 mm.) long. Calyx about one-third the length of the flower, sparingly puberulent with minute gland-like hairs; tube globular, covered with minute setae about one-third line (0.6 mm.) in diameter; limb cupular, about 0.3 line (1.3 mm.) long, divided to its middle into 5 ovate lobes. Corolla-tube cylindrical, about 2 lines (4 mm. long) lobes 5, ovate, obtuse, about 1 line (2 mm.) long. Anthers linear, placed near the orifice of the corolla-tube, on apparently short filaments. Style slender, 1 1/2 line (3 mm.) long, with 2 slender stigmatic branches. Capsules mostly sessile on the stem or in its forks and subtended by adventitious roots, globose, oval or compressed and 2-lobed, often oblique, covered with minute hyaline setae, under 1 line (2 mm.) in diameter, 2-celled. Seeds several in each cell, angular, minutely pitted, about 0.5 line (0.5 mm.) broad.

Hab.: Elderslie, near Winton, F. L. Berney.

The chief distinctions between the species here proposed and D. repens Forst. are—

Leaves mostly above 1 line in length.
Anthers placed near middle of corolla-tube... D. repens.
Leaves all under 1 line in length.
Anthers placed near orifice of corolla-tube... D. minutissima.

Order SAPOTACEÆ.

Hormogyne cotinifolia A. DC. Fruiting specimens of this plant were previously unknown. Following is a description of them:—Fruit green (perhaps immature), subtended by the
persistent calyx-lobes, oval, scarcely succulent, attaining \( \frac{1}{2} \) in. (1.3 cm.) in length, surmounted by the persistent slender style which measures about 3 lines (6 mm.) long; seeds 1-3, obliquely oval, smooth and shining; hilum nearly as long as the seed.

Hab.: Nanango, extreme south of Burnett district, C. H. Grove (fruiting specimens).

*Symplocos Hayesii* sp. nov.  A, single flower, \( \times 6 \). B, calyx laid open, \( \times 6 \). C, part of corolla laid open showing stamens, \( \times 7 \). D, pistil, \( \times 7 \).
Order STYRACACEÆ.

SYMPLOCOS Linn.

S. Hayesii sp. nov. (Text-fig. 2.)

Frutex, ramulis dense hirsutis; foliis breviter petiolatis, lamina glabra, serrata ovata, ad apicem acuminata ad basem rotundata vel subcordata; petiolo dense hirsuto; inflorescentiis lateralibus, breviter spicatis vel fere capitatis bracteatis; rhaeide hirsuta; floribus sessilibus vel subsessilibus glabratis campanulatis, calyces lobis lanceolato-ovatis marginibus ciliolatis; corolla alta in lobes ovatos divisa; staminibus ca. 15; fructibus elliptico-oblongis vel fere cylindricis.

A slender shrub, the young shoots, branchlets, petioles, and bracts clothed with long hairs. Leaves on petioles about 1½ line (3 mm.) long, ovate, prominently acuminate, rounded and slightly cordate at the base, margins acutely serrate, midrib, lateral nerves, and the larger reticulate veins visible, especially on the under side where they are slightly raised, 2½-4½ in. (5.7-11.5 cm.) long, twice to 2½ times as long as broad. Inflorescence shortly spicate or almost capitate, mostly lateral, under ½ in. (1.3 cm.) long, mostly subtended by a leafy, lanceolate, serrate bract, the bract sometimes attaining ½ in. (1.3 cm.) in length. Bracts subtending each flower ovate-lanceolate, acuminate, clothed with a few long hairs, especially on the outside, nearly 1½ line (3 mm.) long; bracteoles narrowly triangular, hirsute, under 1 line (2 mm.) long. Flowers sessile or nearly so, glabrous, campanulate, about 1½ line (3 mm.) long. Calyx about 1¼ line (2.5 mm.) long, divided to about the middle into 5 lanceolate-ovate lobes, their margins minutely ciliate. Corolla slightly exceeding the calyx, divided to about two-thirds of its length into 5 ovate lobes. Stamens about 15, inserted near the base of the corolla-tube, shorter than the corolla. Summit of the ovary protruding from the calyx-tube. Style about ½ line (1 mm.) long; stigma prominent, depressed globular. Fruit indehiscent, scarcely succulent, elliptic-oblong or nearly cylindrical, about ½ in. (13 mm.) long, crowned by the 5 calyx-lobes surrounding the remains of the style, 2-celled, containing in each cell a single narrow seed nearly ½ in. (1.3 cm.) long.

Hab.: Glenallan, Atherton Tableland, H. C. Hayes.

The above species is closely allied to Symplocos paucistaminea F. v. M. & Bail., from which it can be distinguished by its bracteate, short spikes
or heads of flowers, its thinner indumentum and glabrous under side of its leaves, and especially by its long, almost cylindrical fruits. In the shortness of the inflorescence and the shape of the fruit it approaches *S. Bauerlenii* R. T. Baker, from which, however, it is easily distinguished by its densely hirsute character and large bracts of the inflorescence.

**Order SCROPHULARINEÆ.**

**BONNAYA** Link and Otto.

*B. veronicæfolia* Spreng., var. *angustifolia* var. nov.

Herba debilis, caule simplici, foliis anguste linearibus (1-3-3-9 cm. longis, 2-4 mm. latis), inflorescentiis terminalibus racemosis vel raro floribus solitariis axillarius.

An erect, scarcely branched herb attaining 7 in. (18 cm.) in height. Leaves linear, remotely toothed, $\frac{1}{2}$-$1\frac{1}{2}$ in. (1-3-3-9 cm.) long, 1-2 lines (2-4 mm.) broad. Inflorescence lengthening into a terminal raceme or rarely the flowers solitary in the axils. Pedicels slender, attaining $\frac{1}{2}$ in. (1-3 cm.) in length. Flowers very slender, about 3 lines (6 mm.) long; calyx about half the length of the flowers. Capsule terete, linear, attaining $\frac{1}{2}$ in. (1-3 cm.).

Hab.: Kelsey Creek, near Proserpine, *Rev. N. Michael*.

This variety differs from the type in its erect, scarcely branched habit and much narrower leaves. In appearance it bears a very close resemblance to the Asiatic *Vandellia angustifolia* Benth.

**Order LABIATÆ.**

**WESTRINGIA** Sm.

*A Revised Account of the Queensland Species.*

The genus *Westringia* is confined to Australia and consists of about twelve known species. The collection of a new species at Yelarbon in Southern Queensland by one of us (C.T.W.) led to a careful examination of the material in the Queensland Government Herbarium, and it was found that the account of the Queensland species published by the late F. M. Bailey in the "Queensland Flora," part iv, pp. 1205-1206, was badly in need of revision. One more new species and a new record were found amongst the herbarium material, and it was also found that no authentic Queensland material existed of *Westringia rosmariniformis* Sm. and *W. rigida* R. Br. The following amended account of the Queensland species of the genus is therefore offered herewith:
Key to the Species.

Calyx glabrous.
   Calyx-lobes about as long as the tube . . . W. glabra.
   Calyx-lobes much shorter than the tube . . . W. Cheelii.

Calyx pubescent.
   Leaves with thickened margins, but scarcely revolute, under side glabrous.
   Leaves under $2\frac{1}{2}$ lines long, obovate . . . W. parvifolia.
   Leaves 3-8 lines long, linear-elliptical . . . W. tenuicaulis.
   Leaves with recurved margins, lanceolate, under side white tomentose . . . W. rosmariniformis var. grandifolia.
   Leaves with revolute or recurved margins, linear, 4-18 lines long, under side usually clothed with scattered strigose hairs . . . W. eremicola.


Hab.: Shoalwater Bay, R. Brown.

The identity of the New South Wales and Victorian specimens with those from the type locality in Tropical Queensland is a subject which seems worthy of careful investigation. The specimen from Dawson River referred to by Bailey in the "Queensland Flora" belongs to W. Cheelii.


Hab.: Dawson River, Dr. T. L. Bancroft; Roma, Rev. B. Scortechini; Barakula, J. E. Young.

W. parvifolia sp. nov. (Text-fig. 3.)

Frutex parvus, ramulis ternis hexagonis novellis minute pubescentibus; foliis minutis ternis (2-4 mm. longis) subsessilibus obovatis vel ellipticis; floribus breviter pedicellatis (pedicellis ca. 1 mm. longis) axillaribus sed apice ramosum in capitulis fere terminalibus confertis, capitulis 3-7 floris; calyceis pubescentibus, campanulatis, tubo costato, limbo 3-lobo, lobis deltoideis; corolla superne utrinque dense pubescentibus, staminibus extortis; pistillo glabro.

A spreading shrub of 2-3 ft. in height, the young shoots and inflorescence pubescent with minute, white, appressed hairs. Branchlets often hexagonal; three alternate surfaces of each internode transversely striate or wrinkled; in adjoining internodes the order is reversed and the surface, which is plane in the internode above and below, is marked by the transverse wrinkles. The insertions of the leaves and branchlets are generally subtended by a wrinkled surface. Leaves in whorls
of three, very small, obovate or elliptical, subsessile, margins slightly recurved, from under 1 line to 2 lines long. Flowers on pedicels of \( \frac{1}{2} \) line (1 mm.) or less, in the upper axils, forming terminal leafy heads of 3-7 flowers. Bracts minute, linear, inserted at the base of the calyx-tube. Calyx pubescent, campanulate, with 10 longitudinal ribs, about 2 lines (4 mm.) long, the five broad, deltoid lobes less than half the length of the tube. Corolla hoary pubescent on both surfaces in the upper

part, the tube slightly exceeding the calyx and the lobes about as long as the tube. Stamens exerted. Ovary glabrous, 4-lobed; style slender and glabrous, \( 2\frac{1}{2} \) lines (5 mm.) long.
In floral structure this species resembles Westringia Cheelii, which is readily distinguished from W. parvifolia by its larger leaves measuring about 3 lines long. The peculiar hexagonal stems with the transverse markings as described above are also very noticeable in our herbarium specimens of W. Cheelii from Narrabri (N.S.W.) and Barakula (Q.). W. parvifolia was generally seen growing in clumps of Spinifex (Triodia sp.) in the desert country near Yelarbon.

W. tenuicaulis sp. nov. (Text-fig. 3.)

Frutex erectus ca. 46 cm. altus, ramulis junioribus pubescentibus, folis ternis vel rarius quaternis, linearo-ellipticis, basi sensim petiolatis; floribus subsessilibus axillaribus sed apice ramorum in racemis confertis; calycis pubescentibus campanulatis, lobis triangularibus acutis; corolla superne pilosa; pistillo glabro.

A plant of about 18 in. in height with a number of slender stems proceeding from the same rootstock, the young shoots and inflorescence pubescent with appressed hairs. Leaves in whorls of 3 or occasionally 4, linear-elliptical, narrowed at both extremities, the base gradually tapering into a very short petiole, margins slightly thickened but not revolute, with a raised midrib on the under side, 3-7 lines (6-14 mm.) long. Flowers subsessile, solitary in the upper axils or forming short, terminal, leafy spikes. Bracts at the base of the calyx-tube linear and minute. Calyx pubescent, campanulate, nearly 3 lines (6 mm.) long; lobes triangular, acute, more than half the length of the tube. Corolla pubescent in the upper part, the tube about as long as the calyx. Ovary glabrous, 4-lobed. Style slender, glabrous.

Hab.: Burrum River, James Keys; Lake Cootharaba, both in the Wide Bay district, James Keys.

W. tenuicaulis is allied to W. eremicola A. Cunn. and W. Cheelii Maid. & Betche, but it differs in habit from these species and is distinguished from the former by its non-revolute, glabrous leaves and from the latter by its larger leaves and longer calyx-lobes. Its habit suggests that it abounds in the so-called "wallum" country of the coast.


Hab.: Granite Mountains, near Moreton Bay, Queensland.

Through the kindness of Professor A. J. Ewart, late Government Botanist of Victoria, we were enabled to see a specimen of W. grandifolia
F.v.M. The label bears the following particulars:—Westringia grandifolia F.v.M. (W. rosmariniformis Sm., var. grandifolia F.v.M.), Granite Mountains, near Moreton Bay, F. Mueller, 1857. In the "Flora Australiensis" and the "Queensland Flora," Glass House Mountains, which are not granitic, are given as the habitat. Although we know that locality well and have done a good deal of collecting over it, we have never been able to find this variety. It is much more likely that the Granite Mountains of Mueller refer to the Stanthorpe district, especially as the Glass House Mountains are none of them granitic. W. grandifolia does not seem sufficiently well differentiated from the common W. rosmariniformis to stand as a good species, and we have adopted Mueller's second herbarium name; Mueller himself dropped the species in his "Second Census of Australian Plants."

**W. eremicola** A. Cunn.

Hab.: Stanthorpe, L. A. Bernays; Toowoomba, H. A. Longman; Helidon (with leaves attaining 1½ in. in length and occasionally quite flat), F. M. Bailey; Ipswich, C. T. White; Wellington Point, J. Wedd; Brisbane River, F. M. Bailey.

**Excluded Species.**

**W. rosmariniformis** Sm.

F. M. Bailey ("Queensland Flora," iv, 1206) records the habitat of this species as "Southern localities." There are no Queensland specimens of the typical form in the Queensland Government herbarium, and we think it better that it should be removed from the list of Queensland species until authentic material has been gathered.

**W. rigida** R. Br.

The specimens referred to by Bailey ("Queensland Flora," iv, 1206) in our opinion belong to *W. Cheilii*. It is recorded by Mueller for Queensland without definite habitat in the "Second Census of Australian Plants." but we think that it should be removed from the list of Queensland species until authentic material has been collected and placed in some recognised herbarium.

**Order LAURINEÆ.**

**Cryptocarya australis** Benth.

This species has a wide range in coastal Queensland, extending from the Tweed River in the South to the Cairns district in the North. In the Northern specimens as a whole the leaf is much larger and more attenuately acuminate. Some specimens from the Johnstone River collected by Dr. T. L. Bancroft have leaves up to 5½ in. long and look so different from the typical form that we had drawn up a provisional description from them as a new species; the floral structure, however, is wholly that of *C. australis*. 
PROCEEDINGS OF THE ROYAL SOCIETY OF QUEENSLAND.

ENDIANDRA R. Br.

