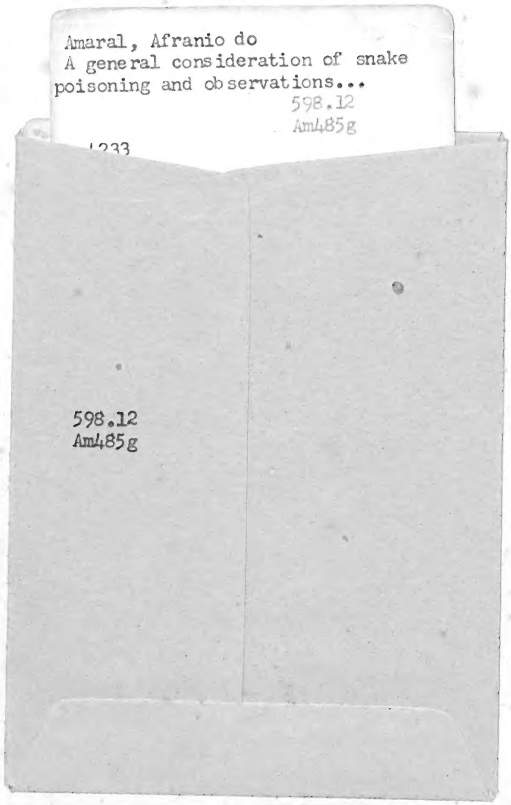
HARVARD INSTITUTE FOR TROPICAL BIOLOGY AND MEDICINE

A General Consideration of Snake Poisoning and Observations on Neotropical Pit-Vipers

AFRANIO DO AMARAL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CONTRIBUTIONS FROM THE HARVARD INSTITUTE FOR TROPICAL BIOLOGY AND MEDICINE, II

A General Consideration of Snake Poisoning and Observations on Neotropical Pit-Vipers

BY

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PREFACE

When Dr. Amaral returned rather hurriedly to Brazil in August 1924 he left several manuscripts in my hands. I have combined these into a series since all pertain to more or less related subjects. To this series I have added a portion of Dr. Amaral's thesis which seems to me the most concise and satisfactory general statement of the principal points of interest concerning snake poisoning that has yet appeared. As such it may give this volume a wider appeal than were it composed of the concluding portions — dealing with the Brazilian pit-vipers — alone.

These studies were carried on in the Herpetological Laboratory of the Museum of Comparative Zoölogy and in the Harvard School of Public Health.

T. B.

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Snake Poisoning

Snakes which may cause serious accidents are provided with fangs in the anterior maxillary region; such are the *Solenoglypha* and the *Proteroglypha*. The *Opisthoglypha*, however, may be considered practically harmless, as their fangs are placed near the angle formed by the mouth opening, and therefore in an unfavorable position for biting. These teeth are, besides, ill-formed for the inoculation of the poison.

From the systematic point of view, the *Solenoglypha* belong to the family *Viperidae* (subfamilies *Viperinae* and *Crotalinae*) and the *Proteroglypha* to the family *Colubridae* (subfamilies *Hydrophiinae* and *Elapinae*).

Viperidae. The *Viperidae* are distributed over the entire world. We may designate them according to the nomenclature used by the Butantan Institute for Brazilian species and also that used in the "Catalogue of Snakes in the British Museum," of G. A. Boulenger, for species from other countries. The following are most important, and deserve special notice (each will be given its scientific name and also the popular name of the region in which it is most prevalent).

America. *Ancistrodon contortrix*, the copper-head, and *A. piscivorus*, the water-moccasin; *Lachesis muta*, the bushmaster or surucucú; *Bothrops alternata*, the urutú or "vibora de la cruz" (cross viper); *B. lanceolata*, the "fer-de-lance"; *B. atrox*, the caiçaca; *B. jararacussu*, the jararacussú; *B. jararaca*, the jararaca; *B. neuwiedii*, the white-tail jararaca; *B. bilineata*, the surucucú de patioba; and *B. ammodytoides*, the yarará ñata or cenicienta; *Sistrurus miliarius*, the ground or pigmy rattlesnake, and *S. catenatus*, the massasauga; *Crotalus terrificus*, the dog-faced rattlesnake, cascavel, boissininga or boiquira; *C. adamanteus*, the diamond rattlesnake; *C. horridus*, the banded rattlesnake; and *C. confluentus*, the prairie rattlesnake.

Asia. *Vipera russellii*, the daboia; *Echis carinatus*, the phoorsa or saw-viper; *Ancistrodon blomhoffii*; *Trimeresurus gramineus*, the green pit-viper, and *T. flavoviridis*, the habu.

Africa. *Causus rhombeatus*; *Bitis arietans*, the puff-adder; *Cerastes cornutus*, the horned viper; and *Echis carinatus*.

Colubridae. Among the *Colubridae*, note may be made of the following:

America. *Micrurus*[1] *fulvius*, the harlequin snake; *M. coralinus*, *M. frontalis*, and *M. marcgravii*, or coral snakes.

Asia. *Naja naja*, the cobra; *N. bungarus*, the king cobra, hamadryas or skull-breaker, the largest poisonous snake known, measuring sometimes 5 meters in length; *Bungarus candidus*, the common krait; *B. fasciatus*, the banded krait.

Africa. *Naja haje*, the Egyptian asp, and *N. flava*.

Oceania. *Diemenia textilis*, the brown snake; *Pseudechis porphyriacus*, the black snake; *Denisonia superba*, the copperhead (of Australia); *Notechis scutatus*, the tiger snake; *Acanthopis antarcticus*, the death-adder.

Europe. *Vipera berus*, the European viper.

Besides the above mentioned *Colubridae*, which are land species, there are the water species (subfamily *Hydrophiinae*), e. g., *Platurus* and *Enhydrina*, which are found in several zones of the Pacific and Indian Ocean and are deserving of notice.

Poison Glands. The poison is the secretion from the supra-labial glands of the Ophidians. These glands are found on either side of the head below and back of the orbit, corresponding to the parotid glands of the mammals.

The poison gland, properly defined, is classed with the serous glands, although the secretion contains a great deal of mucous substance expelled from cells existing in the excretory canal close to its termination, and from more or less abundant alveoli surrounding the same. Its dimensions, which are generally in proportion to the size of the snake, and are relatively larger in the American and Asiatic species than in the European, sometimes reach considerable proportions, as observed, for example, in the species of the genus *Doliophis*, whose glands extend to the precordial region. The gland is surrounded by a fibrous capsule

[1] N.B. *Micrurus* as the earlier name must replace the more commonly used *Elaps*.

which represents a prolongation of the zygomatic ligament, and which divides it into various segments (or lobes) receiving fibers from the anterior and median temporal muscles (Weir Mitchell). It is placed in such a manner in the muscles that when these contract in the act of biting, its contents are synergically expelled.

The excretory canal emerges from the gland, travels in an upward direction, then forward, and then turning downward, opens abruptly through a small papilla on the anterior wall of a mucous membrane, which in the *Solenoglypha* involves the base of the fangs; before its terminal it may have small muscular fibers, originating from the internal pterygoid muscles, as observed in *Crotalus*, or a true non-striated muscle, as is the case with *Hydrophiinae*. These fibers, besides probably serving as a sphincter, always insure perfect connection with the base of the fang.

The fangs, which are appended from the anterior part of the maxilla, have a groove or lumen in the anterior or anterointernal part, extending longitudinally, or always have a perfect canal (as in the *Solenoglyphae*), through which the poison runs. When there is a complete canal the orifice of excretion is near the tip of the fangs, and varies a good deal in size. It is relatively much larger in the *Viperidae* than in the *Colubridae*.

The fangs and the different bones in relation to them are quite movable in the *Viperidae*, being controlled by various muscles, so that when the muscles are contracted for the bite, the fangs come forward automatically, projecting themselves from the maxilla and returning immediately to their resting position solely by the relaxing of the muscles. This movement of maxilla and fang does not take place in the colubrine forms.

The Poison. *Characteristics.* — The poison is a thick liquid, either clear or slightly milky, colorless or more or less yellow, is neutral or slightly acid, of an average specific weight of from 1.030 to 1.050, reaching sometimes 1.110 (C. J. Martin and G. Lamb), and yields approximately from 25 per cent to 50 per cent of solid matter after desiccation. When desiccated it becomes crystalloid in more or less elongated laminae, which are always soluble in a solution of sodium chloride at 0.8 per cent to

1.5 per cent, and in most cases soluble in distilled water also; some are insoluble in water, however, as for example, among others, the *B. jararaca, B. jararacussu, B. atrox, Micrurus frontalis* and *M. corallinus* are only slightly soluble in distilled water. The poison may be obtained either by compression of the gland or by the spontaneous bite of the snake.

The quantity of the secreted poison varies according to each species. Generally, the larger the snake the larger the quantity of poison. There are exceptions to this rule; among others, for example, the *Hydrophiinae* secrete very little poison in relation to their size. The *Crotalus terrificus* secretes less and less poison as it grows older, the individuals of medium age being richest in poison. On the other hand, captivity exercises a noticeable influence on the secreting activity of the glands, retarding and even enervating them. This is principally the case when snakes are submitted to the constant extraction of poison.

G. Lamb has proved that the amount of poison emitted by spontaneous bite is larger than that obtained by compression of the gland; thus, an Indian *Naja* produced in the first instance 373 mg. of desiccated poison, whereas only 231 mg. were obtained by compression.

For medium-sized individuals it may be said that the following is the approximate quantity of dry poison produced by the different species:

Enhydrina valakadien	6 mg.
Cerastes cornutus	25 mg.
Crotalus terrificus	30 mg.
Notechis scutatus	35 mg.
Pseudechis porphyriacus	
Lachesis neuwiedii	
Ancistrodon contortrix	45 mg.
Bothrops jararaca	60 mg.
Bothrops atrox	100 mg.
Crotalus confluentus	
Ancistrodon piscivorus	150 mg.
Bothrops alternata	165 mg.
Vipera russellii	200 mg.
Crotalus adamanteus	240 mg.
Bothrops jararacussu	330 mg.
Lachesis muta	350 mg.

These figures serve as a very valuable indication for the treatment of accidents by specific serum, as the doses of the specific serum should be proportional to the amount of poison inoculated in each case.

Toxic Activity. The toxic activity of snake poison varies with every species of snake and also varies in relation to the animal on which experiments are made. It also varies with the method of introduction employed. The toxic activity is, generally, much greater when the poison is injected intravenously than by any other manner and gives more accentuated results in homeothermic than in poikilothermic animals. This variability, sometimes enormous, depends upon the proportion in which the various active principles participate in the composition of the poison, and on the reacting qualities of each animal.

There is even a certain difference in toxic activity upon the animals which serve as the usual food for the snakes; thus, for example, the poison of the *Hydrophiinae*, which are piscivorous, is very active to fish; that of the *Micrurus* (*Elaps*), which are generally ophiophagous, is very active toward other snakes. The poison of the *Bothrops insularis*, a Brazilian species which the author has lately studied, which is exclusively tree-living and avivorous, has an instantaneous effect on birds, and is powerfully active for fowls in general.

The table on page 8 is a comparative index of the minimum lethal doses of the venom of the more common snakes for two very sensitive animals, the pigeon and the rabbit. The venom was inoculated through a venous channel and the results are in accordance with those obtained by various workers.

Resistance. Poisons, because of their reactions, should be classified with protein substances. Certain reagents, such as nitrate of silver, caustic soda and potash, and to a certain extent, gold chloride, permanganate of potash, and others, can annul the toxic power. Treated by heat, the venoms may lose their toxic power at widely different temperatures, varying from 65° C., as is the case of the *Bothrops alternata* (V. Brazil), to 100° C., as is generally the case with the poison of *Hydrophiinae* (H. Noguchi), or even 120° C., as is the case of *Lachesis muta* (V. Brazil and B. R. Pestana).

Comparative Index of Minimum Lethal Dose of Various Venoms on Pigeons and Rabbits

	Species of venom	DML in. Mg.	Worker
Pigeons (venous channel)	*Crotalus terrificus*	0.001	V. Brazil
	Bothrops insularis	0.004	A. Amaral
	Lachesis muta	0.007	V. Brazil
	B. atrox	0.010	V. Brazil
	B. neuwiedii	0.015	V. Brazil
	B. alternata	0.017	V. Brazil
	B. jararaca	0.020	V. Brazil
	B. jararacussu	0.020	V. Brazil
	Micrurus frontalis	0.070	V. Brazil
Rabbits (venous channel)	*Bungarus candidus*	0.040	G. Lamb
	Bothrops insularis	0.050	A. Amaral
	Enhydrina valakadien	0.050	L. Rogers
	Notechis scutatus	0.060	F. Tidswell
	Bothrops atrox	0.070	V. Brazil
	Vipera russellii	0.075–0.100	G. Lamb
	Bothrops neuwiedii	0.100	V. Brazil
	Crotalus adamanteus	0.200	H. Noguchi
	C. terrificus	0.250	V. Brazil
	Bothrops alternata	0.300	V. Brazil
	B. jararacussu	0.300	V. Brazil
	B. jararaca	0.310	V. Brazil
	Naja bungarus	0.350	G. Lamb
	Naja naja	0.250–0.500	A. Calmette
	Micrurus frontalis	0.500	V. Brazil
	Bungarus fasciatus	0.700	G. Lamb
	Lachesis muta	3.000	V. Brazil

The loss of the toxic qualities of the venom does not depend entirely on the coagulation of the proteins, for some poisons, such as *Crotalus terrificus* and *Lachesis muta*, which coagulate at 65° C. and 80° C., respectively, are only inactive above 100° C., thus indicating that in the normal composition of some poisons there are certain principles which have greater resistance against heat.

Cold and desiccation have little effect on the toxic power of the poison; electricity and radium (M. Phisalix), on the other hand, weaken and then destroy it.

The higher the percentage of albumin contained in the poison the more it will be weakened by dialysis. When filtered through a porcelain filter it leaves as a residue some of its composing elements and thus more or less diminishes in toxicity. The gastric digestion affects the activity of the poison of some species of *Crotalus*, but not that of the *Vipera*, *Naja*, and *Pseudechis*; all venoms, on the contrary, are modified by pancreatic digestion.

Glycerin is entirely harmless to the poison, serving therefore as an excellent means for conservation.

Some poisons, especially that of certain species of *Crotalus*, have the property of changing into toxoides, losing their toxophorous properties under the influence of certain reagents such as gold chloride in a weak solution and also iodin tri-chloride.

Chemical Composition. The researches of Edwin Faust, which have not yet received general acceptance, are interesting. He claims to have obtained from the poison of the Indian cobra, *Naja*, the separation of a non-albuminous substance which he called *ophiotoxin*, an active principle, and he afterwards obtained the same from the *Crotalus adamanteus*, which he called *crotalotoxin*. Very little has been definitely ascertained, with the exception of this study, as to the chemical composition of the poisons. Charles J. Martin and George Lamb have considered the venoms a mixture of substances, the proportions varying with every species. The following substances were found: (1) a powerful fibrin ferment; (2) an anti-fibrin ferment; (3) a proteolytic ferment; (4) various cytolysins capable of acting on the red cells, the leucocytes, the endothelial cells of the blood vessels, the nerve cells, as well as the cells of several other tissues. There were also cytolysins of the nature of amboceptors, which were probably distinct for each variety of cell. (5) Agglutinins for the red blood cells; (6) an anti-bactericidal substance of the nature of an anti-complement; (7) neurotoxin or neurotoxins with special affinity for the nerve cells and particularly for the respiratory center (these special affinities vary according to each poison); (8) a neurotoxin with affinity for the nerve terminations of the muscles and particularly for those of

the diaphragm; (9) a substance which reinforces the cardiac tonus and which, when sufficiently concentrated, causes the isolated heart to stop in systole. This substance is also capable of producing a stimulating action on the muscular fibers of the arteries.

