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Ecology and Behavior of the Six-lined Racerunner, *Cnemidophorus sexlineatus*

BY

DONNA FITZROY HARDY

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INTRODUCTION

Detailed studies of the behavior of most common reptiles and amphibians have yet to be made. The aims of this paper are to describe: (1) behavior of the six-lined racerunner, (2) behavioral mechanisms that this and other terrestrial poikilotherms may employ in their adaptations to the changing environment, and (3) methods by which behavior of lizards can be studied.

The six-lined racerunner, *Cnemidophorus sexlineatus* Linnaeus, was studied because it is by far the most active reptile in the vicinity of Lawrence, Kansas, has "high metabolism, with rapid and almost continuous movements during its periods of activity" (Fitch, 1956b:470), dwells in an open, xeric habitat and can thus be more easily observed than lizards that live in dense vegetation, and, its ecology has been studied (Fitch, 1958) in the vicinity of Lawrence, thus affording a foundation for correlating behavior with ecology.

ABSTRACT: A field and laboratory study of the six-lined racerunner, *Cnemidophorus sexlineatus,* was conducted in 1958. The purpose of the study was the further understanding of the role of behavior in the ecological relationships of this lizard. Food habits were studied, and it was found that choice of prey items varied with the availability of prey, sex and reproductive condition of adults, size of lizard, and between adults and young. Social behavior and dominance hierarchy were exhibited by the lizards; and behavioral releasers are the means by which individuals determine social status. Sequences of behavior are dependent upon attaining bodily temperatures within a "thermal activity-range," the highest temperature of which is the maximum temperature voluntarily tolerated by the individual, and the minimum temperature is the temperature threshold for basking. Fluctuation in daily and seasonal activity is correlated with amount of bodily fat stored by the lizards and their temperature relationships. The behavioral responses of lizards to the thermal characteristics of their environment are discussed in detail.

ACKNOWLEDGMENTS

For helpful criticism and guidance in the course of this study, I am especially indebted to Professor Henry S. Fitch. I would also like to thank Professors Richard F. Johnston and Kenneth B. Armitage for valuable suggestions and Professor E. Raymond Hall and my husband, Dr. John William Hardy, who gave time and assistance in reading and criticizing the manuscript. I thank also Mr. Henry Beuerman for allowing me to use an area of his land for study, Dr. George W. Byers and Miss Ellen Ordway for their aid in identification of insects, Mr. John L. Lenz for his statistical analysis of certain data herein, and Professor A. Byron Leonard for his identification of snails and help with photography.

METHODS

Terrestrial poikilotherms at temperate latitudes necessarily are adapted to much wider fluctuations in external conditions than are aquatic poikilotherms. Therefore, various phases of normal behavior in reptiles and amphibians are not evoked under uniform laboratory conditions; lizards that regulate temperatures of their bodies by behavioral mechanisms are especially affected by laboratory conditions. Studies in the laboratory, of behavior of lizards that practice thermo-regulation are inconclusive as concerns natural existence unless conditions of the normal habitat are duplicated or unless the study is accompanied by field observations. My study emphasized behavior of racerunners in the wild, although detailed observations and experiments were made upon captives kept under conditions similar to those of the natural habitat.

Six-lined racerunners are associated with an open, xeric habitat throughout their geographic range. My study area included such favorable habitat, having patches of open ground, sparse vegetation, and dry, well-drained soil (Figs. 1 and 2). This area was a dune habitat created in 1951 along the south bank of the Kansas River in Douglas County (one mile north and one mile west of Lakeview, Kansas) by a flood that deposited large quantities of sand and much debris. The area of deposited sand is several hundred yards wide and approximately one-fourth mile long. Fitch (1958:19) found racerunners abundant there in May, 1957. Mr. H. Beuerman reports that occasional racerunners are seen on the hills south of the flood plain; presumably, the area along the river was repopulated by individuals moving down to the sandy habitat after the flood waters subsided.

Most of the field work was done in a study area of approximately half an acre near a grove of cottonwoods and the remains of an old building (Fig. 3). Six-lined racerunners were trapped, measured, and marked (by clipping two or three toes and painting the tail with bright enamel) for future identification. Funnel traps (Fitch, 1951:77-80) and pitfall traps (Fig. 4), each made of two one-gallon cans, were placed along board drift-fences in places where lizards most frequently traveled. The 72 records of lizards trapped included 21 recaptures. Although several lizards, especially large adults, stayed in the same general area for a month or more, the home-ranges of most individuals probably shifted out of the study area eventually. Many lizards shifted their home-ranges back into the study area later. A much larger trapping area would have been required to reveal the full extent of home-ranges.

The funnel traps were fairly effective for catching racerunners in the early part of the season, but success in trapping declined during July; 28 of 40 lizards marked were captured before July 1. Adult lizards became much less active in July and August, and those that were observed within this interval seemed to climb over drift fences much more frequently than did adults in June. Milstead (1957:108) likewise noted that individuals of the four species of *Cnemidophorus* studied by him climbed drift fences more readily and were less easily caught late in the season. Toward the end of the summer, pitfall traps were installed in the areas; they proved highly effective in the capture of hatchling racerunners, but adults usually avoided capture by leaping over the opening.

At intervals of approximately two weeks throughout the study, lizards were collected with dust shot at several localities approximately one-fourth mile east of the main study area, in the same kind of habitat, in order to obtain information about food habits and breeding condition.

Most of the field work consisted of observing lizards at close range in the various phases of their daily activity. For these observations binoculars were unnecessary, and, indeed, impractical, because the lizards often moved in dense vegetation. By moving slowly and carefully, I could approach within several feet and follow lizards without disturbing them. The technique used was to select a lizard engaged in basking, feeding, hunting, or foraging, and approach it when its head was turned away or its nearer eye closed. No movement was made by the observer when the lizard watched; no attempt was made to follow lizards that indicated by their actions (such as rapid movements and "starting" at the movements of insects) that their bodily temperatures were above 40 degrees Centigrade. (Unless otherwise stated, "bodily temperature" will be referred to hereafter in this paper merely as "temperature.") Another method was to choose a spot where lizards had frequently been observed, and stand motionless. Eventually, perhaps after an hour or more, racerunners approach to within a few inches. It seems that these lizards do not rely on olfaction in detection of humans and regard a motionless observer as merely a part of the normal environment. Usually such minor disturbances as a sneeze or the turning of a page of a notebook do not alarm a lizard, but a slight movement of a human's foot may cause the lizard to flee. In the course of the summer, many individual racerunners became accustomed to being followed, and usually did not react at all to my movements. Since I avoided alarming any of the lizards in the study area, they probably became conditioned to my presence, just as they might become accustomed to the presence of a grazing animal under the same conditions.

Because hatchlings are easily concealed, even in sparse vegetation, and are extremely wary of moving objects, they are more difficult to observe in the wild than are adults. My only opportunity to study the behavior of hatchlings in the wild was in late September and early October. At this time I observed three hatchlings that were inhabiting a gravel-pile. Although they remained extremely wary (shied at moving beetles, hopping grasshoppers, the flapping of a page of my notebook), they were undisturbed by my presence if I remained motionless.

The second phase of my field work was carried on at the same time as the first phase and consisted of observation of captive racerunners in two circular enclosures (Figs. 5 and 6) made of aluminum sheets 30 inches wide, having their ends bolted together and the lower edges buried eight to 12 inches. Inside surfaces of the enclosures were painted with gray enamel in order to reduce reflection of light. One pen was approximately six feet in diameter and the other approximately eight feet. Several bushels of sand were dumped into the center of each pen, and several large, flat rocks were put in as shelter. A plate glass approximately two feet long and one foot wide was placed in the largest pen. Burrows excavated under this glass could be measured without disturbance to the lizards. Lespedeza (*L. striata*), giant ragweed (*Ambrosia trifida*), sunflowers (*Helianthus* sp.), foxtail grass (*Setaria viridis*) and various other plants grew along the inside edges of the pens, especially the larger one (Figs. 7 and 8). The captive racerunners were fed by dropping insects (collected in a sweep-net) into the center of the pens every few days.

No difference in behavior was found between racerunners in pens and those in the wild, except that the captive racerunners more often displayed social behavior. Information was gathered concerning relationships of temperature, excavation of tunnels, and other phases of daily activity, some of which are rarely observed in wild racerunners. Also, the reactions of lizards long in captivity to those recently introduced into the pen, and reactions to prey and to other stimuli could be tested.

FIG. 1.—A field, looking west, bordering the study area on the west, showing xeric habitat along the Kansas River northwest of Lakeview, Kansas.

FIG. 2.—A view, looking northeast, of the Kansas River northeast of the study area. Note the patches of sand in the foreground; such patches were scattered among clumps of vegetation throughout the area.

FIG. 3.—Pile of boards, wooden shingles, and tarpaper that was a favored site for basking and excavation of escape-burrows by adult racerunners on the study area. The piece of tarpaper in the foreground is approximately two and one-half square feet in area.

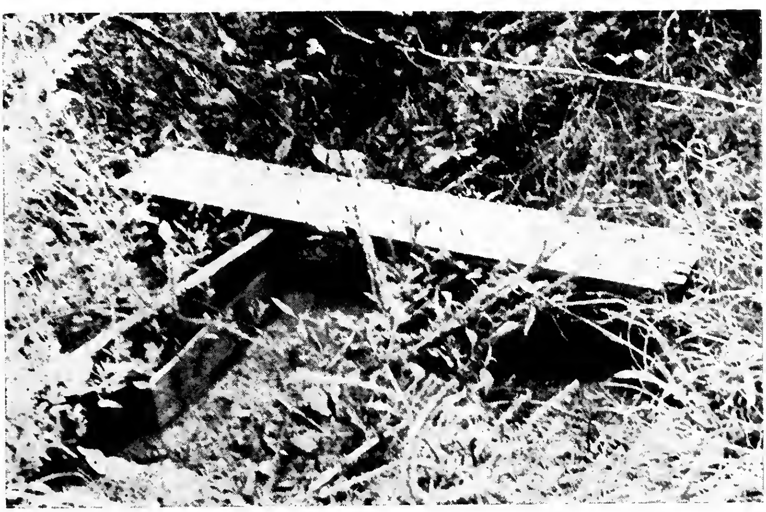

FIG. 4.—A pitfall trap. Note the dense vegetation in which adult racerunners frequently hunt. The upper board in the photograph is approximately four and one-half feet long.

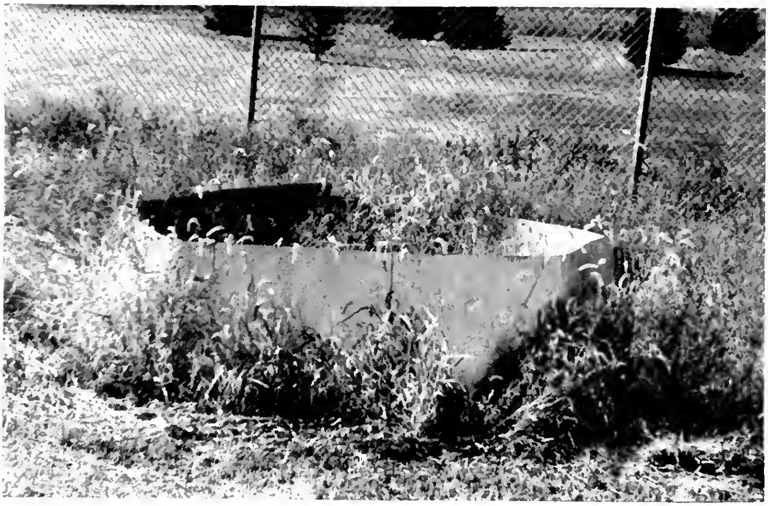

FIG. 5.—The larger observation pen. The enclosure is approximately eight feet in diameter.

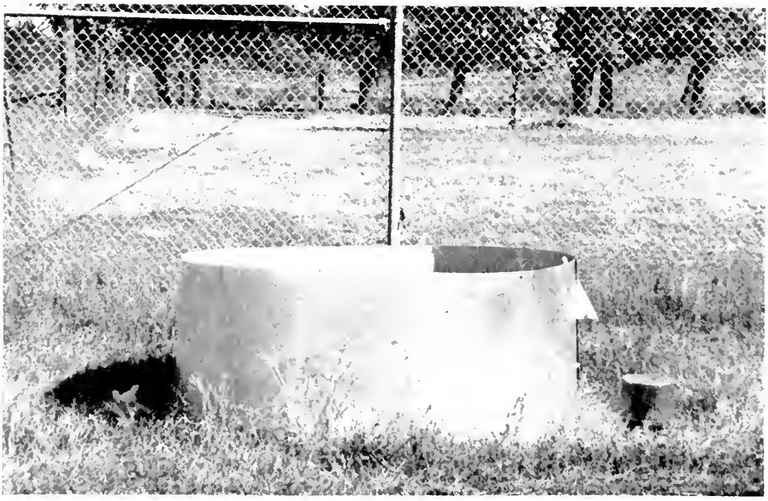

FIG. 6.—The smaller observation pen. The enclosure is approximately six feet in diameter.

FIG. 7.—Interior of the larger observation pen showing dense vegetation. Although this pen approximated the natural habitat more nearly than did the other pen, the dense vegetation was a hindrance to observing lizards. The portion of the circular enclosure visible in the photograph is approximately three feet long (left to right).

FIG. 8.—Interior of the smaller observation pen showing a racerunner basking on a rock. The lizard is × ⅓ natural size.

In the third phase of the study, racerunners were kept in the laboratory in a terrarium (25 x 13 x 13 inches) arranged to simulate natural conditions; it contained sand 3½ inches deep and had a 150-watt light bulb and an aluminum foil reflector placed four inches above the sand. Occasionally an additional light bulb of 100 watts was used to elevate the temperature. Two four-inch finger bowls, one filled with water and the other containing mealworms (*Tenebrio*), and several rocks were placed in the sand. The lizards were unable to excavate tunnels in loose, dry sand; therefore water was occasionally sprinkled on the sand, compacting the surface layer to a depth of approximately one inch. At intervals of one or two days the light bulb was turned on, elevating the temperature of the sand, so that the lizards were able to become active and feed. In warm weather live insects that had been collected in a sweep-net were put in the terrarium, but at other times the food of the lizards consisted mainly of pupae and larvae of the mealworm, and an occasional spider and moth.

TEMPERATURE AS A FACTOR IN ACTIVITY

Thermal activity-range and thresholds of activity

Bogert (1949) found temperatures of the bodies of most individuals in several species of lizards to be uniform and higher than the temperature of the air. He found "optimum" or "preferred" temperature to be uniform for males, females, adults, and hatchlings within each species. Fitch (1958:23) found the modal temperature of collected specimens of *Cnemidophorus sexlineatus* to be between 40° and 41°C.

The temperatures of 18 hatchling racerunners were recorded in August, September, and October, and were compared with corresponding temperatures of the surfaces of the sand on which the hatchlings were active. Fig. 9 shows a high correlation (.85) between temperatures of the hatchlings and temperatures of the surface of the sand. Differences between the temperatures of the sand and the bodies of the lizards are caused by thermotaxis of the lizards. On sand cooler than 36°C, temperatures of the lizards are elevated above that of the sand through insolation (direct absorption of radiant energy); on sand warmer than 41°C, the temperatures of the lizards remain below 41°C, because the lizards move into shade. Transfer of heat between lizard and substrate probably takes place at all times; the rate of this transfer varies directly with the size and posture of the lizard.

Data concerning temperatures of bodies of lizards when the temperature of the surface of the sand is constant would give the impression that the lizards "prefer" specific temperatures. Data on temperatures of lizards in terraria were gathered when the temperature of the surface of the sand was more than 45°C; temperatures of most of the racerunners were near the highest temperature normally tolerated by the species, approximately 40 to 41°C. The fact that temperatures of most of the individuals of this species collected by Fitch and others clustered around 40 and 41°C seems to indicate that many individuals do not become active at lower temperatures.

The lowest bodily temperature at which a racerunner normally will move is between 16° and 20°C. At temperatures as low as 20° to 22°C a hungry racerunner begins "awakening behavior." In early awakening behavior, observed in lizards in their burrows beneath glass, the rate of breathing increases, and the movements involved in the expansion and contraction of the chest cavity become apparent. The lizard then usually moves slightly, opens one or both eyes momentarily, "coughs" several times, occasionally extends its tongue, and moves its head from side to side. Then the lizard usually subsides temporarily to a lethargic state, but at intervals the sequence of activities composing "awakening behavior" is repeated. Periodically the lizard moves forward toward the surface. When the mouth of the tunnel is reached, the lizard stops until its temperature is elevated to a certain level (ordinarily in the high 30's).

After leaving its burrow, a lizard characteristically basks until its temperature either reaches the maximum that the species normally will tolerate or ceases to rise. The lizard then defecates and feeds. When the temperature of the lizard falls below a certain level, the lizard basks again. The level of the threshold for basking, as well as thresholds for other activities, varies with the strength of the drive that has brought about the behavioral pattern (feeding and defecating) and is related to the temperature that the lizard can ultimately attain by basking. For instance, at sand temperatures about 45°C, a lizard typically resumes basking whenever its temperature falls below about 38°C, but if the lizard is hungry, it frequently hunts until its temperature falls to 32°C or lower. Among lizards excavating tunnels in late afternoon, some do so when the temperatures of their bodies are far below the normal range. I found no specific "basking (thermal) range" as proposed by Bogert (1959:116).

Behavior thus depends largely upon the attainment of certain temperatures *at and above* which certain activities take place. There are thresholds for emergence, for seeking of food, and for other activities. Certain kinds of behavior, such as basking or seeking shelter, are initiated when the temperature of the lizard falls *below* a certain level.

Patterns of behavior are normal in racerunners at temperatures within a *thermal activity-range*, which varies with the physiological state of the lizard. This range seems to coincide with the "normal activity range" described by Bogert (1959:116). The thermal activity-range has as its upper limits the maximum temperature normally tolerated by the species and has as its lower limits the threshold for basking, which threshold fluctuates. Normally this range in *Cnemidophorus* is between 38° and 41°C. A strong hunger drive often depresses the threshold for basking, and the thermal activity-range increases; the maximum range seems to be from 34° to 41°C. The upper limit seems to be relatively constant, although under certain circumstances (such as when the lizard is being pursued by a predator over hot sand) the individual of necessity tolerates bodily temperatures up to 44° or 45°C, probably without ill effects. Below the thermal activity-range, a lizard that remains active usually does not behave normally.

Study of daily cycles under natural conditions discloses that racerunners usually become active about the same time from day to day if the weather does not change. Defecation is one of the first responses of a lizard that is becoming active. Defecation usually takes place at approximately 24-hour intervals as a routine part of the behavior of the lizard upon emergence (p. 22). In a large terrarium in the laboratory, the daily photoperiod was maintained by means of artificial illumination. Approximately 22 hours after a lizard had eaten, the temperature of the sand was raised, and the temperature of the lizard rose to 31.5°C. Then the animal emerged from its burrow and commenced basking. Temperature of the lizard rose to 39.5°C, behavior characteristically associated with defecation took place, but no scat was produced. The lizard resumed hunting and feeding and continued these activities until the temperature of the terrarium was lowered. Approximately two hours later, at a bodily temperature of 23.5°C, the lizard produced a scat. This time the defecatory pose alone was assumed by the lizard.

Captive racerunners often feed while their temperatures are far below the thermal activity-range, although behavior seems to be "labored." Such lizards are much less efficient in detecting prey and frequently ignore non-moving prey, which ordinarily would be detected at higher temperatures. Also, captive lizards having low bodily temperatures often excavate tunnels, but the excavation of a tunnel always takes several times longer than does the same operation performed by a lizard whose temperature is within the thermal activity-range. Obvious selective disadvantages would be imposed upon wild individuals that remained active at low bodily temperatures. Occasionally, however, individuals in the wild have temperatures considerably below the normal range, after periods of inclement weather. Hunger seems to depress the threshold for emergence and for basking. Also, if the surface of the sand is cool and damp, these lizards seek prey at relatively low bodily temperatures. Lizards that are active when temperatures of their bodies are below the thermal activity-range probably are especially subject to predation.

Physiological processes, such as enzyme reactions (West and Todd, 1957:436), take place with greatest efficiency at certain temperature levels and within a range of relatively few degrees. Different thermal activity-ranges characteristic of different species of lizards may, therefore, be correlated with—indeed required for —physiological processes. If so, habits of ancestral species are pertinent. The genus *Cnemidophorus* probably was derived from a stock of diurnal teiids that lived in open habitats. Scholander, *et al.* (1953) suggests that there is metabolic adaptation of animals to the temperature of their environment. The ancestral teiids became well adapted to open habitats in the tropics, where high temperatures prevail and thus were able to tolerate bodily temperatures close to the maximum temperature tolerated by any vertebrate. As the range in which their physiological processes could take place effectively shifted to the temperatures at which the lizards were active, thermal requirements of the physiological processes concurrently became higher. It is thus not by chance that the thermal activity-range of *Cnemidophorus sexlineatus* is higher than in any other species of lizard in the eastern United States. This high optimum has been considered to have limited the distribution of *C. sexlineatus* to regions having extensive xeric habitats. Also, perhaps the high thermal activity-range of this species has enabled it to use a habitat (barren, eroded soil) unfavorable for most other diurnal lizards in the eastern United States.

Bogert (1959:108-112) discussed, in somewhat general terms, physiological adaptations to temperature in spiny lizards (*Sceloporus*). He stated that once the "optimum zone of activity" has been established, only modifications in behavior permit the lizards to invade other environments successfully, implying that secondary physiological adaptations are improbable.

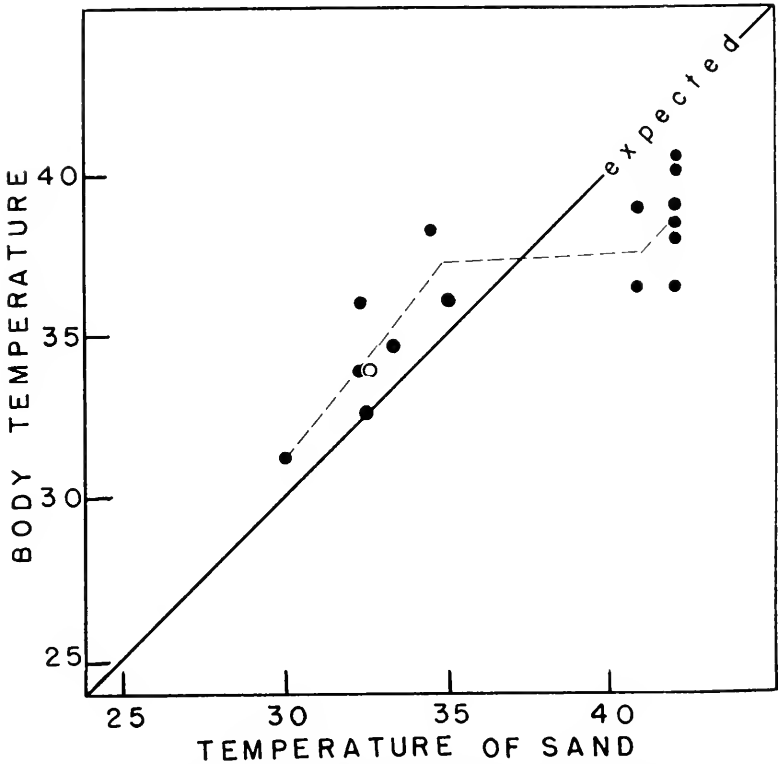

FIG. 9.—The relationship between temperature of active hatchlings and temperature of sand-surface. The solid line represents temperature of hatchlings that would be expected if conduction of heat from sand were the sole heat contributing factor. The broken line represents the average temperature of hatchlings. Each black dot represents the temperature of a single individual, and the white dot represents the temperature of three racerunners. The correlation between temperatures of the sand-surface and temperatures of hatchlings is .85. Due to the difficulty of shooting hatchlings that were on sand having a temperature of more than 41°C (because the hatchlings dart for cover), most of the hatchlings were obtained on sand cooler than 41°C.

Posture as a regulator of bodily temperature

Cowles and Bogert (1944:295) found that certain lizards of the desert attained normal temperatures in two ways: (1) by assuming positions in which heat through direct conduction could be absorbed, and (2) by basking with the body or parts of it exposed to sources of solar heat. High temperatures were avoided by retreating to cooler depths in the ground and by engaging in "respiratory cooling" when heat was extreme.

A racerunner newly emerged from its inactivity-tunnel in the morning basks and warms itself before beginning other activities. Subsequently, when the bodily temperature falls to the thermal threshold for basking, the lizard interrupts its activity from time to time to bask. The frequency with which a lizard basks, as well as the total length of time spent in basking, generally increases with the decrease in temperature of the surface of the soil.

A racerunner usually assumes a characteristic pose when basking. It basks in a warm place in the sunshine, usually on a surface that absorbs the heat and does not reflect it. The lizard moves from side to side, flattening the body. The eyes are closed and the legs, which are held close to the body, are placed flat against the substrate (Fig. 10). The lizard shifts its position to a warmer place from time to time. Each change in position of the lizard is preceded by actions resembling "awakening behavior" (p. 13). Hence, the lizard opens its eyes, moves its head from side to side, flicks out its tongue several times, and sometimes "coughs." Captive racerunners were observed to bask on cool surfaces, holding their bodies clear of the substrate (Fig. 11).

The eyes of a basking lizard are usually closed; a predator (especially a bird) could take such a lizard before it was able to detect the predator's presence. However, even racerunners that are basking with their eyes closed may be extremely wary (especially if their temperatures average more than 34°C) because they are able to hear the approach of predators. Future work with this species, as well as with other lizards, must be done in order to determine what sound frequencies are perceived.

Several behavioral characteristics aid *C. sexlineatus* in maintaining a high temperature, enabling the lizard to hunt in shade where bodily temperatures often decrease rapidly. In addition to possessing a high threshold for basking, the lizard assumes several characteristic postures depending on temperature of its environment. A racerunner with a decreasing bodily temperature often moves across a warm surface in a "basking walk," flattening its body against the substrate, and thus raising its temperature without interrupting other activity. The same lizard moves across a cool surface, avoiding contact with the substrate and preventing rapid loss of heat. A lizard that has a temperature close to the maximum tolerated by the species often prevents overheating when it is moving over a hot surface by using this same walk. The racerunners were not observed to orient to the sun in any special way in "regulating" bodily temperature, as Cowles and Bogert (1944:289-290) have described for desert lizards.

Since the extremities almost certainly absorb heat more rapidly than the rest of the body by virtue of their smaller size, a mechanism probably has been developed by which the lizard "elevates" its bodily temperature more rapidly than that of its extremities. Frequently a lizard basks on a hot surface by lying on its belly with limbs held clear of the substrate. Likewise, a lizard that has a high temperature often holds the tail high while moving across a hot surface. Racerunners were not seen to bask with parts of the body in shade, as Cowles and Bogert (1944:295) found in other reptiles.

Torpid lizards often display characteristic postures. Frequently a lizard that has a temperature below 20°C will stand with its legs held stiff and extended beneath it while the body is held above the substrate. By assuming this posture the lizard prevents further loss of heat to the cool substrate. Torpid lizards also frequently elevate their heads, as do lizards that are placed in cold water; perhaps in heavy rains this response prevents them from drowning. Torpid lizards occasionally elevate their hindquarters while in the defecatory pose, but defecation usually takes place only at temperatures within the normal thermal activity-range.

Limiting effect of moisture content of soil

Burt (1928b:43) suggested that the racerunner is unable to exist where the moisture content of the soil is high. I noted that racerunners ordinarily were not active after rain while the soil remained moist (p. 15). In relatively moist areas the inability to raise temperatures rapidly causes frequent enforced inactivity, limits the amount of fat that the lizards are able to store (causing decreased survival in hibernation), increases losses from predation, and causes eggs to rot or prolongs their incubation period past the optimal time of emergence of hatchlings.

FIG. 10.—A racerunner basking on a warm rock. The body is flattened in a horizontal plane, and the limbs are held against the substrate; the temperature of the body of the lizard is elevated primarily by conduction of heat from the substrate. × approximately 4/5.

FIG. 11.—A captive racerunner basking on cool sand. The body is held clear of the substrate; the temperature of the body is elevated primarily by insolation. × approximately 1.

High content of moisture in the soil further restricts populations of racerunners by producing luxuriant vegetation that limits the basking area. Fitch (1958:14) found that successional changes in the area of his study reduced the amount of barren soil and rock and caused a decrease in the population of racerunners. Since racerunners bask frequently and maintain bodily temperatures within the thermal activity-range of the species, these lizards usually are not able to hunt for long periods in dense vegetation. With a decrease in number of convenient places in which to bask, activity is confined to a smaller area, and the competition for food is intensified, forcing non-aggressive individuals into peripheral areas. If these areas lack suitable basking sites, the less effective reactions of hunting and escape when the temperature of the body is low would result in a low rate of survival.

The importance of exposed basking sites is demonstrated by the appearance of racerunners on recently exposed surfaces in otherwise unfavorable habitats, such as tall grass. In early August, several tons of sand and gravel were dumped along a roadside north of the University of Kansas Natural History Reservation. In late September, three hatchlings were found on this local microhabitat. They probably originated from a clutch of eggs laid there in August by a yearling female that had been forced out of a more favorable habitat (over-grazed pasture) several hundred yards away by competition with larger adults. The hatchlings thrived on this exposed area by hunting in the grass and returning to bask at intervals of a few minutes. This example also suggests that racerunners possibly "migrate" through unfavorable habitats along roads.

Daily cycle

Under usual weather conditions of summer, most racerunners emerge between 8 and 10 a.m. After a rain the thermal threshold for emergence is not reached so soon by the lizards in their tunnels. After heavy rains, lizards remain in their tunnels for several days, even though sunshine warms the surface of the soil. Wet sand does not warm so rapidly as dry sand. As a result, racerunners that are several inches under the surface of damp soil do not attain bodily temperatures high enough to permit normal activity.

The relationship between the threshold for emergence and strength of hunger drive was demonstrated in captive racerunners. When the temperature in the terrarium was raised to permit the lizards to become active, some did not emerge, and those that became active did not all emerge at the same time. Usually they emerged in the order in which they had last fed, although temperatures of the lizards in their tunnels were found to be the same.

For a short time after the lizard leaves its burrow, the animal engages in activity here termed "arousing behavior," a stereotyped series of actions that normally follows "awakening behavior," (p. 13), and begins with a period of concentrated basking. This basking period is seldom interrupted. When the temperature of the lizard has been elevated to the threshold for defecatory behavior, the animal will cease basking and defecate.

In pre-defecatory movements, the body is thrown into an "S"-shape by means of a sudden lateral flexure, with the tail arched upward and its base elevated. Movement appears to be strained; it seems that the lizard is forcing fecal material from the large intestine into the cloaca. The lateral "S" position of the body is maintained only momentarily. The lizard then walks away, sometimes dragging its vent along the ground. These pre-defecatory movements are usually repeated several times in succession in the course of arousing behavior and are normally followed by defecation.

The six-lined racerunner defecates in the same general fashion as other lizards. The hind feet are placed at right angles to the body and extended far apart; the pelvis is then elevated by arching the body and tail and straightening the hind limbs (Fig. 12). As the feces pass through the vent, the lizard shifts its position slightly and alternately lifts its hind feet slightly off the ground. The lizard arches the body and tail even more; then the feces appear and are deposited (Fig. 13). There seems to be much muscular straining by the lizard in voiding the scat, and the hemipenes may protrude momentarily. Arching the back and shifting of position probably aid in voiding feces. Since the feces are always capped posteriorly with a white deposit of uric acid, the position of a scat serves to indicate in which direction the lizard was facing.

Following defecation, the lizard characteristically rubs its vent on the ground and walks slowly away (Figs. 14 and 15). The tail usually remains arched momentarily, and sometimes the body is brought into an "S"-shape again. The post-defecatory walk resembles that of courtship, except that no tail vibration or "shimmying" movements accompany defecation.

Following defecation and related behavior, the lizard usually begins hunting. The duration of this activity is correlated directly with the temperature of the soil and the abundance of available food. If the soil is cool, the lizard occasionally interrupts hunting and basks. Racerunners sometimes remain active only for a few hours in the morning on warm days in early summer when there is a large supply of soft-bodied nymphs of grasshoppers. Often racerunners stay active during most of the period of daylight when the sun is not shining brightly or when soft-bodied nymphs of grasshoppers become scarce.

Hunting by a lizard is often interrupted by various other activities. High temperature of the soil causes the lizard to alter its activities, moving into shade, where it rests or continues to hunt. Disturbance by other lizards hunting in the same area often causes the lizard to seek a place of hiding or an escape-burrow where it can rest safely (p. 35). The temperature of the escape-burrow itself is sometimes no lower than the temperature of the surface of the soil, but the dark shelter affords escape from insolation. A lizard that retires into its escape-burrow usually remains during the hottest part of the day, and if it has been successful in hunting may remain throughout the next day. However, the lizard typically resumes its search for food in the afternoon, and, if it is unsuccesssful in finding enough food, its retirement into a tunnel is presumably a result of lowered bodily temperatures late in the day.

The sequence and pattern of daily activities seem to be similar from day to day. However, external factors, such as moving prey, other lizards, or human activity may interrupt any part of it. For instance, a racerunner sometimes ceases post-defecatory activity in order to feed, when prey appears. A lizard that is taken out of its escape-burrow by hand often hunts when released before it returns to the burrow; individuals removed from traps in late afternoon sometimes hunt before seeking shelter. An aggressive lizard often interrupts the feeding, hunting, defecation, or other activities of another lizard. The temperature of the substratum may alter the normal sequence of activities. For instance on cloudy or cool days a lizard frequently ceases other activities and basks.

Individual behavioral patterns are usually expressions of physiological need but may in themselves satisfy psychological drives and may be performed without the accompanying physiological function. Awakening behavior, for instance, may be, in part, learned. A lizard performs various parts of a behavioral ritual each day. For instance, a lizard that is hungry leaves its tunnel in the morning. Then, after its temperature has been raised, by bask-

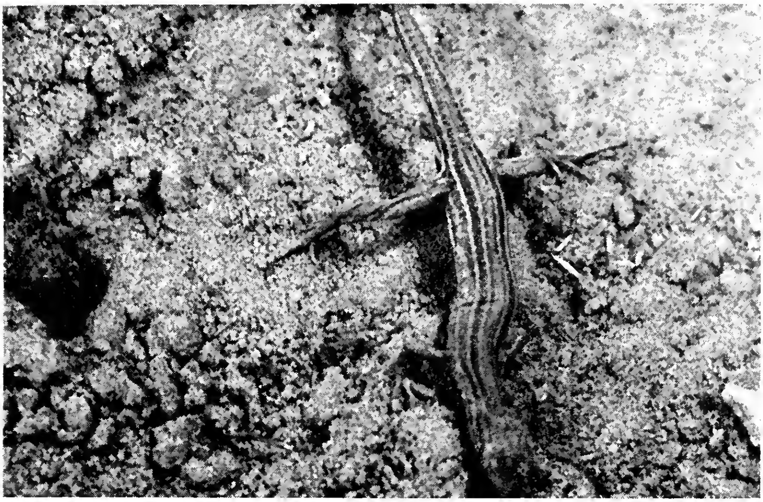

FIG. 12.—A racerunner about to defecate. Note that the body forms an "S" and the pelvis is held clear of the ground. The hind limbs are stiffened and held far apart. × approximately 1.

FIG. 13.—The defecatory pose in a racerunner. Note that the tail is held in an arch. × approximately 1¼.

FIG. 14.—A racerunner that has just deposited a scat. Note the strained appearance of this position. × approximately 1.

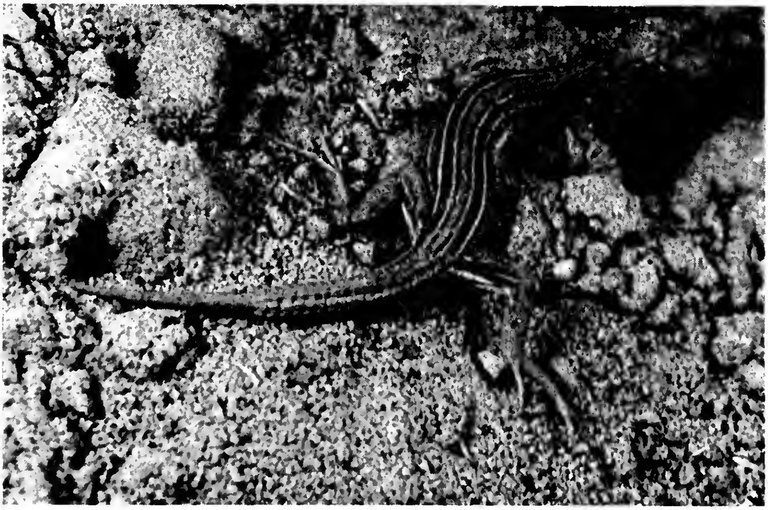

FIG. 15.—Following defecation, the racerunner slowly moves away while rubbing its vent against the substrate. The tail is usually arched more than in this individual. × approximately 1.

ing, to a certain level, the lizard usually has the physiological urge to defecate. The sequence presumably becomes ritualized, and on a morning when no fecal material is present in the digestive tract, the type of behavior that normally accompanies defecation probably will occur at the usual time. The path followed by a hunting lizard each day probably in part results from habit.

Barden (1942) found that captive six-lined racerunners retained their diurnal period of activity whether they were kept in complete darkness (at 29.4°C) or in constant artificial light. He found also that reversal of the periods of light and dark did not always cause a corresponding shift in the time of daily activity, and that newly-captured lizards exhibited the most marked diurnal period of activity. He postulated that the activity of the lizard is due partly to endogenous factors, which are partly habitual, and partly to exogenous factors, or changes in the environment. No lizards were given food in his experiments, and the periods of activity were not regulated by the appearance of hunger and its subsequent satisfaction. Therefore, it seems that the daily cycle was maintained in Barden's captives by a psychological drive (also termed "internal clock"), to become active at regular intervals. This drive was more apparent in newly-captured lizards because of the reinforcement by habit in the wild. These experiments by Barden, as well as most of the other experiments with captive lizards, are misleading because the lizards did not attain temperatures that are necessary for normal activity. The lizards in Barden's experiments were active only because of the lowering by hunger of the threshold for activity.

Seasonal Cycle

During May and June, most of the racerunners in the wild are active every day that they are able to reach the threshold for emergence. As the season passes, progressively fewer lizards are seen each day. Activity of adult racerunners nearly ceases in late summer; only an occasional adult is seen in late August and September (Fig. 16). Day-length seemingly is not correlated with this decrease in activity of adult lizards, since individuals kept in outdoor observation pens remained active in September and early October, long after those in the wild became dormant. Abundance of food seems not to be a factor in decreased activity, since the kinds of prey that adult lizards take before they become dormant are abundant from August into October; this prey is taken by hatchlings.

Decrease in the activity of adults can be explained by the progression of physiological changes throughout the course of the season. At the beginning of the season the lizards have little fat stored and are hungry. They become active each day and take many items of prey in their periods of hunting. As the season progresses, the food is stored in paired bodies of fat in the body cavity of the lizards. Fat in adult racerunners ranges from none at the time of emergence from hibernation to between two and two and one-half percent of the bodily weight at the end of July and four and one-half to eight percent by mid-September. Hunger drive probably decreases with the increase in the amount of fat stored; also, the thermal threshold for daily activity presumably rises with the decrease in the physiological need for food. Thus, racerunners with a relatively large store of fat, more than five percent of bodily weight, may not leave their tunnels at all in late August and September because their temperatures never reach the threshold for activity. As the stored fat is used by the lizard during hibernation, the threshold for emergence decreases. By May of the following year, this threshold is low enough and environmental temperatures are high enough for the lizards to become active and emerge.

The sexes differ in the rate of storage of fat. Females are unable to store fat in the early part of the season because their food is utilized to a large extent in the production of eggs. As a result, those females that produce eggs near the end of the laying season do not have large bodies of fat in early August. These females stay active longer than the lizards that have stored up fat throughout June and July. The greatest percentage of these females that are active in August are yearlings.

Correlation between amount of fat stored and beginning of dormancy was noted in the racerunners kept in the two outdoor pens. Lizards in the large pen had access to more food than those in the small pen, were able to store fat, and consequently retired from activity at about the same time that most of those in the wild became dormant. However, those in the small pen, unable to store fat so rapidly, remained active until mid-October. The first of them to go into hibernation, in early October, was the "fattest;" the second became dormant in mid-October. On October 20, the "thinnest" lizard was found dead (either from exposure to low temperatures or from starvation) in a basking position. Future study of this species might well be concentrated on a determination of the consumption of fat during the late summer period of reduced activity and during hibernation. It seems that the changing physiological state of the lizard influencing thermal thresholds of activity causes a seasonal fluctuation in the numbers of active racerunners as well as a fluctuation in their periods of daily activity.

The only hibernating racerunner found was a large female. Her temperature was 22.8° C, the same as that of the surrounding sand. She was taken at a depth of five inches on September 20. Many hours were spent by my husband and myself in turning over rocks and logs in an otherwise unsuccessful search for hibernating lizards. Excavations 12 to 50 inches deep were made under likely-looking logs and piles of tarpaper and boards. Presumably, most of the racerunners in the study area hibernated in inactivity-tunnels that were spaced uniformly throughout the area.

REPRODUCTION

Eggs and nests

In the study reported on, only one nest was found; it contained four eggs on June 20 and was four and one-half inches below ground. The clutch was transferred to a covered finger bowl containing sand, then placed at the bottom of the hole from which the eggs were taken in order to maintain the normal incubation temperature (approximately 30°C) and to calculate the length of incubation. Although the bowl protected the eggs from predation, lack of drainage from the bowl kept the sand moist and presumably lowered the temperature of the eggs, retarding development. They hatched between August 16 and 19, after a minimum period of incubation of 57 days.

The situations where hatchlings were seen in greatest abundance probably reflects the choice of nest-sites by the gravid female racerunners. These situations, somewhat different from the preferred habitat of adult racerunners in the study area, were characterized by: (1) sloping surface (good drainage allowing the sand to dry out rapidly after a rain would favor maintenance of high temperature in the nests); (2) sand surfaces not shaded by tall plants (direct sunshine would permit maintenance of high temperature in hatchlings); (3) short vegetation (hatchlings could reach insects that live on plants); (4) fine sand in which the hatchlings would easily excavate burrows.

In captivity ovulation did not occur and gravid racerunners resorbed their eggs, or, if the shells had already formed, the eggs were deposited on the surface of the sand, instead of in a nest cavity (perhaps because the sand was too dry to permit excavation).

Reproductive cycles

Most adult females in the area studied produced eggs in June. Fitch (1958:36) found that some females that had hatched in the previous season reached minimal adult size (approximately 62 mm. snout-vent length) and produced their eggs late in June, but most yearling females laid later in summer.

In the summer of 1958, the ratio of non-gravid to gravid females rose abruptly from June 16 to 21 and from July 1 to 11 (Figs. 16 and 17). There were less distinct periods of production of eggs between June 6 and 11, and between August 10 and 15. Fitch (*loc. cit.*) also found egg-laying to be concentrated in periods—the third week of June and the second week of July.

Gravid females comprise four age-size classes. Dates of capture indicate that each class lays at a different time. Yearling females, which probably comprise more than half of the total, can be arranged in two categories according to the time of hatching in the previous year: in July and August or in September. Individuals of the latter group have a shorter period in which to grow before hibernation; those hatched in late September usually have snout-vent lengths of less than 45 mm. at the beginning of the following season. Those hatched in the previous August are able to attain a snout-vent length of 55 mm. or more by June.

Two other size groups of females can be recognized, those 78 mm. or more in snout-vent length, and those of fully adult size but less than 78 mm. Fitch (1958:41) found that second-year females (those having survived two winters) ranged from 68 to 77 mm. in snout-vent length in May and June, averaging approximately 73 mm. in this measurement. Therefore, the smaller adult females are second-year individuals, and the larger adult females are three or more years of age.

The first eggs of the season are laid in the first week of June by females that are 78 to 84 mm. in snout-vent length and three or more years of age. Deposition of eggs by yearling females that hatched in the previous August is concentrated around June 17. The last eggs of the season are laid before August 10 by females that hatched in the previous September. Probably the females more than three years of age that lay eggs in early June also deposit a second clutch in early August.

Fitch (*op. cit.*) stated that 57 percent of racerunners in the population that he studied were yearlings, approximately 25 percent were second-year individuals, and less than 18 percent were older individuals. The yearling females lay from one to three eggs, and the older females lay three to five eggs. Only the old females (fewer than 18 percent of the total) produce clutches in early June, and these clutches hatch in early August, but the young produced from them are much fewer than are produced later in the season. Only a small percentage of the yearling females that are hatched in August lay eggs by the following July 5; most of these yearling females lay their eggs in late July and early August. There is a wide range of bodily lengths in yearlings hatched late in the previous season (late August to late September) since they have had varying lengths of time to grow. Also, competition for favorable home-ranges and varying success in finding food has increased the original differential. Fitch (verbal communication) suggests that site of nest probably is another important factor; greater depth and less sunshine would prolong development. The spread in size of hatchlings from clutches laid on the same date might be substantial. Hence the yearling females mature and ovulate over a period of weeks and their egg-laying extends from early July to early August. As a result, distinct peaks of emergence of hatchlings (from eggs deposited by yearling females) cannot be found in September, although the estimated earliest and latest dates are August 22 and September 26, respectively. These two dates are used in computing the length of the period of incubation for eggs of yearling females. Lizards that hatch in September presumably attain reproductive size and maturity around the first of August the following year. Since I recorded a peak in emergence of hatchlings in September, indicating that a corresponding peak in egg-laying occurred in early August, I assume that the peak of egg-deposition in August and the resultant hatch in September chiefly represent the reproduction of yearling females. Since these two peaks of laying and hatching surpass all similar peaks of reproduction in the year, according to my observations, I presume that this reproductive peak in August and September by yearling females is self-perpetuating from year to year. It should be pointed out, however, that data from gravid females does not clearly substantiate these assumptions.

Approximate peaks of egg-laying were ascertained by me to have occurred at times when I noted sudden reductions of gravid females. The approximate peaks of hatching similarly were ascertained to have occurred immediately prior to times when I noted increases in the number of hatchlings in the population. It is reasonable that the period of incubation corresponds in a general way to the time intervening. From the sequence of concentrated laying and hatching indicated by my records, the following incubation periods are deduced.

Dates of concentrated laying (reduction in gravid females)	Dates of concentrated hatching (more hatchlings seen than immediately prior to this date)	Approximate duration of incubation
June 8	July 29	51 days
June 17	August 7	51 days
July 5	August 22	48 days
August 8	September 26	49 days

In addition to these peaks, a marked general increase in numbers of hatchlings seen began on August 22.

An average period of incubation of approximately 50 days thus seems to have characterized six-lined racerunners in 1958 at Lawrence, Kansas. The longer period of incubation (approximately 60 days) that Brown (1956:38) found in this lizard in North Carolina may have resulted from the incubation of the eggs at laboratory temperatures differing from those in nature.

The incubation period limits the breeding season of racerunners at the latitude of Lawrence, Kansas, since fat must be stored by the hatchlings in order for them to survive the winter. Those hatchlings that emerge after a certain date probably do not survive because they have insufficient time to acquire a supply of fat that will allow them to hibernate or survive the winter in hibernation. This date could be calculated by comparing spring recaptures of hatchlings marked in the fall.

The disadvantages imposed upon females that lay eggs after mid-August constitute another limiting factor. These females must stay active longer than other adults in order to accumulate enough fat to survive the winter. A female that lays eggs in late August or September would be forced to extend her period of activity into cooler weather. Then she would have to spend long periods in basking in order to remain active. When she was not basking her temperature would usually be below the thermal activity-range and her reactions of escape would be low.

Lizards could be observed most easily while they basked and hunted in the open. Such activity was concentrated in the vicinity of a pile of boards and tarpaper (Fig. 3), and most observations were made there. Figure 16 shows that more gravid than non-gravid females were seen. The gravid females had the greater bodily mass and basked longer than did non-gravid females in order to raise their temperatures to the threshold of normal activity. The temperatures of the smaller lizards rose rapidly and they began to hunt in early morning in dense vegetation where observing them was impossible. Therefore, non-gravid females were rarely observed, except in the few days after they had deposited eggs. In this short period the non-gravid females were especially noticeable because of their activity in hunting, which decreased as they gradually compensated for the seeming physiological stress involved in production of eggs and they returned to normal daily cycles.

Conflict between lizards earlier in the season helps to explain why Fig. 16 shows so few individuals involved in the late period of deposition of eggs. Most females that lay eggs in July are yearlings. More than half of the females in the population are yearlings, yet the earlier peaks of deposition *appear* to involve laying by more individuals than do later peaks. The two gravid females represented in the peak at August 10 were both more than three years of age. No gravid yearlings were seen or trapped in the area studied because yearlings as a group are forced into peripheral areas by aggression of adult lizards. This aggression toward yearlings is most pronounced in May and early June, but yearlings that stray back into the area later in the season are usually chased away. As late as August 9, an adult female (76 mm. snout-vent length on July 1, 83 mm. on September 19), which had probably just deposited her second clutch of eggs, chased away a yearling female that was basking nearby.

Newly-hatched lizards can be distinguished from young of previous clutches by the vivid blue coloring of their tails. The vivid color fades after the first molt and becomes dull in the older young. Comparison of snout-vent lengths of juveniles collected on several dates indicates that most were within or near the size range of newly-hatched racerunners (32 to 35 mm. in snout-vent length); the older and larger juveniles were not collected so often (Fig. 18).

The local concentration of nests may be an explanation of the abundance of hatchling racerunners in a given area compared to the abundance of older juveniles. Hatchlings seem to stay in the

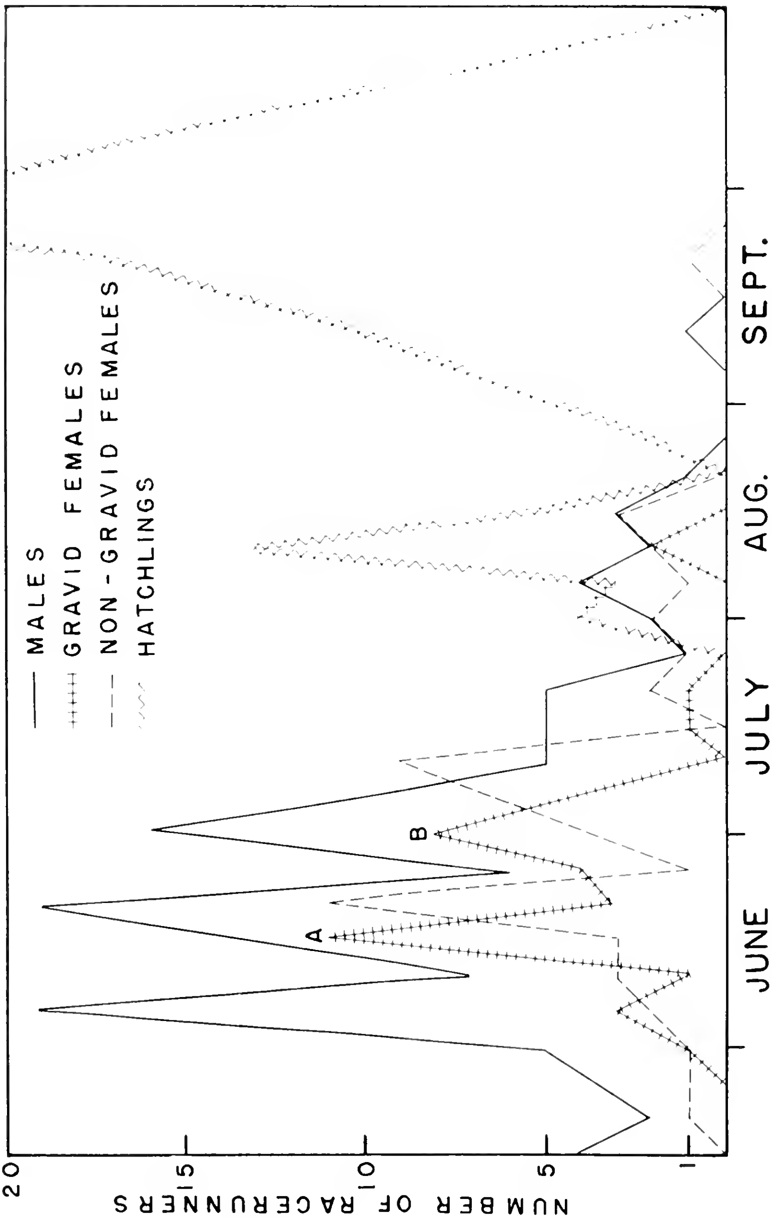

FIG. 16.—Number of racerunners seen throughout the season. Each point on the graph represents the number of lizards seen in the previous five days.

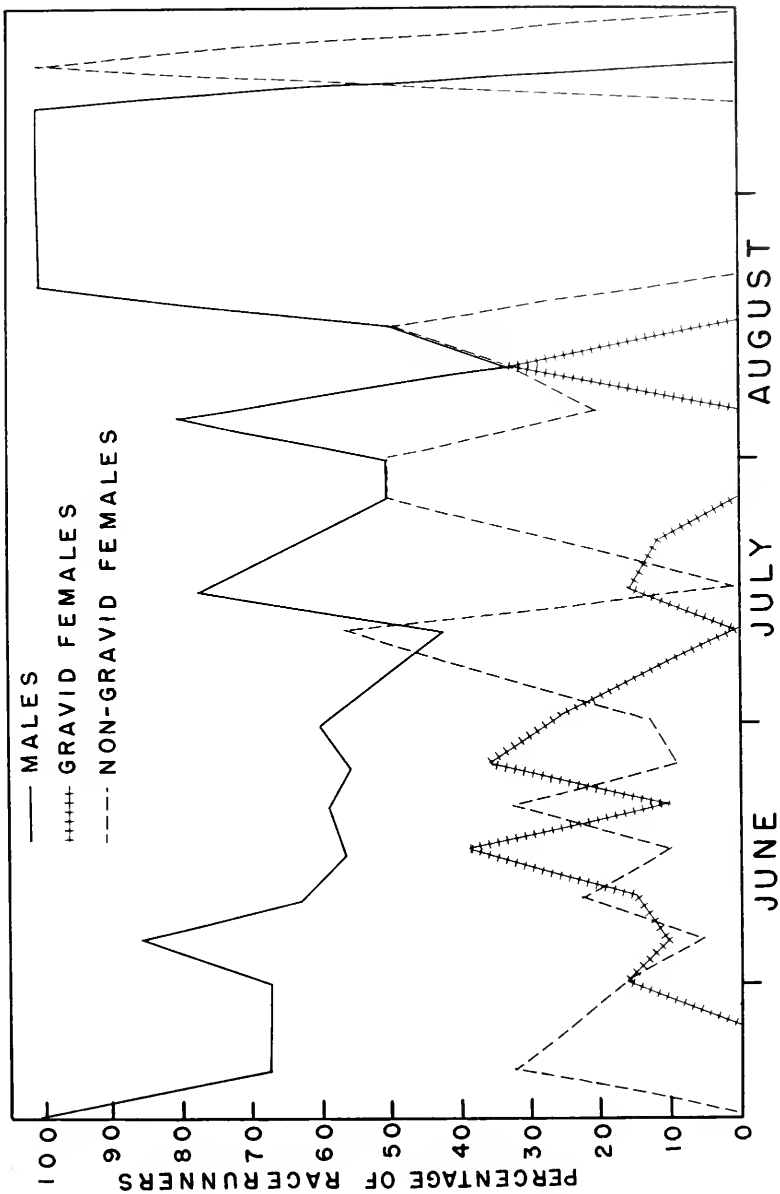

FIG. 17.—Percentages of adult racerunners seen throughout the season. Each point on the graph represents the percentage of the total number of lizards seen in the previous five days. Peaks of deposition of eggs are seen on June 8, June 17, July 5, and August 8.

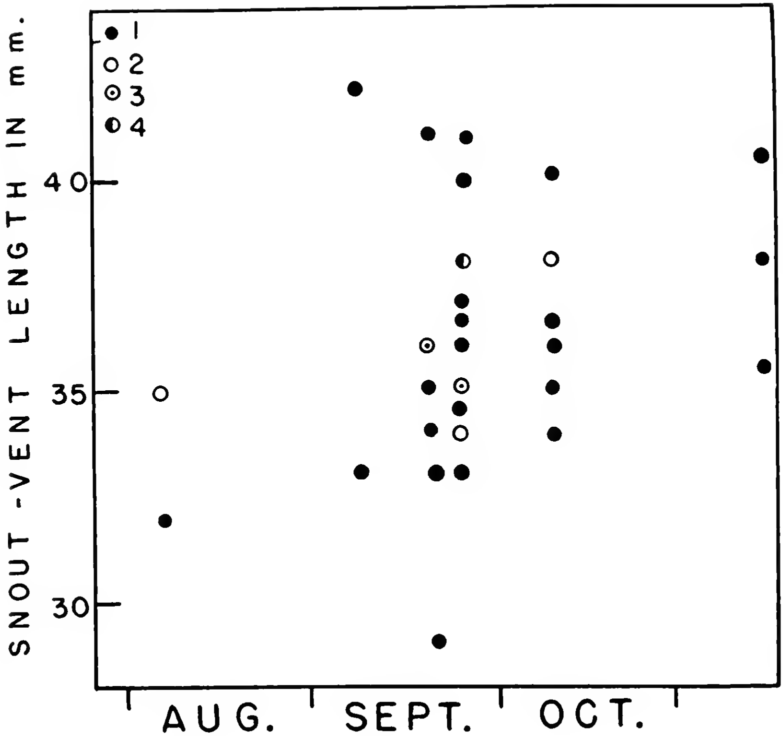

FIG. 18.—Snout-vent lengths of young-of-the-year on specific dates in late summer and fall. The solid dots represent one racerunner each, while the other dots represent two, three, and four racerunners, as indicated in the figure.

vicinity of the nests at first, but later tend to scatter in all directions in search of food, or move to areas in which competition is reduced. Hatchlings occasionally were aggressive toward others, contributing to this dispersal, and the numbers seen decreased after the first and second hatching periods, on July 29 and August 7, respectively (Fig. 16). Increase in hatchlings seen at the end of August results from the large number of eggs deposited around July 5. The peak of emergence of hatchlings probably is reached about the last two weeks of September.

More females lay in July and August than in June; favorable habitat in August contributes to the success of these late clutches. Most of the hatchlings seen in September were on a patch of bare sand about 20 feet wide and 200 feet long on the south slope of the road on the dike, which marked the southern boundary of the study area. This strip of sand had been part of a rye field; earlier in the season it did not afford a favorable habitat for lizards. After the field was cleared at the end of July, the strip took on many characteristics of a favorable habitat for incubation of eggs and for activity of hatchlings.

BURROWS

Types of burrows, their uses and means of excavation

A racerunner seeks shelter in order to prevent overheating and/or to become inactive. Shelters are of four types: temporary unexcavated shelters, escape-burrows, escape-tunnels, and inactivity-tunnels.

The temporary shelter serves chiefly for avoiding high temperatures and is occupied only until the bodily temperature falls into the thermal activity-range, below 41°C. These shelters are of various types, such as the spaces under boards or tarpaper and areas shaded by plants or pieces of debris; all offer protection from the direct sunlight. The lizard makes use of many such temporary shelters on a warm day but returns to the same one repeatedly if activity is concentrated near it.

A second type of shelter is a burrow used when the lizard becomes overheated in the warmest part of the day. This "escape-burrow" consists of a shallow tunnel-like depression excavated by the lizard under a flat rock, board, or piece of tarpaper. A pattern of behavior seems to be correlated with excavation of this type of burrow; presumably the satisfaction of other drives (such as feeding or defecation) initiates the behavioral pattern of excavation. The drive of a lizard to excavate an escape-burrow is sometimes first evidenced in the snakelike motion or vibration of the tail and "shimmying" movements of the pelvis; similar movements are employed in courtship. The lizard then approaches the site of excavation and begins to dig, making several strokes with each forefoot, alternately, advancing into the deepening hole. After a small pile of sand has accumulated under and behind the lizard, it turns and, by using the soles of its forefeet, pushes the sand away from the hole. This alternate excavation and pushing away of accumulated sand is repeated many times before the burrow is completed. Pack (1918:52) described digging by *Cnemidophorus tigris,* which alternates the method of digging described above with single alternate strokes of the forefeet.

The six-lined racerunner frequently leaves the site of excavation in order to bask nearby. When it again approaches in order to resume digging, the vibration of the tail and "shimmying" movements are sometimes repeated. These two movements are also used by the lizard when moving in the burrow in the course of excavation and serve to widen the burrow by pushing loose sand to the sides. When the burrow is completed, it is barely wide enough (20 to 25 mm.) for the lizard to turn around inside, and a few inches to a foot in length. Some burrows are Y-shaped, but each has only one entrance. When the burrow is completed, the lizard retires inside during the warmest part of the day.