E. crassiflora sp. nov.

Arbor ramulis novellis dense ferrugineo-pubescentibus; foliis petiolatis, ellipticis, supra glabris minute reticulatis, subtus glaucescentibus, nervis saepe pubescentibus; paniculis axillaribus quam folia brevioribus; floribus pedicellatis, glabris; perianthii tubo turbinato, segmentis ovatis vel suborbicularibus crassiusculis; staminibus perfectis 3, glandulis minutis, sessilibus; ovario ovoideo.

A tree. Young shoots, young branchlets, and rhachis of inflorescence ferruginous pubescent. Leaves petiolate, petiole 3-5 lines (6-10 mm.) long; lamina elliptical, apex rounded or obtuse or rarely obtusely acuminate, upper surface finely reticulate, under surface mostly glaucous with the midrib and principal lateral nerves prominent, raised, brown and often pubescent, 2-3 in. (5-7-6 cm.) long, twice to 2½ times as long as broad. Panicles very slender or almost raceme-like, in the axils of and much shorter than the leaves. Flowers shortly pedicellate, glabrous. Perianth turbinate, the tube obconical and as long as or longer than the lobes; lobes ovate or nearly orbicular, obtuse, thick in texture, the three outer ones broader than the three inner ones, over 1 line (2 mm.) long. Stamens 3, filling the throat of the perianth, subsessile, suborbicular or broader than long, about ⅓ in. in diameter. On the outside of and at the base of each of the stamens are 2 minute broadly sessile glands sometimes scarcely visible. Ovary enclosed in the perianth-tube, ovoid, tapering into a short style. Fruit not available.


This species appears to be allied to the Northern Endiandra hypote phra F.v.M., from which it is distinguished by its obtuse, rarely acuminate leaves and the absence of a prominent ring surrounding the stamens.

Order URTICACEÆ.


Hab.: Common in the "scrubs" (rain-forests) of the coastal area of Southern Queensland, at such places as Macpherson Range (National
Park), Tweed River, Tambourine Mountain, Mistake Range, Blackall Range, Gympie district, and Bunya Mountains. It extends into New South Wales.

From Moore's brief description and from dried specimens we had for some time been under the impression that his *F. Bellingeri* was identical with the earlier named *F. Watkinsiana* Bail., and recent opportunities of seeing living specimens of the New South Wales trees have confirmed this impression.

**Order GRAMINEAE.**


Hab.: Kelsey Creek, Proserpine district. Rev. N. Michael.

Distribution: Tropical Asia.


Distribution: India, China, Japan, Malay, New Guinea.
On the Larval and Pupal Stages of Myzorhynchus bancrofti Giles, 1902.

By L. E. Cooling, A.R.San.I.

(Read before the Royal Society of Queensland, 26th Sept., 1921.)

This Anopheline was described by Giles in 1902, but hitherto the eggs, larvæ, and males have never been recognised.

On Thursday, 12th May, 1921, during an inspection of certain public health matters at some Chinese gardens in the vicinity of Mott street, Rifle Range, near Brisbane, it was deemed advisable to examine (for the presence of mosquito larvæ) the water of a creek hard by which was used by the Chinamen for irrigating purposes during protracted spells of droughty weather. The creek is in reality a tributary of Kedron Brook, and, after flowing a rather tortuous though short course, joins the Brook some 500 metres downstream.

The creek was more or less stagnant, forasmuch as an earthen dam had been thrown across the bed on the lower side, as Chinamen are wont to do. The water, though kept stagnant, was well aerated by an abundance of green Algae and other aquatic vegetation. Manifestation of the oxygenation was to be had in the extraordinary numbers of small fish with which the water abounded, mostly of the species known as "Crimson-spotted Sun-Fish" and "Firetail" (Rhombatractus fitzroyensis Castelnau, and Austrogobio galii Ogilby, respectively). The excessive growth of vegetation had to a great extent rendered inert the activities of these mosquito-larvivorous fish,

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1 Since having written this paper I find that I have fallen into the grave error of overlooking a remark by F. H. Taylor in his “Report for the Half-year ending December, 1914,” made to the Institute of Tropical Medicine and published in the half-yearly reports from 1st July to 31st December, 1914, and from 1st January to 30th June, 1915, of that Institute. In a batch of mosquitoes collected by an expedition to Port Douglas, Taylor found “the male of Myzorhynchus barbirostris var. bancrofti . . .” Cf. p. 10 l.c.

2 Giles: A Handbook of Gnats or Mosquitoes (2nd ed.), p. 511, 1902.
larvae of *Nyssorhynchus annulipes* Walker were found in moderate numbers floating at the surface film and intercepted from the main body of water by a more or less unbroken layer of green Algae.

After having scooped up many larvae of other species, a specimen was noticed which bore, on examination with a hand-lens, certain characteristics which were at the time regarded as being peculiar to some hitherto unrecognised mosquito larva. It was carefully isolated from the others and its metamorphoses subsequently watched over with interest, for one would have naturally suspected the species under consideration; nor was this anticipation ill-grounded, insomuch that at the final ecdysis the desired imago appeared. Two hours were spent that day, during which time further supplies of the elusive species were sought for, but the collector frankly admits that he played the rôle of the unsuccessful sportsman and returned home with a spoil of three larvae (last larval instar) and one pupa which ultimately gave rise to two females and one male of *Myzorhynchus bancrofti*. Since that time, no less than eight hours (extending into three days) have been devoted to the same spot, but the results were wholly disappointing, not one further specimen having been caught.

**Metamorphoses.**

On reaching home the same day (12th May) the specimens were transferred to a mosquito breeding cage.\(^3\) Two days later the pupal ecdysis took place, resulting in a female specimen. On the third day one of the three larvae had pupated and two days later the pupa gave rise to a female. One of the two remaining larvae was killed for future use; the other eventually pupated, the pupal instar covering two days, and merged as a male specimen. The first of the two females which emerged died during the second day of aerial life without having sucked blood. The remaining female lived with a male four days, when the male died and was most unfortunately destroyed by ants before any microscopic observations could be made.

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\(^3\) The breeding cage takes the form of a parallelopiped of mosquito netting stretched over a wooden frame, about 8 by 8 by 14 inches. Small vessels of water containing larvae are introduced into this mosquito cage by means of a sleeve in the side.
Habits of the Adult Female.—The surviving female, four days after the adult stage had been reached, commenced to bite when the bare arm was placed in the cage. After a short and decided selection of the site of puncture (back of the hand) about two minutes were occupied by haustellation; the female sucked so vigorously that hemolyzed blood (about 0·01 minim) was voided at the anus. This was examined as a blood-smear made on a slide under an oil-immersion lens; it revealed the presence of numerous leucocytes and plasmolyzed erythrocytes. The bite produced a small white induration of the skin surrounded by a diffused erythematous patch, and a painful itching for some minutes followed. A period of four days elapsed before a second haustellation took place, and after a further interval of six days a third meal of blood was taken. Despite the fact that banana and jam were freely offered to the female, as well as a judicious supply of blood, the mosquito died on the sixth day after the third meal, having completed an aerial longevity of 21 days without ovipositing.

Macrosopic Appearance of Male.—Perhaps the most outstanding feature of the male is its relatively smaller size. With reference to the resting posture, it might be said that the body axis, when the insect is on a wall, forms an angle with the wall of 80 degrees; when on a horizontal plane the angle measures about 65 degrees.

Larva.

Macrosopic Appearance and Behaviour.—A large, very dark larva, with very large and pronounced palmate hairs, the latter just discernible to unaided vision under the best illumination (incident obliquely). The chaetotaxy is also rather distinctive. In the living condition, the larva skirts along the surface film of the water by bold lateral strokes of its whole body.

Characters as seen by an Aplanatic Hand-lens (× 20).—When the larva is held in a column of water by means of a pneumatic dropper and examined either by direct transmitted or reflected light, an excellent view of the palmate hairs is to be had. The chaetotaxy may be studied en masse, but the individual structure of "hairs" can only be appreciated after having made microscopic observations of them.

Microscopic Structure.—The following descriptions are based on morphological observations made on two larval
exuviae and an entire specimen, all dehydrated through the graduated alcohols and prepared as permanent microscopic mounts in Canada balsam. It might be added that very little variation was noticed in these three specimens and the characteristics to be noted present a striking constancy.

Length of larva exclusive of caudal chaetae, 7 mm.

Head and anal segment dark and heavily pigmented.

Head.—Head markedly narrower than thorax, mahogany coloured. Eyes roughly triangular in shape, existing merely as aggregations of undifferentiated pigment cells. Antennae slightly curved, covered with many sharply pointed but simple spines the size of which latter decreases from base to apex. Proximal portion of antennae slightly incrassated. A branched seta arises from a submedian point on the antenna, the branches being about 12 in number, of equal length and giving the appearance of a radial grouping. Each antenna is tipped with two stout spine-like processes, weakly chitinised, also with an extremely delicate branched seta of about five branches. Mouth-brushes consisting of moderately chitinised simple "hairs." Labrum clothed with minute slightly recurved and distally serrated setae. Mandibles consisting of small but heavily chitinised "teeth." Labial plate roughly triangular, the base obtusely and symmetrically crenated; there are about three lateral, more or less irregular blunt teeth and a median (apical) one of average size. An asymmetrically shaped hole occurs on either side of the median line of the labial plate. The frontal "hairs" of the head exist as six well-defined branched setae.

Thorax showing the usual divisions, rendered manifest by the pro-, meso-, and meta-thoracic branched setae, the metathoracic tufts being the most defined and outstanding. In addition to this usual chaetotaxic grouping, there is a group of three long simple hairs which arises from a moderately chitinised tubercle on the antero-lateral margins of the thorax; at the base of each of these hair-tufts are two unequal spines, one markedly chitinised, the other (longer one) weakly so. On the inner side of these hair-tufts are two minute, branched setae, one on each side of the median line. There is a small but pronounced feathered hair on each side of the mesothorax and a smaller and less pronounced one on the antero-lateral aspect of the prothorax. Several very minute palmate hairs are to be found on the thorax.
Abdomen.—The abdominal segments 1 to 3 have branched lateral setae rather much like those of the thorax; segments 4 to 6 with long bifid setae. All the abdominal setae arise from distinct chitinous tubercles, and in addition to the ordinary lateral setae there are much smaller branched ones arising near their bases. The typical palmate hair takes the form of rather large and mottled sharply tapering "leaves," the edges of which can be observed to be minutely serrated only by close focussing of the fine adjustment when the iris diaphragm is reduced to a minute aperture; from 15 to 19 such "leaves" go to make up one of the large palmate "hairs." There are large palmate "hairs" on segments 3 to 7, minute ones (less notched) on segment 2, and still more minute ones on the thorax (2 pairs). The thoracic and abdominal palmate hairs show a gradual transition both in size and complexity, which is a good object lesson in the development of the typical "palm" from a simple "hair-tuft."

The spines of the comb on the eighth abdominal segment take the form of simple undifferentiated (except for size) spikes, large roughly alternating with smaller ones. The number is about 14 on either side.

The anal segment is of a mahogany colour, and its surface is invested with numerous minute sharp, simple spines, of about the same shape and size as those existing on the shafts of the antennae. Ventral beard arranged in about 10 paired groups of typically branched hairs. Dorsal beard well represented. Swimming fans equal, moderately elongated and obtusely pointed.

Pupa.

Macroscopic Appearance and Behaviour.—The pupa of M. bancrofti presents nothing extraordinary except for its apparent uniform dark colour and large size. Its movements are rather sluggish.

Lens Characters.—A most striking feature of the pupa is the linear extensions of mottled or variegated colour-markings of the cephalothorax. What were, on the field, taken to be variegated scale-markings of a well-developed contained imago apparently showing through the diaphanous puparium, were, afterwards, by examining the exuvial puparium, undoubtedly due to chitinous incrassations of the pupal skin. When we reflect that it is more difficult to identify Culicid pupæ than
Myzorhynchus bancrofti.

Description of text-figures.—1, ventral beard of larva; 2, tail fin of pupa; 3, branched "hair," 7th abdominal segment of pupa; 4, antenna of larva; 5, mandibles and labial plate of larva (head viewed from a ventral position); 6, shape and disposition of spines of the lateral comb; 7, palmate hair; 8, chitinous "spur" on segments 2-6 of pupa; 9, distal portion of a branched "hair" (from one of the six frontal hairs of the head).
larvae—in the writer’s opinion, such as it is, an anomalous feature of descriptive biology, and if a crude analogy can be drawn, the converse of von Baer’s great law of embryonic generalisation—then the pupa of *M. bancrofti* presents a notable distinction amongst the Culicidæ. The caudal fins are rather striking by reason of their relative diminutiveness. The fans are also closely approximated and do not show any tendency to lateral spreading.

*Microscopic Structure.*—The mottled stripes of the cephalothorax roughly correspond to the lines marked out by the wing venation and the forked cell markings are clearly seen. The breathing trumpets are small, broad and triangular. There is a pair of large tree-like plumes of much-branched setæ at the base of the cephalothorax.

On each of the sides of the abdominal segments 2 to 6 is a short stout bluntly pointed and strongly chitinised spur. Each segment has a pair of branched setæ, each of which branches from a short stalk into 5 more or less equal and regularly disposed "hairs." There are also minute bifid and trifid "hairs" on each segment. The seventh segment bears a pair of small plumes of peculiarly branched hairs on the posterior angles.

The "leaves" of the caudal fin are hyaline, each stiffened in the ordinary way by a midrib, which latter shows a double contour, is very faintly striated transversely, and weakly chitinised, but ending in a short, highly chitinised spur or "bristle."