According to these authors, all these various substances do not occur conjointly in each poison, nor are they found in fixed proportions. Thus it is that they explain the great variability of symptoms in snake-venom intoxication caused naturally or through experiments, on man or animals.

Edwin Faust, analyzing the *Naja naja* poison, found the following well-defined elements: (1) albumin which coagulates with heat (albumin, globulin); (2) albumins non-coagulative by heat (albumose and peptone); (3) mucin and substances pertaining to the same group; (4) ferments; (5) fat; (6) formed elements such as epithelium of the glands of the buccal cavity and epithelial detritus; (7) microörganisms, found only occasionally; (8) salts, chloride and phosphate of calcium, magnesium and ammonium.

Physiological Action. It has been verified that the poisons exercise different actions on the cells, tissues, and liquids of the organism, as well as upon various biological phenomena. The most important of these are the following:

(a) *Neurotoxic Action.* The characteristic action of this portion of the poisons is upon the respiratory center of the medulla.

As a rule, the poison of the *Proteroglypha* (*Colubridae*) is more neurotoxic than that of the *Solenoglypha* (*Viperidae*), and mention should be made of the following as being exceptionally powerful from this point of view: the *Pseudechis porphyriacus, Notechis scutatus, Enhydrina valakadien, Acanthophis antarcticus, Bungarus candidus, B. fasciatus* and *Naja naja.* There is also a species among the *Viperidae, Crotalus terrificus,* the poison of which is strongly neurotoxic having a selective action causing abolition of the visual function, and also causing paralysis of respiration. These peculiarities are non-existent in the other types of this family which have been studied, though their poisons may have a somewhat neurotoxic action.

Certain poisons, such as that of *Naja naja, N. bungarus, Bungarus candidus, B. fasciatus,* and *Enhydrina valakadien,* have a neurotic action which has an inhibitory influence upon the nerve termination of the muscles, especially the termination of the phrenic nerve of the diaphragm, as does curare. This action, however, is entirely independent of that exercised on the respiratory center, inasmuch as there are poisons, such as that of the *Notechis scutatus, Pseudechis porphyriacus, Vipera berus,* and *Crotalus adamanteus,* which produce inhibitory bulbar action yet do not cause diaphragmatic inhibition.

(b) *Agglutinant and hemocytolytic action* are caused by two diverse principles in which the agglutinant, which is destroyed by a temperature of 75° C., may be the same for the red cells and the leucocytes, the hemolytic principle being, however, entirely distinct from the hemocytolytic (S. Flexner and H. Noguchi). According to C. Delezenne, hemolytic action would be produced in an indirect way; when in contact with the blood, *in vitro* or *in vivo,* the poison acts on the serum as a diastase, causing the liberation of a substance which then produces the hemolysis.

Sometimes the *Colubridae* poison is more hemolytic than that of the *Viperidae.* Among the first mentioned the most active *in vivo* is that of the *Pseudechis porphyriacus* and *in vitro* that of the *Naja haje.* Among the Brazilian species, the most hemolytic are the venoms of the *Lachesis muta* and *Bothrops jararacussu.* The poison of the *Micrurus frontalis* (*Colubridae*) does not follow this rule, as there is relatively little hemolytic action (V. Brazil and B. R. Pestana).

This hemolytic property does not in any way correspond to the toxic property, but frequently deviates from it, as demonstrated by many workers, among others, L. Rogers, who examined and established a comparison between the poisons of the *Enhydrina valakadien* and that of the *Naja naja.*

(c) The *cytolytic action* in general affects all animal cells, including those of the nervous system, the spermatozoa and ova of poikilothermic animals, and even certain microörganisms, according to observations made by S. Flexner, H. Noguchi, A. Calmette and F. Noc.

In the light of modern bacteriology this bacteriolytic action does not appear to be direct, but the poison acts on the culture medium, and the medium, influenced by this poison, changes its composition and reaction, becoming unsuited to germ life. Acting so extensively, the cytolysins constitute a very complex group, to which may be added the so-called "hemorragins" and neurotoxins, as well as the erythrocytolysins and leucocytolysins.

S. Flexner and H. Noguchi ascertained that the *Vipera russellii* poison is very cytolytic and that of the *Crotalus adamanteus* only slightly cytolytic, while that of the *Ancistrodon piscivorus*, *Naja naja*, and *Trimeresurus flavoviridis* is in an intermediate grade.

(d) The *proteolysins* contribute, as do cytolysins, to the destruction of cells. The action of the two combined may cause a destruction of the endothelial cells of the blood vessels, and this explains perfectly the sometimes generalized hemorrhages and destruction of the tissues which produce more or less extensive gangrene. This occurs in the intoxication by certain poisons, notably that of *Lachesis*.

The proteolytic action of the poisons manifests itself on gelatin, casein, fibrin, the sero-albumin, and other proteins, but it is less general and intense than that of trypsin. B. Houssay and J. Negretti observed that it is most active in neutral or weakly alkaline media and that it is independent of the toxic, agglutinative, hemocytolytic and other properties. The proteolytic action is accentuated in the poison of *Lachesis*, *Ancistrodon* and *Crotalus adamanteus*, and is very slight in that of the *Naja naja*, *Micrurus marcgravii*, and *Crotalus terrificus*. The above authors determined that proteolytic poisons, acting on dissolved proteins, produce dyalizable biuret substances and also amino acids.

(e) *Blood-coagulating Action.* The action of the poisons in this particular may be considered very variable. Some poisons provoke and greatly accelerate coagulation; others, on the contrary, retard or completely stop it. The general rule is, however, that the poison of the *Viperidae* causes more accentuated

coagulation than that of the *Colubridae*, many of the latter having even an anti-coagulant action.

B. Houssay and A. Sordelli, recently studying the coagulating action of poisons of the *Naja naja, Micrurus marcgravii, Vipera russellii, Ancistrodon piscivorus, A. contortrix, Trimeresurus flavoviridis, Bothrops alternata, B. neuwiedii, B. ammodytoides, B. atrox, B. jararaca, B. jararacussu, Crotalus terrificus*, and *C. adamanteus*, verified previous observations that these poisons exercise a strong effect on the cytozyms, and therefore impede the formation of thrombin; for this reason all would be anti-coagulant, if it were not for the fact that some poisons also possess thrombin properties which coagulate the fibrinogen. Among the anti-coagulants, that is, poisons not possessing the thrombin property, are placed that of the *Naja naja, Micrurus marcgravii, Ancistrodon piscivorus, A. contortrix, Trimeresurus flavoviridis*, and *Crotalus adamanteus*; and among the coagulants, e. g., those that possess the thrombin property are listed that of the *Vipera russellii, Bothrops alternata, B. ammodytoides, B. atrox, B. neuwiedii, B. jararaca, B. jararacussu*, and *Crotalus terrificus*.

(f) *Diastatic Action.* In 1884, J. B. de Lacerda attributed the toxic effects of poisons to the contained diastase. To-day, however, it has been verified that venoms are destitute of amylolytic properties, do not break down the glycosides nor invert saccharose, having, however, lecithinasic properties, principally in the presence of calcium salts or normal serum (B. Houssay, J. Negretti).

The lipolytic action which Neuberg and Rosenberg determined for the poison of *Naja, Ancistrodon*, and *Crotalus*, in relation to lecithin, to olive and castor oil, is very weak. It may be considered of slight importance in all of the poisons.

(g) The *anti-bactericidal* action was first noted by Weir Mitchell, who was surprised by the rapid decomposition which takes place in animals killed by poison, and the facility with which secondary infections occur in those that by chance resist the ophidic intoxication. W. Welch and C. B. Ewing discovered the real cause of this phenomenon, which they con-

sidered as being due to the anti-bactericidal action of the poison. Minute investigations have been made regarding this property by S. Flexner and H. Noguchi. They determined it to be the fixation or inactivation of bacteriolytic complements, which in turn might be brought about either by the amboceptor (F. Noc) or by the poison's own proteolytic ferment (H. Noguchi).

It is the writer's opinion that this anti-bactericidal property may cause erroneous interpretations as to the activity of certain poisons whose effects may be delayed. The animal may be inoculated with a dose, which may sometimes favor the development of secondary infections, in this way bringing about the death of animals on which experiments are made. In estimating the toxicity of a venom, those working on this question should always keep this possible source of error in mind.

Channels of Penetration. In the act of biting, the poison is practically always introduced into the subcutaneous tissues or the muscles, penetrating rapidly to the circulation, either through the blood capillaries or directly through the tissues, which it easily infiltrates, because of its affinity for them. Its absorption is rapid through the conjunctiva (*Lachesis* poison) and slow through the serous cavities. No absorption occurs by digestive channels if there is no break of continuity in the mucosa.

When a suitable dose is directly introduced into the circulation, as may be easily observed experimentally, but as rarely occurs by the natural bite, the poison immediately produces symptoms of intoxication and sometimes instantaneous death.

These facts are of great importance in considering the conditions to be observed in treatment in the case of ophidic accidents.

Types of Poisoning. On account of the variability in composition of the poisons of different species, these poisons produce varying intoxications in man. It is safe to say, however, that as a rule, in cases of bites by the *Colubridae*, the local symptoms are less pronounced than in the case of bites by *Viperidae*. Among the exceptions to this rule, is the poison of *Crotalus ter-*

rificus (*Viperidae*) which produces very few local phenomena. On the contrary, the poison of the *Notechis scutatus, Pseudechis porphyriacus*, and other Australian species of the *Colubridae* occasion, at times, very accentuated local reactions, such as edema, lacerations, and mutilation.

The more or less special symptoms produced by the bites of some important species may be discussed in some detail.

NAJA NAJA. This venom produces an intense local burning sensation, edema and congestion; prostration and somnolence; salivation, nausea and vomiting; cold sweats; accelerated and thread-like pulse; rapid respiration at first, which later becomes weaker and slower. Difficulty of speech occurs; muscular paralysis progresses by degrees; and sometimes hemorrhages occur through the mucosa. If the dose of poison is not sufficient to cause accentuated paralysis, the patient will recover, and the general symptoms disappear rapidly. If the contrary has occurred, the patient dies from respiratory paralysis, the heart action continuing a short time. Albuminuria is never seen.

Similar symptoms of intoxication are caused by *Enhydrina valakadien* poison, with the difference, however, that in this case the local reaction is not severe. There are no hemorrhages, and death occurs after respiratory convulsions.

BUNGARUS CANDIDUS. Intoxication due to the poison of this species is responsible for a great number of deaths in India. This intoxication manifests itself on the nervous centers and especially on the respiratory center. Respiration becomes difficult and stertorous, there is no apparent local reaction, and the patient remains in a subconscious state until death takes place.

BUNGARUS FASCIATUS. Death occurs as a result of paralysis of the respiratory center. This occurs after two or three days or in some cases after a longer period — six or more days — being preceded by anorexia and general depression, loss in weight, muscular weakness, emaciation, oliguria, and other symptoms of slow intoxication.

MICRURUS FULVIUS, MARCGRAVII, and FRONTALIS. No local

phenomena occur other than pain, which is intense. General phenomena are severe, consisting in depression and somnolence, trembling and convulsions, and especially, in case of *Micrurus frontalis* poisoning, salivation, and lacrimation. In these cases death comes on by collapse.

VIPERA RUSSELLII. Characteristic features are a strong local reaction, developing ecchymosis, and hemorrhages. There are also accentuated general phenomena, consisting principally in a tendency to collapse, rapid and thread-like pulse, nausea, vomiting, pupillary dilation, and loss of consciousness. If the patient resists immediate death, the local edema spreads rapidly; there are hemorrhages at the point of the bite or into the mucous membranes; hematuria and albuminuria occur, and finally anemia and intense emaciation, causing death. In these cases no signs of intoxication of nerve centers are found.

BOTHROPS JARARACA, JARARACUSSU, ATROX, NEUWIEDII, ALTERNATA, and TRIMERESURUS FLAVOVIRIDIS. Formidable reaction occurs, consisting in immediate edema, spreading rapidly, glandular reactions, serosanguinolent sub-epidermic infiltrations, terrible pains, ecchymosis, and hemorrhages at the point of the bite. Later, because of the action of the poisons upon the tissues in general and especially upon the proteins of the red cells and upon blood coagulation, general symptoms appear, consisting of parched throat, thirst, congestion, and hemorrhages (except in case of poisoning by *T. flavoviridis*). These hemorrhages occur through ocular, buccal, gastric, intestinal, and vesical mucosa, or even through the skin. Albuminuria also supervenes. Finally the patient becomes completely exhausted, the body temperature falls, and death takes place.

When death does not occur, the gangrene of the tissues in the part of the body which has been bitten progresses until complete necrosis and mutilation occur.

The poisons of *Bothrops* have no manifest effect on the nervous system, except that of *L. jararacussu*, which always causes impairment of the sight, and that of the *T. flavoviridis*, which causes paralysis of respiratory centers.

Crotalus adamanteus. This venom causes local pain and hemorrhage; edema and discoloration of the bitten part, which gradually becomes ecchymotic and covered with phluctenulae; gangrene may occur. General symptoms are apparent almost immediately. The most important are extreme prostration, cold sweats, nausea, vomiting, and sometimes diarrhea, weak and quickened pulse, and, later, dyspnea and repeated collapse, until death takes place.

Crotalus terrificus. There is practically an entire absence of local phenomena in the case of poisoning by this venom. Impairment of the visual function or even absolute blindness may occur, lasting from a few minutes to several days, even after the patient has recovered through treatment or spontaneously. In the later stages there is the impairment or a true paralysis of locomotion, then, of the respiratory muscles, and finally, death.

Summary. We may conclude from the above that each poison causes its peculiar reaction, according to the amount of neurolytic, proteolytic, cytolytic, hemolytic, and coagulant principles contained, giving it a specific character which contributes to the formation of correspondent anti-bodies. Nevertheless, there are certain similarities between the venoms, principally when the snakes which produce them belong to related species or genera.

Death Rate. The death rate caused by snake bite varies in the several geographical regions according to the greater or less aggressiveness or activity of the snakes and the poison of the species to be found in each region. In an article published on this subject in 1910, R. L. Ditmars states that 20,000 to 25,000 deaths occur annually in India due to ophidic accidents. According to H. Noguchi, there were 14 fatal cases of poisoning in Europe during nine years (1883–92), caused by *Vipera berus*, and from 1898 to 1906 there was registered in Okinawa Island an annual average of 225.3 persons bitten by *T. flavoviridis*, with a death rate of 15 per cent. In São Paulo (Brazil) the Butantan Institute has been able to obtain complete statistics of the accidents which have occurred in the state. The number

of fatal accidents during the year 1907 reached 155, that is, 2.6 per cent of the total mortality from all causes. Since then, with the widely distributed use of anti-poison serums, this percentage has diminished rapidly, so that now there are but two, three, or four deaths a year.

In regard to fatal snake-bite accidents in other regions it is not possible to make even an approximate estimate, as there are no statistics on this subject. Calculations seem to indicate that the number of fatal accidents in the rest of the world amount to from 5,000 to 10,000 annually (excepting India).

Treatment. The methods of treatment of ophidic accidents may be divided into specific and non-specific.

Non-specific Treatment. Among the innumerable non-specific methods which have been recommended, one may quote the following:

(1) Those methods which attempt to free the injured part of the body from the poison which has been inoculated.

(2) Those whose purpose it is to impede the penetration of the poison into the circulation.

(3) Those methods that attempt to destroy the poison *in situ*.

Incision and suction by mouth, or application of cupping, — simple or following scarification, — belong to the first group. These methods do not produce appreciable results, however, because the poison, having great affinity for cell elements, fixes itself rapidly and cannot be extracted mechanically.