Lizards excavate new escape-burrows nearly every day, usually in late morning. One female entered a previously excavated escape-burrow after a period of hunting, was subsequently disturbed and fled, but later returned to the same place and seemed to attempt to find the entrance of the escape-burrow, which had been obscured when she was disturbed. After many unsuccessful "attempts" with intervening retreats to a temporary shelter under a board, she finally crawled under the tarpaper several inches from the original entrance an hour after she had been disturbed. This incident indicates that a lizard sometimes uses escape-burrows already excavated, remembering the location and returning to them, rather than digging a new burrow. Lizards do not repeat "shimmying" movements when returning merely to enter a burrow.

Another type of shelter is termed an "escape-tunnel." Fitch (1958:29-30) described such unplugged burrows into which racerunners retreat in order to maintain their temperatures at a level of approximately 40°C. About 20 mm. below the surface of the sand, Edgren (1955:1-2) found short burrows in which racerunners lay facing away from the tunnel openings. When the lizards were disturbed, he found that they "exploded" through the surface of the sand. Edgren stated that the lizards in these tunnels are able to control their temperatures because their bellies are in contact with the damp soil and their backs are adjacent to the warm, dry surface. These escape-tunnels are presumably modified escape-burrows and are excavated only in areas where there are no flat objects or temporary shelters from the sun.

My study area had many ready-made shelters for adult racerunners. As a result, no escape-tunnels were found there. Several times, however, escape-tunnels were found in an observation pen that contained few ready-made shelters. Also, captive lizards often retreated into the entrances of inactivity-tunnels during the heat of the day. Often when the open holes of tunnels were probed, resting lizards, which were warm and fully active, "exploded" through the surface of the sand, as described by Edgren and Fitch. Hatchlings that inhabit open situations and that became overheated usually retreat into entrances of tunnels.

An "inactivity-tunnel" is a fourth type of shelter, usually occupied by the racerunner during the night or during long periods of inactivity. It is excavated in the same manner as the escape-burrow, except that no "shimmying" movements or tail vibrations are employed. Loose sand inside the tunnel is not pushed to the sides, as is done in the shallow escape-burrows. Like the escape-burrows, the inactivity-tunnels that were found by me each had only one entrance, although Blanchard (1922:6-7) found tunnels with two openings, one of which was plugged with sand.

Open entrances of inactivity-tunnels are often found under objects, sometimes near escape-burrows. When the tunnels are dug in open areas, the racerunners plug up the entrances with loose sand that is pushed through the tunnel from its closed end. An emerging racerunner does not push this plug out of the entrance of the tunnel, but pulls the sand inward, then turns and pushes the sand back toward the deepest end of the tunnel. No recently excavated sand is found near the tunnel from which a lizard has emerged. An inactive lizard remains in the deepest part of the tunnel, which may be seven or more inches beneath the surface of the soil. The entrance of the tunnel usually makes a 45-degree angle with the surface of the soil, except when the tunnel is excavated on a slope. The tunnel itself is horizontal.

No racerunners were seen to excavate inactivity-tunnels in the wild, but captive lizards were observed to dig such tunnels in the pens and terraria. All tunnels in the pens were excavated in late afternoon by individuals whose temperatures were not elevated by basking. Under such conditions, the excavation of tunnels took as long as 50 minutes; captive lizards with temperatures within the thermal activity-range often excavated inactivity-tunnels in the terrarium within ten minutes.

Occasionally I found adults in their tunnels by turning the sand over with a shovel or rake; this method was successfully used in finding hatchlings. Most of the inactive adults that were found were in escape-burrows under boards and tarpaper, although some adults were dug out of their inactivity-tunnels. These tunnels were located by finding unplugged entrances under debris or by finding recently excavated sand (damper than the rest of the sand at the surface) near plugged entrances of tunnels. Most of the tunnels that were found in the open, however, had open entrances and were unoccupied.

Inactivity-tunnels in the wild are usually situated where the morning sunshine strikes their entrances, in the open or on the east, north, or south sides of clumps of brush, logs, or debris. In the terrarium, captive lizards placed their tunnels in the warmest sand (near the lightbulb or on the side of the terrarium that was reached by the morning sunshine). Lizards in the outdoor pens did not always excavate tunnels in the warmest sand. Tunnels were on the west side of the pens where the sun first reached the sand in the morning. The racerunners in the terrarium might have been responding to the position of the light-bulb and the sunshine, and not merely to the temperature of the sand. Each captive racerunner habitually excavated its inactivity-tunnels in the same place each day.

Commensalism

Occasionally racerunners use burrows excavated by other animals. Pearson and Nelson (1952:188) found lateral tunnels that had been excavated by racerunners in the burrows of the oldfield mouse (*Peromyscus polionotus*). Hallinan (1923:19) observed racerunners going in and out of burrows of the gopher tortoise (*Gopherus polyphemus*). Some racerunners in the present study were found to make use of burrows that had probably been made by the mole (*Scalopus aquaticus*), as Fitch (1958:30) found in his study of the same lizard.

In my examination of the escape-burrows and inactivity-tunnels, I found several species of insects to be commensal with racerunners. These insects (except members of the genus *Gryllus*) are not preyed upon by racerunners at any time. Moreover, the psychological state of the lizard in its burrow would probably prevent it from feeding, even when its temperature is above the threshold for that activity. The insects found associated with the lizards include tiger beetles (*Cincindela*), false bombadier beetles (*Galerida virginata*), crickets (*Gryllus assimilis*), and nymphs of the assassin bug (Reduviidae).

Length of occupancy of burrows

The frequency with which burrows and tunnels are excavated and abandoned depends upon the location, the type of burrow, and the type of substrate. In the study area, several sites were favorable for the excavation of shelters. Inactivity-tunnels beneath large piles of boards and tarpaper were sometimes maintained for many weeks. A lizard often returned to the same escape-burrow repeatedly, if the burrow was situated near the area where the lizard spent most of its time. Ordinarily these shelters are excavated daily, but inactivity-tunnels are usually used longer than escape-burrows.

In areas where digging is easy (as in fine sand), tunnels are probably not used more than a few times and are abandoned for new ones frequently. The hatchlings that were observed in an open, sandy area seemed to excavate new tunnels regularly. The dry, fine sand provided a favorable medium for excavation, and many patches of exposed sand had more than ten entrances of empty burrows per square foot. In contrast, hatchlings that were observed in a pile of sand and gravel, which had a hard surface, seldom changed burrows.

FOOD HABITS

Roles of olfaction and visual stimuli in detection of food

Most of the daily activity of a racerunner consists of searching for food. In this report the term "sluggish prey" refers to inactive, minute, or slowly-moving animals (caterpillars, ants, small spiders, snails) that are often hidden under debris. Olfaction was most often used by racerunners in seeking sluggish prey, whereas hunting by sight was used in seeking active prey. The thermal threshold for hunting by sight was several degrees lower than that for hunting by olfaction. In general, aggressive behavior seemed to be correlated with hunting by sight. Non-aggressive individuals (such as gravid females and yearlings) were seldom observed to run after moving grasshoppers and catch them in mid-air.

Grasshoppers and moths are usually taken as they are moving past a hunting lizard. A basking racerunner occasionally feeds upon active prey, and this behavior may have been misinterpreted by Householder (1917:61); he described racerunners as "lying in wait" for insects to come within reach. Active prey is often detected by a racerunner (especially if the bodily temperature is near 40°C or the lizard is unusually hungry) and then taken after the prey has stopped moving.

In detecting sluggish prey by olfaction, a racerunner employs its nose and/or tongue. The description by Stebbins (1948:200) of the highly-developed nasal epithelium in the genus *Cnemidophorus* suggests that these lizards have a keen sense of smell. In some instances lizards were seen to touch their snouts to objects, testing them olfactorily by means of Jacobson's organ. It could not be determined whether the lizards were employing their nasal epithelium.

Hunting behavior

The behavior of a hunting lizard varies somewhat according to strength of hunger drive and bodily temperature. A lizard having a temperature in the low thirties is usually less successful in hunting than a lizard having a higher temperature within the thermal activity-range of the species. Characteristic patterns of hunting (such as gait, chasing prey) are altered in a lizard having a low temperature. For example, a lizard having a temperature of 32°C is much more likely to lose a pursued insect that stops moving than is one with a temperature of 40°C; presumably the temperature of the former lizard prevents it from receiving stimuli through its sense organs efficiently.

In general, larger prey is hunted by sight, and smaller prey by olfaction. A racerunner unable to find large prey by sight may change its tactics to the more detailed investigation of its surrounding, characteristic of hunting by olfaction. In hunting by sight, a racerunner walks rapidly with short, uneven movements and moves its head from side to side in order to locate prey. Sometimes the lizard pauses under a plant and looks up into the leaves for active insects and leaps at the prey in an effort to catch it in midair. The lizards usually hunt on the ground, but occasionally one scrambles into low plants in pursuit of prey. Such a lizard usually falls to the ground within a few seconds. Similar climbing behavior has been described in other species of *Cnemidophorus* by Milstead (1957:110). I recorded many instances of hunting lizards climbing from several inches to a foot into vegetation.

Hunting by olfaction and by sight is frequently alternated by a racerunner that has a temperature above 38°C. A lizard that is hunting by olfaction moves its head jerkily but probably does not cover as much area as does a lizard that is hunting by sight. There are rapid movements of the head with simultaneous use of the tongue in olfaction. The racerunner typically probes with its snout under leaves and into small holes, then rapidly draws back and probes again. It paws at the surface of the sand or at small piles of dead leaves and twigs, and then touches its snout tentatively to objects that it has uncovered. At a bodily temperature above 40°C, the lizard becomes extremely wary of moving objects and often "starts" at the approach of an insect or another lizard. Under such conditions observations of normal hunting becomes difficult, because the lizard often reacts to the movements of an observer. Frequently, a lizard hunting by olfaction (judged to be warm because of its sensitivity to stimuli) stands on its hind legs and places its forelegs several inches up the stalk of a plant and then extends its tongue, seemingly seeking sluggish prey by olfaction.

Hunting begins when the temperature of the basking lizard reaches the required level. The period usually extends over many hours, but it is often interrupted during the heat of mid-day when the lizard seeks cover. The actual time of day at which the lizard hunts varies with the temperature of the soil. After periods of rainy weather, the temperature of the lizard sometimes remains below the thermal activity-range until mid-afternoon. In June, July and August, percentages of hunting lizards observed in periods in the morning were as follows:

	June	July	August
Before 9:30	13.0	59.0	83.0
9:30 to 10:45	43.5	41.0	17.0
10:45 to 12:00	43.5	...	...
	100.0	100.0	100.0

Thus, hunting became increasingly restricted to early morning as the summer progressed. June, 1958, was an unusually wet month in Kansas, and on many days the lizards were confined to their tunnels until the sand dried and the warmth from the sun reached them. July had less rain than June and the lizards emerged from their tunnels and began hunting earlier in the morning. August was relatively dry; the lizards confined their activity to the early part of the day before the sand absorbed too much heat. In every month of activity, some individuals resumed their search for food in the afternoon.

Little hunting behavior was observed in May or the first part of June, presumably because of the large number of conflicts between individuals. The area studied attracted many racerunners because of its abundant shelter and favorable conditions for basking. Aggressive tendencies in many adults resulted in conflict each time the two lizards met. Non-aggressive racerunners concentrated their activity in peripheral areas where disturbance by other lizards was limited. Only three racerunners were seen feeding before June 19; two of these were large, aggressive males and the third was not in the area where the population was most concentrated.

Feeding and factors determining choice of prey

Fitch (1958:32) describes racerunners as "dainty" feeders. They spend varying lengths of time crushing hard prey in their jaws and dismembering large prey. Small, soft-bodied prey (mites, fulgorids, ants, minute spiders, and nymphs of grasshoppers) are taken into the mouth with the aid of the tongue and swallowed without being crushed. These prey usually reach the stomach intact. Snails, leafhoppers, and beetles, may be crushed in the jaws before being swallowed and usually are not intact in the stomach. Larger and more active prey is usually subdued by the racerunner before being swallowed. The lizard usually seizes the prey and crushes it laterally (Fig. 22); the prey is often dropped (especially if it is more than six mm. in length), touched several times with the tongue, then taken back into the mouth. The lizard shakes off the legs of a grasshopper, rubs off the wings of a moth, and tears a caterpillar into small pieces. Large prey that is too durable to be dismembered usually is abandoned. In several instances in the wild and in captivity, racerunners were seen to retrieve hind-legs that they had shaken off of grasshoppers, after devouring the insects' bodies; occasionally these hind-legs were eaten before the rest of the grasshopper was ingested. Hence, grasshoppers and their hind legs are occasionally found separately in stomachs of racerunners.

Size of prey is less limiting than might be supposed. The ability of racerunners to dismember large prey by shaking or rubbing off parts, and to crush large prey between the jaws allows relatively small lizards to take large prey; a female 68 mm. in snout-vent length ate an adult cicada (presumably newly metamorphosed) 22 mm. in length; a male 68 mm. in snout-vent length ate a nymph of a grasshopper 25 mm. in length. More important than size of prey is the ease with which the lizard is able to reduce it to smaller parts. Frequently two or more captive racerunners simultaneously seized katydids as long as two and one-half inches and were thus enabled to dismember the prey much more quickly than they could by the usual methods (Fig. 23). Large butterflies and moths are less easily dealt with and are usually not preyed upon. It seems that the effectiveness of hunting (energy used in hunting *versus* energy derived from prey) is increased by the taking of large prey.

Occasionally, small stones (one to three mm. in diameter) were found in the stomachs of adult racerunners. These would have been regarded as accidental inclusions, as was the sand that sometimes clung to prey, if captive racerunners had not been observed deliberately to ingest such stones while hunting by olfaction. One individual was seen to alternate this behavior with feeding upon mealworms. It seems doubtful that these inclusions serve as "gizzard stones;" possibly they serve as an additional source of calcium in the diet, in addition to the calcium that the lizards presumably derive from the salts in the exoskeletons of the insects and from the shells of snails.

The posture of the racerunners in feeding on most prey is characteristic. Whether picking up minute prey off the ground, touching the tongue to a grasshopper that has been dropped, or crushing a mealworm, the lizard stiffens its forelegs, elevates the forepart of its body, and then bends the head down until it is nearly vertical to the substrate. Large prey is usually swallowed head-first; the racerunner maneuvers the prey into position by rubbing the part of the prey that is projecting from the mouth against the substrate, or dropping the prey and picking it up again, headfirst. In swallowing, a racerunner usually tilts its head upward at a 45° angle. Several minutes may be required to swallow large prey, after which a lizard usually opens and closes its mouth, flicks out its tongue several times and licks its lips, and then flexes its body into a lateral "S"-shape, much as in pre-defecatory behavior. Snakelike flexing of the body seems to aid the passage of food in the esophagus; the action may be vigorous if the prey is more than 15 mm. in length, but the lizard seldom flexes its body at all if the prey is less than 3 mm. in length.

Hotton (1955:108, 109) stated that predation of iguanid lizards upon grasshoppers probably required little more of the teeth than holding the prey. However, racerunners subdue grasshoppers and kill them primarily by crushing with jaws and teeth. Occasionally the teeth serve to grip while the racerunner struggles to free large prey from a plant to which it is securely holding. Perhaps the holding function of the teeth described by Hotton in some iguanids has promoted the development of conspicuous heterodonty. In racerunners, however, the teeth are used mostly for crushing prey and are all approximately the same size.

The most frequent prey of racerunners are soft-bodied insects, according to Burt (1928a:59). Of 11 animals of prey recognized while lizards under natural conditions were catching and eating them, five were nymphs of grasshoppers, two were small, white moths, one was a caterpillar, one was a meloid beetle, and one was a wasp. Racerunners rarely take noxious prey into their mouths, although Burt (1928a:60) reported that individuals (presumably captive) accepted ladybird beetles, then quickly ejected them and wiped their lips on the ground, "displaying great discomfort." Usually, however, racerunners test prospective food by olfaction, touching "questionable" prey with their tongues before taking the animal into their mouths. The attention of captive racerunners was attracted by the movements of toads 20 mm. in length that were introduced, but the toads were rejected as prey after the racerunners had touched them with their tongues. Tiger beetles, sexually mature grasshoppers, and hairy caterpillars are usually completely ignored by hunting racerunners. Perhaps olfactory cues are involved. One racerunner took a meloid beetle into its mouth but quickly dropped this insect, probably in reaction to the noxious secretion of the beetle. The "hair" of certain caterpillars seems to irritate the racerunner. The lizards are often reluctant to take such prey, although Burt (1928a:59) describes how racerunners remove the hair from caterpillars by shaking and rubbing them in the sand. This behavior was observed in the present study. Also, captive hatchlings that manipulated small moths were seen to "spit out" the fuzz that had come off in the mouths of the lizards. No racerunners were seen to pull hair or fuzz from their prey.

Kinds of prey

The kinds of prey that a lizard takes indicate the method of hunting and the degree of "selectivity." Fitch's (1958:31) résumé of the published food habits of the six-lined racerunner indicated the following order of preference: grasshoppers and crickets, spiders, moths and caterpillars, ants and wasps, snails, beetles, flies, cockroaches, and hemipterans. Also, the aquatic larvae of mayflies and mosquitos were listed by Force (1925:26) as part of the diet, but probably are only rarely eaten. Captive racerunners that pursue insects into the water usually abandon pursuit, emerge hurriedly, and shake off the water.

Data from 69 stomachs indicate that kinds and numbers of prey taken by adult racerunners differ according to sex and size of the lizard and the time of year.

Thirty-four racerunners one year or more in age were collected as follows: 18 on June 16, four on June 26, one on July 1, one on July 14, six on July 29, one on August 15, one on September 8, and two on September 19. The average numbers of food items per stomach in the samples were, respectively, 11.4, 3.5, 5, 8, 5.3, 5, 2, and none. Since the fat stored by a lizard gradually increased from June to September (p. 26), it seemed that, in general, the number of items eaten decreased with the increase in fat and presumably corresponding decrease in hunger.

Categorizing prey by size indicates that methods employed by adult racerunners finding food vary with the time of year and sex and size of the lizard. Prey less than six mm. in length is probably found by olfaction, and prey more than ten mm. in length is usually found by sight. Prey that is six to ten mm. in length may be found by either sight or olfaction, depending on whether or not the prey moves.

Figure 19 suggests a seasonal fluctuation in size of prey correlated with changing availability. The highest percentage of prey less than six mm. in length was taken in the last half of July. The highest percentage of prey more than ten mm. in length was taken in late June. These data suggest that hunting by sight reached a peak in late June, and hunting by olfaction was most frequent after mid-July. Table 1 shows that the smaller kinds of prey presumably found by olfaction included spiders, leafhoppers, and beetles. The prey most often taken in hunting by sight are nymphs of grasshoppers (mostly *Melanoplus bivittatus*). Racerunners in the wild do not usually take adult grasshoppers (which have hard exoskeletons and wings); the decrease in number of items of prey taken that are more than ten mm. in length probably resulted from maturing of the grasshopper nymphs. Minute prey is always available, and the racerunners presumably resorted to hunting for such prey when the number of large, soft-bodied nymphs of grasshoppers decreased in July. Termites were scarce on the study area and were absent in the samples of food that I obtained. Captive racerunners eagerly fed on termites; they fed also on ant pupae, likewise not found in my samples, perhaps because the pupae usually occur under objects too large for a hunting racerunner to overturn.

In general, the larger the racerunner, the larger the prey (Fig. 20). Table 2 shows that the lizards less than 50 mm. in snout-vent length took spiders, leafhoppers, and small snails (*Pupoides albilabris*) in mid-June, and nymphs of grasshoppers in late June.

Racerunners from 60 to 66 mm. in snout-vent length took mostly spiders, leafhoppers, and grasshopper nymphs in mid-June and spiders and beetles (mostly Carabidae) in late June, mid-July, and late July. Lizards from 67 to 71 mm. in snout-vent length took mostly nymphs of grasshoppers, spiders, and mites (Erythraeidae) in mid-June, spiders, nymphs of grasshoppers, and leafhoppers in late June, and spiders and leafhoppers in mid-July and late July. Lizards that were more than 71 mm. in snout-vent length took mostly nymphs of grasshoppers in mid-June, spiders in late June, and spiders and nymphs of grasshoppers in mid-July and late July. Hunting by olfaction seems to have been more characteristic of the smaller lizards, especially in mid-June. The large lizards were more noticeable because they ran after large prey more frequently, covered more area in hunting, and took longer in killing and swallowing their prey.

Figure 21 shows that the nine males (averaging 65.2 mm. in snout-vent length) taken in mid-June took more prey exceeding ten mm. in length than did the nine females (averaging 65.4 mm. in snout-vent length). I was tempted to explain this difference by noting that adult male racerunners seem to be "inherently" more aggressive than females. However, in mid-July and late July two females 66 mm. and 77 mm. in snout-vent length took more prey that was more than six mm. in length than did the five males averaging 66.6 mm. Although the present sample is too small to be significant, further study of food habits in late summer may show that the gravid females are largely restricted to olfaction in finding their food. In mid-June the larger females that had deposited their eggs seemed to hunt by sight more than the males did, although most of the grasshoppers that were more than ten mm. in length were too hard to be eaten. In mid-July and late July, the average number of prey taken by males was 5.4, and the average number taken by females was 6. Perhaps the females, having depleted supplies of fat after production of eggs, sought out larger prey than the males. Table 3 shows that the males in my sample took more grasshoppers than did the females in mid-June and more spiders and leafhoppers than did the females in mid-July and late July. The females took more caterpillars, leafhoppers, and mites than did the males in mid-June, and more grasshoppers, caterpillars, and hemipterans in mid-July and late July.

In June and July, gravid females were more frequently observed to hunt by olfaction than were non-gravid females, adult males or yearlings; the latter were observed to hunt in this manner next most frequently. Large males were observed to hunt by sight (running after flying insects, climbing into low plants in pursuit of prey) more often than large females in June and July, although more non-gravid females than males hunted by sight in late July.

Thirty-five hatchling racerunners were collected at intervals from early August to mid-October as follows: two on August 7, one on August 12, one on August 28, two on September 8, seven on September 9, 15 on September 26, and seven on October 10. The average number of food items per stomach in these samples were, respectively, 4.0, 1.0, 3.0, 2.5, 4.3, 9.5 and 4.6.

Table 4 shows the food of hatchlings. Although no major trends are evident, it can be seen that fluctuation of average number of prey taken in each period roughly corresponds with the number of kinds of prey taken. For instance, hatchlings in late September took the largest number of prey (9.5 per stomach) as well as the greatest variety (ten kinds). Spiders and leafhoppers were represented in each of the six periods and constituted a major part of the diet of hatchlings, as well as of adults in late summer.

Table 5 shows the four size groups of prey taken by two groups of hatchlings, those presumably recently hatched (less than 38 mm. in snout-vent length) and those hatched sometime previously (more than 38 mm. in snout-vent length). These somewhat artificial groupings show that in late September, when 15 hatchlings were collected, the smaller hatchlings took a slightly greater percentage of large prey than did the larger hatchlings. It may be that the fat stored by older hatchlings influenced the taking of smaller prey, as was proposed for adults.

Table 6 shows the prey of four size groups of hatchlings taken in late September. The first group (33-35 mm. in snout-vent length) is clearly made up of hatchlings that emerged in late September, whereas the last group (40-41 mm. in snout-vent length) hatched several weeks before the first group. These data indicate that the prey most often taken by newly-hatched racerunners are spiders and leafhoppers, whereas larvae of beetles and leafhoppers form the bulk of the diet of older hatchlings. The importance of fulgorids in the diet of hatchlings is questionable, because all of these insects were found in one stomach.

No significant difference was found between kinds of food taken by male and female hatchlings. Sizes of samples collected, however, were too small to allow any definite conclusions concerning comparison of food habits of the sexes at the age of hatchlings.

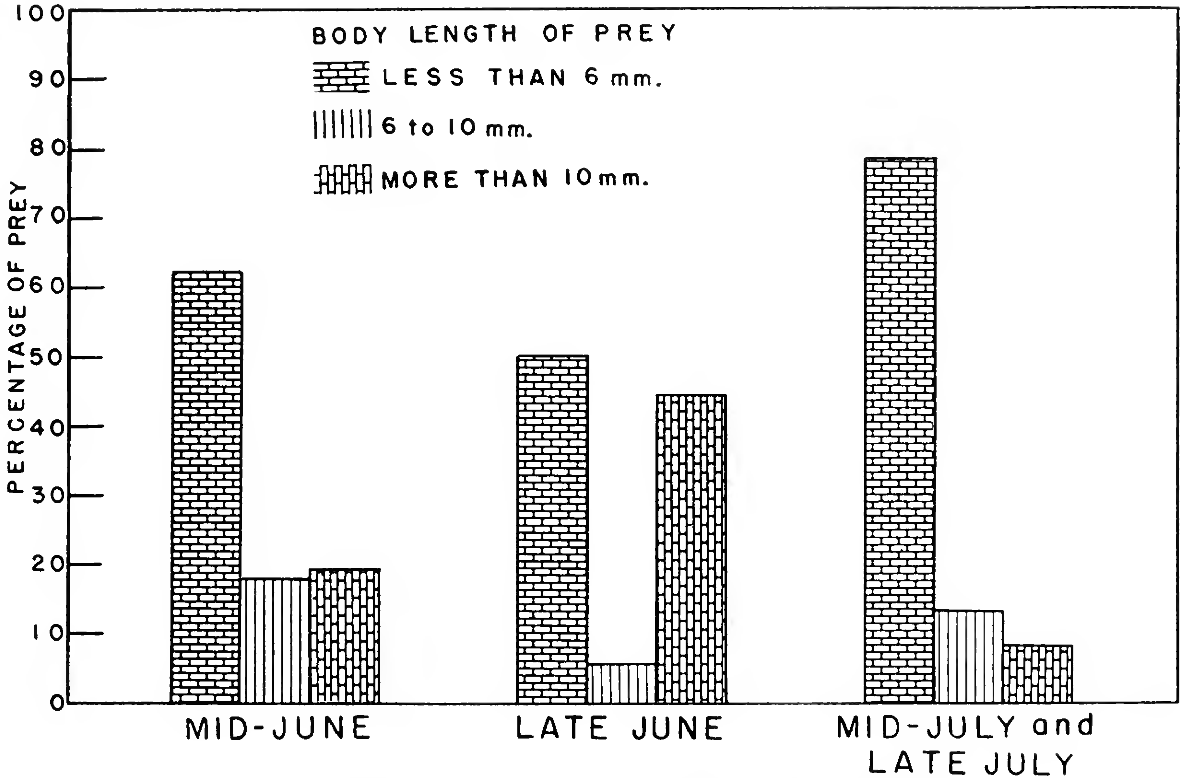

FIG. 19.—Seasonal fluctuation in size of prey taken by 30 adult racerunners.

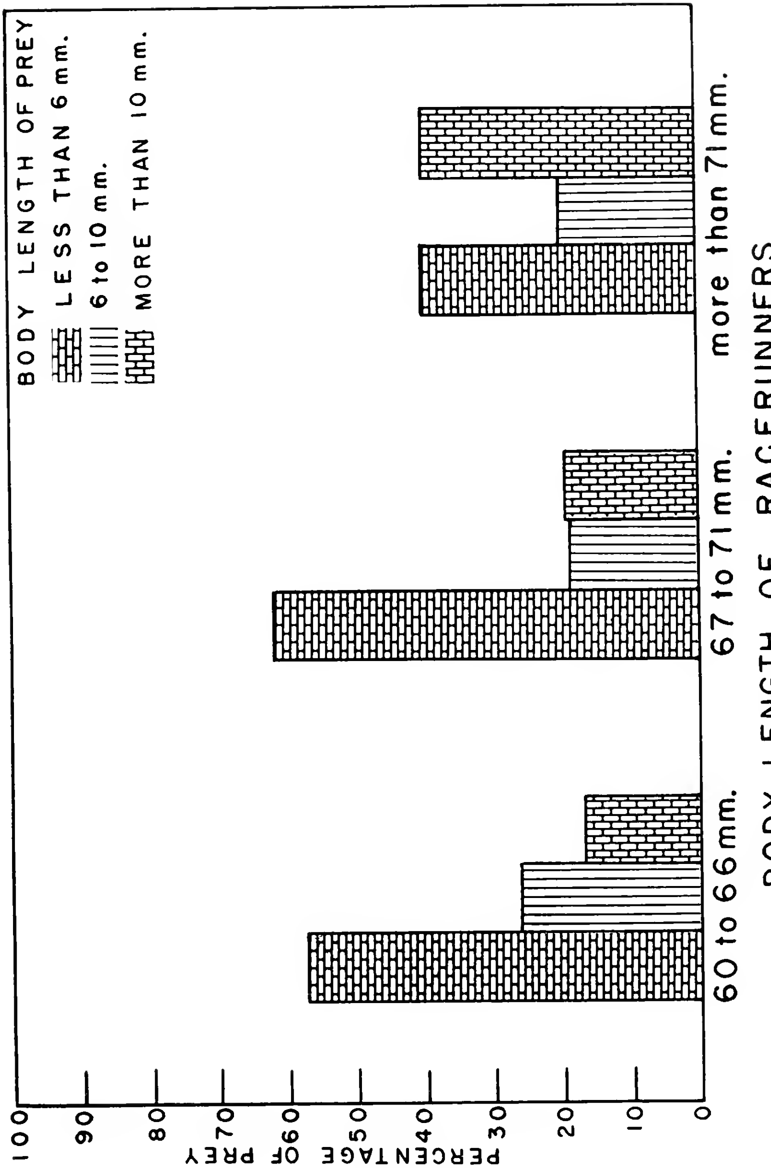

Fig. 20.—Size of prey taken by three size groups (snout-vent length in mm.) of 18 adult racerunners in mid-June.

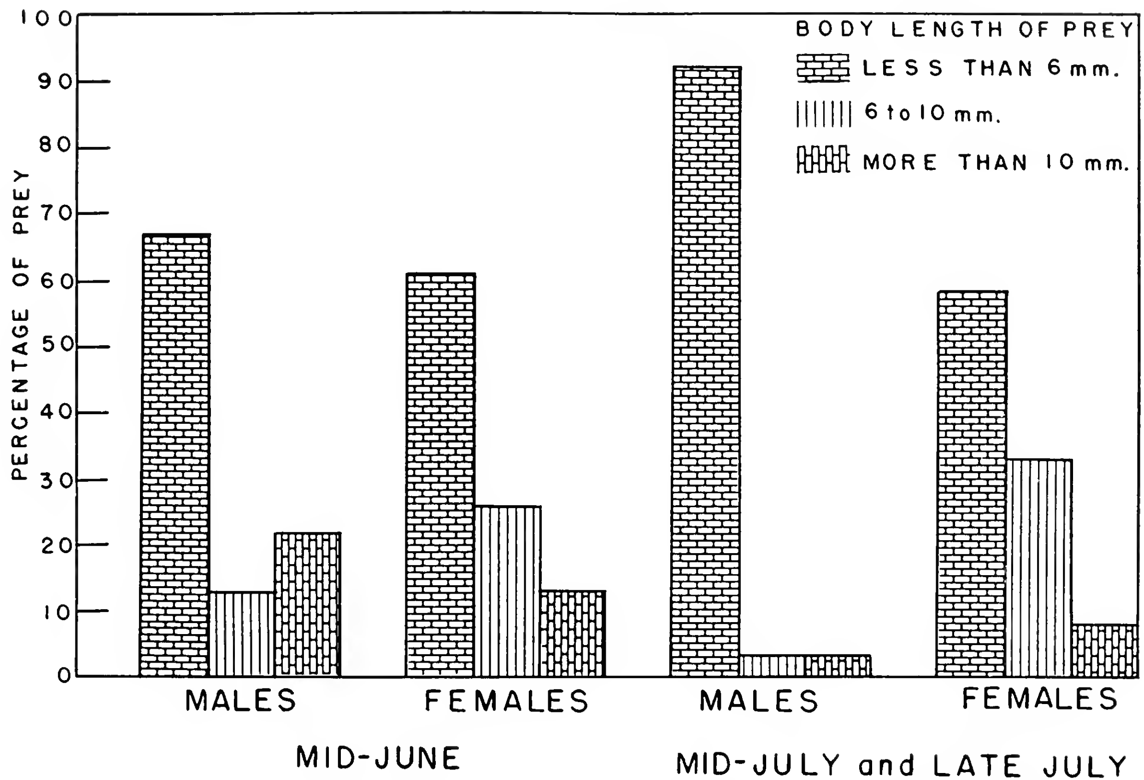

FIG. 21.—Differences in sizes of prey taken by adult male and female racerunners. Nine males (average snout-vent length 65.2 mm.) took 92 prey items in mid-June; nine females (average snout-vent length 65.4 mm.) took 102 prey items in this period. Five males (average snout-vent length 66.6 mm.) took 27 prey items in mid-July and late July; two females (66 and 77 mm. in snout-vent length) took 12 prey items in this period.

TABLE 1.—Seasonal fluctuations in size and kind of prey taken by adult racerunners.

Number in sample	Mid-June 18			Late June 5			Mid-June and Late July 7		
Lengths of prey in mm.	Less than 6	6 to 10	More than 10	Less than 6	6 to 10	More than 10	Less than 6	6 to 10	More than 10
Grasshoppers	8.8	6.8	11.7	5.6		16.7	8.1	5.4	2.7
Caterpillars	1.0	1.0	4.9			5.6			5.4
Beetles	3.9	1.5	2.0			5.6	10.8		
Moths	0.5	1.5	0.5			5.6			
Spiders	19.0	3.9		33.3	5.6		35.1	2.7	
Leafhoppers	14.6	0.5		11.1			16.2		
Hemiptera	3.9							5.4	
Snails	2.0	0.5					2.7		
Ants	2.4	1.0					2.7		
Mites	6.3								
Beetle larvae		0.5	0.5				2.7		
Cicadas						11.1			
Bittacids		0.5							
Diptera		0.5							
Percentage of prey	62.4	18.2	19.6	50.0	5.6	41.6	78.3	13.5	8.1
Total number of prey measured	128	37	40	9	1	8	29	5	5

TABLE 2.—Prey taken by four size groups of adult racerunners. Percentages are based on total number of prey identified in each size group of racerunners for each of the three periods.

Snout-vent lengths of lizards in mm.	Mid-June				Late June				Mid-July and Late July			
	Less than 50	60 to 66	67 to 71	More than 71	Less than 50	60 to 66	67 to 71	More than 71	Less than 50	60 to 66	67 to 71	More than 71
Grasshoppers 10 mm. in length and less		12.3	19.2	40.0	50.0		14.3			12.5	11.4	25.0
Grasshoppers more than 10 mm. long		11.3	9.6	30.0	50.0		14.3	16.7				
Caterpillars		8.5	6.1					16.7		12.5		12.5
Beetles		6.6	8.5	10.0		25.0				25.0	9.5	
Moths		1.9	3.7					16.7				
Spiders	40.0	27.4	15.9	10.0		75.0	28.6	33.4		25.0	42.8	37.5
Leafhoppers	40.0	18.9	9.8	10.0			28.6			12.5	23.8	
Hemiptera		5.7	2.4								4.8	12.5
Snails	20.0	2.8	1.2									12.5
Ants		3.8	3.7							12.5		
Mites		0.9	14.7									
Beetle larvae			2.4								4.8	
Cicadas							14.3	16.7				
Bittacids			1.2									
Dipterans			1.2									
Number of stomachs	1	10	6	1	1	1	1	2	0	3	3	1
Total number of prey identified	5	106	82	10	2	4	7	6		8	21	8

TABLE 3.—Differences between the food taken by adult male and female racerunners. Percentages are based on total number of prey identified in each of the four categories.

	Mid-June		Mid-July and Late July	
	Males	Females	Males	Females
Grasshoppers less than 10 mm. in length	24.7	13.3	11.5	25.0
Grasshoppers more than 10 mm. in length	13.4	5.7	....	....
Caterpillars	3.1	10.5	3.8	8.3
Beetles	7.2	7.6	11.5	8.3
Moths	3.1	1.9	....	....
Spiders	22.7	21.9	42.3	33.3
Leafhoppers	11.3	18.1	19.2	8.3
Hemipterans	4.1	2.9	3.8	8.3
Snails	3.1	1.9	....	8.3
Ants	5.2	1.9	3.8	....
Mites	....	12.4	....	....
Beetle larvae	1.0	1.0	3.8	....
Bittacids	....	1.0	....	....
Dipterans	1.0	....	....	....
Number of stomachs	9	9	5	2
Total number of prey	97	105	26	12

TABLE 4.—Food of hatchlings from early August to mid-October (in percentages of total prey taken in each period).

	Early August	Mid-August and Late August	Early September	Mid-September	Late September	Mid-October
Spiders	25.0	33.3	60.0	13.3	25.9	31.3
Caterpillars	12.5	33.3	....	6.6	4.9	6.3
Beetles	12.5	....	....	3.3	....	....
Beetle larvae	....	....	20.0	3.3	10.5	6.3
Leafhoppers	12.5	33.3	20.0	66.6	34.3	50.0
Hemipterans	12.5	....	....	6.6	11.9	....
Snails	....	....	....	....	1.4	....
Fulgorids	....	....	....	....	7.7	....
Crickets	....	....	....	....	0.7	....
Grasshoppers	....	....	....	....	2.1	3.1
Hymenopterans	12.5	....	....	....	0.7	....
Ants	....	....	....	....	....	3.1
Number of stomachs examined	2	2	2	7	15	7
Number of empty stomachs	0	1	0	0	0	2
Total number of prey	8	3	5	30	143	32

TABLE 5.—Four size groups of prey taken by hatchlings from early August to mid-October (in percentages of prey taken by each size group for each period).

Hatchling lengths in mm.	Early August		Mid-August and Late August		Early September		Mid-September		Late September		Mid-October	
	Less than 38	More than 38	Less than 38	More than 38	Less than 38	More than 38	Less than 38	More than 38	Less than 38	More than 38	Less than 38	More than 38
Length of prey in mm. 1 to 3	50.0	......	25.0	......	......	......	12.5	......	42.0	50.9	33.3	11.1
4 to 6	33.3	......	75.0	......	100.0	......	81.3	100.0	46.0	44.1	61.1	88.9
7 to 9	16.7	......	......	......	......	......	6.3	......	8.1	3.4	......	......
10 to 12	......	......	......	......	......	......	......	......	4.1	1.7	5.6	......
Number of stomachs	2	......	2	......	1	1	6	1	9	6	4	3
Total number of prey measured	6	......	4	......	2	0	16	8	74	59	18	9

TABLE 6.—Prey taken by four size (snout-vent length in mm.) groups of hatchlings in late September (in percentages of total prey taken by each size group).

Size of young (snout-vent length)	33-35	36-37	38	40-41	Total
Spiders	35.1	....	18.7	7.7	25.5
Caterpillars	6.5	....	2.1	7.7	4.8
Beetles	....	....	....	....	....
Beetle larvae	11.7	....	2.1	38.5	10.4
Leafhoppers	27.3	83.4	39.6	30.7	33.8
Hemipterans	14.3	....	12.5	7.7	12.4
Snails	....	....	2.1	7.7	1.4
Fulgorids	....	....	22.9	....	7.6
Crickets	1.3	....	....	....	0.7
Grasshoppers	3.9	....	....	....	2.7
Hymenopterans	....	16.7	....	....	0.7
Ants	....	....	....	....	....
Number of stomachs	7	2	4	2	15
Total number of prey	77	6	48	13	144

FIG. 22.—An adult racerunner feeding on a nymph of a grasshopper. The hind legs have been shaken off of the grasshopper, and the lizard is crushing the thorax laterally. × approximately ¾.

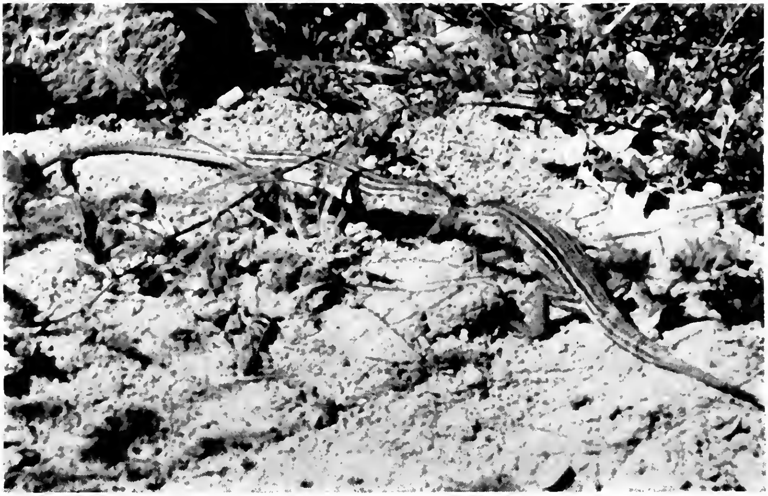

Fig. 23.—Two racerunners grasping the same prey. One of them will either release the prey or tear off part of it, leaving the remainder to the other. × approximately ½.

Drinking

No racerunners were seen to drink in the wild. Captives drank frequently, lapping up water with their tongues (Fig. 24). After from one to 20 laps, the lizard elevates its head causing water to run down the throat; then it usually licks its lips. Occasionally a racerunner flexes its body into a lateral "S"-shape after drinking, much as in pre-defecatory behavior and post-feeding behavior. A racerunner often repeats drinking several times. One hatchling submerged its head while drinking; occasionally racerunners climbed into the water dish while drinking, despite the consequent rapid loss of bodily heat to the cool water. The type of food probably influences the amount of water consumed; it seemed that fewer racerunners drank in summer when they were fed grasshoppers and other insects caught in a sweep-net than in fall and winter when their diet was mostly mealworms.

FIG. 24.—A captive racerunner drinks by lapping water with its long tongue, and then holds the head up causing water to run down the throat. Note dead epidermis adhering to tail. × approximately 1¼.

PREDATORS AND PARASITES

Fitch (1958:51-53) listed 12 reptiles, four birds, and six mammals as possible predators on *Cnemidophorus sexlineatus.* Scats from the University of Kansas Natural History Reservation showed that adults and hatchlings of the glass-snake lizard (*Ophisaurus attenuatus*) and of the yellow-bellied racer (*Coluber constrictor*) occasionally take racerunners as prey. A copperhead (*Agkistrodon contortrix*) that was found in the study area may have fed on racerunners, which were among the most abundant vertebrates there. On June 19 a blue jay (*Cyanocitta cristata*) was seen to run rapidly on the ground after prey that may have been a racerunner; blue jays are known to feed upon lizards. Hatchling racerunners may form an important part of the diet of hatchling yellow-bellied racers; one of these snakes that eagerly ate them in captivity was found near an escape-burrow of a hatchling lizard on the study area.

Presumably speed was developed in *Cnemidophorus,* which normally dwells in open habitats, as a means of escaping predators; lizards that inhabit less open areas have developed other means of escape, such as climbing trees and hiding in leaf-litter and under objects. Burt (1928b:44) observed that racerunners running at top speed always go in a straight line; Hoyt (1941:180) clocked one at 18 m. p. h. This straight-line, rapid flight requires areas of bare soil, uninterrupted by surface vegetation; in less open areas these lizards sometimes use surface runways cleared by other animals. Fitch (1958:30) found that racerunners pursued by an observer often took refuge in the runways of the prairie vole (*Microtus ochrogaster*). In certain areas, racerunners sometimes use other means of escaping predators. Stille (1947:143) and Dillon and Baldauf (1945:174) mention instances of six-lined racerunners voluntarily entering water when pursued, although racerunners normally avoid water. Captives that I caused to jump into water having temperatures of 10° and 25° C always came to the surface and attempted to escape by swimming, probably in response to the rapid lowering of bodily temperature by the water. This reaction was observed by Burt and Hoyle (1934:202), who chased a racerunner into a stream; the lizard escaped by swimming to the opposite bank, about 12 feet away. Racerunners, such as seen by Stille and Dillon and Baldauf, escaping by concealing themselves beneath the surface of the water, exhibit an unusual escape-reaction for a species of lizard having high thermal requirements, but a reaction possibly invaluable in an area in which no other means of escape are possible.

Harwood (1933:65) found oxyurid nematodes, *Pharyngedon warneri*, in the recta of two of four racerunners taken at Huntsville, Texas; oxyurid nematodes were also found in the stomachs and intestines of four adults collected by me in June. Loewen (1940:512) found that 91 out of 144 racerunners collected in Kansas were infested with the tapeworm *Oochoristica bivitellobata;* three racerunners from Georgia were not infected.

Loomis (1956:1386) found that nearly all racerunners that he examined were infested with chiggers (*Trombicula alfreddugèsi*) in June, July, and August, and that the number of chiggers per host reached a peak of 653 in June. No chiggers were noted on racerunners studied by me at Lakeview, and chiggers have been noted to be scarce or absent where there are such extensive sand areas.

MOLT

Figure 25 shows percentages of marked racerunners that were molting on various dates; the three major peaks of molting were separated by approximately 30-day intervals. Fitch (1958:47) found that 28 days is near the maximum interval between molts of individual racerunners. Molting may also occur in early May shortly after the lizards emerge from hibernation.

The dead skin usually first splits at the lips, then becomes loose on the top of the head, and the molt progresses posteriorly. Skin usually flakes off in small pieces, aided by abrasion against the sand, as the lizard scrapes its sides over the substrate. A lizard often scratches its sides with its hind feet; the mouth and forefeet are not known to be used in such activity. A racerunner usually begins to rub its sides over the sand and to scratch a few days before molt begins. Usually the skin on the throat and belly is shed in one piece after that of the dorsal surface has been lost. The limbs and tail lose their skin last (Fig. 24).

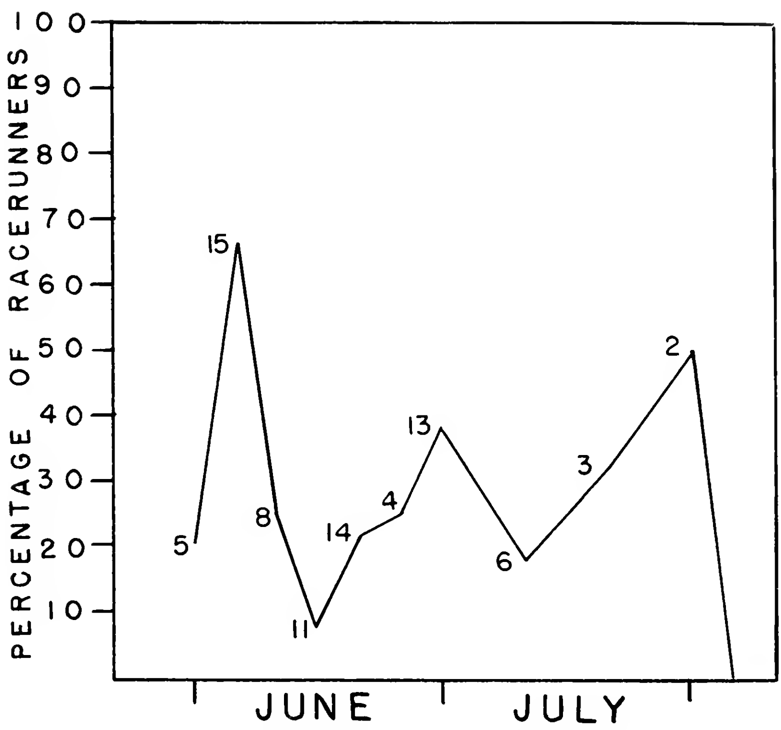

FIG. 25.—Percentages of marked racerunners that were shedding or that had recently shed. Each point on the graph represents the percentage of total number of lizards seen in the previous five days; the total number of racerunners seen is shown opposite each point.

SOCIAL BEHAVIOR

Social relationships

Conflict in the wild was frequently observed from mid-May through the first week of June. A lizard would "charge," open-mouthed, at another, five or more feet away and chase it ten or more yards until the pursued lizard escaped. Serious wounds were never inflicted, although sometimes the skin of the back was slightly torn. Adults frequently chased yearlings. Aggression was weak in hatchlings; one was seen to charge a distance of two or three feet at another hatchling that was basking.

Most intraspecific aggression in the spring (Fig. 28) seemed related to overcrowding in an area that was unusually favorable habitat for racerunners. It provided many basking sites on which the temperatures of the lizards rose rapidly. Debris scattered on the sand provided many places for excavation of escape-burrows and for temporary shelter from the heat (Fig. 3). A high level of testosterone in adult males probably caused them to approach other lizards; a decline in aggression of males roughly paralleled the decrease in size of testes after June (p. 67).

Conflict presumably served as a spacing mechanism for racerunners. A possible selective advantage of spacing was assurance of an adequate nearby supply of food (Hesse, *et al.*, 1951:157) for resident lizards; spacing presumably reduced competition. Conflict also resulted in displacement of non-aggressive individuals, small adults (approximately 25 percent of the population) and yearlings (more than 50 percent of the population), into marginal habitat of peripheral areas, where sites for basking and other favorable features were relatively scarce. A large percentage of the displaced, surplus lizards probably did not survive. New favorable habitats such as those created by droughts and floods presumably are populated by such displaced individuals.

Racerunners are relatively unsocial. Subordinant individuals, which have been forced into marginal habitats by aggressive lizards, seem to be sparsely distributed. Individuals that are active simultaneously are often hidden from each other by vegetation; those that live in the same area sometimes are not active on the same day, especially in July and August. However, at high density of population, social interactions become an important part of the activity of racerunners.

Those in enclosures had relatively stable social hierarchies. Non-aggressive individuals avoided aggressive lizards (Fig. 27); aggressive males approached other lizards (Fig. 26), and returned the threat of other aggressive males; receptive females usually did not react to other lizards. The behavior of each lizard seemed to function as the releaser for the responses of fleeing, avoidance, or threat by that lizard. Racerunners reacted to stationary models of their own species or to dead lizards only by approaching and touching them with their tongues, in the same way that many stationary, unfamiliar objects are tested.

Most of the social interaction that occurs between captive racerunners is characterized by a complete lack of aggressiveness. A lizard moves away when some individuals approach, but stands its ground against others; it approaches some individuals but avoids others. These responses are altered when the bodily temperatures of the lizards are low or the lizards are disturbed. It seems that individual lizards recognize each other by their characteristic behavior, if not by their physical characters. The "peck-order" in social groups of chickens and certain other animals has its equivalent "approach-order" involving the "right" of a lizard to approach subordinates without eliciting aggressive behavior.

In captive racerunners, approach-order was in a straight-line hierarchy; that is, lizard "A" was able to approach any other lizard, lizard "B" was able to approach any other lizard except "A" and so on to the lizard in the bottom position, which did not approach any other. Aggressive behavior was elicited only by the introduction of a new lizard into the pen. Then, one lizard would "threaten" another, and two lizards frequently would switch positions in the approach-order. Ordinarily these fluctuations in position in the approach-order took place between individuals of adjacent rank. although sometimes an interaction occurred between individuals not adjacent in rank; in such instances an individual low in rank might momentarily dominate a lizard higher in rank.

Most "competition" for rank was between a newcomer and a lizard that was either first or second in the approach-order; lizards of high rank usually ignored the "threats" of newly-introduced lizards that later became low in rank. A lizard that was taken out of the pen for periods as long as several weeks always regained its former position in the approach-order, usually by threat, when it was returned to the pen.

Such a social hierarchy in an enclosure or in a restricted area of favorable habitat might reduce competition for food and reduce active conflict between individuals. When insects were dropped into an observation pen the aggressive lizards fed while the non-aggressive individuals usually did not approach. Consequently, the aggressive lizards obtained more food and grew fatter. Frequently, two lizards seized the same prey (Fig. 23). One then worked the prey out of the mouth of the other lizard or broke off parts of it.

Hatchlings that I placed in observation pens disappeared, presumably having starved because they were reluctant to hunt in the presence of adults. After the first frost the hatchlings did not behave normally in terraria, probably because I was unable to supply them with suitable prey, and they died within a few months.

Some individuals continued to exhibit consistent aggressive tendencies after the period of frequent conflict in spring. A dominant male sometimes occupied a specific area for periods of a week or more and consistently charged at other lizards. Such a male was observed on 16 days between May 31 and July 1. Other lizards seemed to avoid him. On one occasion, he chased two adult males and a yearling. It is doubtful that his aggression can be interpreted as "defense of territory," since he defended only his immediate surroundings, a relatively small part of his home-range; obstructing vegetation prevented him from extending this aggression to the rest of the area that he normally covered in his daily activity.

Occasionally a racerunner enters a temporary shelter whereupon another individual immediately leaves. This does not involve defense of burrows any more than aggression between individuals that are hunting can be interpreted as defense of territory. In some instances the same temporary retreat is used by many individuals, and aggression is sometimes observed between them. Captive lizards were often chased out of holes that they had entered; Fitch (1958:30) observed an immature racerunner chasing another that had entered the burrow of the first one.

A burrow or tunnel in an area providing many favorable sites for excavation is seldom used by more than one lizard. A racerunner tends to excavate burrows and tunnels in the same place repeatedly. Presumably it seldom enters the burrow of another individual under natural conditions. Thus, the opportunities for defense of burrows are limited by their being spaced over a wide area.

Aggressive interaction in the wild takes place chiefly when racerunners are at the peak of their daily activity and have bodily temperatures within the thermal activity-range; hence the failure of the racerunners to defend escape-burrows and inactivity-tunnels consistently. The lizards retreat to escape-burrows and inactivity-tunnels when this peak of activity has passed and they are no longer in the proper psychological state to react when two lizards meet. The need to seek shelter overrides any aggressive tendency between individuals at this time.

Functions of color in social behavior

In several families of lizards, color of males functions as a releaser in recognition of sexes. Greenberg (1945:230) found that males of the collared lizard, *Crotaphytus collaris* (Iguanidae), recognize other males by the yellow-orange color of the throat. Fitch (1940:163) stated that the male western fence lizard, *Sceloporus occidentalis* (Iguanidae), "announces" its sex to other lizards by displaying its blue sides and throat. Noble (1934:12) found that color of the male in *Sceloporus undulatus* (Iguanidae) was the chief factor in discrimination of sexes. Evans (1951:2) found that in *Hemidactylus flaviviridis* (Gekkonidae) a male makes his sex known by displaying color. The red head of the breeding male skink, *Eumeces fasciatus* (Scincidae), was found by Fitch (1954: 49) to evoke hostile behavior on the part of other males.

In lizards that rely on sight in much of their activity, color is sometimes used as a releaser in functions other than recognition of sexes. Fitch (1956a:259) suggested that the bright spots in young males of *Crotaphytus collaris* served to inhibit attack by larger lizards. Scent is sometimes a releasing mechanism in lizards that

FIG. 26.—An instance of social interaction between two racerunners. The lizard on the left is moving away at the approach of the lizard on the right, which was the highest in the approach-order. × approximately ¾.

rely on olfaction in much of their activity. Fitch (1954:48) stated that the male of *Eumeces fasciatus* seems to rely on scent to trail females or detect their presence.

FIG. 27.—An instance of lack of social interaction between two racerunners. The lizard at the left rear was lowest in the approach-order and avoided other lizards even while they were basking. × approximately ½.

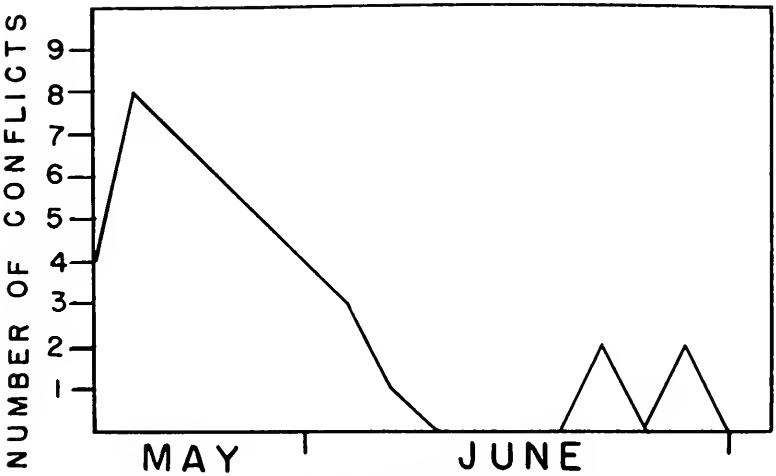

FIG. 28.—Frequency of conflict between racerunners; such interactions decreased rapidly from a peak reached early in the season. After June, conflict was observed on only two occasions, both in the first part of August. The points on the graph represent the number of conflicts observed in the previous three days.

In *Cnemidophorus sexlineatus* neither color nor scent seem to function in recognition of sexes. I found in racerunners, as did Noble and Bradley (1933), that males employ behavioral releasers as signals of sex; the blue ventral color of males functions, along with posture, only in threat-display. Noble and Teale (1930:54) found that males of *Ameiva chrysolaema*, of the genus considered to be ancestral to *Cnemidophorus*, used differential responses or displays in distinguishing sexes. Noble and Bradley (1933:42) observed no "fighting behavior" (presumably threat-behavior) in *A. chrysolaema*, in which the sexes are similarly colored; threat-behavior has not been reported in any species of *Cnemidophorus* in which the sexes are similarly colored. Presumably, then, sexual dichromatism has developed in North American teiids in correlation with threat-behavior.

The color in males, as well as females, of the six-lined racerunner is always of a deeper hue after they have molted. Since most lizards molt in the first few weeks after emerging from hibernation, most of the males have vivid colors early in the season. Adults do not molt oftener than once a month, and many of the males that Burt (1931:95) observed late in the summer had not recently molted; consequently, their colors were not vivid.

Threat-behavior between aggressive males seems to be the only behavior in which color is functional. Most adult males have ventral scales that are blue. In older males the lateral stripes fade. A threatening male compresses his body laterally and stands high, exposing the blue ventral parts and the yellow or green color of his sides. He then tilts his head slightly downward, opens his mouth, and slowly moves toward the approaching male, tail vibrating. The threatened male occasionally "bobs" his head. If the other male returns the threat, the two lizards follow each other in a circle several inches in diameter with their heads turned in toward the center of the circle. After approximately ten seconds, one of the lizards intimidates his adversary sufficiently to end the encounter. No lizards were observed to bite their opponents in these encounters as they were observed to do by Noble and Bradley (1933:42-43), although fleeing lizards were frequently bitten by their pursuers and receptive females by courting males. Threat-behavior is sometimes reduced to mere lateral movements with tail vibration, without exhibition of mating behavior.

A despotic captive male was only 68 mm. in snout-vent length. His immediate subordinate was another male, 73 mm. in length.

The latter lizard had only a little blue coloration on his ventral scales. This second male retained his dominance in threatening interactions with males that were somewhat larger than himself and had more vivid coloration. The most vividly colored captive male, 77 mm. in snout-vent length (Fig. 27), was at the bottom of the social order throughout the study. Therefore, it seems that color and size are not so important, in influencing aggression, as other factors such as hormonal levels and age.

Old females are higher in the approach-order than most young lizards of either sex, although females do not threaten other lizards. Estrogen probably functions in suppressing aggressive tendencies; females that were hunting were more aggressive toward yearlings in late summer than in early summer (reproductive phase). Such effects on aggressive behavior by the sexual hormones have been demonstrated in other vertebrates (Beach, 1948:100-102).

Threat-behavior presumably functions in the reproductive success of aggressive males. Seemingly only the aggressive males copulate, since non-aggressive males tend to avoid approaching lizards that do not move away from them, such as receptive females. An aggressive male that wins in a threatening interaction with another male has a reproductive advantage, because the loser is forced out of the immediate area. If a home-range is in a favorable habitat, more females will be found there than in other areas. Thus, the winner will probably fertilize more eggs and sire more offspring.

Mating behavior

The first few weeks after the lizards emerge from hibernation have been mistakenly called the "breeding season" by Burt (1931:95). The increased conflict between adult males at this time is probably related to hormonal balance. However, this aggression does not seem to result solely from the increased sexual drive of males, since sexually inactive and sexually immature racerunners may at times be the aggressors.

Fitch (1958:34, 35) stated that breeding in the six-lined racerunner begins a few weeks after emergence from hibernation and continues throughout much of the season. He observed copulating pairs in the wild on May 30 and June 7. In the present study, mating was seen in captive lizards on May 17, May 22, and June 9 (as well as in February and March), and on June 19 in lizards living under natural conditions. Most yearling females that deposit eggs in early August seemed too small to have bred before mid-July.

Shaw (1952:78) found that in a captive female western whiptail

(*Cnemidophorus tigris multiscutatus*), deposition of eggs followed mating by 24 and 19 days, the female laying two clutches of eggs, 36 days apart. In *Cnemidophorus sexlineatus* mating probably precedes each laying, and approximately two weeks elapse between mating and deposition of eggs. If these suppositions are correct, breeding occurs chiefly in the last week of May and the first week of June, the third week in June and the last week in July. After June primary sexual behavior probably decreases in older males in response to regression of the testes; nine males (average snout-vent length 65.2 mm.) in mid-June had testes averaging 6.7 x 4.7 mm., and four males (average snout-vent length 66.3 mm.) in late July had testes averaging 4 x 2.5 mm. Insemination of yearling females in July is probably accomplished by yearling males.