**Note on the Taxonomic Position of Myzorrhynchus bancrofti.**

Taylor (1911), after having examined specimens of *M. bancrofti* in conjunction with those of *M. barbirostris* v. d. W. from Philippine Islands, came to the conclusion that the former should be classed as a variety of the latter; he evidently assumed that the older-described species should necessarily be the one of longer standing (in nature), but, even if there be grounds for the justification of this sort of reasoning, the present writer is of opinion that one should be careful in drawing conclusions on hasty premises, the more so when it is said that

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⁴Taylor, F. H.: Report of the Australian Institute of Tropical Medicine, 1911.
Taylor was working with a species of which, except for the female, little else was known. He is further of opinion that, now we are in a position to compare larval forms of both mosquitoes, and having already made a comparison with the brief intelligence he could glean from Theobold's Monograph of the Culicidae of the World (iii, p. 86), relating to larval barbirostris, there is every reason for rejecting Taylor's synonymy on the differences observed in frontal hairs (p. 18 *l.c.* fig. 4f) and palmate hairs alone. Theobold's descriptions are unfortunately too brief, nor has the writer been able to obtain any other literature on the subject of larval forms of *M. barbirostris*. Nevertheless, it is only reasonable to conclude on the transmutation hypothesis that, when obvious differences are manifested in two larvae, the imagines resulting from these forms will be more or less different.
The Freshwater Fish Epidemics in Queensland Rivers.

By Professor T. Harvey Johnston, M.A., D.Sc., F.L.S., and M. J. Bancroft, B.Sc., formerly Walter and Eliza Hall Fellow in Economic Biology, University, Brisbane.

(Read before the Royal Society of Queensland, 28th Nov., 1921.)

At irregular intervals very widespread and deadly epidemics have appeared amongst freshwater fish in Queensland rivers, more especially those in the western portions of the State. We have endeavoured to ascertain the cause of the mortality but have not as yet succeeded. The outbreaks occur usually in localities that are not readily accessible and moreover generally last for a short time. These facts, together with tardy arrival of information as to the presence of the malady in any particular district, have prevented either of us from being present during an actual outbreak, though on one occasion a visit was paid to a locality just as an epidemic had subsided.

Since one of us has now left the State and the other has undertaken additional duties, it seems unlikely that either will be able, for some time at least, to give further attention to the matter now under consideration. We have therefore thought it advisable to bring together the information which we have collected, so that it may form a basis for some future worker.

We take this opportunity to express our indebtedness to the following for their kind assistance:—Mr. W. Hamilton, Chief Inspector of Fisheries, Brisbane; Mr. R. Caldwell (Charleville); Messrs. M. J. Bergin (Goondiwindi), W. H. Ryan (Charleville), J. McKinley (Goondiwindi), and J. Hogan (Inglewood) of the Police Department; Messrs H. A. Longman and J. D. Ogilby, Queensland Museum; Messrs. F. Mills, T. Woulfe, and members of the Longreach Shire Council; R. Varney (Brisbane); A. V. Stretton (Rankine River); J. F. Colbert (Lake Nash); W. H. Rudd (Austral Downs); the last-mentioned three localities being situated in the Northern
FRESHWATER FISH EPIDEMICS IN QUEENSLAND RIVERS. 175

Territory. We are also indebted to the Commonwealth Bureau of Meteorology for furnishing full particulars regarding temperatures and rainfall recorded at various Queensland stations.

A preliminary report was published in 1917 by the senior author, but the information and material then available were very scanty. In that report it was regarded as likely that, prolonged dry weather having converted the rivers into a chain of stagnant waterholes, an unhealthy environment for fish had been created, such leading to weakness which gave the fungus Saprolegnia an opportunity to exchange its saprophytic life for a parasitic mode of existence, the invasion of the gills leading to death. Decomposing fish would cause a still further reduction of the oxygen supply and thus aggravate the condition. It was believed that the arrival of good rains would remove the stagnation, improve the aeration of the water, and establish a suitable environment for healthy fish life (Johnston, 1917, p. 131).

OCCURRENCE OF EPIDEMICS ALREADY RECORDED.

1892.—An officer of the Fisheries Department, N.S.W., mentioned the occurrence in 1892 of an epidemic causing mortality among fish in a tributary of the Barcoo near Lammermoor Station, in the vicinity of Winton, Queensland (Johnston, 1917, p. 126). A Longreach resident (Mr. Coleman) informed us that a similar outbreak happened in the Thomson River in that year.

No other record of such an occurrence was made until 1917, when widespread mortality appeared among the fishes of the western rivers of Queensland, while milder outbreaks occurred in certain rivers in the south-eastern portion of this State.

1917.—In July, Mr. F. Mills, Clerk of Longreach Shire, reported that fish were dying in the Thomson River and that similar conditions prevailed right out to the Mackinley River, nearly all species being affected.

In August of the same year Mr. A. Sugden sent down a catfish (Neosilurus hyrtliti Steind.), taken from the Bulloo River near Quilpie, and reported that fish were dying in large numbers in that river, and that similar conditions had occurred in Cooper's Creek.

In August and September 1917, Dr. J. S. Elkington saw
fish (perch and catfish) floating down the Brisbane River. Mr. C. Booker reported that during the same months a widespread mortality had occurred among the fish in Wide Bay Creek and Mary River.

In the September number of the "Scientific Australian" (1917, p. 17) there appeared the following paragraph:

"Mr. C. A. Baker writes from Kapunda that the proposed trip from Adelaide to the Gulf (of Carpentaria), which was to start on 17th of this month, has now been postponed until the end of March next year for the following reasons:

"Mr. Kidman has been advised by some of his back-station managers that a most extraordinary and unique fish epidemic has occurred in the following rivers:—Diamantina, Bulloo, Cooper's Creek, and Wilson Creek. The fish have died in such quantities that the water in these rivers has become so polluted that it is not only unfit for human consumption but also for stock. The most extraordinary thing about the death of the fish in these rivers is that the epidemic has occurred in rivers, the headquarters of which are remote from each other and have different sheds and exits."

THOMSON RIVER, COOPER'S CREEK SYSTEM OF DRAINAGE.

Information regarding the earlier outbreak at Longreach (1917) is contained in the previous report (Johnston, 1917).

Early in April 1918 a letter, dated 30th March 1918, was received from Mr. F. Mills stating that fish were again dying in the Thomson River in the neighbourhood of that town. The following notes are taken from his letter:

The river was in high flood during the months of January and February of this year and large numbers of fish were to be seen after the floods, apparently in a healthy condition but seemed to have a most voracious appetite as plenty were caught with the least of trouble. The river was still running strong and there was no stagnant water in this locality\(^1\) as was the case during the previous epidemic. The fish principally affected were what are commonly known as yellow-belly, black bream, bony bream, and perch. They came to the surface of the water in an inert state, suddenly appeared to

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\(^1\) Italics ours.
take a fit and swam towards the shallow water or bank of the river, where they died. Their eyes bulged out and they appeared to be sightless. Inside the mouth was of a bluish colour. Their gills and scales appeared to be normal. The fish upon being opened up were found to be very fat. Neither the jewfish nor the freshwater tortoises, which were plentiful in the river, were affected. The epidemic, which commenced shortly after the heavy rains, was still present at the time of writing. i.e., for a period of from three to four weeks. On 22nd March this outbreak was reported in the "Brisbane Courier."

On 23rd April Mr. Mills again wrote reporting that the mortality was not so pronounced and that difficulty had been experienced in obtaining for us a fish in the moribund state. Eventually a specimen, identified by Mr. J. D. Ogilby as Therapon carbo Ogilby & McCulloch, was sent down.

In the middle of May a rise in the river was occasioned by rains up country, sweeping away all signs of the outbreak, which had apparently lasted for almost two months, being at its height at the end of March.

On 7th August Mr. Mills informed us that the mortality had reappeared at the end of July, fish dying in large numbers. The senior author was away from town at the time and the junior author was not able to arrive at Longreach until 17th August. On the following day, although prolonged search was made up and down the large lagoon adjacent to the town, only two moribund fish were obtained, one being a Therapon hillii Castln., the other a bony bream, Nematalosa elongata Macleay. Dead and rotting fish were exceedingly abundant, especially at the lower end of the lagoon, where they were piled up against the crossing. Although close search was made, no more dying fish were obtained. On several days hauls were made with a small-meshed net in the hope of obtaining diseased specimens. An astonishingly large number of fish were caught in each haul but none appeared diseased, so the majority were returned to the water, a few being kept for examination. Three species, Plectroplites ambiguus Richardson (golden perch or yellow-belly), Therapon hillii ("black bream" or grunter), and Nematalosa elongata (slender bony bream) were by far the most abundant. No catfish were caught in these hauls.

During the week previous to the 18th, men had been employed raking the fish out of the river and burning them.
Heaps of fish could be seen along the bank for about two miles. A large proportion of those seen in the unburnt heaps were small jewfish (resembling *Neosilurus*), but specimens of black bream, golden perch, and bony bream could also be recognised. The mortality apparently had affected old and young fish alike, as large and small specimens of perch and bream were found.

Flocks of water-birds had also assisted in clearing the river of dying fish. Cormorants (*Phalacrocorax sulcirostris* and *P. melanoleucus*), snake-birds (*Plotus novaehollandiae*), white egrets (*Herodias timoriensis*), blue cranes (*Notophoyx novaehollandiae*), nankeen herons—so-called bitterns (*Nycticorax caledonicus*)—and kites (*Milvus affinis*) were all present in large numbers. Black ibis (*Plegadis falcinellus*) and white ibis (*Ibis molucca*) were also numerous, but pelicans (*Pelecanus conspicillatus*), though present, were not common. In the upper reaches of the lagoon wild pigs had been seen feeding on the dead fish.

Mr. W. Woulfe wrote from Longreach (26th December 1918) stating that the epidemic had reappeared in the Thomson River, affecting chiefly fish of from four to six pounds in weight. He counted 111 dead fish that morning along a length of only fifty yards of the bank. Cormorants were present in countless thousands, while pelicans, herons, blue cranes, &c., were in great numbers.

In the "Courier" of 7th January, 1919, it was stated that during the preceding three weeks great mortality of fish had occurred in the Thomson River, deaths being more numerous than on the previous occasion, large fish especially being the victims.

As an outbreak was reported in the Brisbane daily press (27th August 1919) as having occurred in the Bulloo and Wilson Rivers, we wrote to Mr. Mills who informed us that the epidemic had broken out at Longreach during the winter and had lasted about six weeks, terminating in early August.

**McINTYRE AND SEVERN RIVERS.**

Through the kindness of Mr. W. Hamilton, Fisheries Department, Brisbane, we had access to reports from the police officers at Goondiwindi (Messrs. M. J. Bergin, J. McKinley) and Inglewood (Mr. J. Hogan) relating to an epidemic during the late winter of 1918 in these two rivers.
Mr. Hogan reported (10th August 1918) that large numbers of fish, principally jewfish and golden perch, had died recently in the McIntyre and Severn (Dumaresq) Rivers, the outbreak being locally regarded as due to one or other of the following:—

(1) intense cold and continual heavy frosts destroying fish, especially in shallow water; (2) the prevalence of a disease; (3) the low state of the river. Death of the fish was not due to the use of dynamite though this had been put forward as a possible explanation.

Mr. Bergin reported (7th August) that dead fish were coming down the river past Bengalla Station. On 28th August he kindly forwarded to us additional information. The McIntyre River had been rather dry and stagnant, as little rain had fallen from Christmas 1917 until August 1918, when rain caused a fresh in the river and the epidemic ceased. Murray cod, yellow-belly, and jewfish were especially affected, and diseased specimens were all found to be fat. During his ten years' residence in the district he had only once previously noted a similar epidemic, viz., during the great drought of 1915. He also stated that he remembered fish dying in the Condamine River some years ago, but believed that it was due in that particular case to the pollution of the water by an adjacent wool-scour.2

Mr. J. McKinley referred (2nd September 1918) to the mortality in the McIntyre in the Goondiwindi district affecting chiefly the Murray cod and golden perch, mainly small specimens. Such fish when opened were found to be very fat, though otherwise they looked normal. Since the recent heavy rains the disease had disappeared.

BURNETT RIVER.

In July 1918 fish died in the lagoon at the junction of the Nogoa and Burnett Rivers. When visited by Dr. T. L. Bancroft some weeks later only a few dead fish were to be seen and these were all in the shallow water.

2 H. B. Ward has drawn attention to the effect of industrial wastes on fish life in his paper on "The Elimination of Stream Pollution in New York State" (Trans. Amer. Fisheries Soc. 48, 1918, pp. 1-25). See also Shelford 1917, 1918a, 1918b, 1919a; Shelford and Powers 1919; Hofer 1906, pp. 83-86.
On 4th September 1918 a paragraph appeared in the Brisbane "Daily Mail" announcing that a mysterious disease was attacking fish in the Bulloo River from Adavale to the vicinity of Toompine, where they were dying in countless numbers, rendering the water unfit for human consumption. A local theory attributed the disease to the extraordinary season and to overbreeding.

The Commissioner of Police was approached on this matter, and communicated with one of his officials in the Bulloo district to find out whether the epidemic had ceased. Subsequently the text of Sub-inspector W. H. Ryan's reply and, later, a copy of his report (dated 12th September, 1918) on the matter were forwarded. This officer stated that some weeks previously the fish had been dying in great numbers in the Bulloo, but since then rain had fallen in places and as a result of the fresh in the river the mortality had ceased. All species of fish in the stagnant waterholes were affected but golden perch appeared most susceptible, being the first to die. It was considered locally that the mortality was caused by lack of oxygen in the stagnant water. It was noticed at Quilpi that fish were not killed in Hoodrum Lake, though this contained Bulloo River water and was only a short distance from the smaller stagnant river-waterholes where fish were dying in hundreds.

In the "Daily Mail" of 27th August 1919, mention was made that the epidemic had reappeared in the Bulloo and in the Wilson River, fish of three pounds and upwards dying in extraordinary numbers, smaller specimens apparently escaping the disease.

GEORGINA AND DIAMANTINA RIVERS.

In the Brisbane "Daily Mail" of 14th September 1918, the observations of Mr. E. R. Caldwell on the condition of fish in the Georgina River were given. Evidences of an epidemic were first seen by him in the Georgina near Lake Nash (Northern Territory), but on following the river southward dead fish could be seen piled up along the banks. Mr. Ogilby had suggested this might be due to the salmon disease which affected fish when the water was low. There were many large pools in the Georgina, however, and no sign of contaminating influence, the only places in which fish were not dying being the "kopai"
(mineralised) holes. All kinds of fish were affected and in each case the disease showed the same symptoms—"a blue spot on the side, upon the bursting of which the fish died." Mr. Ogilby subsequently supplied information to the Press that *Saprognia* would not live in water which contained any degree of salinity, as was the case with the "kopai" holes.