The ligature applied above the point of the bite is the principal process of the second method of treatment. Though recommended by a great number of observers, especially before scientific therapy was introduced, ligatures are not practical; first, because they do not prevent the poison spreading by infiltration through the tissues and thus reaching the center of the body; second, because the resulting prevention of circulation very often produces serious results. When the ligature is applied for a long time, as is usually the case, it may contribute in causing gangrene of the tissues, thus accentuating the destructive effects of the proteolytic and cytolytic qualities of the poison.

Thermo-cauterization of the part and injections of neutralizing or reducing substances, such as permanganate of potash, chromic acid, gold chloride, and other chemical substances, form the third group of non-specific methods of treatment.

Thermo-cauterization may practically be considered as inefficient, since it can seldom be applied in time to prevent the symptoms of general intoxication.

Of the reducing substances, the most important is permanganate of potash, which was used for the first time by J. Fayrer and has been recommended highly by J. B. de Lacerda. In mild cases of poisoning the drug may produce slight benefit to the patient, but frequently it exercises a deleterious action on the tissues, since, in order to have any effect, the solutions must be administered in concentrations that are toxic for animal tissues. Experimenting with permanganate of potash, for instance, W. B. Bannerman found that when applied locally, a concentration of at least 5 per cent of this salt was required before it produced any effect upon the venom. At the same time it produced scar formation in the wound. He found that by intravenous injection, even a dilution of 0.5 per cent of potassium permanganate caused death, and concluded, therefore, that the process had no practical value.

Serum Treatment. The treatment by serum is the sole means of neutralizing the poisons and arresting the noxious action which their several toxic elements exercise on the tissues of the body.

At present it is generally admitted that the serum, to be highly efficient, must be produced by an animal immunized to the poison of the species of snake causing the particular accident, or at least a related species; that is, the anti-poison should be specific or nearly so. According to this principle, a variety of serums have been prepared by the Pasteur Institute of Lille and the Pasteur Institute of India, against *Naja naja* and *Vipera russellii*; by the Rockefeller Institute of New York, against *Crotalus adamanteus* and *Ancistrodon piscivorus*; by the Institute for Infectious Diseases of Tokyo, against *Trimeresurus flavoviridis*, and by F. Tidswell, against *Notechis scutatus*.

Vital Brazil, at the Butantan Institute in São Paulo, who specialized in this subject, has solved the problem of the treatment of accidents caused by the most important venomous species occuring in Brazil, especially in its meridional regions. He has produced four classes of serums: (a) anti-crotalic, to counteract *Crotalus terrificus*; (b) polyvalent anti-bothropic, to be used against *Bothrops jararaca, B. jararacussu, B. atrox, B. neuwiedii*, and *B. alternata*; (c) polyvalent anti-ophidic, which is both anti-crotalic and anti-bothropic; (d) anti-elapine, to be used against the *Micrurus* venom.

The Butantan Institute is far in advance of any other similar institute in this line of work. Vital Brazil and, later, J. Florencio Gomes have produced highly effective serums, due to the improvements which they have gradually introduced in the process of immunizing animals. The use of neutral mixtures (poison-anti-poison) for immunizing horses is the present practice at the Institute. For over five years the Institute has possessed ophidic antitoxins refined by the concentration process, having thus been able greatly to increase their therapeutic value.

Following the example of the Butantan Institute, the Bacteriological Institute of Buenos Aires in Argentina began work about five years ago on this question, and obtained a bivalent serum to counteract the *Crotalus terrificus* and *Bothrops alternata*, species predominating in that region.

There are three principal factors which influence the success of the use of anti-venom serums:

(1) Early administration.

(2) A mode of administration adapted to the gravity of the accident.

(3) Dosage proportional to the estimated quantity of poison inoculated in each bite.

In reference to the first factor, it is obvious that, as with other therapeutic serums, the sooner the anti-venoms are administered, the better will be the effects which they produce.

The subcutaneous and intramuscular methods of injection may serve in the majority of cases of snake-poison treatment,

but preference should be given to the intravenous channel whenever the case is of a dangerous character. When in doubt as to the gravity of the case, it is best not to hesitate, but to make the injection directly into the vein.

The doses of serum should be proportional to the toxic activity of the poison and also to the estimated quantity of poison inoculated by the snake. As has already been mentioned, the quantity of poison is greater in the larger species of snakes. The quantity of antitoxin may vary within certain limits, but should never be less than an average of 20 c.c. Even 100 c.c. or more of anti-venom may be given in special cases, as for example, in case of bite by the *Vipera russelli* or *Lachesis muta*.

Immediately after the accident it is necessary to ascertain what species of snake caused the bite or, at least, to verify the type of poisoning and obtain the specific serum. A dose capable of neutralizing all the poison should be administered at once through the channel deemed best at the moment. A period of expectation should follow, during which time it is necessary to watch the progress of the symptoms with great care, to determine whether they show a tendency to disappear or, on the contrary, to recrudesce. In case the symptoms become more pronounced, a greater dose should at once be administered by intravenous injection. When the anti-venomous sera are properly prepared and well administered they greatly reduce or entirely eliminate all cases of fatal accidents caused by snake bite, as demonstrated by the results that have actually been achieved in Brazil.

On the differentiation of the species *Bothrops atrox* (Linné, 1758), *B. jararaca* Wied, 1824), and *B. jararacussu* Lacerda, 1884

The most difficult problem in the differentiation of Neotropical snakes is that concerning the species which are commonly called "Echis" ("X"), "Fer-de-lance," "Barcin" and "Caissaca," "Jararaca" and "Yarará," and "Jararacussú" and "Yararaguassú" wherever they occur.

Such difficulty is due to the fact that those snakes are very closely allied to each other and that they may all occur at the same places. Besides, the various herpetologists who have dealt therewith have practically all examined only preserved specimens. These specimens, as a rule, very rapidly lose their color characteristics, which, of course, are among the main points on which their specific differentiation can be based.

Aware of that difficulty I have tried to examine the largest possible number of live specimens since 1920 when I first became engaged in this study. I have now examined 6,019 specimens belonging to the three above-mentioned species, which number is large enough to warrant a complete discussion of the matter.

Before going into further detail I must point out that I have come to the conclusion that the "Echis" of most of the Spanish-American countries, the "Fer-de-lance" of Martinique, the "Barcin" of Trinidad and the "Caissaca" of Brazil are all the same species, that is the *Bothrops atrox* (Linné, 1758). The "Jararaca" of Brazil and the "Yarará" of Argentina and Paraguay are both referable to the species *B. jararaca* (Wied, 1824). Finally, the "Jararacussú" of Brazil and the "Yararaguassú" of Argentina, Paraguay, and Bolivia must all be identified with *B. jararacussu* Lacerda, 1884.

I. Historical and Critical

1. The first reference to either one of these snakes after the consistent application of the binary nomenclature was inaugurated in zoölogy is that of the tenth edition of Linné — Systema Naturae, 1758. I: 222, No. 263. Linné, in referring to that No. 263, described the species now named *Bothrops atrox* as follows:

"*Coluber atrox*. o. 196–69. C. Amoen. Acad. I, p. 305, n. 35 Mus. Ad. Fr. 1, p. 33. t. 22. f. 2. Seba Mus. I. t. 43. f. 5.

"Habitat in Asia. Canus squamis carinatis. Caput depressum, angulatum squamis minimis."

In Linné — Mus. Reg. Ad. Frid. 1758, I: 33, t. 22, fig. 22, reference is found to two specimens figured as "*Coluber atrox*" but mistakenly named "*Coluber angulatus*" in the text where they are described as follows:

"Coluber scutellis abdominalibus 200 squamis caudalibus 70. Coluber scutellis abdominalibus 196, squamis caudae 67.

"Diagnoscitur facile a reliquis: capite angulato, supraplano, lateralibus compresso, imbricato, squamis omnibus; aequalibus minimis; longitudine vix pedali; colore cinereo; squamis carina elevata distinctis.

"Numerus scutorum parum differt.

A. abdominalibus 196 caud. 69 — ergo — 265.

B. abdominalibus 200 caud. 70 — ergo — 270."

Criticism. — Three points must be taken into consideration in Linné's publications as follows:

A. The wrong indication of the locality, viz., Asia instead of America.

B. The duplication of specific names as found in Mus. Ad. Fr. 1754: 53, viz., *angulatus* and *atrox*.

C. The change of figures concerning the scutellation of one of the specimens considered, viz., V. 196–C. 69 as in Syst. Nat. 1758 (X ed.): 222 and in Mus. Ad. Fr. 1754: 33, versus V. 196–C. 67 also in the latter paper and in Syst. Nat. 1748 (I ed.): 34.

1*a*. Lacépède, in Hist. Nat. des Serpents, 1789. 2: 80, 121, pl. 5, fig. 1, described the species *Coluber lanceolatus* as from Martinique and perhaps from Dominica and Cayenne.

He based his description on two specimens that have V. 228, and 225 and C. 61 and 59, respectively.

Criticism. — This species is very poorly figured in Lacépède's publication. It is a strict synonym of the Linnéan *atrox*.

2. The species "Jararaca" or "Yararâ" was described as *Cophias jararaca* by Wied, who first referred thereto in Isis, 1824. 2: 1103, pl. 6. It was afterwards described in more detail by Wied himself in Abbild. z. Naturg. Brasiliens. 1824: fasc. 7, its description being based on two specimens from E. Brazil that have V. 193 and 201 and C. 59 and 68, respectively.

Criticism. — Wied, although having really figured a young specimen of the "Jararaca," yet called it *Cophias atrox* Merr., *pullus*, in fasc. 7 of his Abbildungen, 1824; and in fasc. 8, having figured a typical specimen of *B. atrox* called it *Cophias jararaca*.

I must also emphasize that Wied's Abbildungen, in which the "Jararaca" was described, both date from 1824, not 1825 as found in Boulenger, Cat. Sn. 1896. 3: 535 and in Procter, Proc. Zoöl. Soc. 1918: 163.

2*a*. Wagler, in Spix. Serp. Brazil. species novae, 1824: 50, pl. 19–21, described the species *megaera, furia, leucostigma, tessellatus* and *taeniatus*. His description of *B. megaera* is based on one adult specimen from Bahia that has V. 195, C. 53. *B. furia* refers to one adult specimen from Amazon that has V. 201, C. 65. *B. leucostigma* and *B. tessellatus* both refer to young specimens from Bahia. *B. taeniatus* also refers to one young specimen but from Bahia or from Amazon, the former locality being given in the French text of Spix's work and the latter in its Latin text.

Criticism. — Wagler's descriptions were probably published earlier but in the same year as Wied's Abbildungen, fasc. 7 and 8, but Wagler's name *megaera*, although the same as Wied's *jararaca*, cannot be preferred to this because that name was

preoccupied by Shaw, Gen. Zoöl. 1803. 2: 406–409 for another species, viz., that from Martinique whose valid name is *Bothrops atrox* (Linné, 1758). Wagler's *furia* occurs in Amazonas, therefore very far on the north, beyond the area of distribution of the "Jararaca." It is a strict synonym of *B. atrox*. Finally, the species *leucostigma, tessellatus,* and *taeniatus,* which were all poorly described and figured, and are all synonymous with each other and with *megaera.*

3. The species "Jararacussú" or "Yararaguassú" was described as *Bothrops jararacussú* by Lacerda in Léçons sur le Venin des Serpents du Brésil, 1884: 8–10. The characteristics of the type that is now in the Museu Nacional of Rio, were given as follows:

"L'individu, dont la description suit, peut être pris pour type de cette espèce brésilienne.

Il a 1 mètre 50 centimètres de long et 22 centimètres dans sa partie la plus grosse. La tête est parfaitement triangulaire et l'angle du sommet est très prononcé. La partie supérieure de la tête est plate et un tant soit peu déprimée dans la région frontale. Du rostre au commencement de la région cervicale, il y a 6 centimètres. Le museau est tronqué, la plaque rostrale est grande, convexe et presque triangulaire. Les plaques sus-orbitaires sont saillantes et forment comme un toit aux orbites. Celles-ci sont oblongues, les globes oculaires saillants et la pupille fendue dans le sens vertical. Les fossettes lacrymales sont très ouvertes. Les écailles sont lanceolées, carenées et imbriquées.

"Pour ce qui est de la coloration, la partie supérieure de la tête est noire, avec deux lignes jaunes de chaque côté; ces lignes partent des plaques sus-orbitaires et se continuent jusqu'aux limites de la région cervicale. La partie dorsale du corps est également noire, avec des lignes obliques jaunes. Toutefois, la partie inférieure est jaune et pointillée de taches noires. Les écailles qui recouvrent la partie inférieure de la tête ont plutôt la forme de plaques que celle d'écailles. Elles sont grandes, irregulières de forme, lisses et coriaces.

"La bouche est profondément fendue; la machoire supérieure est armée de deux longues dents canaliculées, recourbées et isolées. Le longueur de ces dents est de plus de 2 centimètres. La machoire inférieure est garnie de deux faisceaux de dents courtes, solidement inserées, droites et très aigues. La queue est conique, unguiculée et a 12 centimètres de long."

Criticism. — Lacerda's description is quite deficient. Indeed, it does not refer to the scutellation, nor does it emphasize the very peculiar dorsal markings of his species.

Among the recent references to these species I must cite the following:

1. G. A. Boulenger, in his Cat. Sn. 1896. 3: 535–539, accepted two of the above species as valid, namely, *lanceolatus* and *atrox*. He considered both Wied's *jararaca* and Lacerda's *jararacussu* as synonymous with his *Lachesis lanceolatus*, but he was very cautious indeed in so doing for he stated as follows:

"It is not impossible that two or three species are confounded here under *L. lanceolatus*, but I have been unable to trace any limits or to find any correlation between the modifications in scaling and coloration."

Criticism. — In Boulenger's Catalogue these species are really all confusedly dealt with. The name *lanceolatus* as used by Lacépède is a strict synonym of the Linnean *atrox*, the "Fer-de-lance" being the same as the "Echis," the "Barcin" or the "Caissaca." But it is a composite of *atrox*, *jararaca* and *jararacussu* as used by Boulenger. Both *B. jararaca* and *B. jararacussu* are species distinct from each other as well as from *B. atrox*. Boulenger's *atrox* is also a composite, but of the Linnean *atrox* and of *B. neglecta* Amaral (in Proc. New Engl. Zoöl. Club, 1823. 8: 100).

2. V. Brazil, in La Defense contre l'Ophidisme, 1914: 78–95, indentified the "Jararaca," the "Echis" etc., with Lacépède's *lanceolatus*, the "Caissaca" with Linné's *atrox* and the "Jararacussù" with Lacerda's *jararacussu*.

Criticism. — Since the species *lanceolatus* is a strict synonym of *atrox*, V. Brazil's identification of the "Jararaca" with the former is incorrect.

3. Thomas Barbour, in Mem. Mus. Comp. Zoöl. 1914. 44.2: 343, called the "Fer-de-lance" *Lachesis lanceolatus* but emphasized the fact that this species is not found upon Dominica and Guadeloupe as incorrectly recorded by Boulenger.

4. J. F. Gomes, in Mem. Inst. Butantan, 1918. I. 1: 76, identified the "Caissaca" with Linné's *atrox* and seemed to be rather skeptical about the identification of the "Jararaca" with Lacépède's *lanceolatus*.

Criticism. — Gomes should have compared specimens from different countries with his Brazilian material in order to be sure about the real rank to be assigned to the "Jararaca."

As I showed in An. Mem. Inst. Butantan, Sec. Ofiologia, 1921. I. 1: 37 and 78, this snake must be identified with Wied's *jararaca*.

5. J. B. Procter, in Proc. Zoöl. Soc. 1918. 163–182, accepted only the species *atrox* as valid and ascribed thereto "four principal forms based chiefly on markings, more or less in conjunction with geographical distribution."

The forms described were the following:

Form 1, var. *affinis*, corresponding to *Bothrops atrox* Gray, 1849, and extending from Mexico to S. Brazil and Peru.