Mating behavior in captive six-lined racerunners was described in detail by Noble and Bradley (1933:40-41). There is no courtship display. Sexual activity begins with the male rubbing his cloacal area from side to side on the ground. He then approaches a female, and if she is receptive he bites or pokes at her neck, rubs her with his femoral pores, moves his cloaca from side to side on her back, and then arches his body over her back, grasping her flank in his jaws. He then loops his tail under hers and brings his cloaca into contact with her cloaca. Noble and Bradley also found that coition in successful mating lasted from five to 15 minutes with the male thrusting forward his pelvic region (and hemipenis) at the rate of two thrusts per second. These same authors found that if the female escapes after a shorter period of coition, the hemipenis of the male usually remains everted for a few minutes as he retains the arched position, and goes through the "usual convulsive movements in mid-air." The matings occurred when the temperature of the laboratory averaged 82.2° F (27.9°C). Although temperatures of the laboratory are not an accurate indication of the temperatures of the lizards, Fitch (1958:33) suggested that the lizards observed by Noble and Bradley were too cold to behave normally. The temperatures of most of the captive lizards were far below the thermal activity-range of the species. As a result, most of the lizards remained inactive; many torpid males were perhaps "mistaken" for receptive females because they did not flee or threaten males that approached them. Some males were active as a result of the lowering of their thresholds for activity because of their increased urge to copulate.

In my own study, mating behavior was observed several times in the laboratory, as well as in the field. In May newly-captured racerunners displayed mating behavior at bodily temperatures far below the thermal activity-range (temperature of the air was 23.9°C). Under these conditions, coition lasted as long as 28 minutes. Although some aspects of the breeding behavior seemed typical (male vibrated tail during courtship, both lizards rubbed their vents from side to side following coition), others of the actions were not later observed in lizards at higher temperatures. For instance, immediately following copulation, the male defecated, then moved about the terrarium. Ten minutes later he returned to the site of coition and for several minutes made pelvic thrusts with body and tail arched as in the copulatory position.

Pre-copulatory behavior in the six-lined racerunner serves to stimulate both male and female. In February a sexually-active captive male engaged in pre-copulatory activity (vibration of tail, and rubbing vent and femoral pores from side to side on the substrate) while basking and moving about the cage, although no other lizards were present; the presence of other lizards stimulated him to perform more vigorously. When other lizards were introduced, he performed after climbing upon their backs; he did not discriminate between the sexes. The pre-copulatory movements of the sexually-active male seemed to stimulate the other males to dash away when he approached, whereupon he "charged" after them with open jaws, presumably in an attempt to grasp the loose skin of their backs or necks, as when "courting" a female. When these males were grasped by the sexually-active male, they struggled violently to free themselves, unless they were engaged in other activities. One male that was actively feeding did not seem to notice the other male clinging to his back. Before coition, a female appeared to be calmed by the movements of the male on her back, and she usually stopped all movement. During the first 41 seconds of coition (of 55 seconds duration altogether) the pelvic thrusts and convulsive jerks of the forelimbs of the male continued, seemingly, to stimulate the female; after this time the movements of the male ceased, whereupon the female struggled free. The hemipenis of the male was immediately retracted, and he engaged in basking, although there remained a convulsive "twitch" in the base of his tail. Six minutes later, the male commenced courtship again, although the female appeared to be "unreceptive"; she did not submit to stimulation by the male but dashed away at his approach. The female became receptive again after several hours.

The racerunners in the previous account had temperatures within the thermal activity-range of the species; the temperature of the male during copulation was 36.9°C and the temperature of the female was 34.0°C. Although sexual activity in February is certainly unnatural for these lizards, all aspects of their behavior resembled those observed in the wild. A correlation was found to exist between sexual activity and secretion of the femoral pores of male racerunners; the cylindrical exudate from the pores of one male reached nearly one-eighth inch in length at the height of his sexual activity.

Summary and Conclusions

In the summer of 1958, information concerning the behavior and ecology of the six-lined racerunner was obtained from observation in a xeric habitat one mile north and one mile west of Lakeview, Douglas County, Kansas, in outdoor pens, and in the laboratory.

Previous studies of thermal relationships of lizards have emphasized the importance of an innate "optimum body temperature." My study has provided evidence that racerunners sometimes carry out their activities with bodily temperatures many degrees below this "optimum" level. A thermal activity-range is described for the species—the highest temperature being the maximum temperature ordinarily tolerated by the species (above which temperature the lizards move into shade), and the lowest temperature being the thermal threshold for basking, which varies with the physiological state of the individual. The origin of high thermal requirements of the six-lined racerunner is discussed.

It was postulated that the behavior of racerunners depends upon a series of thresholds, which fluctuate with the physiological state of the individuals. For instance, a strong hunger drive depresses the threshold for an activity (such as feeding) that normally occurs *above* a certain level, as well as for an activity (such as basking) that normally occurs *below* a certain level. Temperature was found to regulate cycles of both daily and seasonal activity.

Defecation, hunting, feeding, drinking, excavation of burrows and tunnels, mating, and other social activity have been discussed in detail. The same motor patterns are used by a racerunner in more than one activity. For example, a male employs similar aggressive movements in pre-copulatory behavior, threatening interaction, and pursuit of non-aggressive individuals. Such movements include vibrations of the tail, opening mouth and biting, and raising body off the ground by stiffening the legs. In addition, vibration of the tail is sometimes used in the excavation of escape-burrows. A racerunner thrusts its body into a lateral "S"-shape after swallowing large prey, in movements that accompany defecation, and sometimes after drinking.

Racerunners "control" their temperatures by orientation. When the environmental temperature is below the maximum temperature tolerated by the species, a lizard responds to substrate warmer than itself by flattening the body dorso-ventrally while basking or moving; the lizard responds to a cooler substrate by allowing only the limbs to touch it while basking or moving. When the temperature is near the maximum tolerated by the species, the racerunner responds to a surface 41°C or warmer by allowing only the limbs to touch while moving, basking with the limbs (which become overheated before the rest of the body does) held clear of the substrate, or by seeking shelter. This adaptive behavior possibly has enabled *Cnemidophorous sexlineatus* (and probably other members of the genera *Cnemidophorous* and *Ameiva*) to extend their ranges farther north than most members of the family Teiidae.

Four main periods of egg-laying were indicated by the ratios of gravid to non-gravid females seen. Newly-hatched lizards were especially in evidence after intervals of approximately 50 days following these peaks—the time required for incubation.

Racerunners use four kinds of shelters. Temporary, unexcavated shelters (beneath plants or debris) serve for avoidance of high temperature; shallow escape-burrows, excavated under flat rocks or debris, similarly serve for retreat from high temperatures and from activity; shallow escape-tunnels, excavated in sand, function as escape-burrows in the absence of debris on the ground; and inactivity-tunnels, excavated in sand, serve for retreat from daily and seasonal activity.

The contents of 69 stomachs were analyzed according to size, number, and kind of prey, and these data were compared among the various size groups of racerunners and the dates the prey was taken, and between the sexes. Kinds of prey taken fluctuate according to their seasonal abundance. Also indications were found that age of individual lizard, hormone level, strength of hunger drive, and sex, influence the kind of prey that is taken by a racerunner as well as size and number.

Except for small items (aphids, ants, tiny spiders), prey is crushed between the teeth. The appendages of large prey are often shaken off or rubbed off on the ground and eaten separately. Large prey is torn apart, sometimes by two or more lizards. It is suggested that the effectiveness of hunting (energy used in hunting *versus* energy derived from prey) is increased by taking large prey. The habit of feeding upon small stones is discussed.

The glass-snake lizard (*Ophisaurus attenuatus*), copperhead (*Agkistrodon contortrix*), and blue jay (*Cyanocitta cristata*) were added to the list of 12 reptiles, 4 birds, and 6 mammals that are known or suspected predators of the six-lined racerunner. Hatchling snakes, especially the racer (*Coluber constrictor*) are important predators upon hatchling racerunners in August and September. An oxyurid nematode was found to be parasitic in the digestive tract of the racerunner.

Although racerunners do not often display social behavior in the wild, captives developed a relatively stable social hierarchy, characterized by a straight-line "approach-order."

Intraspecific aggression is discussed with respect to threat-display, conflict between individuals, defense of burrows, and territoriality in the six-lined racerunner. Color, which functions in sex-recognition in many lizards, functions only in threat-display in this species. All instances of social interaction (threat, conflict, mating) were determined by the behavioral response of another lizard to this aggression.

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A *Palaeostachya* Cone from Southeast Kansas

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INTRODUCTION

The current literature of American coal ball fossil plants contains mention of only four different occurrences of the Calamitean cone genus, *Palaeostachya.* These are *P. andrewsii* Baxter (1955), *P. decacnema* Delevoryas (1955), and *P. multifolia* Anderson (1954) who in the same publication gives a brief description of a fragmentary specimen referred to simply as *Palaeostachya* sp. Of these four, *P. multifolia* has since been redescribed by Arnold (1958) as *Calamostachys americana.*

Other than Anderson's (1954) statement that his *Palaeostachya* sp. had 24 bracts and 14 sporangiophores vs. 24 bracts and 12 sporangiophores for *P. andrewsii,* there seems to be no significant differences between the specimens and it is likely that his material is assignable to *P. andrewsii.* Both specimens are from the same locality near What Cheer, Iowa.

Accordingly the total of American coal ball *Palaeostachys* seems reducible to the two species *P. decacnema* and *P. andrewsii.* The former is known only from one coal ball from the Fleming Coal of southeast Kansas while the latter, up to now, has only been reported from the one central Iowa locality.

The purpose of this report is to describe a new specimen of *Palaeostachya andrewsii* from coal ball material collected from the old Kruger shaft mine about 1½ miles north of the town of Cherokee, Crawford County, Kansas. The fossil material is believed to have come out of the Weir-Pittsburg coal which is slightly below the level which produced *P. decacnema.*

General Description

The cone consists of a central fragment, both the apex and base being absent. In diameter it ranges from 2.2 cm. to 1.8 cm., the smaller width being present towards the upper portion, possibly representing a natural tapering of the original cone. The cone axis averages .5 cm. measured in the internode region between the nodal discs. There are 28 bracts and 14 sporangiophores at each node (Fig. 1). The sporangiophores are distinctly axillary (Fig. 2), while the bracts extend upwards two and one half internodes above their node of origin and are fused into a common sheath nearly to their apex (Fig. 3). Only disorganized remnants of sporangial walls are preserved and no spores are present in the specimen. These last two features along with the slightly greater size as compared to the Iowa holotype (1.5 cm. vs. 2.2 cm.) suggest that the Kansas material represents an older cone in which complete dehiscence of the sporangia has taken place.

The cone agrees exactly (except in size and number of parts) with the holotype of *P. andrewsii*. However as Arnold (1958) points out, "The exact numbers of parts are not important and vary in proportion to the size of the particular specimen." Accordingly the new, larger specimen might reasonably be expected to show the slight increase from 24 to 28 bracts and 12 to 14 sporangiophores.

The present specimen also serves to emphasize the differences between *P. andrewsii* and *P. decacnema*. In addition to the former's much larger size and greater number of bracts and sporangiophores per whorl (which we know may be variable in both species), the basic distinctions are felt to be respectively: (1) the recurved versus direct course of the sporangiophore trace, (2) the distinctly axillary versus only approximately so position of the sporangiophores, (3) the peltate sporangiophore apex versus a somewhat "peaked" apex, (4) alternate bracts extending upwards over two internodes versus superposed bracts extending upwards less than one internode, (5) bracts fused tangentially nearly to their tips versus bracts fused only at their bases and, (6) spores 270-320μ versus spores 45-50μ.

If one now summarizes the differences between *Palaeostachya andrewsii* and *Calamostachys americana* (*Palaeostachya multifolia*), we find the following respective variations: (1) Cone diameter of 2.2 cm. versus 4.0 cm., (2) axillary verus internodal position of sporangiophores, and (3) 24-28 bracts per whorl versus 40-45.

It is of interest to note that except for these three distinctions outlined above (which are, in the main, those of recognized variability) there are an even larger number of similar features which may be listed: (1) Arnold's plate VI, Fig. 3, shows two alternating whorls of bracts, the inner one fused and the outer free indicating a comparable situation to that in *P. andrewsii;* (2) recent re-examination of the spores of the holotype of *P. andrewsii* shows a remarkable resemblance to Arnold's *C. americana* megaspores. They are of the *Calamospora* type, spherical and with a smooth, thin wall marked by a small trilete scar, one ray of which is usually slightly longer than the others. As shown in Fig. 4, they would be almost impossible to distinguish from Arnold's (1958) illustrations in his Plate 11, Figs. 3 and 4, of *C. americana* megaspores. Arnold gives the size range of these spores as 150-260 microns which is close to the lower range of the *Palaeostachya andrewsii* spores which average from 270-320 microns. Since both Anderson and Arnold note that the megaspores are smaller when found in the same cone with microspores and larger when isolated (as in *P. andrewsii*) the size range would appear potentially identical; (3) the primary bundles of *C. americana* as shown in Arnold's Pl. IV. Fig. 2, appear to be paired as in *P. andrewsii* and the "cortical air cavities" appear identical to the "phloem areas" of *P. andrewsii.* Arnold states (page 154) ". . . some of the volume that is now space (cortical cavity) was originally phloem tissue, which does not show because it has decayed." It also seems probable from the photographs in his Pl. IV that degredation of tissues has taken place in these areas as shown by the numerous intrusions of stigmarian rootlets; (4) the anatomy of the free tips of the bracts (Baxter, 1955, Fig. 9) is nearly identical and (5) similar "melismatic tissue" occurs in both specimens.

As Arnold (1958) and Delevoryas (1955) state, it now seems that the only distinction between *Calamostachys* and *Palaeostachya* is the position of the sporangiophore and the validity of this character is apparently sometimes difficult to determine in cases where the sporangiophore arises a slight distance above the bract (as in *P. decacnema*) rather than in the exact bract axil. Accordingly not only is the "difference between *Calamostachys* and *Palaeostachya* . . . not great" as suggested by Delevoryas but it becomes doubtful, in some cases, whether it is consistently possible to distinguish between them. Certainly in the comparisons made above, other than the sporangiophore position, *Palaeostachya andrewsii* has more similarities to *Calamostachys americana* than it does with *Palaeostachya decacnema.*

When one considers that the observations of both Arnold (1958) and Hickling (1910) have shown that the origin of the sporangiophore trace is the same in *Calamostachys* as in *Palaeostachya, i. e.,* from the same node as the subtending bract and that the course of the trace may be direct or reflexed in either genus, the exact position of the sporangiophore, itself, seems of questionable generic distinction. As Arnold (1958) states, "The ultimate validity of sporangiophore position as a generic character in *Calamostachys* [and *Palaeostachya*] will depend on the discovery of intermediate forms in which the sporangiophores are definitely above the bract axils but well below the mid-portion of a node." The tendency towards this situation exhibited by *Palaeostachya decacnema* and the remarkable agreement between *Palaeostachya andrewsii* and *Calamostachys americana* makes the existence of "intermediate forms" seem like a reasonable possibility. Whether they will be "discovered" in the near future does not seem quite as certain. The paucity of petrified specimens of calamitean cones is rather difficult to account for. Not only is the total American coal ball flora represented by the single species of *Calamostachys* and the two species of *Palaeostachya* but the species are based (except for the present account of *P. andrewsii*) on single collections and often a single coal ball.

The situation is particularly puzzling when one considers that compression material of *Calamites, Asterophyllites, Annularia, Calamostachys,* and *Macrostachya,* etc., is reasonably abundant throughout the Pennsylvanian shales of the United States and that vegetative organs of the calamite complex are not at all rare in the coal ball flora.

Isolated sporangiophores surrounded by four pendant sporangia are frequently found in Kansas coal balls and suggest a remote possibility that the articulate cones may have been subject to rapid disintegration prior to fossilization under the conditions incident to the formation of the coal ball type of preservation.

Of the American petrified Calamitean cones, *Palaeostachya andrewsii* is now the only species having been reported from more than one locality. Its occurrence in the Des Moines series of central Iowa and the Cabaniss Formation of southeastern Kansas adds to the list of fossil plants known solely from these two geographic regions. In addition to *P. andrewsii* this includes *Microspermopteris aphyllum, Dolerotheca schopfii,* and *Medullosa primaeva.* Darrah (1941) noted that ". . . it is a striking fact that nearly all of the species from Frontenac (Kansas) deposits occur also at the Shuler Mine in Iowa." The Schuler Mine referred to is in the vicinity of Des Moines.

Several papers of L. R. Wilson (1940, 1944) describe a microspore flora from coals in the vicinity of What Cheer and Oskaloosa, Iowa, which is the same region producing the above-named coal ball megafossils. According to A. L. Hornbaker (personal communication) of the Kansas Geological Survey, who has recently made a definite correlation of the Kansas Bevier Coal with a coal just east of What Cheer, Iowa, the microspores described by Wilson are most nearly comparable to those of the Kansas Fleming and Mineral Coals, a relationship which is now given added significance by the similarity in the coal ball plant megafossils.

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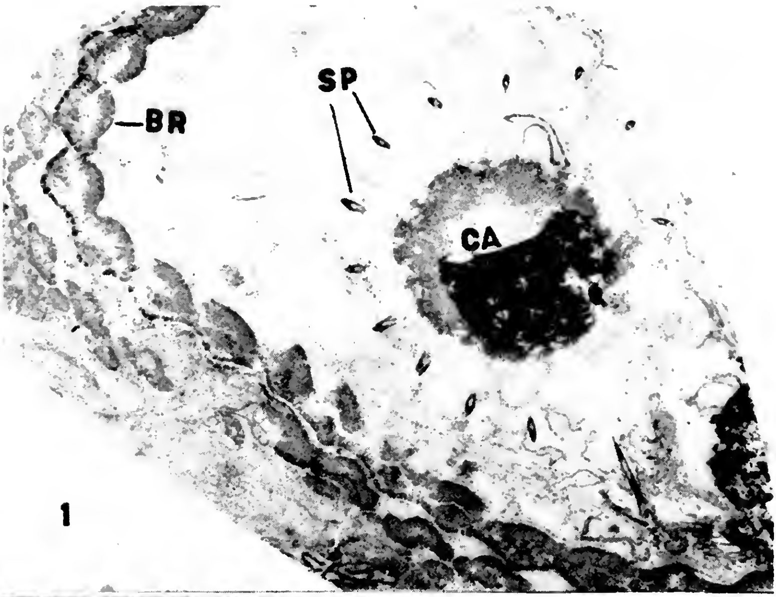
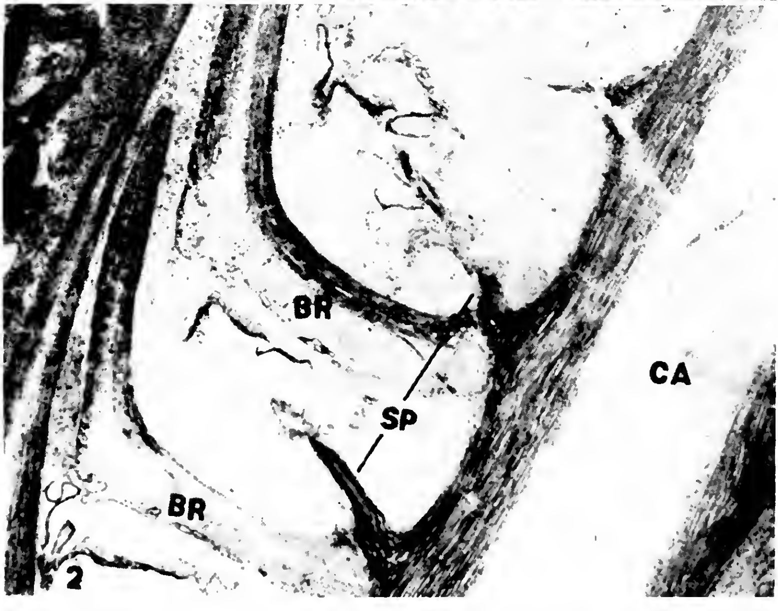
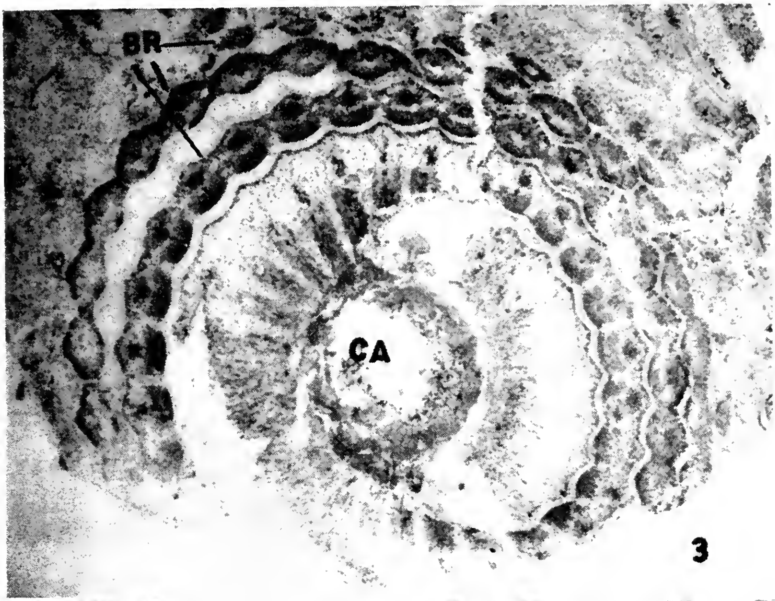
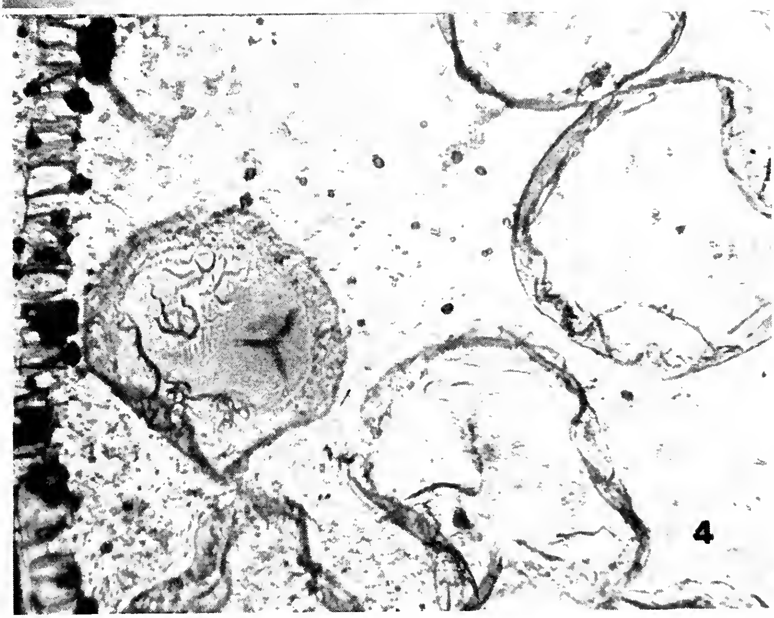




FIGS. 1-2.—*Palaeostachya andrewsii.* FIG. 1. Oblique-transverse section of cone. BR, inner whorl of connate bracts; sp, sporangiophores thirteen of which are visible with the broad gap on the right of the cone axis showing position of the fourteenth; CA, cone axis lower half of which is coalified. × 6. FIG. 2. Radial-longitudinal section of cone BR, bracts; SP, axillary sporangiophores; CA, cone axis. × 8.





FIGS. 3-4.—*Palaeostachya andrewsii*. FIG. 3. Transverse section of cone. BR, three whorls of sterile bracts the inner two connate, the outermost showing free tips; CA, cone axis. × 6. FIG. 4. Megaspores of holotype specimen showing trilete tetrad scar. Sporangium wall on extreme left. × 150.

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The Genus *Cylindrostethus* Fieber from the Eastern Hemisphere*

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ABSTRACT: This paper proposes *Cylindrostethus productus* (Spinola) as the type species of the genus *Cylindrostethus* Fieber instead of *C. linearis* (Erichson) as stated by Kirkaldy.

The following species are synonyms:

C. fieberi Mayr = *C. productus* (Spinola).
C. nietneri Schmidt = *C. productus* (Spinola) (male), new synonymy.
C. bituberculatus Schmidt = *C. productus* (Spinola) (female), new synonymy.
C. flaviventer Schmidt = *C. scrutator* (Kirkaldy).
C. naiades Kirkaldy = *C. scrutator* (Kirkaldy), new synonymy.

A key is given for the seven species of *Cylindrostethus* from the Eastern Hemisphere and all species are illustrated.

The genus *Cylindrostethus* was described by Fieber (1860) without naming any species. Erichson (1848) described *Hydrobates linearis.* However, *Hydrobates* Erichson was preoccupied by *Hydrobates* Boie (1822) in Aves. Mayr (1865) described *Cylindrostethus fieberi* from Ceylon. This was the first species to be assigned to *Cylindrostethus* Fieber. Actually *C. fieberi* Mayr is, as discussed elsewhere, a synonym of *C. productus* (Spinola). Therefore, *C. productus* (Spinola) is the type species of *Cylindrostethus.*

Unfortunately, Kirkaldy (1897) wrote: "Hydrobates Erichson 1848 is preoccupied by Boie (Aves) 1822 . . . it will be therefore necessary to employ *Cylindrostethus* first characterized by Fieber, Europ. Hem. 33 (1861); as however no species was there assigned to it, one must write *Cylindrostethus* Mayr, that author being the first to adopt a species.

"The synonymy can therefore be stated:

"*Cylindrostethus* Mayr Verh. z. b. Ges. Wien XV, 444 (1865)—*Hydrobates* Erichs. l. c. 614."

* Contribution number 1112 from the Department of Entomology. The University of Kansas. This investigation was carried out with the aid of a grant from the National Science Foundation.

These errors of crediting *Cylindrostethus* to Mayr instead of to Fieber and naming *Hydrobates linearis* Erichson as type instead of *Cylindrostethus fieberi* Mayr have been repeated from time to time. The junior author (1960) corrected them without giving reasons, therefore we have given them above.

The genus *Cylindrostethus* Fieber is one of the most easily recognized genera in the Gerridae. It is represented in South America by eight species, in Africa by one species (from Liberia), and by six other species ranging from western India and Ceylon, to the Philippines. One species described from Jordan was correctly transferred to *Gerris* by Wagner (1954). Drake and Harris (1934) gave a key to five South American species, two of which were new. Kuitert (1942) gave a key to six species from South America, one of which was new. Since then Drake (1952) described *C. bassleri* from Peru, which runs to the *linearis-erythropus* complex in either of the above keys but differs from them, says its author, by its larger size, longer first and last antennal segments and by the absence of a spine at the middle of U-shaped emargination on the rear margin of the last ventral (seventh) abdominal segment. The same author (1958) further described *C. podargus,* also from Peru. He said it belongs to the group containing *C. palmaris* Drake and Harris, *C. regulus* (Buchanan-White) and *C. hungerfordi* Drake and Harris. The narrow chocolate brown stripes (one on each side of the dorsal surface) of meso- and metanota distinguish *C. podargus* from the other related species. Thus anyone can easily identify the South American species.

On the other hand, no key is available for the species of *Cylindrostethus* from the Eastern Hemisphere. Schmidt (1915) described *C. flaviventer* from Sumatra, which Lundblad (1933) regarded as a synonym of *C. scrutator* (Kirkaldy) (1899) from Tenasserim. Schmidt also proposed the names *C. nietneri* for a male and *C. bituberculatus* for a female, both from Ceylon, and *C. costalis* for a winged male from Cambodia. Thanks to the kindness of Dr. Jaczewski of the Polish Academy of Sciences, we have been able to study Schmidt's types of *Cylindrostethus.* We find that only *C. costalis* is a valid species, and *C. nietneri* and *C. bituberculatus* are the male and female of *C. productus* (Spinola). We believe that *C. flaviventer* Schmidt from Sumatra is certainly a synonym of *C. naiades* Kirkaldy from Malacca (1909), the types of which are in the Kirkaldy Collection at the University of Kansas. In *C. flaviventer* Schmidt the wingless male type does not have a pair of fine sutures down the middle of the mesosternum, which are present in the male type of *C. scrutator* (Kirkaldy) (1899) from Upper Tenasserim (Lower Burma). However, we believe that the presence of longitudinal sutures on the mesosternum is confined only to the winged individuals, and therefore both *C. naiades* Kirkaldy and *C. flaviventer* Schmidt are synonyms of *C. scrutator* (Kirkaldy). Since Schmidt did not know *C. vittipes* Stål, *C. scrutator* (Kirkaldy), and *C. productus* (Spinola) and that the apterous female of several species have two lobes on the mesonotum, it is not surprising that three of his four new species should fall as synonyms. Lundblad (1933) saw the Schmidt types and the types of *C. scrutator* (Kirkaldy) and of *C. vittipes* Stål. He made *C. flaviventer* a synonym of *C. scrutator* (Kirkaldy) but permitted Schmidt's other species to stand without comments. He also listed *C. productus* (Spinola) and did not mention *C. fieberi* Mayr which Distant (1904) placed as a synonym of *C. productus* (Spinola). Lundblad described *C. sumatranus* in the same paper. Evidently Mayr did not know *Gerris producta* Spinola when he described *fieberi* from Ceylon. Whether Distant had seen the type of *C. productus* (Spinola) when he made *C. fieberi* Mayr a synonym we do not know. We expected the type of *C. productus* (Spinola) to be in Spinola's collection at the castle of Tassarolo in Italy. The junior author (1960, summer), however, failed to find the type specimen there. Instead, he found two specimens labelled "*Gerris macrops* Hoffmannsegg, Java" which he believed to be the same as that known as *C. productus* (Spinola). While we cannot prove the synonymy of *C. fieberi* Mayr, we accept Distant's work since he had specimens from both India and Ceylon. The type of *C. fieberi* Mayr is not now at the Museum in Vienna.

KEY TO THE SPECIES OF CYLINDROSTETHUS FROM THE EASTERN HEMISPHERE

1. Connexival spines short, not as long as first genital segment (eighth abdominal segment) dorsally in both sexes. 2
   Connexival spines nearly as long as or longer than first genital segment dorsally in both sexes. 5
2. Mesonotum with two pairs of black longitudinal stripes on yellowish ground color. . . . . *C. quadrivittatus* Bergroth (Liberia)
   Mesonotum without black longitudinal stripes. Ground color either chocolate brown or black. 3
3. Ground color of mesonotum chocolate brown. Female connexivum overlapping apical abdominal tergites. Lateral wings of suranal plate of male asymmetrical and conspicuous.
   C. sumatranus Lundblad (Sumatra)

Ground color of mesonotum black. Female connexivum not overlapping apical abdominal tergites. Lateral wings of suranal plate of male symmetrical or nearly symmetrical. . . . 4

4. Seventh abdominal tergite including connexivum broader on caudal margin than on front margin in male. Mesonotum without bands of hairs in female. . . . . *C. persephone* Kirkaldy (S. Celebes)

Seventh abdominal tergite including connexivum broader on front margin than on caudal margin in male. Mesonotum with two elongate bands of long hairs in female. . . . . . *C. vittipes* Stål (Philippines)

5. Length of wingless forms not more than 15 mm. long. Connexival spines of male at least not surpassing and of female only slightly surpassing tip of abdomen.
C. scrutator (Kirkaldy) (Upper Tenasserim, Malacca, Sumatra)

Length of wingless forms more than 17 mm. Connexival spines surpassing tip of abdomen in both sexes. 6

6. Length of wingless forms not over 21 mm. Mesonotum in wingless forms with a broad median longitudinal yellow band that is broader on caudal half. In winged forms hemelytra chocolate brown, with darker veins and costal margin yellow.
C. costalis Schmidt (Cambodia)

Length of wingless forms more than 22 mm. Mesonotum in wingless forms with a narrow, longitudinal, yellow stripe which sometimes reaches caudal margin. In winged forms costal margin of hemelytra not margined with yellow. *C. productus* (Spinola) (India, Ceylon)

Cylindrostethus productus (Spinola)

(Pl. I, Figs. A, B, C; Pl. 4, a, e-g)

1840. *Gerris producta* Spinola, Essai sur les insectes Hémiptères, Rhynchotes ou Hétéroptères, pp. 64-65 (described from Bombay, India).

1865. *Cylindrostethus fieberi* Mayr, Verh. zool.-bot. Ges. Wien, p. 444 (described from Ceylon).

1904. *Cylindrostethus productus*, Distant, Faun. Brit. Ind. Rhynchota, 2:184, fig. 132 [records Travancore, Bombay, Ceylon (Kandy) and gives *C. fieberi* as synonym].

1910. *Janias elegantulus* Distant, Faun. Brit. Ind. 5:148 (described from Travancore, India).

1915. *Cylindrostethus bituberculatus* Schmidt, Stett. Ent. Zeit. 76:364 (described a female from Ceylon; a new synonymy).

1915. *Cylindrostethus nietneri* Schmidt, Stett. Ent. Zeit. 76:363-364 (described a male from Ceylon; a new synonymy).

1925. *Cylindrostethus productus*, Torre-Bueno, Spolia Zeylandica, 8:228-229 (makes *Janias elegantulus* a synonym, because it is a nymph of *C. productus*).

1927. *Cylindrostethus productus*, Dover, Jour. Bombay Nat. Hist. Soc. 32:614.

1929. *Janias elegantulus*, Esaki, Ann. Mag. Nat. Hist. 10(4):416 (regarded as nymph of *C. scrutator*).

1933. *Cylindrostethus productus*, Lundblad, Arch. Hydrobiol. Suppl. 12:370.

Size: Winged males 23 mm. to 27 mm. long; width of head across eyes 2.06 mm. to 2.2 mm.; width across humeri 2.52 to 2.77 mm. Winged females 23.3 to 27 mm. long; width of head across eyes

1.93 mm. to 2.2 mm.; width across humeri 2.52 to 2.94 mm. Wingless males 23 mm. to 27 mm. long; width of head across eyes 2.06 mm. to 2.2 mm.; width across mesoacetabula 3.15 to 3.32 mm. Wingless females much the same in length of body and width of head as in winged females; width across mesoacetabula 3.36 mm. to 3.53 mm.

Color: Black above, venter of thorax and sometimes of abdomen testaceous, covered with a silvery pile. Head black, with a median longitudinal testaceous spot that is broadest at or behind emarginations of eyes. In *winged forms* anterior lobe of pronotum with a median longitudinal line; posterior lobe more or less completely margined, on sides and rear, with a testaceous band. Hemelytra chocolate brown to black with black costal margin. Sides of thorax and abdomen black, with a silvery pilose longitudinal band upon black on either side. Venter of thorax testaceous, covered with a silvery pile and usually abdominal venter of females also covered with silvery pile. Abdominal venter of male either as in female or dark brown to nearly black, with a pale median line. Antennae, front tibiae except sometimes their bases, and front tarsi dark brown to black. Front femur testaceous, with a black longitudinal band above and another one beneath. Basal portions of middle and hind femora dark brown to black at least on dorsal side, elsewhere on legs testaceous to dark brown. Thoracic acetabula, coxae and trochanters usually testaceous, acetabulum with a black spot that may cover it dorsally. *Wingless forms* as above except as follows: pronotum with a median longitudinal testaceous line that is continuous as a more slender line on mesonotum, which is occasionally continuous to its caudal margin. Metanotum and abdominal tergites black. Connexivum black, margined with testaceous above and below.

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th are as follows:

In a winged pair from N. Canara (Bombay, India): Male (25 mm. long) 180:70:44:64; female (26 mm. long) 180:70:40:63. In winged female (23.3 mm. long) from Bengal (India) 158:63:38:63. In a winged pair from Ceylon: Male (24 mm. long) 180:68:42:61; female (26 mm. long) 180:70:47:68. In a wingless pair from Ceylon: Male (24 mm. long) 180:70:42:60; female (26 mm. long) 195:70:45:66. In wingless male (26.7 mm. long) from Travancore (India) 194:77:45:?

In *winged forms* head, as seen from above, longer than anterior lobe of pronotum (105:70 in male and 110:70 in female). Anterior lobe of pronotum medially depressed; its posterior lobe with a transverse depression at its anterior third, dorsal surface of anterior two-thirds of posterior lobe more or less transversely wrinkled, a faint median longitudinal carina more or less visible on posterior lobe. Hemelytral tip not reaching caudal margin of last abdominal tergite. In *wingless* forms, head, as seen from above, longer than pronotum (110:70 in male, 113:73 in female). Pronotum medially depressed. Mesonotum not depressed, somewhat elevated, with a median longitudinal pale line ending at apex of a wedge shaped notch on rear margin; with two tuberculous elevations on mesonotum, one on either side in female, distance between their bases equal to their distance from rear margin. Metanotum somewhat elevated, with a median longitudinal depressed line, and caudal margin bilobed. First abdominal tergite of male roundly elevated, of female with a conspicuous conical elevation; other abdominal tergites longer than wide. Connexivum nearly erect in male, nearly erect to overlapping margins of tergites in female. Connexival spines extending far beyond apex of suranal plate in both sexes. Suranal plate of male as shown on pl. 4, fig. f. Metasternum shorter than first two abdominal ventrites together (125:165 in male and 128:185 in female). Abdominal venter with a median longitudinal carina. In ventral view first genital segment of male longer than last pregenital abdominal ventrite (75:50) which is much shorter than the one before it. Rear margin of first genital segment of male, in ventral view, slightly caudally produced at middle (pl. 4, fig. e). Rear margin of last abdominal segment of female slightly produced at middle and subequal to the one before it.

Relative lengths of leg segments

	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Male (25 mm.)					
Front leg	270	240	12	35	47
Middle leg	860	560	330	53	383
Hind leg	860	640	30	18	48
Female (26 mm.)					
Front leg	270	240	15	35	50
Middle leg	890	570	340	60	400
Hind leg	895	695	30	25	55

Type: Spinola described *Gerris producta* from a male specimen from Bombay sent to him by M. Dupont. The junior author did not find the type specimen at the castle Tassarolo in Italy as noted earlier in this work (see p. 85).

Comparative notes: This is the largest species of *Cylindrostethus* so far described from the Eastern Hemisphere. Its nearest relative is *C. costalis* Schmidt, which is the only other species having the connexival spines usually surpassing the suranal plate in both sexes. It is not only larger than *C. costalis* but differs in the shape of the male suranal plate (see Pl. 4, Figs. b and f), and in winged forms the costal margin of hemelytra is black, not yellow as in *C. costalis*.

Distribution: This species has been recorded from *South India* and *Ceylon*. We have seen the following specimens from:

INDIA—17 winged ♂ ♂ and 15 winged ♀ ♀, North Kanara, Anshi, 26 Jan. 1956 (Hamburg Zool. Mus.); 12 winged ♂ ♂, 5 winged ♀ ♀, North Kanara, Anshi, Madgau river, 24 Jan. 1956 (Hamburg Zool. Mus.); 1 winged ♀, Manbhum, West Bengal, K. A. Hallowes coll. (Brit. Mus.); 1 wingless ♂, Tenmalai, W. Ghats (west side), Travancore, 22 Nov. 1908 (Brit. Mus. det. by Izzard); 2 wingless ♂ ♂, Castle Rock, N. Kanara Dist.; 1 winged ♂ and 1 winged ♀, Nechal, W. Ghats, ca. 2000 ft. Satara Dist. (Zoo. Surv. of India, Calcutta). CEYLON—1 winged ♂, 6 winged ♀ ♀, 1 wingless ♂, 3 wingless ♀ ♀, Kandy, E. E. Green coll. (Kirkaldy Coll. Univ. Kansas); 1 winged ♂, 1 wingless ♀ (Brit. Mus.); 1 winged ♂, 1 wingless ♀, Kandy, H. Rolle (Torre-Bueno Coll. Univ. Kansas); 6 winged ♀ ♀, 1 wingless ♀, Paradeniya, 19 Jul. 1920 (Kirkaldy Coll. Univ. Kansas); 2 winged ♂ ♂, 1 winged ♀, Suduganga river, Matala, R. A. Senior-White (Torre-Bueno Coll. Univ. Kansas); 4 wingless ♂ ♂, 4 winged ♀ ♀, Madirigiriya, 17 Jan. 1958, K. L. A. Perera (Univ. Kansas); 19 wingless ♂ ♂, 12 wingless ♀ ♀, Hinidoma, S. P. Jan. 1958, K. L. A. Perera (Univ. Kansas); 1 wingless ♂, Badulla, Dec. 28 (Brit. Mus.); 1 winged ♂, Haragawa, Apr. 1911 (Brit. Mus.); 1 wingless ♀, Ratnapura, 19 Sept. 1927 (Brit. Mus.).

Cylindrostethus costalis Schmidt

(Pl. 2, A-C; Pl. 4, a-d)

1915. *Cylindrostethus costalis* Schmidt, Stett. Ent. Zeit. 76:364
1933. *Cylindrostethus costalis,* Lundblad, Arch. Hydrobiol. Suppl. 12:370
1960. *Cylindrostethus costalis,* Matsuda Univ. Kansas Sci. Bull. 41(2):224, 225, fig. 435

The type, a winged male from Cambodia, is redescribed below:

Size: Schmidt gives its length as 20.5 mm. which is correct;

width of head across eyes 1.93 mm.; width of pronotum across humeri 2.52 mm.

Color: Nearly black above, hemelytra brown with darker veins, costal margin pale yellow from near base to a point beyond Sc_2, one third of distance from base of Sc_2 to hemelytral tip on costal margin.

Head between eyes pale yellow except for dark spot joining emargination of each eye, with a black band across antennal bases. Underside of head, genae, basal two segments of beak pale, last two segments of beak black; clypeus brown. Pronotum black, anterior lobe with a median longitudinal line and posterior lobe margined with a broader pale yellow band in winged forms. Mesopleura with a broad longitudinal black band and it is divided into two by a longitudinal silvery pilose band. Metapleura also black, with a black spot on meso- and metacetabula. Connexivum pale yellow above and below. Venter silvery white. Antenna nearly black. Front femur pale yellow, with a longitudinal black band above not reaching its end and a narrow one below; tibia and tarsus darker.

Structural characteristics: The type specimen (male) has lost the last two segments from both antennae. The relative lengths of remaining segments: 1st:2nd::130:62.

Head longer than anterior lobe of pronotum, which is medially slightly depressed; posterior lobe transversely depressed at about half way between anterior lobe and rear margin; posthumeral space short and broadly rounded apically. Hemelytra not reaching to base of connexival spine which slightly surpass suranal plate. Mesosternum with two longitudinal sutures. Metasternum shorter than first two abdominal ventrites together (110:132). Rear margin of last ventral abdominal segment (seventh) simply emarginate. First genital segment ventrally longer than last abdominal ventrite

Relative lengths of leg segments of the type

	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Front leg	220	200	13	30	43
Middle leg	780	520	250	missing	
Hind leg	810	500	missing		

at middle (55:42). Last abdominal ventrite shorter than the one before it (42:62). Left wing of suranal plate (pl. 4, a) broader than right one. Abdominal venter with a median longitudinal carina.

Type: Schmidt stated "Cambodia. Typus in Stettiner Museum." The type is at present at the Polish Academy of Sciences, Warsaw.

We have in our collection three winged specimens (one male, two females) and two wingless males that were taken in Thailand by Dr. M. E. Griffith. Two wingless males and one winged female with the label "Chiengmai Prov., Thailand, Sept. 25, 1952, M. E. Griffith." The winged male and one winged female bear the label "Ngao Dist., Lampang Prov., Thailand, Oct. 3, 1952, Stream, M. E. Griffith (Neallotype)." The male is nearly identical with the type of *C. costalis* Schmidt and is now labelled "Compared with type." The winged female from this series is described below:

Size: Length 22.5 mm.; width of head across eyes 2.0 mm. plus; width of pronotum across humeri 2.52 mm.; width across mesoacetabula 3.23 mm.

Color: The same as in the winged male type described above.

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th::130:56:40:52. Head longer than anterior lobe of pronotum which is medially depressed (100:60); posterior lobe of pronotum transversely depressed half way between anterior lobe and rear margin; posthumeral space short and broadly rounded on apical margin. Hemelytra reaching base of connexival spines which surpass suranal plate by a third of their length.

Relative lengths of leg segments of a winged female

	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Front leg....................	220	195	13	30	43
Middle leg..................	730	480	240?	48?	288?*
Hind leg.....................	785	470	35?	15?	50?

*? Difficult to measure.

Type: This neallotype from the above mentioned locality is in the Collection of the University of Kansas.

Wingless males from "Chiengmai Prov. Thailand, Sept. 25, 1952,

M. E. Griffith" are here designated neomorphotypes and described below:

Size: Length 17.6 mm. to 18.7 mm. long; width of head across eyes 1.85 mm. to 1.93 mm.; width across mesoacetabula 2.73 mm. to 2.86 mm.

Color: General color brownish black above, with a yellow, rather broad, median longitudinal band on pronotum, continuing onto mesonotum, metanotum and first abdominal tergite, thereafter replaced by a yellow streak on one or more of abdominal tergites. Markings on head, pleura and venter same as in winged forms.

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th::130:63:38:55. Head longer than pronotum (93: 70) which is medially slightly depressed. Mesonotum very faintly transversely depressed, with a median longitudinal depressed line on caudal three-fourths of mesonotum which becomes deeper caudally, so that broadly rounded caudal margin appears faintly bilobed. Connexival spines barely surpassing suranal plate. Suranal plate as shown on Pl. 4, b. Metasternum shorter than first two abdominal ventrites together. Last two ventral abdominal segments and genital segments as shown on Pl. 4, Fig. a.

Relative lengths of leg segments

	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Front leg	220	200	12	32	44
Middle leg	750	488	220+	40	260+
Hind leg	780	450+	26	14	40

Types: These two neomorphotypes from the above mentioned locality are in the Snow Entomological Museum, The University of Kansas.

Comparative notes: While the author of *Cylindrostethus costalis* did not mention in his description that the hemelytral costal margin is yellow, it may have suggested the specific name. Its smaller size, in addition to the yellow costal margin of the hemelytra, readily separates it from *C. productus* (Spinola).

Distribution: The type came from *Cambodia,* and we have the specimens from *Thailand* mentioned above and one winged female with the label "Schwaner, *Borneo*." There are two wingless males from *Burma* in the British Museum.

Cylindrostethus scrutator (Kirkaldy)

(Pl. 3, Figs. G, H; Pl. 5, a-c)

1899. *Gerris scrutator* Kirkaldy, Rev. Ent. 18:90 (described from Upper Tenasserim).
1904. *Cylindrostethus scrutator,* Distant, Faun. Brit. Ind. Rhynchota 2: 184-185.
1909. *Cylindrostethus naiades* Kirkaldy, Canad. Ent. 41:389 (types from Malacca, Perak).
1915. *Cylindrostethus scrutator* Schmidt, Stett. Ent. Zeit. 76:362 (said "I do not know this species," and credits Distant with Burma and Ceylon but Distant did not mention in the reference Schmidt gave. We have seen no specimens from Ceylon).
1915. *Cylindrostethus flaviventer* Schmidt, Stett. Ent. Zeit. 76:363.
1933. *Cylindrostethus flaviventer,* Lundblad, Arch. Hydrobiol. Suppl. 12:372 (says is a synonym of *C. scrutator*).
1933. *Cylindrostethus naiades,* Lundblad, Arch. Hydrobiol. Suppl. 12:370 (new synonymy by Hungerford and Matsuda in this paper).
1960. *Cylindrostethus naiades,* Matsuda, Univ. Kansas Sci. Bull. 41(2):223, 224, Fig. 442.

Size: Winged male 12.5 mm. long, wingless males 10.0 mm. to 13.0 mm. long; width of head across eyes 1.43 mm. to 1.47 mm.; width across mesoacetabula 1.78 mm. to 1.99 mm. Wingless females 13.8 mm. to 14.7 mm. long; width of head across eyes 1.22 mm. to 1.64 mm.; width across mesoacetabula 2.39 mm. to 2.77 mm.

Color: General color above blackish, sometimes with a metallic greenish sheen on thorax; wingless forms more or less covered with short brown hairs especially on abdomen. A fulvous spot on base of head, a narrow fulvous median longitudinal line on pronotum; margin of connexivum above and below fulvous. Sides of mesothorax and abdomen with a band of silvery hairs, and a patch of such hairs on all acetabula. Extreme sides of thorax black. Venter yellowish, yellowish area on mesosternum sometimes confined anteriorly as a narrow longitudinal band. Antennae and legs dark brown to black. Anterior femur with a yellowish wedge-shaped spot on basal half and sometimes one or two other pale lines or spots.

Structural characteristics: Relative lengths of antennal segments of wingless male: 1st:2nd:3rd:4th::75:43:27:42, of wingless female 92:43:30:42. Head longer than pronotum (62:38 in male and 77:40 in female). Pronotum medially depressed. Mesonotum not depressed, with a median longitudinal depressed line on caudal half or caudal fourth, and with an elongate, caudally directed tubercle on either side in female, and this marks beginning of rounded, bilobed caudal margin of mesonotum. Connexivum flattened to nearly erect in male and narrower than half the width of tergite, narrow and erect to slightly folded over tergites in female. Connexival spines of male as long as or longer than first genital segment, of female often as long as first genital segment in dorsal view, the spines nearly parallel in both sexes. Suranal plate in male as shown on Plate 5, Fig. c. Mesosternum with two longitudinal sutures in winged forms as shown on Plate 5, Fig. a. Metasternum a trifle longer than first two abdominal ventrites together in male (60:54) or shorter than first two ventrites in female (65:82). In ventral view first genital segment of male subequal in length to last abdominal ventrite which is not longer than the one before it. Rear margin of first genital segment of male, as seen from beneath, slightly but broadly medially produced. Rear margin of the last ventral abdominal segment of female slightly medially produced and subequal to abdominal ventrite before it.

Relative lengths of leg segments

	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Wingless male					
Front leg	138	133	7	21	28
Middle leg	540	300	120	30	150
Hind leg	580	250	20	14	34
Wingless female					
Front leg	147	135	8	27	35
Middle leg	565	360	175	37	222
Hind leg	620	295	25	15	40

Types: The types of *Gerris scrutator* Kirkaldy, a winged male and wingless female from Upper Tenasserim are in the British Museum along with many other wingless specimens from the same place that were not seen by Kirkaldy. The types of *Cylindrostethus naiades* Kirkaldy are two wingless females labelled "Malacca, Perak" and are at the University of Kansas. The types of *Cylindrostethus flaviventer* Schmidt, a wingless male and wingless female from "Sumatra Sinabang (Dr. Dohrn)," were at the Museum in Stettin, but now are at the Polish Academy of Sciences, Warsaw. They are damaged by dermestid and the head of the male specimen is missing.

Comparative notes: In 1957 Dr. W. E. China wrote to us: "I have examined the male type and paratype female of *Cylindrostethus scrutator* Kirkaldy. The male has a pair of sutures on the mesosternum as shown in the accompanying sketch (Pl. 5, Fig. a). This structure is not present in the female nor other males we have from Tenasserim." Since it is true in other species of *Cylindrostethus* from the Eastern Hemisphere that only winged specimens of both sexes have the two fine sutures on the mesosternum, while the wingless specimens lack them, we believe they do not provide a specific character (see remarks under *C. productus*). It is unfortunate that Kirkaldy did not see all Distant's specimens, for if he had he surely would not have later described *C. naiades.*

While we were convinced that both *C. naiades* Kirkaldy and *C. flaviventer* Schmidt are synonyms of *C. scrutator* (Kirkaldy), we were confronted with a hastily-written description of *C. scrutator* by Kirkaldy that did not fit either of the other species. We therefore asked Mr. R. J. Izzard of the British Museum to compare the winged male type of *C. scrutator* with Kirkaldy's description. He reported that the middle femur of *C. scrutator* is about one and one-half times as long as tibia, *not* more than twice as long as the tibia as stated by Kirkaldy. The hind femur is *not* two and one-fourth times as long as tibia and tarsus united, but only slightly more than twice. The hind tibia is *not* ten and one-half times as long as the tarsus but only approximately seven and one-half times as long as the tarsus. The type has lost the hind tarsi but other wingless specimens from the same locality show the above and that the first tarsal segment is considerably longer than the second, not just a little longer, as stated by Kirkaldy.

Distribution: Besides the type localities (Tenasserim, Malacca and Sumatra) we can add the following:

BURMA—6 wingless ♂♂ and 3 wingless ♀♀, Myitkyina, 31 March, 1945, L. C. Kuitert (Univ. Kansas); 1 wingless ♂ and 1 wingless ♀ (Brit. Mus.). INDIA—2 wingless ♂♂ and 1 wingless ♀ (Brit. Mus.). JAVA—2 wingless ♀♀ Muller Coll. (Univ. Kansas); 1 wingless ♂ and 1 wingless ♀, West Java, Radjamandale, 4200′, M. E. Walsh. 6-3-37 (Basel Nat. Hist. Mus.); 1 wingless ♂ and 1 wingless ♀ (Univ. Kansas). SUMATRA—5 wingless ♂♂ and 7 wingless ♀♀, Mentawei, Sipora Sereinu, 5-6-94, Modigliani (Island off west coast of Sumatra) (Kirkaldy Coll. Univ. Kansas).

Cylindrostethus vittipes (Stål)

(Pl. 3, Figs. A, B; Pl. 5, Figs. d, e)

1870. *Hydrobates vittipes* Stal, Öfv. Kongl. Vet. Akad. Förh. for 1870, 7:705 (described from the Philippines).

1909. *Cylindrosthethus vittipes*, Kirkaldy, Canad. Ent. 41:389.

1933. *Cylindrostethus vittipes*, Lundblad, Arch. Hydrobiol. Suppl. 12:370, 372, 373.

1960. *Cylindrostethus vittipes*, Matsuda, Univ. Kansas Sci. Bull. 41(2):223, 235, Fig. 444.

Size: Wingless male 8.74 mm. long; width of head across eyes 1.22 mm.; width across mesoacetabula 1.98 mm. Wingless female 11.97 mm. long; width of head across eyes 1.47 mm.; width across mesoacetabula 2.73 mm.

Color: Black above, covered with a pubescence that on mesonotum and abdomen gives a brown appearance. A fulvous spot on base of head and a slender median stripe on pronotum. Connexival margin yellow to fulvous. Sides of thorax black, with a broad pubescent silvery band on either side and similar spots on all acetabula. Anterior portion of mesosternum black, elsewhere pale yellow with an over-all covering of silvery pubescence. Antennae and legs black to brown, except anterior femora, which are pale yellow with two black longitudinal bands, one above and one below. Anterior coxae yellow, with a black band beneath.

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th::65:43:?:? in wingless male, 76:50:26:38 in wingless female. Head longer than pronotum (56:40 in male, 67:43 in female). Pronotum medially depressed. Mesonotum not depressed. Female with two longitudinal bands of long curved hairs, one on either side of caudal half of mesonotum replacing short ridges of other species. Caudal margin of mesonotum broadly rounded and medially notched. Metanotum flat. First abdominal tergite broader than long. Connexivum flat to obliquely elevated; connexival spines of male minute, of female nearly half as long as first genital segment which is transversely depressed laterally. Lateral wing of suranal plate of male as shown on Pl. 5, Fig. e. Metasternum longer than first two abdominal ventrites together in male (47:40), or shorter than the same in female (60:65). Ventrally first genital segment of male subequal in length to the one before it, its ventral rear margin slightly but broadly produced at middle; second genital segment of male ventrally equal in length to first genital segment, and has some short spines before its tip. Rear margin of last abdominal ventrite of female not or very faintly produced medially and the segment not longer than the segment before it.

Relative lengths of leg segments

	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Wingless male (8.74 mm.)					
Front leg	110	106	8	20	28
Middle leg	440	263	85	27	112
Hind leg	465	195	14	16	30
Wingless female (11.97 mm.)					
Front leg	136	124	8	28	36
Middle leg	530	330	165	36	201
Hind leg	535	310	26	20	46

Types: Six syntypes, of which two are adult males and four are nymphs. They are in the Naturhistoriska Riksmuseet in Stockholm, Sweden.

Comparative notes: This species is nearer to *C. scrutator* in color pattern than to others but is distinguishable from the latter by its minute connexival spine in the male and by the presence of two long bands of curved hairs on the mesonotum in the female.

Distribution: The types came from the Philippines. We have seen specimens labelled "Agusan River, Mindanao, Philippines, C. S. Banks, Nov. 23" belonging to the Museum of Comparative Zoology, Harvard University. These specimens were compared with types by Dr. O. Lundblad and were used for redescription of this species.

Cylindrostethus persephone Kirkaldy

(Pl. 3, Figs. E, F; Pl. 5, Figs. h, i)

1899. *Cylindrostethus persephone* Kirkaldy, Ann. Soc. Ent. Belg. 43:508.
1901. *Cylindrostethus persephone,* Breddin, Naturf. Ges. Halle, 24:20.
1915. *Cylindrostethus persephone,* Schmidt, Stett. Ent. Zeit. 76:362 (records 1 male and 2 females from Samanga, South Celebes).
1933. *Cylindrostethus persephone,* Lundblad, Arch. Hydrobiol. 12:370 (says from Celebes).
1960. *Cylindrostethus persephone,* Matsuda, Univ. Kansas Sci. Bull. 41(2): 223, fig. 445.

Size: Wingless males 10.9 to 11.5 mm. long; width of head across eyes 1.47 mm.; width across mesoacetabula 2.31 mm. Wingless females 13.7 to 14.5 mm. long; width of head across eyes 1.68 mm.; width across mesoacetabula 3.0 mm.

Color: Dull black with pale yellowish pubescence. A fulvous spot on base of head; a narrow median longitudinal line on pronotum. Mesonotum usually black, sometimes with a faint median longitudinal fulvous line. Metanotum usually black, sometimes with a faint median longitudinal fulvous line. Abdominal tergites black to brown; first tergite sometimes with a faint pale longitudinal line. Connexivum of male black, of female may be lighter brown. Sides of mesothorax and abdomen with a band of silvery hairs and a patch of such hairs on all acetabula. Sides of thorax and abdomen black. Venter of thorax and abdomen of male black or brown and covered with a silvery pubescence. Female with venter yellowish as in *C. scrutator.* Antennae and legs dark brown to black. Front femur with a yellowish wedge shaped spot on basal half.

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th::85:45:30:42 in wingless male (10.9 mm.) and 100:50:30:42 in wingless female (13.8 mm.). Head, as seen from above, longer than pronotum (62:49 in male, 77:50 in female). Pronotum slightly medially depressed. Mesonotum not depressed; a median longitudinal depressed line on mesonotum often visible for its entire length; mesonotum of female with an obliquely directed ridge one either side, marking the beginning of rounded bilobed caudal margin of mesonotum. Metanotum of both sexes rather flat, its rear margin bilobate. Rear margin of first abdominal tergite nearly straight. Connexivum half as broad as tergite, erect to overlapping lateral margins of some of tergites. Connexival spines of male shorter than first genital segment and with tips usually laterally divergent; connexival spines of female shorter than first genital segment and parallel. Suranal plate in male as shown in Pl. 5, Fig. i. Note that the wings of suranal plate are parallel and that its inner margin at base is straight. Metasternum with lateral groove leading from omphalium, deep and well marked, much more prominent than caudal margin of metasternum, which is shorter than first two abdominal ventrites together in female and subequal to them in male. Ventrally first genital segment of male subequal to last abdominal ventrite which is not longer than the one before it; its ventral rear margin slightly produced at middle. Rear margin of last abdominal ventrite of female very slightly produced caudally at middle; the segment very little longer than the one before it.

Relative lengths of leg segments

	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Male (10.9 mm.)					
Front leg	145	142	10	26	36
Middle leg	520	340	150	38	188
Hind leg	540	303	24	20	44
Female (13.8 mm.)					
Front leg	160	150	11	30	41
Middle leg	532	355	195	42	237
Hind leg	555	350	30	18	48

Types: Wingless male holotype, wingless female allotype, four wingless male and one wingless female paratypes are in the Institute Royal des Sciences Naturelles de Belgique, Bruxelles. Seven wingless male and five wingless-female paratypes bearing the labels "S. Celebes, Samanga, Nov. 1895, H. Fruhstorfer" and "H. Fruhstorfer vend. 30 XII, 1896" are in the Kirkaldy Collection, in the Snow Entomological Museum, The University of Kansas.

Comparative notes: This species is very close to *C. scrutator* Kirkaldy. There seems to be a difference in color in the males. The venter of *C. scrutator* is yellowish, while in the male of this species it is black to brown. The connexival spines of *C. persephone* are shorter than the first genital segment in both sexes and those of male are usually divergent, whereas in *C. scrutator* they are longer than first genital segment. The shape of the lateral wing of the suranal plate of the male of *persephone* is also different (see Pl. 5, *c* and *i*).