Mr. Caldwell informed us that the epidemic had appeared in November 1917 and June and July 1918, in the upper reaches of the Georgina, in the vicinity of Lake Nash. Tons of dead fish were to be seen and plenty of sick fish were being caught near the surface and along the edge of the lake by aboriginals. The species represented were yellow-bellies, catfish (jewfish), bony bream, and another kind. The stretch of water in which the mortality occurred was five or six miles long and in places between 20 and 30 feet in depth. Commonly associated with the disease was the presence on attacked fish of a bluish swelling about the size of a sixpence or shilling, at the side in the abdominal region, the aboriginals stating that when these "boils" burst the fish turn over and die. In "kopai" holes the water was clear and brackish owing to abundance of calcium sulphate ("kopai") and the fish were normal, whereas in the adjacent waterholes containing clayey or muddy water, even though somewhat brackish, the fish were dying. This happened between May and September 1918 while Mr. Caldwell was on the Georgina. There was no drought at the time and cattle were fat.

Mr. Caldwell also stated that in large waterholes in the Austral Downs district (Northern Territory) near Camooweal, though fish were plentiful, no dead ones were seen by him during his visit in May 1918.

In subsequent communications (October and November 1919) he informed us that attacked fish came to the surface and were very sluggish in their movements. An old aboriginal had informed him that fish had died periodically in the Georgina River as long as he could remember. Mr. Caldwell stated that one view as to the cause was that it was due to overstocking and consequent shortage of food; another, that it was due to cold weather, or to the prevalence of "umbrella grass" which blocked up the gills of the fish. Cormorants were especially abundant, and these, together with the large numbers of pelicans present, were in his opinion sufficient to prevent any overstocking.
Mr. J. F. Colbert, of Lake Nash Station, Northern Territory, in reply to a series of questions, gave the following information (September-November 1919). He had met with the epidemic on the Diamantina, Bourke, and Georgina Rivers, especially during June and July. In these rivers and particularly at Lake Nash and at Boulia (Bourke River), the dead fish were at times piled up on the banks by the wind, forming a mass some feet across, and this in spite of the presence of enormous numbers of water-birds which were engaged in devouring them. The chief kinds affected were yellow-belly, bream, and perch. The bluish "boil" mentioned by Mr. Caldwell was not observed. Diseased specimens were fat. He was unaware whether there was any relation between the occurrence of the epidemic and drought or cold. The water was not obviously mineralised, and bore-water was not present at Lake Nash. The disease, which appeared and disappeared suddenly, was found both in shallow and in deep holes containing water which was of a dark-green colour—"as green as a typical duck-pond"—whereas during the time that the epidemic was not present it was muddy or milky. In places, e.g. Old Cork Station (Diamantina), the stench from the decomposing fish was so bad that people had to leave the homestead and camp elsewhere. The epidemic did not make its appearance at Lake Nash during 1919. Mr. Colbert questioned large numbers of aboriginals, who believed that the death of the fish was brought about by one of two causes:—(a) the water turned green and killed them; (b) the fish fought and killed each other. The latter is obviously an insufficient explanation.

Mr. W. H. Rudd, Austral Downs, Northern Territory, stated (January 1920), in reply to our questions, that he had observed the condition in the Georgina and Diamantina Rivers during September, October, and November 1917, and in the former river during the latter half of 1918. It was not seen during 1919. Yellow-bellies and a kind of catfish were especially affected, becoming drowsy, swimming slowly near the banks in shallow water, and then floating and dying on the surface. Though the fish were fat and appeared to be somewhat swollen, no discoloration was noticed. The epidemic appeared each time rather suddenly about midwinter, finally disappearing when the rivers began to flow as a result of heavy rainfall. Though it occurred during the dry time of the year, there was no drought, but there were very cold periods with ice on the water occasionally. Good rains had fallen each
year prior to the outbreak. Fish died chiefly in the large waterholes. The water was described as good; though not clear it was not muddy, and as far as Mr. Rudd knew it contained very little mineral matter. No bore-water entered the holes where the epidemic occurred, and weeds were not obvious. He mentioned that some local people thought that overstocking was the cause, but stated that bird life was as plentiful as during the period when the epidemic was not prevalent. The aboriginals informed him that they had never known fish to die in such quantities before and believed that the cold weather was the cause. In places blacks were employed to drag the dead fish out of the waterholes with wire-netting, the water having become too polluted to be used for drinking. Sick fish were eaten by the blacks without apparent ill effect.

Mr. A. V. Stretton, who is in charge of the police station at Rankine River, wrote on 31st July 1920 regarding the outbreaks at Anthony’s Lagoon (Northern Territory) where he was previously stationed. From his replies to questions submitted to him, the following information has been taken. The fish affected were chiefly perch (*Plectropilates*), only a few catfish being among them. They could be readily caught by hand when near the water’s edge. All were very fat. A noticeable feature in regard to affected catfish was the presence of a red streak along the abdomen. Though the fish were slightly swollen, the bluish colour referred to by some of the previously reported observers was not noticed. He stated that they began to die at the lagoon on 10th August 1917, destruction proceeding for eleven days, the fish dying in “countless thousands.” On 20th March 1918 the epidemic reappeared in spite of the fact that the river was running, and continued until 12th April, a period of about 23 days. There was another outbreak on 16th July 1918, lasting nine days. There had not been any further occurrence up to the time that Mr. Stretton had left the locality.

The epidemic appeared and disappeared suddenly, and in his opinion had no relation to drought. Though no rain fell during the periods when the mortality was in evidence, yet there had been abundant rainfall in 1917 and 1918—viz., 32 and 30 inches respectively, whereas the annual average was only 18 inches. There was no relation to abnormally cold weather, as the temperatures during the winter were not noticeably lower than during other years. The water was not charged
PROCEEDINGS OF THE ROYAL SOCIETY OF QUEENSLAND.
with mineral. Artesian bore water did not enter the creeks. All permanent waterholes were affected irrespective of depth. The colour of the water during the epidemic was milky or muddy, which was the normal appearance in the district.

He concurred in the opinion generally held in the locality that the cause of the mortality was "overstocking," since fish were present in enormous numbers in the rivers and creeks. Birds such as ibises, spoonbills, pelicans, jabirus, herons, cormorants, were extremely abundant at the time.

Owing to the amount of pollution which had occurred, Mr. Stuart forwarded a sample of the water to the Health Department, Darwin, with a view to ascertaining whether it was fit for human consumption. The report of the analysis is referred to later.

WARREGO RIVER.

Mr. Caldwell, in a letter to the Brisbane "Daily Mail" of 7th December 1918, stated that, though the epidemic was in evidence in the more northerly situated rivers in this State, it had not appeared in the Warrego and its tributaries, e.g. Langlo and Ward Rivers, during 1918, whereas it had caused heavy mortality in these rivers during 1918. He mentioned the current belief that it was due to overstocking in stagnant pools, and stated that though fish might be dying in the main streams, yet in the billabongs or lagoons only a short distance away, and fed by the flood-waters of these streams, fish life was healthy and plentiful.

He informed us by letter dated November 1919 that he had been told that the epidemic had made its appearance in the Warrego River near Cunnamulla and that the decomposing fish were constituting a nuisance to the townspeople (October). Conditions were hot and very dry, stock dying from drought. At Dillalah, also on the Warrego but some distance to the north, a very large waterhole was at the time apparently free from the disease.

OTHER LOCALITIES.

Mr. R. Varney reported (April 1920) that he had observed the epidemic amongst yellow-bellies and black bream, particularly in the muddy water of lagoons in the Longreach and Winton districts, during very dry weather in 1918 and 1919. The condition was noticed in the Cork Lagoon near Winton late in 1919. [Thomson and Diamantina Rivers.]
He also gave an account of some other observations. The heavy thunderstorm which ended the long drought in 1902 caused an enormous quantity of vegetable débris, dead leaves and grass, to come down Enoggera Creek, Brisbane, this forming a blanket about six inches in thickness covering the surface. Fish, mainly mullet, died in hundreds but only a few eels seem to have been affected. Although the water was clear and the bottom was sandy and rocky, the fish, he believed, had been suffocated.

In midwinter 1909 very cold weather was experienced in the Mount Tambourine district, and large numbers of mullet were killed in the Albert River. He believed this to have been due to poisoning by the Moreton Bay chestnut, since large numbers of these trees which were growing along the banks were killed by the cold, their leaves and fruit falling into the water.

He also mentioned that at Cania, 80 miles west of Many Peaks, large numbers of fish—chiefly bony bream and mullet—came to the surface of the water in Three Moon Creek (a tributary of the Upper Burnett) and died, as did also the eels which fed on them. In this case the water was clear and running over a sandy and rocky bottom with plenty of weed present. He believed the occurrence to be due to some form of poisoning.

We are not in a position to comment on any of these three occurrences, which appear to be isolated.

It will thus be seen that during 1917 and 1918 fish epidemics occurred in many rivers widely remote from one another and belonging to different drainage systems. It is reported that an outbreak occurred in July 1917 at McKinley on a tributary of the Cloncurry, itself a tributary of the Flinders, flowing into the Gulf of Carpentaria. This is the northernmost locality known to us. The most seriously affected was that system of rivers which flow inland towards Lake Eyre—the Georgina, Eyre's Creek, the Diamantina, Cooper's Creek or Barcoo with its tributaries, the Thomson and Wilson Creeks. All exhibited the same phenomena at one time or another. Four outbreaks have been recorded from the Thomson. The mortality occurred during the winter of each year in the Bulloo, another inland river. An epidemic was reported in July 1918
in the Severn (Dumaresq) and McIntyre Rivers on the southern border of Queensland. These rivers form part of the Barwon or Darling River system. Three rivers flowing east from the Great Dividing Range were affected though not very seriously—viz., the Brisbane and Mary in the winter of 1917 and the Burnett in 1918.

We may note that the outstanding features of the epidemic were as follows:

(a) The species especially affected were the golden perch or yellow-belly (*Plectroplites ambiguus*), the freshwater black bream or grunters (*Therapon spp.*), Murray cod or perch (*Oligorus macquarrii*), and bony bream (*Nematalosa elongata*), and jewfish or catfish (various species of *Siluridae*).

(b) It usually occurred during the colder and drier portion of the year, July and August, though sometimes earlier and often persisting later.

(c) The water was nearly always stagnant and the epidemic ceased suddenly, after heavy rains had caused the rivers to flow.

(d) The affected fish were always fat; they became lethargic, swam slowly at the surface of the water, and died. A bluish colour was commonly seen in the mouth region.

**POSSIBLE CAUSES.**

1. The use of dynamite or other explosive.

2. Climatic—
   (a) Dry weather;
   (b) Low temperature.

3. State of the water—
   (a) Physically, *i.e.* presence of suspended matter or weeds which might clog fish-gills;
   (b) Chemically, *e.g.* excess of carbon dioxide, deficiency of oxygen, acidity or alkalinity, etc.

4. Poisoning due to the presence of some toxic substance in the water.

5. Overstocking and consequent starvation.
6. Disease caused by parasites which may be—
   (a) Helminths,
   (b) Protozoa—
       (i.) Myxosporidia,
       (ii.) Flagellata, Infusoria,
   (c) Fungi,
   (d) Bacteria.

7. Two or more of the foregoing acting at the same time.

(1) DYNAMITE THEORY.

It has been suggested that the use of dynamite as an illegal means for obtaining fish might be an explanation of the widespread mortality.

The reports from the Severn and McIntyre Rivers are opposed to such an opinion. We think that the presence of dead fish floating down the Brisbane River in 1918 was, at least in part if not entirely, due to this cause. Specimens from the locality submitted to us by Mr. H. A. Longman, Director of the Queensland Museum, were found to have the swim-bladder burst and the viscera disorganised, an effect such as one might expect from the use of some high explosive.

Mr. Ogilby of the Queensland Museum, in a letter to the Brisbane "Sunday Times" of 18th September 1918, referred to the matter and stated definitely that boating parties in the vicinity of Ipswich were in the habit of using dynamite, and since they probably obtained not more than one in five of the fish killed by the explosion the remainder would float downstream, such fish as perch (*Scianna australis*), sea mullet (*Magil* spp.), and catfish (*Tandanus* and *Neosilurus*) being recognised. Mayer\(^3\) has recently referred to the effects of high explosives on fish, especially on those possessing a swim-bladder.

We believe that we may then rule out the Brisbane River reports regarding the epidemic, but there is no justification for attributing the widespread mortality elsewhere to this cause.

(2) EFFECT OF CLIMATE.

This should be treated under two headings—(a) the influence of dry weather and (b) the effect of temperature—but we have not sufficient data to allow us to consider them separately.

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Queensland is a country in which heavy rain normally falls during the summer, December to April, while the winters are dry. Thus cold and dry conditions commonly go together, although in the early summer the weather may be hot and dry.

The Commonwealth Meteorologist, in a letter dated 31st January 1918, drew our attention to the following statement by Mr. J. B. Henderson, Government Analyst, Brisbane, in a report on a sample of water from Cooper’s Creek at Windorah:

"With reference to your letter . . . and sample of water, no poisons were found in the water. A small fish placed in the water for 48 hours was quite normal at the end of that time.

"The enormous number of dead fish referred to in your letter points either to suffocation by mud or to a more common cause, a sudden drop in temperature. Nothing in your letter indicates or contra-indicates the presence of either of these causes."

The Meteorologist went on to state that an investigation of the temperature records for June 1917 showed rather remarkable departures from the normal and appeared to bear out Mr. Henderson’s theory. A copy of minima records for a number of inland stations in Queensland was enclosed.

The localities were Urandangie, Boulia, Winton, Longreach, Isisford, Windorah, Tambo, Adavale, Thargomindah, and Cunnamulla. From the 1st to the 15th of that month there was a warm period in which the averages of daily minimum temperatures for the fifteen days and the number of degrees above June normal—given in brackets—for each locality were as follows, respectively: —52-3 (6-8); 51-2 (6-5); 51-3 (1-6); 50-5 (2-8); 48-4 (1-4); 48-8 (4-0); 47-2 (3-8); 49-5 (5-7); 50-0 (4-9); 49-4 (7-2). During the remainder of the month there was a sudden drop experienced at all these stations, commencing on 16th June. The mean of the daily minima during the cold period and the number of degrees below the June normal, for each of the ten localities were respectively as follows: —37-8 (7-7); 38-6 (7-1); 40-5 (9-2); 38-2 (9-5); 37-9 (9-1); 35-8 (9-0); 32-6 (10-8); 35-3 (8-5); 38-5 (6-6); 38-0 (4-2). The mean of daily minima for June 1917 at each locality as compared with the normal (calculated from twelve years’ records) were given as follows: —45-1 (45-5); 44-9 (45-7); 45-9 (49-7); 44-4 (47-7); 43-2 (47-0); 42-3 (44-8); 39-9 (43-4); 42-4 (43-8); 42-2 (45-1); 43-7 (42-2).
Thanks to the kindness of the Commonwealth Meteorologist we have been able to attempt the correlation of weather records and outbreaks of the epidemic.