Form 2, var. *jararaca*, corresponding to Wied's species *jararaca* and inhabiting Brazil and especially Bahia, São Paulo and Rio.

Form 3, the typical *atrox* (*lanceolatus*), occurring principally in the West Indies as well as in the Guianas, Venezuela, and in Peru.

Form 4, var. *jararacussu*, corresponding to Lacerda's species *jararacussu* and living in Brazil (São Paulo and Rio).

Criticism. Procter's monograph is divided into four paragraphs. In the first paragraph, that headed "Historical," Procter fails to refer to Linné — Syst. Nat. 1758 (X ed.) — where the species *atrox* was consistently described. She also misquotes the date on which Wied's *jararaca* was described, viz., 1825 instead of 1824.

In the second paragraph that deals with "Form and Lepidosis" she suggests the name *affinis* to be given to the species that bears high- and short-keeled scales, as well as the name *atrox* (*lanceolatus*) to be given to the species that bears low- and long-keeled scales. However, this change of names which

was suggested to Procter by Andersson's findings (in Bih. t. K. Vet.-Akad. Handl. 1899. 24. 4. 6: 20) regarding the characteristics of the carination in the Linnean type of *atrox*, does not seem to be really indicated, because Andersson himself, having recently reëxamined the Linnean types upon request of my friend, Dr. Thomas Barbour, kindly wrote the following:

"This latter specimen is very well preserved and reëxamining it and comparing it with specimens of Lachesis atrox and L. lanceolatus, I find that the scales of the *median* rows are similar to those of L. atrox, the keels being rather high and not extending to the extremity of the scales. In the other specimen, which is not in so good state, the keels are lower and generally perceived along the whole scale. In some parts of the back, however, the scales of this specimen also have more the atrox than the lanceolatus type, and Linneus says regarding this that it is "striatus" by the keels, which are very distinct in his figure (on the back as well as on the sides). If specimens of both species or forms had been at my disposal, when I wrote my paper cited, I do not believe that I should have stated the Linnean specimens as belonging to "the low- and long-keeled form." With certainty, the one of them is a true *L. atrox* with short and high keel on the dorsal scales, and with great probability this is the case regarding the other, too."

Moreover, Procter states that the obtuse snout of *jararaca* is not very distinct from that of the typical *atrox*, as several specimens of the latter (apparently all young, however), present a snout similar to the former's. This may be explained by the fact that Procter, as well as Boulenger, failed to recognize the three species, apparently either because she had at her disposal only the preserved specimens of the British Museum, most of which are probably discolored, or because the specimens she examined bore wrong indications of locality, inasmuch as she repeatedly refers to intermediate forms which I myself have never found in a very much larger series.

In the third and fourth paragraphs that respectively deal with "System of Markings" and "Individual Variation and Evolution of Markings" she undoubtedly studied specimens which belong to the three mentioned species. This remark also holds good in regard to the fifth paragraph, which deals with "Phylogenetic Relations between the Types." Here, as in the preceding paragraph on evolution, she endeavors to trace the

changes that may be found in the species but she unfortunately followed such changes in specimens from different localities and belonging to more than one species.

II. Material Examined

The material which I examined consisted of 6,019 specimens, 697 of the species *B. atrox*, 4,992 of the species *B. jararaca* and 330 of the species *B. jararacussu*. Of those, only 13 specimens of *B. atrox* had no definite data as to the localities where they were obtained; they are recorded as from South America because they surely belong to material collected there.

Of the remainder, 684 specimens of *B. atrox* were from Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Bolivia, Peru, Martinique, Santa Lucia, Tobago, Trinidad, Venezuela, French and British Guianas, and Brazil, therefore practically from every country where it actually occurs.

The specimens of *B. jararaca* all were from Brazil. This species also occurs in N. Argentina and N. E. Paraguay where, however, it is relatively rare.

The specimens of *B. jararacussu* were distributed as follows: 328 from Brazil and 2 from Bolivia. This species also occurs in N. Argentina and Paraguay where, however, it seems to be rare.

Four thousand seven hundred eighty-four specimens of *B. jararaca*, 402 of *B. atrox*, and 224 of *B. jararacussu* were examined while alive.

The whole material was distributed among the different collections as follows:

1. *Bothrops atrox:*
   Instituto Butantan 438
   Museum of Comparative Zoölogy 73
   U. S. National Museum 91
   American Museum of Natural History 75
   Carnegie Museum 15
   Comm. Rondon (Museu Nacional do Rio de Janeiro) 5

Among the Carnegie specimens, 11 formerly belonged to the Le Boutellier collection as recorded in Griffin (Mem. Carn. Mus., 1915, 7, 222–223), under the name of *Lachesis lanceolatus*. These specimens were originally labelled carelessly, most of the localities assigned to them being manifestly incorrect. For this reason they are herein recorded only as from South America.

2. *Bothrops jararaca:*
   Instituto Butantan 4,903
   Museum of Comparative Zoölogy 79
   U. S. National Museum 5
   American Museum of Natural History 3
   Carnegie Museum 2
3. *Bothrops jararacussu:*
   Instituto Butantan 274
   Museum of Comparative Zoölogy 49
   U. S. National Museum 2
   American Museum of Natural History 3
   Carnegie Museum 2

III. Comparative Study. Results

I have found that the distinction of the three species *B. atrox*, *B. jararaca*, and *B. jararacussu* lies in the following points:

A. Coloration and dorsal markings.
B. Dorsal scalation and carination; their evolution.
C. Shape of the body.
D. Shape of the head and snout.
E. Scutellation of the top of head.
F. Number of upper and lower labials.
G. Number of scale rows, ventrals, and subcaudals.
H. Hemipenis characteristics.
I. Geographical distribution.
J. Habits in life.

A. *Coloration and Dorsal Markings*

1. As represented in Plate I, the coloration of a live adult specimen of *B. atrox* may be described as follows:

Dark pink or brown above with triangular or quadrangular brownish-black light-edged markings (lateral series), alternate

with or opposite to those of the other side, each marking corresponding to two rounded dark, light-edged spots placed near the side of the ventrals (marginal series); head very dark above with a darker streak from the eye to the angle of the mouth; a dark, light-edged streak along each side of the nape; belly yellowish, irregularly blotched or powdered with blackish or uniform yellow.

As seen in Plates V and VI a few changes take place during growth. In old specimens one may find a marked tendency for the lateral markings to be constricted, thus forming a kind of dark stripe along the vertebral region. This stripe may (as in old specimens from Brazil) or may not (as in old specimens from Martinique and Santa Lucia) show accessory dark, light-edged ocelli.

2. As represented in Plate II, the coloration of a live adult specimen of *B. jararaca* may be described as follows:

Olive above, anteriorly with triangular brown, light-edged markings, alternate with or opposite to those of the other side, gradually changing into brown, light-edged blotches, more or less irregularly distributed along the posterior parts; head dark olive with a dark-brown, light-edged streak from the eye to the angle of the mouth and with a few irregular dark, light-edged spots or two to five vermiculations (especially in young specimens) on the top of head, occiput and nape; belly light yellow, irregularly blotched or powdered with dark grey or uniform dark grey.

As described in another paper of this series (II), a great many variations may be found in the coloration of *B. jararaca*.

3. As represented in Plate III, the coloration of a live adult specimen of *B. jararacussu* may be described as follows:

Dark yellow above with wide angular black markings (lateral series), alternate with or opposite to those of the other side, each branch of the marking inferiorly followed by a round black spot with which, however, it is usually connected in adult specimens; wide areas of dark pigment with a few lighter or double-colored ocelli sometimes found among the lateral markings along the vertebral region; head black above with a yellow

streak along each temporal region from the supraocular to the side of the nape; belly yellow, irregularly blotched with dark brown or black.

As explained later, changes in pattern may be observed in *B. jararacussu*; and a few variations may also occur in the coloration itself.

B. *Dorsal Scalation and Carination; their Evolution*

Plate VI (1 and 1′) shows that the scales of *B. atrox* are very short and bear a short and high keel; that those of *B. jararaca* (2 and 2′) are long, lanceolate, and bear a long and low keel; and that those of *B. jararacussu* (3 and 3′) are intermediate in shape, showing a tendency to be rounded and bearing a rather long and high (swollen in the middle) keel.

As a result of the ontogenetic evolution (Plate V, 1′–4′), the scales of *B. atrox* become longer and somewhat lanceolate; their keels, however, never become as low as those of *B. jararaca*. Low-keeled scales may be found in specimens of *B. atrox* but only on the sides near the ventrals or in poorly preserved specimens, cadaveric decomposition causing the swollen part of the keel to disappear entirely.

The keels of *B. jararaca* never lose their characteristics either through evolution or through decomposition. Those of *B. jararacussu* become low and flattened through decomposition, but are not affected during their development from young to adult.

C. *Shape of the Body*

Upon comparing specimens of *B. atrox*, *B. jararaca* and *B. jararacussu* of the same size, one observes that they show a striking difference in their body shape. *B. jararaca* is very slender, thus looking relatively the longest of all. *B. jararacussu* is very flat and wide, thus looking relatively the thickest and the shortest of all. *B. atrox* is just intermediate between them. These differences are always present in living and in well-preserved specimens. Cross-sections of the body of these species are figured in Plate VII, figs. 1′, 2′, and 3′.

A comparison of the length with the maximum thickness of the body yields the following figures:

1. *B. atrox*..... 1, 10.2–13.8 (average 1, 12)
2. *B. jararaca*..... 1, 12.2–17 (average 1, 14.6)
3. *B. jararacussú*..... 1, 8.5–11.5 (average 1, 10)

D. *Shape of the Head and Snout*

Specimens of the same size show that the head of *B. jararaca* is the most depressed and elongate and the slenderest of all, thus looking longer than that of either *B. atrox* or *B. jararacussu*. The head of *B. jararacussu* is the deepest and far the widest and relatively the shortest of all. The head of *B. atrox* is intermediate.

The snout also differs from one species to another. That of *B. jararacussu* is sharp or acutely pointed and short; that of *B. jararaca* is somewhat rounded and rather long and that of *B. atrox*, which is intermediate is obtusely pointed. These differences are figured in Plate IV.

A study of their cephalic diameters (Plate VII, A), as well as the application of anthropological nomenclature to them, affords the following data:

When the rostro-nuchal diameter *a b*, used as a basis, is of the same length in the three species, the bi-temporal diameter *g g* is the widest in *B. jararacussu* and the narrowest in *B. jararaca*; the rostro-preocular diameter *a c* is the shortest in *B. jararacussu* and the longest in *B. jararaca*. The length of these two diameters always occupies an intermediate position in *B. atrox*.

E. *Scutellation of the Top of Head*

As seen in Plate IV the characteristics of the top of the head vary in the three species. *B. atrox* has a highly raised canthus, and possesses notched internasals and canthals. These shields are rather long and narrow and seem to be placed longitudinally along the canthus. They usually are longer than wide. *B. jararacussu* has a distinctly raised canthus rostralis and possesses very large canthals, which are almost continguous with each

other. Both canthals and internasals seem to be placed transversely along the canthus. They are flat and usually wider than long. *B. jararaca* has a slightly raised canthus, and possesses a large pair of internasals and a rather small pair of canthals, which occupy a position intermediate to that found in *atrox* and in *jararacussu*.

F. *Number of Upper and Lower Labials*

The lips are consistently shorter in *Bothrops atrox* than in the two other species (Plate IV, 1′, 2′, and 3′).

(*a*) The number of upper labials is as follows:

1. *B. atrox:* usually 7, exceptionally 8. Among the 697 specimens examined, 665 (95.5%) had 7 on the right and 668 (95.8%) had 7 on the left; 32 (4.5%) had 8 on the right and 29 (4.2%) had 8 on the left.

2. *B. jararaca:* usually 8, exceptionally 7 or 9. Among the 4,992 specimens examined, 4,438 (89%) had 8; 350 (7%) had 7; and 204 (4%) had 9 on the right; and 4,839 (97%) had 8; 20 (0.4%) had 7; and 132 [1] (2.6%) had 9 on the left.

3. *B. jararacussu:* usually 8 on each side, only 3 specimens among the 328 examined having 7 on the right.

(*b*) The number of lower labials is as follows:

1. *B. atrox:* 9–11, exceptionally 8–12.
2. *B. jararaca:* 10–12, exceptionally 9–13.
3. *B. jararacussu:* 10, exceptionally 9–11.

G. *Number of Scale Rows, Ventrals, and Subcaudals*

(*a*) Scale rows.

1. *B. atrox* has 23–33. Specimens from Martinique and from Tobago have the highest number, viz., 31–33. These figures are not found in specimens from the continent in which the maximum of rows is 29, as in those from Mexico, Guatemala, Costa Rica, Ecuador, and Brazil.

2. *B. jararaca* has 20–27.

3. *B. jararacussu* has 23–27.

[1] One specimen had the fifth upper labial so subdivided as to show one extra scale.

(*b*) Ventrals.

1. *B. atrox* has 180–231. Specimens from Martinique and Tobago have the highest number, viz., 218–231. These figures are overlapped by those of Mexican specimens, viz., 190–220. Therefore, there is no definite basis for recognizing even any local race. The maximum found in Brazilian specimens is 212, as in No. 1671 Inst. Butantan, collected in Piauhy by Dr. F. A. Iglesias.

2. *B. jararaca* has 175–216. Only one specimen among the 4,992 examined had 216. This is No. 1076 Inst. Butantan, collected at Prainha de Iguape on the coast of the State of S. Paulo, Brazil.

3. *B. jararacussu* has 170–186. Only one specimen among the 328 examined has 186. This is No. 2643 b, M. C. Z., collected in Brazil (probably in Rio) by the Thayer Expedition. One specimen from Bolivia has 185. This is No. 121 Carnegie Museum.

(*c*) Subcaudals.

1. *B. atrox* has 50–75.

2. *B. jararaca* has 52–70.

3. *B. jararacussu* has 60–66. Indeed, this species has the shortest tail of all.

I have found no marked distinction between the figures yielded by ♂♂ and those by ♀♀ as far as the number of ventrals and subcaudals is concerned.

The above data were taken from the following tables in which the various figures yielded by the material examined are briefly summarized:

1. Specimens of *Bothrops atrox*

Locality	No. of specimens	Upper labials		Lower labials		Sc.	V.	C.
		right	left	right	left			
Mexico	19	7– 19[1]	7– 19	9– 3 10– 8 11– 8	8– 1 9– 4 10– 9 12– 1	25–29	199–220	60–72
Guatemala	2	7– 2	7– 2	11– 2	10– 1 11– 1	25–29	213	64–68
Honduras	4	7– 3 8– 1	8– 4	9– 1 10– 2 11– 1	10– 3 11– 1	25–27	195–205	58–63
Nicaragua	12	7– 11 8– 1	7– 11 8– 1	9– 3 10– 7 11– 2	9– 1 10– 7 11– 4	25–27	188–201	60–73
Costa Rica	28	7– 28	7– 28	8– 1 9– 9 10– 18	8– 1 9– 4 10– 21 11– 2	25–29	193–209	57–72
Panama	5	7– 5	7– 5	9– 1 10– 3 12– 1	9– 1 10– 4	25–27	198–199	61–69
Colombia	8	7– 8	7– 6 8– 2	9– 3 10– 4 12– 1 12– 1	9– 3 10– 4 12– 1 12– 1	25–27	192–211	62–69
Ecuador	29 29	7– 21 8– 8 8– 8	7– 26 8– 3 8– 3	9– 1 10– 12 10– 12 11– 14 12– 2	9– 2 10– 19 10– 19 11– 7 12– 1	23–29 23–29	191–207 191–207	57–71 57–71
Bolivia	1	8– 1	8– 1	9– 1	10– 1	25	182	62
Peru	3	7– 3	7– 3	10– 3	9– 1 10– 2	23–27	190–200	62–71
Martinique	62	7– 57 8– 5	7– 54 8– 8	10– 15 11– 42 12– 5	10– 8 11– 38 12– 16	31–33	218–228	57–68

[1] The second figures refer to the number of specimens examined.