Distribution: Known only from the type series from South Celebes. 2 ♂♂, 3 ♀♀ (wingless) from "Zuid Celebes, Nanggala 900" (Brit. Mus.).

Cylindrostethus sumatranus Lundblad

(Pl. 3, figs. C, D; pl. 5, figs. j, k.)

1933. *Cylindrostethus sumatranus* Lundblad, Arch. Hydrobiol. Suppl. 12: 392-394, fig. 124, Taf. 13.

1960. *Cylindrostethus sumatranus,* Matsuda, Univ. Kansas Sci. Bull. 41(2): 223, fig. 443.

Size: Wingless male 12.0 mm. long; width of head across eyes 1.47 mm.; width across mesoacetabula 2.30 mm.

Color: Chocolate brown above, pale yellewish beneath where it is more or less covered with silvery pubescence. Head testaceous, with a brown band laterally from eye to base of antenna. Pronotum with a median longitudinal pale line margined on either side by a more or less definite dark band. Pattern of meso- and metanota faint and variable, sometimes caudal half of mesonotum and metanotum with a median longitudinal darker band. Sides of mesothorax dark brown with a more or less distinct longitudinal band of silvery hairs, giving the appearance of two broad dark brown bands, lower one broader. Abdominal tergites brown. Connexivum testaceous to reddish yellow above and below.

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th::54:27:17.2:29.2 in male according to Lundblad (1933), our male specimen lacks all but basal two segments which measure 85:47. In one of female specimens the relative lengths: 1st:2nd:3rd:4th::88:43:28:?

Head longer than pronotum (65:45 in male and 70:50 in female). Pronotum longitudinally depressed in caudal half at middle. Mesonotum in caudal half somewhat elevated, conspicuously so in female where there is a laterally rounded swelling instead of a ridge or tubercle on either side, marking the beginning of bilobed caudal margin. First abdominal tergite of male somewhat elevated and that of female nearly conically elevated. Abdominal tergites broader than long. Connexivum of male obliquely erect; of female erect on basal segments then overlapping tergites, and their margins meeting before short caudal connexival spines, which are much shorter than first genital segment in both sexes. Suranal plate of male as shown on Plate 5, Fig. k. Metasternum longer than first two abdominal ventrites together (70:50 in male and 78:67 in female). Ventrally first genital segment a little longer than the one before it. Rear margin of last abdominal ventrite of female slightly produced at middle and plainly longer than the ventrite before it.

Types: A wingless female type collected at Tjurup, Musi area, South Sumatra is in the Naturhistoriska Riksmuseet in Stockholm, Sweden, and a wingless male from an unknown place in the Breddin Collection, Entomological Institute at Berlin, Dahlem.

Comparative notes: The chocolate brown color and the raised first abdominal tergite separate this species readily from the others of similar size.

Distribution: Besides the type locality we can add Kloempang, *Sumatra* based on one apterous male and three apterous females bearing the label "Sumatra Expedition, Kloempang, August 1878." These are in the Kirkaldy Collection, University of Kansas.

Cylindrostethus quadrivittatus Bergroth

(Pl. 2, Figs. D, E; Pl. 5, Figs. f, g)

1916. *Cylindrostethus quadrivittatus* Bergroth, Proc. U. S. Nat. Mus. 51:237 (described from Liberia).

Size: Apterous male 10.0 to 10.4 mm. long; width of head across eyes 1.47 mm.; width across mesoacetabula 2.52 mm. Apterous female 11.5 to 12.0 mm. long; width of head across eyes 1.57 mm.; width across mesoacetabula 2.52 mm.

Color: So well done by Bergroth that we quote his description: "Apterous form": Above fulvous with a distinct buffy tinct, beneath pale testaceous; clypeus and adjacent parts of juga, apex of antenniferous tubercles, an oblong spot at posterior half of inner margin of eyes, two vittae slightly curved outward to pronotum, four vittae to mesonotum [the two median ones shortly interrupted (male) or narrowed (female) behind the middle], two vittae to metanotum, dorsum of abdomen [except the first (female) or three first (male) segments in the middle], apical spines of last abdominal segment, a vitta to upper side of genital segments, an apical spot to all acetabula, a basal streak to middle acetabula, and sublateral vitta to venter (but faintly indicated in the male) black; a line externally bordering the lateral vittae of mesonotum, a spot at basal angles of mesonotum, a spot on upper side of acetabula, and a slightly waved line anteriorly bordering the ventral vittae, clothed with very short but thick golden yellow sericeous pubescence; antenna, last joint of rostrum, an upper (abbreviated) and lower vitta to fore femora, the fore tibia and tarsi, and the four posterior legs (except coxae and trochanters) fuscous black."

Structural characteristics: Relative lengths of antennal segments: 1st:2nd:3rd:4th::85:45:22:44 in wingless male, and 88:45:22:42 in wingless female. Head, seen from above, longer than pronotum (60:45 in male and 70:47 in female). Pronotum slightly medially depressed on caudal half. Mesonotum not depressed; a median longitudinal depressed line on mesonotum often visible for its entire length, somewhat depressed longitudinally between two black bands; mesonotum of female has neither tubercle nor hair tufts so characteristic of other species. Mesonotum slightly elevated in both sexes, its rear margin bilobate. First abdominal tergite slightly elevated in male, flat in female. Second to sixth tergites of male broader than long. Seventh tergite of male longer than two preceding tergites together. Connexivum of male reflexed but not erect; that of female reflexed, covering most of abdominal tergite, their margins nearly meeting beyond third tergite. Connexival spines of male divergent and fully half as long as first genital segment; connexival spines of female minute and meeting or overlapping. Suranal plate of male as shown on Plate 5, Fig. g. Metasternum relatively long, a trifle longer (female) or very distinctly longer (male) than first two abdominal ventrites together. Ventrally first genital segment of male longer than last abdominal ventrite, which is a little longer than the one before it. Rear margin of last abdominal ventrite of female produced at middle and longer than ventrite before it.

Relative lengths of leg segments

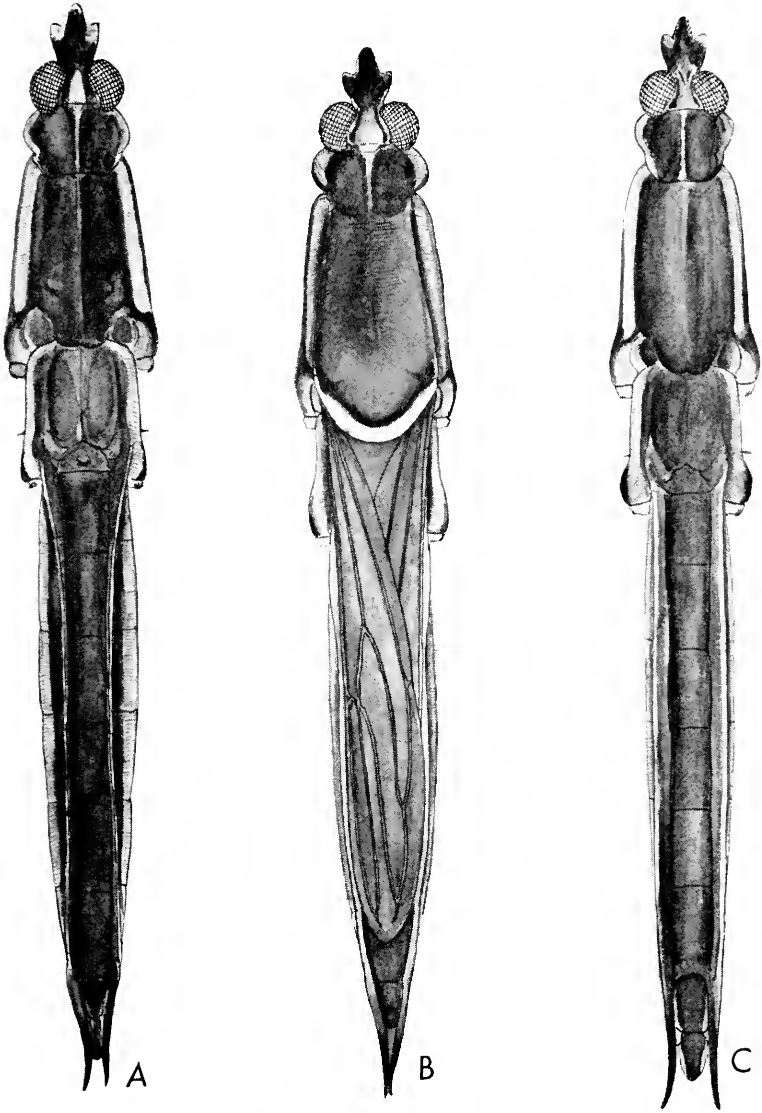
	Femur	Tibia	First tarsal segment	Second tarsal segment	Total tarsal length
Male (10.0 mm.)					
Front leg	130	120	7	18	25
Middle leg	420	300	110	28	138
Hind leg	460	240	17	15	32
Female (11.5 mm.)					
Front leg	138	130	8	20	28
Middle leg	465	315	125	32	157
Hind leg	500	280	18	15	33

Types: Wingless male holotype, wingless female allotype and thirty-five paratypes, bearing the label "M't Coffee, Liberia, Feb. 1897, (R. P. Currie) Cat. No. 20155" are in the U. S. National Museum, Washington, D. C. Six paratypes are in the Drake Collection in the U. S. National Museum. Two specimens, a male and a female, from the same series as types are in the Snow Entomological Museum, The University of Kansas. A male specimen with the same label as types is in the Zoological Museum in Helsinki. All of the above specimens are wingless forms.

Comparative notes: The striking color pattern separates this species from all other old world species.

Distribution: Known only from the type locality (Liberia).

PLATE 1



Cylindrostethus productus (Spinola) from Ceylon.
A. Wingless female. B. Winged female. C. Wingless male.

PLATE 2

A-C. *Cylindrostethus costalis* Schmidt.

A. Winged female (Thailand) B. Wingless male (Thailand) C. Winged male (Cambodia, type).

D-E. *Cylindrostethus quadrivittatus* Bergroth from Liberia (types).

D. Wingless male. E. Wingless female.

PLATE 2

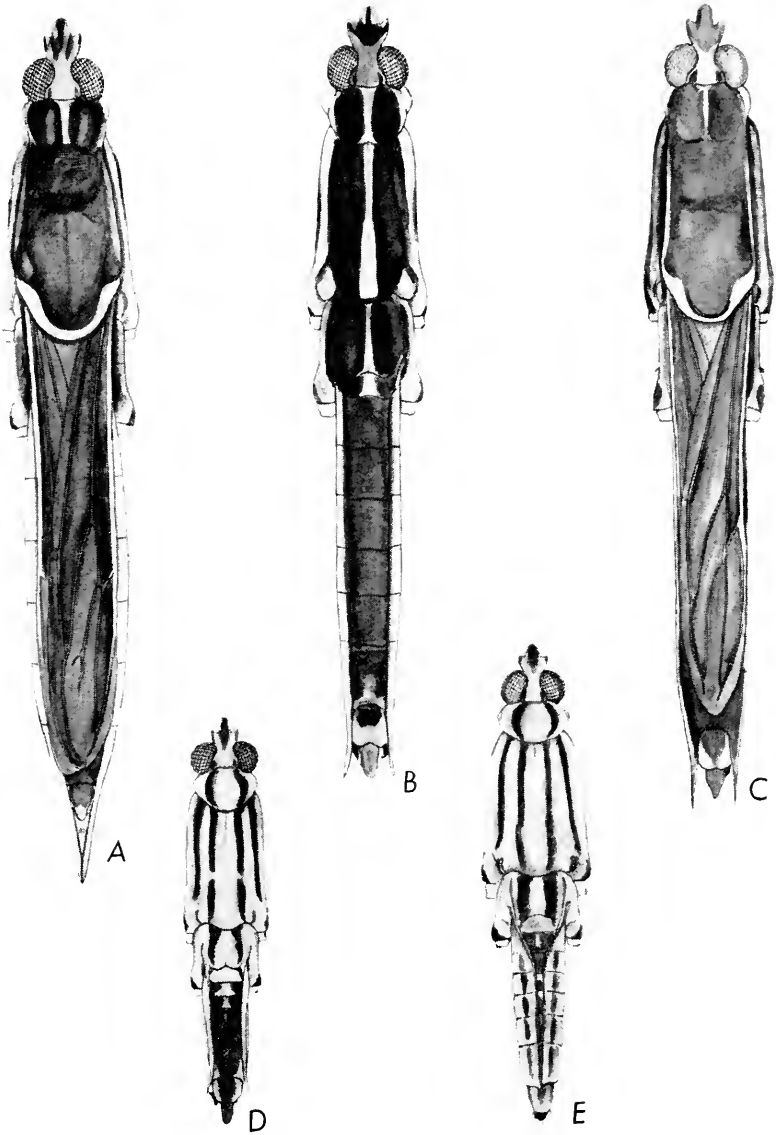


PLATE 3

A. Wingless female of *Cylindrostethus vittipes* Stål (Philippines).
B. Wingless male of *Cylindrostethus vittipes* Stål (Philippines).
C. Wingless male of *Cylindrostethus sumatranus* Lundblad (Sumatra).
D. Wingless female of *Cylindrostethus sumatranus* Lundblad (Sumatra).
E. Wingless female of *Cylindrostethus persephone* Kirkaldy (Celebes, paratype).
F. Wingless male of *Cylindrostethus persephone* Kirkaldy (Celebes, paratype).
G. Wingless male of *Cylindrostethus scrutator* (Kirkaldy) (Burma).
H. Wingless female of *Cylindrostethus scrutator* (Kirkaldy) (Burma).

PLATE 3

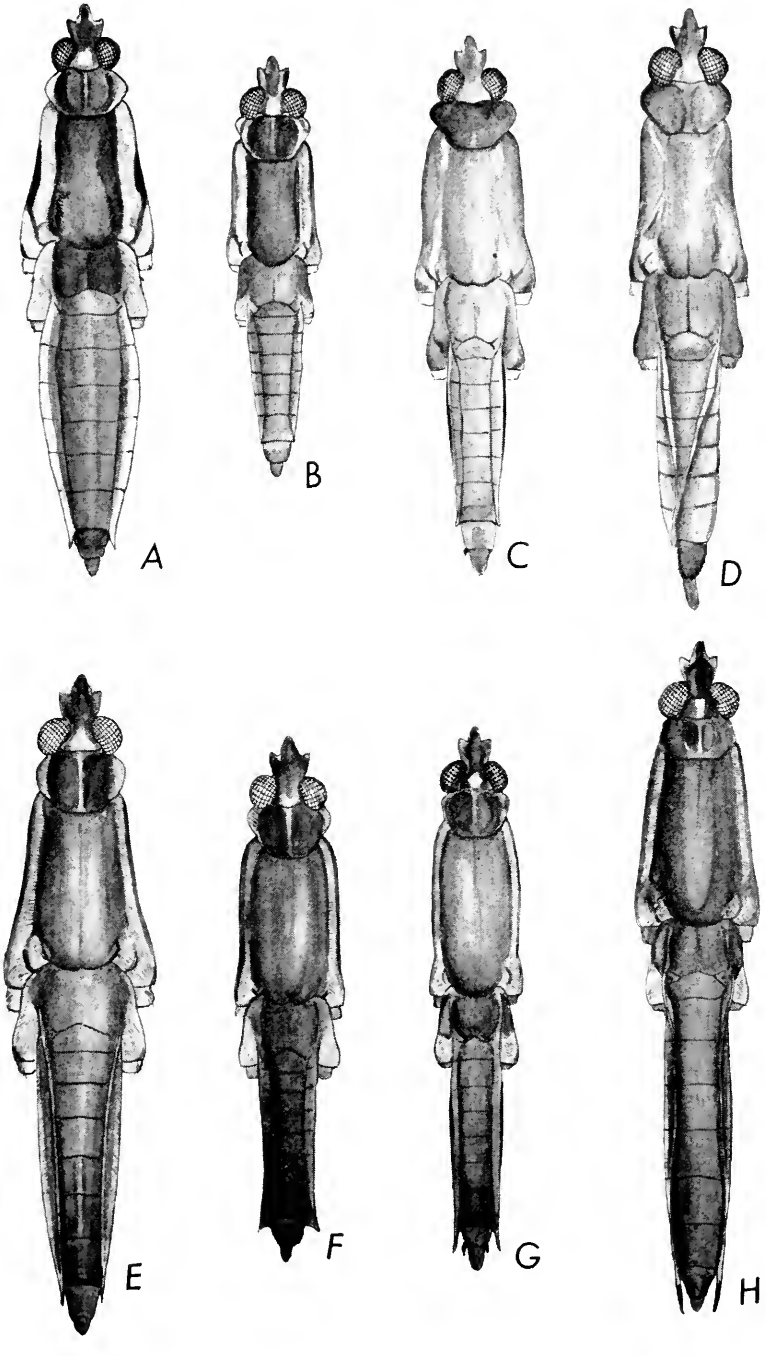


PLATE 4

a-d. *Cylindrostethus costalis* Schmidt.
  a. Ventral view of apical abdominal segments of male (type).
  b. Dorsal view of suranal plate of male (Thailand).
  c. Ventral view of apical abdominal segments of male (Thailand).
  d. Ventral view of apical abdominal segments of female (Thailand).
e-g. *Cylindrostethus productus* (Spinola) from Ceylon.
  e. Ventral view of apical abdominal segments of male.
  f. Dorsal view of suranal plate of male.
  g. Ventral view of apical abdominal segments of female.

PLATE 4

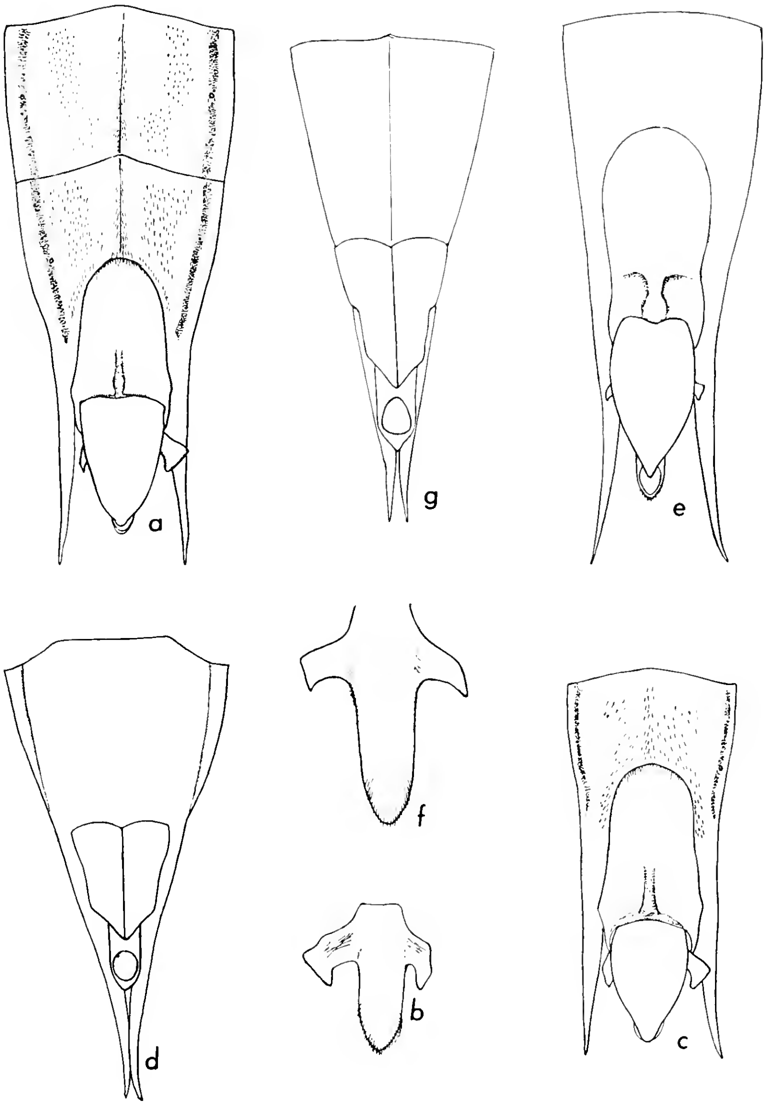


PLATE 5

a. Ventral view of mesosternum showing paired longitudinal sutures in *Cylindrostethus scrutator* (Kirkaldy) (type, drawn by Dr. W. E. China).

b. Ventral view of apical abdominal segments of female in *Cylindrostethus scrutator* (Kirkaldy) (Burma).

c. Dorsal view of suranal plate of male in *Cylindrostethus scrutator* (Kirkaldy) (Burma).

d. Ventral view of apical abdominal segments of female in *Cylindrostethus vittipes* (Stål) (Philippines).

e. Dorsal view of suranal plate of male in *Cylindrostethus vittipes* (Stål) (Philippines).

f. Ventral view of apical abdominal segments in *Cylindrostethus quadrivittatus* Bergroth (type, Liberia).

g. Dorsal view of suranal plate of male in *Cylindrostethus quadrivittatus* Bergroth (type, Liberia).

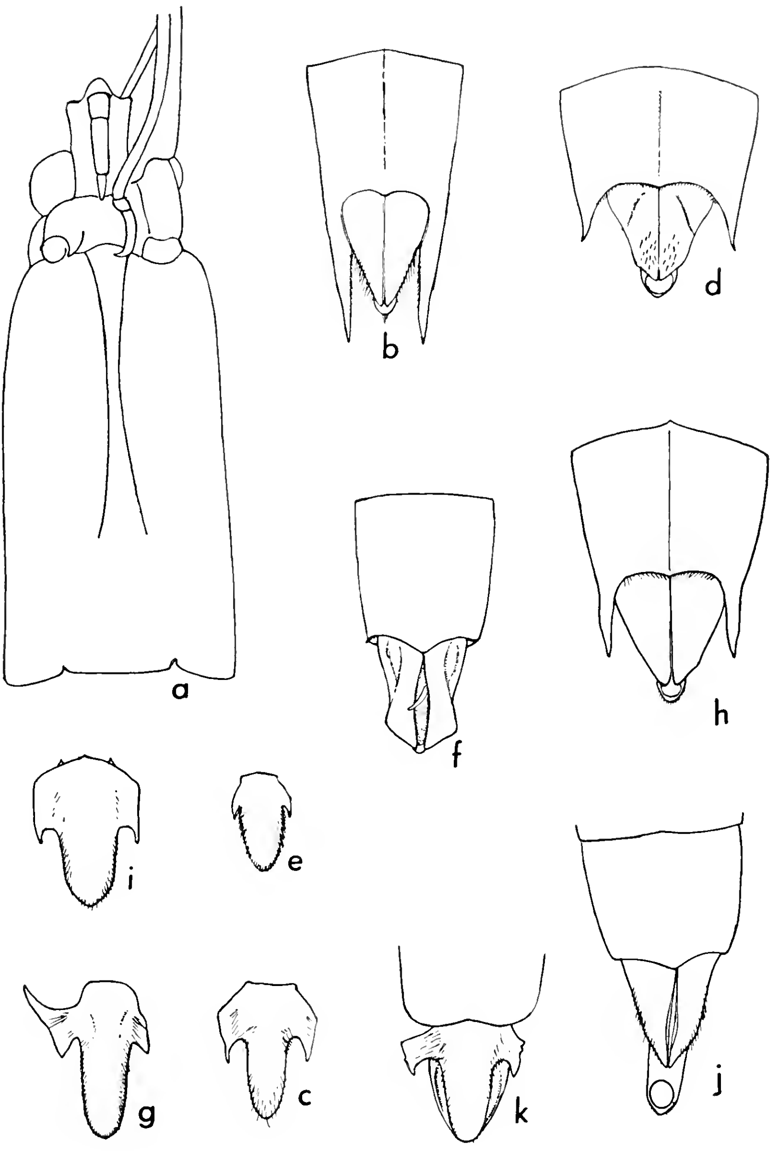
h. Ventral view of apical abdominal segments of female in *Cylindrostethus persephone* (Kirkaldy) (type, Celebes).

i. Dorsal view of suranal plate of male in *Cylindrostethus persephone* Kirkaldy (type, Celebes).

j. Ventral view of apical abdominal segments of female in *Cylindrostethus sumatranus* Lundblad (Sumatra).

k. Dorsal view of suranal plate of male in *Cylindrostethus sumatranus* Lundblad (Sumatra).

PLATE 5



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Studies of Relative Growth in Gerridae. VI. Comparison of Two Species of *Trepobates* * (Hemiptera: Insecta)

BY

RYUICHI MATSUDA

ABSTRACT: The relative growth of antennal and leg segments (as functions of the head width) between two species of *Trepobates, T. trepidus* Drake and Harris and *T. panamensis* Drake, were compared. It was found that growth ratios are greater in *T. panamensis* than in *T. trepidus* for all segments, when there is a statistically significant difference between homologous segments. Initial growth indices are greater in *T. trepidus* than in *T. panamensis* when there is a statistically significant difference between homologous segments. It was found also that there is a tendency for the segments with relatively high growth ratios to be more similar between homologous segments than the segments with relatively low growth ratios in the two species. The species-form allomorphosis in the genus *Trepobates* was studied, and the taxonomic significance of growth pattern is discussed.

In the present study the growth pattern of leg and antennal segments of two species of *Trepobates, T. trepidus* Drake and Harris and *T. panamensis* Drake are compared. The problems concerned were stated in the form of hypotheses in the first paper of this series (Matsuda, 1961a), and they are referred to whenever necessary in the discussion that follows. *T. trepidus* was collected from a small permanent pond on the campus of the Agricultural College, The University of Costa Rica, and *T. panamensis* was collected also from a population found in a small pond (ca. 6 feet square and ca. 5 feet deep) formed on the bank of the river Tiribi, San José, Costa Rica. Ten individuals of each postembryonic developmental stage from the second instar ** on (only females from the fifth stage on) were measured. The growth ratio (regression coefficient) and the initial growth index (Y-intercept) were computed. The formula used is the same as the first paper of this series, *i. e.*, $Y = bX^k$, where

* Contribution number 1116 from the Department of Entomology, The University of Kansas. This study was carried out with the aid of a grant from the National Science Foundation.

** Only six individuals of the first stage in *T. panamensis* were caught, so that the measurements of the first stage nymphs of both species are not included in calculation.

b is the initial growth index, or the value of Y when X equals unity, and k is the equilibrium constant (growth ratio, regression coefficient) by which Y (segments) grows in relation to X throughout developmental stages. In this study the head width was used as the reference size (X). Since the correlation coefficients among segments and head width throughout the developmental stages are extremely high (over 0.99 in a great majority of cases), the above formula provides reasonably good fit for the description of growth pattern of segments in relation to the head width.

For the study of species-form allomorphosis (explained later) the following species were measured, and the mean values (based on three individuals in most cases) were plotted on the graphs (Figs. 1, 3, 5, 7, 9). They were: *Trepobates floridensis* Drake and Harris, *T. inermis* Esaki, *T. knighti* Drake and Harris, *T. pictus* (Herrich-Schaeffer), *T. taylori* (Kirkaldy), *T. vazquezae* Drake and Harris.

RECOGNITION OF NYMPHS

As noted from Plates 1 and 2 the change of color pattern during the postembryonic development in the two species is similar, so that it is rather difficult to distinguish them on this basis except for adults. The best characters to separate them are the differences in lengths of middle and hind leg segments in relation to the total body length, as can easily be visualized from Figs. 5, 7 and 9. Sex becomes recognizable from the fifth stage on in both species.

RESULTS AND DISCUSSION

As noted in Table 3, the growth ratios for segments in *T. panamensis* are consistently greater than those of homologous segments in *T. trepidus,* although the differences in a few segments are not statistically significant. The initial growth indices in *T. panamensis* are, however, smaller than those of homologous segments in *T. trepidus* although the differences in a few segments are not statistically significant. These facts substantiate, to a large measure, hypothesis 1 stating that *when the growth ratio or the initial growth index varies for a segment among a group of related species, the ratio or index for other segments varies in a parallel fashion* and *hypothesis* 3 that *when the growth ratio increases the initial growth index decreases, or vice versa* at the interspecific level.

It should also be noted that there is a strong tendency for the segments with relatively high growth ratios (such as the first antennal segment, front femur, middle tibia and hind femur) to be more similar between homologous segments in the two species than the growth ratios of the segments with relatively low growth ratios (such as the fourth antennal segment, middle tarsus,* or hind tarsus), although the growth ratios of the second and third segments between the two species are rather conspicuously different despite their high growth ratios. This situation is also visualized from Fig. 11 in which the difference in the angle between two regression lines (growth lines) of homologous segments are plotted against the average slope of the regression lines. The correlation between the difference in angle and average slope is $-0.547(0.1 > P > 0.05$, very near the level of $P \leqq 0.05$). The same correlation between the two populations of *T. trepidus* (Fig. 12) is $-0.832(P0.01)$ or $r = -0.603(0.05 > P > 0.01)$ when segments are plotted against the general size factor (Matsuda and Rohlf, 1961). It can thus be said that *the tendency for the growth patterns (growth ratio or the initial growth index) of the segments with higher growth ratios to be more similar than those with lower growth ratios between the two species* (hypothesis 2) is less pronounced at the interspecific level than that between the two populations of *T. trepidus*, as far as the growth ratio is concerned. It is also interesting to point out that in some segments there is a statistically significant difference in the initial growth index (Y-intercept) when there is no statistically significant difference in growth ratio between homologous segments. The middle femur, middle tibia, hind femur are the cases in point (Figs. 7, 9). This in turn indicates that the initial growth index is more variable or less stable than the growth ratio. Because of this tendency hypothesis 2 does not hold for the initial growth index. The degree of difference in initial growth index between different levels of comparison in these segments (interspecific and interpopulations) can easily be visualized by comparing Fig. 7 with Fig. 8 and Fig. 9 with Fig. 10.

SPECIES-FORM ALLOMORPHOSIS AND TAXONOMIC SIGNIFICANCE

As noted from Figs. 1 and 5 the points representing the adults of different species of *Trepobates* more or less conform to the growth lines of corresponding segments (first antennal segment, front leg segments, and to a lesser extent second antennal segment). Between homologues of these segments in *T. trepidus* and *T. panamensis* there is no statistically significant difference in growth ratio

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* In *T. knighti* the middle tarsus, as in *T. trepidus*, is smallest among middle leg segments (Matsuda, 1960). A high growth ratio of this segment in *T. panamensis* is rather abnormal. When computed for the whole developmental stages the growth ratio of this segment in *T. panamensis* it is probably smaller than that of the femur as in the other two species.

and initial growth index except for the second antennal segment. These facts reflect the presence of similar growth patterns for these segments (both in growth ratio and initial growth index) in all species of *Trepobates.*

The points for the middle femur, hind femur and middle tibia * (Figs. 7. 9) in adults of different species tend to fall nearly vertically, in spite of the fact that there are no statistically significant differences in growth ratio between homologous segments in the two species compared. These nearly vertical allomorphic slopes (slopes represented by regression lines for points of adults of different species) probably results primarily from significant differences in the initial growth index between homologous segments among species, as significant differences in the initial growth index for these segments between *T. trepidus* and *T. panamensis* suggest.

In all other segments the points for adults of different species also do not conform to the growth lines. This is due probably to significant differences in growth ratios among different species, as the differences in growth ratios and their initial growth indices between *T. trepidus* and *T. panamensis* indicate.

The above-mentioned facts in turn suggest that the growth patterns of the first antennal segment and front leg segments are probably highly constant generically. The growth pattern of other segments are apparently variable either in the initial growth index or in both initial growth index and growth ratio. It should be emphasized that the initial growth index is really of biological significance only when the growth ratios of segments remain similar among comparable species, as indicated in the middle femur, middle tibia and hind femur in this genus. Situations similar to this were already observed in antennal segments in the species of *Limnogonus* (Matsuda, 1961a) and certain leg and antennal segments in *Eurygerris* (Matsuda, 1961b). A number of cases, in which the initial growth index alone is different while the growth ratio remaining the same, are known in other groups of animals.** It appears that the initial growth index is often subject to variation while the growth ratio remains similar or the same among related forms, hence it is generally of taxonomic significance at lower taxonomic levels than is the growth ratio.

* There is no statistical significance in growth ratio of this segment between *T. trepidus* and *T. panamensis* if the measurements at the first stage nymphs are included in calculation.

** *e. g.*, between local forms in a moluscan species, *Littorina sitchana* (Nomura, 1926), or between different species of crustaceans, *Maia squinado* and *Maia verrucosa* (Teissier, 1937).

ACKNOWLEDGMENTS

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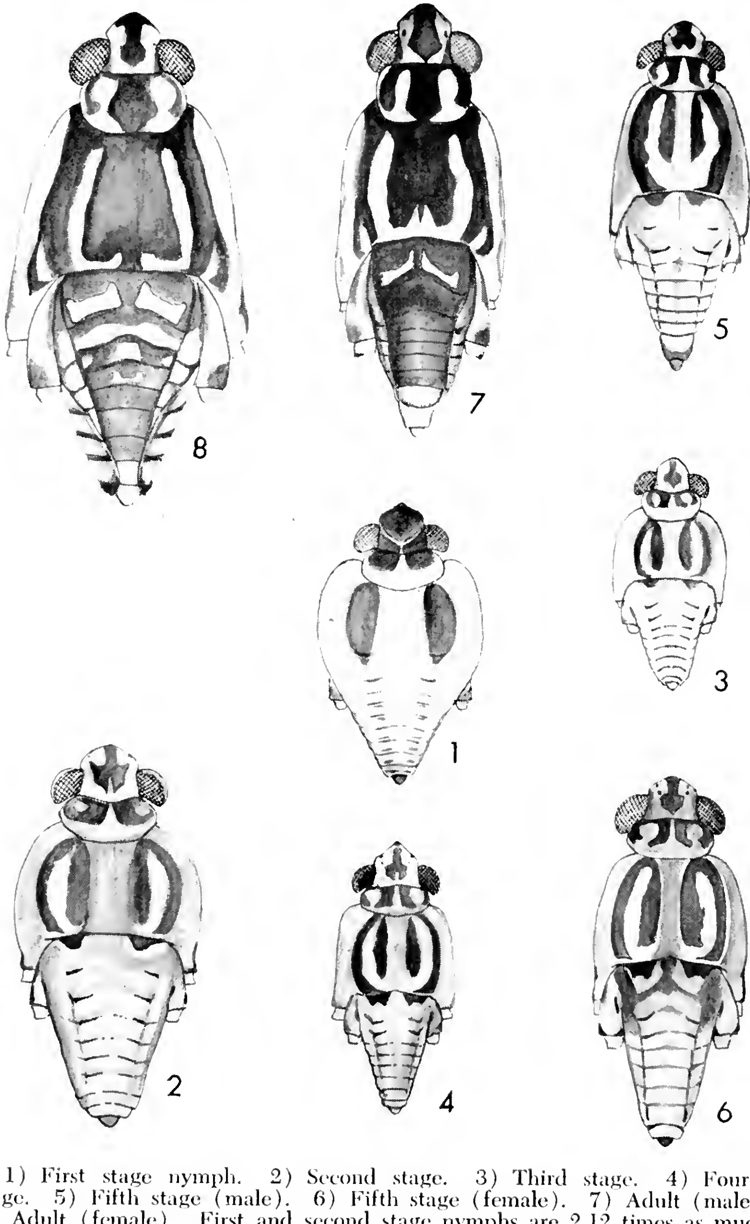
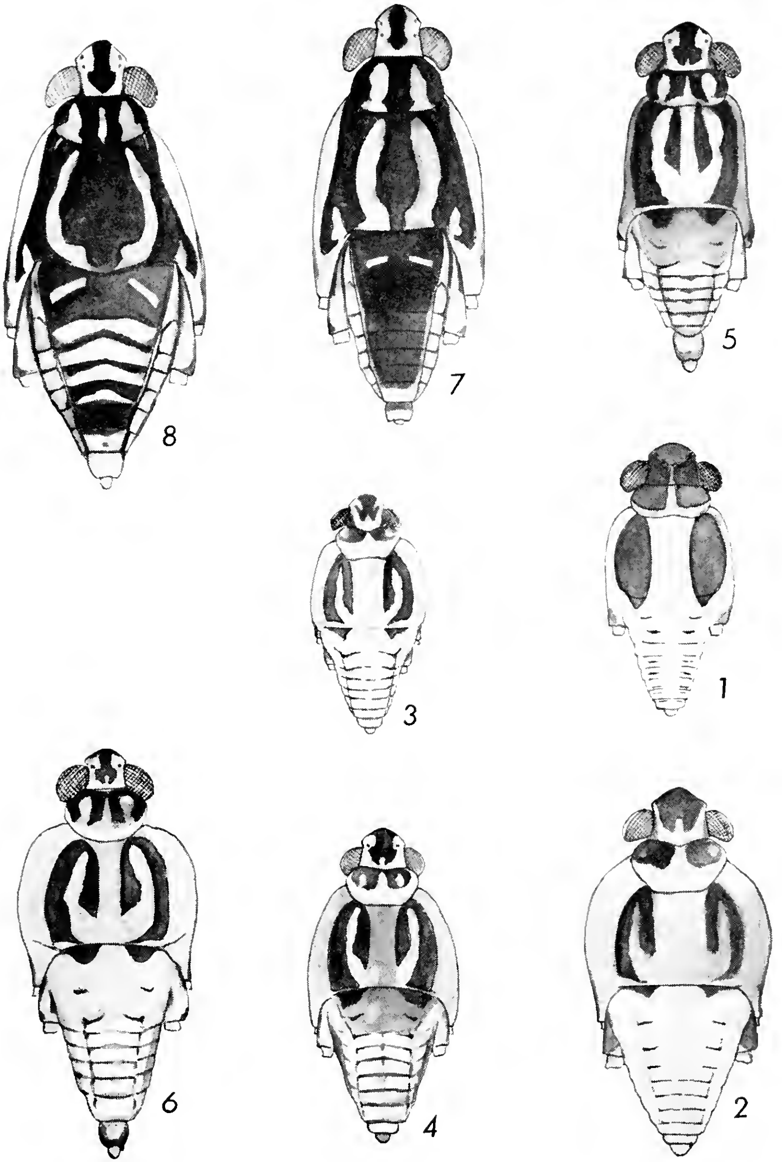
Plate 1. *Trepobates trepidus* Drake and Harris.

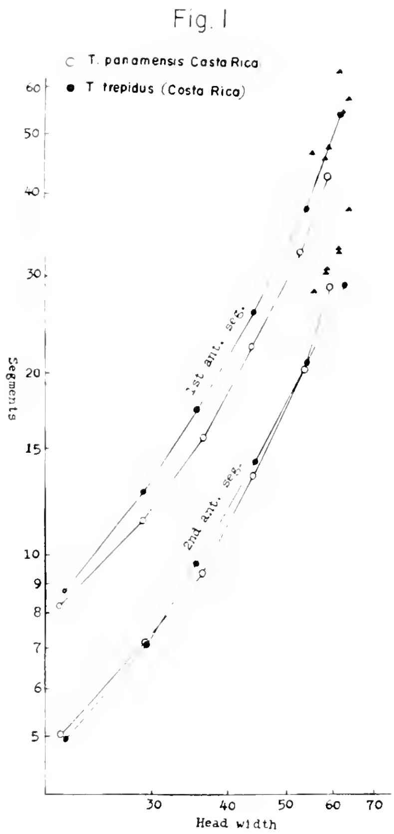


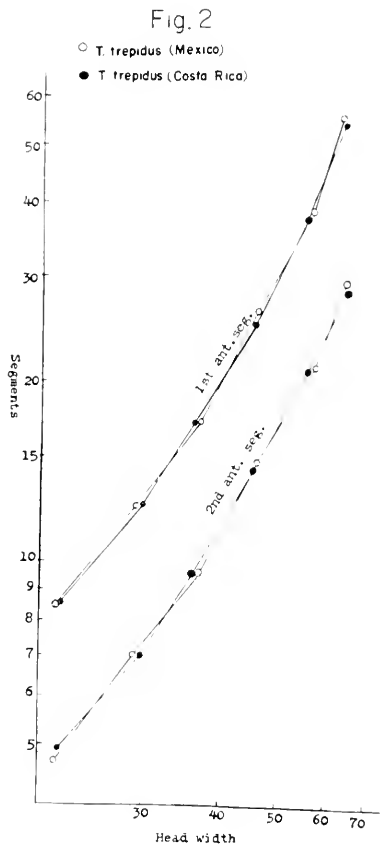
1) First stage nymph. 2) Second stage. 3) Third stage. 4) Fourth stage. 5) Fifth stage (male). 6) Fifth stage (female). 7) Adult (male). 8) Adult (female). First and second stage nymphs are 2.12 times as much magnified as the rest.

Plate 2. *Trepobates panamensis* Drake.

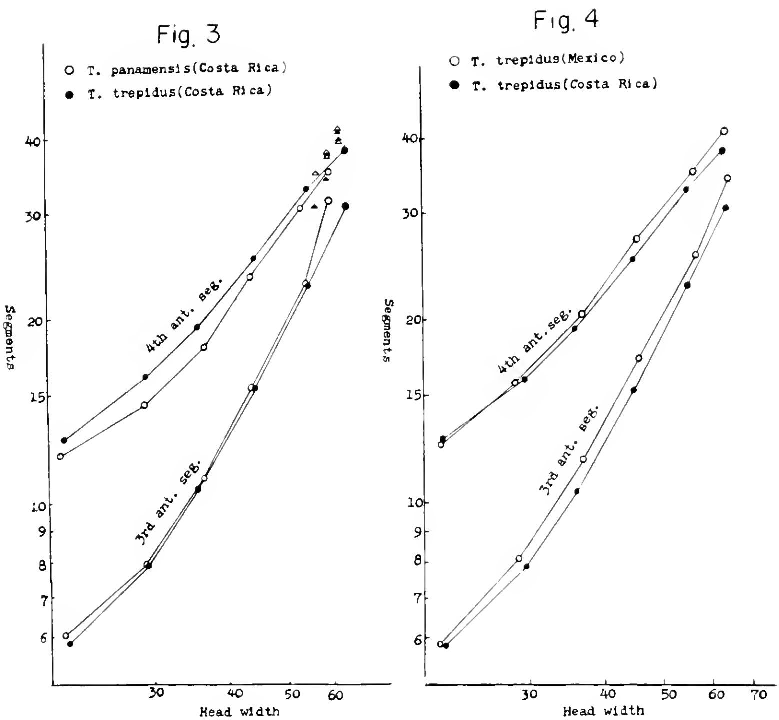


1) First stage nymph. 2) Second stage. 3) Third stage. 4) Fourth stage. 5) Fifth stage (male). 6) Fifth stage (female). 7) Adult (male). 8) Adult (female). First and second stage nymphs are 2.12 times as much magnified as the rest.

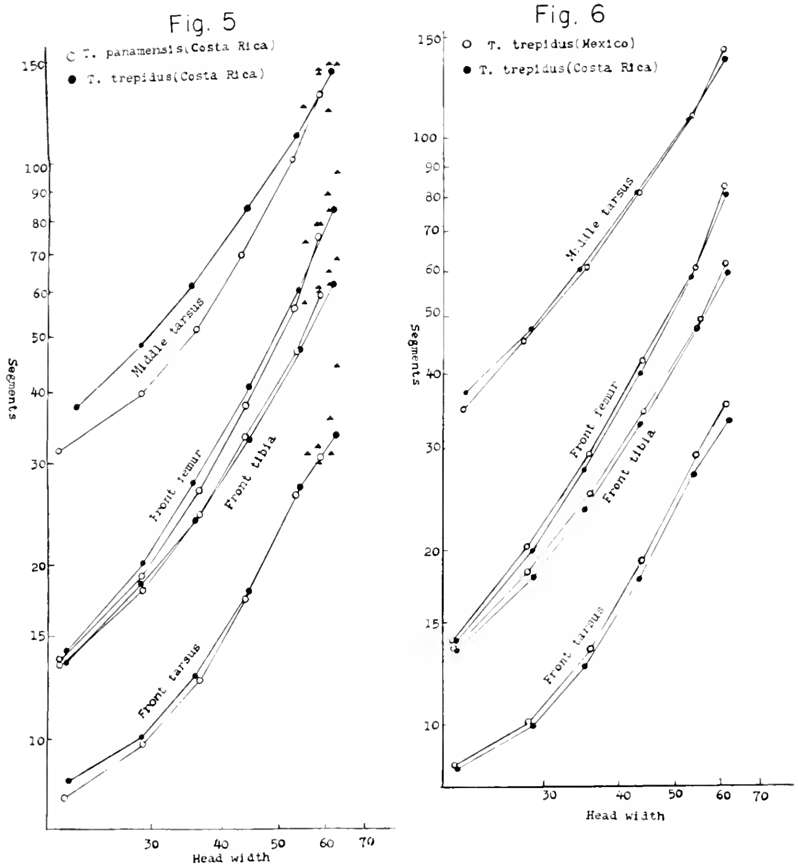




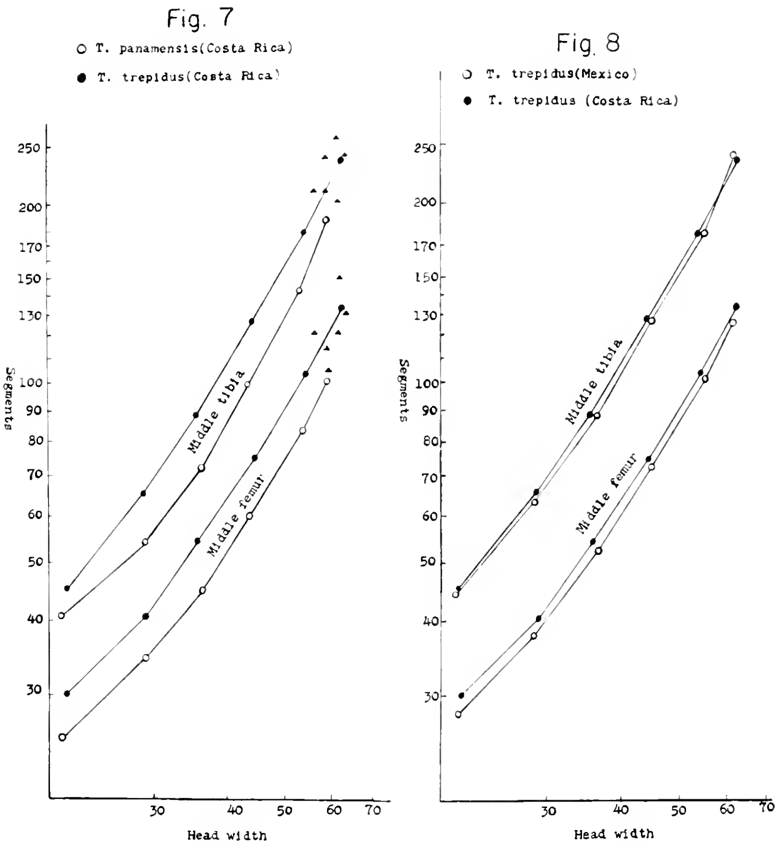
FIGS. 1 and 2. Circles connected by lines represent mean values at each developmental stage. Triangles are adults of different species.



Figs. 3 and 4. Circles connected by lines represent mean values at each developmental stage. Empty triangles are fourth segments and solid triangles are third segments in adults of different species respectively.



FIGS. 5 and 6. Circles connected by lines represent mean values at each developmental stage. Triangles represent adults in different species.



FIGS. 7 and 8. Circles connected by lines represent mean values at each developmental stage. Triangles are adults in different species.

Fig. 9

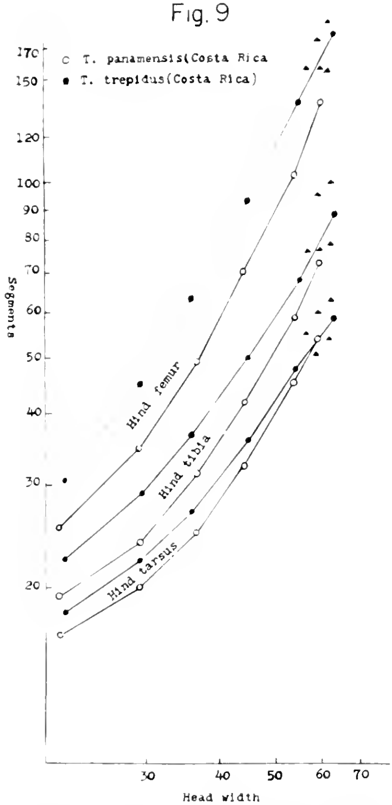
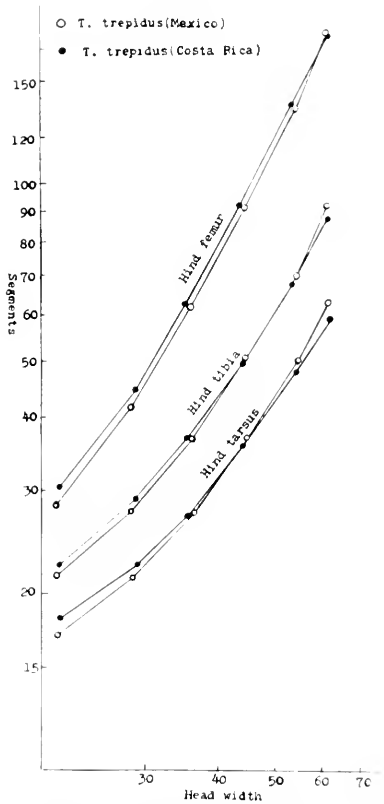


Fig. 10



FIGS. 9 and 10. Circles connected by lines represent mean values at each developmental stage. Triangles are adults in different species.

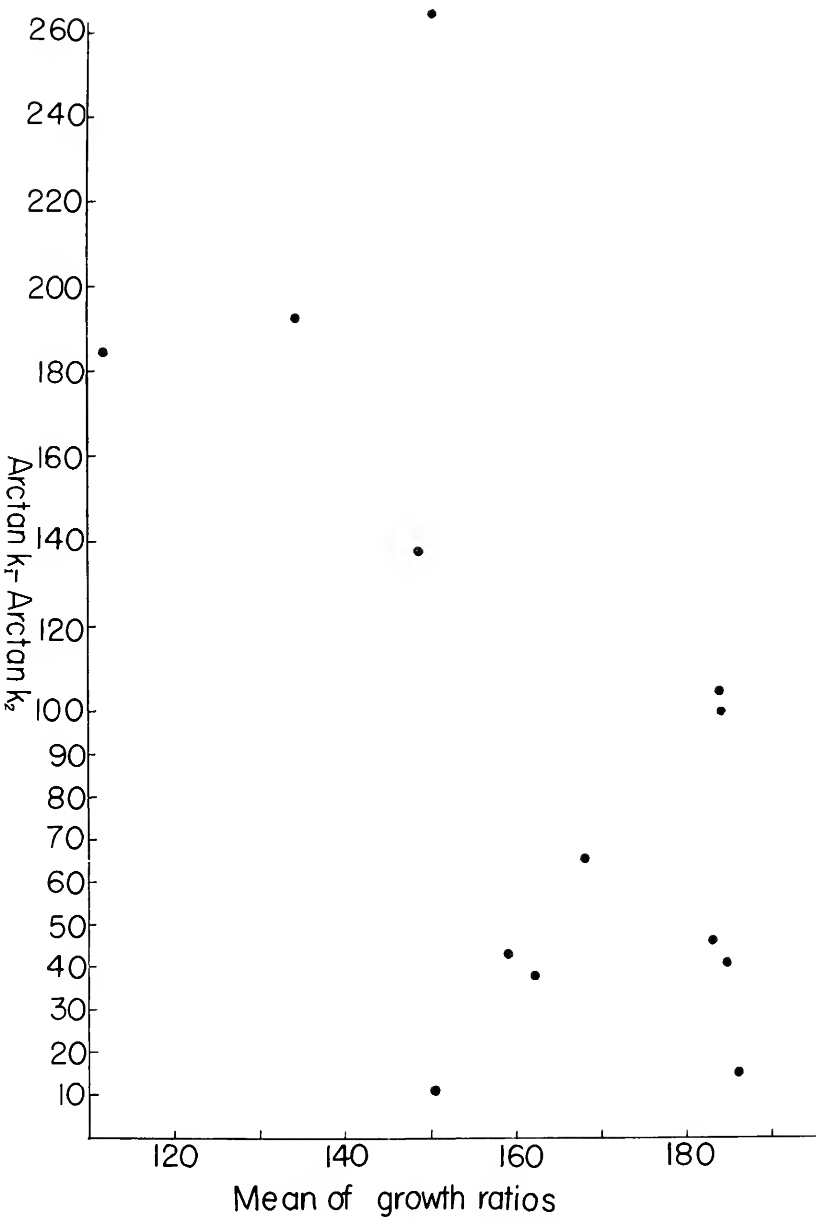


Fig. 11. Scatter diagram of 13 segments plotted as their average growth ratio in the two species (*T. trepidus* and *T. panamensis*) against the angle between their regression lines in the two species.

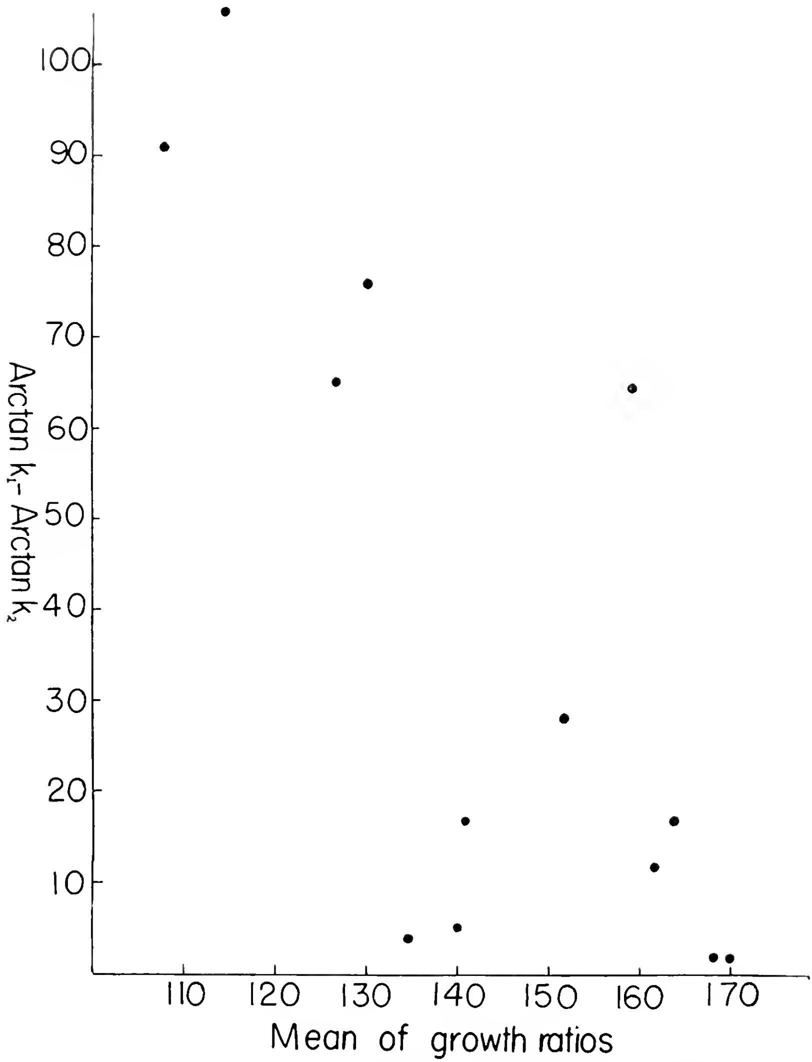


Fig. 12. Scatter diagram of 13 segments plotted as their average growth ratio in the two populations (*T. trepidus*) against the angle between their regression lines in the two populations. The growth ratios were calculated for all development stages.

TABLE 1.—Measurements of head width, leg and antennal segments
Trepobates panamensis Drake

	First stage	Second stage	Third stage	Fourth stage	Fifth stage	Adult
Head width	20.5–22.0 (21.07)	27.5–30.0 (29.10)	35.0–38.0 (36.40)	42.0–46.0 (43.70)	51.5–56.0 (53.19)	56.5–61.0 (59.35)
First antennal segment	7.8–8.5 (8.21)	11.5–12.0 (11.69)	15.0–16.0 (15.40)	21.5–22.0 (21.85)	30.5–32.0 (31.37)	40.0–44.5 (42.15)
Second antennal segment	4.7–5.5 (5.06)	6.7–7.2 (6.97)	9.0–9.5 (9.25)	13.0–14.2 (13.57)	19.5–20.5 (20.08)	26.0–29.0 (27.65)
Third antennal segment	5.3–6.3 (6.03)	7.5–8.2 (7.86)	10.5–11.5 (10.80)	15.0–16.0 (15.20)	22.0–24.0 (22.87)	29.0–32.5 (31.25)
Fourth antennal segment	11.5–12.5 (11.83)	13.7–14.8 (14.27)	17.0–18.5 (17.85)	22.0–24.0 (23.25)	28.5–31.0 (30.00)	32.0–39.0 (34.65)
Front femur	13.0–14.2 (13.67)	18.5–19.5 (19.10)	26.0–27.0 (26.70)	36.0–39.0 (37.45)	53.5–58.0 (55.00)	69.0–77.0 (73.70)
Front tibia	13.0–14.2 (13.50)	18.0–19.0 (18.40)	24.0–25.5 (24.30)	32.0–34.5 (33.00)	45.0–47.5 (46.00)	55.0–60.0 (58.00)
Front tarsus	7.8–8.2 (8.00)	9.2–10.0 (9.74)	12.5–13.0 (12.65)	17.0–18.0 (17.40)	24.5–28.0 (25.92)	29.0–32.0 (30.65)
Middle femur	24.0–26.0 (25.42)	33.0–36.0 (34.30)	44.0–46.0 (45.00)	58.0–61.0 (59.80)	80.0–86.0 (83.75)	94.0–104.0 (100.60)
Middle tibia	40.0–42.0 (40.85)	51.5–57.0 (53.90)	69.0–74.0 (72.30)	94.0–102.0 (99.00)	137.0–150.0 (143.60)	180.0–196.0 (189.50)
Middle tarsus	31.0–32.5 (31.79)	38.0–41.0 (39.70)	49.0–53.0 (50.85)	65.0–70.0 (68.35)	96.0–102.0 (99.50)	115.0–136.0 (128.20)
Hind femur	24.0–26.0 (25.00)	34.0–36.0 (34.85)	48.0–50.0 (48.85)	67.0–72.0 (68.95)	98.0–105.0 (101.87)	126.0–145.0 (136.40)
Hind tibia	19.0–20.0 (19.35)	22.0–25.0 (23.87)	30.0–32.0 (31.25)	41.0–43.0 (41.80)	56.0–60.0 (58.12)	68.0–76.0 (73.10)
Hind tarsus	16.5–17.0 (16.74)	19.5–21.0 (20.00)	23.5–26.0 (21.90)	31.0–33.0 (32.00)	43.5–48.0 (45.90)	47.0–59.0 (54.30)

60 units equal 1 mm. Values in parentheses are mean values.