Detailed climatological data from several localities for certain specified months were supplied and the following particulars have been abstracted and presented for convenience of reference in tabular form:

1. The average minimum for the month for all years in which records were taken, i.e. the normal minimum.

2. The minimum recorded for the actual month under review.

3. The mean of the minima for that month.

4. The average of total rainfall (in points) for the month for previous years.

5. The actual rainfall recorded for the month.

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| Bulloo River, Adavale. |      |      |      |       |      |      |      |      |       |
| 1 | 43·5 | 42·3 | 43·3 | 52·0 | 43·1 | 41·5 | 43·8 |       |       |
| 2 | 30·8 | 31·5 | 32·2 | 36·8 | 31·2 | 26·1 | 34·2 | 26·0 |       |
| 3 | 42·4 | 42·2 | 44·4 | 51·5 | 41·2 | 36·7 | 46·0 | 49·4 |       |
| 4 | 121  | 74   | 55   | 64   | 117  | 73   | 57   |       |       |
| 5 | 88   | 25   | 91   | 167  | 15   | 32   | 91   |       |       |

| Bulloo River, Thargomindah. |      |      |      |       |      |      |      |      |       |
| 1 | 45·0 | 42·1 | 44·8 | 50·6 | 45·0 | 42·0 | 45·0 | 50·5 |       |
| 2 | 33·0 | 37·5 | 35·0 | 39·0 | 34·0 | 31·0 | 40·0 | 39·1 |       |
| 3 | 41·2 | 44·6 | 45·5 | 51·2 | 44·0 | 40·4 | 48·9 | 49·8 |       |
| 4 | 84   | 51   | 56   | 56   | 82   | 51   | 59   | 49   |       |
| 5 | 90   | 27   | 6    | 75   | 0    | 85   | 164  | 0    |       |

| McIntyre River, Goodwiindi. |      |      |      |       |      |      |      |      |       |
| 1 | 43·7 | 41·1 | 42·1 | 48·7 | 43·3 | 40·6 | 42·4 | 48·6 |       |
| 2 | 28·4 | 29·0 | 30·8 | 31·2 | 27·8 | 23·2 | 37·2 | 39·9 |       |
| 3 | 40·5 | 39·8 | 42·4 | 49·8 | 39·1 | 35·4 | 46·3 | 47·5 |       |
| 4 | 178  | 170  | 133  | 162  | 174  | 177  | 136  | 159  |       |
| 5 | 113  | 77   | 64   | 440  | 22   | 94   | 252  | 15   |       |

| Mary River, Gippy. |      |      |      |       |      |      |      |      |       |
| 1 | 46·0 | 43·9 | 44·1 | 52·2 | 45·1 | 42·9 | 44·7 | 51·6 |       |
| 2 | 29·0 | 29·0 | 31·0 | 33·0 | 30·0 | 29·5 | 39·0 | 35·2 |       |
| 3 | 42·4 | 39·9 | 46·8 | 50·4 | 40·8 | 38·1 | 47·6 | 48·8 |       |
| 4 | 252  | 218  | 193  | 218  | 247  | 214  | 194  | 219  |       |
| 5 | 56   | 114  | 173  | 363  | 2    | 30   | 215  | 205  |       |
(i) Thomson River.—Longreach records for 1917 shew that June and July of that year were both colder and drier than in the average year (2·7° and 67 points less for June; 1·1° and 77 points less for July). An outbreak occurred in July. The lowest minima recorded during June and July were 32·2° on 22nd June and 35·5 on 5th July. Thus, although both months were colder and drier than usual, the thermometer reached freezing point only once. We are not aware of the condition of the river prior to the outbreak.

The outbreak which occurred in March 1918 can scarcely have had any dependence on the temperature. The records again shew that it was colder (by 4·7°) and drier (140 points less) than the average, but the lowest minimum recorded was only 51°, viz., on 18th March.

The rainy season had begun early in November 1917. The Thomson was in high flood during part of January and February 1918, and was still running when the outbreak began in March (vide Mr. Mill's letter of 30th March), there being no stagnant water at the time.

June 1918 was again colder and drier (2·3° and 85 points less) than the average, while the lowest minimum (35·2°) occurred on the 28th. In July, however, a more decided cold snap was experienced; for the nine days following 8th July the minimum records were consistently low, culminating in three nights of frost—28·5° on the 15th, 27° (lowest recorded) on the 16th, and 31·7° on the 17th. After this no further frosts were experienced.

No rain fell in the district during May, June, or July, so that the river was fairly low when the outbreak began at the end of July. The epidemic was at its height during the first week in August and had abated completely by the middle of the third week. Showers of rain yielding 45 points fell on 3rd and 4th of August. During September 1918 no rain fell. The minimum temperature fell to 36° on the 5th, this being the lowest for the month, though the three succeeding days experienced low minima.

An outbreak occurred during the latter half of December 1918, extending into early January 1919 (midsummer), when the temperatures were certainly not low. It was a very dry period and the water was stagnant. Another made its appearance in July and early August 1919, but particulars as to the weather are not in our possession.
(ii) Bulloo River.—Weather records for Adavale shew that June and July 1917 were drier and colder than the normal, being, however, only very slightly colder for July. The outbreak was reported in August but probably began in July. June 1918 was again colder and drier than normal. The epidemic began about the end of July and ceased after a fresh had occurred in the river in August. It reappeared in August 1919.

(iii) McIntyre River.—With regard to the epidemic occurring in the McIntyre and Severn Rivers during July and August 1918, the records shew that during June and July both minimum and rainfall records were considerably below the normal. The river was very low until rain fell in August.

(iv) Mary River.—Gympie weather records shew that June 1917 was colder and drier, and July 1917 much colder and drier, than the normal. An epidemic was reported to have occurred in the Mary River in August and September of that year.

June and July 1918 were both still colder and drier than in the preceding year, but no epidemic followed.

(v) Burnett River.—For the last ten days of June 1918 and the first eighteen days of July frosts were experienced practically every night (twenty nights) at Eidsvold. We are indebted to Dr. T. L. Bancroft for allowing us to use his records.

(vi) Georgina and Diamantina Rivers.—The outbreaks took place in September, October, and November 1917 and from June to September 1918, but none occurred during 1919. Though the epidemic made its appearance during the dry weather, conditions were not those of drought. Many local people thought that cold was the cause of the trouble.

From the foregoing it will appear that cold is not a necessary factor though it was a very common concomitant. Neither is drought a necessary condition, though dry weather appeared to be common to nearly all the outbreaks.

One can, however, state that dry cold conditions, and especially abnormally dry weather, favour the epidemic, and that the advent of sufficient rain to set the rivers in motion terminates it.

Heath (1883) found that certain species of fish were able to survive after having been frozen in blocks of ice for a few
hours, provided they were slowly thawed out. Bumpus (1898) suggested that the heavy mortality of tile-fish off Florida in 1878 might be due to a sudden diminution of temperature as a result of an alteration of the Gulf Stream. Hofer, in his valuable work on fish diseases (1906, pp. 87-93), gave an account of the effects of cold on the skin of freshwater fish in Europe.

Wells, in one of his many papers dealing with the relation of fish to their environment, stated that many species can detect and react to temperature differences as small as 1 to 2 degrees Centigrade (1913, p. 339). Next year he published a paper giving an account of his investigations regarding the resistance and reactions to temperature (1914). He found that, in the case of freshwater fish, the degree of resistance varied with the species and with the size of the individual, large specimens being more resistant to high temperatures than small fish of the same species, while small individuals were able to adapt themselves more successfully to sudden changes from warm to cold. He also reported that in no case did death result from sudden change from a higher to a lower temperature, though the widest range—viz., from the maximum for the species down to freezing point—was tried. He admitted that it was possible that a sudden and great lowering of temperature might cause death in the case of certain species. His experiments showed that fish can detect and react to variations of temperature amounting to only 0.1 degree Centigrade.

Shelford and Powers (1915, p. 325) ascertained that marine fish were capable of detecting differences of -5° to -6° C., and probably as low as -2° C.

3. STATE OF THE WATER.

This may be considered under various headings—viz., alterations in regard to amount of suspended matter or weeds, the amount of gases (oxygen and carbon dioxide) present, in the degree of alkalinity or acidity, and in the amount of salts in solution.

(a) Suspended Matter.

We know that the amount of suspended matter in stagnant pools depends mainly on the chemical composition of the water, since the presence of certain substances leads to the precipitation of finely divided and colloidal material. One might draw attention to the muddy water of a stream and the clear water of adjacent "kopai" holes rich in sulphate of lime.
Under this heading one may refer to the presence of organisms, whether plant or animal, which could act mechanically by interfering with the passage of water through the fish-gills.

Reference was made to the suggestion that overgrowth of water-weeds, including "umbrella grass," might cause trouble. It is to be pointed out that weeds grow only under certain conditions of light, depth, etc., and in the case of rooted plants form only a fringe around deep lagoons. Some of the waterholes in which the epidemic occurred were many miles long and up to 30 or more feet in maximum depth, the greater part of the lagoons being too deep for rooted plant growth. Abundance of green water-vegetation improves aeration, though one must admit that organic decomposition results in the using up of oxygen and the liberation of carbon dioxide and other gases. Moreover, the presence of abundant decomposing matter is associated with abundance of saprophytic and saprozoic organisms—e.g. fungi, bacteria, and certain protozoa—all of which are using up oxygen instead of liberating it.

Mr. Colbert referred to the deep-green colour of the water in his locality, Lake Nash, during the periods in which the fish epidemic occurred. The colour suggests that phytoflagellates were present in enormous numbers. It is not impossible that they might set up some irritation of the gills and become entangled in the mucus produced, and thus lead to partial or complete suffocation. But the presence of this intense colouration does not seem to have been a constant feature of the outbreaks, and suggests to us that the stagnant conditions allowed the organisms to grow at a much more rapid rate than they were being devoured by the various other organisms present. As a rapid decomposition of these might cause the liberation of toxic substances, the matter will be referred to later, under the heading of poisons as possible causes.

(b) Effect of Alterations in Chemical Composition of Water.

An analysis of samples of Longreach water, one from the Thomson River and the other from an adjacent billabong, was made by the Government Analyst, Mr. J. B. Henderson,
his report to the Longreach Shire Council, dated 29th August 1918, being as follows:

<table>
<thead>
<tr>
<th>Odor</th>
<th>Earthy and fœtid</th>
<th>Same but much more pronounced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total solids</td>
<td>41.0</td>
<td>36.8 parts per 100,000</td>
</tr>
<tr>
<td>Chlorine</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>Alkalinity</td>
<td>6.0</td>
<td>6.0</td>
</tr>
<tr>
<td>Sulphates</td>
<td>2.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Nitrates as nitrogen</td>
<td>0.048</td>
<td>trace</td>
</tr>
<tr>
<td>Free ammonia</td>
<td>0.01</td>
<td>0.044</td>
</tr>
<tr>
<td>Albuminoid ammonia</td>
<td>0.06</td>
<td>0.094</td>
</tr>
<tr>
<td>Oxygen consumed in 15 minutes at 90°F.</td>
<td>281</td>
<td>462</td>
</tr>
<tr>
<td>Oxygen consumed in 4 hours at 90°F.</td>
<td>536</td>
<td>782</td>
</tr>
<tr>
<td>Hardness</td>
<td>5.5</td>
<td>5.5</td>
</tr>
</tbody>
</table>

The samples are highly contaminated with organic matter and are unfit for drinking.

We do not know what was the composition of the water from either situation during periods when the epidemic was not present.

When discussing the above analysis of the Longreach water with Mr. Henderson, he informed us that the sample was milky and was taken at a time when the Thomson River was covered with dead or dying fish, the water being then green and stagnant. He said that the results relating to the presence of ammonia were of no value as indicating the constituents of the original sample. The amount of total solids was distinctly low and the organic matter unduly high.

On the occasion of our visit the water in the billabong was found to be very darkly coloured, with a greenish tint, apparently on account of an exaggerated growth of algae. The escape of fat or oil from the mass of decomposing fish present caused the water to be fœtid and to possess a greasy feel. Ciliates and flagellates were in abundance, as were tiny crustaceans.

A report on a sample of water from Anthony's Lagoon, Northern Territory, sent by Mr. Stretton to the Health Department, Darwin, during the 1918 epidemic, was issued by Mr. M. A. Kelly for the Chief Health Officer, and contained the following information:—Colour, dirty greenish white; odour,
sulphuretted hydrogen; reaction, none, neither acid nor alkaline: residue on evaporation, ash and a slight charring; free ammonia in considerable amount; chlorides, equivalent to 16 grs. per gallon; sodium chloride 26.3 grs. per gallon; hardness, 8 degrees of temporary hardness; nitrates, none; metallic impurities—iron, strong trace; zinc, lead, copper, and arsenic absent; oxygen absorbed in 15 minutes at .212° F., 1.30 grs. per gallon; microscopic examination, grass and weeds in all stages of putrefaction; bacteriological examination, innumerable colonies.

These last two findings might have been expected owing to the time which would necessarily elapse between the collecting of the sample and its examination. The analysis suggests that the sample originally contained a considerable amount of organic matter.

Marsh (1908, p. 905-6) has pointed out that there is as yet no sure method of determining by chemical tests whether water is suitable for fish-life. The ordinary "sanitary analysis" determines whether water is fit for drinking and for domestic use, but water which may be passed as suitable for such purpose may kill fish in a short time, and we know that fish can thrive in waters which on routine examination would be pronounced unfit for human use. Both Marsh (1908) and Shelford (1918c, p. 39 footnote) point out that, in this connection, it is important that such additional items as acidity or alkalinity, the amount of hydrogen sulphide, carbonaceous material capable of being utilised as food, unusual metals, dissolved air, etc., should be known.