1. Specimens of *Bothrops atrox* (*continued*)

Locality	No. of specimens	Upper labials		Lower labials		Sc.	V.	C.
		right	left	right	left			
Sta. Lucia	7	7– 7	7– 7	9– 2 10– 5	9– 2 10– 3 11– 2	25–27	198–213	66–75
Tobago	2	7– 2	7– 2	11– 2	11– 2	31	219–231	61–66
Trinidad	13	7– 13	7– 13	9– 5 10– 8	9– 6 10– 6 11– 1	25–29	192–210	58–71
Venezuela	2	7– 2	7– 2	9– 1 10– 1	9– 1 12– 1	25–27	190–207	57–68
Fr. Guiana	1	7– 1	7– 1	9– 1	9– 1	25	191	72
Br. Guiana	6	7– 6	7– 6	9– 2 10– 4	9– 3 10– 3	25	199–207	60–73
Brazil	480	7–466 8– 14	7–471 8– 9	10–364 9– 78 11– 38	9–118 8– 41 10–295 11– 26	23–29	180–212	50–75
So. America [2]	13	7– 12 8– 1	7– 12 8– 1	9– 2 10– 11	9– 1 10– 12	25–27	180–198	51–71

2. Specimens of *Bothrops jararaca*

Brazil	4992	7–350 8–4384 9–204	7– 20 8–4839 9–132 10– 1	9–220 10–1980 11–2307 12–331 13–154	9–308 10–2126 11–1810 12–612 13–146	20–27	175–216	52–70

3. Specimens of *Bothrops jararacussu*

Brazil	328	7– 3 8–325	8–328	9– 42 10–230 11– 56	9– 42 10–254 11– 32	23–27	170–186	44–66

[2] These specimens had no further reliable data.

H. *Hemipenis Characteristics*

The characteristics of the hemipenis are very peculiar in every one of these species. A comparative study of specimens of the same size warrants the following conclusions:

1. In *B. atrox,* the hemipenis is rather cylindrical (Plate VII, 1). The spinous area (proximal) covers about half of the organ and the calyculate area (distal) covers the other half; calyces distributed in 16–20 transverse rows.

2. In *B. jararaca,* it is an ovoid relatively the smallest of all (Plate VII, 2). The spinous area covers about half of the organ and the calyculate area covers the other half; calyces distributed in 8–12 transverse rows.

3. In *B. jararacussu,* it is also ovoid and relatively the largest of all (Plate VII, 3). The spinous area covers about half of the organ and the calyculate area covers the other half; calyces distributed in 10–16 transverse rows.

I. *Geographical Distribution*

1. *B. atrox* occurs in Mexico, Guatemala, Honduras, Nicaragua, Costa Rica, Panama, Colombia, Ecuador, Peru, Bolivia, Martinique, Santa Lucia, Tobago, Trinidad, Venezuela, Guianas, and Brazil. It is not found upon Dominica and Guadeloupe, as incorrectly recorded in Boulenger's Catalogue. Its area of distribution in Mexico extends up to parallel 21° N. since specimen No. 25,212 U. S. N. M. was collected in Texapa, Vera Cruz. Its area of distribution in Brazil extends down to parallel 23° S., specimens never having been collected beyond the States of São Paulo and Matto Grosso.

2. *B. jararaca* occurs mostly in Brazil where it is by far the commonest species of Crotalidae (it is also likely to be the commonest solenoglyphous snake in the world); in northern Argentina, as recorded in Serié (Cat. Ofidios Argentinos, 1921, 27), under the name of *Lachesis lanceolatus;* and in NE. Paraguay. However, its area of distribution in Brazil is confined to the southern states, never extending toward the north beyond the State of Bahia, near the parallel 10° S.

3. *B. jararacussu* occurs in Brazil, especially along the east coast and in the southeast and central states; in Bolivia (in the lowland east of the Andes); and in Paraguay and in northern Argentina.

I am perfectly sure that there is no such thing as an intermediate form between these species, as frequently referred to in Procter's monograph, although these species may occur side by side in some Brazilian districts, as follows:

1. Brazilian localities where both the species *B. atrox* and *B. jararaca* occur according to the records of the Inst. Butantan:

(*a*) State of Minas Geraes: Carandahy and Sacramento.

(*b*) State of Rio de Janeiro: Campo Grande.

(*c*) State of Matto Grosso: Campo Grande and Joaquim Martinho.

(*d*) State of São Paulo: Agua Vermelha, Agudos, Americo Brasiliense, Annapolis, Araçatuba, Araraquara, Arraial dos Souzas, Barão Geraldo, Barretos, Batataes, Boituva, Botucatú, Brotas, Cajurú, Campo Alegre, Campos Novos do Paranapanema, Cascavel, Conde do Pinhal, Coronel Correa, Corrego Fundo, Cosmopolis, Descalvado, Dobrada, Dois Corregos, Elihu Root, Eng. Brodowsky, Eng. Coelho, Espraiado, Francisco Maximiano, Grauna, Guariba, Hammond, Ibaté, Ibitinga, Indaya, Itaicy, Itaquere, Ityrapina, Jacaré, Jatahy, Java, Mendonças, Miguel Calmon, Mococa, Mogy-guassú, Motuca, Mutum, Nhumirim, Nogueira, Ouro, Palmeiras, Pantano, Paula Souza, Pedregulho, Pedro Alexandrino, Platina, Ponte Alta, Porto Ferreira, Prata, Ribeirão Bonito, Rio Claro, Rio Preto, Salles Oliveira, Sta. Exudoxia, Sta. Josepha, Sta. Olivia, Sta. Rita do Passo Quatro, Santa Rosa, Serra Azul, Suzano, Tabapuan, Tambahú, Tatuca, Terra Roxa, Tibiriçá, Tombadouro, Turvinho, Villa Olympia and Visconde de Parnahyba.

2. Brazilian localities where both the species *Bothrops jararaca* and *B. jararacussu* occur, according to the records of the Inst. Butantan:

(*a*) State of Espirito Santo: S. João do Muquy.

(*b*) State of Minas Geraes: Caparão, Cataguazes, Chapéo d'Uvas, Chopotó, Guaxupé, Mar de Espanha, Mathias Barbosa, Retiro, Santa Rita da Extrema, Socego and Tabocas.

(*c*) State of Rio de Janeiro: Barra do Pirahy, Boa Vista, Chacrinha, Commercio, Ipauma, Massambará, Mendes, Miguel Pereira, Monnerat, Rezende, Sta. Thereza, Suruby, Tres Ilhas, Valença, Vargem Alegre, Vassouras and Vera.

(*d*) State of São Paulo: Arpuhy, Ataliba Leonel, Avahy, Bacaetava, Bernardino de Campos, Blumenau, Bocaina, Caçapava, Cachoeira, Canoas, Chavantes, Cincinnato Braga, Coronel Barretos, Eng. Maia, Faxina, Fernando Prestes, Girivá, Guarapessaba, Guaratingueta, Ibitirama, Ilha das Bichas, Ipaussú, Itahy, Itaoca de Apiahy, Itararé, Itatinga, Jacarehy, Juquiá, Lauro Muller, Lavrinhas, Mattão, Mirantes, Mogy das Cruzes, Monte Alto, Monte Serrat, Nogueira, Nova Europa, Oleo, Oliveira Coutinho, Parahybana, Perús, Piratininga, Prainha, Presid. Alves, Presid. Penna, Tibiriçá, Queluz, Reboucas, Rio das Pedras, Roseira, Salto Grande, Sta. Cruz do Rio Tardo, Sta. Sophia, Santos, São Bartholomeu, Sussuhy, Taubaté, Toledo Piza, Tremembé, Treze de Maio, Ubatuba and Victoria.

(*e*) State of Paraná: Jacaretinho, Jaguariahyba, Paulo Frontin, Santo Antonia do Platina and Sengés.

(*f*) State of Santa Catharina: Blumenau, Hansa, Jaraguá, Legrú and Massaranduba.

3. Brazilian localities where the species *B. atrox*, *B. jararaca*, and *B. jararacussu* occur together according to the records of the Inst. Butantan:

(*a*) State of Bahia: Vicinity of the capital.

(*b*) State of Minas Geraes: Burity and Eng. Lisboa.

(*c*) State of Rio de Janeiro: Ilha Grande and Werneck.

(*d*) State of São Paulo: Altinopolis, Assis, Avaré, Banharão, Baurú, Bento Quirino, Boa Esperança, Campinas, Casa Branca, Cerqueira Cesar, Itahyquara, Jahú, Lenções, Lorena, Nova Odessa, Ourinhos, Palmital, Pennapolis, Pindamonhangaba, Regente Feijo, Sta. Adelia, Sta. Ernestina, São Manoel, São Simão and Villa Americana.

J. *Habits in Life*

1. *B. atrox* prefers woody or rocky places to live in. It is especially found in humid localities. It feeds on small rodents.

2. *B. jararaca* prefers open places to live in. It is especially found in hayfields. It also feeds on small rodents.

3. *B. jararacussu,* which is an amphibious species, prefers marshy places to live in. It is always found near rivers, streams, or lakes. It feeds almost exclusively on batrachians.

NOTE. Differences that are found in the activity of their venom or in the properties of their serum are reported in an article which I have recently published in the number for July 1924, of the American Journal of Tropical Medicine.

IV. REDESCRIPTION OF THE THREE SPECIES

Based on the material which I have examined, I am taking this opportunity to redescribe the three species dealt with in this paper.

1. *Bothrops atrox* (Linné, 1758).

(Plates I; IV, 1 and 1′; V, 1–4 and 1′–4′; VI, 1–4 and VIa, 1 and 1′; VII, 1 and 1′).

Snout obtusely pointed with highly raised canthus. Rostral usually a little deeper than broad; internasals and canthals notched at their outer edge, longer than wide and longitudinally placed along the canthus; nasal divided; upper head-scales small, imbricate, strongly keeled, in five to eleven longitudinal rows between the supraoculars which are smooth, large and longer than wide; two preoculars; one to three postoculars; one to three suboculars separated from the upper labials by one or even two rows of scales; temporal scales strongly keeled; seven (exceptionally eight) upper labials, second forming the anterior border of the loreal pit; nine to eleven (exceptionally eight to twelve) lower labials. Scales in 23 to 33 rows, short, strongly keeled, the keels of the high and short type, the scales relatively longer and somewhat lanceolate in old specimens. Ventrals 180–231; anal entire; subcaudals 50–75, practically all divided.

Coloration: as described in Paragraph III. A. 1. of this publication.

Maximum length: 1910 mm.; tail 210 mm.

Distribution: Mexico, Central America, Martinique, Santa Lucia, Tobago and Trinidad, Venezuela, Guianas, Colombia, Ecuador, Bolivia, Peru, and Brazil (down to parallel 23° S.).

Living habits: It lives in woody or rocky places, especially in humid localities. It feeds on small rodents.

Hemipenis: cylindrical; proximal half covered with spines and distal half covered with calyces which are distributed in sixteen to twenty transverse rows.

2. *Bothrops jararaca* (Wied), 1824.

(Plates II; IV, 2 and 2′; VIa, 2 and 2′; VII, 2 and 2′).

Head elongate. Snout somewhat rounded and long, with slightly raised canthus. Rostral usually a little deeper than broad; internasals large, about as long as wide; canthals usually small; nasal divided; upper head-scales small, imbricate, feebly keeled, in six to twelve longitudinal rows between the supraoculars, which are smooth and usually much longer than wide; two preoculars; one to three postoculars; one to three suboculars, separated from the upper labials by one series of scales; temporal scales feebly keeled; eight (exceptionally seven or nine) upper labials, second forming the anterior border of the loreal pit; ten to twelve (exceptionally nine to thirteen) lower labials. Scales in 20–27 rows, lanceolate, feebly keeled, the keels of the low and long type. Ventrals 175–216; anal entire; subcaudals 52–70, practically all divided.

Coloration: as described in Paragraph III, A. 2. of this publication.

Maximum length: 1600 mm.; tail 195 mm.

Distribution: Brazil (up to parallel 10° S.), northern Argentina, and northeastern Paraguay.

Living habits: It lives in open places, especially in hayfields. It feeds on small rodents.

Hemipenis: ovoid; proximal half covered with spines and distal half covered with calyces, which are distributed in eight to twelve transverse rows.

3. *Bothrops jararacussu* Lacerda, 1884.

(Plates III; IV, 3 and 3′; VIa 3 and 3′; VII, 3 and 3′).

Head short and very wide posteriorly. Snout short and acutely pointed with distinctly raised canthus. Rostral as deep as wide; internasals and canthals very large, flat, and usually wider than long, transversely placed along the canthus; nasal divided; upper head-scales usually small, imbricate, distinctly keeled, in four to eight longitudinal rows between the supraoculars, which are smooth and usually a little longer than wide; two preoculars; one to three postoculars; one to three suboculars separated from the upper labials by one to two series of scales; temporal scales distinctly keeled; eight upper labials, second forming the anterior border of the loreal pit; ten (exceptionally nine to eleven) lower labials. Scales in 23–27 rows, somewhat rounded, distinctly keeled, the keels of the high and long type. Ventrals 181–185; anal divided; subcaudals 60–66, practically all divided.

Coloration: as described in Paragraph III. A. 3. of this publication.

Maximum length: 1500 mm.; tail 175 mm.

Distribution: Brazil (especially in the southern district), Bolivia (east of the Andes), Paraguay, and northern Argentina.

Living habits: It is amphibious and lives near rivers, streams, or lakes. It feeds on batrachians.

Hemipenis: ovoid; proximal half covered with spines and distal half covered with calyces, which are distributed in ten to sixteen transverse rows.

On the Variation of Dorsal Markings in *Bothrops jararaca* (Wied, 1824)*

In a previous paper [1] I attributed to Wied the priority of description of the species of Viperidae which the people in Brazil call "Jararaca" and more recently I pointed out how correct Wied [2] was when he considered this species different from the Linnean species *B. atrox*.

In regard to the dorsal coloration of "Jararaca," Wied's original description is as follows:

> Farbe graubraun, mit abwechselnden dunkleren, heller eingefasten Querflecken, welche am Bauche breit, am Rücken schmal, bei alten Thieren am Vordertheile kaum bemerkbar sind. . . .

In 1825 he completed his former description of the markings by adding the following characteristics:

> Die Grundfarbe des Thiers ist einfach bräunlichgrau, oft etwas mehr in's Bläuliche, oft mehr in's Bräunliche fallend, mit dunkeler graubraunen oder schwärzlichbraunen grossen dreieckigen Flecken in jeder Seite, welche am Rande der Bauschilde breit sind und nach dem Rücken hinauf schmäler werden; sie stehen meistens abwechselnd, sind aber auch zum Theil oben mit ihren Spitzen vereinigt, oder wenn sie nicht berühren, so sind sie zum Theil durch graubraune Flecken vereinigt; sie haben sämmtlich einen allmälig dunkeler werdenden Rand, besonders nach oben, und an ihrer Basis an der Seite des Bauchs auf jeder Seite einen runden, dunkelgraubraunen Fleck; am Halse sind die Flecken blässer und undeutlich, am Rumpfe stark ausgedrückt, und am Schwanze bilden sie breite Querbinden. . . . [3]

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* A preliminary report of this paper was read by Amaral before the American Society of Ichthyologists and Herpetologists, on Oct. 12, 1923. (Copeia, Jan., 1924, 126, p. 18.)

[1] A. Amaral. I Contr. Conhec. Ofidios Brasil — *in* An. Mem. Inst. Butantan Ofiologia, 1921, pp. 34, 78.

[2] Wied. In Isis, 1824, XIV, p. 987; and Abbildungen z. Naturgeschichte Brasiliens, 1824, f. 7 (*Cophias jararaca*).