TABLE 2.—Measurements of head width, leg and antennal segments
Trepobates trepidus (San Jose, Costa Rica)

	First stage	Second stage	Third stage	Fourth stage	Fifth stage	Adult
Head width	21.0–22.0 (21.52)	28.5–30.0 (29.10)	35.0–37.0 (35.70)	43.0–47.0 (44.55)	53.0–55.0 (54.40)	60.0–65.0 (63.05)
First antennal segment	8.5–9.0 (8.57)	12.0–13.0 (12.52)	17.0–18.0 (17.25)	24.0–26.0 (25.00)	36.0–38.0 (37.20)	51.0–57.0 (52.80)
Second antennal segment	4.5–5.5 (4.93)	7.0–7.5 (7.05)	9.5–10.0 (9.60)	14.0–15.0 (14.10)	20.0–21.0 (20.60)	27.0–29.0 (27.90)
Third antennal segment	5.5–6.0 (5.84)	7.5–8.0 (7.77)	10.0–11.0 (10.40)	15.0–16.0 (15.10)	22.0–23.0 (22.70)	29.5–31.0 (30.45)
Fourth antennal segment	12.0–13.0 (12.57)	15.5–16.0 (15.85)	19.0–20.0 (19.45)	23.0–26.0 (25.05)	31.0–33.5 (32.60)	37.0–40.0 (37.75)
Front femur	13.5–14.3 (14.00)	19.5–20.0 (19.90)	26.5–29.0 (27.70)	40.0–42.0 (40.60)	56.0–61.0 (59.10)	80.0–85.0 (81.90)
Front tibia	13.0–14.0 (13.53)	17.5–18.5 (18.00)	23.0–24.0 (23.40)	31.0–35.0 (32.90)	45.0–49.0 (46.90)	58.0–63.0 (60.70)
Front tarsus	8.0–8.8 (8.43)	10.0–10.2 (10.04)	12.5–13.0 (12.70)	17.5–18.0 (17.85)	26.0–28.0 (27.20)	32.0–35.0 (33.50)
Middle femur	30.0–31.0 (30.10)	40.0–41.0 (40.30)	54.0–56.0 (54.90)	71.0–77.0 (75.10)	100.0–106.0 (103.10)	129.0–139.0 (133.60)
Middle tibia	47.0–49.0 (47.80)	64.5–67.5 (65.95)	84.0–90.0 (88.60)	123.0–131.0 (126.80)	173.0–183.0 (178.50)	224.0–250.0 (237.60)
Middle tarsus	36.0–39.0 (37.25)	46.0–49.0 (47.90)	59.0–65.0 (62.70)	80.0–87.0 (81.80)	106.0–115.0 (109.40)	129.0–146.0 (140.50)
Hind femur	30.0–31.0 (30.55)	43.5–46.0 (44.45)	61.0–64.0 (62.70)	90.0–95.0 (92.40)	132.0–140.0 (136.20)	180.0–202.0 (189.10)
Hind tibia	21.5–23.0 (22.40)	28.0–29.5 (28.90)	35.0–39.0 (36.70)	48.0–52.0 (49.65)	66.0–70.0 (67.50)	82.0–94.0 (87.50)
Hind tarsus	17.5–19.0 (18.18)	22.0–23.0 (22.35)	26.0–28.0 (26.95)	35.0–38.0 (35.90)	46.0–50.0 (47.70)	55.0–60.0 (58.80)

60 units equal 1 mm. Values in parentheses are mean values.

TABLE 3.—Comparison of growth patterns

	T. panamensis	*T. trepidus*	Significance level	Q=Arctan k_1-Arctan k_2
		Growth ratio (k)		
1st ant. seg.	1.886	1.833	$0.5>P>0.1$	41′
2nd ant. seg.	1.905	1.772	$P<0.01$	100′
3rd ant. seg.	1.900	1.768	$P<0.01$	102′
4th ant. seg.	1.254	1.114	$P<0.01$	151′
Front femur	1.856	1.802	$0.5>P>0.1$	46′
Front tibia	1.601	1.577	$P>0.5$	43′
Front tarsus	1.640	1.600	$0.5>P>0.1$	38′
Middle femur	1.510	1.500	$P>0.5$	11′
Middle tibia	1.718	1.646	$0.5>P>0.1$	65′
Middle tarsus	1.628	1.378	$P<0.01$	264′
Hind femur	1.870	1.851	$P>0.5$	15′
Hind tibia	1.522	1.423	$P<0.01$	138′
Hind tarsus	1.420	1.264	$P<0.01$	192′
		Initial growth index (b)		
1st ant. seg.	−1.735	−1.601	$0.5>P>0.1$	
2nd ant. seg.	−1.972	−1.758	$P<0.01$	
3rd ant. seg.	−1.885	−1.714	$P<0.01$	
4th ant. seg.	−0.689	−0.488	$P<0.01$	
Front femur	−1.452	−1.348	$0.5>P>0.1$	
Front tibia	−1.095	−1.067	$P>0.5$	
Front tarsus	−1.430	−1.361	$0.5>P>0.1$	
Middle femur	−0.686	−0.578	$0.05>P>0.02$	
Middle tibia	−0.800	−0.599	$P<0.01$	
Middle tarsus	−0.808	−0.348	$P<0.01$	
Hind femur	−1.211	−1.072	$P<0.01$	
Hind tibia	−0.909	−0.718	$P<0.01$	
Hind tarsus	−0.797	−0.517	$P<0.01$	

Q is the angle between the two regression lines expressed in minutes of a degree (k_1 for *T. panamensis*, k_2 for *T. trepidus*).

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Catalogue of the Types in the Snow Entomological Museum. Part III (Diptera)

BY

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ABSTRACT: Types of 1,380 species and subspecies of Diptera are catalogued, with references to original description (except for species represented by paratypes only), number and condition of specimens, and type numbers as recorded in the catalogue of types in the Snow Entomological Museum.

INTRODUCTION

Many distinguished students of Diptera have been associated with the Snow Entomological Museum, either directly, as students or curatorial staff, or indirectly, as specialists making extensive use of this collection. As a result, the number of species of Diptera represented in the Snow Museum by types probably exceeds that of any other order of insects. This part of the catalogue lists 1,380 species and subspecies.

Among staff members of the University of Kansas who contributed to the early growth of the Diptera collection were Dr. Francis H. Snow, who established the museum, Dr. S. W. Williston, Dr. W. A. Snow (son of the founder) and Dr. C. P. Alexander. Students of Diptera at the University of Kansas who later were close associates of the museum include C. F. Adams, J. M. Aldrich, J. M. Brennan, C. H. Curran, D. E. Hardy, C. H. Martin and E. S. Tucker. Outstanding dipterologists at other institutions, who have included materials from the museum in their studies and have therefore deposited certain type specimens in the Snow collection, include H. R. Dodge, C. L. Fluke, F. C. Harmston, L. Haseman, F. M. Hull, M. T. James, R. H. Painter, C. B. Philip, H. J. Reinhard, C. W. Sabrosky and M. C. Van Duzee. We are indebted to many of these

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specialists for assistance in compiling information about the types of species described by them. This list is by no means complete but names the major contributors to the collection of types presented hereinafter.

One important acquisition by the Snow Museum was the collection of North American Diptera made by Dr. C. H. T. Townsend during the years before 1894. This purchase was briefly discussed by Professor Williston in a note in Entomological News, vol. 5, p. 186, in 1894. Through exchanges, representative types of several species described by the following authors have been placed in the Snow Museum: F. W. Edwards, C. W. Johnson, A. L. Melander and C. R. Osten Sacken.

In the list of type specimens that follows, the families are arranged alphabetically. Certain family names based on genera proposed by Meigen in 1800 (Nouvelle classification des mouches à deux ailes, [Diptera L.], d'apres un plan tout nouveau) are not used. Beneath the family headings, types are arranged in two separate lists. The first of these includes holotypes, allotypes, syntypes and lectotypes, as well as paratypes if these are present in addition. This list contains references to the original description of each species and to the designation of lectotypes, where applicable. The second list includes species represented in the Snow collection by paratypes only and omits literature references. Both lists indicate the sex of types (except in case of large series including both sexes, where the total number only is given) and their condition, if seriously damaged. The type number from the Catalogue of Types in the Snow Entomological Museum is given for each species.

Secondary types, such as homotypes, metatypes and plesiotypes, are not included in this catalogue. Furthermore, only those type specimens of available species actually present in the museum as of 1960 are included. In some cases an original description indicated one or more types were deposited in the Snow Museum, whereas none—or a lesser number than that indicated—was actually found in the collection. On the other hand, an author may have stated that certain types were deposited in another museum, while in fact they were placed in the Snow Museum. No attempt has been made to rectify these inconsistencies.

Names of species appear in alphabetical order in the appropriate family list. Only original combinations of generic and specific names have been used, as it would be impracticable to attempt to give the current generic assignment or synonymic status of every species. There are certain exceptions to this rule, however. If a syntype or paratype of a species is later made a part of the type series of another species, this is noted. Also, the spelling used in the original description has, in some instances, been regarded as incorrect; in such cases, the supposedly correct spelling (usually of a generic name) is used and the actual spelling indicated in a note after the species' entry. Family assignment has, in rare cases, been altered from the original, to conform to the assignment currently recognized by appropriate authorities. In some families, the entry for sex of a type or types has been queried: (?). This is because the original description of the species did not state the sex, and it cannot easily be determined. In such cases, we have made a tentative judgment and marked it questionable. Occasionally, we have determined the sex of a type to be different from that indicated by the author, such action being appropriately noted.

ACKNOWLEDGMENTS

In addition to expressing thanks to the specialists on Diptera mentioned above, for their kind co-operation, we wish to thank the University of Kansas for providing from its General Research Fund financial support which has made possible the completion of this catalogue.

ACROCERIDAE

Acrocera hungerfordi Sabrosky, 1944, Amer. Midl. Nat., vol. 31, no. 2, pp. 406-407. ♀ holotype, 1 ♂ paratype. 3527.

Acrocera liturata Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 294. ♂ holotype. 101.

Acrocera steyskali Sabrosky, 1944, Amer. Midl. Nat., vol. 31, no. 2, pp. 401-403. ♂ holotype, 1 ♀ paratype. 3526.

Pterodontia notomaculata Sabrosky, 1948, Amer. Midl. Nat., vol. 39, no. 2, pp. 393-394. ♂ holotype, 4 ♂ paratypes. 3804.

ACROCERIDAE—Paratypes

Ogcodes marginatus Cole. 2 ♂. 5548.

AGROMYZIDAE

Agromyza lateralis Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 428. 1 ♀ syntype (= lectotype of *Phytobia allecta* Melander). 723.

Phytobia allecta Melander—see *Agromyza lateralis* Williston.

AGROMYZIDAE—Paratypes

Agromyza sorosis Williston. 1 ♀ lectoparatype. 724.

Liriomyza hawaiiensis Frick. 3 ♀. 5141.

Liriomyza minutiseta Frick. 1 ♀. 5143.

Melanagromyza splendida Frick. 2 ♂. 5142.

Phytobia ambrosiae Frick. 1 ♂. 5530.

Phytoliriomyza montana Frick. 1 ♂, 1 ♀. 5145.

ANTHOMYIIDAE

Caricea flavipes Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 206. 2 ♀ syntypes. 732.

Caricea multimaculata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 205. 3 ♂, 1 ♀ syntypes. 731.

Caricea sexnotata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 205. 1 ♀ syntype. 730.

Chortophila linearis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 206. 167 ♂ and ♀ syntypes. 744.

Coenosia lineata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 208. 1 ♀ syntype. 756.

Coenosia valida Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 207. 6 broken syntypes, sex unkown. 775.

Helina cruciata Snyder, 1941, Amer. Mus. Novit. No. 1134, p. 9. ♀ holotype. 3351.

Hydrophoria tarsata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 206-207. 1 ♂ syntype. 776.

Spilogaster latifrons Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 204-205. 2 ♂ and 1 broken syntypes. 729.

Spilogaster quadriseta Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 203-204. 1 ♂, 7 ♀ syntypes. 728.

ANTHOMYIIDAE—Paratypes

Fannia enotahensis Seago. 1 ♂, 1 ♀. 1352.

Hylemyia (Delia) setifirma Huckett. 1 ♀. 4495.

Hylemyia (Botanophila) subspinata Huckett, 1 ♂, 1 ♀. 3652.

Hylemyia (Phorbia) conicans Huckett. 3 ♂, 1 ♀. 3821.

APIOCERIDAE

Apiocera beameri Painter, 1936 (1938), Univ. Kans. Sci. Bull., vol. 24, no. 12, pp. 198-199. ♂ holotype, ♀ allotype. 5531.

Apiocera bilineata Painter, 1932, Ann. Ent. Soc. Amer., vol. 25, no. 2, pp. 351-352. ♂ holotype, ♀ allotype, 1 ♀ paratype. 3713.

Apiocera martinorum Painter, 1936 (1938), Univ. Kans. Sci. Bull., vol. 24, no. 12, pp. 197-198. ♂ holotype, ♀ allotype, 50 ♂ and ♀ paratypes. 5532.

Apiocera notata Painter, 1936 (1938), Univ. Kans. Sci. Bull., vol. 24, no. 12, pp. 199-200. ♂ holotype, ♀ allotype, 1 ♂ paratype. 5534.

Rhaphiomidas mellifex Townsend, 1895, Proc. Cal. Acad. Sci., series 2, vol. 4, p. 604. 1 ♀ lectotype, 1 ♀ lectoparatype, Cazier, 1941, Amer. Midl. Nat., vol. 25, p. 619. 147.

Rhaphiomidas xanthos Townsend, 1895, Proc. Cal. Acad. Sci., series 2, vol. 4, p. 606. 1 ♂ lectotype, 2 ♂ lectoparatypes, Cazier, 1941, Amer. Midl. Nat., vol. 25, p. 619. 148.

APIOCERIDAE—Paratypes

Apiocera aldrichi Painter. 1 ♂. 2039.

Apiocera interrupta Painter. 2 ♀. 5533.

Rhaphiomidas parkeri Cazier. 1 ♂. 3044.

ASILIDAE

Andrenosoma chalybea Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 56. ♀ holotype. 180.

Apachekolos confusio Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, pp. 354-355. ♀ allotype. 5758.

Aphamartania fur Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, pp. 53-54. ♂ holotype. 173.

Asilus (Neoitamus) affinis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 73-74. ♂ holotype. 212.

Asilus angustifrons Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 71-72. 1 ♂ syntype. 216.

Asilus (Stenoprosopus) arizonensis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 76. ♀ holotype. 209.

Asilus astutus Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 70. 1 ♂ syntype. 217.

Asilus (Neoitamus) distinctus Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 73. 1 ♂, 1 ♀ syntypes. 5483.

Asilus (Rhadiurgus) leucopogon Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 75-76. 2 ♂ syntypes and 1 with broken abdomen. 208.

Asilus (Tolmerus) callidus Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 75. 1 ♂ syntype. 214.

Atomosia (Atractia) mikii Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, pp. 290-291. ♂ (?) holotype. 178.

Beameromyia chrysops Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, pp. 356-357. ♂ holotype, ♀ allotype, 13 ♂, 18 ♀, and 1 broken paratypes. 5651.

Beameromyia kawiensis Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, p. 358. ♂ holotype, ♀ allotype. 5757.

Beameromyia lacinia Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, pp. 358-359. ♂ holotype, ♀ allotype, 27 ♂, 24 ♀ paratypes. 5650.

Beameromyia macula Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, p. 360. ♂ holotype, ♀ allotype, 2 ♂, 2 ♀ paratypes. 5652.

Beameromyia prairiensis Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, p. 361. ♂ holotype, ♀ allotype. 5756.

Beameromyia punicea Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, p. 362. ♂ holotype, ♀ allotype, 6 ♂, 10 ♀, and 1 broken paratypes. 5653.

Bombomima nigella Bromley, 1934, Ann. Ent. Soc. Amer., vol. 27, no. 1, p. 93. ♂ holotype. 3825.

Bromleyus flavidorsus Hardy, 1944, Canad. Ent., vol. 76, no. 11, pp. 226-227. ♀ holotype. 5537.

Cerotainiops kernae Martin, 1959, Jour. Kans. Ent. Soc., vol. 32, no. 2, p. 52. ♀ holotype. 6079.

Cerotainiops lucyi Martin, 1959, Jour. Kans. Ent. Soc., vol. 32, no. 2, pp. 50-51. ♂ holotype, ♀ allotype, 1 ♀ paratype. 6080.

Cyrtopogon beameri Wilcox & Martin, 1936, Ent. Americana, vol. 16, no. 1, pp. 84-85. ♂ holotype, ♀ allotype, 1 ♂, 5 ♀ paratypes. 2242.

Cyrtopogon dasyllis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 66-67. 4 ♂ syntypes. 158.

Cyrtopogon dubius Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, pp. 13-14. ♀ holotype. 159.

Cyrtopogon gibber Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 14. ♀ holotype. 160. Originally published with genus queried.

Cyrtopogon praepes Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 12. 2 ♂, 2 ♀ syntypes. 162.

Daulopogon terricola Johnson, 1900, Ent. News, vol. 11, no. 1, p. 326. 2 ♂, 1 ♀ syntypes (1 ♀ missing head). 168.

Deromyia perplexa Back, 1909, Trans. Amer. Ent. Soc., vol. 35, no. 9, p. 360. 1 ♀ syntype. 172.

Dioctria (Neodioctria) albicornis Wilcox & Martin, 1941, Ent. Americana, vol. 21, no. 1, pp. 7-8. ♂ holotype, ♀ allotype. 3081.

Dioctria (Eudioctria) beameri Wilcox & Martin, 1941, Ent. Americana, vol. 21, no. 1, pp. 13-15. ♂ holotype, ♀ allotype, 1 ♂, 4 ♀ paratypes. 3080.

Dioctria nitida Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 8. 1 ♂, 3 ♀ syntypes. 154.

Dioctria sackeni Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, pp. 8-9. 3 ♂ syntypes (1 with abdomen missing). 155.

Erax benedicti Bromley, 1940, Bull. Brooklyn Ent. Soc., vol. 35, no. 1, pp. 15-16. ♂ holotype, ♀ allotype, 15 ♀ paratypes. 5536.

Erax cuervanus Hardy, 1943, Jour. Kans. Ent. Soc., vol. 16, no. 1, p. 27. ♂ holotype, ♀ allotype, 1 ♂, 5 ♀ paratypes. 5539.

Erax dubius Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, pp. 64, 68. ♂ holotype. 182.

Erax jubatus Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, pp. 66-67. 1 ♂, 1 ♀ syntypes. 183.

Erax latrunculus Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 67. 2 ♂, 1 ♀ syntypes. 184.

Erax leucocomus Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, pp. 69-70. 1 ♂, 1 ♀ syntypes. 185.

Erax plenus Hine, 1916, Ohio Jour. Sci., vol. 17, p. 21. ♂ holotype, 6 ♀ paratypes. (All specimens labeled "cotype" but ♂ listed as type by Hine.) 2080.

Erax similis Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 68. 2 ♀ syntypes. 186.

Erax stamineus Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 68. 1 ♂ syntype. 187.

Erax subaridus Bromley, 1940, Bull. Brooklyn Ent. Soc., vol. 35, no. 1, pp. 14-15. ♂ holotype, ♀ allotype, 8 ♂, 16 ♀ paratypes. 5540.

Erax varipes Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 71. 1 ♂ syntype. 188.

Erax vertebratus Bromley, 1940, Bull. Brooklyn Ent. Soc., vol. 35, no. 1, p. 14. ♂ holotype, ♀ allotype, 1 ♂, 1 ♀ paratypes. 5541.

Hodophylax aridus James, 1933, Amer. Mus. Novit. No. 596, p. 2. ♂ allotype. 3822.

Holopogon snowi Back, 1909, Trans. Amer. Ent. Soc., vol. 35, pp. 316-317. ♀ lectotype, 1 ♀ lectoparatype and 1 ♂ allotype by subsequent designation, Martin, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 2, pp. 35-36. 169.

Holopogon texanus Bromley, 1934, Ann. Ent. Soc. Amer., vol. 27, no. 1, pp. 89-90. ♀ holotype, ♂ allotype. 3823.

Hyperechia atrox Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 28. ♀ holotype. 179.

Laphria anthrax Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 29. ♀ holotype. 190. Homonym of *L. anthrax* Meigen 1829; renamed *L. carbonarius* by Williston, Kans. Univ. Quart., vol. 4, p. 181 (1896).

Laphria canis Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 31. 1 ♂, 1 ♀ syntypes. 189.

Laphria carbonarius (see *Laphria anthrax*).

Laphria ferox Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, pp. 29-30. 2 ♀ syntypes. 191.

Laphria pubescens Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 32. 1 ♂, 2 ♀ syntypes. 192.

Laphria ruficauda Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 55. ♀ holotype. 193.

Laphria ventralis Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 55. ♀ holotype. 194.

Laphria vivax Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 30. ♂ holotype. 195.

Laphria xanthippe Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, pp. 31-32. 2 ♀ syntypes. 196.

Leptogaster altacola Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, p. 373. ♀ allotype, 7 ♂, 6 ♀ paratypes. 5657.

Leptogaster bifidus Hardy, 1942, Jour. Kans. Ent. Soc., vol. 15, no. 2, pp. 59-61. ♂ holotype, ♀ allotype, 4 ♂, 6 ♀ paratypes and 1 paratype with broken abdomen. 5542.

Leptogaster lanata Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, p. 382. ♂ holotype, ♀ allotype. 5660.

Leptogaster occidentis Hardy, 1942, Jour. Kans. Ent. Soc., vol. 15, no. 2, p. 61. ♂ holotype, ♀ allotype, 2 ♂, 5 ♀ paratypes and 2 paratypes with broken abdomens. 5543.

Leptogaster panda Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, pp. 372-373. ♂ holotype. 5661.

Leptogaster parvoclava Martin, 1957, Bull. Amer. Mus. Nat. Hist., vol. 111, no. 5, pp. 371-372. ♂ holotype, ♀ allotype, 1 ♂, 4 ♀ paratypes. 5658.

Leptopteromyia americana Hardy, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 2, pp. 74-75. ♂ holotype, ♀ allotype (head missing), 1 ♂, 3 ♀ paratypes and 3 paratypes with broken abdomens. 3757.

Mallophora clausicella intermedia Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, p. 92. 3 syntypes (1 ♀ and 2 with broken abdomens). 5676.

Mallophora guildiana Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 60. 4 ♀ syntypes. 205.

Myelaphus rufus Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 7. ♀ holotype. 153.

Nannocyrtopogon j-beameri Wilcox and Martin, 1957, Ann. Ent. Soc. Amer., vol. 50, no. 4, p. 385. ♂ holotype. 6081.

Nicocles abdominalis Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, pp. 17-18. 2 ♂ syntypes. 176.

Nicocles bromleyi Hardy, 1943, Jour. Kans. Ent. Soc., vol. 16, no. 1, pp. 28-29. ♂ holotype, ♀ allotype, 2 ♂, 4 ♀ paratypes. 5544.

Nicocles rufus Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 18. ♀ holotype. 177.

Nicocles scitulus Williston, 1883 (1884), Trans. Amer. Ent. Soc., vol. 11, p. 19. ♀ holotype. 174.

Ommatius baboquivari Wilcox, 1936, Bull. Brooklyn Ent. Soc., vol. 31, no. 4, pp. 174-176. ♂ holotype. 2240.

Ommatius beameri Wilcox, 1936, Bull. Brooklyn Ent. Soc., vol. 31, no. 4, p. 174. ♂ holotype, ♀ allotype. 2241.

Philonicus rufipennis Hine, 1907, Ohio Naturalist, vol. 7, no. 6, pp. 117-118. 1 ♂ syntype. 207.

Proctacanthus arno Townsend, 1895, Proc. Calif. Acad. Sci., vol. 4, pp. 599-600. 2 ♂, 3 ♀ syntypes. 198.

Proctacanthus zamon Townsend, 1895, Proc. Calif. Acad. Sci., vol. 4, pp. 600-601. 1 ♂, 2 ♀ syntypes. 1701.

Promachus albifacies Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, p. 63. 2 ♂ syntypes. 199.

Promachus apicalis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 153. 1 ♀, 2 broken syntypes. 200.

Promachus flavibarbis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 152-153. ♀ holotype. 201.

Promachus negligens Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 154. 1 ♂, 1 ♀ syntypes and 1 with broken abdomen. 202.

Promachus painteri Bromley, 1934, Ann. Ent. Soc. Amer., vol. 27, no. 1, p. 93. ♂ holotype, ♀ allotype. 3824.

Promachus princeps Williston, 1885, Trans. Amer. Ent. Soc., vol. 12, pp. 62-63. 4 ♂ syntypes. 203.

Promachus solus Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 153-154. ♀ holotype. 204.

Saropogon albifrons Back, 1904, Canad. Ent., vol. 36, no. 10, p. 291. 2 ♀ syntypes. 170.

Saropogon pritchardi Bromley, 1934, Ann. Ent. Soc. Amer., vol. 27, no. 1, p. 90. ♂ holotype, ♀ allotype. 3288.

Sisyrnodytes major Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 155. 3 ♀ syntypes. 210.

Stenopogon acacidinus Williston, 1896, Trans. Amer. Ent. Soc., vol. 13, p. 289. 2 ♂ syntypes. 150.

Stenopogon andersoni Bromley, 1937, Jour. N. Y. Ent. Soc., vol. 45, nos. 3-4, p. 302. ♂ holotype, ♀ allotype, 1 ♂ paratype. 2200.

Stenopogon brevinsculoides Bromley, 1937, Jour. N. Y. Ent. Soc., vol. 45, no. 3-4, pp. 299-300. ♂ holotype, ♀ allotype, 1 ♂, 2 ♀ paratypes. 2230.

Stenopogon californioides Bromley, 1937, Jour. N. Y. Ent. Soc., vol. 45, no. 3-4, pp. 304-305. ♂ holotype, ♀ allotype, 1 ♂, 5 ♀ paratypes and two with broken abdomens. 2235.

Stenopogon dispar Bromley, 1937, Jour. N. Y. Ent. Soc., vol. 45, no. 3-4, p. 306. ♂ holotype, ♀ allotype. 2239.

Stenopogon huachucanus Hardy, 1942, Jour. Kans. Ent. Soc., vol. 15, no. 2, pp. 57-58. ♂ holotype, ♀ allotype, 1 ♂, 1 ♀ paratypes. 5546.

Stenopogon jubatoides Bromley, 1937, Jour. N. Y. Ent. Soc., vol. 45, no. 3-4, p. 297. ♂ holotype, ♀ allotype. 2238.

Stenopogon nigriverticellus Bromley, 1937, Jour. N. Y. Ent. Soc., vol. 45, no. 3-4, p. 298. ♀ holotype. 2203.

Stenopogon wilcoxi Bromley, 1937, Jour. N. Y. Ent. Soc., vol. 45, no. 3-4, pp. 300-301. ♂ holotype, ♀ allotype, 4 ♂, 13 ♀ paratypes and two with broken abdomens. 2204.

Taracticus brevicornis Williston, 1883, Trans. Amer. Ent. Soc., vol. 11, pp. 22-23. 1 ♂, 1 ♀ syntypes. 175.

Tolmerus annulipes delusus Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, p. 92. 2 ♂, 2 ♀ syntypes. 213.

Tolmerus mesae Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, pp. 92-93. 1 ♂, 2 ♀ syntypes. (Abdomen of ♂ damaged.) 215.

Triclis tagax Williston, 1883, Trans. Amer. Ent. Soc., vol. 11, pp. 9-10. ♀ holotype. 152.

ASILIDAE—Paratypes

Ablautus nigronotum Wilcox. 2 ♂, 2 ♀. 2205.

Asilus kuulli Bromley. 1 ♂. 5535.

Backomyia schlingeri Wilcox and Martin. 1 ♀. 6082.

Beameromyia lunula Martin. 2 ♂, 4 ♀. 5655.

Beameromyia monticola Martin. 1 ♂, 1 ♀. 5656.

Beameromyia silvacola Martin. 1 ♂, 2 ♀. 5654.

Beameromyia vulgaris Martin. 4 ♀. 5649.

Cerotainiops mcclayi Martin. 4 ♂. 6083.

Cerotainiops wilcoxi Pritchard. 1 ♀. 3286.

Coleomyia hinei Wilcox & Martin. 2 ♂, 8 ♀. 2192.

Comantella rotgeri James. 1 ♂, 1 ♀. 2281.
Cophura acapulcae Pritchard. 4 ♀. 3285.
Cophura calla Pritchard. 1 ♂. 3284.
Cyrtopogon albifrons Wilcox & Martin. 3 ♂, 1 ♀. 3722.
Cyrtopogon auripilosus Wilcox & Martin. 4 ♂, 3 ♀. 2186.
Cyrtopogon banksi Wilcox & Martin. 6 ♂, 2 ♀. 2189.
Cyrtopogon fumipennis Wilcox & Martin. 1 ♀. 3719.
Cyrtopogon montanus wilcoxi James. 2 ♂, 3 ♀. 3347.
Cyrtopogon punctipennis Melander. 1 ♀. 161.
Cyrtopogon tacoma Melander. 2 ♂, 2 ♀. 163.
Cyrtopogon willistoni Curran. 2 ♂, 2 ♀. 157.
Dioctria (Eudioctria) monrovia Wilcox & Martin. 1 ♂, 1 ♀. 3083.
Dioctria (Metadioctria) rubida atripes Wilcox & Martin. 1 ♂. 3717.
Dioctria rubida nigripilosa Wilcox & Martin. 2 ♂. 3082.
Diogmites crudelis Bromley. 2 ♀. 2194.
Diogmites esuriens Bromley. 4 ♂, 3 ♀. 2195.
Diogmites grossus Bromley. 3 ♂, 3 ♀. 2196.
Diogmites pritchardi Bromley. 1 ♀. 2197.
Diogmites properans Bromley. 5 ♂, 7 ♀. 2198.
Diogmites salutans Bromley. 2 ♂, 10 ♀ and 1 with broken abdomen. 2199.
Erax helenae Bromley. 3 ♂, 7 ♀. 3816.
Erax tricellus Bromley. 1 ♂, 2 ♀. 3840.
Heteropogon currani Pritchard. 2 ♂, 2 ♀. 3287.
Heteropogon maculinervis James. 2 ♂. 2220.
Heteropogon wilcoxi James. 1 ♂, 1 ♀. 1994.
Holcocephala bullata Bromley. 1 ♀. 1988.
Holopogon acropennis Martin. 1 ♂, 2 ♀. 6084.
Holopogon caesariatus Martin. 1 ♂, 1 ♀. 6085.
Holopogon currani Martin. 1 ♂, 4 ♀. 6086.
Holopogon mingusae Martin. 1 ♂, 1 ♀. 6087.
Holopogon oriens Martin. 1 ♀. 6088.
Holopogon stellatus Martin. 4 ♂, 1 ♀. 6089.
Holopogon vockerothi Martin. 1 ♂, 2 ♀. 6090.
Holopogon wilcoxi Martin. 2 ♂, 2 ♀. 6091.
Laphria sackeni Wilcox. 2 ♂, 2 ♀. 2193.
Laphystia lanhami James. 2 ♀. 3073.
Lasiopogon actius Melander. 1 ♂. 164.
Lasiopogon aldrichii Melander. 1 ♂, 3 ♀. 165.
Lasiopogon chaetosus Cole & Wilcox. 2 ♂, 1 ♀. 2190.
Lasiopogon dimicki Cole & Wilcox. 2 ♂, 2 ♀. 2191.
Lasiopogon gabrieli Cole & Wilcox. 1 ♂, 1 ♀. 3716.
Lasiopogon martinensis Cole & Wilcox. 2 ♂ (1 missing head). 3720.
Lasiopogon monticola Melander. 1 ♂, 1 ♀. 166.
Lasiopogon pacificus Cole & Wilcox. 1 ♂, 1 ♀. 3715.
Lasiopogon ripicola Melander. 1 ♀. 167.
Lasiopogon willametti Cole & Wilcox. 2 ♂, 2 ♀. 1797.
Leptogaster arborcola Martin. 1 ♂, 1 ♀. 5662.
Leptogaster hesperis Martin. 5 ♂, 1 ♀. 5677.
Leptogaster nitoris Martin. 1 ♂, 2 ♀. 5659.
Nannocyrtopogon atripes Wilcox & Martin. 2 ♂, 2 ♀. 3718.

Nannocyrtopogon monrovia Wilcox & Martin. 1 ♂. 3723.
Nannocyrtopogon mingusi Wilcox and Martin. 1 ♂, 1 ♀. 6092.
Nannocyrtopogon neoculatus Wilcox and Martin. 3 ♂, 1 ♀. 6093.
Promachus oklahomensis Pritchard. 1 ♂, 1 ♀. 3289.
Promachus texanus Bromley. 3 ♂, 3 ♀. 1989.
Stenopogon kelloggi Wilcox. 2 ♂, 1 ♀. 2201.
Stenopogon martini Bromley. 4 ♂, 6 ♀. 2202.
Stenopogon rufibarboides Bromley. 1 ♀. 2237.

ASTEIIDAE

Asteia longipennis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 188. ♂ holotype. 751.

ASTEIIDAE—Paratypes

Asteia multipunctata Sabrosky. 1 ♀. 2944.

BIBIONIDAE

Bibio albipennis beameri Hardy, 1945, Univ. Kans. Sci. Bull., vol. 30, no. 15, pp. 451-452. ♂ holotype, ♀ allotype, 122 ♂ and ♀ paratypes. 3208.

Philia globosa Hardy, 1942, Jour. Kans. Ent. Soc., vol. 15, no. 4, pp. 128-129. ♂ holotype, ♀ allotype, 1 ♂ paratype. 3338.

Philia tingi Hardy, 1942, Jour. Kans. Ent. Soc., vol. 15, no. 4, pp. 132-133. ♀ holotype, ♂ allotype, 2 ♀ paratypes. 3228.

Plecia (Rhinoplecia) biformis Hardy, 1942, Canad. Ent., vol. 74, no. 6, p. 106. ♂ holotype, ♀ allotype. 3236.

Plecia edwardsi Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 1, p. 17. ♂ holotype, ♀ allotype, 1 ♂ paratype. 3241.

Plecia lopesi Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 1, pp. 19-20. ♂ holotype, ♀ allotype. 3245.

Plecia nearctica Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 1, p. 20. ♂ holotype, ♀ allotype, 25 ♂, 12 ♀ paratypes. 3246.

Plecia (Rhinoplecia) rectiora Hardy, 1942, Canad. Ent., vol. 74, no. 6, p. 113. ♂ holotype, ♀ allotype, 1 ♂ paratype. 3256.

BIBIONIDAE—Paratypes

Bibio columbiaensis Hardy. 2 ♂. 3209.
Bibio flukei Hardy. 1 ♂. 3210.
Bibio kansensis James. 1 ♂, 1 ♀. 2130.
Bibio knowltoni paltidus Hardy. 2 ♂, 1 ♀. 2394.
Bibio macateei James. 1 ♂. 2129.
Bibio melanopilosus Hardy. 6 ♂, 3 ♀. 2393.
Bibio mickeli Hardy. 1 ♂, 1 ♀. 3211.
Bibio monstri James. 5 ♂ (1 with head missing). 2397.
Bibio necotus Hardy. 1 ♂. 3220.
Bibio nigrifemoratus gilvus Hardy. 1 ♂. 3223.
Bibio painteri James. 2 ♂. 5547.
Bibio peruvianus Edwards. 1 ♂. 3263.
Bibio sericata Hardy. 3 ♂. 2392.
Bibio townesi Hardy. 5 ♂. 3224.
Bibio velcida Hardy. 3 ♂. 3225.
Dilophus bicoloripes Edwards. 1 ♂, 1 ♀ (wings missing). 3264.
Dilophus flavicornis Edwards. 1 ♂, 1 ♀. 5683.
Dilophus flavihalter Edwards. 1 ♂, 1 ♀. 3265.

Dilophus gracilipes Edwards. 1 ♂. 3266.
Dilophus luteus Edwards. 1 ♀ (head missing). 3267.
Dilophus microcerus Edwards. 1 ♂. 3268.
Dilophus nubilipennis Edwards. 1 ♂ (abdomen missing). 3269.
Dilophus patagonicus Edwards. 2 ♂. 3270.
Dilophus plaumanni Edwards. 1 ♂, 3 ♀. 5682.
Dilophus serotinus Loew. 1 ♂, 1 ♀. 3227.
Dilophus tetracanthus Edwards. 1 ♂, 1 ♀. 3272.
Penthetria appendicula Hardy. 3 ♂, 1 ♀. 3229.
Penthetria distincta Hardy. 8 ♂, 1 ♀. 3230.
Philia jamesi Hardy. 2 ♂. 2945.
Philia minima Hardy. 4 ♂. 3339.
Philia oklahomensis Hardy. 3 ♂. 2391.
Philia ornata Hardy. 3 ♀. 3340.
Philia variceps Hardy. 2 ♀. 3341.
Plecia alaeris Curran. 2 ♂. 3231.
Plecia americana Hardy. 11 ♂, 6 ♀. 3232.
Plecia avicephaliforma Hardy. 1 ♂. 3233.
Plecia (Rhinoplecia) biarmata Hardy. 1 ♀. 3234.
Plecia (Rhinoplecia) brazilana Hardy. 3 ♂. 3237.
Plecia (Plecia) curvistylata Hardy. 1 ♂. 3238.
Plecia (Rhinoplecia) ecuadorensis Hardy. 1 ♂. 3239.
Plecia ecuadorensis micans Hardy. 2 ♂, 3 ♀. 3240.
Plecia (Rhinoplecia) gibbosa Hardy. 2 ♂, 1 ♀. 3242.
Plecia impilosa Hardy. 10 ♂, 4 ♀. 3244.
Plecia nitidicollis Edwards. 2 ♂. 3247.
Plecia (Rhinoplecia) panamaensis Hardy. 5 ♂. 3249.
Plecia (Rhinoplecia) perplexa Hardy. 1 ♀. 3250.
Plecia persimilis Hardy. 3 ♂. 3251.
Plecia (Plecia) pertinens Hardy. 1 ♂, 1 ♀. 3252.
Plecia pictipennis Edwards. 1 ♂. 3253.
Plecia (Rhinoplecia) pruinosa Hardy. 1 ♂, 1 ♀. 3254.
Plecia (Rhinoplecia) punctulata Hardy. 1 ♂, 1 ♀. 3255.
Plecia rufithorax concava Hardy. 6 ♂, 2 ♀. 3257.
Plecia (Rhinoplecia) rugosa Hardy. 1 ♂. 3258.
Plecia (Rhinoplecia) trilobata Hardy. 1 ♂. 3259.
Plecia (Rhinoplecia) uberta Hardy. 6 ♂, 1 ♀. 3260.
Plecia (Rhinoplecia) variabilis Hardy. 6 ♂, 3 ♀. 3261.
Plecia (Rhinoplecia) xenia Hardy. 9 ♂, 1 ♀. 3262.

BOMBYLIIDAE

Anastoechus melanohalteralis Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, p. 91. 1 ♂, 1 ♀ syntypes. 107.

Anastoechus melanohalteralis fulvipennis Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, p. 91. ♂ holotype. 108.

Anthrax agrippina Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, p. 139. 1 ♂ syntype. 113.

Anthrax alta Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, pp. 89-90. ♀ holotype. 114.

Anthrax comparata Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, p. 90. 1 ♀ syntype and 1 syntype, sex unknown with head missing. 115.

Anthrax cuniculus Osten Sacken, 1886, Biologia Centr. Amer., Diptera, vol. 1, p. 125. 1 ♀ syntype. 116.

Anthrax faustina Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, pp. 136-137. 1 ♀? syntype. 117.

Anthrax livia Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, p. 139. 1 ♀? syntype. 5684.

Anthrax moneta Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, p. 138. 1 ♂ syntype. 118.

Anthrax sabina Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, p. 137. 1 ♀? syntype (abdomen damaged). 102.

Aphoebantus carbonarius Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, p. 149. 1 ♀? syntype. 123.

Aphoebantus conurus Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, p. 148. 1 ♂ syntype. 124.

Aphoebantus cyclops Osten Sacken, 1887, Biologia Centr. Amer., Diptera, vol. 1, p. 146. 1 ♂ syntype. 125.

Comastes sackeni Williston, 1893, N. Amer. Fauna, No. 7, Dipt. of Death Valley Exped., part 2, p. 255. ♀ holotype. 105.

Desmatomyia anomala Williston, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 268-269. ♀ holotype. 127.

Desmatomyia argentifrons Williston, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 267-268. ♀? holotype. 126.

Dolichomyia gracilis Williston, 1894, Kans. Univ. Quart., vol. 3, no. 1, pp. 41-43. 1 ♂, 1 ♀ syntypes. 128.

Eclimus auratus Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 66. 2 ♀ syntypes. 119.

Eclimus lotus Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 66. ♂ holotype. 120.

Eclimus melanosus Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 65-66. 4 ♀ syntypes. 121.

Eclimus sodalis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 65. ♀ holotype. 122.

Geron (Empidigeron) aridus Painter, 1932, Trans. Amer. Ent. Soc., vol. 58, no. 2, p. 163. ♂ holotype, ♀ allotype. 132.

Geron digitaria Cresson, 1919, Proc. Acad. Nat. Sci. Phila., vol. 71, pp. 184-185. ♀ allotype, 22 ♀ paratypes. 129.

Geron (Empidigeron) snowi Painter, 1932, Trans. Amer. Ent. Soc., vol. 58, no. 2, p. 164. ♂ holotype, ♀ allotype, 6 ♂, 10 ♀ paratypes. 133.

Lordotus pulchrissimus Williston, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 64. 2 ♀ syntypes. 109.

Phthiria coquilletti Johnson, 1902, Canad. Ent., vol. 34, no. 8, pp. 240-241. 1 ♀? syntype. 5842.

Poecilanthrax apache Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 31-37. ♂ holotype, ♀ allotype. 5975.

Poecilanthrax eremicus Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 51-54. ♂ holotype, ♀ allotype. 5976.

Poecilanthrax hyalinipennis Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 64-67. ♂ holotype, ♀ allotype. 5977.

Poecilanthrax litoralis Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech Bull. no. 106, pp. 71-74. ♂ holotype, ♀ allotype. 5978.

Poecilanthrax moffitti Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 78-82. ♂ holotype, ♀ allotype. 5979.

Poecilanthrax montanus Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 82-86. ♂ holotype, ♀ allotype. 5980.

Poecilanthrax poecilogaster interruptus Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 97-98. ♀ holotype. 5981.

Poecilanthrax tanbarkensis Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 109-111. ♂ holotype, ♀ allotype. 5982.

Poecilanthrax varius Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 114-118. ♂ holotype, ♀ allotype. 5983.

Poecilanthrax vexativus Painter & Hall, 1960, Agr. Exp. Sta., Kansas State Univ., Tech. Bull. no. 106, pp. 119-123. ♂ holotype, ♀ allotype. 5984.

Systropus snowi Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 156. 14 ♂ syntypes (5 with abdomens missing). 104.

Triplasius novus Williston, 1893, N. Amer. Fauna, No. 7, Dipt. of Death Valley Exped., part 2, pp. 254-255. 1 ♂ syntype. 103.

BOMBYLIIDAE—Paratypes

Bombylius albicapillus diegoensis Painter. 1 ♀. 1802.

Bombylius medorae Painter. 46 ♂, 25 ♀. 2583.

Bombylius texanus Painter. 1 ♀. 2596.

Conophorus painteri Priddy. 4 ♂ (one with head missing), 3 ♀ (one with abdomen missing). 5678.

Exoprosopa anomala Painter. 1 ♀. 2038.

Exoprosopa panamensis Curran. 2 ♀. 111.

Exoprosopa xanthina Painter. 4 ♀. 2597.

Geron albaria Painter. 2 ♂, 1 ♀. 131.

Geron grandis Painter. 2 ♂, 2 ♀. 130.

Geron versicolor Painter. 1 ♂, 1 ♀. 134.

Heterostylum croceum Painter. 1 ♂, 5 ♀. 106.

Lordotus bipartitus Painter. 1 ♂, 1 ♀. 2581.

Lordotus ermae Hall. 1 ♂, 1 ♀. 5485.

Lordotus gibbus striatus Painter. 1 ♂, 2 ♀. 2582.

BORBORIDAE

Apterina polita Williston, 1893, N. Amer. Fauna, No. 7, Dipt. Death Valley Exped., part 2, p. 259. ♀ holotype (lost off pin). 616.

Borborus gravis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 199. 2 ♂, 2 ♀ syntypes. 780.

Borborus marginatis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 198-199. ♀ holotype. 753.

Limosina atra Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 5, p. 223. ♀ holotype. 620.

Limosina evanescens Tucker, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, pp. 102-103. 2 ♂, 2 ♀ syntypes (one lost off pin). 621.

Limosina exigua Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, pp. 454-455. 2 ♂, 2 ♀ syntypes (one with head missing). 622.

Limosina marginata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 200. 3 ♂, 1 ♀ syntypes and one with abdomen missing. 781.

Limosina obtusipennis Stenhammar, 1855, Svenska Vetenskapsakademien, Stockholm, Handlingar 1853, p. 422. 1 ♀ syntype. 619.

Limosina occidentalis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 455. ♂ holotype. 623.

Limosina setigera Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 5, p. 223. 2 ♀ syntypes. 624.

Limosina sordipes Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 455. 1 ♂, 3 ♀ syntypes. 625.

Borboridae—Paratypes

Leptocera abundans Spuler. 2 ♂. 617.
Leptocera longicosta Spuler. 2 ♂. 618.
Leptocera michigana Sabrosky. 2 ♂, 3 ♀. 4077.

Calliphoridae

Chrysomyia desvoidyi Hough, 1900, Kans. Univ. Quart., vol. 9, no. 3, p. 208. 2 ♂ syntypes. 551.

Chrysomyia wheeleri Hough, 1899, Zool. Bull., vol. 2, no. 6, p. 284. 2 ♂ syntypes. 554.

Melanodexia tristis Williston, 1893, N. Amer. Fauna, No. 7, Dipt. of Death Valley Exped., part 2, p. 257. ♂ holotype. 5806.

Paracompsomyia houghi Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 201. 3 ♂, 2 ♀ syntypes. 553.

Paracompsomyia splendida Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 202. 8 ♂, 4 ♀ syntypes. 555.

Paracompsomyia verticalis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 202. ♀ holotype. 552.

Calliphoridae—Paratypes

Acronesia abina Hall. 1 ♂. 3400.
Apaulina basingeri Hall. 6 ♂. 3402.
Calliphora grahami Aldrich. 1 ♂, 1 ♀. 556.
Calliphora livida Hall. 6 ♂, 6 ♀. 3401.
Lucilia pallescens Shannon. 1 ♂, 1 ♀. 558.
Thelychaeta villeneuvei Curran. 1 ♂, 1 ♀. 557.

Calobatidae

Calobata pleuritica Johnson, 1894, Proc. Acad. Nat. Sci. Phila., pp. 279-280. 4 ♀ syntypes. 671.

Cecidomyiidae

Cecidomyia atriplicis Townsend, 1893, Amer. Naturalist, vol. 27, no. 11, p. 1021 (gall only). See: Cockerell, T. D. A., 1895, Amer. Naturalist, vol. 29, no. 8, pp. 766-767. ♀ holotype. 51.

Diplosis pini-radiatae Snow, 1900, Ent. News, vol. 11, no. 6, p. 491. 1 ♂, 3 ♀ syntypes. 52.

Ceratopogonidae

Ceratopogon dimidiatus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 27. 4 ♀ syntypes. 18.

Ceratopogon flavus Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 280. 1 ♂ syntype. 19.

Tersesthes torrens Townsend, 1893, Psyche, vol. 6, no. 201, p. 371. 1 ♀ syntype. 4661.

Ceratopogonidae—Paratypes

Culicoides palmerae James. 4 ♂, 4 ♀. 3370.
Johannseniella flavidula Malloch. 1 ♂, 1 ♀. 30.
Johannsenomyia albibasis Malloch. 1 ♂, 1 ♀. 29.
Probezzia pallida Malloch. 1 ♂. 5579.

Chironomidae

Ablabesmyia aurea Johannsen, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 1, p. 110. ♀ holotype. 17.

Chironomus anonymus Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 274. ♂ holotype. 21.

Chironomus flaviventris Johannsen, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, p. 111. 1 ♂ lectotype (genitalia missing), 1 ♂ (abdomen and antennae missing) and 1 ♀ lectoparatypes, Townes, 1945, Amer. Midland Nat., vol. 34, no. 1, p. 59. 22.

Chironomus longimanus Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 274. 1 ♂ syntype. 23.

Chironomus lucifer Johannsen, 1907, Univ. Kans. Sci. Bull., vol. 4, no. 2, p. 110. 1 ♂ lectotype, Townes, 1945, Amer. Midland Nat., vol. 34, no. 1, p. 108. 24.

Harnischia (Cladopelma) orbicus Townes, 1945, Amer. Midland Nat., vol. 34, no. 1, pp. 151-152. ♂ holotype. 3107.

Tanytarsus (Stictochironomus) albicrus Townes, 1945, Amer. Midland Nat., vol. 34, no. 1, p. 79. ♀ holotype. 3112.

CHIRONOMIDAE—Paratypes

Chironomus basalis Malloch. 1 ♀. 27.

Chironomus cinereus Townes. 2 ♂, 3 ♀ and 2 with abdomens missing. 3105.

Chironomus dimorphus Malloch. 1 ♂, 1 ♀. 20.

Chironomus illinoensis Malloch. 1 ♂, 1 ♀. 31.

Chironomus senilis Johannsen. 1 ♂. 5843.

Glyptotendipes musculus Townes. 25 ♂, 9 ♀. 3103.

Glyptotendipes testaceus Townes. 5 ♂. 3104.

Harnischia (Harnischia) collator Townes. 2 ♂. 3108.

Harnischia (Harnischia) emorsa Townes. 1 ♂. 3109.

Orthocladius (Trichocladius) distinctus Malloch. 1 ♂. 33.

Orthocladius distinctus basalis Malloch. 1 ♂, 1 ♀. 5844.

Polypedilum (Polypedilum) ophioides Townes. 1 ♂. 3350.

Pseudochironomus richardsoni Malloch. 1 ♂. 28.

Tanytarsus dubius Malloch. 1 ♂. 32.

Tanytarsus (Stictochironomus) varius Townes. 1 ♂. 3113.

Tendipes (Tendipes) carus Townes. 1 ♀. 3110.

Tendipes (Chaetolabis) ochreatus Townes. 1 ♂. 3106.

Xenochironomus scopula Townes. 1 ♂. 3585.

Xenochironomus virgatior Townes. 1 ♂. 5845.

CHLOROPIDAE

Chlorops albifascies Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, p. 42. 2 ♂, 1 ♀ syntypes (one with head missing). 698.

Chlorops appropinqua Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, pp. 39-40. 4 ♀? syntypes (one with head missing, one with broken abdomen). 699.

Chlorops bilineata Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, p. 40. ♂ holotype. 700.

Chlorops cinerapennis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, p. 40. 2 ♂ syntypes. 701.

Chlorops halteralis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, pp. 41-42. ♀ holotype. 702.

Chlorops ingrata Williston, 1893, Bull. Ohio Agr. Exper. Sta., Tech. Ser. 1, no. 3, pp. 156-157. 1 ♂, 1 ♀ syntypes. 704.

Chlorops liturata Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, pp. 40-41. 2 ♂ and 2 damaged syntypes. 703.

Chlorops parva Adams, Univ. Kans. Sci. Bull., vol. 2, no. 1, pp. 42-43. ♀? holotype (head missing). 705.

Chlorops recurva Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, p. 41. ♀ holotype. 706.

Chlorops rubicunda Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 1, p. 43. 3 ♀ syntypes. 707.

Chlorops trimaculata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 196-197. ♀ ? holotype (tip of abdomen missing). 772.

Crassiseta atricornis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 190-191. ♀ lectotype, ♂ lectoallotype, 1 ♂, 1 ♀ lectoparatypes, Sabrosky, 1951, Ruwenzori Expedition 1934-5, British Museum (Natural History), vol. 2, no. 7, p. 795. 767.

Crassiseta conjuncta Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 190. ♂ lectotype, ♀ lectoallotype, Sabrosky, 1951, Ruwenzori Expedition 1934-5, British Museum (Natural History), vol. 2, no. 7, p. 787. 769.

Crassiseta scapularis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 189. ♂ lectotype, ♀ lectoallotype, Sabrosky, 1951, Ruwenzori Expedition 1934-5, British Museum (Natural History), vol. 2, no. 7, pp. 794-795. 771.

Crassiseta tarda Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 189. ♀ lectotype, ♂ lectoallotype, Sabrosky, 1951, Ruwenzori Expedition 1934-5, British Museum (Natural History), vol. 2, no. 7, p. 790. 768.

Crassiseta tuberculata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 191. ♀ holotype. 770.

Crassiseta vulgaris Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 191-192. ♂ lectotype, ♀ lectoallotype, 50 ♂ and ♀ lectoparatypes, Sabrosky, 1951, Ruwenzori Expedition 1934-5, British Museum (Natural History), vol. 2, no. 7, pp. 795-796. 779.

Elachiptera bilineata Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 453. ♀ holotype. 713.

Elachiptera tau Sabrosky, 1948, Jour. Wash. Acad. Sci., vol. 38, no. 11, p. 374. ♀ holotype. 3838.

Haplegis scutellaris Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 196. ♀ ? holotype. 747.

Hippelates splendens Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 453. ♀ holotype. 714.

Madiza submarginalis Sabrosky, 1935, Jour. Kans. Ent. Soc., vol. 8, no. 3, p. 111. ♀ allotype. 3097.

Meromyza opaca Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 193. ♂ lectotype, ♀ lectoallotype, 22 ♂ and 35 ♀ lectoparatypes, Sabrosky, 1956, Jour. Kans. Ent. Soc., vol. 29, no. 1, p. 20. 777.

Oscinella beameri Sabrosky, 1940, Canadian Ent., vol. 72, no. 11, pp. 221-222. ♀ holotype. 3091.

Oscinella hesperia Sabrosky, 1940, Canadian Ent., vol. 72, no. 11, p. 219. ♂ holotype, ♀ allotype, 79 ♂ and ♀ paratypes. 3084.

Oscinis basilaris Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 192. ♂ lectotype, ♀ lectoallotype, Sabrosky, 1956, Jour. Kans. Ent. Soc., vol. 29, no. 1, p. 20. 773.

Oscinis collusor Townsend, 1895, Proc. Calif. Acad. Sci., vol. 4, pp. 619-620. ♀ lectotype, 2 ♀ lectoparatypes (one with head missing), Sabrosky, 1941, Canadian Ent., vol. 73, p. 26. 715.

Oscinis incipiens Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 424-425. 1 ♀ syntype, 2 broken syntypes, one with broken abdomen, the other without head. 716.

Oscinis polita Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 192. ♀ holotype. 750.

Pachylophus fossulata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 195-196. ♂ lectotype, ♀ lectoallotype, 6 ♂ and 4 ♀ lectoparatypes, Sabrosky, 1956, Jour. Kans. Ent. Soc., vol. 29, no. 1, pp. 20-21. 774. There are three additional specimens of the original syntypic series not conspecific with the lectotype and accordingly not made lectoparatypes by Sabrosky.

There is also a damaged specimen from the original series that was not available at the time of lectotype designation.

Pachylophus proxima Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 194-195. ♂ lectotype, ♀ lectoallotype, 27 ♂ and 36 ♀ lectoparatypes, Sabrosky, 1956, Jour. Kans. Ent. Soc., vol. 29, no. 1, p. 20. 783. There are an additional 82 ♂ and ♀ specimens from the original syntypic series which were apparently not sent to Sabrosky at the time of lectotype designation.

Pachylophus splendida Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 193-194. ♀? holotype. 748.

Pachylophus varipes Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 195. ♂ lectotype, ♀ lectoallotype, 35 ♂ and ♀ lectoparatypes, Sabrosky, 1956, Jour. Kans. Ent. Soc., vol. 29, no. 1, p. 20. 759. Sabrosky lists only 3 ♀ lectoparatypes.

Thaumatomyia apache Sabrosky, 1943, Canadian Ent., vol. 75, no. 6, pp. 111-112. ♂ holotype, ♀ allotype, 143 ♂ and ♀ paratypes. 3528.

Tricimba occidentalis Sabrosky, 1938, Jour. N. Y. Ent. Soc., vol. 46, no. 4, pp. 431-432. ♀ holotype, 3 ♀ paratypes. 2942.

Chloropidae—Paratypes

Ectecephala sulcata Sabrosky. 1 ♀. 3090.
Elachiptera angustistylum Sabrosky. 4 ♀. 3834.
Elachiptera californica Sabrosky. 1 ♂. 3836.
Elachiptera erythropleura Sabrosky. 4 ♂, 8 ♀. 3839.
Elachiptera knowltoni Sabrosky. 1 ♂, 1 ♀. 3835.
Elachiptera willistoni Sabrosky. 1 ♂. 3837.
Hippelates bishoppi Sabrosky. 3 ♂, 22 ♀. 3365.
Hippelates hermsi Sabrosky. 1 ♂. 3364.
Hippelates montanus Sabrosky. 6 ♂, 8 ♀. 3362.
Hippelates robertsoni Sabrosky. 2 ♂, 16 ♀. 3363.
Lasiopleura barberi Sabrosky. 2 ♂, 2 ♀. 5474.
Lasiopleura grisea Malloch. 2 ♂ lectoparatypes. 3095.
Lasiopleura panamensis Malloch. 2 ♂, 2 ♀ lectoparatypes. 3096.
Madiza trivittata Sabrosky. 1 ♀. 2943.
Melanochaeta kaw Sabrosky. 1 ♀. 3833.
Oscinella fronto-orbitalis Sabrosky. 2 ♀. 3085.
Oscinella grandissima Sabrosky. 1 ♀. 3087.
Oscinella grisescens Sabrosky. 1 ♂, 1 ♀. 3088.
Oscinella luteiceps Sabrosky. 1 ♂. 3094.
Oscinella neocoxendix Sabrosky. 1 ♂, 2 ♀. 3093.
Oscinella ochripes Sabrosky. 1 ♂, 1 ♀. 3092.
Oscinella painteri Sabrosky. 3 ♀. 3086.
Oscinella triorbiculata Sabrosky. 4 ♀. 3089.
Thaumatomyia rubrivittata Sabrosky. 1 ♂, 2 ♀. 3529.

Coenomyiidae

Arthroceras pollinosum Williston, Ent. Americana, vol. 2, no. 6, p. 108. 1 ♂, 1 ♀ syntypes. 5846.

Subula parens Williston, 1885, Canadian Ent., vol. 17, no. 7, pp. 122-123. ♀ holotype. 614.

Xylophagus decorus Williston, 1885, Canadian Ent., vol. 17, no. 7, p. 121. ♀ holotype. 612.

Xylophagus gracilis Williston, 1885, Canadian Ent., vol. 17, no. 7, p. 121. 1 ♂, 1 ♀ syntypes. 613.

CONOPIDAE

Conops affinis Williston, 1882, Trans. Conn. Acad., vol. 4, pp. 339-340. ♀ holotype. 300.

Conops bellus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 44. ♂ holotype. 292.

Conops burgessi Williston, 1882, Trans. Conn. Acad., vol. 4, p. 337. 3 ♀ syntypes. 301.

Conops fronto Williston, 1885, Trans. Conn. Acad., vol. 6, pp. 378-379. 1 ♂, 1 ♀ syntypes, and 1 syntype with abdomen missing. 295.

Conops fumipennis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 43-44. 6 ♀ syntypes. 294.

Conops furcillatus Williston, 1882, Trans. Conn. Acad., vol. 4, pp. 336-337. 3 ♀ syntypes. 302.

Conops gracilis Williston, 1885, Trans. Conn. Acad., vol. 6, pp. 377-378. ♀ holotype. 296.

Conops obscuripennis Williston, 1882, Trans. Conn. Acad., vol. 4, pp. 328-329. ♀ holotype. 293.

Conops semifumosus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 44. 2 ♂, 1 ♀ syntypes. 297.

Conops sylvosus Williston, 1882, Trans. Conn. Acad., vol. 4, pp. 329-330. ♀ holotype. 298.

Conops xanthopareus Williston, 1882, Trans. Conn. Acad., vol. 4, pp. 332-333. ♂ holotype. 299.

Dalmannia picta Williston, 1883, Trans. Conn. Acad., vol. 6, p. 94. ♀ holotype. 311.

Myopa pictipennis Williston, 1885, Trans. Conn. Acad., vol. 6, pp. 382-383. 3 ♂, 1 ♀ syntypes. 318.

Myopa pilosa Williston, 1885, Trans. Conn. Acad., vol. 6, pp. 383-384. ♀ holotype. 316.

Myopa plebia Williston, 1885, Trans. Conn. Acad., vol. 6, pp. 384-385. 1 ♂, 2 ♀ syntypes. 317.

Myopa tectura Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 35-36, ♀ holotype. 319.

Oncomyia baroni Williston, 1883, Trans. Conn. Acad., vol. 6, pp. 97-98. 3 ♂, 1 ♀ syntypes. 312.

Oncomyia modesta Williston, 1883, Trans. Conn. Acad., vol. 6, p. 96. 3 ♂, 1? (abdomen missing) syntypes. 313.

Oncomyia modesta melanopoda Williston, 1883, Trans. Conn. Acad., vol. 6, p. 96. 1 ♂, 1? (abdomen missing) syntypes. 314.

Oncomyia propinqua Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 32-33. ♂ holotype. 315.

Stylogaster neglecta Williston, 1883, Trans. Conn. Acad., vol. 6, pp. 91-92. 2 ♀ syntypes. 310.

Zodion abitus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 33-34. 1 ♂, 1? (abdomen missing) syntypes. 303.

Zodion bicolor Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 35. 2 ♀ syntypes. 304.

Zodion leucostoma Williston, 1885, Trans. Conn. Acad., vol. 6, p. 380. 1 ♂, 2 ♀ syntypes. 305.

Zodion parvis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 34-35. 2 ♂ syntypes. 306.

Zodion pictulum Williston, 1885, Trans. Conn. Acad., vol. 6, pp. 379-380. 1 ♀ syntype. 308.

Zodion pygmaeum Williston, 1885, Trans. Conn. Acad., vol. 6, p. 381. 1 ♂, 4 ♀ syntypes. 307.

Zodion scapularis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 34. ♀ holotype. 309.

CONOPIDAE—Paratypes

Myopa boharti Camras. 1 ♀. 4612.

Myopa perplexa Camras. 1 ♂, 1 ♀. 4613.

Zodion cyanescens Camras. 1 ♂. 5772.