The most important items in the above analyses seem to be those relating to the amounts of oxygen and carbon dioxide present. The blue colour inside the mouths of affected fishes suggests a deficient oxygenation of the blood, and this may be due either to a diminished amount of oxygen or to a greatly increased amount of carbon dioxide, or to both.

Wells (1913) has studied the resistance of fishes to different concentrations and combinations of oxygen and carbon dioxide. In regard to the latter he pointed (p. 329) out that the presence of a high and low concentration of CO₂ is affected by many factors, such as the amount of vegetation in the water, character of the surrounding soil and incoming water, depth of water, season of the year, daily temperature, animals present,
amount of decaying organic matter, rainfall, and exposure of the surface to winds. Hence great variation may occur within the same body of water at different times. He stated (p. 344) that small variations (e.g. 5 to 10 cc. CO₂ per litre) from the normal in regard to the amount of CO₂ present apparently produce ultimately effects similar to those caused by greater variations (25 cc. CO₂ per litre) in relatively short periods. Certain species are more sensitive than others in this respect and would therefore react first—i.e. they would endeavour to move away from the adverse conditions. Resistance comes into play when organisms cannot move away from unsuitable surroundings but must adapt themselves to the unfavourable environment. We know that fish are able to withstand stagnant water during dry seasons by gulping air at the surface. We also know that some fish are less affected than others. Wells found—(1) that the presence of oxygen in large amounts (10 cc. per litre) counteracted the detrimental effect of high CO₂ content (50 cc. per litre); (2) that low oxygen content (0·1 cc. per litre) in alkaline water caused death sooner than when it occurred in slightly acid water; (3) that the resistance of fishes to fatal concentrations and combinations of oxygen and carbon dioxide varied with the individual, with the species, and with the weight, small fish being more resistant per unit weight than were large ones.

Wells (1916) investigated the seasonal resistance of fishes in the United States, and stated that as a result of several years' observations he had been noted that in nature their resistance to detrimental factors in general was lowest in late summer (July to October) and highest in spring (February to May or June). They were found to be least resistant just after the breeding season.

Shelford and Allee had previously (1913) pointed out that young fish were more sensitive to changes in regard to the amounts of these two gases than older fish were, and that some species reacted to a concentration of CO₂ as low as 5 to 7 cc. per litre, and of oxygen as high as 7 to 1 cc. per litre.

Powers (1914) found that freshwater crayfishes reacted to very weak concentrations of CO₂.

Wells (1918) stated that at a concentration of 10 cc. per litre CO₂ soon proved fatal to more sensitive species, and that it was doubtful if there were any freshwater fish which could
continue to live in water where the CO₂ content averaged as high as 6 cc. per litre throughout the year, but that it was still to be demonstrated whether there were any species of truly freshwater fish which could reproduce successfully in water that was decidedly alkaline to phenolphthalein throughout the year. Shelford (1918c, pp. 45-6) pointed out that since CO₂ results from the decomposition of organic matter, in the process of which oxygen is consumed, so the presence of any large quantity of CO₂ nearly always indicates a lack of oxygen. He thinks it probable that the CO₂ content should not average more than 3 cc. per litre over breeding grounds, and more than 6 cc. per litre during the summer, as such quantities are not usually accompanied by lack of oxygen. He suggested that the amount of CO₂ might be taken as an index of the suitability of the water for fish-life. Wells (1915) found that the CO₂ optimum for the various species of freshwater fish experimented upon under summer conditions varied from the acid side of neutrality to 6 cc. per litre. Marine fish behaved differently as they preferred slight alkalinity to acidity (Shelford and Powers, 1915; Shelford 1918c, p. 40; 1919). The time taken to kill freshwater fish, using higher concentrations of acid, was found by Wells to be proportional to the hydrogen ion concentration. This author gave considerable attention to the reactions of fish to the ions of H and OH.  

4 See also Birge and Juday (1914, pp. 583-7) regarding the distribution of CO₂ in lakes. Also Shelford, 1918c, pp. 40-1; 1914.

5 "The theory of solution explains acidity in water by the occurrence of hydrogen ions, formed from dissolved electrolytes, in excess of hydroxyl ions; and alkalinity by a similar excess of hydroxyl over hydrogen ions. Neutrality is, then, the condition when, as in pure water, the two concentrations are equal." (L. J. Henderson, The fitness of the environment. MacMillan, New York, 1913, p. 142.)

6 By titration, using phenolphthalein and methyl orange as indicators, Wells (1915) determined the amount of CO₂ present in a fixed condition (as carbonates), "half bound" (i.e. bicarbonates), and free (as CO₂), since methyl orange remains unaffected by carboxylic acid so that the bases present as carbonates or bicarbonates can be titrated with an acid; while carbonates are alkaline to phenolphthalein, bicarbonates neutral, and free CO₂ acid. Methyl orange is very sensitive to OH ion whereas the latter indicator reacts to the H ion instead and consequently gives an acid reaction with CO₂. In the presence of CO₂, methyl orange will give an alkaline reaction though the water may still be acid owing to the presence of a higher concentration of H than OH ion. See also Shelford, 1919b.
Distilled water has been shown to be toxic to various organisms owing to its influence on the permeability of the gill membranes, leading to the loss of salts by the animal and the absorption of water by osmosis (Abbot, 1913). Such water was found by Wells (1915, pp. 241, 254) to be not toxic if rendered slightly acid, but remained so if made slightly alkaline.

The following extract from Wells's paper (1915, pp. 243-4) is of interest:—"The fact that in natural bodies of water the chemical reactions of the water may vary from alkalinity through neutrality to acidity, or the reverse, makes the practical importance of a knowledge of the reactions and resistance of fishes and other organisms to such chemical conditions an obvious one. From the experiments (referred to in his paper) it is clear that water which gives an alkaline reaction to phenolphthalein for any length of time during the year is undesirable as a home for most freshwater fishes. On the other hand, marine fishes with the exception of anadromous species would probably not survive in water which was even faintly acid. Since algae or other phytoplankton forms may cause a body of water to become wholly or partly alkaline, through their ability to dissociate the bicarbonates, vegetation in fish waters assumes a line of importance heretofore little considered. The effects of sewage upon the acidity or alkalinity of natural bodies of water must be reconsidered in the light of its possible injurious or beneficial effects due to its chemical action. . . . Henderson's work (1913) on the mechanism which maintains a constant proportion of H and OH ions in the blood of animals, suggests the physiological reason for this extreme sensitiveness of the fishes. Very small variations in the proportions of these two ions in the blood of the organism are of grave importance and we find in the blood a combination of gases and salts that makes such variations impossible as long as the animal is normal. The blood will maintain its normal chemical reaction (just on the alkaline side of neutrality) in the face of relatively large changes in the environment, yet we know that the mechanism breaks down when the change is either too great or too long continued. . . . The hypersensitiveness of the animals to the chemical reaction of the water in the case of aquatic organisms is another important factor in preserving the normal reaction of the blood, as the reactions

of the organisms work in a way that causes them to turn back from concentrations of H and OH ions that would be detrimental. . . . The physiological effect of the acid, neutral, and alkaline water upon the organism very probably has to do with decrease or increase in the permeability of the exposed tissue cells (especially the gills in the case of fishes).” Alkalinity increased and acidity at first caused a decrease in permeability, but acidity if increased caused an increase in permeability, so that, as in the case of alkalinity, death was ultimately the result. In regard to marine fishes the results of Shelford and Powers indicated that the action of alkaline water produced a normal permeability of the membranes, and it is likely that an acid condition of the water would kill such fish by diminishing the permeability (Wells, 1915, p. 245).

As already stated, the appearance of the affected Queensland fish suggested suffocation, while the bulging of the eyes noted by some observers strengthens the suggestion that the water contained excess of carbon dioxide.8

Carbon monoxide is very poisonous to freshwater fish (Shelford, 1917). Wells (1918, p. 562) ascertained that a concentration of from 75 to 100 cc. per litre CO₂ would be required to produce as deadly results as 1 cc. per litre CO, and that a saturated solution of CO in water did not lose its toxic effects even after two weeks’ exposure to the air (p. 563).

Another gas which is formed as a result of organic decomposition, and may be added to water supplies as a result of pollution by industrial waste, is sulphuretted hydrogen. Shelford and Powers (1915; Shelford, 1918b) drew attention to the extreme sensitiveness of fish to this gas, as they endeavoured to avoid the presence of even a fraction of a cubic centimetre per litre. Fish died in a few minutes in water containing 7-6 cc. H₂S per litre, and a combination of this gas with CO₂ was reported to be “exceedingly deadly.” “Since decomposition yields CO₂ and consumes oxygen and is accompanied by the production of hydrogen sulphide which is also accompanied by the consumption of oxygen, it is reasonable to suppose that on a bottom from which vegetation is absent and decomposition actively takes place, a fatal combination of lack of oxygen and presence of hydrogen sulphide and probably

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carbon dioxide can quickly develop" (Shelford and Powers, 1915, p. 322). No doubt, in the case of the Queensland epidemics H₂S has played an important rôle in aggravating the condition, though it probably did not cause it in the first place.

Ammonia is very toxic to fish and is apparently not recognised by them, as they do not react in such a way as to avoid it when given the opportunity (Wells, 1915a).

The reactions and resistance of fishes in their natural environment to salts were studied by Wells (1915b), who used the chlorides, nitrates, and sul, hates of the commoner bases—e.g. sodium, ammonium, potassium, calcium, and magnesium. He found—(1) that freshwater fish reacted to their presence in solution but were not as sensitive to salt ions as to H and OH ions; (2) that they reacted to combinations of antagonistic salts or salt and acids in a manner which tended to bring them into a region of optimum stimulation; and (3) that rhythmic alterations in metabolic activity in the case of anadromous fish (such as salmon) were correlated with their migrations.

Powers (1917) has studied the relative toxicity of the chlorides and nitrates of the alkalies and alkaline earths, as well as various other substances, on goldfish. He pointed out that it is improbable that toxicity of a substance is due to osmotic pressure.

Reduction in salinity as a result of flood-waters being turned aside to cover certain Japanese reefs led to very great destruction of marine alge and the associated fauna.

4. Poisons as a Possible Cause of the Epidemic.

Apart from the toxic effects likely to be caused by the agencies referred to in the last section, one can probably dismiss the possibility of the mortality being caused by a poison—e.g. one of plant or mineral origin—on account of the wide area involved, the different flora in each region, the different types of water, and the character of the outbreaks.

9 Whetmore (1918) in his investigations regarding the epidemic amongst wild ducks in Utah, U.S.A., proved that it was due to alkali poisoning, especially by the chlorides of calcium and magnesium which are brought to the surface of the soil of the swamps by capillary attraction.

In a report Mr. J. B. Henderson stated that toxic effects were not produced by a sample of the water in which the epidemic had occurred, when a fish was kept in it for 48 hours. It should be pointed out, however, that all species are not equally susceptible, and that it was possible that gaseous poisons, if such were the cause, may have escaped or have become altered.

The possibility of some toxic substance being liberated as a result of decomposition of myriads of dinoflagellates has been mentioned. It is known that certain phytoflagellates, especially Peridinium, Gonyaulax, and allied forms, have caused very serious epidemics amongst various organisms, the result being brought about by the death of immense numbers of these tiny organisms, the decomposition products destroying fish, molluscs, etc., In fact, such water, which is generally coloured reddish by these flagellates, is often spoken of as "poison water." The animals so killed, on decomposing, aggravate the condition so that widespread mortality has been caused.

In the "Sydney Morning Herald" of 27th December 1918, attention was drawn to the "red weed pest" destroying fish and oysters owing to its extraordinary abundance in Port Macquarie, N.S.W. Mr. A. H. Lucas described this dull-red seaweed as Falkenbergia ulens. He stated that it probably lived on plants in deeper water, being brought inshore in great masses at irregular intervals, sometimes collecting on oyster-beds with disastrous results, owing to its rapid decomposition and putrefaction, a great deal of gas being evolved.

Hedley (1915, p. 29) referred to two sudden and widespread epidemics which occurred amongst sedentary intertidal organisms in Port Jackson in 1866 and 1891. In regard to the latter Whitelegge (1891) reported that immense numbers of the dinoflagellate Glenodinium rubrum caused the clogging of the gills of various molluscs and led to their death and ultimately, through their decomposition, to the destruction of great numbers of other organisms.

Other accounts of heavy mortality amongst marine fish, caused by flagellates, have been published by Torrey, 1902 [Gonyaulax—Californian Coast in 1901]; Gilchrist, 1914 [Noctiluca, Peridinium—South Africa]; Hornell, 1917 [Eule-
noids—South India]; Nishikawa, 1901 [Gonyaulax—Japan]. Taylor (1917) rejects these as being a likely cause of certain epidemics in Florida waters, one being previously reported by Ingersoll (1882).

5. OVERSTOCKING.

Overstocking is commonly regarded as being the cause. Owing to dry weather, the rivers and waterholes shrink considerably, and as a consequence there is much less water and food for the fish which come to occupy the restricted areas. It seems likely that overstocking may be a contributing factor to the epidemic. The increased number of fish would use up more food and oxygen and liberate more CO₂, which would lead to ill effects unless there were increased plant activity to preserve the balance and so prevent the water from becoming more and more acid. Besides, should the real cause of the epidemic be some protozoan, fungoid, or bacterial organism, then the greater density of the fish population would be favourable to the rapid spread of the disease.

6. PARASITISM AS A POSSIBLE CAUSE.

It is well known that organisms may cause serious epidemics. Animal parasites likely to be incriminated may be (a) Helminths, and (b) Protozoa such as (i) Sporozoa (Myxosporidia and Microsporidia), or (ii) Flagellates, perhaps Ciliates. Amongst plant parasites one must consider (c) Fungi and (d) Bacteria.

(a) Helminth Infection.