Wied also gave a very good figure of this species (Abbild. 7th fascicle), the dorsal markings of which he carefully represented.

[3] Wied — *in* Beiträge zur Naturgeschichte von Brasilien, 1825, pp. 475–476.

Plate VIII, Fig. A, of this paper represents the typical dorsal markings as shown in Wied's figure.

Having so far examined more than ten thousand living specimens of *Bothrops jararaca* among those which have been sent from different Brazilian localities to the Instituto de Butantan for the preparation of antivenine, I am able now to bring Wied's description up-to-date by showing the variations which occur in the dorsal markings of many specimens.

The variations which may take place during the ontogenetic development of the Jararaca can be summarized as follows:

I. *Constriction* (Plate VIII, fig. 1) of the branches of the Λ-like markings so that they sometimes seem to form only a single transverse band.

This variation is seen specially in specimens from the State of Rio and from some islands situated near the coast of the State of São Paulo.

II. *Longitudinal division* (Plate VIII, fig. 2) or separation of the two convergent branches of the markings so that they are shown as two parallel bands on the back of the snake. These double markings are alternate with or even opposite to those of the other side, and in this case they form complete cross-bands.

This variation which is far the most frequent of all is found specially in specimens from the States of São Paulo and Bahia.

III. *Transverse division* of the branches so that the markings assume the feature which is seen in Plate VIII, fig. 3.

This variation which can very frequently be seen along the back of specimens from the States of São Paulo and Minas Geraes seems to be the rule for the markings near the tail of most of the Jararacas.

IV. *Transverse reduction* and *longitudinal elongation* of the markings which are shown as Ω-like, dark, light-edged bands instead of Λ-like ones as is the case in the type (Plate VIII, fig. 4).

V. *Longitudinal elongation* and *anastomosis* of the markings which assume the very peculiar feature of a stripe running all along each side of the back. Some specimens having this kind of marking look so different from the typical ones that it is not

an easy matter to identify them when found in old collections (Plate IX, fig. 5).

VI. *Total constriction* of the markings which appear as small roundish or triangular spots on the back. In this case the markings scattered all along the back of the snake are widely separated one from the others and sometimes only 9–14 are found on each side of the back. Specimens of this kind are principally found on some islands off the sea-coast of the States of São Paulo and Rio (Plate IX, fig. 6).

VII. *Longitudinal elongation* and *narrowing* of the markings which look like discontinuous bands placed on each side of the snake (Plate IX, fig. 7).

This type as well as Types IV and V occur very frequently in specimens from the State of Paraná, localities Dorizon and Marechal Mallet. Type IV is also found sometimes in specimens coming from the northeast of the State of São Paulo and especially from the localities Taubaté, Lorena, and Pindamonhangaba.

VIII. *Blending* of the markings with the background color of the dorsum. I have found this variation, although only exceptionally, in specimens from the States of Rio and Goyaz. It is the most uncommon of all the variations of the dorsal markings of Jararacas (Plate IX, fig. 8).

It is to be pointed out, however, that such variations cannot serve as a basis for the distinction of local races of *Bothrops jararaca*, because they may occur, although infrequently, in specimens caught in many localities besides those which I have indicated above.

As far as the evolution is concerned, Types I, II, and VIII seem to come from Type A (Wied's type) which is by far the commonest form of markings shown by Jararacas. Type VI apparently may be derived from Type I. Types IV, V, and VII belong to a series the most primitive form of which is IV, which itself may be derived from Type I. Finally, Type III probably must be considered apart, because it does not show any connection with the other types.

On the Evolution of Dorsal Markings in *Bothrops jararacussu* Lacerda, 1884*

Lacerda,[1] in 1884, described the species which is commonly called "Surucucú tapete" in the State of Rio, "Urutú dourado" in some localities in the State of São Paulo, and "Jararacussú" in all the other parts of the Brazilian territory where it occurs, under the name of *B. jararacussu*. He ascribed the following characteristics to its coloration:

"Pour ce qui est de la coloration, la partie supérieure de la tête est noire, avec deux lignes jaunes de chaque côté; ces lignes partent des plaques susorbitaires et se continuent jusqu'aux limites de la région cervicale. La partie dorsale du corps est également noire, avec des lignes obliques jaunes. Toutefois, la partie inférieure est jaune et pointillée de taches noires."

Boulenger,[2] in 1896, placed this species in the synonymy of his composite *Lachesis lanceolatus*.

R. von Ihering,[3] in 1910, named it *atrox jararacussu* (Lacerda), thus considering it rather a race of the Linnean species.

Vital Brazil,[4] in 1914, disagreeing with Boulenger's and von Ihering's opinion, maintained the specific rank assigned to it by Lacerda on account of the color, size, number of ventral shields, head shape, venom properties and other less important peculiar characteristics which the "Jararacussú" presents.

Miss J. B. Procter,[5] in 1918, rather following Boulenger's point of view, thought that this snake could not "be regarded

* A preliminary report of this paper was read by Amaral before the American Society of Ichthyologists and Herpetologists, Oct. 12, 1923. (Copeia, Jan., 1924, 126, p. 17.)

[1] Lacerda. Leçons sur le Venin des Serpents du Bresil, Rio, 1884, pp. 8–10, Plate III.

[2] Boulenger. Cat. Sn. III, 1896, p. 535.

[3] R. von Ihering. As Cobras do Brasil, *in* Rev. Museu Paulisto, 1910, pp. 348, 356.

[4] V. Brazil. La Défense contre l'Ophidisme (2d ed.) 1914, p. 89.

[5] J. B. Procter. On the Variation of the Pit-Viper, *Lachesis atrox*, *in* Proc. Zoöl. Soc., 1918, p. 167.

as more than a color variety of *L. atrox L.*" Her opinion, however, as well as Boulenger's, cannot be sustained.

J. F. Gomes,[1] in 1918, maintained V. Brazil's standpoint and pointed out differences existing between this and other species of the same group.

Finally, Werner,[2] in 1921, agreed with Miss Procter in considering Lacerda's species merely a variety of his composite *Trimeresurus atrox*, though he had not brought any new argument to the controversy.

I think, however, that this difference in the authors' opinions comes especially from the quantity and quality of specimens examined. Boulenger and Procter had only a few specimens at their disposition in the British Museum and all of them preserved in alcohol; Brazil and Gomes, on the contrary, examined many living specimens from different localities and most of them in different stages of growth.

This paper deals with the differences found in *Bothrops jararacussu* Lacerda as regards its dorsal markings, which are the most easily visible characters having a value for specific determination.

Having so far examined some hundred live specimens of Jararacussú (embryos, just-born young, medium-sized, adult, and old examples) and having carefully observed the evolution of some of them kept in captivity through various stages of development, I write this paper with the hope of preventing other herpetologists from perpetuating mistakes and so continuing the enormous confusion already existing with respect to the Brazilian pit-vipers.

Rather than use the nomenclature proposed by Miss Procter in her study on *B. atrox*, I prefer to divide the dorsal markings of *B. jararacussu* into two systems:

1. Principal system. 2. Accessory system.

(1) The Principal system is composed of two groups of markings:

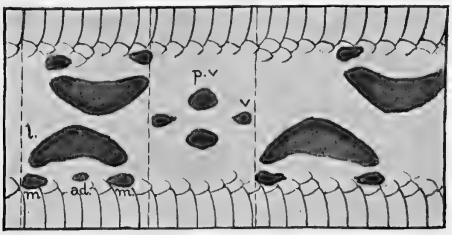
(*a*) lateral markings; (*b*) marginal markings.

[1] J. F. Gomes. Ofidios do Mus. Paraense *in* Mem. Inst. Butantan, I, 1918, p. 77.
[2] Werner. Syn. d. Schlangenfamilien d. Amblyceph. u. Viperiden, 1921, p. 230.

(2) The Accessory system is also formed by two groups of markings:

(*a*) vertebral markings; (*b*) para-vertebral markings.

As a rule the lateral markings are large, triangular with the obtuse angle near the vertebral line, or slightly arciform and light-edged, their center being paler in young specimens. The marginal markings are much smaller, roundish, usually ar-



PRINCIPAL SYSTEM ACCESSORY SYSTEM

ranged in couples; they are placed on the side of the ventral shields and under the two inferior angles of the correlated lateral markings with which they gradually unite during evolution; sometimes they are three in number and in this case the additional one is the smallest and is found between the other two.

The vertebral markings of the accessory system which occupy the interspaces of the principal system are very small, black, usually arranged in couples, somewhat long and show a marked tendency to disappear during development. The para-vertebral markings, on the contrary, are a little larger, black, light-edged (in adult and old specimens), usually two in number, one on each side of the vertebral line.

The above figure shows the arrangement of these markings.

Several changes take place in these two systems of markings during their evolution, so that an old specimen usually is very different from a young one. The evolution of the markings can, however, be divided into six characteristic stages as follows:

Stage I. Embryos and young specimens during the first week:

Background greyish brown; lateral and marginal markings of the principal system black, not light-edged; vertebral and para-vertebral markings showing but slightly, irregularly distributed, colored pale greyish black and arranged in a quadrangular brownish zone, a little darker than the dorsal background color.

Stage II. Young specimens, from one week to one month old:

Background color more marked. Lateral markings very accentuated and all of them white-edged. During this stage, which occurs between the summer and the autumn in southern Brazil, the specimens show very clear-cut colors, on account of their rapid successive changes of epidermis.

Stage III. Young specimens from three to six months old:

Markings much less accentuated, because the epidermis is not renewed ordinarily, the specimens not feeding during this stage which occurs during the winter.[1]

Lateral markings begin to show a tendency to become arciform and relatively shorter transversely; vertebral and para-vertebral markings are shown all gathered in the interspaces of the lateral ones. A slight amount of yellow pigment is seen in the dorsal background.

Stage IV. Specimens about one year old:

Background of yellow pigment more marked; lateral markings again light-edged; vertebral and para-vertebral markings showing in a quadrangular zone, the shade of which is darker than that of the dorsal background.

Stage V. Specimens from about one to three years old:

Yellow pigment of background and black color of dorsal markings still more accentuated. Marginal markings usually united to each extremity of the correlated lateral markings, the apices of which are sometimes fused with those of the opposite side; vertebral and para-vertebral markings are seen on a dark-

[1] The epidermic changes seem to depend essentially upon how frequently the snakes feed.

grey background contrasting with the yellowish pigment of the back.

Stage VI. Adult specimens:

The contrast between the yellow pigment of the background and the black color of the markings is very distinct. Marginal markings usually fused with the lateral ones; these also fused with those of the opposite side and formed a kind of complete or incomplete $\times\times$ on the vertebral line; vertebral markings no more to be distinguished, already covered by or fused with the black pigment of the accessory system background; para-vertebral markings, however, very distinct, light-edged. The accessory system's black background forms a quadrangular or trapezoidal broad stripe which runs all over the back of the snake, crossing the center of the $\times\times$ of the lateral markings.

Having reached this stage, the specimens evolve themselves into two different definitive types: (*a*) *melanic type*; (*b*) *xanthic type.*

(*a*) *Melanic type.* A great many old specimens of *B. jararacussu* have the backs covered with a black pigment (melanin) resulting from the coalescence of the several dorsal markings and scarcely interrupted by yellow forks issuing from the ventrals which very rarely reach the median line.

(*b*) *Xanthic type.* The yellow pigment, on the contrary, is *sometimes* prevalent in old specimens. In this case the marginal and lateral markings are fused in each group; the principal system is much more reduced and the accessory system appears as a single black stripe running on the vertebral region. No vertebral or para-vertebral marking is visible.

On the Variation of Dorsal Markings in Three Brazilian Pit-Vipers

Bothrops jararacussu Lacerda, 1884*

In a previous paper I pointed out the characteristics of the dorsal markings of *B. jararacussu*, after having examined many living specimens from different localities and in successive evolutionary stages. I divided these markings into two systems which I called *principal* and *accessory*, each one being formed by two groups of spots: *lateral* and *marginal* markings for the principal system; *vertebral* and *para-vertebral* markings for the accessory system. I write now to show that some variations of these markings can occur, and that they take place especially in the principal system.

The variations consist chiefly in the following:

1st. Ontogenetic fusion (coalescence) of the lateral with the marginal markings. This is seen in Plate XII, fig. 1, which represents the back of a young specimen in the Stage II of growth as was referred to in my paper on "Evolution of Dorsal Markings of *Bothrops jararacussu* Lacerda."

2d. Anastomosis of two adjacent marginal markings, as seen in Plate XII, figs. 1, 2, 3, and 4. This variation takes place in any stage of growth.

3d. Transverse constriction (reduction in height) of the lateral markings, as seen in Plate XII, figs. 1, 3, and 4.

4th. Finally, lengthening (elongation) and anastomosis of the adjacent lateral markings and their tendency to form longitudinal bands. This variation is very marked in the specimen No. 17366 (Plate XII, fig. 4) of the collection of the M. C. Z., received from São Paulo (Inst. Butantan).

* A preliminary report of this paper was read by A. Amaral before the Am. Soc. of Ichthyologists and Herpetologists on Oct. 12, 1923 (Copeia, Jan. 1924, 126, p. 18).

It is important to keep in mind these variations because it is sometimes a hard matter to identify specimens found in old collections and showing a different color in the dorsal background and spots and stripes all faded instead of the black markings found in typical Jararacussús.

Bothrops cotiara (Gomes), 1913

Gomes,[1] in 1913, described the species *Lachesis cotiara*, based on three specimens from the locality Marechal Mallet, State of Paraná, southern Brazil.

He recorded the following characteristics of the dorsal markings:

> "Olive green above, with two series of triangular spots, black around the edges and brown in the centre, surrounded by a clear edge, which are alternated or corresponding without fusing with each other. To each one of these spots there are two smaller lateral spots of the same color, corresponding, some of which may be glued to the corresponding dorsal spot or to the next of the next design. One dark band surrounded by black edge follows above the contour of the head, limiting a greenish design forming a more or less regular two branched cross."

Having so far examined about one hundred specimens of the "Cotiara" received by the Instituto de Butantan from the same locality as the type and from other localities in southeastern Brazil, especially from the south of Minas Geraes, of São Paulo, and of Paraná and northeast of Santa Catharina, I found a very striking variation of the dorsal markings which I want to point out in this paper.

This variation, which is very marked in the specimen No. 3004 of the collection of the Instituto de Butantan, consists in the fusion of the round marginal (para-ventral) markings with either the adjacent ones of the next systems or with the correlated triangular dorsal markings and, furthermore, in the elongation and coalescence of these dorsal markings so that a black-brown centered, and light-edged stripe runs along each side of

[1] J. F. Gomes. A New Brazilian Poisonous Snake — *in* Annaes Paulistas de Med. e Cirurgia, 1913, I, 3, pp. 65–66.

the back. This begins on the top of the head and is continued even beyond the middle of the body.

The Plate XII, fig. 5, shows just how this stripe changes into the typical markings beyond the middle of the body.

Bothrops alternata Dum. et Bibr., 1854

Duméril and Bibron,[1] in 1854, described the species *Bothrops alternatus* the dorsal markings of which have been described as follows:

"une ligne dorsale blanche, sinueuse d'abord, pour constituer ensuite de doubles bandes transversales et alternes sur un fond brun."

I have had the good luck to find two different variations in the dorsal markings in *B. alternata* by examining the snakes which the Instituto de Butantan has received alive during the last few years.

These variations consist of:

1st. Existence of opposite Λ-shaped dorsal spots instead of alternate ones and their fusion with those of the opposite side over the vertebral line.

This variation (Plate XII, fig. 7) which is very marked on the back of specimen No. 3005 of the Instituto de Butantan collection seems to be frequent in specimens found in the locality Ponta Grossa, State of Paraná.