CORDYLURIDAE

Cleigastra suisterci Townsend, 1891, Canadian Ent., vol. 23, no. 7, pp. 153-155. 1 ♀ syntype. 4665.

CORDYLURIDAE—Paratypes

Cordilura (Cordilurina) albicoxa James. 2 ♂. 5159.

CULICIDAE

Culex affinis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 25. ♀ holotype. 35. Type on indefinite loan to U. S. National Museum.

Culex apicalis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 26. ♀ lectotype, 1 ♀ lectoparatype, Stone, 1958, Jour. Kans. Ent. Soc., vol. 31, no. 3, p. 236. 36. Types on indefinite loan to U. S. National Museum.

Culex particeps Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 26-27. ♀ lectotype, 1 ♂, 2 ♀ lectoparatypes, Stone, 1958, Jour. Kans. Ent. Soc., vol. 31, no. 3, p. 237. 37. Lectotype, 1 ♂ and 1 ♀ lectoparatypes on indefinite loan to U. S. National Museum.

CULICIDAE—Paratypes

Psorophora longipalpis Roth. 1 ♀. 3544.

CUTEREBRIDAE

Cuterebra beameri Hall, 1943, Proc. Ent. Soc. Wash., vol. 45, no. 1, p. 25. ♂ holotype, 1 ♀ paratype. 3447.

DIOPSIDAE

Diopsis affinis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 45. ♀ holotype. 672.

Diopsis pollinosus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 45. ♀ holotype. 674.

Teleopsis nitidus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 46. ♀ ? holotype. 673.

DOLICHOPODIDAE

Anepsius linearis Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 317-318. 3 ♂, 3 ♀ syntypes (one ♂ without head). 243.

Asyndetus caudatus Van Duzee, 1916, Psyche, vol. 23, no. 3, pp. 92-93. ♂ holotype. 227.

Asyndetus fratellus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 332-333. 4 ♀ syntypes. 228.

Asyndetus latus Van Duzee, 1916, Psyche, vol. 23, no. 3, pp. 91-92. ♂ holotype. 229.

Asyndetus spinitarsis Harmston, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 3, pp. 108-109. ♂ holotype. 5781.

Asyndetus texanus Van Duzee, 1916, Psyche, vol. 23, no. 3, p. 90. ♂ holotype, ♀ allotype. 230.

Chrysotimus occidentalis Harmston, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 3, p. 109. ♂ holotype, ♀ allotype, 45 ♂ and ♀ paratypes. 5779.

Chrysotus albipalpus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 327. 2 ♂, and 1 ♀ syntypes. 231.

Chrysotus arkansensis Van Duzee, 1930, Canadian Ent., vol. 62, no. 4, pp. 84-85. ♂ holotype, ♀ allotype, 2 ♂, 1 ♀ paratypes (1 ♂ missing head, ♀? missing abdomen). 2935. (The generic name was spelled *Chrusotus* in the original description, but this is regarded as a misspelling.)

Chrysotus excisus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 325-326. 1 ♂, 1 ♀, 2? (1 without abdomen and part of head, 1 with head only remaining) syntypes. 232.

Chrysotus hirsutus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 328. 4 ♀ syntypes. 233.

Chrysotus intrudus Harmston, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 3, pp. 107-108. ♂ holotype, ♀ allotype, 2 ♂ paratypes. 5778.

Chrysotus niger Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 327. 1 ♂ syntype. 234.

Chrysotus proximus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 326. 1 ♂, 2 ♀ syntypes (1 ♀ without head). 235.

Dactylomyia gracilipes Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 3, pp. 151-152. 2 ♂, 2 ♀ syntypes. 241.

Diaphorus approximatus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 321. 2 ♂ syntypes. 225.

Diaphorus contiguus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 323. 1 ♂ syntype. 220.

Diaphorus dubius Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 324-325. 1 ♀ syntype (head missing) and 1? syntype lost off pin. 221.

Diaphorus flavipes Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 323-324. 2 ♂, 2 ♀ syntypes. 222.

Diaphorus insulanus Van Duzee, 1930, Canadian Ent., vol. 62, no. 4, pp. 86-87. ♂ holotype, 2 ♂ paratypes. 2937.

Diaphorus snowii Van Duzee, 1917, Psyche, vol. 24, no. 2, pp. 36-37. ♂ holotype. 223.

Diaphorus vulsus Van Duzee, 1917, Psyche, vol. 24, no. 2, pp. 38-39. ♂ holotype, ♀ allotype. 226.

Dolichopus accidentalis Harmston & Knowlton, 1941, Jour. Kans. Ent. Soc., vol. 14, no. 3, p. 93. ♂ holotype. 5780.

Dolichopus agilis Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 16 (note: this name preoccupied, so species renamed on p. 26 of same paper as *D. coloradensis*). 1 ♂, 2 ♀ syntypes. 252.

Dolichopus albicoxa Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 10. 2 ♀ syntypes. 249.

Dolichopus angustatus Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 15. ♂ holotype. 250.

Dolichopus arizonicus Harmston, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 3, pp. 103-104. ♂ holotype, ♀ allotype, 4 ♂ and 3 ♀ paratypes (1 ♂ and 1 ♀ with heads missing). 5782.

Dolichopus beameri Harmston & Knowlton, 1941, Jour. Kans. Ent. Soc., vol. 14, no. 3, pp. 92-93. ♂ holotype, ♀ allotype, 1 ♂ paratype. 3066.

Dolichopus coloradensis Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 16. (new name for *D. agilis*, which see). 1 ♂, 2 ♀ syntypes. 252.

Dolichopus convergens Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 9. 4 ♂ syntypes. 253.

Dolichopus dakotensis Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 11. 2 ♂ syntypes. 254.

Dolichopus duplicatus Aldrich, 1893, Kansas Univ. Quart., vol. 2, no. 1, p. 18. ♂ holotype. 255.

Dolichopus grandis Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 21-22. 1 ♂, 1 ♀ syntypes. 256.

Dolichopus kansensis Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 8-9. ♂ holotype. 257.

Dolichopus marginatus Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 17. 2 ♂, 2 ♀ syntypes. 259.

Dolichopus neomexicanus Harmston, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 3, pp. 104-105. ♂ holotype. 5783.

Dolichopus obcordatus Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 14-15. 2 ♂, 2 ♀ syntypes. 260.

Dolichopus occidentalis Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 19. 2 ♂ syntypes. 261.

Dolichopus plumosus Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 18. 2 ♂ syntypes. 262.

Dolichopus silvicolus Harmston, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 3, pp. 106-107. ♂ holotype. 5784.

Dolichopus tenuipes Aldrich, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 155-156. 2 ♂, 2 ♀ syntypes. 263.

Dolichopus vigilans Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 13-14. 1 ♂, 1 ♀ syntypes. 264.

Dolichopus willistonii Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, pp. 22-23. 4 ♂ syntypes (1 missing head). 265.

Eutarsus sinuatus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 334-335. 1 ♂, 1? (damaged) syntypes. 236.

Hercostomus chaetilamellus Harmston & Knowlton, 1941, Canadian Ent., vol. 73, no. 1, pp. 127-129. ♂ holotype. 3062.

Hercostomus latipes Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 311-312. 2 ♂, 1 ♀ syntypes (♀ without head). 266.

Hercostomus (Gymnopternus) pallidiciliatus Van Duzee, 1930, Canadian Ent., vol. 62, no. 4, p. 85. ♂ holotype, ♀ allotype. 2926.

Hygroceleuthus ciliatus Aldrich, 1893, Kans. Univ. Quart., vol. 2, no. 1, p. 25. 2 ♀ syntypes. 251.

Hygroceleuthus idahoensis Aldrich, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 154. 2 ♂, 1 ♀ syntypes (one ♂ with head missing). 2927.

Leptocorypha pavo Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 316-317. 1 ♂ syntype. 2931.

Liancalus hydrophilus Aldrich, 1893, Psyche, vol. 6, no. 212, pp. 567-571. 1 ♂, 3 ♀, 1? (abdomen missing) syntypes. 247.

Liancalus similis Aldrich, 1893, Psyche, vol. 6, no. 212, p. 571. 1 ♂, 2 ♀ syntypes. 248.

Lyroneurus simplex Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 333-334. 2 ♂, 1 ♀ syntypes. 218.

Medeterus albosetosa Van Duzee, 1928, Psyche, vol. 35, no. 1, pp. 36-37. ♂ holotype. 712.

Medeterus alpinus Harmston & Knowlton, 1941, Jour. Kans. Ent. Soc., vol. 14, no. 3, pp. 95-96. ♂ holotype. 3061.

Metapelastoneurus kansensis Aldrich, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 153. 2 ♂ syntypes. 275.

Neurigona signifera Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 337. 1 ♂ syntype (head missing). 2932.

Nothosympycnus abbreviatus Van Duzee, 1917, Canadian Ent., vol. 49, no. 10, p. 341. ♂ holotype. 240.

Paraclius elongatus Van Duzee, 1930, Ent. News, vol. 41, no. 3, pp. 72-73. ♂ holotype, ♀ allotype. 2925.

Paraclius filiferus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 314-315. 2 ♂, 2 ♀ syntypes (both ♀ lack heads). 268.

Paraclius flavicornis Van Duzee, 1918, Ent. News, vol. 29, no. 2, p. 48. 2 ♀ syntypes. 270.

Paraclius nigrocaudatus Van Duzee, 1918, Ent. News, vol. 29, no. 2, pp. 47-48. ♂ holotype. 271.

Paraclius venustus Aldrich, 1901, Biologia Centr. Amer., Dipt., vol. 1, pp. 340-341. 3 ♂ syntypes and 1 syntype lost off pin. 269.

Parhydrophorus canescens Wheeler, 1896, Ent. News, vol. 7, no. 6, pp. 187-189. 1? syntype (abdomen, head, wings and 3 legs missing). 246.

Pelastoneurus argentiferus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 313-314. 1 ♂, 1 ♀ syntypes (both badly damaged by dermestids). 274.

Pelastoneurus lineatus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 312-313. 3 ♂, 1 ♀ syntypes. 2930.

Pelastoneurus seticauda Van Duzee, 1930, Canadian Ent., vol. 62, no. 4, pp. 85-86. ♂ holotype. 2936.

Polymedon flavitibialis Van Duzee, 1930, Ent. News, vol. 41, no. 3, pp. 71-72. ♂ holotype. 2928.

Polymedon nigrifemoratus Van Duzee, 1927, Ann. Ent. Soc. Amer., vol. 20, no. 1, pp. 125-126. ♂ neallotype, Harmston, 1941, Jour. Kans. Ent. Soc., vol. 14, no. 3, pp. 96-97. 3067.

Polymedon superbus Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 318-320. 2 ♂ syntypes (both without head). 2933.

Psilopodinus crinitus Aldrich, 1904, Trans. Amer. Ent. Soc., vol. 30, p. 283. 1 ♂, 2 ♀ syntypes (♂ without head). 1975.

Psilopodinus pilicornis Aldrich, 1904, Trans. Amer. Ent. Soc., vol. 30, p. 282. 2 ♂, 2 ♀ syntypes. 1976.

Psilopus insularis Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 344-345. 2 ♀ syntypes. 219.

Sympycnus frater Aldrich, 1902, Univ. Kans. Sci. Bull., vol. 1, no. 3, pp. 83-84. ♀ holotype. 239. (The generic name was spelled *Sympyonus* in the original description, but this is regarded as a misspelling.)

Sympycnus hardyi Harmston, 1940, Ann. Ent. Soc. Amer., vol. 33, no. 2, pp. 397-398. ♂ holotype, ♀ allotype, 2 ♂, 2 ♀ paratypes. 4477.

Sympycnus occidentalis Aldrich, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 153-154. 1 ♀, 1? (without abdomen) syntypes. 238.

Sympycnus thoracicus Van Duzee, 1930, Pan-Pacific Ent., vol. 7, no. 2, pp. 51-52. ♂ holotype. 2934.

Thinophilus pectinifer Wheeler, 1896, Ent. News, vol. 7, no. 5, p. 155. ♀ holotype (head missing). 242.

Thrypticus parvulus Van Duzee, 1930, Canadian Ent., vol. 62, no. 4, pp. 86-87. ♂ holotype, ♀ allotype. 2939.

Xanthotricha cupulifera Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 339-340. 3 ♀ syntypes. 244.

Xanthotricha singularis Aldrich, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 340-341. 2 ♀ syntypes. 245.

Dolichopodidae—Paratypes

Argyra flavicornis Van Duzee. 1 ♂, 1 ♀. 237.

Dolichopus vernaae Harmston & Knowlton. 1 ♂, 1 ♀. 3069.

Hercostomus albipodus Harmston & Knowlton. 1 ♂. 3063.

Hercostomus cryptus Harmston & Knowlton. 1 ♂, 1 ♀. 3064.

Hercostomus torridus Harmston & Knowlton. 1 ♂, 1 ♀. 3065.
Polymedon dilaticosta Van Duzee. 1 ♂, 1 ♀. 272.
Syntormon uintaensis Harmston & Knowlton. 1 ♀. 3078.
Tachytrechus tahoensis Harmston & Knowlton. 1 ♀. 3077.
Tachytrechus utahensis Harmston & Knowlton. 1 ♀. 3076.
Teuchophorus diminucosta Harmston & Knowlton. 1 ♀. 3071.
Teuchophorus utahensis Harmston & Knowlton. 2 ♀. 3070.

DROSOPHILIDAE

Drosophila apicifera Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 185. ♀ holotype. 733.

Drosophila basilaris Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 184. 6 ♂, 3 ♀ syntypes. 760.

Drosophila coffeata Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 409-410. 1 ♂ syntype (head missing). 717.

Drosophila facialis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 183. ♂ holotype (specimen lost off pin). 734.

Drosophila flaviseta Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 184. ♀ holotype. 737.

Drosophila mansura Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 185. ♀ holotype. 738.

Drosophila mutabilis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 187-188. 7 ♂, 2 ♀ syntypes, plus 1 ♀ off pin, and 13 ♂ and ♀ syntypes subsequently determined as belonging to other species. 778.

Drosophila ornatipennis Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 407. 1 ♂, 1 ♀ syntypes. 719.

Drosophila pallida Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 415. 1 ♂, 2 ♀, 1? (without abdomen) syntypes. 720.

Drosophila palpalis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 185-186. ♂ holotype. 739.

Drosophila proxima Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 186. 1 ♂, 2 ♀ syntypes. 736.

Drosophila quadrimaculata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 182-183. ♂ holotype. 735.

EMPIDIDAE

Drapetis flavidus Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 308. 1 ♀ syntype. 393.

Drapetis xanthopodus Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 308. 1 ♀ syntype. 708. The specimen bears only a red, hand lettered label with an unpublished name indicating "yellow head." It seems likely this is a slip of the pen in transcribing the name *flavipes*, a name used for *xanthopodus* on p. 441 of the work cited above (see also Melander, A. L., 1902, Trans. Amer. Ent. Soc., vol. 28, p. 212). The specimen agrees with the description of *xanthopodus*.

Elaphropeza dispar Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 157-158. 4 ♂, 4 ♀ syntypes. 711.

Empis sociabilis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, p. 76. 2 ♂, 2 ♀ syntypes. 278.

Empis validis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 158. ♂ holotype. 5848.

Hilara nugax Melander, 1902, Trans. Amer. Ent. Soc., vol. 28, p. 273. ♀ holotype. 277.

Parathalassius aldrichi Melander, 1906, Ent. News, vol. 17, no. 10, pp. 374-375. ♂ holotype. 276.

Stilpon obscuripes Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 156-157. 2 ♀ syntypes. 710.

Thinodromia inchoata Melander, 1906, Ent. News, vol. 17, no. 10, p. 370. ♂ holotype. 267.

EMPIDIDAE—Paratypes

Empis browni Curran. 1 ♂. 1741.

Empis (Pachymeria) montiradicis James. 2 ♂, 2 ♀. 3348.

Hilara juno Curran. 1 ♂, 1 ♀. 1740.

EPHYDRIDAE

Allotrichoma lacteum Cresson, 1926, Trans. Amer. Ent. Soc., vol. 52, pp. 252-253. ♂ holotype, ♀ allotype. 696.

Caenia albifacies Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 181. 1 ♂, 2 ♀ (one ♀ missing head) syntypes. 752.

Dichaeta atriventris Cresson, 1915, Ent. News, vol. 26, no. 2, p. 68. ♂ holotype. 675.

Discocerina obscura Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 397. 2 ♂? syntypes. 678.

Discomyza dubia Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 392. 1 ♂, 3 ♀? syntypes. 679.

Ephydra pectinulata Cresson, 1916, Ent. News, vol. 27, no. 4, pp. 151-152. ♂ holotype, ♀ allotype, 1 ♂, 1 ♀ paratypes. 682.

Ephydra pygmaea Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 402. ♂ holotype. 683.

Ephydra tarsata Williston, 1893, North Amer. Fauna, no. 7, Dipt. of Death Valley Exped., part 2, pp. 257-258. ♂? holotype. 684.

Hyadina longicornis Sturtevant & Wheeler, 1953, Trans. Amer. Ent. Soc., vol. 79, p. 214. ♀? holotype. 5140. Sex of type not indicated in original description.

Ilythea flaviceps Cresson, 1916, Ent. News, vol. 27, no. 4, pp. 147-148. ♀ holotype. 685.

Notiphila confinis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 178. 5 ♂, 2 ♀ syntypes (2 ♂, 1 ♀ missing heads). 765.

Notiphila decoris Williston, 1893, North Amer. Fauna, no. 7, Dipt. of Death Valley Exped., part 2, p. 258. ♂? holotype. 688.

Notiphila varitarsus Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 177. 46 ♂ and ♀ syntypes. 766.

Ochthera subtilis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 180. 1 ♂, 8 ♀ syntypes. 745.

Ochtheroidea atra Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 401-402. ♂ holotype. 690.

Paralimna multipunctata Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 390-391. 1 ♂, 1 ♀ syntypes. 691.

Paralimna nigripes Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 178. 126 ♂ and ♀ syntypes. 763.

Paralimna obscura Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 391. 1 ♂, 1 ♀? syntypes and 1 lost off pin. 692.

Paralimna ornatipennis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 179. 1 ♂, 4 ♀ syntypes. 687.

Parydra tibialis Cresson, 1916, Ent. News, vol. 27, no. 4, pp. 150-151. ♂ holotype, ♀ allotype, 9 ♀ paratypes. 694.

Typopsilopa flavitarsis Cresson, 1916, Ent. News, vol. 27, no. 4, p. 147. ♂ holotype, 1 ♂ paratype. 695.

HELOMYZIDAE

Blepharoptera specus Aldrich, 1896, 21st Report, State Geologist of Indiana, pp. 189-190. ♂ holotype. 2938.

HELOMYZIDAE—Paratypes

Acantholeria oediemus Garrett. 4 ♂, 3 ♀. 2984.
Helomyza americana Garrett. 5 ♂, 6 ♀. 2986.
Suilla loewi Garrett. 2 ♂, 3 ♀. 2985.

HIPPOBOSCIDAE

Trichobius dugesii Townsend, 1891, Ent. News, vol. 2, no. 6, p. 106. ♀? holotype. 726.

HIPPOBOSCIDAE—Paratypes

Lipoptena ferrisi Bequaert. 3 ♂. 1801.

LAUXANIIDAE

Pachycerina dolorosa Williston, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 37. 4 ♀ syntypes. 629.

Pachycerina vaga Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 172-173. 2 ♀ syntypes. 742.

Physogenua bimaculata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 171. ♂ holotype. 740.

Sapromyza africana Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 171-172. 1 ♂, 1 ♀ syntypes. 764.

Sapromyza ingrata Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 385. 3 ♀? syntypes. 630.

Sapromyza ocellaris Townsend, 1893, Canadian Ent., vol. 24, no. 12, pp. 303-304. ♀? holotype. 4662.

Sapromyza octovittata Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 382. ♀? holotype (head missing). 631.

Sapromyza puella Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 381. 3 ♂? syntypes (1 with head missing). 633.

Sapromyza sororia Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 385. 2 ♂, 2 ♀ syntypes. 634.

LONCHAEIDAE

Dasiops alveofrons McAlpine. 1 ♂ paratype. 6049.

LONCHOPTERIDAE

Lonchoptera africana Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 159. ♀ holotype. 741.

MYCETOPHILIDAE

Ceroplatus apicalis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 22. ♂ holotype. 39.

Macrocera diluta Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 22. 1 ♂, 1 ♀ syntypes. 48.

Neoglaphyroptera cuneola Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 25. ♀ holotype. 46.

Neoglaphyroptera lineola Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 25. ♀ holotype. 47.

Neoglaphyroptera striata Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, p. 60. ♂ holotype. 5856.

Platyura gracilis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, p. 60. ♂ holotype. 40.

Platyura notabilis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, pp. 59-60. ♂ holotype. 41.

Platyura pulchra Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, p. 59. ♂ holotype (part of abdomen missing). 42.

Sciophila angulata Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 22-23. ♀ holotype (antennae missing). 44.

Sciophila nigricauda Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 23. ♀ holotype (antennae missing). 43.

Syntemna mutor Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 24. 2 ♂, 2 ♀ syntypes. 45.

MICROPEZIDAE

Micropeza abnormis Cresson, 1938, Ent. News, vol. 49, no. 3, pp. 72-73. ♂ holotype, ♀ allotype, 2 ♂, 1 ♀ paratypes. 5849.

Micropeza compar Cresson, 1938, Ent. News, vol. 49, no. 3, pp. 73-74. ♂ holotype, ♀ allotype, 3 ♀ paratypes. 5850.

Micropeza turcana Townsend, 1892, Trans. Kans. Acad. Sci., vol. 13, p. 136. 1 ♂ lectotype, 1 ♂ lectoparatype, Cresson, 1938, Trans. Amer. Ent. Soc., vol. 64, no. 4, pp. 316-317. 670.

MICROPEZIDAE—Paratypes

Micropeza setaventris Cresson. 2 ♀. 5851.

MUSCIDAE

Euryomma panamensis Chillcott, 1958, Canadian Ent., vol. 90, no. 12, pp. 730-731. ♂ holotype, ♀ allotype, 12 ♂, 10 ♀ paratypes. 5811.

Euryomma rettenmeyeri Chillcott, 1958, Canadian Ent., vol. 90, no. 12, pp. 725-730. ♂ holotype, ♀ allotype, 9 ♂, 2 ♀ paratypes. 5810.

Haematobia alcis Snow, 1891, Canadian Ent., vol. 23, no. 4, pp. 88-89. 1 ♂, 3 ♀ syntypes. 560.

Morellia nigricosta Hough, 1900, Kans. Univ. Quart., vol. 9, no. 3, pp. 216-218. 1 ♀ syntype. 559.

MYDAIDAE

Ecthypus limbatus Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 292. ♀ holotype. (Published as *Ectypus* but this is regarded as a misspelling.) 5852.

Ecthypus townsendi Williston, 1897, Trans. Kans. Acad. Sci., vol. 15, p. 58. ♀ holotype. 143.

Heteromydas bicolor Hardy, 1944, Canadian Ent., vol. 76, no. 11, pp. 227-229. ♂ holotype, ♀ allotype, 9 ♂, 23 ♀ paratypes. 5853.

Mydas abdominalis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 434. 2 ♂, 2 ♀ syntypes. 145.

Mydas scitulus Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, pp. 291-292. ♂ holotype. (Published as *Midas* but this is regarded as a misspelling.) 146.

Nemomydas intonsus Hardy, 1950, Wasmann Jour. Biol., vol. 8, no. 1, pp. 27-29. ♂ holotype, ♀ allotype. 3819.

Nemomydas intonsus fumosus Hardy, 1950, Wasmann Jour. Biol., vol. 8, no. 1, pp. 29-30. ♂ holotype, ♀ allotype. 3818.

NEMESTRINIDAE

Hirmoneura flavipes Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, pp. 292-293. ♀ holotype (most of head, 1 wing, 4 legs missing). 96.

Hirmoneura texana arizonensis Bequaert, 1934, Jour. N. Y. Ent. Soc., vol. 42, p. 180. ♂ holotype, ♀ allotype, 4 ♂ paratypes. 1840.

Rhynchocephalus flavus Curran, 1931, Canadian Ent., vol. 63, no. 3, pp. 70-72. ♂ holotype, ♀ allotype, 2 ♂, 3 ♀ paratypes. 100.

Rhynchocephalus maculatus Curran, 1931, Canadian Ent., vol. 63, no. 3, pp. 69-70. ♂ holotype, ♀ allotype, 2 ♀ paratypes. 99.

Rhynchocephalus sackenii Williston, 1880, Trans. Conn. Acad., vol. 4, pp. 243-244. ♂ holotype (described as ♀). 97.

Rhynchocephalus volaticus Williston, 1883, Canadian Ent., vol. 15, no. 4, pp. 71-72. 1 ♀ syntype. 98.

NYCTERIBIIDAE

Nycteribia antrozoi Townsend, 1893, Jour. N. Y. Ent. Soc., vol. 1, no. 2, pp. 79-80. ♂ holotype. 727.

OTITIDAE

Acrosticta similis Cresson, 1924, Trans. Amer. Ent. Soc., vol. 50, p. 238. ♂ holotype, ♀ allotype. 641.

Chaetopsis magna Cresson, 1924, Trans. Amer. Ent. Soc., vol. 50, p. 241. ♀ holotype, ♂ allotype, 1 ♀ paratype (head missing). 646.

Euxesta apicalis Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 375. 1 ♂? syntype. 642.

Euxesta magdalenae Cresson, 1924, Trans. Amer. Ent. Soc., vol. 50, p. 240. ♂ holotype. 224.

Euxesta remota Cresson, 1924, Trans. Amer. Ent. Soc., vol. 50, p. 238. ♀ holotype. 645.

Ortalis snowi Cresson, 1924, Trans. Amer. Ent. Soc., vol. 50, p. 234. ♂ holotype, ♀ allotype. 638.

Rivellia australis Namba, 1956, Proc. U. S. Nat. Mus., vol. 106, p. 32. ♀ holotype, ♂ allotype, 1 ♀ paratype. 5134.

Rivellia brevifasciata Johnson, 1900, Ent. News, vol. 11, no. 1, p. 326. 4 ♀ syntypes. 635.

Rivellia inaequata Namba, 1956, Proc. U. S. Nat. Mus., vol. 106, p. 62. ♂ holotype, ♀ allotype, 5 ♂, 13 ♀ paratypes. 5130.

Rivellia maculosa Namba, 1956, Proc. U. S. Nat. Mus., vol. 106, p. 35. ♂ holotype, ♀ allotype, 4 ♂, 17 ♀ paratypes. 5129.

Rivellia tersa Namba, 1956, Proc. U. S. Nat. Mus., vol. 106, p. 31. ♂ holotype, ♀ allotype. 5133.

Rivellia vaga Namba, 1956, Proc. U. S. Nat. Mus., vol. 106, p. 50. ♂ holotype, ♀ allotype, 63 ♂, 91 ♀ paratypes. 5126.

Stenopterina bicolor Johnson, 1900, Canadian Ent., vol. 32, no. 7, p. 246. 1 syntype (poor condition). 636.

Tephronota canadensis Johnson, 1902, Ent. News, vol. 13, no. 5, p. 144. 1 ♂ syntype. 639.

Tetanops magdalenae Cresson, 1924, Trans. Amer. Ent. Soc., vol. 50, p. 233. ♀ holotype, 1 ♂ paratype. 637.

OTITIDAE—Paratypes

Rivellia colei Namba. 1 ♂ (head missing). 5128.

Rivellia munda Namba. 3 ♀. 5127.

Rivellia socialis Namba. 1 ♂, 2 ♀. 5132.

Rivellia steyskali Namba. 6 ♂, 16 ♀. 5131.

Rivellia winifredae Namba. 1 ♂. 5135.

PHORIDAE

Phora halictorum Melander & Brues, 1903, Biol. Bull., vol. 5, no. 1, pp. 14-15. 1 ♀ syntype. 279.

PIPUNCULIDAE

Allomethus brimleyi Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 128-129. ♂ holotype, 1 ♂ paratype. 3188.

Cephalosphaera maxima Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 50-51. ♂ holotype, ♀ allotype, 2 ♀ paratypes. 3133.

Cephalosphaera tibialis Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 53-55. ♂ holotype, ♀ allotype, 2 ♂, 1 ♀ paratypes. 3135.

Chalarus latifrons Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 33-36. ♂ holotype, ♀ allotype, 91 ♂ and ♀ paratypes. 3125.

Dorilas (Eudorylas) aquavicinus Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 72-74. ♂ holotype, ♀ allotype, 2 ♂, 2 ♀ paratypes. 3144.

Dorilas (Eudorylas) arundani Hardy, 1954, Jour. Kans. Ent. Soc., vol. 27, no. 4, pp. 122-123. ♂ holotype, ♀ allotype, 1 ♂ paratype. 5177.

Dorilas (Eudorylas) bidactylus Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 80-81. ♂ holotype, 3 ♂ paratypes. 3146.

Dorilas cinctus subtilis Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 84-85. ♂ holotype, ♀ allotype, 25 ♂ and ♀ paratypes. 3150.

Dorilas (Eudorylas) curtus Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 85-86. ♂ holotype, 2 ♂ paratypes. 3151.

Dorilas dreisbachi Hardy, 1948, Jour. Kans. Ent. Soc., vol. 21, no. 3, p. 89. ♂ holotype. 4523.

Dorilas (Eudorylas) grandis Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 90-92. ♂ holotype, ♀ allotype, 1 ♂ paratype. 3154.

Dorilas (Eudorylas) huachucanus Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 95-97. ♂ holotype, ♀ allotype, 28 ♂ and ♀ paratypes. 3158.

Dorilas (Eudorylas) kansensis Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, pp. 102-103. ♂ holotype, ♀ allotype, 37 ♂ and ♀ paratypes. 3159.

Dorilas (Eudorylas) lautus Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 99-100. ♂ holotype, ♀ allotype, 2 ♂, 2 ♀ paratypes. 3160.

Dorilas (Eudorylas) michiganensis Hardy, 1948, Jour. Kans. Ent. Soc., vol. 21, no. 3, p. 90. ♂ holotype. 4524.

Dorilas (Eudorylas) montivagus Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 104-106. ♂ holotype, ♀ allotype. 3164.

Dorilas (Eudorylas) nevadaensis Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 106-107. ♂ holotype, ♀ allotype, 3 ♂, 8 ♀ paratypes. 3165.

Dorilas (Eudorylas) stainsi Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 113-114. ♂ holotype, 1 ♂ paratype. 3170.

Dorylomorpha tridentata Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 141-142. ♂ holotype, ♀ allotype, 50 ♂ and ♀ paratypes. 3186.

Dorylomorpha uncinata Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 142-144. ♂ holotype, ♀ allotype, 2 ♂ paratypes. (1 paratype without head.) 3187.

Pipunculus glabrum Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 165. ♂ holotype. 743.

Pipunculus nigricornis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 36. ♂ holotype. 5761.

Tömösváryella agnesea Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, pp. 103-106. ♂ holotype, ♀ allotype, 27 ♂ and ♀ paratypes. 3189.

Tömösváryella armata Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, pp. 106-107. ♂ holotype, ♀ allotype, 1 ♂, 2 ♀ paratypes. (1 ♀ paratype without head.) 3191.

Tömösváryella beameri Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, p. 107. ♂ holotype, ♀ allotype, 7 ♂, 2 ♀ paratypes. 3192.

Tömösváryella brevijuncta Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 155-156. ♂ holotype, ♀ allotype, 6 ♂, 6 ♀ paratypes. 3194.

Tömösváryella dissimilis Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 161-162. ♂ holotype, ♀ allotype, 18 ♂, 3 ♀ paratypes. 3197.

Tömösváryella exilidens Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 162-164. ♂ holotype, ♀ allotype, 19 ♂, 1 ♀ paratypes. 3198.

Tömösváryella floridensis Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, pp. 109-110. ♂ holotype, ♀ allotype, 3 ♂, 1 ♀ paratypes. 3199.

Tömösváryella lepidipes Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 166-167. ♂ holotype, ♀ allotype, 72 ♂ and ♀ paratypes. 3200.

Tömösváryella minacis Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, pp. 110-112. ♂ holotype, ♀ allotype, 2 ♂ paratypes. 3201.

Tömösváryella pauca Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 168-169. ♂ holotype, 3 ♂ paratypes. 3202.

Tömösváryella propinqua Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 169-171. ♂ holotype, ♀ allotype, 194 ♂ and ♀ paratypes. (Holotype without head.) 3203.

Tömösváryella quadradentis Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 172-173. ♂ holotype, ♀ allotype, 149 ♂ and ♀ paratypes. 3205.

Tömösváryella tumida Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, pp. 112-113. ♂ holotype, ♀ allotype, 26 ♂ and ♀ paratypes. 3217.

Tömösváryella turgida Hardy, 1940, Jour. Kans. Ent. Soc., vol. 13, no. 4, pp. 113-114. ♂ holotype, ♀ allotype, 12 ♂ paratypes. 3218.

Tömösváryella xerophila Hardy, 1943, Univ. Kans. Sci. Bull., vol. 29, no. 1, pp. 188-190. ♂ holotype, ♀ allotype, 27 ♂ and ♀ paratypes. 3206.

Verrallia fasciatus Hardy, 1939, Jour. Kans. Ent. Soc., vol. 12, no. 1, pp. 16-17. ♀ holotype. 3127.

PIPUNCULIDAE—Paratypes

Dorilas decorus Hardy. 2 ♂. 3826.

Dorilas mikenensis Hardy. 1 ♂, 1 ♀. (♂ missing head.) 3828.

Dorilas (Eudorylas) sabroskyi Hardy. 3 ♀. 3169.

Dorilas wittei Hardy. 1 ♂, 1 ♀. 3827.

Dorylomorpha canadensis Hardy. 4 ♂, 3 ♀. 3180.

Dorylomorpha ornata Hardy. 1 ♀. 3185.

Pipunculus appendipes Cresson. 1 ♂. 3190.

Pipunculus atramontensis occidens Hardy. 1 ♂. 3184.

Pipunculus brachystigmaticus Hardy & Knowlton. 1 ♀. 3172.

Pipunculus contortus Hardy. 1 ♂. 3196.

Pipunculus femoratus curvitibiae Hardy. 1 ♂. 3157.

Pipunculus knowltoni Hardy. 15 ♂, 11 ♀. 5497.

Pipunculus minor Cresson. 1 ♂. 5760.

Pipunculus toxodentis Hardy & Knowlton. 6 ♂, 1 ♀. 3216.

Pipunculus utahensis Hardy & Knowlton. 4 ♂, 1 ♀. 3222.

Pipunculus wilburi Hardy. 4 ♂, 2 ♀. 3221.

PLATYPEZIDAE

Callomyia aldrichii Snow, 1894, Kans. Univ. Quart., vol. 3, no. 2, p. 152. ♀ holotype. 281.

Callomyia venusta Snow, 1894, Kans. Univ. Quart., vol. 3, no. 2, pp. 151-152. 1 ♂, 2 ♀ syntypes. 282.

Calotarsa ornatipes Townsend, 1894, Canadian Ent., vol. 26, no. 2, p. 52. (Family placement corrected, pp. 102-103.) ♂ holotype. 284.

Platypeza abscondita Snow, 1895, Kans. Univ. Quart., vol. 3, no. 3, p. 205. ♂ holotype (abdomen, hind legs missing). 285.

Platypeza calceata Snow, 1894, Kans. Univ. Quart., vol. 3, no. 2, p. 146. 29 ♂ syntypes (4 damaged). 283.

Platypeza cinerea Snow, 1894, Kans. Univ. Quart., vol. 3, no. 2, pp. 150-151. 2 ♀ syntypes. 286.

Platypeza pulchra Snow, 1894, Kans. Univ. Quart., vol. 3, no. 2, pp. 149-150. 2 ♂ syntypes. 287.

Platypeza pulla Snow, 1895, Kans. Univ. Quart., vol. 3, no. 3, p. 206. 4 ♂ syntypes. 5498.

Platypeza taeniata Snow, 1894, Kans. Univ. Quart., vol. 3, no. 2, p. 149. ♀ holotype. 290.

Platypeza umbrosa Snow, 1894, Kans. Univ. Quart., vol. 3, no. 2, p. 148. 3 ♂, 1 ♀ syntypes (♀ without head). 288.

Platypeza unicolor Snow, 1895, Kans. Univ. Quart., vol. 3, no. 3, p. 206. ♀ holotype. 289.

PLATYPEZIDAE—Paratypes

Platypezina pacifica Kessel. 2 ♂, 2 ♀. 3817.

PSILIDAE

Loxocera californica Capelle, 1953, Ann. Ent. Soc. Amer., vol. 46, no. 1, pp. 106-107. ♂ holotype, ♀ allotype, 3 ♂ paratypes. 5805.

PSYCHODIDAE

Pericoma longiplata Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, p. 308. ♂ lectotype (on slide), 3 ♀ lectoparatypes, Quate, 1955, Univ. Calif. Pub. Ent., vol. 10, no. 3, p. 177. 5486.

Pericoma scala Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, pp. 307-308. ♀ holotype. 5496. This species was described on the basis of one specimen, "probably a female." However, there is another specimen (♀) on a microscope slide labeled "cotype," with same locality, date and collector. The pinned specimen is taken to be the holotype as it is so labelled.

Pericoma trialbawhorla Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, pp. 306-307. ♂ lectotype (on slide), Quate, 1955, Univ. Calif. Pub. Ent., vol. 10, no. 3, p. 170. 5489.

Psychoda floridica Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, pp. 316-317. ♀ lectotype (on slide), Quate, 1955, Univ. Calif. Pub. Ent., vol. 10, no. 3, p. 221. 5493.

Psychoda horizontala Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, p. 313. ♂ lectotype (on slide), Quate, 1955, Univ. Calif. Pub. Ent., vol. 10, no. 3, p. 211. 5492.

Psychoda nocturnala Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, pp. 319-320. ♀ holotype (on slide). 5491.

Psychoda slossoni Williston, 1893, Ent. News, vol. 4, p. 114. ♀ lectotype (body on slide, wings on point, pinned), Quate, 1955, Univ. Calif. Pub. Ent., vol. 10, no. 3, pp. 143-145. 38.

Psychoda snowii Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, pp. 311-312. 4 ♀ syntypes. 5487.

Psychoda uniformata Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, p. 319. ♀ lectotype (on slide), Quate, 1955, Univ. Calif. Pub. Ent., vol. 10, no. 3, p. 213. 5490.

Trichomyia unipunctata Haseman, 1907, Trans. Amer. Ent. Soc., vol. 33, no. 9, pp. 323-324. ♀ lectotype, 1 ♀ lectoparatype, Quate & Wirth, 1951, Wasmann Jour. Biol., vol. 9, no. 2, p. 156. 5488.

PSYCHODIDAE—Paratypes

Psychoda salicornia Quate. 1 ♂, 1 ♀ (on slides). 5494.

Telmatoscopus nebraskensis Quate. 1 ♀ (on slide). 5495.

PTYCHOPTERIDAE—Paratypes

Ptychoptera uta Alexander. 1 ♂. 5327.

RHAGIONIDAE

Chrysopila bella Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 13, p. 438. ♂ lectotype, 1 ♂, 1 ♀ lectoparatypes, Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, p. 161. 90.

Chrysopila flavibarbis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 13, p. 438. ♂ lectotype, 3 ♂ lectoparatypes (1 with head missing), Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, p. 154. 91.

Chrysopila lucifera Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 13, p. 437. ♂ lectotype, 2 ♂, 1 ♀ lectoparatypes (abdomen of 1 ♂ broken), Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, p. 160. 92.

Chrysopilus angustifacies Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, pp. 148-149. ♂ holotype, 3 ♂ paratypes. 3782.

Chrysopilus beameri Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, pp. 151-152. ♂ holotype, ♀ allotype, 6 ♂, 5 ♀ paratypes. 3783.

Chrysopilus divisus Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, pp. 152-153. ♂ holotype. 3785.

Chrysopilus georgianus Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, p. 154. ♂ holotype. 3786.

Chrysopilus longipalpus Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, pp. 157-158. ♂ holotype, ♀ allotype, 1 ♀ paratype. 3784.

Chrysopilus xanthopus Hardy, 1949, Amer. Midland Nat., vol. 41, no. 1, pp. 163-164. ♂ holotype, ♀ allotype, 1 ♂, 3 ♀ paratypes. 3787.

Leptis palpalis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 13, p. 442. ♂ holotype. 88.

Leptis pleuralis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 13, p. 441. ♀ holotype. 89.

Ptiolina vicina Hardy & McGuire, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 1, p. 12. ♀ holotype. 3748.

Ptiolina zonata Hardy & McGuire, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 1, pp. 13-15. ♀ holotype. 3747.

Symphoromyia flavipalpis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 13, p. 439. ♀ holotype. 93.

Symphoromyia pachyceras Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 287. 1 ♂, 3 ♀ syntypes. 94.

Symphoromyia plagens Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 287. 1 ♂ syntype. 95.

RHAGIONIDAE—Paratypes

Chrysopilus alaskaensis Hardy. 1 ♂, 1 ♀. 3788.

Ptiolina nigripilosa Hardy & McGuire. 1 ♂. 3746.

SARCOPHAGIDAE

Archimimus canatus Reinhard, 1952, Canadian Ent., vol. 84, no. 5, p. 140. ♂ holotype, ♀ allotype, 1 ♂, 1 ♀ paratypes. 4654.

Brachycoma chihuahuensis Townsend, 1892, Canadian Ent., vol. 24, no. 7, pp. 165-166. ♂ holotype. 400.

Cacotrophus beameri Reinhard, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 3, pp. 99-100. ♂ holotype, ♀ allotype. 3770.

Cattasoma festinans Reinhard, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 3, pp. 98-99. ♂ holotype. 3771.

Eumacronychia decens Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 99-100. 1 ♂, 2 ♀ syntypes. 454.

Eumacronychia duplicata Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 57-58. ♂ holotype, ♀ allotype, 1 ♂ paratype. 5857.

Eumacronychia elita Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 100. ♂ holotype. 458.

Gymnoprosopa argentifrons Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 109. ♂ holotype. 457.

Gymnoprosopa clarifrons Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 109-110. ♂ holotype. 456.

Gymnoprosopa polita Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 109. ♀ holotype. 455.

Metopia luggeri Townsend, 1892, Canadian Ent., vol. 24, no. 3, p. 69. ♀ holotype. 479.

Miltogramma argentifrons Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, p. 357. 2 ♂ syntypes. 498.

Miltogramma cinerascens Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, p. 358. 3 ♀ syntypes. 499.

Miltogramma decisa Townsend, 1892, Ent. News, vol. 3, no. 4, p. 81. ♀ holotype. 497.

Miltogramma flavicornis Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, p. 355. 1 ♂, 1 ♀? syntypes. 500.

Miltogramma kansensis Townsend, 1892, Canadian Ent., vol. 24, no. 3, pp. 68-69. ♂ holotype. 502.

Pachyophthalmus aurifrons Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 354-355. 1 ♂, 1 ♀ syntypes. 592.

Sarcoclista dakotensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 123. ♀ holotype. 496.

Sarcodexia sternodontis Townsend, 1892, Jour. Inst. of Jamaica, vol. 1, no. 3, p. 106. ♂ holotype. 3009.

Sarcomacronychia sarcophagoides Townsend, 1892, Canadian Ent., vol. 24, no. 7, p. 165. ♀ holotype. 590.

Sarcomacronychia trypoxylonis Townsend, 1893, Bull. Ohio Agr. Exp. Sta., Tech. Ser., vol. 1, no. 3, pp. 165-166. 2 ♂, 2 ♀ syntypes (one ♀ without head). 3574.

Sarcomacronychia unica Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 101-102. ♂ holotype. 591.

Sarcophaga beameri Hall, 1931, Pan-Pacific Ent., vol. 8, no. 2, p. 52. ♂ holotype. 2131.

Sarcophaga chaetopygialis Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 366. 3 ♂ syntypes. 564.

Sarcophaga cimbicis Townsend, 1892, Canadian Ent., vol. 24, no. 5, pp. 126-127. 1 ♂, 1 ♀ syntypes. 565.

Sarcophaga complosa Reinhard, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 4, pp. 123-124. ♂ holotype, 2 ♂ paratypes. 3762.

Sarcophaga concinnata Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 364. 1 ♀ syntype. 567.

Sarcophaga helicis Townsend, 1892, Psyche, vol. 6, p. 220. ♀ holotype. 569.

Sarcophaga hetaera Reinhard, 1952, Canadian Ent., vol. 84, no. 5, pp. 146-147. ♂ holotype. 4655.

Sarcophaga libera Aldrich, 1916, Sarcophaga and Allies (North America), Thomas Say Foundation, La Fayette, Indiana, pp. 235-236. ♂ holotype, ♀ allotype. 573.

Sarcophaga litorosa Reinhard, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 3, pp. 115-116. ♂ holotype, 12 ♂ paratypes. 3767.

Sarcophaga micropygialis Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 363-364. ♂ holotype. 576.

Sarcophaga prohibita Aldrich, 1916, Sarcophaga and Allies (North America), Thomas Say Foundation, La Fayette, Indiana, pp. 133-134. ♀ holotype, ♂ allotype, 1 ♀ paratype. 578.

Sarcophaga prolepsis Reinhard, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 4, pp. 120-121. ♂ holotype, ♀ allotype, 1 ♂, 2 ♀ paratypes. 3764.

Sarcophaga siccana Reinhard, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 4, p. 117. ♂ holotype. 3769.

Sarcophaga sigilla Reinhard, 1947, Jour. Kans. Ent. Soc., vol. 20, no. 4, pp. 118-119. ♂ holotype. 3765.

Sarcophaga statuta Reinhard, 1952, Canadian Ent., vol. 84, pp. 144-145. ♂ holotype. 4656.

Sarcotachinella intermedia Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 111. ♂ holotype. 580.

SARCOPHAGIDAE—Paratypes

Chaetoravinia anandra Dodge. 4 ♀. 4496.
Emblemasoma erro Aldrich. 1 ♂. 561.
Gymnoprosopa milanoensis Reinhard. 2 ♀. 3517.
Idoneamima acrophila Dodge. 1 ♂. 5858.
Idoneamima fattigi Dodge. 2 ♂. 5859.
Idoneamima helicivora Dodge. 1 ♂. 5860.
Idoneamima monticola Dodge. 3 ♂. 5861.
Idoneamima rabunensis Dodge. 2 ♂. 5862.
Idoneamima sabroskyi Dodge. 9 ♂. 5863.
Idoneamima seagoi Dodge. 5 ♂. 5864.
Idoneamima sudiai Dodge. 1 ♂. 5865.
Sarcophaga aculeata taediosa Aldrich. 1 ♂. 562.
Sarcophaga alcedo Aldrich. 1 ♂. 563.
Sarcophaga alopecis Reinhard. 1 ♂, 2 ♀. 3759.
Sarcophaga coloradensis Aldrich. 1 ♂, 1 ♀. 566.
Sarcophaga ignipes Reinhard. 1 ♀. 3760.
Sarcophaga johnsoni Aldrich. 2 ♂. 571.
Sarcophaga kellyi Aldrich. 2 ♂. 572.
Sarcophaga latisterna irrisoris Reinhard. 3 ♂, 1 ♀. 4657.
Sarcophaga marginata Aldrich. 1 ♂. 574.
Sarcophaga melampyga Aldrich. 3 ♂. 575.
Sarcophaga mimoris Reinhard. 1 ♂. 3758.
Sarcophaga omani Hall. 3 ♂. 2132.
Sarcophaga pagella Reinhard. 1 ♂. 3768.
Sarcophaga planifrons Aldrich. 4 ♂. 577.
Sarcophaga putilla Reinhard. 1 ♂, 2 ♀. 3761.
Sarcophaga reperta Reinhard. 3 ♂. 3763.
Sarcophaga robusta Aldrich. 2 ♂, 1 ♀. 579.
Sarcophaga sulculata Aldrich. 2 ♂, 1 ♀. 581.
Sarcophaga vernilis Reinhard. 3 ♂. 3766.
Sphenometopa violae Reinhard. 1 ♂, 1 ♀. 3516.

SCENOPINIDAE

Omphrale beameri Hardy, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, p. 43. ♂ holotype, ♀ allotype, 13 ♂, 7 ♀ paratypes (holotype, 2 paratypes without heads). 3750.

Omphrale beameri fusca Hardy, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 43-44. ♂ holotype, ♀ allotype, 8 ♂, 13 ♀ paratypes. 3749.

Omphrale kuiterti Hardy, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 46-47. ♂ holotype, 1 ♂ paratype. 5866.

Omphrale valga Hardy, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 50-51. ♂ holotype, 2 ♂ paratypes. 5867.

Omphralosoma albifasciata Hardy, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 41-42. ♂ holotype, ♀ allotype, 1 ♂ paratype. 5869.

Pseudatrichia punctulata Hardy, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 3, pp. 104-105. ♂ holotype, ♀ allotype, 1 ♂, 1 ♀ paratypes. 3278.

Scenopinus electa Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, pp. 445-446. 1 ♂, 1 ♀ syntypes. 141.

Scenopinus mirabilis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 445. ♀ holotype. 142.

SCENOPINIDAE—Paratypes

Belosta albipilosa Hardy. 3 ♂, 2 ♀. 5868.

Omphrale adventicia Hardy. 3 ♀. 5144.

SCIARIDAE

Eugnoriste occidentalis Coquillett, 1896, Proc. Ent. Soc. Wash., vol. 3, p. 321. 3 ♀ syntypes. 49.

SCIARIDAE—Paratypes

Zygoneura fenestrata Malloch. 1 ♀. 50.

SCIOMYZIDAE

Sepedon ornatifrons Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 166. 2 syntypes (both without abdomen, one without head). 627.

Sepedon scapularis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 46-47. 1 ♂, 1 ♀ syntypes. 628.

Tetanocera inopa Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, pp. 448-449. ♂ holotype. 626.

SCIOMYZIDAE—Paratypes

Dictya currani Steyskal. 1 ♂. 2946.

Dictya sabroskyi Steyskal. 1 ♀. 2947.

SEPSIDAE

Sepsis astutis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 174. 2 ♂, 1 ♀, 3? (without abdomen) syntypes. 755. One ♂ has been identified as *S. glabrata* Duda, by Curran.

Sepsis delectabilis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 174-175. 2 ♂, 1? (without abdomen) syntypes. 758.

Sepsis petulantis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 176. ♂ holotype. 757.

Sepsis propinquus Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 175. ♂ holotype. 754.

SIMULIIDAE

Simulium argus Williston, 1893, North Amer. Fauna, No. 7, Dipt. of Death Valley Exped., part 2, pp. 253-254. ♀ holotype. 53.

Simulium beameri Stains & Knowlton, Ann. Ent. Soc. Amer., vol. 36, no. 2, pp. 279-280. ♀ holotype, ♂ allotype, 28 ♂ & ♀ paratypes. 3283.

Simulium notatum Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 13, p. 434. 2 ♀ syntypes. (One lacks abdomen and head). 54.

Simulium occidentale Townsend, 1891, Psyche, vol. 6, no. 183, p. 107. 4 ♀ syntypes. 55.

SIMULIIDAE—Paratypes

Eusimulium pilosum Knowlton & Rowe. 1 ♀. 3048.

Simulium twinni Stains & Knowlton. 1 ♂, 1 ♀. 3049.

STRATIOMYIDAE

Adoxomyia appressa James, 1935, Pan-Pacific Ent., vol. 11, no. 2, p. 63. ♂ holotype, ♀ allotype, 4 ♂, 1 ♀ paratypes. 2125.

Adoxomyia appressa cibolae James, 1950, Jour. Kans. Ent. Soc., vol. 23, no. 2, p. 71. ♂ holotype, ♀ allotype, 19 ♂, 1 ♀ paratypes. 4207.

Adoxomyia claripennis James, 1935, Pan-Pacific Ent., vol. 11, no. 2, pp. 62-63. ♂ holotype. 2126.

Adoxomyia micheneri James, 1950, Jour. Kans. Ent. Soc., vol. 23, no. 2, pp. 71-72. ♂ holotype, ♀ allotype. 5169.

Chrysochlora flavescens James, 1937, Bull. Brooklyn Ent. Soc., vol. 32, no. 4, pp. 151-152. ♂ holotype, 10 ♂ paratypes. 2280.

Chrysochroma albipes Townsend, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 31-32. ♂ holotype. 59.

Clitellaria argentata Williston, Canadian Ent., vol. 17, no. 7, pp. 127-128. ♂ holotype. 73.

Dieuryneura callosa James, 1937, Bull. Brooklyn Ent. Soc., vol. 32, no. 4, p. 153. ♂ holotype, ♀ allotype. 2282.

Euparyphus albipilosus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 30. 1 ♂, 2 ♀ syntypes. 68.

Euparyphus limbrocutris Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 31. ♀ holotype. 69. This species was earlier described without name by Williston, 1885, Canadian Ent., vol. 17, no. 7, p. 126.

Euparyphus mutabilis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, pp. 29-30. 4 ♂, 4 ♀ syntypes. 70.

Euparyphus ornatus Williston, 1885, Canadian Ent., vol. 17, no. 7, pp. 126-127. ♀ holotype. 71.

Euparyphus sabroskyi James, 1936, Pan-Pacific Ent., vol. 12, no. 2, p. 88. ♂ holotype. 2949.

Euparyphus septem-maculatus Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 2, p. 31. ♂ holotype. 72.

Hermetia comstocki Williston, 1885, Canadian Ent., vol. 17, no. 7, pp. 125-126. 1 ♂, 3 ♀ syntypes. 57. Original description indicates only two specimens.

Hermetia eiseni Townsend, 1895, Proc. Cal. Acad. Sci., 2nd series, vol. 4, pp. 594-595. 2 ♀ syntypes (one without head). 5873.

Labidostigmina novella Steyskal, 1938, Occ. Papers, Mus. Zool. Univ. Mich., no. 386, pp. 1-3. ♂ allotype. 2222.

Macrosargus clavis Williston, 1885, Canadian Ent., vol. 17, no. 7, pp. 123-124. 1 ♂, 1 ♀ syntypes. 60.

Merosargus beameri James, 1941, Ent. News, vol. 52, no. 4, pp. 107-108. ♂ holotype. 3075.

Nemotelus abdominalis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 5, p. 221. 3 ♂, 1 ♀ syntypes. 74.

Nemotelus beameri James, 1933, Jour. Kans. Ent. Soc., vol. 6, no. 2, p. 70. ♀ holotype, ♂ allotype (designated by Hanson, 1958, Univ. Kans. Sci. Bull., vol. 38, Pt. 2, no. 19, p. 1378). 5874.

Nemotelus bellulus Melander, 1903, Psyche, vol. 10, nos. 325-326, p. 183. 1 ♀ syntype. 2923.

Nemotelus bruesii Melander, 1903, Psyche, vol. 10, nos. 325-326, p. 179. 1 ♂, 3 ♀ syntypes. 75.

Nemotelus communis Hanson, 1958, Univ. Kans. Sci. Bull., vol. 38, Pt. 2, no. 19, pp. 1376-1377. ♂ holotype, ♀ allotype, 10 ♂, 10 ♀ paratypes. 5875.

Nemotelus halophilus Hanson, 1958, Univ. Kans. Sci. Bull., vol. 38, Pt. 2, no. 19, pp. 1372-1373. ♂ holotype, ♀ allotype, 10 ♂ paratypes. 5876.

Nemotelus kansensis Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 5, pp. 221-222. 86 ♂, 66 ♀ syntypes. Two Anthomyiidae also bear type labels of this species. 76.

Nemotelus lambda James, 1933, Jour. Kans. Ent. Soc., vol. 6, no. 2, pp. 70-71. ♂ holotype. 5881.

Nemotelus politus Hanson, 1958, Univ. Kans. Sci. Bull., vol. 38, Pt. 2, no. 19, pp. 1364-1365. ♂ holotype, ♀ allotype, 3 ♂, 1 ♀ paratypes. 5877.

Nemotelus trinotatus Melander, 1903, Psyche, vol. 10, nos. 325-326, p. 180. 3 ♂, 2 ♀ syntypes (one ♂ with abdomen missing). 77.

Nemotelus variabilis Hanson, 1958, Univ. Kans. Sci. Bull., vol. 38, Pt. 2, no. 19, pp. 1368-1369. ♂ holotype, ♀ allotype, 2 ♂ paratypes. 5878.

Nemotelus wheeleri Melander, 1903, Psyche, vol. 10, nos. 325-326, pp. 182-183. 1 ♀ syntype (without abdomen). 2924.

Odontomyia americana Day, 1882, Proc. Acad. Nat. Sci. Phila., p. 77. 2 ♂ syntypes. 63.

Odontomyia bellula James, 1936, Ann. Ent. Soc. Amer., vol. 29, no. 3, pp. 528-529. ♀ holotype. 2948.

Odontomyia colei James, 1936, Ann. Ent. Soc. Amer., vol. 29, no. 3, pp. 532-533. ♀ allotype (formerly a syntype of *O. pubescens* Day), 1 ♂ paratype (formerly a syntype of *O. pilosus* Day). 2127.

Odontomyia flava Day, 1882, Proc. Acad. Nat. Sci. Phila., p. 76. ♂ holotype (badly damaged). 64.

Odontomyia leucogaster James, 1933, Jour. Kans. Ent. Soc., vol. 6, no. 2, pp. 69-70. ♂ holotype, 1 ♂ paratype. 5885.

Odontomyia nigra Day, 1882, Proc. Acad. Nat. Sci. Phila., p. 75. 2 ♂, 7 ♀ syntypes. 320.

Odontomyia painteri James, 1936, Ann. Ent. Soc. Amer., vol. 29, no. 3, p. 530. ♀ holotype, ♂ allotype, 7 ♂, 6 ♀ paratypes. 2041.

Odontomyia pilosus Day, 1882, Proc. Acad. Nat. Sci. Phila., pp. 76-77. 4 ♂ syntypes (one additional ♂ removed as paratype of *O. colei* James). 65.

Odontomyia pubescens Day, 1882, Proc. Acad. Nat. Sci. Phila., p. 77. 1 ♂, 1 ♀ syntypes (one additional ♀ removed as allotype of *O. colei* James). 66.

Odontomyia willistoni Day, 1882, Proc. Acad. Nat. Sci. Phila., pp. 78-79. 1 ♀ syntype. 5886.

Ptecticus sackenii Williston, 1885, Canadian Ent., vol. 17, no. 7, p. 124. 1 ♂, 3 ♀ syntypes (head of ♂ damaged). 58.

Ptecticus similis Williston, 1885, Canadian Ent., vol. 17, no. 7, pp. 124-125. 1 ♂, 1 ♀ syntypes. 61.

Scoliopelta luteipes Williston, 1885, Ent. Americana, vol. 1, pp. 154-155. 2 ♂ syntypes (one without head). 56.

Stratiomys beameri James, 1933, Jour. Kans. Ent. Soc., vol. 6, no. 2, p. 66. ♀ holotype. 5887.

Stratiomys media James, 1933, Jour. Kans. Ent. Soc., vol. 6, no. 2, p. 67. ♀ holotype. 5870.

Stratiomys rubra James, 1933, Jour. Kans. Ent. Soc., vol. 6, no. 2, pp. 68-69. ♂ holotype, 1 ♂ paratype. 5871.

Stratiomys vespoides James, 1933, Jour. Kans. Ent. Soc., vol. 6, no. 2, pp. 67-68. ♀ holotype. 5872.

STRATIOMYIDAE—Paratypes

Nemotelus (Nematotelus) albimarginatus James. 2 ♂. 2221.

Nemotelus jamesi Hanson. 1 ♂, 1 ♀. 5879.

Nemotelus knowltoni James. 1 ♂. 5880.

Nemotelus picinus Hanson. 2 ♂, 1 ♀. 5882.

Nemotelus sabroskyi Hanson. 1 ♂, 1 ♀. 5883.

Nemotelus tenuistylus Hanson. 3 ♂, 8 ♀. 5884.

Odontomyia alberta Curran. 1 ♂, 1 ♀. 67.

Odontomyia communis James. 1 ♂, 1 ♀. 3074.

Odontomyia confusa James. 1 ♂. 2128.
Ptilcocera bergi James. 1 ♂, 1 ♀. 3781.
Stratiomys jamesi Steyskal. 2 ♀. 4626.

SYRPHIDAE

Brachymyia lupina Williston, 1882, Canadian Ent., vol. 14, no. 4, pp. 77-78. 1 ♂ syntype. 376.

Brachyopa cynops Snow, 1892, Kans. Univ. Quart., vol. 1, no. 1, pp. 37-38. ♀ holotype. 375.

Callicera montensis Snow, 1892, Kans. Univ. Quart., vol. 1, no. 1, p. 34. 4 ♂ syntypes. 371.

Ceria townsendi Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 246-247. ♂ holotype. 322.

Cerioides abdominalis Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 26-27. ♂ holotype. 321.

Chalcomyia (Chalcosyrphus) atra Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 122-123. ♀ holotype. 374.

Chilosia chalybescens Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, pp. 76-77. ♂ holotype. 369.

Chilosia lucta Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 228-229. ♀ holotype. 367.

Chilosia lugubris Williston, 1886, Bull., U. S. Nat. Mus., vol. 31, p. 45. 1 ♂ syntype. 370.