The cyanosed appearance of infected fish suggested the possibility of gill parasites, especially Heterocotylean Trematodes, being a cause, through their interference with normal gill function. It is known that infection is sometimes extremely heavy, and Ward (1918, p. 374) has stated that Gyrodactylus may be in sufficient numbers to cause death. McCallum (1915, p. 410) has reported that infestation by Diplectanum may be so intense as to bring about the death of its host. Pratt (1919, p. 2) has also referred to gill-infesting trematodes as a cause of considerable mortality, especially in enclosed bodies of water. Magath (1917, p. 59) in a paper dealing with a fluke, Lissorchis, which was regarded as causing heavy losses amongst certain fish in Iowa, U.S.A., mentioned that some parasites so weaken their hosts that the latter may die from some cause which would otherwise not have so affected them.
A careful examination of a considerable number of affected and healthy fish, chiefly from the Thomson River, revealed the presence of many species of Gyrodactyloid trematodes infesting the gills in both cases, so that invasion by the minute parasites can at most be only a contributing factor and not the cause of the outbreaks.

Though an examination of the viscera revealed the presence of digenetic trematodes, various nematodes and echinorhynchus, as well as occasional cestode larvae, none of these can be incriminated. The marked fatty degeneration of the viscera has already been mentioned.

(b) Protozoa as a Cause.

(i) Sporozoa.

Of the Sporozoa the most important groups in the present connection are the Myxosporidia and the Microsporidium. It is well known that some species give rise to epidemics amongst freshwater fish, while many produce lesions resulting in the death of the host, though an epidemic may not follow. The best known is Myxobolus pfeifferi Thel., which at times brings about a tremendous destruction of barbels in the Moselle, Rhine, Meuse, Marne, Aisne, and Seine. Full accounts of this Myxoboliasis are given by Hofer (1906, p. 71) and Gurley (1894, p. 227), in whose works further references to literature are to be found. The fatty degeneration which takes place as a result of that disease reminds one somewhat of the condition commonly associated with the Australian outbreaks, but the "boil formation" so common in the barbel disease is not manifested in our epidemics. Though some observers have referred to the presence of a bluish swelling on the under side of affected fish, it is not a constant feature and is certainly not of the type associated with the European epidemics. A disintegration of muscular tissue of fish is also caused by certain other Sporozoa—e.g. some species of Chloromyxum and Glugea (G. destruens Thel.).

Though some of the diseased fish first examined by us were found to be parasitized by Myxosporidia, belonging to the genera Myxobolus, Myxosoma, Myxidium, and Hennequaya, and occurring in various organs such as the gills, gall-bladder, and kidneys, yet a search through healthy material showed the
presence of similar organisms, so they may be disregarded as
direct causes of the mortality. Those met with have been
already described by us (J. & B. 1918).

_Lymphosporidium truttae_, a member of the Haplosporidia
and a parasite of the lymph system, was described by Calkins
(1900) as a cause of an epidemic amongst trout. (See also Hofer,
p. 60; Doflein, p. 934.) Another member of this Sporozoon
group, _Ichthyosporidium_ sp., near _I. gasterophilum_ Caull. &
Mesnil, has been recorded by Robertson (1909) as fatal to
sea-trout. (See also Hofer, p. 60; Doflein, p. 934.) Another
member of this Sporozoon group, _Ichthyosporidium_ sp., near _I.
gasterophilum_ Caull. & Mesnil, has been recorded by Robertson
(1909) as fatal to sea-trout.

(ii) Protozoa—Infusoria and Flagellata.

The chief ciliate parasites harmful to freshwater fish are
_Withyphthirius_, _Chilodon_, and _Cyclocheta_. The first-named
causes epidemics in aquaria (Hofer, pp. 122-7). The other two
appear to be of less importance.

Of the Flagellata, _Costia_ is said to cause at times heavy
mortality amongst salmon fry in Austria (Franke, 1910; Hofer, p. 115).

None of these protozoa except an occasional _Cyclocheta_
was detected during our examinations of Queensland material,
whether diseased or not.

(c) Fungi as a Possible Cause.

As a result of our examination of fish dead or dying from
the disease, we found the fungus _Saprolegnia_ constantly
present, either on the general body-surface (including fins and
tail) or on the gills, or even on both situations. A similar
finding was reported by one of us (Johnston, 1917) when
dealing with a specimen previously sent down. In addition to
the records of Australian occurrences contained in that paper,
there is a short one by Waite (1894), who mentioned finding
the fungus on _Ctenolates ambiguus_ Richdsn. (= _Plectroplites_).
Further references to the disease and to literature relating to
it can be found in papers by Hofer (1906), Clinton (1893), and
Johnston (1917).

It was previously regarded as the cause of the salmon
disease, but it is now recognised that the fungus is secondary
and is capable of readily exchanging a saprophytic mode of
existence for a parasitic one, should it have an opportunity.
Such would be given by injuries as well as by the presence of
external conditions or diseases which interfere with normal
healthy fish-life. Bacterial maladies of fish are commonly associated with Saprolegnia attack, and Shelford (1918c, p. 46) has stated that excessive acidity due to CO₂ probably favours the development of this destructive fungus.

(d) Bacteria as a Possible Cause.

Almost the whole of the diseased material was already dead at the time of our examination, and as putrefactive changes had taken place a bacterial exploration under field conditions would probably have been of little value. Though bacteria were found in various tissues, the possibility of a bacterial disease being the cause of the epidemic had not been provided for by us, and as a consequence cultures were not able to be made on the occasion of our only visit to a locality in which the epidemic was present.

Several bacterial diseases of fish are known, the most destructive being probably that which has at different times caused heavy mortality amongst salmon. The so-called "salmon disease," which was formerly attributed to Saprolegnia, has been shown by J. H. Patterson in his Parliamentary Report, Fishery Board for Scotland (1903), to be due to a diplobacillus, Bacillus salmonis pestis. Additional information was given by Drew (1909). [See also Hofer, pp. 19-22]. Marsh had previously (1902, 1904) described Bacterium truttæ, a pleomorphic organism, sometimes assuming the form of a coccus, or a bacillus, or a diplobacillus, which was found to be fatal to various kinds of trout in the United States.

Hofer (1906) gave a summarised account of the various bacterial diseases described as occurring in freshwater fish in Central Europe, the causative organisms being Bacillus salmonicida, B. pestis astaci, B. cyprinicida, B. anguillarum, B. vulgaris, B. piscicidus, B. piscicidus agilis, and a few others.

Grieg Smith (1900a) described one as B. piscicidus bipolaris, which was found to be fatal to certain marine fish in New South Wales; and also another (1900b) called by him Vibrio bresimae, which destroyed marine bream in that State.

7. Is it Due to More Than One Cause?

The epidemic nature of the Queensland disease, the apparently rapid course which it runs, and the particular susceptibility of certain species, all suggest that the malady is
of bacterial origin, and that various local and climatic conditions favour it. We then offer the suggestion that the epidemic may be due to a high acidity on account of excess of CO₂ in stagnant water, favouring the spread of a virulent bacterial disease amongst the weakened fish. The presence of *Saprolegnia* aggravates the condition, as probably also does hydrogen sulphide, which is itself a decomposition product resulting from the effects of the disease.

**SUMMARY.**

A very destructive epidemic makes its appearance amongst freshwater fish in Queensland and Northern Territory at very irregular intervals, usually during dry and cold conditions, ceasing when the rivers run freely. The affected streams belong to various watersheds—*e.g.*, Lake Eyre basin (Cooper’s Creek, Diamantina, Georgina, Thomson, and Wilson Rivers); Bulloo River; Warrego River; Darling system (McIntyre and Severn Rivers); Flinders system (McKinley River); Burnett. It is apparently not due to the following:—Use of explosives; dry weather; low temperature; overstocking; animal parasites (helminth or protozoon).

It is suggested that the prime cause will be found to be a bacterial organism, whose spread is favoured by a high acidity of the water due to excess of CO₂. The presence of the fungus *Saprolegnia* aggravates the disease, as no doubt does hydrogen sulphide also.

**ADDENDUM.**

Dr. J. Shirley informed us that a series of epidemics causing considerable mortality occurred in the Logan River, in South-eastern Queensland, during the drought years just prior to 1902, but further information regarding these outbreaks is not yet available.

Mr. W. B. Alexander supplied us with the following statement which is of interest. Early in July 1921 a steamer arrived at Fremantle with its hold on fire, and large quantities of water were pumped into it. Among the cargo was a consignment of cyanide for the Kalgoorlie mines, which partly dissolved and entered the harbour water, causing the death of a large number of fish belonging to many different species. The occurrence was reported in the Perth daily Press.
LITERATURE.


1918c. Shelford, V. E.—The conditions of existence. Chapter 2 in "Freshwater Biology" by Ward and Whipple, pp. 21-60.


To the Members of the Royal Society of Queensland.

Your Council has pleasure in submitting its Report for the year 1920.

During the year eleven papers were read before the Society and published. In addition the following lectures were delivered:—"Petroleum in Queensland," by Mr. J. B. Henderson, F.I.C.; "The Origin of Petroleum," Mr. W. H. Bryan, M.Sc.; "The Einstein Theory," Professor H. J. Priestley, M.A.; "The Hawaiian Islands," Professor H. C. Richards, D.Sc.; and "The Czecho-Slovakia Republic," Dr. J. V. Danes (Consul-General for Czecho-Slovakia).

On the occasion of the visit of the Prince of Wales an address was presented to His Royal Highness by the President on behalf of the Society.

An event of scientific significance during the year was the Pan-Pacific Conference held at Honolulu in August. The Society was represented by Professor H. C. Richards, D.Sc.

The Society is again indebted to the Queensland Government for a vote of £50 towards the publication of scientific papers. It is also indebted to the Trustees of the Walter and Eliza Hall Fund for defraying part of the cost of publication of the following papers by Professor T. Harvey Johnston and Miss M. J. Bancroft (Walter and Eliza Hall Fellow in Economic Biology): "Notes on the Chalcid Parasites of Muscoid Flies in Australia," "Experiments with Certain Diptera as Possible Transmitters of Bovine Onchocerciasis," "The Life History of Habronema in relation to Musca domestica and Native Flies in Queensland," "Notes on the Life History of Certain Queensland Flies."
There have been nine meetings of the Council, the attendances being as follows:—F. B. Smith (President) 8, W. H. Bryan 4, F. Butler-Wood 4, B. Dunstan 4, W. D. Francis 9, E. H. Gurney 5, T. H. Johnston 2 (granted leave of absence), H. A. Longman 6, H. C. Richards 6, J. Shirley 8, C. T. White 8.

The roll of members consists of ten corresponding and ninety-one ordinary members. During the year eight new members were admitted and three resignations were accepted.

Since the last annual meeting the deaths of Sir Hamilton Goold-Adams, late Governor of Queensland and Patron of the Society, and of Sir S. W. Griffith, late Chief Justice of Australia and a life member of the Society, have occurred. Letters expressing the sympathy of the Society were forwarded to the relatives of the deceased in each instance.

To the University of Queensland our thanks are tendered for affording accommodation for meetings and for housing the library.

The Financial Statement for the past year shows a credit balance of £101 10s. 8d., but against this there is a printer’s bill amounting to £111 4s.

F. B. SMITH, President.

W. D. FRANCIS, Hon. Secretary.
# The Royal Society of Queensland.

## Balance Sheet for Year ending 31st December, 1920.

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Examined and found correct.

(Signed) H. J. PRIESTLEY, 1st March, 1921,
Hon. Auditor.

The Printers' Account for Vol. XXXII (£111 4s.) is not included.
Abstract of Proceedings, 30th March, 1921.

The Annual General Meeting of the Royal Society was held on Wednesday, 30th March, 1921, at 8 p.m., in the Geology Lecture Theatre of the University.

Mr. F. B. Smith, B.Sc., F.I.C., President, in the chair.

The President referred to the return of Professor T. Harvey Johnston from America and Europe.

The minutes of the previous Annual General Meeting were read and confirmed.

The Annual Report of the Council and the Financial Statement were adopted on the motion of Dr. J. Shirley, seconded by Mr. E. H. Gurney.

The following officers were elected for 1921:—

President: C. T. White, F.L.S.

Vice-Presidents: F. B. Smith, B.Sc., F.I.C. (ex officio): Professor H. J. Priestley, M.A.

Hon. Treasurer: Dr. J. Shirley, F.M.S.

Hon. Secretary: W. D. Francis.

Hon. Editor: H. A. Longman, F.L.S.

Hon. Librarian: W. H. Bryan, M.Sc.


Mr. C. R. Morton was elected an ordinary member.

The congratulations of the Society were tendered to Mr. W. E. Cameron, B.A., on his appointment as Consulting Geologist to the Federated Malay States.

The newly elected President was installed and returned thanks for his election.

The retiring President delivered his address entitled "Prickly Pear as Stock Feed." At its conclusion, Professor T. H. Johnston moved a vote of thanks, which was seconded by Mr. H. Tryon and supported by Mr. Gurney and the President. Mr. Smith suitably responded.
Abstract of Proceedings, 27th April, 1921.

The Ordinary Monthly Meeting of the Royal Society was held in the Geology Lecture Theatre of the University at 8 p.m. on the 27th April, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

His Excellency Sir Matthew Nathan and Lieut.-Colonel Parsons (private secretary) were among the visitors.

The minutes of the last monthly meeting were taken as read.

Mr. J. L. Froggatt, B.Sc., was nominated for Ordinary Membership.

The President then introduced Professor S. B. J. Skertchly, a Past-President of the Society, who gave a lecture on "Glacial Man." In an entertaining manner he outlined the events leading up to his discovery, in 1876, of palaeolithic flint implements below the boulder clay of East Anglia. Although his conclusions were not generally accepted at the time, recent evidence supports them, and the lecture was the result of a special invitation to the Professor to speak on the subject. The actual implements, now in the Queensland Museum, were exhibited.

A hearty vote of thanks to Professor Skertchly was proposed by His Excellency the Governor, seconded by Professor H. C. Richards, supported by Mr. H. A. Longman and Dr. Shirley, and carried with applause from the large audience.

Abstract of Proceedings, 30th May, 1921.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 30th May, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the last monthly meeting were read and confirmed.

The President extended a welcome to Professor Ernest H. Wilson, Assistant Director, Arnold Arboretum, Harvard University, who was present.
Mr. J. L. Froggatt, B.Sc., was elected to ordinary membership.


A vote of thanks to Captain White was moved by Dr. J. Shirley, seconded by Professor Richards, supported by Professor Johnston, and carried by acclamation. The lecturer suitably responded.