2d. Elongation and anastomosis of the different dorsal spots by their extremities, so that the snake assumes an appearance very different from the typical one, as seen in Plate XII, fig. 6. This figure represents the left side of No. 3009 (Instituto Butantan collection) caught in Bagé, in the State of Rio Grande do Sul.

This elongation of the dorsal markings which also occurs in *B. cotiara* and in *B. jararaca*, as I pointed out before, is by far the most important of the color variations occurring in Brazilian pit-vipers. Very recently Octavio Magalhaes [2] found this sort

[1] Duméril and Bibron. Erpétologie générale, 1854, VII, 2, p. 1512, pl. 8 bis, fig. 1.
[2] Octavio Magalhaes — *in* A. Folha Medica, 1923, III. 16.

of marking in specimens of *B. alternata* collected in the locality of S. Laurenço, in Rio Grande do Sul, and, having assigned to it specific rank, described his new species as *Lachesis inaequalis*. He made a mistake, however, because all the characteristics of his specimens as to size, head and body shape and scutellation, as well as head and body markings, are as in the typical race, and so his description simply deals with a local color race of *B. alternata*.

Brazilian Subspecies of *Bothrops neuwiedii* Wagler, 1824*

A CAREFUL examination of a great many live snakes received at the Instituto de Butantan from different districts in Brazil and studies of practically all the Brazilian collections have led me to recognize eight races of *Bothrops neuwiedii* Wagler, 1824, which I am now describing.

As shown in Plate XIII, *B. neuwiedii* is, in Brazil, one of the most wide-spread species of Crotalidae, its distribution covering almost all the northeastern, central, southeastern, and southern States. Through living in both the tropical and the subtropical regions and through occurring in different zoögeographical areas, this species really shows noteworthy localized variations chiefly in coloration, form, and disposition of the cephalic and dorsal markings. These variations are so well fixed indeed as to permit their being assigned subspecific rank.

Although this is rather a radical view to introduce into the study of Brazilian snakes, still the subdivision of *B. neuwiedii* seems to me perfectly justified by the remarkable fixity of the chromatic characters found in the various groups within this species and by the close relationship existing between such characters and both the geographical and the meteorological features of the corresponding Brazilian areas.

The subspecies that up to this time I can recognize are the following, which I am naming after the districts in which they occur: *bahiensis*, *piauhyensis*, *goyazensis*, *minasensis*, *pauloensis*, *matto-grossensis*, *paranaensis*, and *riograndensis*.

The type of *B. neuwiedii* came from Bahia where it occurs especially in Sincorá, Curralinho, Sitio Novo and other rather low and humid localities south of the Paraguassú River, in the

* A preliminary report of this paper was read by A. Amaral before the American Society of Ichthyologists and Herpetologists on Oct. 12, 1923 (Copeia, Jan. 1924, 126, p. 19).

"reconcavo," near the capital of that State. This is the true *Bothrops neuwiedii neuwiedii*.

As figured by Wagler,[1] it is yellowish-brown above with blackish-brown, yellow-edged quadrangular or rhomboidal markings transversely placed along the vertebral line; a series of round spots of the same color on the sides above the ventrals; yellowish beneath, ventrals and subcaudals dark-edged; top of the head with a pair of dark bands, running on each side from between the eyes to the nape.

The type was described as having 8 upper labials, 173 ventrals and 46 pairs of subcaudals. A series of 26 specimens of this race which I have examined yielded the following formula: Lab. 8, V. 166–175, C. 42–47 p.

Bothrops neuwiedii bahiensis subsp. n.

This race, also, occurs in the State of Bahia but in the north, in rather arid, high, dry and very warm places at about 300–500 m. altitude, around Serra de Monte Santo and on both banks of the São Francisco River. It is abundant in the localities Jaguarary and Itiuba.

As shown in Plate XV, fig. 1, it is vinaceous grey above, with irregular dark-brown light-edged markings; yellowish-white beneath, irregularly spotted with dark brown; head usually with 5 round black spots, as figured in Plate XIV, fig. 1.

A series of 26 specimens yielded the following:

Formula: Lab. 8 (9), V. 164–180, C. 40–46.

Type: No. 3,012 in the collection of the Instituto de Butantan, captured in Itiuba, Bahia, and received from the branch of the Instituto de Butantan in Bahia.

Note: *Bothrops lutzi* (Ribeiro, 1915)[2] the type of which (Lab. 8, V. 180, C. 40 p) I examined at Dr. A. Lutz's laboratory in the Instituto Oswaldo Cruz of Rio may be identical with this subspecies. I, however, am unable definitely to settle this point because the type of *lutzi* is quite faded.

[1] Wagler. Serp. brasil. species novae, 1824, pp. 56–57, Pl. XXII.

[2] M. Ribeiro. Lachesis muta *in* Arch. Museu Nacional Rio, 1915, 17. Part III.

Bothrops neuwiedii piauhyensis subsp. n.

This race occurs in arid, low, or slightly humid and very warm areas in the west and south of the State of Piauhy, near the Rivers Gurgueia and Parnahyba. It is abundant in Fazenda Grande and Jurumenha, being also found round Therezina.

As shown in Plate XV, fig. 2, it is cinnamon-drab above with irregularly rhomboidal darker markings edged with black and white; yellowish-brown beneath dotted with brown and black; head with a prefrontal dark light-edged spot, a frontal dark light-edged horseshoe-shaped marking, and other irregular markings on the temporal and occipital regions, as seen in Plate XIV, fig. 2.

A series of 20 specimens yielded the following formula: Lab. 8, V. 163–170, C. 43–48.

Type: No. 1,672 in the collection of the Instituto de Butantan, captured in Fazenda Grande, Piauhy, by the former travelling collector of Butantan, Dr. Fr. Iglesias.

Bothrops neuwiedii goyazensis subsp. n.

This race occurs in rather high, dry, and cool areas on the plateau of the State of Goyaz, near Serra dos Crystaes and is especially abundant in the localities Santa Cruz, Ipamery, and Catalão.

As shown in Plate XV, fig. 3, it is greyish-olive above with alternate dark-brown, light-edged markings along the paravertebral region and a series of rounded spots of the same color near the ventrals; yellowish-white beneath regularly blotched with brown at the base of the ventrals; head with three blackish, light-edged rounded spots and two dark, light-edged elongated bands from the occiput to the neck, as seen in Plate XIV, fig. 3.

A series of 13 specimens yielded the following formula: Lab. 8–9, V. 168–180, C. 40–49.

Type: No. 3,016 in the collection of the Instituto de Butantan, from Ipamery, Goyaz.

Bothrops neuwiedii minasensis subsp. n.

This race occurs in high, humid, and cool places at more than 600 m. altitude, on the plateau of the State of Minas Geraes, especially between Serra do Espinhaço and Serra do Mar and also in the northern and northeastern districts of the State of São Paulo which are known to be zoögeographically identical with the plateau region of the State of Minas. It is abundant at the following localities: Alfenas, Antonio Justiniano, Baependy, Bello Horizonte, Burity, Cachoeira do Campo, Cambuquira, Caxambú, Cesario Bastos, Congonha do Campo, Dores da Boa Esperança, Esperd, Francisco Justiniano, Ipuyuna de Caldas, Jubahy, Lobo Leite, Macaia, Ouro Preto, Perypery, Poços de Caldas, Retiro, Santa Catharina, Santa Rita de Extrema, Santo Antonio do Jacutinga, S. Sebastião da Encruzilhada, Suruby (Minas Geraes); Altinopolis, Batataes, Cajurú, Casa Branca, Cascavel, Cravinhos, Corrego Fundo, Crystaes, Eng. Brodowsky, Eng. Röhe, Franca, Itapira, Itoby, Lagoa, Mococa, Mogy-guassú, Orlandia, Pedregulho, Porangaba, Prata, Ribeirão Preto, Salles Oliveira, S. José do Rio Pardo, Serra Azul, Tombadouro, and Visconde de Parnahyba (São Paulo).

As shown in Plate XV, fig. 4, it is fuscous above with irregularly rhomboidal black, yellow-edged markings having 2 series of dark rounded spots in their intervals near the vertebral line, and with a para-ventral series of black light-edged spots; yellowish beneath irregularly blotched with dark; head with five black light-edged elongate spots or bands, as shown in Plate XIV, fig. 4.

A series of 204 specimens yielded the following formula: Lab. 8–9, V. 166–182, C. 40–51.

Type: No. 3,015 in the collection of the Instituto de Butantan, from Francisco Justiniano, Minas.

Bothrops neuwiedii pauloensis subsp. n.

This race occurs in rather high, humid, and cold places, at about 200–500 m. altitude, in the central and southwestern districts of the State of São Paulo. It is abundant in the following

localities: Agudos, Andrade, Angatuba, Aracassú, Assis, Avaré, Baurú, Bernardino de Campos, Botucatú, Bury, Cerqueira Cesar, Dona Catharina, Eng. Hermillo, Faxina, G. Oetterer, Ipanema, Itapetininga, Itatinga, Lençoes, Leme, Lobo, Morrinhos, Oity, Oliveira Coutinho, Osasco, S. Manoel, Serra Azul, Sorocaba, Treze de Maio, Victoria.

As shown in Plate XVI, fig. 5, it is ochre-red above with irregularly triangular blackish-brown, light-edged markings having one or two series of spots of the same color in their intervals near the vertebral line, and with a series of rounded dark, light-edged para-ventral spots; yellowish-white beneath, irregularly spotted with blackish light-edged spots and two dark, light-edged bands laterally situated on the occiput, as seen in Plate XIV, fig. 5.

Examination of a series of 123 specimens yielded the following formula: Lab. 9 (8), V. 171–187, C. 40–53.

Type: No. 3,013 in the collection of the Instituto de Butantan, from Leme, São Paulo.

Bothrops neuwiedii mattogrossensis subsp. n.

This race occurs in rather low, very humid and warm places in the southern part of the State of Matto Grosso and especially in the localities Arapuá, Campo Grande, Guayacurús, Miranda, Mutum, and Porto Esperança.

As shown in Plate XVI, fig. 6, it is characterized by its coloration, which is pale brownish-drab above, and by its dorsal markings, which are rather small, very irregular, blackish-brown, and light-edged slightly yellowish beneath, irregularly blotched or powdered with dark brown; head with 4–5 dark, light-edged, rather triangular spots with two curved bands of the same color on the nape, as seen in Plate II, fig. 6.

A series of 9 specimens yielded the following formula: Lab. 8–9, V. 170–178, C. 42–50.

Type: No. 3,011 in the collection of the Instituto de Butantan, from Miranda, Matto-Grosso.

Bothrops neuwiedii paranaensis subsp. n.

This race occurs in high, dry, and cold places in the central and southeastern parts of the State of Paraná, and especially in the localities Cachoeirinha, Castro, Curityba, Entre Rios, Julio de Castilhos, Ponta Grossa, and Rio Negro.

As shown in Plate XVI, fig. 7, it is hair-brown above with triangular or semilunar greyish-black, light-edged markings having two series of rounded spots in their intervals near the vertebral line, and with another series of para-ventral spots disposed in pairs, each pair corresponding to one triangular marking; pale (yellowish?) beneath blotched with dark; head with 5–7 blackish, light-edged elongated spots or bands, as figured in Plate II, fig. 7.

A series of 15 specimens yielded the following formula: Lab. 8–9, V. 168–177, C. 40–49.

Type: No. 3,014 in the collection of the Instituto de Butantan, from Castro, Paraná.

Bothrops neuwiedii riograndensis sp. n.

This race occurs in rather low, humid, and cold places in the State of Rio Grande do Sul and is especially abundant in Bagé, Boqueirão, Caçapava, Canguassú, Itaquy, Maria Gomes, Uruguayana, and other localities of the center and south of that State. A report[1] of the director of the Instituto de Hygiene de Pelotas (formerly a branch of the Instituto de Butantan) shows that this is the commonest poisonous snake in Rio Grande do Sul, 773 specimens of it having been captured in three years (March 1918–March 1921).

As shown in Plate XVI, fig. 8, it is chocolate above with blackish-brown, light-edged angular or triangular markings, opposite to or alternate with those of the other side, and having a series of dark, light-edged spots in their intervals, and with another series of para-ventral spots disposed in pairs, each pair corresponding to one triangular marking; pale brownish be-

[1] O. Magalhaes. Contr. para o estudo dos ophidios brasileiros. Repr. from Folha Medica, 1922, I, 3, pp. 2–3.

neath, more or less regularly spotted with dark brown at the base of the ventrals; head with one rounded dark-brown, light-edged spot on the snout and two pairs of elongated spots or bands of the same color, one on the frontal and another on the occipital and nuchal regions, as seen in Plate II, fig. 8.

A series of 32 specimens yielded the following formula: Lab. 8–9, V. 170–185, C. 42–51.

Type: No. 1,476 in the collection of the Museu Paulista, from Itaquy, Rio Grande do Sul.

Explanation of the Plates

PLATE

I. *Bothrops atrox* (live specimen).

II. *Bothrops jararaca* (live specimen).

III. *Bothrops jararacussu* (live specimen).

IV. Figs. 1 and 1′. Head scutellation of *B. atrox*.
Figs. 2 and 2′. Head scutellation of *B. jararaca*.
Figs. 3 and 3′. Head scutellation of *B. jararacussu*.

V. Figs. 1–4. Ontogenetic evolution of dorsal markings in specimens of *B. atrox* from Martinique:
Fig. 1 = No. 2645 (yg) A.M.N.H., received from the New York Zoölogical Park.
Fig. 2 = No. 4816 (half-grown) M. C. Z.
Fig. 3 = No. 11,318 (full-grown) U. S. N. M.
Fig. 4 = No. 11,319 (old) U. S. N. M.
a. 1′–4′. Ontogenetic evolution of scales and keels in specimens of *B. atrox* from Martinique.

VI. Figs. 1–4. Ontogenetic evolution of dorsal markings in specimens of *B. atrox* from Sta. Lucia:
Fig. 1 = No. 4815 (yg.) M.C.Z.
Fig. 2 = No. 11,812 (half-grown) U. S. N. M.
Fig. 3 = No. 15,082 (full-grown) U. S. N. M.
Fig. 4 = No. 4814 (old) M.C.Z.
a. 1 and 1′. Scales and keels of *B. atrox* (adult).
2 and 2′. Scales and keels of *B. jararaca* (adult).
3 and 3′. Scales and keels of *B. jararacussu* (adult).

VII. Fig. A. Cephalic diameters (*B. atrox*):
ab = rostro-nuchal.
ac = rostro-preocular.
ad = rostro-postocular.
ee = bi-preocular.
ff = bi-postocular.
gg = bi-temporal.
Fig. 1. Hemipenis of *B. atrox*.
Fig. 2. Hemipenis of *B. jararaca*.
Fig. 3. Hemipenis of *B. jararacussu*.
Fig. 1′. Cross-section of *B. atrox* (middle of the body).
Fig. 2′. Cross-section of *B. jararaca* (middle of the body).
Fig. 3′. Cross-section of *B. jararacussu* (middle of the body).

VIII. Fig. A. Typical markings (as in Wied's type) (Specimen No. 3704 in M.C.Z.).
Fig. 1. Constriction (Specimen No. 2837 in M.C.Z.).
Fig. 2. Longitudinal division (Specimens Nos. 17,347, 17,355 in M.C.Z.).
Fig. 3. Transverse division (Specimen No. 17,330 in M. C. Z.).
Fig. 4. Transverse reduction and longitudinal elongation (Specimen No. 17,533 in M. C. Z.).

IX. Fig. 5. Longitudinal elongation and anastomosis (Specimen No. 17,329 in M. C. Z.).
Fig. 6. Total constriction (Specimen No. 2837 in M. C. Z.).
Fig. 7. Longitudinal elongation and narrowing (Specimen No. 17,331 in M. C. Z.).
Fig. 8. Blending (Specimen No. 17,365 in M. C. Z.).