Chilosia nigripennis Williston, 1886, Bull. U. S. Nat. Mus., vol. 31, p. 44. 1 ♂ syntype. 372.

Chrysogaster nitidula Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 116-117. ♀ holotype, ♂ allotype. 373.

Epistrophe mediaconstrictus Fluke, 1930, Ann. Ent. Soc. Amer., vol. 23, no. 1, p. 135. ♀ holotype. 347.

Eristalis aequalis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 161-162. ♀ holotype. 382.

Eristalis communis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 162-163. 2 ♂, 1 ♀ syntypes. 381.

Eristalis dissimilis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 163. 4 ♂ syntypes. 384.

Eristalis longicornis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, pp. 160-161. ♀ holotype. 383.

Eristalis montanus Williston, 1882, Proc. Amer. Phil. Soc., vol. 20, no. 112, p. 322. ♂ holotype. 386.

Eristalis texanus Hull, 1925, Ohio Jour. Sci., vol. 25, no. 1, pp. 28-29. ♂ allotype. 3304.

Heliophilus azureus Fluke, 1953, Jour. Kans. Ent. Soc., vol. 26, no. 4, pp. 126-128. ♂ holotype, ♀ allotype, 3 ♂, 1 ♀ paratypes. 4686.

Helophilus dychei Williston, 1897, Canadian Ent., vol. 29, no. 6, pp. 136-137. 2 ♂ syntypes. 380.

Hiatomyia niveifrons Hull & Fluke, 1950, Bull. Amer. Mus. Nat. Hist., vol. 94, no. 6, pp. 373-374. ♂ allotype, 8 ♂, 2 ♀ paratypes. 3581.

Lepidostola micheneri Fluke, 1953, Jour. Kans. Ent. Soc., vol. 26, no. 4, p. 126. ♂ holotype. 4685.

Mallota albipilis Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, p. 244. ♀ holotype. 379.

Melanostoma atra Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, p. 114. ♀ holotype. 364.

Melanostoma bituberculata Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 160. 2 ♂, 2 ♀ syntypes. 360.

Melanostoma coerulescens Williston, 1886, Bull. U. S. Nat. Mus., vol. 31, p. 49. ♂ holotype. 362.

Melanostoma concinnum Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, p. 229. 3 ♂ syntypes (one with head missing). 361.

Melanostoma kelloggi Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 230-231. ♂ holotype. 359.

Mesograpta teligera Fluke, 1953, Jour. Kans. Ent. Soc., vol. 26, no. 4, p. 125. ♂ holotype 4681.

Metasyrphus talus Fluke, 1933, Wisconsin Acad. Sci. Arts & Let., vol. 28, p. 95. ♂ holotype, 1 ♂ paratype. 1880.

Microdon bombiformis Townsend, 1895, Trans. Amer. Ent. Soc., vol. 22, p. 33. ♀ holotype. 3579.

Microdon conflictus Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 58-60. ♀ allotype. 325.

Microdon diversipilosus Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, p. 76. ♂ holotype. 331.

Microdon eutristis Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 74-75. ♂ holotype. 330.

Microdon lanceolatum Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 5, pp. 222-223. ♂ holotype. 328.

Microdon megalogaster Snow, 1892, Kans. Univ. Quart., vol. 1, no. 1, p. 34. ♂ holotype. 326.

Microdon pallipennis Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 89-90. ♂ holotype (without head). 333.

Microdon pseudoglobosus Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 57-58. ♂ holotype, 1 ♀ paratype. 324.

Microdon violens Townsend, 1895, Trans. Amer. Ent. Soc., vol. 22, pp. 34-35. ♀ holotype (abdomen damaged). 332.

Microdon xanthopilus Townsend, 1895, Proc. Calif. Acad. Sci., vol. 4, p. 611. 1 ♂ syntype. 327.

Myiolepta bella Williston, 1882, Proc. Amer. Phil. Soc., vol. 20, no. 112, p. 308. 1 ♀ syntype (head and abdomen missing). 357.

Nausigaster scutellaris Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, pp. 446-447. 2 ♂ syntypes. 336.

Parhelophilus currani Fluke, 1953, Jour. Kans. Ent. Soc., vol. 26, no. 4, pp. 128-129. ♀ holotype, ♂ allotype. 4557.

Platychirus palmulosus Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 231-232. ♂ holotype. 358.

Rhopalosyrphus carolae Capelle, 1956, Jour. Kans. Ent. Soc., vol. 29, no. 4, pp. 174-175. ♀ holotype, ♂ allotype. 5888.

Sphaerophoria melanosa Williston, 1886, Bull. U. S. Nat. Mus., vol. 31, pp. 106-107. ♂ holotype. 354.

Sphyximorpha snowi Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, pp. 447-448. 2 ♀ syntypes. 323.

Spilomyia kahli Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 245-246. ♂ holotype. 377.

Syrphus creper Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, p. 234. 3 ♂, 1 ♀ syntypes. 346.

Syrphus disgregus Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 233-234. 3 ♂, 1 ♀ syntypes. 345.

Syrphus montanus Curran, 1924, Univ. Kans. Sci. Bull., vol. 15, no. 1, pp. 174-175. ♂ holotype. 340.

Syrphus montivagus Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, p. 236. 4 ♂ syntypes. 341.

Syrphus pullulus Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 237-238. 4 ♂ syntypes (1 without head, 1 without abdomen). 352.

Syrphus ruficauda Snow, 1892, Kans. Univ. Quart., vol. 1, no. 1, p. 36. 2 ♂ syntypes. 339.

Tropidia incana Townsend, 1895, Trans. Amer. Ent. Soc., vol. 22, pp. 52-53. ♀ holotype. 378.

Volucella correcta Curran, 1927, Bull. Brooklyn Ent. Soc., vol. 22, no. 2, pp. 87-88. ♂ holotype, ♀ allotype. 2940.

Volucella inops Townsend, 1895, Trans. Amer. Ent. Soc., vol. 22, pp. 43-44. ♀ holotype. 334.

Volucella vagoides Curran, 1927, Bull. Brooklyn Ent. Soc., vol. 22, no. 2, pp. 86-87. ♀ holotype. 5511.

Xanthogramma habilis Snow, 1895, Kans. Univ. Quart., vol. 3, no. 4, pp. 238-239. ♀ holotype. 353.

SYRPHIDAE—Paratypes

Chilosia nigrofasciata Curran. 2 ♂, 2 ♀. 366.
Chilosia orilliaensis Curran. 2 ♂, 2 ♀. 368.
Eristalis erraticus Curran. 2 ♂, 1 ♀. 385.
Melanostoma luteipennis Curran. 1 ♀. 363.
Metasyrphus luniger astutus Fluke. 1 ♀. 4556.
Metasyrphus sculleni Fluke. 1 ♂. 4687.
Metasyrphus vinelandi Curran. 1 ♀. 343.
Microdon champlaini Curran. 1 ♂, 1 ♀. 329.
Mixogaster beameri Weems. 1 ♂. 1357.
Sphaerophoria nigratarsi Fluke. 1 ♂, 8 ♀. 355.
Sphaerophoria robusta Curran. 2 ♂, 1 ♀. 1742.
Stenosyrphus albipunctatus Curran. 1 ♂, 1 ♀. 351.
Stenosyrphus grossulariae melanis Curran. 1 ♀. 349.
Syrphus aberrantis Curran. 2 ♂, 2 ♀. 338.
Syrphus bigelowi Curran. 1 ♂, 3 ♀. 348.
Syrphus currani Fluke. 1 ♂. 3072.
Syrphus pallifrons Curran. 1 ♀. 342.
Syrphus pingreensis Fluke. 1 ♀. 337.
Toxomerus occidentalis Curran. 2 ♂, 1 ♀. 356.
Volucella barei Curran. 1 ♀. 335.
Volucella visiculana Curran. 1 ♂, 1 ♀. 3755.
Volucella visicularia Curran. 1 ♂, 1 ♀. 3754.

TABANIDAE

Apatolestes (Apatolestes) albipilosus Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, p. 371. ♀ holotype. 2178.

Apatolestes (Apatolestes) ater Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, pp. 371-372. ♀ holotype, ♂ allotype, 1 ♀ paratype. 2179.

Apatolestes comastes Williston, 1885, Ent. Americana, vol. 1, pp. 12-13. 1 ♀ syntype. 78.

Apatolestes (Apatolestes) comastes willistoni Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, p. 373. ♀ holotype, 14 ♀ paratypes. 2180.

Apatolestes (Apatolestes) hinei Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, p. 374. ♀ holotype, ♂ allotype, 1 ♀ paratype. 2181.

Atylotus baal Townsend, 1895, Trans. Amer. Ent. Soc., vol. 22, pp. 58-59. ♀ holotype. 584.

Bequaertomyia anthracina Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, pp. 377-378. ♀ holotype, ♂ allotype, 2 ♀ paratypes. 2182.

Chrysops beameri Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, p. 265. ♀ holotype, 8 ♀ paratypes. 2156.

Chrysops bistellatus Daecke, 1905, Ent. News, vol. 16, no. 8, pp. 249-250. 1 ♀ syntype. 583.

Chrysops clavicornis Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, pp. 277-278. ♀ holotype, ♂ allotype, 3 ♀ paratypes. 2159.

Chrysops discalis Williston, 1880, Trans. Conn. Acad. Sci., vol. 4, pp. 245-246. 1 ♀ syntype. 83.

Chrysops dissimilis Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, pp. 288-289. ♀ holotype, ♂ allotype, 8 ♂, 12 ♀ paratypes. 2154.

Chrysops frazari Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 133. ♀ holotype. 84.

Chrysops hungerfordi Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, pp. 306-308. ♀ holotype, ♂ allotype, 5 ♀ paratypes. 2155.

Chrysops pachycera Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, pp. 134-135. 1 ♂ syntype. 5889.

Chrysops pertinax Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 132. 2 ♀ syntypes. 86.

Chrysops robusta Brennan, 1935, Univ. Kans. Sci. Bull., vol. 20, no. 13, pp. 333-335. ♀ holotype, ♂ allotype, 1 ♂ paratype. 2172.

Chrysops sequax Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, pp. 133-134. 1 ♂, 1 ♀ syntypes. 87.

Chrysops sordidus Osten Sacken, 1875, Mem. Boston Soc. Nat. Hist., vol. 2, part 4, no. 1, pp. 376-377. 1 ♀ syntype. 2259.

Diachlorus guttatulus Townsend, 1893, Trans. Kans. Acad. Sci., vol. 13, pp. 134-135. 1 ♀ lectotype, 2 ♀ lectoparatypes (both without heads), Philip, 1959, Trans. Amer. Ent. Soc., vol. 85, no. 3, p. 215. 587.

Dichelacera mexicana Fairchild & Philip, 1960, Studia Ent., n. s., vol. 3, fasc. 1-4, pp. 48-49. ♀ holotype, ♂ allotype, 4 ♂, 4 ♀ paratypes. 5896.

Dichelacera pullata Fairchild & Philip, 1960, Studia Ent., n. s., vol. 3, fasc. 1-4, pp. 57-59. ♀ holotype. 5897.

Hineia flavipes Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 150. ♀ holotype. 81.

Pangonia dives Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, pp. 130-131. 2 ♂, 1 ♀ syntypes. 5898.

Pangonia fera Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 130. ♂ holotype. 80.

Silvius laticallus Brennan, 1935, Univ. Kans. Sci. Bull., vol. 22, no. 13, pp. 353-354. ♀ holotype, ♂ allotype, 1 ♂, 2 ♀ paratypes. 2153.

Silvius pollinosus Williston, 1880, Trans. Conn. Acad. Sci., vol. 4, pp. 244-245. ♀ holotype. 82.

Snowiellus atratus Hine, 1904, Ohio Nat., vol. 5, no. 2, p. 230. ♀ holotype. 611.

Tabanus astutus Osten Sacken, 1875, Mem. Bost. Soc. Nat. Hist., vol. 2, part 4, no. 4, p. 471. 1 ♀ syntype. 2183.

Tabanus epistates Osten Sacken. See *Tabanus socius*.

Tabanus exul Osten Sacken, 1878, Mem. Bost. Soc. Nat. Hist., vol. 2, part 2, Supplement, pp. 557-558. 1 ♀ syntype. 2255.

Tabanus fenestra Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 141. ♀ holotype. 585

Tabanus (Stenotabanus) flavidus Hine, 1904, Ohio Nat., vol. 5, no. 2, pp. 236-237. ♂ allotype. 5890.

Tabanus fratellus Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 140. 1 ♀ syntype. 5891.

Tabanus fur Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, pp. 139-140. 1 ♀ syntype. 607.

Tabanus hyalinipennis Hine, 1903, Canadian Ent., vol. 35, no. 9, pp. 244-245. 1 ♀ syntype. 588.

Tabanus laticeps Hine, 1904, Ohio Nat., vol. 5, no. 2, p. 239. 1 ♀ syntype. 589.

Tabanus microcephalus Osten Sacken, 1876, Mem. Bost. Soc., Nat. Hist., vol. 2, part 4, no. 4, pp. 470-471. 1 ♀ syntype. 5894.

Tabanus osburni Hine, 1904, Ohio Nat., vol. 5, no. 2, p. 241. 4 ♀ syntypes. 5895.

Tabanus parvulus Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 141. ♀ holotype. 604.

Tabanus productus Hine, 1904, Ohio. Nat., vol. 5, no. 2, p. 242. 1 ♀ syntype. 605.

Tabanus pygmaeus Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 141. ♀ holotype. 606.

Tabanus quaesitus Stone, 1938, U. S. Dept. Agr., Misc. Publ., no. 305, p. 54. ♀ holotype. 2133.

Tabanus (Taeniotabanus) rhizonshine Philip, 1954, Amer. Mus. Novit., no. 1695, pp. 13-15. ♀ holotype, ♂ allotype. 5442.

Tabanus socius Osten Sacken, 1876, Mem. Boston Soc. Nat. Hist., vol. 2, part 4, no. 4, p. 467. (Preoccupied by *T. socius* Walker and renamed *T. epistates* Osten Sacken, same paper, p. 555.) 1 ♀ syntype. 2254.

Tabanus sodalis Williston, 1887, Trans. Kans. Acad. Sci., vol. 10, p. 139. ♀ lectotype, 2 ♀ lectoparatypes, Pechuman, 1960, Canadian Ent., vol. 92, no. 10, p. 798. 608.

Tabanus sonomensis Osten Sacken, 1877, Bull. of U. S. Geol. & Geog. Survey of Territories, F. V. Hayden Geologist-in-charge, vol. 3, no. 2, pp. 216-217. 1 ♀ syntype. 2256.

Tabanus tarsalis Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 151. 4 ♀ syntypes. 609.

TABANIDAE—Paratypes

Chrysops aberrans Philip. 1 ♂, 18 ♀. 2612.
Chrysops asbestos Philip. 1 ♂, 2 ♀. 4020.
Chrysops atlantica Pechuman. 1 ♀. 4113.
Chrysops bishoppi Brennan. 2 ♂, 3 ♀. 2157.
Chrysops carbonaria nubiapex Philip. 1 ♂. 4514.
Chrysops clavicornis brennani Philip. 1 ♀. 5807.
Chrysops dacne Philip. 10 ♀. 4220.
Chrysops dawsoni Philip. 1 ♀. 5808.
Chrysops dilatus Rowe & Knowlton. 1 ♂, 1 ♀. 2265.
Chrysops flavida celata Pechuman. 1 ♂. 4112.
Chrysops fulvistigma dorsopuncta Fairchild. 1 ♀. 2488.
Chrysops furcata chagnoni Philip. 2 ♀. 5809.
Chrysops latifrons Brennan. 1 ♀. 2166.
Chrysops reicherti Fairchild. 1 ♀. 2487.
Chrysops venus Philip. 1 ♀. 4037.
Chrysops wileyae Philip. 3 ♂, 2 ♀. 4513.
Chrysozona champlaini Philip. 2 ♀. 4219.
Chrysozona willistoni Philip. 1 ♀. 4189.
Hybomitra aatos Philip. 7 ♀. 2611.
Silvius sayi Brennan. 2 ♀. 5899.
Stonemyia abaureus Philip. 4 ♀. 2883.
Tabanus aar Philip. 1 ♂, 4 ♀. 2610.
Tabanus abactor Philip. 1 ♀. 2124.
Tabanus cazieri Philip. 1 ♀. 5519.
Tabanus coarctatus Stone. 1 ♀. 2506.
Tabanus criddlei Brooks. 1 ♀. 5900.

Tabanus eurycerus Philip. 1 ♂. 2404.
Tabanus fulvulus pallidescens Philip. 1 ♀. 2208.
Tabanus gladiator Stone. 1 ♀. 2507.
Tabanus kesseli Philip. 1 ♀. 4073.
Tabanus lineola hinellus Philip. 1 ♂, 2 ♀. 5826.
Tabanus lineola schwardti Philip. 3 ♂, 4 ♀. 5893.
Tabanus molestus mixis Philip. 1 ♀. 4453.
Tabanus nigrescens atripennis Stone. 1 ♀. 2152.
Tabanus sackeni Fairchild. 2 ♀. 2258.
Tabanus stonei Philip. 2 ♂, 19 ♀. 2964.
Tabanus subfronto Philip. 9 ♀. 2150.
Tabanus sublongus Stone. 2 ♀. 2260.
Tabanus zythicolor Philip. 1 ♀. 2206.

TACHINIDAE

Anisia vanderwulpi Townsend, 1892, Ent. News, vol. 3, no. 4, p. 81. ♀ holotype (described as ♂). 389.

Aphria ocypterata Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 361-363. 1 ♂, 1 ♀ syntypes. 390.

Aporia limacodis Townsend, 1892, Psyche, vol. 6, no. 194, pp. 275-276. ♂ holotype. 3420.

Archytas lobulatus Curran, 1928, Canadian Ent., vol. 60, no. 11, p. 279. ♀ allotype. 547.

Archytas prudens Curran, 1928, Canadian Ent., vol. 60, no. 11, p. 275. ♂ holotype. 546.

Atropharista jurinoides Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 92-93. 2 ♂, 1 ♀ syntypes. 477.

Atrophopalpus angusticornis Townsend, 1892, Ent. News, vol. 3, no. 6, p. 131. ♂ holotype. 394.

Atrophopoda braueri Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, p. 357. 1 ♂ syntype. 1808.

Atrophopoda singularis Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 374-375. 1 ♀ syntype. 4674.

Belvosia vanderwulpi Williston, 1885, Trans. Amer. Ent. Soc., vol. 13, p. 303. (spelled *Belvoisia v. d. Wulpi* in original description.) ♀ holotype. 397.

Blepharipeza exul Townsend, 1892, Canadian Ent., vol. 24, no. 3, pp. 64-65. ♀ holotype. 3568.

Blepharipeza nigrisquamis Townsend, 1892, Ent. News, vol. 3, no. 4, p. 80. ♀ holotype (described as ♂). 398.

Blepharipeza rufescens Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 90. ♀ holotype. 399.

Calodexia continua Curran, 1934, Amer. Mus. Novit., no. 685, pp. 10-11. ♀ holotype. 5901.

Calodexia interrupta Curran, 1934, Amer. Mus. Novit., no. 685, pp. 9-10. ♀ allotype. 5919.

Ceratomyiella conica Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, p. 380. ♂ holotype (described as ♀). 401.

Chaetoglossa nigripalpis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 126. ♂ holotype. 404.

Chaetoglossa picticornis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 126. 2 ♀ syntypes. 402.

Chaetoglossa violae Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 126. 2 ♂ syntypes. 403.

Cistogaster pallasii Townsend, 1891, Proc. Ent. Soc. Wash., vol. 2, pp. 142-143. ♀ holotype. 406.

Clista americana Townsend, 1892, Canadian Ent., vol. 24, no. 4, p. 78. ♀ holotype. 4672.

Clistomorpha hyalomoides Townsend, 1892, Canadian Ent., vol. 24, no. 4, pp. 80-81. ♂ holotype. 408.

Clytia flava Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 372-373. 2 ♂ syntypes. 407.

Cnephalia finitima Snow, 1895, Kans. Univ. Quart., vol. 3, no. 3, pp. 184-185. 3 ♂, 1 ♀ syntypes. 507.

Cnephalia pansa Snow, 1895, Kans. Univ. Quart., vol. 3, no. 3, p. 182. 1 ♂, 4 ♀ syntypes. 508.

Coronimyia geniculata Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 129-130. ♂ holotype (described as ♀). 421.

Cuphocera beameri Reinhard, 1934, Proc. U. S. Nat. Mus., vol. 83, no. 2973, pp. 66-67. ♂ holotype. 1813.

Cuphocera contigua Reinhard, 1934, Proc. U. S. Nat. Mus., vol. 83, no. 2973, pp. 61-63. ♂ holotype, 24 ♀ paratypes. 1805.

Cuphocera flavicornis Reinhard, 1934, Proc. U. S. Nat. Mus., vol. 83, no. 2973, pp. 58-59. ♂ holotype. 1812.

Cuphocera incongrua Reinhard, 1934, Proc. U. S. Nat. Mus., vol. 83, no. 2973, pp. 68-70. ♂ holotype. 1809.

Daeochaeta harveyi Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 98. ♂ holotype. 410.

Dejeania hystricosa Williston, 1885, Trans. Amer. Ent. Soc., vol. 13, p. 297. ♂ lectotype, 5 ♂, 11 ♀ lectoparatypes, Townsend, 1931, Rev. de Ent., vol. 1, fasc. 2, p. 163. 415.

Drepanoglossa lucens Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 378-379. 9 ♂ syntypes (one missing abdomen). 422.

Echinomyia dakotensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 94. 2 ♂ syntypes. 414.

Emphanopteryx eumyothyroides Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 121. ♀ holotype (described as ♂). 434.

Ennyomma clistoides Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 371-372. ♂ holotype. 482.

Epigrimyia polita Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, p. 376. ♂ holotype. 423.

Eucnephalia gonoides Townsend, 1892, Canadian Ent., vol. 24, no. 7, p. 167. ♀ holotype. 427.

Eulasiona comstocki Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 120. ♂ holotype. 429.

Eumyothyria illinoiensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 122. ♀ holotype (described as ♂). 391.

Euphorocera tachinomoides Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 112. ♂ holotype. 425.

Euryceromyia robertsonii Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 116. ♀ holotype. 426.

Euscopolia dakotensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 124-125. ♀ holotype. 428.

Euthyprosopa petiolata Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 107. 3 ♀ syntypes (one without head). 430.

Exopalpus pompalis Reinhard, 1941, Jour. Kans. Ent. Soc., vol. 14, no. 2, pp. 58-60. ♀ holotype, 3 ♀ paratypes. 3342.

Exorista chrysophani Townsend, 1891, Ent. News, vol. 2, no. 10, p. 198. ♀ holotype. 431.

Exorista ciliata Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 363-364. ♂ holotype, 1 ♀ paratype. 525.

Exorista eudryae Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 287-288. ♂ holotype. 432.

Exorista lagoae Townsend, 1891, Ent. News, vol. 2, no. 8, p. 159. ♂ holotype (head missing; remainder in poor condition). 433.

Frontina acroglossoides Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 367-368. ♀ holotype. 4667.

Ginglymia acrirostris Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 119. ♂ holotype. 437.

Gonia exul Williston, 1887, Canadian Ent., vol. 19, no. 1, p. 11. 5 ♀ syntypes (one without head). 441.

Gonia porca Williston, 1887, Canadian Ent., vol. 19, no. 1, p. 10. 2 ♂ syntypes. 443.

Gonia sagax Townsend, 1892, Canadian Ent., vol. 24, no. 3, p. 65. ♂ holotype. 445.

Gonia senilis Williston, 1887, Canadian Ent., vol. 19, no. 1, p. 10. ♂ holotype. 444.

Gonia sequax Williston, 1887, Canadian Ent., vol. 19, no. 1, p. 12. 3 ♂ syntypes. 446.

Goniochaeta plagioides Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 352-353. 1 ♀ syntype. 451.

Gymnochaeta ruficornis Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 302. ♀ holotype. 452.

Gymnochaeta vivida Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 302. ♀ holotype. 453.

Hyalomyia aeneoventris Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 296. 1 ♂ syntype. 387.

Hyalomyia aldrichii Townsend, 1891, Proc. Ent. Soc. Wash., vol. 2, p. 136. 1 ♂ syntype. 4670.

Hyalomyia celer Townsend, 1895, Trans. Amer. Ent. Soc., vol. 22, pp. 65-66. ♀ holotype, 1 ♀ paratype. 3571.

Hyalomyia purpurascens Townsend, 1891, Proc. Ent. Soc. Wash., vol. 2, p. 137. 6 ♂ syntypes (two without heads; one without abdomen). 3569.

Hyalomyia robertsonii Townsend, 1891, Proc. Ent. Soc. Wash., vol. 2, pp. 136-137. 2 ♀ syntypes. 3570.

Hyalomyodes weedii Townsend, 1893, Psyche, vol. 6, no. 204, p. 430. 5 ♂? syntypes. 3572.

Hypertrophocera parvipes Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, p. 361. ♂ holotype (described as ♀). 461.

Hystricia aldrichi Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 91-92. 1 ♂, 2 ♀ syntypes. 3567.

Hystricia soror Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 298. ♀ holotype (missing head). 468.

Hystrichodexia roederi Williston, 1894, Kans. Univ. Quart., vol. 2, no. 2, pp. pp. 77-78. ♂ holotype. 550.

Jurinia (Fabricia) histricoides Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 300. 4 ♂, 4 ♀ syntypes. 544.

Laccoprosopa sarcophagina Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, p. 366. ♂ holotype. 582. Species originally placed in Sarcophagidae.

Leschenaultia grossa Brooks, 1946, Canadian Ent., vol. 78, nos. 9-10, pp. 176-178. ♂ holotype, ♀ allotype, 11 ♂, 2 ♀ paratypes. 3607.

Leucostoma atra Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 380-381. ♂ holotype. 470.

Leucostoma neomexicana Townsend, 1892, Canadian Ent., vol. 24, no. 7, pp. 169-170. ♂ holotype. 471.

Loewia globosa Townsend, 1892, Ent. News, vol. 3, no. 6, pp. 129-130. ♂ holotype. 484.

Loewia nigrifrons Townsend, 1892, Canadian Ent., vol. 24, no. 4, pp. 77-78. ♂ holotype. 485.

Loewia ruficornis Townsend, 1892, Canadian Ent., vol. 24, no. 4, p. 77. ♂ holotype. 483.

Macquartia johnsoni Townsend, 1892, Canadian Ent., vol. 24, no. 4, pp. 81-82. ♀ holotype (described as ♂). 459.

Masicera datanarum Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 287. 2 ♀ syntypes. 439.

Masicera eufitchiae Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 286-287. ♂ holotype. 476.

Masicera (Ceromasia) nigrita Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 358-359. ♂ holotype (genitalia missing). 513.

Masicera protoparcis Townsend, 1892, Jour. Jamaica Inst., vol. 1, no. 2, p. 70. 1 ♂, 1 ♀ syntypes. 4664.

Masicera schizurae Townsend, 1891, Psyche, vol. 6, no. 188, pp. 187-188. 2 ♂ syntypes. 438.

Masicera sordicolor Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 359-360. ♂ holotype. 4673.

Masicera sphingivora Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 286. 2 ♂ syntypes. 436.

Masicera tenthredinidarum Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 285-286. ♀ holotype (without abdomen). 440.

Meigenia hyphantriae Townsend, 1891, Psyche, vol. 6, no. 187, pp. 176-177. 2 ♀ syntypes. 463.

Meigenia websteri Townsend, 1891, Canadian Ent., vol. 23, no. 10, pp. 206-207. 1 ♂, 1 ♀ syntypes. 491.

Megaprosopus michiganensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 111-112. ♀ holotype. 480.

Melanophrys flavipennis Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, p. 306. 1 ♂, 3 ♀ syntypes. 478.

Minthozelia gracilis Reinhard, 1946, Jour. Kans. Ent. Soc., vol. 19, no. 2, pp. 56-57. ♂ holotype, 5 ♂ paratypes. 3646.

Minthozelia nitens Reinhard, 1946, Jour. Kans. Ent. Soc., vol. 19, no. 2, p. 58. ♀ holotype. 3643.

Muscopteryx chaetosula Townsend, 1892, Canadian Ent., vol. 24, no. 7, pp. 171-172. ♀ holotype (described as ♂). 486.

Myothyria vanderwulpi Townsend, 1892, Ent. News, vol. 3, no. 6, p. 131. ♀ holotype (described as ♂). 466.

Nemoraea nigricornis Williston, 1908, Manual of North American Diptera, third ed., pp. 370-371 (manuscript name of C. H. T. Townsend; *nomen nudum* in Townsend, 1893, Psyche, vol. 6, p. 467). ♂ lectotype, 2 ♂ lecto-paratypes (lectotype here designated by C. W. Sabrosky, at his request). 6037.

Neotractocera anomala Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 106. 2 ♀ syntypes. 487.

Nicephorus floridensis Rienhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 64-65. ♂ holotype, ♀ allotype, 9 ♂, 4 ♀ paratypes. 3511.

Ocyptera argentea Townsend, 1891, Proc. Ent. Soc. Wash., vol. 2, no. 1, pp. 144-145. 3 ♂ syntypes. 488.

Ocypterosipha willistoni Townsend, 1894, Jour. N. Y. Ent. Soc., vol. 2, no. 2, p. 79. 2 ♂ syntypes. 4669.

Olenochaeta kansensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 115. ♀ holotype. 411.

Orestilla primoris Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, p. 63. ♂ holotype, ♀ allotype, 3 ♂, 3 ♀ paratypes. 3510.

Orthosia montana Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 61-62. ♂ holotype. 3508.

Orthosia palaga Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, p. 62. ♀ holotype. 3509.

Peleteria biangulata Curran, 1925, Trans. Roy. Soc. Canada, Sect. 5, Series 3, vol. 19, pp. 255-256. ♂ holotype, ♀ allotype, 3 ♂ paratypes. 527.

Peleteria convexa Curran, 1925, Trans. Roy. Soc. Canada, Sect. 5, Series 3, vol. 19, pp. 251-252. ♂ holotype. 531.

Peleteria mediana Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 71-72. ♂ holotype, ♀ allotype, 3 ♂, 4 ♀ paratypes. 3515.

Peleteria neglecta Curran, 1925, Trans. Roy. Soc. Canada, Sect. 5, Series 3, vol. 19, p. 243. ♂ holotype, ♀ allotype, 5 ♂, 2 ♀ paratypes. 535.

Peleteria regalis Curran, 1925, Trans. Roy. Soc. Canada, Sect. 5, Series 3, vol. 19, p. 235. ♀ holotype. 536.

Phasioclista metallica Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 370-371. 2 ♂ syntypes. 481.

Phorocera edwardsii Williston, 1889, Scudder's Butterflies of New England, vol. 3, pp. 1921-1922. ♀ holotype. 3573.

Phorocera lophyri Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 289. ♂ holotype. 3575.

Phorocera promiscua Townsend, 1891, Psyche, vol. 6, no. 181, pp. 84-85. 2 ♀ syntypes. 490.

Phorocera (Prospherysa?) puer Williston, 1896, Trans. Ent. Soc. London, series 4, vol. 29, pp. 354-355. ♂ holotype. 595.

Phyto nigricornis Townsend, 1892, Canadian Ent., vol. 24, no. 7, p. 170. 4 ♂ syntypes. 473.

Phyto senilis Townsend, 1892, Canadian Ent., vol. 24, no. 4, pp. 81-82. ♂ holotype. 472.

Plagia aurifrons Townsend, 1892, Canadian Ent., vol. 24, no. 3, p. 67. ♂ holotype. 597.

Plagiomima haustellata Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 59-60. ♂ holotype, ♀ allotype, 3 ♂, 5 ♀ paratypes. 3507.

Plagiprospherysa floridensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 114. ♂ holotype. 600.

Plagiprospherysa valida Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 113-114. ♂ holotype. 602.

Polidea americana Townsend, 1892, Canadian Ent., vol. 24, no. 4, p. 82. 1 ♂ syntype. 4668.

Prosenoides grandis Reinhard, 1954, Canadian Ent., vol. 86, no. 9, p. 413. ♂ holotype, ♀ allotype, 7 ♂, 2 ♀ paratypes. 5448.

Pseudogonia ruficauda Townsend, 1892, Canadian Ent., vol. 24, no. 3, p. 66. ♂ holotype. 4671.

Pseudohystricia exilis Townsend, 1892, Ent. News, vol. 3, no. 6, pp. 146-147. ♀ holotype. 467.

Pseudomyothria indecisa Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 132. ♂ holotype. 465.

Pseudatractocera neomexicana Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 108. 3 ♂, 1 ♀ syntypes. 493.

Rhinophora mexicana Townsend, 1892, Canadian Ent., vol. 24, no. 7, pp. 168-169. 4 ♂ syntypes. 494.

Rhinophora valida Townsend, 1892, Canadian Ent., vol. 24, no. 7, pp. 167-168. ♂ holotype (with part of abdomen broken). 495.

Saundersia bicolor Williston, 1887, Trans. Amer. Ent. Soc., vol. 13, p. 304. 1 ♂, 1 ♀ syntypes. 416.

Saundersia maculata Williston, 1887, Trans. Amer. Ent. Soc., vol. 13, p. 304. ♀ holotype (described as ♂). 417.

Sciasma lustrans Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 58-59. ♂ holotype. 3506.

Scopolia sequax Williston, 1875, *in* Cook, Notes on Injurious Insects, Entomological Laboratory, Michigan Agric. College. ♀ holotype. 596.

Siphoclytia robertsonii Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 117-118. ♂ holotype. 424.

Siphona illinoiensis Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 368-369. 1 ♀ syntype. 503.

Siphophyto floridensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 128. ♂ holotype (described as ♀). 419.

Siphophyto neomexicanus Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 128. ♀ holotype. 420.

Siphoplagia anomala Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 350-351. 3 ♀ syntypes. 505.

Tachina clisiocampae Townsend, 1891, Psyche, vol. 6, no. 181, pp. 83-84. 1 ♂ syntype. 514.

Tachina orgyiae Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 284-285. ♀ holotype. 515.

Tachina spinosula Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 353-354. ♀ holotype. 520.

Tachina tenthredinivora Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 285. ♀ holotype. 516.

Tachinomyia floridensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 97. ♂ holotype. 518.

Tachinomyia robusta Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, pp. 96-97. 4 ♂ syntypes. 511.

Tachinophyto floridensis Townsend, 1892, Trans. Amer. Ent. Soc., vol. 19, p. 131. ♀ holotype. 464.

Thryptocera americana Townsend, 1892, Canadian Ent., vol. 24, no. 3, pp. 69-70. ♀ holotype. 4666.

Trichopoda subcilipes Townsend, 1894, Jour. N. Y. Ent. Soc., vol. 2, no. 2, pp. 78-79. 3 ♂, 1 ♀ syntypes. 521.

Trixa gillettei Townsend, 1892, Canadian Ent., vol. 24, no. 3, p. 68. ♂ holotype. 5804.

Tryphera americana Townsend, 1892, Canadian Ent., vol. 24, no. 4, pp. 78-79. ♀ holotype. 601.

Vanderwulpia atrophopodoides Townsend, 1891, Trans. Amer. Ent. Soc., vol. 18, pp. 381-382. 2 ♀ syntypes (described as ♂). 523.

Vanderwulpia sequens Townsend, 1892, Canadian Ent., vol. 24, no. 7, p. 172. ♀ holotype (described as ♂). 524.

Wahlbergia atripennis Townsend, 1891, Proc. Ent. Soc. Wash., vol. 2, no. 1, pp. 145-146. ♂ lectotype, 2 ♂ lectoparatypes (one without abdomen), Sabrosky, 1950, Jour. Wash. Acad. Sci., vol. 40, p. 365. 418.

Zenillia collina Reinhard, 1944, Jour. Kans. Ent. Soc., vol. 17, no. 2, pp. 68-69. ♂ holotype, ♀ allotype, 6 ♂ paratypes. 3514.

TACHINIDAE—Paratypes

Aglummyia percinerea Townsend. 1 ♀. 435.

Alophorella polita Brooks. 1 ♂. 3545.

Anetia parvula Reinhard. 4 ♀. 5785.

Archytas dux Curran. 8 ♀ (1 without head). 548.

Archytas vulgaris Curran. 302 ♂ & ♀. 545.
Belvosia semiflava Aldrich. 6 ♂, 7 ♀. 395.
Belvosia spinicoxa Aldrich. 1 ♀. 396.
Belvosia townsendi Aldrich. 1 ♂, 1 ♀. 405.
Cryptomeigenia muscoides Curran. 2 ♂ (1 without abdomen). 392.
Cuphocera aurifrons Reinhard. 1 ♂, 4 ♀. 409.
Cuphocera parksi Reinhard. 1 ♂. 1811.
Cuphocera torosa Reinhard. 1 ♂. 1810.
Cylindromyia armata Aldrich. 5 ♂ (1 without abdomen). 541.
Cylindromyia decora Aldrich. 10 ♂, 2 ♀. 540.
Cylindromyia nigra Aldrich. 2 ♂ (1 missing abdomen). 542.
Cylindromyia vulgaris Aldrich. 32 ♂ & ♀ (3 heads, 3 abdomens missing). 543.
Ernestia platycarina Tothill. 1 ♂ (genitalia missing), 3 ♀. 549.
Eudexia dreisbachi Reinhard. 5 ♂, 7 ♀. 5786.
Fabriciella lutzi Curran. 1 ♂. 413.
Fabriciella nivalis Tothill. 1 ♂, 1 ♀. 412.
Gonia aldrichi Tothill. 2 ♂. 442.
Gonia breviforceps Tothill. 2 ♂. 447.
Gonia brevipulvilli Tothill. 2 ♂. 448.
Gonia longiforceps Tothill. 2 ♂. 449.
Gonia longipulvilli Tothill. 1 ♂. 450.
Hyalomyiopsis robusta Brooks. 1 ♀. 3584.
Hypenomyia petiolata Townsend. 1 ♀. 460.
Leschenaultia halisidotae Brooks. 2 ♂, 1 ♀. 3608.
Leucostoma acirostre Reinhard. 1 ♂. 5787.
Lixophaga fasciata Curran. 2 ♂, 3 ♀ (one without head). 469.
Masiphyomyia paralis Reinhard. 2 ♂. 3512.
Microphthalma phyllophagae Curran. 3 ♂, 2 ♀. 5789.
Minthozelia argentosa Reinhard. 1 ♂. 3645.
Neonyctia ciliata Townsend. 1 ♀. 462.
Onychogonia magna Brooks. 2 ♀. 3518.
Orphanotrophus orbitalis Reinhard. 1 ♂. 5773.
Pantagathus curulis Reinhard. 1 ♂. 3343.
Paradidyma affinis Reinhard. 1 ♂, 2 ♀. 1806.
Paradidyma apicalis Reinhard. 2 ♂. 5774.
Paradidyma petiolata Reinhard. 1 ♂, 1 ♀. 1807.
Peleteria aclista Reinhard. 1 ♂. 5775.
Peleteria bryanti Curran. 18 ♂ & ♀. 528.
Peleteria campestre Curran. 73 ♂ & ♀. 529.
Peleteria clara Curran. 27 ♂ & ♀. 530.
Peleteria confusa Curran. 4 ♂, 5 ♀. 532.
Peleteria conjuncta Curran. 1 ♂, 1 ♀. 539.
Peleteria cornigera Curran. 3 ♂, 1 ♀. 537.
Peleteria cornuta Curran. 1 ♀. 533.
Peleteria eronis Curran. 102 ♂ & ♀. 534.
Peleteria texensis Curran. 1 ♂, 1 ♀. 538.
Phryxe tolucana Reinhard. 1 ♀. 5776.
Plagiomima alternata Aldrich. 2 ♀. 598.
Plagiomima cognata Aldrich. 2 ♂. 599.
Pseudochaeta perdecora Reinhard. 1 ♀. 3644.

Rileymyia triseta Brooks. 6 ♂, 1 ♀. 3609.
Siphophyto politura Reinhard. 1 ♂. 3583.
Siphophyto turmalis Reinhard. 1♀. 3582.
Siphoplagiopsis similis Townsend. 2 ♀. 506.
Siphosturmia confusa Reinhard. 4 ♂, 4 ♀. 5803.
Sthenopleura latifrons Aldrich. 2 ♂. 504.
Sturmia crescentis Reinhard. 5 ♂, 7 ♀. 3513.
Tachinomyia apicata Curran. 1 ♂, 1 ♀. 510.
Tachinomyia dakotensis Webber. 1 ♂. 519.
Tachinomyia occidentalis Curran. 2 ♂. 509.
Tachinomyia variata Curran. 3 ♂, 2 ♀. 512.

THEREVIDAE

Epomyia flavipes Hardy, 1943, Jour. Kans. Ent. Soc., vol. 16, no. 1, p. 26. ♂ holotype, 3 ♂ paratypes. 3277.
Psilocephala acuta Adams, 1903, Univ. Kans. Sci. Bull., vol. 2, no. 5, p. 222. 1 ♂, 3 ♀ syntypes (2 ♀ broken but repaired). 135.
Psilocephala lateralis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 444. ♂ holotype. 136.
Psilocephala occipitalis Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 443. ♂ holotype. 138.
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Thereva anomala Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, p. 444. 1 ♂, 1 ♀ syntypes. 139.
Thereva crassicornis Williston, 1886, Trans. Amer. Ent. Soc., vol. 13, pp. 293-294. 1 ♂ syntype. 140.

THEREVIDAE—Paratypes

Psilocephala frontalis Cole. 1 ♂, 6 ♀. 137.

TIPULIDAE

Dolichopeza (Dolichopeza) borealis Byers, 1961, Univ. Kans. Sci. Bull., vol. 42, no. 6, pp. 795-796. ♀ holotype. 6094.
Eriocera eriophora Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, pp. 61-62. 1 ♂, 1 ♀ syntypes. 1.
Eriocera obscura Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, p. 61. 4 ♀ syntypes. 2.
Eriocera rubrinota Alexander, 1918, Canadian Ent., vol. 50, no. 5, p. 165. ♀ holotype. 3.
Raphidolabis debilis Williston, 1893, Kans. Univ. Quart., vol. 2, no. 2, p. 62. 1 ♀ syntype (thorax only). 4.
Tipula acuta Doane, 1901, Jour. N. Y. Ent. Soc., vol. 9, no. 3, pp. 116-117. 1 ♂ syntype (genitalia missing). 6.
Tipula dorsolineata Doane, 1901, Jour. N. Y. Ent. Soc., vol. 9, no. 3, p. 98. 1 ♀ syntype. 5.
Tipula mandan Alexander, 1915, Proc. Acad. Nat. Sci. Phil., vol. 67, pp. 499-501. ♂ holotype, ♀ allotype (without abdomen), 5 ♂ paratypes. 11.
Tipula rangiferina Alexander, 1915, Proc. Acad. Nat. Sci. Phil., vol. 67, pp. 498-499. ♂ holotype, ♀ allotype. 9.
Tipula retusa Doane, 1901, Jour. N. Y. Ent. Soc., vol. 9, no. 3, p. 109. 1 ♂ syntype. 13.
Tipula spectabilis Doane, 1901, Jour. N. Y. Ent. Soc., vol. 9, no. 3, pp. 120-121. 1 ♂ syntype (without abdomen). 8.

Tipula streptocera Doane, 1901, Jour. N. Y. Ent. Soc., vol. 9, no. 3, p. 113. 1 ♀ syntype. 12.

Tipula sulphurea Doane, 1901, Jour. N. Y. Ent. Soc., vol. 9, no. 3, p. 99. 1 ♂ syntype. 14.

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TIPULIDAE—Paratypes

Cryptolabis (Cryptolabis) sica Alexander. 2 ♂, 1? (without abdomen). 5328.

Dicranoptycha minima Alexander. 2 ♂. 15.

Dicranoptycha tigrina Alexander. 2 ♀. 16.

Erioptera maria Alexander. 1 ♂? (apex of abdomen missing). 5329.

Oropeza obscura Johnson. 1 ♂. 1350.

Tipula flavibasis Alexander. 2 ♂, 1? (apex of abdomen missing). 10.

Tipula spenceriana hardyi Alexander. 2 ♂. 5326.

TRYPETIDAE

Dacus africanus Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 169. 1 ♂ syntype. 784.

Euaresta bellula Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 172. ♀ lectotype, 1 ♂ (without head), 2 ♀ lectoparatypes, Foote, 1962, Jour. Kans. Ent. Soc., vol. 35, no. 1, p. 173. 475.

Euaresta latipennis Townsend, 1893, Zoe, vol. 4, no. 1, pp. 13-15. ♀ holotype. 666.

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Eurosta fenestrata Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 169-170. ♀ holotype. 658.

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Eutreta diana var. *tricolor* Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 168. ♀ lectotype, Foote, 1962, Jour. Kans. Ent. Soc., vol. 35, no. 1, p. 178. 656.

Eutreta longicornis Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 168. ♂ holotype (only thorax and parts of legs remain). 657.

Icterica fasciata Adams, 1904, Univ. Kans. Sci. Bull., vol. 2, no. 14, pp. 449-450. ♀ lectotype, 1 ♂, 2 ♀ lectoparatypes, Foote, 1962, Jour. Kans. Ent. Soc., vol. 35, no. 1, p. 174. 661.

Oedaspis minuta Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 164. ♂ holotype. 650.

Oedaspis montana Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 163-164. ♂ holotype. 651.

Oedicarena diffusa Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 161-162. ♀ lectotype, 2 ♂, 1 ♀ lectoparatypes, 2 additional ♀ with "type" labels, Foote, 1962, Jour. Kans. Ent. Soc., vol. 35, no. 1, p. 174. 647.

Polymorphomyia basilica Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 165-166. ♀ holotype. 649.

Rhagoletis zephyria Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 164-165. ♂ lectotype, 3 ♂ lectoparatypes, Foote, 1962, Jour. Kans. Ent. Soc., vol. 35, no. 1, pp. 178-179. 654.

Stenopa affinis Quisenberry, 1949, Jour. Kans. Ent. Soc., vol. 22, no. 3, pp. 87-88. ♀ allotype. 4543.

Tephritis arizonaensis Quisenberry, 1951, Jour. Kans. Ent. Soc., vol. 24, no. 2, pp. 62-64. ♀ holotype, ♂ allotype, 1 ♂, 3 ♀ paratypes. 5902.

Tephritis dupla Cresson, 1907, Trans. Amer. Ent. Soc., vol. 33, p. 102. 1 ♂ syntype made lectoparatype, by Foote, 1962, Jour. Kans. Ent. Soc., vol. 35, no. 1, p. 174. 662.

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Tephritis obscuripennis Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 174. ♂ holotype. 663.

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Trypeta occidentalis Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, p. 163. ♀ lectotype, 1 ♂, 2 ♀ lectoparatypes, McFadden and Foote, 1961, Proc. Ent. Soc. Wash., vol. 62, pp. 253-261. 648.

Trypeta straminea Doane, 1899, Jour. N. Y. Ent. Soc., vol. 7, no. 3, pp. 179-180. 2 ♂ syntypes (1 without head) made lectoparatypes by Foote, 1962, Jour. Kans. Ent. Soc., vol. 35, no. 1, p. 177. 655.

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Urellia peregrina Adams, 1905, Univ. Kans. Sci. Bull., vol. 3, no. 6, p. 170. 5 ♂ (1 without head), 1 ♀ syntypes. 749.

Xenochaeta dichromata Snow, 1894, Kans. Univ. Quart., vol. 2, no. 3, pp. 166-167. ♂ holotype. 660.

TRYPETIDAE—Paratypes

Dacus (Strumeta) arceae Hardy and Adachi. 2 ♂. 5314.

Dacus (Paratridacus) expandens melanius Hardy and Adachi. 1 ♂. 5317.

Dacus (Strumeta) kraussi Hardy. 2 ♂. 5315.

Dacus (Strumeta) laticaudus Hardy. 2 ♀. 5316.

Dacus (Heterodaculus) visendus Hardy. 1 ♂. 5318.

Rhagoletis symphoricarpi Curran. 1 ♂, 2 ♀. 652.

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Effects of Narcosis on Motility in the Embryonic Toadfish (*Opsanus tau*)

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Abstract: *d-tubo-curarine.* 1. Since curarine dramatically and completely abolished all somatic movements, it must be concluded that the spontaneous motility and somatic reaction to exogenous stimuli of the intact toadfish embryo are nervous in character.

2. The onset of respiration by the gills was observed to coincide with a smaller dosage being effective and a significant increase in mortality.

Veratrine sulfate. 1. Veratrine always produces contracture, spasm, and heightened motor activity in the toadfish embryo.

2. From the reported mechanism of veratrine's action in the literature and from the empirical fact that curarine masks its action, it was concluded that the motor neuron—motor end plate—muscle chain must be intact for veratrine to act.

Veratrine and curarine. 1. The empirical results support the thesis that curarine is physiologically active in less than two minutes.

2. The reaction to veratrine of the toadfish embryo is judged to be additional evidence in favor of the neurogenic origin of motility.

Strychnine. 1. Although the toadfish embryo will not react to tactile stimuli for four days or more after hatching, at hatching the toadfish embryo does have a functional reflex arc—as indicated by the reaction to strychnine.

Also, histological studies show that it is not until the middle of stage VI (approximate hatching time) that the toadfish has developed a complete system of afferent spinal nerve fibers (Tracy '60).

2. It is of significance that the reaction to strychnine is commensurate with hatching, for hatching is a time of tremendous flux for the toadfish.

3. The earlier assumption of function by the flexor musculature is of interest; this parallels what Coghill found to be true for amphibians and reptilians. These results strengthen Sherington's original interpretation of noiceptive reflexes.

4. The sudden increase in mortality rate in stage VIII and later stage embryos following injection of strychnine or curarine has direct bearing on the problem of assumption of function by the respiratory apparatus since the toadfish embryo is making the transition from respiration by diffusion to respiration by regular movement of the gills. This conclusion is quite feasible since both curarine and strychnine bring about death to the embryo by interference with respiration that results in exhaustion and asphyxia.

5. The sudden decrease in dosage in stage VIII and later stage embryos for both curarine and strychnine may have several different interpretations; it may mean that the target cells of the drugs are more differentiated now and hence metabolism in them is more delicately balanced; this in turn may be related to the changes in the toadfish that occur at hatching.

Camphor. 1. The spinal convulsions which begin at hatching when the toadfish is exposed to camphor are not as vigorous as the strychnine convulsions which also begin at hatching.

2. The camphor epileptiform convulsions which begin in late stage VI are believed to indicate stimulation of higher centers which are capable of activity at that time.

NARCOTIZATION OF EMBRYONIC TOADFISH

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CONTENTS

Narcotization of Embryonic Toadfish

INTRODUCTION

This study is a phase of the problem of development of behavior and motility of the toadfish (*Opsanus tau*). The effects of four drugs—d-tubo-curarine, veratrine sulfate, strychnine sulfate, and camphor—on the motor activity of the toadfish embryo are reported. The major part of the experimental work was carried out at the Marine Biological Laboratory at Woods Hole, Massachusetts.

There has been considerable progress in embryonic neurophysiology, but still much of embryonic neurophysiology concerns itself with observation and interpretation of the gross movements of the embryo. Such studies are of special value when they lead to direct physiological experimentation.

The stages in the development of behavior and motility in the toadfish embryo have been accurately established (Tracy '59), and thus the experimenter has a stable foundation for neurophysiological work.

When drugs enter the embryo by immersion, the yolk sac with its rich vascular network furnishes an easy access to the blood stream. For this reason a detailed description of the vascular net follows.

The blood supply to the yolk sac is through the vitelline artery which is located in a more or less sagittal position posteriorly and ends frequently in bilateral branches which form a loop at the base of the yolk sac. The anterior convergence of this loop is the beginning of the vitelline vein which runs dorsally in an anterior sagittal position, ending in the snus venosus. Between these two large vitelline vessels, numerous connecting links occur; some are true arteriovenous anastomoses; others are arterioles ending in capillary loops which converge to form venules which in turn enter the vitelline vein. The arterial twigs end in truncated cones as does the vitelline artery. The flow of blood is non-laminar, that is, it is turbulent. This turbulence has the appearance of a true "sludge," using Knisely's terminology ('47). The basic units are two or three agglutinated red cells. The embryos are thrown into violent "spasms" of S-shape movements due to the accumulation of metabolic products in the internal environment. After each of such episodes, the turbulence of the blood is increased. Periods of inactivity allow the turbulence to clear up. The reason for the agglutination and its partial disappearance is unknown.

Stages in the Development of Motility and Behavior in *Opsanus tau* According to Tracy ('59)

Age in days:	Stage of develop-ment	Duration of stage in days	Length	General description
0-5-6	I	1-5		Germ ring and primitive streak, to formation of first somite.
7-8	II	2-3		1-11 somites; two half tubes fuse to form heart.
8-9	III	2-3	2.75mm.	12-17 somites inclusive. Heart commences beating. First somatic contractions in 2-5 most anterior somites occur at beginning of stage IV.
9-11	IV	2	4mm.	18-30 somites. Body contracts into "C" coil; tail is dragged passively; embryo rolls on side. Yolk sac response to stimulation begins. At 30 somites 8 neuromeres in 4th ventricle; first 8 somites contract.
17	V	6	6mm.	31 somites to the beginning of respiratory movements. Tail becomes motile; embryo, as a result, is often contracted into an "S" coil.
26-27	VI	9-10	7.5mm.	Tentative respiratory jaw movements begin and are irregular and jerky (either side of mandible may move separately). Hatching early in this stage, very variable in time. Reaction to exogenous stimuli begins.
36	VII	9	9-13mm.	At transition to this stage, tactile reflex is obtainable from margins of mouth and on pectoral fin; reaction to same side: response over whole body is completed in this stage. Reaction to vibration elicited in latter part of stage. Spontaneous movements of individual eye muscles are developed in this stage.
35 to 40 or more	VIII	4	15mm.+	Reaction of eyes to rotation develops in this stage; slightly before reaction of body coiling to rotation. These reactions overlap so that it is difficult to separate stages. Beyond about 40 days age, all reflexes seem complete and motility responses belong to study of behavior.

MATERIALS AND METHODS

Eggs. The fish embryos were obtained by collection trips at low tide to shallow waters in the vicinity of the Marine Biological Laboratories, Woods Hole, Massachusetts, where the toadfish spawns in June and July.

A total of 441 eggs were used. One hundred eggs were used for preliminary calculation of dosage and development of technique. The remaining 341 eggs were divided into two groups, the control and the experimental, comprising 21 and 320 embryos, respectively.

Immersion. The toadfish embryos were immersed in isotonic drug (curarine, veratrine, strychnine, camphor) solutions at the various stages of development.

There is no information of how much of the drug is absorbed when the embryo demonstrates the effects of immersion. And further, since it is not likely that all drugs are absorbed directly through the body wall or yolk sac (during early stages when there are few or no respiratory movements), it was necessary to develop a technique of microinjection.

Injection. The drugs used were either obtained in an isotonic medium directly from a pharmaceutical supply house or were procured in powder form from the Marine Biological Laboratories and then dissolved in isotonic medium.

Glass needles (0.8 mm. outside diameter) drawn out to an outside diameter of 0.07 to 0.09 mm. were used in the injections. The microneedles were held by a microneedle holder which, in turn, was connected by metal tubing to a ¼ cc. syringe. The plunger of the syringe was in contact with the head of a micrometer screw; by turning the micrometer through a certain number of degrees an injection of 0.0001 cc. could be made.

Several sites for injection are possible in the toadfish embryo. Because of the consistency of results and comparative ease of injection the ventricles of the developing nervous system were the favored site of injection; this is the only type of injection reported in this paper. Histological study indicates that damage to the embryo from such an injection is negligible.

Because of the delicacy of the operation a team of two people made the injections. One person inserted the microneedle into the embryo (the embryo was removed previously from its delicate protective membrane and placed in a sponge in a dish of sea water). The other person timed the operation, manipulated the micrometer, and ascertained that the pressure of the drug solution in the microneedle, tubing, and syringe was equal.

Methods of observation. In all embryos the heart rate, the respiratory rate, the somatic movements (number, kind, strength), and the response to stimulation (yolk sac pressure and cutaneous stimulation) were noted for approximately 5 to 10 minutes before injection. The same observations were made after injection or immersion until the full pharmacological action of the drug was apparent; (this period varied from 5 to 30 minutes, depending upon which drug was used and the dosage of the same). The embryos were then observed at 15-minute intervals until they had fully recovered from the injection or immersion.

EXPERIMENTS AND RESULTS

1. Injection of curarine

Dosage. One hundred embryos were injected with d-tubo-curarine. Of these embryos, 30 were of stage IV, 15 of stage V, 15 of stage VI, 10 of stage VII, 10 of stage VIII, and 20 were of later stages. Different dosages were effective at each stage of development. The physiologically effective dosage at the various stages (curarine) is summarized in Table VII; it is that dosage which produces consistent results and the lowest mortality rate.

TABLE I.—Effect of Various Dosages of Curarine on Stage IV Toadfish Embryos

Number	Age in somites	Dosage	Complete curarization	Partial curarization	Full recovery time (from injection)
101–103	20–22	2 μ gm.	2–2½ hr.	2–2½ hr.	4–5½ hr. (No. 101 dead, 12 hr.)
104–106	23–24	3	2½–3	3–3½	6–6½
107	24	6	4½	5	dead, 9½ hr.
108–111	26	3	2–2½	2½–4	5½–6
112	26	2	2	1	3
113	26	6	4	3	dead, 7 hr.
114	27	3	2	....	dead, 2 hr.
115–119	29–30	4	2–2½	2–3½	4–6
120–123	30–31	6	2½–3	3½–4	6–7 (No. 120 dead, 11 hr.)
124–124	31	10	3–3¼	3½–4	both dead, 7 hr.
126	31	4	2	½	2½
127–128	31	2	....	½	½
129–130	31–32	7	2	1½–2	3½–4

COMMENT

Stage IV embryos—Injection of d-tubo curarine. In 25-70 seconds after injection of curarine all somatic movements were completely and dramatically abolished (embryos number 127 and 128 and were not completely curarized; they received ¼ the dosage of other embryos of similar somite number).

The duration of complete abolition of all movement (complete curarization) was variable (two-three hours). While completely curarized the embryos exhibited paralysis, resembling that usually described as the spastic type, although no conclusions regarding the mechanism of the paralysis are here drawn. The individual muscle of the curarized embryo will respond to direct stimulation (with fine pointed glass microneedle).

Following complete curarization there was a period of apparent recovery from the effects of the drug in which the embryo was judged to be partially curarized (yolk sac stimulation must be of higher intensity or frequency than before injection in order to provoke motor activity). The duration of the period of apparent recovery is variable (one-six hours) and difficult to determine accurately for the embryo is gradually assuming all of the overt activities and reactions that it had previous to injection.

Within 18 hours, 7 of 30 embryos died; four of these embryos (numbers 107, 113, 124 and 125) received double dosages (as compared to other embryos of similar somite number). The mortality rate was therefore 11.5% (three deaths, 26 embryos).

There was no difference in heart rate between control and experimental groups.

TABLE II.—Effect of Various Dosages of Curarine on Stage V Toadfish Embryos

Number	Age by stage	Dosage	Complete curarization	Partial curarization	Full recovery time (from injection)
131–133	early V	7 u gm.	1–1½ hr.	1–2 hr.	2–3 hr. (No. 132 dead, 24 hr.)
134		15	4	1	dead 5 hr.
135–137		7	½–1	½–1½	1½–2
138		3	....	2	2
139–142	late V	8	1–1¼	1–3	2–4 (No. 141 dead, 26 hr.)
143–144		9	1¼–1½	1½–2	3–3½
145		15	6	2	8 (dead, 12 hr.)

COMMENT

Stage V embryos—Injection of d-tubo-curarine. The results of the stage V injections are essentially similar to that of the stage IV injections. Complete curarization varied from ½ to 1½ hours in duration; partial curarization varied from one to two hours. Half dosage (number 138) was ineffective; double dosage (numbers 134 and 145) resulted in 100% mortality. The mortality rate was 13% (two deaths, 13 embryos).

TABLE III.—Effect of Various Dosages of Curarine on Stage VI Toadfish Embryos

Number	Age by stage	Dosage	Complete curarization	Partial curarization	Total recovery time
146–148	early VI	8 u gm.	0–½ hr.	1–1½ hr.	1½–2 hr.
149–150		8	½	½–1	1–1½ (both dead, 18 hr.)
151	middle VI	8	....	1½	1½
152	early VI	8	1	1	2
153–154	middle VI	10	1–1½	1–1½	2½
155–158		11	1–1½	1¼–1½	2½–3
159		16	3	5	8 (dead, 9 hr.)
160		4	....	¼	¼

COMMENT

Stage VI embryos—Injection of d-tubo-curarine. Embryos of stage VI exhibit a very characteristic period of irregular convulsant activity for 40-105 seconds immediately following injection of curarine; this period of heightened motor activity and convulsant spasms is soon masked by the spastic paralysis of complete curarization.