Professor E. H. Wilson outlined some of the objects of the Arnold Arboretum, and gave his impressions of the Australian true flora.

Abstract of Proceedings, 27th June, 1921.

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University on 27th June, 1921, at 8 p.m.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. C. L. Thompson, B.D.Sc., was nominated for ordinary membership. Misses E. Muir and C. Moxon and Mr. F. W. Whitehouse were nominated as Associates.

Mr. H. A. Longman, F.L.S., exhibited a specimen of Trachysaurus rugosus Gray, the "Shingle-back Lizard," which had been born in the Museum on 11th May. When born this lizard was nearly half the size of its mother. This specific peculiarity was first pointed out in 1885 by Frederick McCoy.


Dr. J. Shirley, F.M.S., read a paper entitled "The Acacias of South-East Queensland," and illustrated his remarks by a series of lantern slides of photo-micrographs. The President commented on the paper.
Mr. O. W. Tiegs, M.Sc., submitted a paper by Professor T. H. Johnston, M.A., D.Sc., and himself entitled "New and Little-known Sarcophagid Flies from South-Eastern Queensland," which was taken as read. Messrs. Tryon, Cooling, and Dr. Turner took part in the discussion.


The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University on 25th July, 1921, at 8 p.m.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. C. L. Thompson, B.D.Sc., was elected an Ordinary Member. Misses E. Muir and C. Moxon and Mr. F. W. Whitehouse were elected as Associates.

Dr. J. Shirley, F.M.S., exhibited species of Typhobia, Raymondia, Lithoglyphus, Syrnolopsis, &c., from Lake Tanganyika. It was pointed out that these shells, with a marine facies, were absent from Lakes Victoria and Albert Nyanza and Nyassa, though similar species inhabit Lake Mweru to the west. The likelihood of geological formations containing these shells being regarded as of marine origin was also stressed.

Mr. H. A. Longman, F.L.S., exhibited the malformed hoof of a horse from Beerburrum, which had been donated to the Queensland Museum by Mr. T. B. Tripeony. The proximal, medium, and distal phalangeal bones were in pairs, whilst the hoof itself was tripartite, the median segment being very small. The specimen is of considerable interest as probably illustrating a reversion to an ancestral condition.

Mr. C. T. White, F.L.S., exhibited specimens of—(1) Bassia lanuginosa C.T.W., from sandstone country near the junction of the Mayne and Diamantina Rivers. The species, which is closely allied to the West Australian B. carnosa F.v.M., is characterised by exceptionally long silky hairs covering the perianth. (2) Heliotropium indicum Linn. This plant was recorded by F. v. Mueller in the Second
Systematic Census of Australian Plants as a native of the Northern Territory and Queensland. In Queensland, however, it has all the appearances of a naturalised weed and is spreading rapidly about many of the Northern townships.

Mr. H. A. Longman, F.L.S., read a paper entitled "The Magnificent Spider: Dicrostichus magnificus Rainbow: Notes on Cocoon spinning and method of catching prey." Mr. H. Tryon discussed the paper.

Mr. O. W. Tiegs, M.Sc., read a paper by Professor T. Harvey Johnston, M.A., D.Sc., and himself, entitled "On the Biology and Significance of the Chalcid Parasites of Australian Sheep Maggot-flies." Professor Johnston and Mr. Tryon took part in the subsequent discussion.

**Abstract of Proceedings, 29th August, 1921.**

A Special Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on the 29th August, 1921.

His Excellency Sir Matthew Nathan, accompanied by Captain Harbord, A.D.C., was among the visitors.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

It was proposed by Professor Richards, seconded by Mr. F. Bennett, and carried by acclamation, that the congratulations of the Society be extended to Professor T. H. Johnston on his appointment to the chair of Zoology in the Adelaide University. At the same time much regret was expressed at Professor Johnston's eventual departure from Brisbane.

It was proposed by Professor Richards, seconded by Dr. Shirley, and carried unanimously, that Rule 29, so far as it refers to the number of printed papers (reprints) supplied to authors, be amended as follows:—

... Authors shall receive 25 copies of their printed papers except in the case of joint authors when a maximum of 50 copies will be provided if requested.
Abstract of Proceedings, 26th September, 1921.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 26th September, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Miss B. Ludgate, B.A., and Mr. W. B. Alexander, M.A., were nominated for ordinary membership.

Dr. E. O. Marks exhibited a stone tomahawk found in alluvium at Bulimba Point, Brisbane, at a depth of 3 ft. 6 in. below the surface. Messrs. Bryan, Bennett, and Longman discussed the exhibit.

Mr. H. A. Longman, F.L.S., exhibited mandibles of *Phascolonus gigas* and *Euryzygoma (Nototherium) dunesc*. In view of the discussion of species of *Nototherium* by Scott and Lord (Pr. Roy. Soc. Tas., 1921, p. 2) and their earlier association of De Vis' *dunesc* with *Phascolonus*, as criticised by the exhibitor (Longman, Mem. Qld. Mus., vi, pt. 2, 1921, p. 77), these fossil marsupial mandibles were shown side by side. Not only are the dental characters totally distinct, but the large ectocrotaphyte depression and the associated external ridge readily distinguish all *Phascolomyidae* from *Euryzygoma dunesc*, which is the most specialised member of the Nototheriidae yet found. The fact that the two families probably had a common ancestry does not make less remarkable their present divergencies. The exhibit was discussed by Mr. Bryan and Dr. Marks.

Mr. H. A. Longman communicated a paper by Mr.
L. E. Cooling entitled, "On the Larval and Pupal Stages of Myzorhynchus bancrofti." The paper was discussed by Mr. Bennett and Mr. Tiegs.

Mr. W. D. Francis read a paper by Mr. C. T. White and himself entitled, "Contributions to the Flora of Queensland." The paper was discussed by Mr. Longman.

**Abstract of Proceedings, 31st October, 1921.**

The Ordinary Monthly Meeting of the Royal Society of Queensland was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 31st October, 1921.

Dr. J. Shirley, F.M.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Mr. J. H. Reid was nominated for ordinary membership.

Miss B. Ludgate, B.A., and Mr. W. B. Alexander, M.A., were elected as ordinary members.

Dr. Shirley exhibited (1) a specimen of Hakea plurinervia F.v.M., given in the "Flora Australiensis" as from Rockingham Bay but found by Messrs. Tryon, White, and Shirley near Mount Gravatt; (2) specimens of the following shells from the Solomon Islands: Chloritis customa Pfr., Microcystis nitidissima E. A. Smith, Papuina leucothoë Pfr. and P. vexillaris Pfr., Placostylus Strangei Pfr., Trochomorpha xiphas Pfr.

Mr. H. A. Longman, F.L.S., exhibited a fossil fragment of a mandible of Sarcophilus laniarius, a carnivorous marsupial related to the Tasmanian "Devil" of the present day. The fragment consisted of part of the right side of the mandible with one molar well preserved. The fossil was found in the Guano Fertiliser Company's deposits, near Rockhampton, being donated to the Queensland Museum by Mr. P. H. Ebbott. Several remains of this animal have been secured from the Darling Downs.

Dr. H. I. Jensen delivered a lecture entitled "The Relation of the Oil Fields of the World to the Continental Shelves of the Archæan Continents." The Chairman, Dr. E. O. Marks, Mr. F. Bennett, and Hon. Randolph Bedford took part in the discussion.
Abstract of Proceedings, 28th November, 1921.

The Ordinary Monthly Meeting of the Society was held in the Geology Lecture Theatre of the University at 8 p.m. on Monday, 28th November, 1921.

The President, Mr. C. T. White, F.L.S., in the chair.

The minutes of the previous monthly meeting were read and confirmed.

Dr. A. J. Sawyer was nominated for Ordinary Membership.

Mr. J. H. Reid was elected as an ordinary member.

Dr. J. Shirley, F.M.S., exhibited specimens of Arcidae from the following localities:—Arca mosambicana Bianconi, Solomon Islands; A. nigra Lamy, Moreton Bay, usually reported as A. tenebrica; A. scapha, Moreton Bay; A. vellicata Reeve, Elliot River. All these shells formed part of the collection of the late Dr. May, of Bundaberg, and were determined by Mons. Lamy of the Museum of Natural History, Paris.

Mr. H. A. Longman, F.L.S., exhibited the type specimen of Nyctimene tryoni, a new species of Megachiroptera, secured by Mr. D. Lahey at Canungra, South Queensland, and described in the Memoirs of the Queensland Museum, vol. vii, part 3. The occurrence of this tubular-nosed bat so far south of previous records for the genus was of special interest.

Mr. C. T. White, F.L.S., exhibited specimens of Hedypnois polymorpha Linn., a Mediterranean plant found as a naturalised alien near Brisbane by Mr. F. F. Coleman; Cichorium intybus Linn., the Chicory, and Carthamus lanatus Linn., the Saffron Thistle, both naturalised in Queensland for some years past but only now showing a tendency to become bad weeds; and Lamium amplexicaule Linn., Henbit or Dead Nettle, with which feeding experiments have recently been conducted in New South Wales showing the plant to be capable of causing the disease popularly known in Australia as "Staggers" or "Shivers." As yet the last-mentioned example is not a very common weed in Queensland.

Professor T. Harvey Johnston, M.A., D.Sc., read a paper by himself and Miss M. J. Bancroft, B.Sc., entitled "The Freshwater Fish Epidemics in Queensland Rivers." Dr. Shirley, Hon. A. J. Thynne, and Messrs. Longman, Sylow, and Alexander discussed the paper.
Publications have been received in exchange from the following Institutions and Societies, and are hereby acknowledged.

AFRICA.
Durban Museum, Durban.
Government of the Gold Coast.

AMERICA.

Brazil—
Instituto Oswaldo Cruz, Rio Janeiro.
Museu Paulista Sao Paulo.
Ministerio da Agricultura Industria and Commercio, Rio Janeiro.
Servio Geologio e Mineralogico de Brazil, Rio Janeiro.

Canada —
Department of Mines, Ottawa.
Department of Agriculture, Ottawa.
Royal Canadian Institute, Toronto.
Royal Society of Canada, Ottawa.

United States—
American Academy of Arts and Sciences, Boston.
American Museum of Natural History, New York City.
Boston Natural History Society, Boston.
Californian Academy of Science, San Francisco.
Department of Commerce and Labour, New York.
Field Museum of Natural History, Chicago.
Geological and Natural History Society of Minnesota, Minneapolis.
Librarian Ohio State University, Columbus.
Missouri Botanic Gardens, St. Louis, Missouri.
National Academy of Science and Smithsonian Institute, Washington.
University of California, Berkeley.
University of Minnesota, Minneapolis, Minnesota.
University of Illinois, Urbana.
University of Kansas, Lawrence.

Oceania—
Bernice Pauahi Bishop Museum, Honolulu, Hawaii Islands.

Mexico—
Instituto Geologico de Mexico, Mexico.
Sociedad Cientifica.
PUBLICATIONS RECEIVED.

ASIA.

India—
Director Agricultural Institute, Pusa, Bengal.
Board of Scientific Advice for India, Calcutta.
Director Geological Survey of India, Calcutta.

Java—
Department van Landbrouw.
Koninklyke Natuurkundige.

Philippine Islands—
Librarian Bureau of Science, Manilla.

AUSTRALASIA AND NEW ZEALAND.

New Zealand—
Auckland Institute, Auckland.
Dominion Laboratory, Wellington.
Geological Survey of New Zealand, Wellington.
New Zealand Institute, Wellington.
New Zealand Board of Science and Art.

Queensland—
Department of Mines, Brisbane.
Field Naturalists' Club, Brisbane.
Geological Survey of Queensland.
Government Statistician, Brisbane.
Queensland Museum, Brisbane.

New South Wales—
Australian Museum, Sydney.
Director of Botanic Gardens, Sydney.
Department of Agriculture, Sydney.
Geological Survey of New South Wales, Sydney.
Linnean Society of New South Wales, Sydney.
Naturalists' Society of New South Wales, Sydney.
Royal Society of New South Wales, Sydney.
University of Sydney.

South Australia—
Geological Survey of South Australia, Adelaide.
Public Library of South Australia, Adelaide.
Royal Society of South Australia, Adelaide.

Tasmania—
Geological Survey of Tasmania, Hobart.
Field Naturalists' Club, Hobart.
Royal Society of Tasmania.

Victoria—
Advisory Council Science and Industry, Melbourne.
Australasian Institute of Mining Engineers, Swanston Street, Melbourne.
Commonwealth Statistician, Melbourne.
Field Naturalists' Club, Melbourne.
Department of Fisheries, Commonwealth, Melbourne.  
Field Naturalists' Club of Victoria, Melbourne.  
Royal Society of Victoria, Melbourne.  
Scientific Australian, Melbourne.

Western Australia—
Geological Survey of West Australia, Perth.  
Royal Society of West Australia, Perth.

Europe.

Belgium—
Société Royale, de Botanique de Belgique.  
Academie Royale, Brussels.  
Jardin Botanique, Brussels.  
Institut de Sociologie Solvay, Belgium.

England—
Cambridge Philosophical Society, Cambridge.  
Conchological Society, Blackpool.  
Literary and Philosophical Society, Manchester.  
Royal Botanic Gardens, Kew, London.  
Royal Colonial Institute, London.  
Royal Society of London.  
British Museum, London.  
Imperial Bureau of Entomology, London.

France—
Institut de Zoologie de l'Université de Montpellier.  

Italy—
Laboratoria Zoologia Generale di Agraria.  
Società Africana d'Italia, Naples.

Portugal—
Academia Polytechnica, Porto.

Roumania—
Institute Meteorologie Central.

Scotland—
Royal Society of Edinburgh.

Spain—
Academia Real de Ciencias, Madrid.  
Academia Real dell Ciencias y Artes, Barcelona.  
Junta Para Ampliacion de Estudios, Madrid.

Switzerland—
Naturforschende Gesellschaft, Zürich  
Société de Physique et d'Histoire, Geneva.
List of Members.

CORRESPONDING MEMBERS.

‡Danos, Dr. J. V.  Consulate-General for Czecho-Slovakia, Sydney.
David, Professor Sir T. W. E., F.R.S.  The University, Sydney, N.S.W.
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