X. Figs. 1–6. Different evolutionary stages of the dorsal markings of *Bothrops jararacussu* LACERDA. (Specimens Nos. 17,306, 17,298, 17,296, 17,290, 17,381, 17,371 in the M. C. Z. collection, received from the Inst. Butantan.)

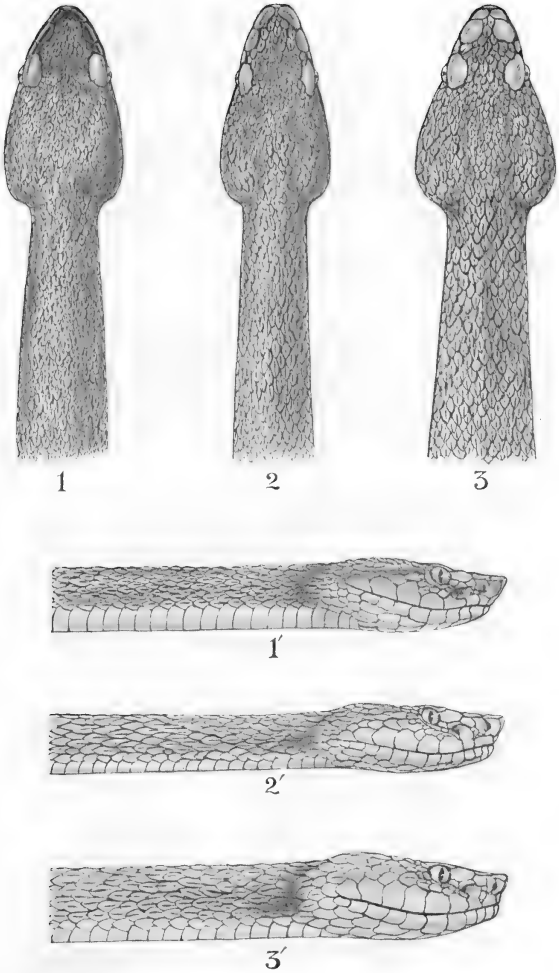
XI. Figs. 6*a*–7. Last evolutionary stages of the dorsal markings in the melanic type of *B. jararacussu*. (Specimens Nos. 17,380, 17,287 in the M. C. Z. collection, received from the Inst. Butantan.)
Figs. 6*a*′–7*a*. The same in the xanthic type. (Specimens Nos. 17,376, 17,288 in M. C. Z.)

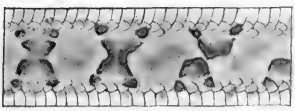
XII. Figs. 1–4. Variation of dorsal markings of *Bothrops jararacussu* LACERDA. (Specimens Nos. 17,305, 17,295, 17,379, 17,366 in the M. C. Z. collection.)
Fig. 5. Variation of dorsal markings of *Bothrops cotiara* (GOMES). (Specimen No. 3004 in the Inst. Butantan collection.)
Figs. 6–7. Variation of dorsal markings of *Bothrops alternata* DM., BIBR. (Specimens Nos. 3009, 3005 in the Inst. Butantan collection.)

XIII. Map of South America, showing the different Brazilian areas in which the subspecies of *B. neuwiedii* occur as follows:
T = Bahia ("reconcavo"): *B. neuwiedii neuwiedii*.
1 = Bahia (North): *B. neuwiedii bahiensis*.
2 = Piauhy: *B. neuwiedii piauhyensis*.
3 = Goyaz: *B. neuwiedii goyazensis*.
4 = Minas Geraes: *B. neuwiedii minasensis*.
5 = São Paulo: *B. neuwiedii pauloensis*.
6 = Matto-Grosso: *B. neuwiedii mattogrossensis*.
7 = Paraná: *B. neuwiedii paranaensis*.
8 = Rio Grande do Sul: *B. neuwiedii riograndensis*.

XIV. Head markings of the different subspecies.

XV and XVI. Dorsal markings of the different subspecies.





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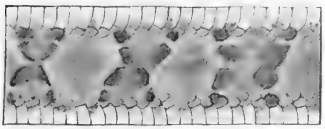

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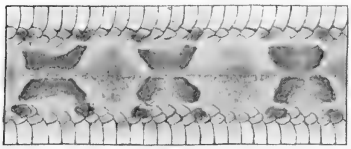

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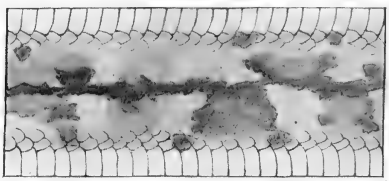

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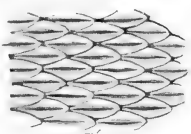

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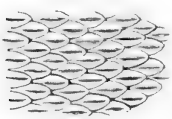

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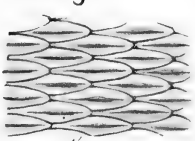

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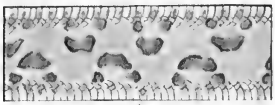

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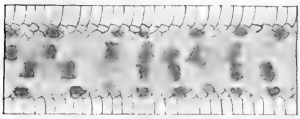

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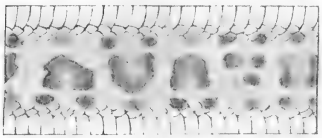

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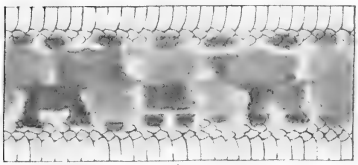

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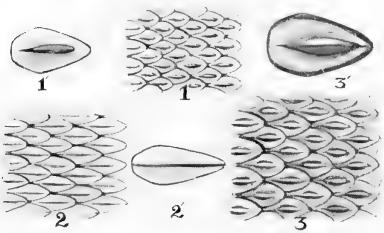

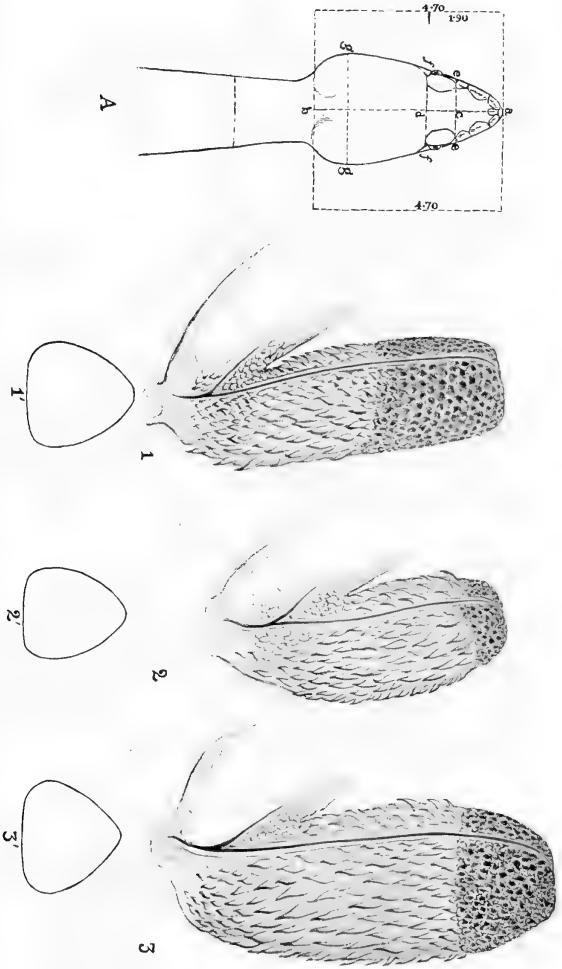
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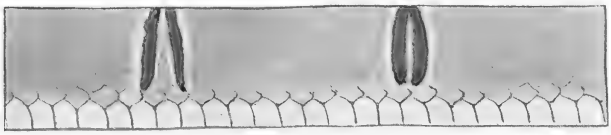
1.90
1.70
1'
1
2'
2
3'
3

A



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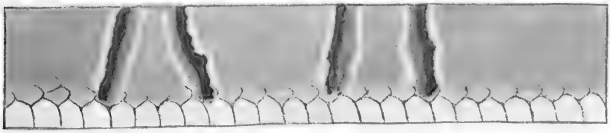

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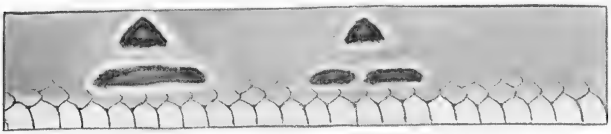

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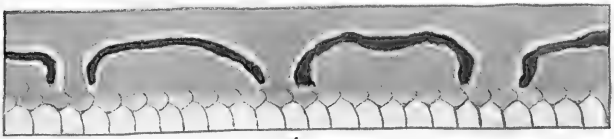

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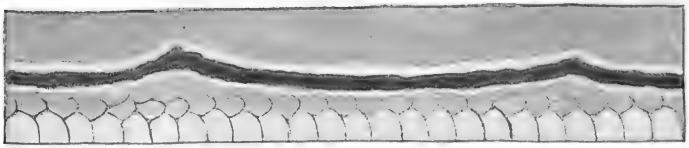

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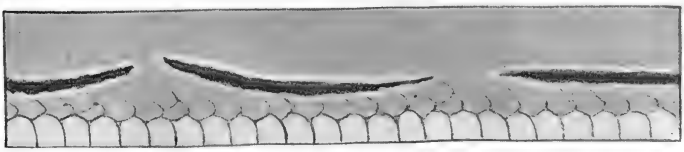

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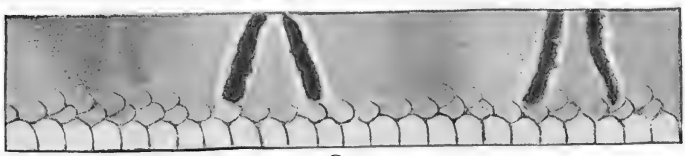

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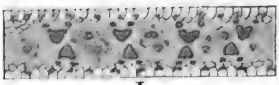

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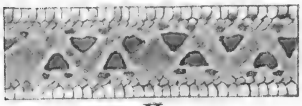

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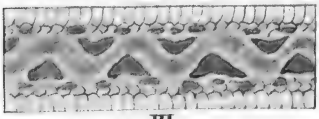

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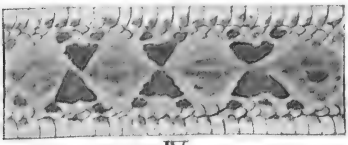

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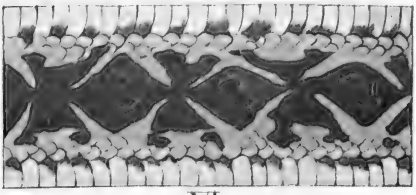

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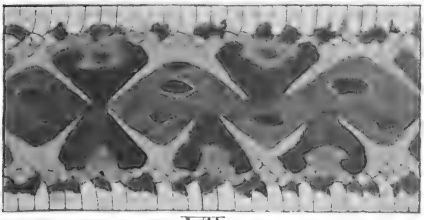

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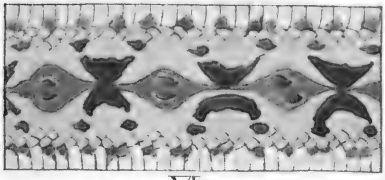

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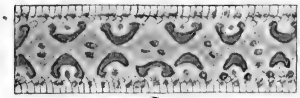

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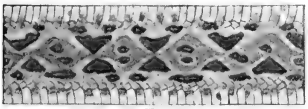

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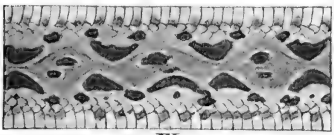

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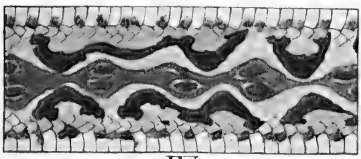

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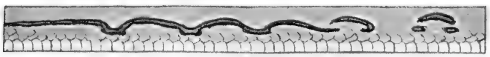

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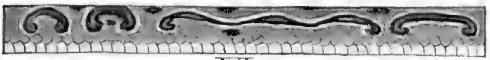

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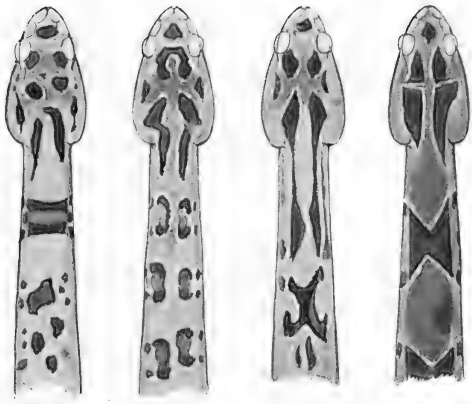

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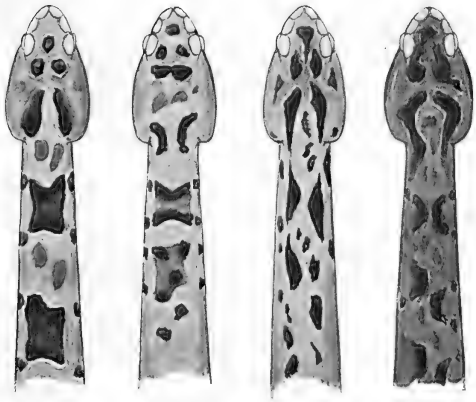

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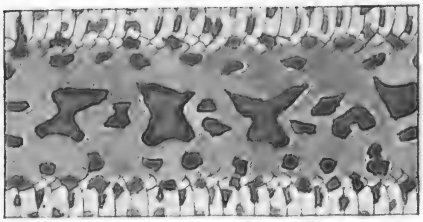

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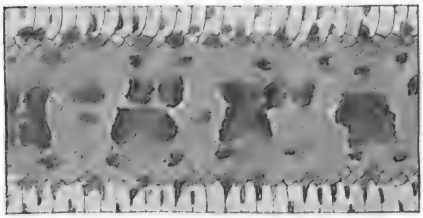

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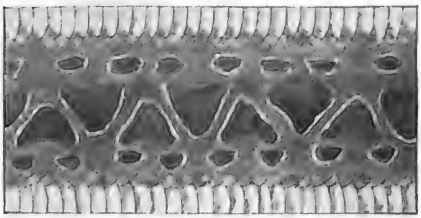

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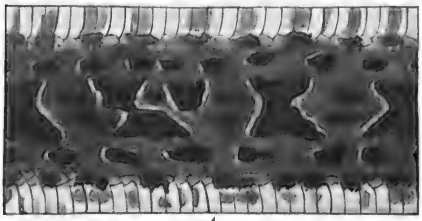

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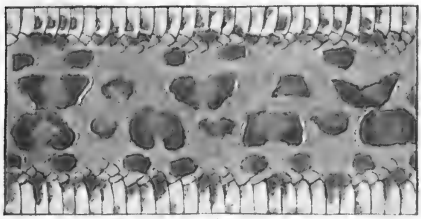

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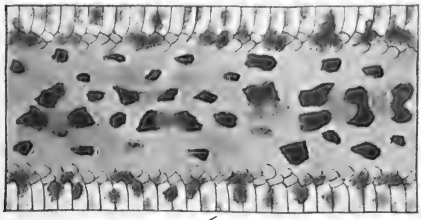

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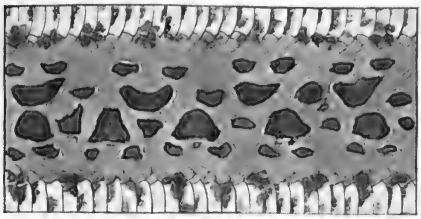

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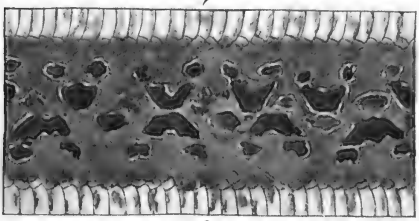

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