Again small dosage (numbers 147, 151 and 160) failed to completely curarize; these embryos reacted with convulsions to yolk

TABLE IV.—Effect of Various Dosages of Curarine on Stage VII Toadfish Embryos

Number	Age by stage	Dosage	Complete curarization	Partial curarization	Total recovery time
161–164	early VII	11 u gm.	2½–3½ hr.	5–7½ hr.	8–9½ hr. (3 dead, 20 hr.)
165–169	(7.6 to	6	1–1¼	1–1½	2–2½
170	7.9 mm.)	2	....	¼	¼

sac stimulation (the tail contracted at the same time through a smaller arc).

An elevated dosage (number 159) resulted in curarization of long duration and death. The mortality rate was 14% (two death, 14 embryos).

COMMENT

Stage VII embryos—Injection of d-tubo-curarine. The results of the stage VII injections are essentially similar to that of the stage VI injections. High dosage (numbers 161-164) resulted in long duration of curarization and a 75% mortality rate. Small dosage (number 170) produced convulsant activity.

The mortality rate was 0.0% for those embryos who received a dosage near the correct level (numbers 165-169).

TABLE V.—Effect of Various Dosages of Curarine on Stage VIII Toadfish Embryos

Number	Age by stage	Dosage	Complete curarization	Partial curarization	Total recovery time
171–174	early VIII	7 u gm.	2–3 hr.	4–5 hr.	6½–7 hr. (all dead, 14 hr.)
175–177		5	1–1¼	1–1½	2–2½ (177 dead, 19 hr.)
178–179		4	½	½	1 (178 dead, 12 hr.)
180		2	. . . .	½	½

COMMENT

Stage VIII embryos—Injection of d-tubo curarine. The results of the stage VIII injections are similar to that of the stage VII injections. High dosage (numbers 171-174) resulted in 100% mortality.

The mortality rate was 40% for those embryos who received a therapeutic dosage (two deaths, 5 embryos).

TABLE VI.—Effect of Various Dosages of Curarine on Later Stage Toadfish Embryos

Number	Age by length	Dosage	Complete curarization	Partial curarization	Total recovery time
181–183	13.2 mm.	12 gm.	1 hr.	3–3¼ hr.	4–4½ hr. (No. 182 dead, 30 hr.)
184–185	13.6	10	1–1½	3–3¼	4–4½
186	13.6	20	3½	4½	8 (dead, 14 hr.)
187–188	18.1	15	1½–2	2½–3	4¼–5 (No. 187 dead, 18 hr.)
189–190	18.6	30	4½–5½	6–6½	11–11½ (both dead, 12 hr.)
191–195	19.5	15	2–2½	2½–3	4½–5½ (2 dead, 32 hr.)
196	20.4	30	4	3½	7½ (dead, 13 hr.)
197–198	20.7	18	2–2½	3–3½	5–6 (No. 197 dead, 26 hr.)
199–200	22.4	30	3½–4	2½–3	6½–7½ (both dead, 14 hr.)

COMMENT

Later Stage Embryos—Injection of de-tubo-curarine. The results of these injections are similar to those of stage VIII injections. The mortality rate was 36% (5 deaths, 16 embryos).

TABLE VII.—Summary of Physiologically Effective Dosages of D-Tubo-Curarine for the Various Stages of Development of the Toadfish Embryo

Stage of development	Dosage	Mortality rate
Early stage IV (20–26 somites)	2–3 u gm.	9%
Late stage IV (28–30 somites)	4–6	15
Early stage V	7	17
Late stage V	8–9	15
Stage VI	10–11	14
Early stage VII	6	0
Early stage VIII	5	40
Later stages (13.2–22.6 mm.)	12–18	36

2. Immersion in veratrine sulphate

Fifty embryos were immersed in an isotonic solution of veratrine sulfate (one milligram per cc. of sea water). It was not necessary to inject these embryos as the effect of the drug was very apparent. Of these embryos, 20 were of stage IV, 5 of stage V, 5 of stage VI, and 10 were of later stages.

Stage IV embryos—Immersion in veratrine sulfate. Since immersion of the embryos in veratrine produced marked and consistent alterations in behavior, this paper reports observations only of embryonic toadfish immersed in sea water containing one milligram of veratrine sulfate per cc.

Within two minutes after immersion the embryos demonstrated three effects: First, there was a striking increase in movement (200-2100% increase as compared to control groups); secondly, all movement resulted in a characteristically prolonged contracture of the body musculature (the embryo, having contracted into a coiled "C," would remain in that position for several seconds); in the third place there was convulsant activity that usually expressed itself either just previously to or immediately following the periods of contracture (the tail would shake either while contracted and in a coil or while relaxed and straight—less frequently there would be convulsions of the tail in the partially contracted state). This period of high motor activity varied from two to six minutes.

These periods of high activity occurred spontaneously and seemed to recur in cycles; stimulation of the embryo (yolk sac) resulted in a typical period of heightened activity and convulsive contracture.

All embryos were removed from the isotonic veratrine within five minutes. Recovery from the effects of immersion was variable (11-19 hours). The mortality rate was 20% (4 deaths, 20 embryos). The embryos were distributed throughout stage IV as follows:

20 somites—two embryos
21 somites—two embryos
22 somites—three embryos
23 somites—two embryos
23 somites—three embryos
25 somites—two embryos
26 somites—four embryos
28 somites—one embryo
29 somites—one embryo

Stage V and VI embryos—Immersion in veratrine sulfate. Five embryos of stage V and 5 embryos of stage VI were immersed in isotonic veratrine with results similar to that obtained upon immersion of stage IV embryos. The mortality rate in both instances was 20%.

Later stage embryos—Immersion in veratrine sulfate. The 10 embryos that were used varied from 14-19 millimeters in length; again there were cycles of heightened activity with convulsant wriggling and spasms terminating in contracture.

First there was a slight lowering of heart rate (10-15%). This was followed by a period of heightened convulsant and contracture activity (three-six minutes); the heart rate was now increased

(30-60%); respiration was also increased (40-80%), becoming deeper and then very irregular. This period of high activity terminated with the embryo undergoing irregular, slow, and extremely forced respiratory movements; it was usually not possible to stimulate the embryo to further activity at this time.

After a variable duration of time (10 minutes to several hours) the embryo again underwent a similar period of high activity. The duration of time between periods of high activity became greater and gradually the embryos assumed reactions to stimuli and spontaneous movements that were normal for their stage of development.

Two embryos died in 24 hours. There were no other deaths. The mortality rate was therefore 20%.

3. Combination experiments—veratrine and curarine

Forty embryos (10 of stage IV, 10 of stage V, 10 of stage VI, and 10 of stage VII) were used in various combination of curarine and veratrine.

Sixteen embryos (4 of stage IV, 4 of stage V, 4 of stage VI, 4 of stage VII) were immersed in isotonic veratrine (1 mgm. veratrine per cc. sea water). At the onset of the veratrine reaction the embryos were injected with the empirically effective dosage of d-tubocurarine. Within 45-90 seconds following the injection of curarine all movement was abolished. The embryos were kept in the veratrine about 5 minutes. The embryos were slow to recover from the effect of both the drugs (15-32 hours). The mortality rate was 56% (three of stage IV, one of stage V, three of stage VI, and two of stage VII were dead within 36 hours).

Twelve embryos (three of stage IV, three of stage V, three of stage VI, three of stage VII) were first injected with the correct dosage of curarine and then immediately immersed in isotonic veratrine and left in the veratrine for 5 minutes. All somatic movements were abolished in 50-68 seconds. Full recovery time varied from 18-28 hours; the mortality rate was 50% (two of stage IV, one of stage V, and one of stage VI, and two of stage VII were dead in 36 hours).

Twelve embryos (three of stage IV, three of stage V, three of stage VI, three of stage VII) were injected with the correct dosage of curarine and immersed in isotonic veratrine two-four minutes later. There was no movement in any of the embryos. Full recovery time varied from 16-23 hours; the mortality rate was 42% (one of stage IV, two of stage V, one of stage VI, one of stage VII were dead in 36 hours).

4. Injection of Strychnine sulphate

One hundred and ten embryos were injected with strychnine. Of these embryos, 10 were of stage IV, 30 of stage V, 30 of stage VI, 14 of stage VII, 16 of stage VIII and 10 were of later stages. The physiologically effective dosage at the various stages (strychnine) is summarized in Table VIII.

Stage IV embryos—Injection of strychnine sulfate. There was no significant change in heart rate, reaction to stimuli, or in the character of motility following injection of 10 embryos (representative of stage IV) with dosages of strychnine varying from 0.5 to 5 micrograms. The mortality rate was 10% (one death, 10 embryos).

Stage V embryos—Injection of strychnine sulfate. There was no significant change in behavior following injection of 20 embryos (representative of stage V) with dosages of strychnine varying from 0.5 to 5 micrograms. The mortality rate was 10% (one death, 20 embryos).

Immersion of 10 stage V embryos in isotonic strychnine (two mgm. strychnine per cc. sea water) for variable durations (up to two hours) also failed to produce any alteration in behavior.

Stage VI embryos—Immersion in isotonic strychnine sulfate. The 15 stage VI embryos which were immersed in isotonic strychnine (two mgm. strychnine per cc. sea water) from three-six minutes demonstrated typical strychnine convulsions in three-four minutes. The mortality rate for this group was 20%. The reaction to strychnine is commensurate with hatching (stage VI). The most obvious results of a physiologically effective dosage of strychnine are the symmetrical, vigorous, and rhythmic spinal convulsions that occur spontaneously or in response to stimulation.

The tail of the embryo underwent extremely rapid shaking and contractions; the contractions were of a fine, high frequency. The tail was slightly lowered during these convulsive seizures, indicating stronger contraction of the epaxial musculature; the duration of the convulsive seizures varied from 2 to 10 minutes.

Respiratory movements were stimulated, increasing 30-60% before termination of a convulsive seizure; respiration was usually irregular within 10 minutes after convulsions. The heart rate increased 10-15% at the onset of convulsions and slowed down shortly thereafter so that at the termination of a convulsive seizure the heart rate was slower (25-45% decrease from initial rate) and the heart beat was more forceful. Thus a period of convulsant activity is generally followed by a period of inactivity, with a slower and more forceful heart beat and irregular respiration; this period would in turn be followed by another convulsive period, giving way again to a period of somatic inactivity and cardio-respiratory struggle. The periods of convulsions gradually became less severe and the embryo again assumed his normal rate of activity.

Complete recovery from the effects of the injection varied from 6-19 hours. A high dosage (numbers 351 and 352) resulted in 100% mortality. One embryo of the 13 who received dosages near the therapeutic level (one-three micrograms) died within 23 hours; the mortality rate was therefore 7%.

TABLE VIII.—Effect of Various Dosages of Strychnine on Stage VI Toadfish Embryos

Number	Age by stage	Dosage	Percent increase highest resp. rate	Percent increase highest heart rate	Percent decrease lowest heart rate	Results and mortality
341–342	Early VI	1 u gm.	(no data available)			all gave typical strychnine pattern
343–345		2	(no data available)			
346–347		3	(no data available)			"
348–350	middle VI	2	31–51%	9–12%	26–39%	
351–352		5	44–49	12–14	43–45	both dead, 11 hr.
353	late VI	1	47	10	27	
354		2	59	14	42	
355		3	47	12	40	

Stage VII and VIII embryos—Injection of strychnine sulfate. The 8 embryos of early stage VII and the 8 embryos of early stage VIII that were injected with various dosages of strychnine reacted similarly to the stage VI embryos with three additions: First, the injection of strychnine lowered the threshhold of stimulus necessary to arouse response (if the same strength stimulus is now applied the embryo responds by a convulsive seizure—a weaker stimulus generally spread so that it became convulsive too); secondly, there was no lowering of the tail during a convulsive seizure in the early stage VII embryos, indicating approximately equal hypaxial and epaxial contractions; in the third place, in all stage VIII embryos there was an elevation of the tail during convulsions, indicating more vigorous contraction on the part of the epaxial musculature.

High dosages (numbers 371, 372, 373, and 387) resulted in 100% mortality and death in three-ten hours. The mortality rate of stage VII was 0%; the mortality rate of stage VIII was 43%.

TABLE IX.—Effect of Various Dosages of Strychnine of Stage VII and VIII Toadfish Embryos

Number	Age by stage	Dosage	Total recovery time	Results and mortality
371–373	Early VII	4 u gm.		(typical strychnine pattern in all) all dead, 10 hr.
374–376		2	8–11 hr.	
377–378		1	8–9	
385–388	Early VIII	1	9–12	No. 385 and No. 387 dead, 14 hr.
389		3	3	dead, 3 hr.
390–392		5	8–10	No. 390 dead, 12 hr.

COMMENT

Later stage embryos—Immersion in isotonic strychnine sulfate. The physiological effects of immersion in isotonic strychnine (two mgm per cc. sea water) on these 20 embryos (15-19 millimeters in length) was very similar to those described previously for stage VII and VIII embryos.

Reflex action is sharper and more distinct; the stimulation threshold is lower; and response to even a weak stimulus generally spreads so that convulsions result. The heart rate increased 30-50% at the onset of a period of intense activity and convulsant spasms; the respiratory rate underwent a parallel increase of 25-45%. Both the respiratory rate and heart rate decreased markedly toward the end of a convulsive period; the heart contractions became very

TABLE X.—Physiologically Effective Dosages of Strychnine Sulfate for the Various Stages of Development of the Toadfish Embryo

Stage of development	Dosage	Mortality rate
Stage IV	None effective	10%
Stage V	None effective	10
Stage VI	1–3 u gm.	7
Stage VII	1–2	0
Stage VIII	5–1	43

forced and labored; the respiratory movements became very irregular. This phase may become very exaggerated indeed if the embryo is left in the isotonic strychnine for a long duration, in which case death usually terminates a prolonged struggle.

5. Injection of isotonic camphor

Forty embryos were immersed in sea water saturated with camphor. Of these embryos, 5 were of stage V, 15 were of stage VI, 10 were of stage VII, and 10 were of later stages.

Twenty-one embryos were injected with isotonic salt solution. Of these embryos 6 were of stage IV, three of stage V, three of stage VI, three of stage VII, three of stage VIII, and three were of later stages. The results of these injections were so uniform (no change in heart rate or somatic movements) that it was judged unnecessary to add more embryos to this control group.

Stage V embryos—Immersion in isotonic camphor. The immersion of 5 embryos for variable lengths of time (up to 30 minutes) in sea water saturated with camphor failed to produce any observable alteration in behavior. The mortality rate was 0%.

Early stage VI embryos—Immersion in isotonic camphor. The 7 embryos of early stage VI (up to 7.0 millimeters in length) which were immersed in sea water saturated with camphor all developed spinal convulsions within two-four minutes after immersion; the embryos were removed from the drug solution at the onset of the convulsant activity.

The convulsions resembled strychnine convulsions; these camphor spinal convulsions are of slower frequency and are more irregular than strychnine convulsions; only the tail of the embryo appeared to be active in the camphor spinal convulsive spasms and twitchings.

Late stage VI embryos—Immersion in isotonic camphor. The 8 embryos of late stage VI (over 7.0 millimeters in length) which were immersed in isotonic camphor developed what may be termed an epileptic-like convulsion within 30-70 seconds after immersion.

The convulsions involved the entire embryo (head, body, and tail); the frequency of the convulsions was considerably slower than strychnine convulsions or camphor spinal convulsions. This period of epileptiform convulsions (one-four minutes) would sometimes change into a brief period (5-40 seconds) of camphor spinal convulsions.

Periods of activity and convulsions were followed by periods of inactivity, as the convulsive seizure repeated themselves. It was impossible to stimulate the embryo to activity at the beginning of the period of inactivity, for the embryo was spastic for a short while at that time. After a certain variable length of time stimulation would result in another epileptiform camphor convulsive seizure.

An elevation in heart rate and respiratory rate accompanied the convulsions; toward the end of a period of convulsions and in the post convulsive depression the heart beat became slower and more forced, and respiration became very irregular and slower. Complete recovery time varied from 8-22 hours; the mortality rate was 5%.

Stage VII and later stage embryos—Immersion in camphor. Ten embryos of stage VII and 10 embryos of later stages (16.9-20.6 millimeters in length) were immersed in sea water saturated with camphor with results that compare very favorably with those described for immersion of late stage VI embryos in camphor.

DISCUSSION

The investigator encountered several difficulties when he used narcotic drugs at different stages of embryonic life. While the mechanism of a drug's action in the adult mammalian organism is sufficiently known to justify clinical application, the exact mechanism of a drug's action (which would include an explanation of the so-called "side effects" of the drug) is not known in detail. Further, whether the drug will have the same effect in the embryonic nervous system as it does in the adult is, at best, uncertain. The interpretations that follow studies such as these should therefore be examined with reservation.

It is impossible to evaluate much of the earlier work that has bearing on this problem. The methods were inadequate; the data were incomplete (Coghill '34, Angulo Gonzalez '35, Tuge '37, Coghill in Herrick '49).

Regarding the effects of curarization of embryonic movements very few data are available. There is only one set of systematic experiments with regard to variation in dosage (Kuo '39). Almost no adequate determinations as to age, stage of development, or weight differences in susceptibility are available. The number of experiments has usually been so small, with such a large variation in results that no quantitative interpretation could be made. The manner of administration of the drug has not been clearly stated, leaving considerable doubt as to how much drug actually entered the embryonic circulation. Further, control groups have only rarely been employed. Finally, the recovery rates have been so low that many investigators have been left with the opinion that the embryos were poisoned.

d-tubo-curarine. Observations that d-tubo-curarine is effective in abolishing all somatic movements in the toadfish embryo have been presented.

The physiological dosage of d-tubo-curarine for the various stages of development was determined. The time required for the drug to take effect did not vary significantly with age. The ability of the embryo to recover from the effect of the drug varied somewhat with age.

Consideration of these results on the question of the myogenic or neurogenic nature of embryonic movements leads to the conclusion that the spontaneous motility and somatic reactions to exogenous stimuli of the toadfish embryo are nervous in character.

This does not imply that there is no type of myogenic behavior. The toadfish heart beats rhythmically long before it has any innervation. The ability of striated muscle to contract without nerve impulse is well known; the ability of the myoblast to contract in tissue culture without nerve impulse is also well known. Nevertheless, it is believed that in the intact embryo motility begins through physiological co-operation between the nervous system and the muscular system and that the types of motility in the toadfish embryo presented in this paper are in no case myogenic.

Morphogenetically the nervous system develops in advance of the muscular system. When the toadfish embryo shows the first sign of visible muscular contraction, its musculature is already innervated.

Since injection of the physiological dosage of d-tubo-curarine completely abolished the yolk sac response at all stages of development, this supports the contention that this response is of neurogenic nature and that it is brought about by pressure changes in the immediate environment of the ventral root.

The physiologically effective dosage of d-tubo-curarine for stages VII and VIII are much lower than for earlier stages of development. The dosages for stages VII and VIII are approximately 1/10 that of earlier stages if the dosages are roughly calculated in terms of milligrams of drug per weight of embryo.

It is interesting to note that this decrease of effective dosage is well correlated with the assumption of function by the respiratory mechanism. Respiratory movements are irregular throughout stage

VI, becoming regular in stage VII, and well established in stage VIII.

Thus a much lower dosage of curarine is effective after the respiratory mechanism has assumed its function than in earlier stages of development, when respiration is largely by diffusion.

The reaction to yolk stimulation (bursts of motor activity in response to pressure on the yolk sac) begins in stage IV (Tracy '59). Since curarization abolishes this response completely it would seem that the yolk response is brought about by pressure (mediated through the extra embryonic coelom → embryonic coelom → dorsal aorta → ventral roots) changes in the immediate environment of the motor nerves, and therefore would not be an expression of myogenic activity as suggested earlier (Coghill in Herrick '49).

It is unfortunate that data of the weight by somite number of the toadfish embryo during this critical stage IV (when movement first begins) that would permit further calculation of dosage (in terms of milligram of drug per milligram of wet weight or milligram of dry weight) are not available.

Veratrine sulfate. Observations that veratrine sulfate is readily absorbed when the toadfish embryo is immersed in an isotonic solution of the drug, and that this drug produces a characteristic reaction in the toadfish embryo at all stages of developmnt have been presented.

The veratrine contracture is thought of as repetitive responses, both of the nerve and muscle, which outlast the stimulus (Krayer and Acheson '46) by sensitization of the muscle to the potassium ions liberated by stimulation of the nerve. Since the motor neuron is an integral and essential part of the mechanism whereby the veratrine reaction is brought about in the intact organism, the reaction of the toadfish embryo of veratrine is judged to be additional evidence in favor of neurogenic origin of motility.

The consistent lowering of the heart rate in response to immersion in veratrine of the later stage embryos (14-19 mm.) may mean that the vagus nerve is functioning for the first time.

Because of the unusual increase in movement under the influence of this drug, immersion of the toadfish embryo in isotonic veratrine sulfate becomes a very useful tool in the study of beginning motility. In determining how many somites are active at a particular stage of development it was previously necessary to watch the embryo for a period of hours; if the embryo is immersed in isotonic veratrine sulfate, the same observations can be made in a matter of minutes.

Veratrine sulfate and d-tubo-curarine. These observations substantiate the contention that injected curarine is physiologically active in less than two minutes; these particular observations also indicate that veratrine sulfate will produce characteristic contracture, spasm, and heightened activity in the toadfish embryo only if the motor neuron—motor end plate—muscle mechanism is physiologically intact.

Strychnine sulfate. Observations of the toadfish embryo following injection of strychnine sulfate and immersion of the embryo in an isotonic solution of the drug have been presented.

The reflex nature of the principal symptoms of physiologically active strychnine has been known for some time. All empirical results in the toadfish embryo are referable to modified and increased reflex excitability of the spinal cord. The convulsions occurred as a result of exogenous stimulation. They also occurred spontaneously; but even here it is believed they are really reflex, due to slight sensory stimulations. All forms of sudden sensory stimulation that were tried provoked the convulsions.

Strychnine convulsions occurred from the beginning of stage VI through adult life. No dosage was found previous to stage VI that would bring about a convulsive reaction. Thus physiological reaction to strychnine is commensurate with hatching, a time of flux for the embryo from the sheltered and protected life inside the egg membrane to his adult environment of vastness and danger.

Since it has been established that both the motor and sensory portions of the cord must be poisoned to obtain typical strychnine convulsions, the experiments with strychnine sulfate in the toadfish embryo tend to demonstrate that the nervous system has developed sufficiently by stage VI to be capable of reflex activity. However it is impossible to stimulate the embryo tactilely for four days after it first reacts to strychnine (during stage VI of development). Histological examination at the beginning of stage VI (hatching) demonstrates a sensory apparatus which appears identical to that of an embryo four days later (beginning of stage VII) except that the receptor apparatus does not extend to the surface; the receptor apparatus reaches the surface at the time the embryo reacts to cutaneous stimulation (beginning of stage VII, approximately four days after hatching).

These empirical findings are in conformity with the thesis that at hatching the toadfish embryo has a functional reflex arc which is prevented from being physiologically active by the fact that its receptor apparatus is not as yet in functional contact with the surface of the embryonic body.

The difference in position of the convulsive tail is of interest. Stage VI embryos underwent convulsions with a lowering of the tail; early stage VII embryos underwent strychnine convulsion with approximately equal contraction of epaxial and hypaxial musculature; and early stage VIII embryos and later stages underwent convulsions with a slight elevation of the tail. The convulsions were always symmetrical. Presumably all functional muscles are contracted under the influence of strychnine; the body would therefore tend to assume the position corresponding to the stronger muscles, or the musculature that is more capable of functioning.

The earlier assumption of function by the flexors in the toadfish embryo is identical to what Coghill supposed to be true for the amphibian and reptilian embryos (Coghill in Herrick '49). The arching backwards of the body under the influence of strychnine from early stage VIII through the free-swimming stage and in the adult life of the toadfish is identical to the position of mammals under the influence of strychnine (opisthotonus).

Again the lower physiologically effective dosage (if evaluated in terms of milligrams of drug per weight of embryo) for stages VII and VIII are very apparent (see comment—curarine). As has been previously mentioned this decrease in dosage is well correlated with the assumption of function by the respiratory mechanism. Previous to stage VI respiration occurs by diffusion. During stage VI the embryo develops very irregular respiratory movements which gradually become regular in very late stage VI, stage VII, and stage VIII.

Curarine usually brings about death by paralysis of respiration. Strychnine generally causes death by the spasmodic or highly irregular respiratory movements which are ineffective physiologically (almost no water moves through the gills when the respiration is convulsive). Both curarine and strychnine, then, bring about death to the embryo generally by interference with respiration that results in exhaustion and asphyxia.

It must be concluded that the lower physiologically effective dosage for stages VII and VIII, are low mortality rates of stage VII after injection of curarine and strychnine (0.0% in both cases), the high (40%) mortality rate of the stage VIII curarine injections, and the high (43%) mortality rate for the stage VIII strychnine injections have direct bearing on the problem of assumption of function by the respiratory apparatus.

The above data tend to demonstrate that as late in embryonic life as early stage VII (no other stage VII embryos were injected with strychnine or curarine) the toadfish embryo can revert to respiration by diffusion (at least sufficiently so to maintain life).

The data also support the thesis that by early stage VIII respiration is well established physiologically. As previously mentioned, since no late stage VII embryos were used in the experimental work it is impossible to be more accurate as to the exact onset of respiratory movements that closely resemble adult respiratory movements pharmacologically and physiologically.

Camphor. Spinal convulsions upon immersion in sea water saturated with camphor are provoked in the toadfish embryo for the first time at the beginning of stage VI (hatching). These camphor-spinal convulsions occur at the same time as strychnine first brings about strychnine-spinal convulsions.

When the embryo has attained a length of approximately 7.0 millimeters (late stage VI) the convulsions assume an epileptic-like pattern, involving irregular twitchings and spasms of not only the tail, but the body and head also. The spinal cord also shows some stimulation (described previously), and finally paralysis; then the cycle repeats itself.

It has been known for some time that camphor stimulates the central nervous system, and that this action is more marked on the higher centers, although all parts of the cerebro-spinal axis share it to some degree. In mammals the convulsant action is believed to be chiefly above the optic thalami, for sections below these abolishes or greatly diminishes the convulsion. In mammals it is also known that the motor cortex participates in the convulsions (Trabuschi, '28). In the frog the discharge from the higher centers is obscured by a spinal paralysis.

It is believed that the spinal convulsions of early stage VI toadfish embryos are indicative of stimulation of the spinal cord. The epileptiform convulsions which begin in late stage VI indicate stimulation of higher centers which have become functional or active for the first time.

SUMMARY

d-tubo-curarine. 1. Since curarine dramatically and completely abolished all somatic movements, it must be concluded that the spontaneous motility and somatic reaction to exogenous stimuli of the intact toadfish embryo are nervous in character.

2. The onset of respiration by the gills was observed to coincide with a smaller dosage being effective and a significant increase in mortality.

Veratrine sulfate. 1. Veratrine always produces contracture, spasm, and heightened motor activity in the toadfish embryo.

2. From the reported mechanism of veratrine's action in the literature and from the empirical fact that curarine masks its action, it was concluded that the motor neuron—motor end plate—muscle chain must be intact for veratrine to act.

Veratrine and curarine. 1. The empirical results support the thesis that curarine is physiologically active in less than two minutes.

2. The reaction to veratrine of the toadfish embryo is judged to be additional evidence in favor of the neurogenic origin of motility.

Strychnine. 1. Although the toadfish embryo will not react to tactile stimuli for four days or more after hatching, at hatching the toadfish embryo does have a functional reflex arc—as indicated by the reaction to strychnine.

Also, histological studies show that it is not until the middle of stage VI (approximate hatching time) that the toadfish has developed a complete system of afferent spinal nerve fibers (Tracy '60).

2. It is of significance that the reaction to strychnine is commensurate with hatching, for hatching is a time of tremendous flux for the toadfish.

3. The earlier assumption of function by the flexor musculature is of interest; this parallels what Coghill found to be true for amphibians and reptilians. These results strengthen Sherington's original interpretation of noiceptive reflexes.

4. The sudden increase in mortality rate in stage VIII and later stage embryos following injection of strychnine or curarine has direct bearing on the problem of assumption of function by the respiratory apparatus since the toadfish embryo is making the transition from respiration by diffusion to respiration by regular movement of the gills. This conclusion is quite feasible since both curarine and strychnine bring about death to the embryo by inter-

ference with respiration that results in exhaustion and asphyxia.

5. The sudden decrease in dosage in stage VIII and later stage embryos for both curarine and strychnine may have several different interpretations; it may mean that the target cells of the drugs are more differentiated now and hence metabolism in them is more delicately balanced; this in turn may be related to the changes in the toadfish that occur at hatching.

Camphor. 1. The spinal convulsions which begin at hatching when the toadfish is exposed to camphor are not as vigorous as the strychnine convulsions which also begin at hatching.

2. The camphor epileptiform convulsions which begin in late stage VI are believed to indicate stimulation of higher centers which are capable of activity at that time.

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New Oriental Reptiles

BY

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ABSTRACT: The following reptiles from southeastern Asia are described as new. One new genus, *Keiometopon* is proposed for a small Malayan snake obtained on Fraser's Hill, Malaya.

Cyrtodactylus quadrivirgatus sp. nov.
Cyrtodactylus peguensis zebraicus subsp. nov.
Phyllodactylus melanostictus sp. nov.
Peropus laceratus sp. nov.
Peropus fehlmanni sp. nov.
Luperosaurus amissus sp. nov.
Gekko petricolus sp. nov.
Sphenomorphus lineopunctulatus sp. nov.
Sphenomorphus mimicus sp. nov.
Sphenomorphus grandisonae sp. nov.
Riopa frontoparietalis sp. nov.
Riopa haroldyoungi sp. nov.
Leiolopisma pootipongi sp. nov.
Dibamus alfredi sp. nov.
Typhlops khoratensis sp. nov.
Typhlops trangensis sp. nov.
Typhlops klemmeri sp. nov.
Calamaria fraseri sp. nov.
Keiometopon gen. nov.
Keiometopon booliati sp. nov.
Liopeltis baliodeirus cochranae subsp. nov.

INTRODUCTION

The species described herein as new have been collected for the most part by me while carrying on herpetological research in Thailand. One, however, is from the Philippines and two forms were obtained in Malaya.

The type of one species was presented to me by Mr. Harold Young of Chiang Mai who collected it at the base of Doi Suthep, a mountain some five kilometers northwest of the city of Chiang Mai. Two species of lizards were loaned to me by Miss Alice Grandison of the British Museum of Natural History with permission to describe them. One small snake was loaned by Dr. Doris Cochran of the U. S. National Museum with permission to describe it. I am under obligation to Dr. Adair Fehlmann who assisted in the capture of the type of a species of *Peropus* that bears his name.

Cyrtodactylus quadrivirgatus sp. nov.

Type: No. 387 ♀, taken at Khao Chong Forest Experiment Station, Trang province, November 10, 1959, by Edward H. Taylor.

Paratypes: No. 388 ♂, same date, taken with the type. EHT-HMS Nos. 2595 Kuala Tahan, Pahang, Malaya; M. 36 Fraser's Hill, Malaya; 3595, 10 mi. E Seremben, Malaya.

Diagnosis: A terrestrial species 67 mm. snout to vent; head blackish brown above; a strong blackish stripe from eye along dorsolateral part of body to base of tail; a second stripe, less distinct, begins behind orbit, fuses on neck with its fellow, then separating they continue to base of tail separately but are connected at two or three points; five grayish lines, one below, one above dorsolateral black stripe on each side, and a median, interrupted line; or lines may be broken tending to form transverse bands. Tail with transverse black bands separated by white bands that may or may not be complete. No median enlarged series of scales under tail; usually four preanal pores in both male and female *; no curved band across nape extending to eyes.

Description of type: A rather small species; rostral not twice as wide as high, its upper edge with a V-shaped notch cutting scale half in two, the area of the notch being filled with three internasal scales; rostral bordered by these three scales, first supralabials, and nostrils; nostril bordered by rostral, first labial, a large and a small supranasal, and three small postnasals; 56 scales across snout between fifth supralabials; about 64 small granular scales between median edges of eyelids; eye diameter less than snout length; ten smooth supralabials, posterior ones small, followed by eight or ten small granular scales reaching back to angle of mouth; ten infralabials, last three small, followed by seven very small scales to mouth angle; mental triangular with a labial border equal to that of rostral; a pair of chinshields separated for more than half their length by mental; second pair of chinshields separated by five scales, scarcely differentiated; ear diagonally elongate; tympanum deeply sunk; a slight depression on occiput more or less connected with a depression on snout.

Scales on occipital region very small with a few scattered rounded tubercles; dorsum with somewhat larger granular scales intermixed with minute scales and with large conical or pyramidal tubercles forming about 24 irregular rows; a bare trace of a ventrolateral fold,

* Sometimes the scales are pierced with pores; sometimes there is only a circular depression.

Fig. 1.—*Cyrtodactylus quadrivirgatus* sp. nov. Type. Actual length, 144 mm. Khao Chong Forest Station, Trang, Thailand.

separated from its fellow by about 40 scalerows, the outer rows small, median ones considerably larger; group of four preanal pores in a Λ-shaped arrangement, continuous with two series of 17 enlarged femoral scales. Tail above dimly segmented; dorsal scales smaller than ventral ones; no median widened series of scales on undersurface of tail but there may be four or five series subequal in size, a little larger than dorsal caudal scales; no caudal tubercles, the tail slender tapering to a fine point. Leg reaches to elbow of adpressed arm; toes subequal, six or seven lamellae under basal part of fourth toe; all digits clawed.

Color in life: Above gray on body; head uniform blackish on top; a distinct black band begins behind eye extending back on sides of body to base of tail, bordered above by a wide gray stripe and below by a narrow one; two other lines begin behind eye and run back to form an angular union on nape; they then separate and continue to tail where they are rejoined; median gray line interrupted in two places by connecting lines between the two median dark stripes; a very indistinct darker line low on sides; chin and venter uniformly whitish with a peppering of black. Tail banded with black and gray, the basal gray bands including some black; underside of tail blackish with white flecks; gray bands surrounding tail only on distal part; some indistinct lighter flecks on labials; arms and legs with spots or bands of black above, whitish below.

Measurements in mm. of type and paratype: Snout to vent, 67, 39; tail, 77, 22 (broken); snout to arm, 32, 16; axilla to groin, 34, 19; width of head, 13, 8; length of head, 18, 13; arm, 21, 13; leg, 26, 17.

Remarks: The color pattern of the young male topotypic paratype is quite similar to the type. There is, however, some indication of lighter and darker areas on the head. The distal part of the tail has been lost. In the Malayan specimens the two median stripes are broken sometimes forming a series of spots.

The relationship of this species may be with *Cyrtodactylus oldhami,* however, the absence of the enlarged transverse subcaudal series of scales, and the absence of the curving band about occiput from eye to eye suggests a different relationship. *Oldhami* may occasionally lack pores. Absence of femoral pores would seem to preclude close relationship with *marmoratus.*

The type specimen was found at an elevation of about 400 meters on Khao Chong, under a decaying log. A specimen of *Cnemaspis siamensis* was taken in the immediate vicinity.

Cyrtodactylus peguensis zebraicus subsp. nov.

Type: No. 35522, taken at Tonka Harbour Tin Dredging Co., Ronpibon, Nakhon Si Thammarat, May 21, 1958, by Edward H. Taylor.

Diagnosis: Head somewhat depressed, spotted above; brown bar behind eye more or less confluent with angular band bordering occiput behind; body with pair of spots on neck and eight transverse stripes wider than gray interspaces; certain of these may be discontinuous, while last between legs is broken mesially; eight femoral pores; no ventrolateral fold.

Description of type: Head moderately depressed; length of snout a little longer (1.1 mm.) than distance between orbit and ear-opening; strongly depressed area on frontal region extending back between orbits; snout rather compressed with slight depression in front of nostrils; rostral about twice as wide as high, bordering nostril, first labials, pair of supranasals, and two small internasals; nostril surrounded by first labial, rostral, two supranasals one large and one small; postnasal seemingly fused to flap within nostril.

There are 32 scales across snout between posterior ends of 2nd supralabials; across snout between anterior part of fifth labials, 49 scales; occipital region with small scales intermixed with rounded, somewhat conical tubercles, much smaller than tubercles on back; supralabials, 11-11, very small posteriorly followed to angle of mouth by five or six small scales; nine infralabials, followed by four scales to mouth-angle; pair of chinshields, about twice as long as wide forming a common suture for about half their length; mental with labial border distinctly larger than rostral border; second pair of chinshields about half as large as first pair, widely separated by first pair; 77 granules in a row between chinshields and a line drawn at front level of shoulders; from breast to vent, 76 scales; a wide-angled series of eight preanal pores with two angular rows of larger scales between pores and vent; two large lateral postanal tubercles. Tail lost and beginning to regenerate.

Digits short, basal part scarcely widened with two or three flat imbricate scales; distal part somewhat compressed; two scales surround claw; no ventrolateral folds; about 35 scalerows across venter. Scales on sides and dorsum small, equal, interspersed with about twenty rows of enlarged trihedral tubercles. Diameter of ear-opening (1.2 mm. high) four times in diameter of orbit (5 mm.); adpressed leg does not reach axilla.

FIG. 2.—*Cyrtodactylus peguensis zebraicus* subsp. nov. Type. Actual length, snout-vent, 58.5 mm. Ronpibon, Nakhon Si Thammarat, Thailand.

Color in life: Above blue-white with transverse brown stripes with blackish edges. Head with about twenty dark spots in a blue-white reticulum; venter and chin cream-white with fine powdering of black, visible under a lens. Dark band from eye passes around occiput, angular rather than curving; lips dark spotted; regenerated tail blackish.

Measurements in mm.: Snout to vent, 58.5; snout to arm-insertion, 23; axilla to groin, 26; width of head, 12; head length, 19.4; arm, 22; leg, 28.

Remarks: This specimen was taken from a large rotting stump in the forest at Tonka Harbour Tin Mine, Ronpibon, Nakhon Si Thammarat. Its relationship is certainly with *Cyrtodactylus peguensis.*

Phyllodactylus melanostictus sp. nov.

Type: No. 33333; collected at Mauk Lek Road-Camp (Friendship Highway) Sara Buri; Oct. 1957; Edward H. Taylor collector.

Paratypes: Nos. 33331-32; 33334-35. Same date, locality, and collector.

Diagnosis: Differs from *Phyllodactylus siamensis* in having a black stripe from tip of snout through eye to shoulder where it widens and continues along the side of the body and then narrows on tail; dorsal spots if present very small, arranged in four longitudinal lines; a series of small dots on dorsal part of tail; arms and legs colored like sides of body; no white rings on tail.

Rows of enlarged trihedral or keeled tubercles present; median rows smaller than the other rows, separated by three rows of small granules; next two rows separated by one row of granules; nine preanal pores in males.

Description of type: Rostral large, subquadrangular, wider than high with a median entrant suture in upper mesial part, bordering the nostril; a pair of enlarged internasals forming a straight median suture, and forming part of the border of nostril; behind internasals another slightly enlarged pair of scales; first labial and two tiny postnasals form remainder of border of nostril; 29 scales in a row across head between edges of eyelids, and 28 scales in a row across snout between the posterior edges of third labials; scales on snout slightly larger than those on interocular and occipital regions; granules in temporal areas slightly larger, with some still larger scales intermixed. Nine supralabials, seventh directly below pupil of eye; seven infralabials, fifth below pupil of eye; auricular-opening small, little larger than an internasal scale; mental with larger labial

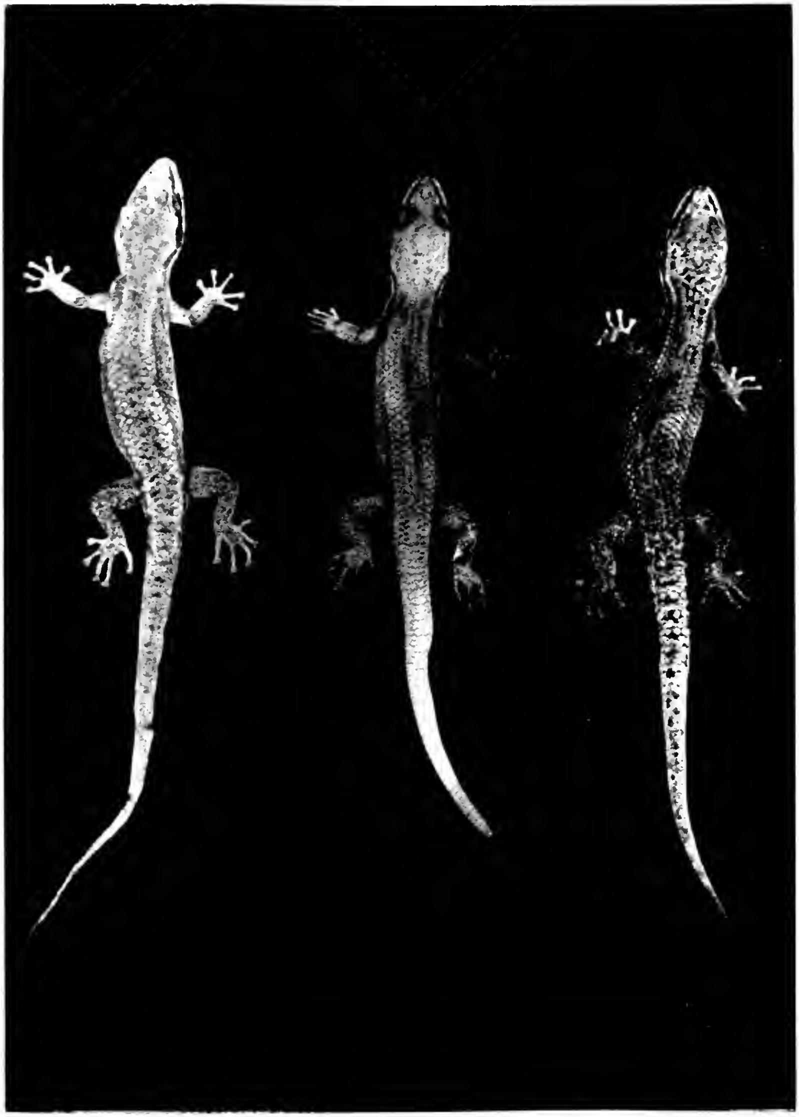

FIG. 3.—*Phyllodactylus melanostictus* sp. nov. Left figure, No. 33335, paratype. Actual length, 97 mm. Middle figure, No. 33334, paratype. Actual length, 79.2 mm. Right figure, type. Actual length, 97 mm. All from Mauk Lek Road Camp, Sara Buri, Thailand.

border than rostral, its posterior sides forming a right angle; a median pair of enlarged postmentals, each followed by two smaller widely separated pairs of scales; granules on chin and throat very small, subequal.

Dorsum covered with rows of trihedral or bluntly keeled tubercles, the two rows near middle separated by three rows of small granules; next row separated from these by an irregular row of granules; subsequent rows are contiguous or with only a few scattered granules between them; about ten or eleven scalerows on sides and dorsum but there is no distinct line of demarcation between these and the flat cycloid scales of venter; latter scales in about 22 rows. A curving row of nine preanal pores; subcaudals enlarged, widened. Two postanal swellings indicate position of hemipenes, two rounded tubercles arising from each swelling. Limbs well developed, each digit with paired leaflike lamellae at tip, between which may be seen a small retractile claw; when limbs are adpressed, toe reaches halfway to elbow. Ten lamellae under longest fingers; fifteen under fourth toes, distal one usually divided. Segments of tail distinct each segment with three or four transverse rows of scales arranged in whorls; posterior row with at least four enlarged keeled scales; on underside of each whorl, two subcaudals, anterior the larger (a total of about 30 segments in a complete tail).

Color in life: Above lavender-gray, the top of head lighter, mottled with some darker color; a moderately distinct cream-white stripe from tip of snout through eye, disappearing on shoulder; bordering this below is a black stripe extending from tip of snout onto tail, widening on sides and less distinct; labials and side of neck below stripes, white. Chin, throat, and venter white but under a lens fine pigmentation is evident, less on chin than on venter; latter half of tail regenerated; basal part with a series of black spots marking segments.

Measurements of *Phyllodactylus melanostictus* sp. nov.

Number	33333	33334	33335	33331	33332
Sex	♂	♂	♂	♀	♀
Snout to vent	42.5	40.2	41	35	38.5
Tail	54.5	39+	56	43	?
Snout to arm	18.5	18	17.3	16	16
Axilla to groin	19	18	19	17.2	16
Arm	12	12.3	12.2	11	11.6
Leg	17	18	17	14	15
Head width	8.2	8	8.2	7	7.4
Head length	12.8	12.4	12.8	10.5	11

Variation: The following variation is evident:

No. 33334 ♂: The dorsum is lighter than the type and the stripe on the side of the body is dimly evident. The entire tail has only vague lines marking the segments. There are nine preanal pores. There is no spotting or reticulation on head or body except two or three dark spots on labials.

No. 33331 ♀: The dorsolateral light stripes can be traced to tail as a series of dots. The pigment on the back is segregated into dark flecks forming four fine broken lines while the median line is nearly as light as the dorsolateral line. The head has numerous brown-lavender flecks. The labials have more distinct spotting; and the subcaudal region is darker.

No. 33332 ♀ resembles No. 33334. The tail is missing, and the lateral body stripe is more distinct.

Remarks: The specimens were taken from under logs or boards on wet earth. *Phyllodactylus siamensis* was taken less than 300 meters away. All specimens are from Muak Lek Road Camp, near the town of Muak Lek, on the Friendship Highway, and actually less than three hundred yards from the boundary between the provinces of Sara Buri and Nakhon Ratchasima (Korat).

Peropus laceratus sp. nov.

Type: EHT-HMS No. 1504; taken 4 km. NW Kanchanaburi, Kanchanaburi, Thailand, July 16, 1959; Edward H. Taylor, collector.

Paratype: No. 33471, topotype, October 26, 1957; Nos. 33280-81, Ang Hin, Chon Buri, Oct. 5-7, 1957, Edward H. Taylor, collector.

Diagnosis: Preanal pores 20, forming an angular series extending slightly onto femoral region; preanal area covered with enlarged, somewhat pointed scales, but scales on areas lateral to this on underside of femora scarcely half as large. About 48 scales in a line across venter between indistinct ventrolateral folds, the scales pointed posteriorly rather than rounded; no web on hand or foot; ten labials to a point below median part of eye; tail distinctly shorter than body, the subcaudals not widened, median five or six rows similar to scales on venter; segmentation of tail not clearly indicated; dorsal scales very small, nearly uniform.

Description of type: Snout oval, with a frontal depression extending back between orbits to a shallow depression on occiput; areas in front of orbits distinctly swollen; rostral one and three-fourths times as wide as high, its median upper portion with a depression and an entrant groove from above; a pair of enlarged supranasals

Fig. 4.—*Peropus laceratus* sp. nov. Type. Actual length, 93 mm. Four km. NW Kanchanaburi, Kanchanaburi, Thailand.

separated mesially by a small scale; nostril bordered by rostral, supranasal, first labial, and three small postnasals; 53 scales across snout at level of suture between fifth and sixth labial; twelve supralabials, tenth, or tenth and eleventh below middle of eye; a series of tiny scales from last supralabial to back of mouth angle. Mental moderate, its border on mouth equal to that of rostral, forming a right angle with median pair of chinshields, each of which is pointed anteriorly and rounded behind; second pair of chinshields lateral to first, angular anteriorly, rounded behind; third chinshields small, followed by row of slightly enlarged scales bordering infralabials; ten or eleven infralabials, ninth below eye; last followed by tiny scales to mouth-angle; chinshields somewhat raised and rounded across upper surface, with regular depressions between them; eye moderate; eyelid evident from the median lower edge of eye, running around the front and upper edge of eye; length of snout from orbit (5.5 mm.) greater than diameter of orbit (4 mm.).

Arm moderate, with an indistinct narrow web in front of elbow; all digits widened, the shortest with five, longest with seven paired lamellae and a single anterior one; lamellae following on narrow proximal portion of digit scalelike, paired or single; on outer toe there may be as many as four rows of scales. From middle of upper surface of widened portion of digits, distal clawed joints arise nearly vertically or bend forward on all digits except on inner finger which lacks the terminal phalanges but has a small claw.

Scales of dorsal and lateral surfaces of head and body very small, conelike, tubercles varying somewhat in size on head but tending to form straight longitudinal and diagonal rows. Scales on venter in about 48 rows between the slight ventrolateral folds; scales imbricate, bluntly pointed, rather than rounded, in fairly straight longitudinal rows. In preanal region scales form somewhat angular series, the series bearing 20 preanal pores, a trifle larger in males, some scales following these bearing indistinct depressions; pore-scales followed by four shorter angular series in the region preceding vent; four or five subcaudal scalerows, larger than adjoining scales but median series not widened transversely, the scales resembling those on venter. Segmentation of tail not or scarcely discernible.

No webs between digits on hand or foot; ear small, situated on a level with lower part of eye; tail thickened, widened near base.

Color: Above gray on back and sides, with small, darker gray spots of which there are about twenty on head; spots on body and sides a little larger, more widely scattered, with a double row of very indistinct rounded lighter spots on back; some darker spots on middle of limbs; under surfaces of body cream to whitish yellow.

Measurements in mm.: Snout to vent, 55; tail, 38; total length, 93; width of head, 12; length of head, 15; tip of snout to arm-insertion, 18; axilla to groin, 25; arm, 17.5; leg, 21.

Variation: No. 33471, a young male topotypic paratype, has the pore-scales forming a highly arched angular series, nine on each side, the median one almost separating the two mesial pore-scales that are normally in contact. The dorsal and lateral caudal scales form distinct transverse scalerows ventrally; the segments can be discerned since the last transverse row of subcaudal scales usually has one a little larger than the others.

A second young male (No. 33280 from Ang Hin, Chon Buri), has a similar series of pores but a median scale separates the two series of pore-scales. No. 33281 has lost all skin from the preanal area.

In markings all are much the same except that the rounded lighter marks are dimly present over entire dorsal and lateral surfaces of body.

Distribution: Known only from the type locality and Ang Hin, Chon Buri province. All were found under rocks or logs.

Peropus fehlmanni sp. nov.

Type: EHT-HMS No. 1503. Collected 4 km. NW Kanchanaburi, Kanchanaburi, Thailand, July 16, 1960, by Edward H. Taylor and Adair Fehlmann.

Paratype: No. 3526, Tonka Harbour Tin Mine, Ronpibon, Nakhon Si Thammarat province, Edward H. Taylor, collector.

Diagnosis: Scales on dorsal part of head and body not distinctly conical; scales on snout subimbricate, double size of those on occiput and interorbital region; small distinct webs between digits on hands and feet; subcaudal scales at base of tail somewhat enlarged, followed by a single row of greatly enlarged subcaudals; largest body scales in preanal area; femoropreanal pores, 22, forming an arched series extending onto femur for nearly half its length; scales on dorsal surface of slender tail somewhat irregular not forming distinct transverse rows; segments of tail not or scarcely indicated; seventh or eighth supralabial, and seventh infralabial below pupil of eye; third (outer) pair of chinshields separated from infralabials; ventrolateral fold not indicated.

Description of type: Rostral twice as wide as high, with a slight median depression on upper border and with an entrant suture

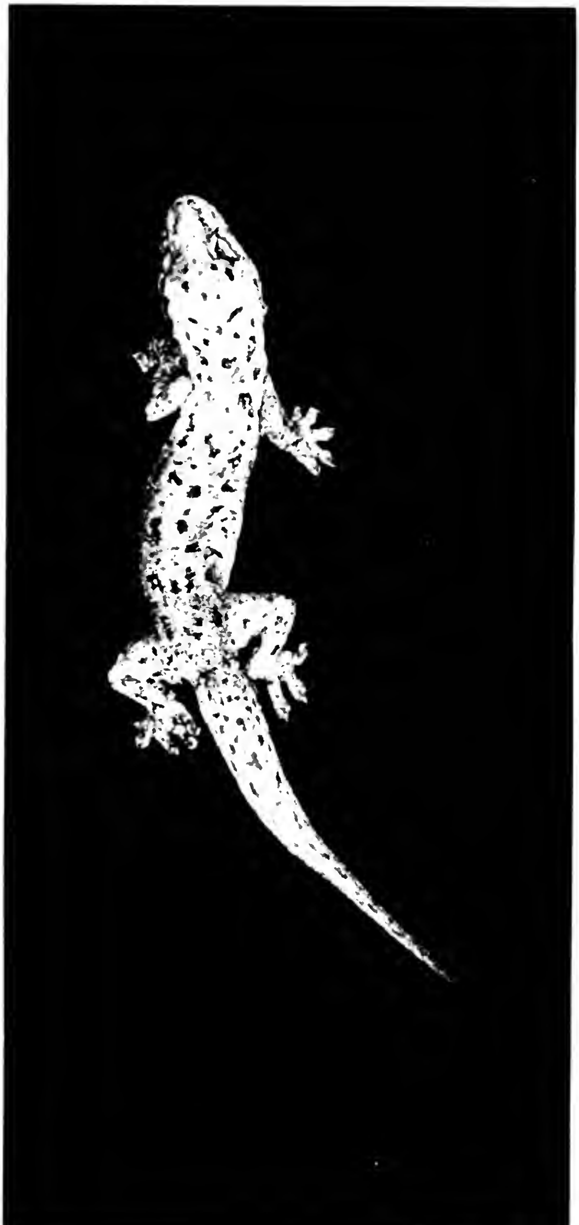

FIG. 5.—*Peropus fehlmanni* sp. nov. Type. Actual length, 70 mm. Four km. NW Kanchanaburi, Kanchanaburi, Thailand.

whose length is slightly less than half height of scale; nostril surrounded by rostral, first supralabial, a supranasal, and two clearly differentiated postnasals; a slight frontal depression; supranasals separated by two small scales one behind the other; about 44 scales across snout between fifth supralabials; eight supralabials, last two small, with a row of about ten small body scales to mouth-angle; seven infralabials, likewise followed by small scales to mouth-angle; mental with labial border equal to that of rostral, shaped like a quarter section of a circle; length of snout (4.2 mm.) greater than diameter of orbit, (3.5 mm.); ear rather large, (.7 to 1.0 mm. in diameter); median pair of chinshields pointed (angular) anteriorly, the width across upper half much greater than width posteriorly; second pair of chinshields much smaller than first, separated by first pair; third pair separated by preceding pairs and separated from infralabials by a scale; lower edges of chinshields forming a curve.

Arm with a very slight web in front of elbow joint; a distinct but small web between fingers; digits widened, each bearing six or seven paired lamellae preceded by a single lamella on under surface of widened part. Toes similarly widened, one-fourth webbed. On all digits except inner, two distal phalanges rise vertically from near middle of upper surface of widened part, all clawed; inner digits lack the two distal phalanges, but a small claw present at anterior edge of widened portion.

Scales on snout irregularly shaped, distinctly not conical, in places subimbricate. Scales on sides and latter half of back large, juxtaposed, flat, and much larger than scales on shoulders, neck, or occiput; venter covered with somewhat larger imbricating scales in about 42 rows; those low on sides and those on sides of venter not or scarcely differentiated from each other; seemingly there are no ventrolateral folds. An angular series of small rounded femoropreanal pores, eleven on each side extending halfway on femora.

Scales on dorsal and lateral surface of tail irregular, suggesting the possibility that the entire tail has been regenerated; tail narrow with fringe along edges of tail, and tapering rapidly to a fine point; subcaudal scales widened, appearing to be normal and not reproduced.

Color: Above light brown with black flecks scattered on head, body, limbs, and tail; ventral surface yellowish white, but all scales with small pigment dots; underside of tail more heavily pigmented with brown; the pigment on pore-scales tend to make an indefinite brownish circle on scale, but is not especially conspicuous.

Measurements in mm.: Snout to vent, 37; tail, 33; total length, 70; width of head, 8.2; length of head, 11.8; snout to arm-insertion, 15; axilla to groin, 16; arm, 10.5; leg, 13.2.

Variation: Not known.

Distribution: Known only from the type locality and Ronpibon, Nakhon Si Thammarat.

Remarks: The type specimen was taken at night along the edges of a small rain-pool close to the road. It was moving about on the ground when discovered.

The second specimen in the collection, No. 35526 ♀, is from near Tonka Harbor Tin Mine, Ronpibon, Nakhon Si Thammarat. It has a snout-to-vent length of 40 mm. There is a rather sharply defined canthal line of cream dots, bordered below by a darker line passing through the eye and terminating on the side of the neck. Two dark brown marks extend back from nostrils to the frontal region; the back is brownish with small darker brown spots, some arranged transversely and at least two indefinite longitudinal rows of white dots or flecks. The ventral surface has a dense powdering of cinnamon brown. The tail has been lost.

Luperosaurus amissus sp. nov.

Type: EHT-HMS No. M. 30, collected near Odiongan, Tablas I., Philippines, Jan. 1921, by Edward H. Taylor.

Diagnosis: A small gekkonid (snout to vent, 46 mm.; tail, 46 mm.); head wider than body; rostral without a median entrant suture, twice as wide as high, entering nostril; ten or eleven supralabials; a pair of pentagonal chinshields touching mental; fingers and toes with a small web-remnant; lamellae under digits, widened, undivided, extending to near base of digits; inner fingers and toes without compressed distal joint and claw; eight preanal pores in a straight transverse line; no femoral pores; tail narrow, lacking lateral fringe or denticulations; no free skin-flap on arms or sides. Scales small, tubercular, intermixed with larger rounded tubercles.

Description of type: Rostral twice as wide as high, bordered posteriorly by two supranasals separated by an internasal, and laterally by first supralabial; nostril surrounded by rostral, first supralabial, supranasal, and two postnasals; ten or eleven supralabials, ninth or tenth below vertical pupil of eye; 46 tubercles across snout between fifth supralabials, those bordering labials largest; eye large, its diameter (3.5 mm.) smaller than length of snout (4.7 mm.); ear-opening vertically oval, its diameter (.95) about

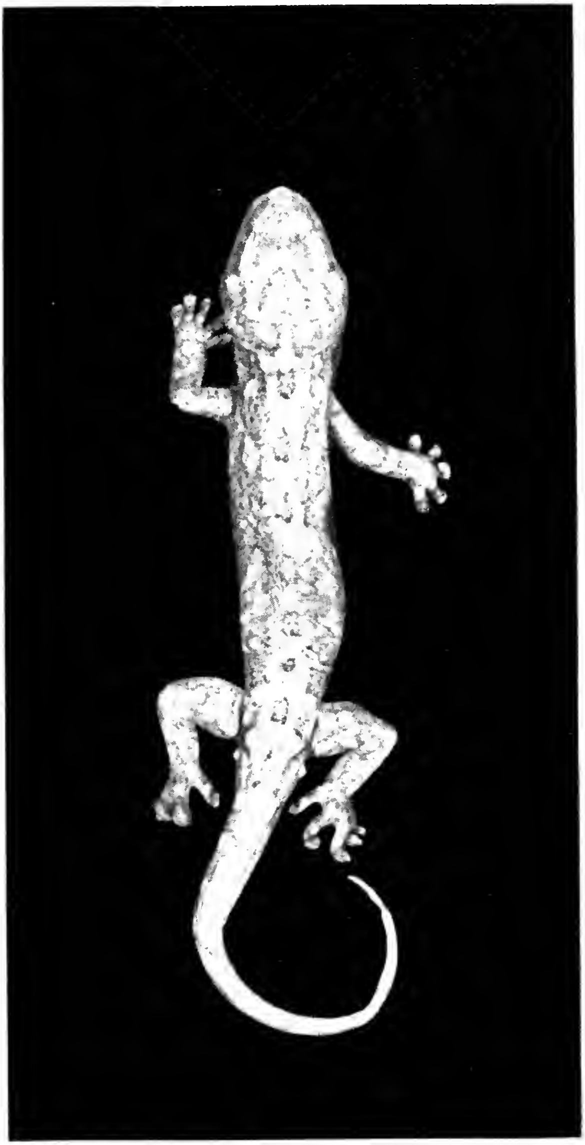

FIG. 6.—*Luperosaurus amissus* sp. nov. Type. Actual length, 92 mm.; near Odiongan, Tablas I, Philippine Islands.

3½ times in eye diameter; mental much smaller and with shorter labial border than rostral; median pair of pentagonal chinshields border mental followed by two rounded scales half size of chinshields; lateral to the median pair, a second pentagonal pair separated by the first; scales following these somewhat enlarged; infralabials, ten; scales on head granular or tubercular, largest on periphery of snout and on upper eyelids, smallest on occiput; dorsal and lateral body scales small juxtaposed granular tubercles with several irregular rows of larger rounded tubercles; a diagonal row of three or four enlarged scales in temporal area and one or two above ear; from level of shoulders about nine irregular longitudinal rows of enlarged tubercles, widely spaced, not continuing on tail; tail segmented, segments not strongly marked; scales form more or less straight transverse rows, scales larger laterally; median subcaudal scales widened, usually three below each basal segment, the third larger than other two; occasionally subcaudal scales divided; distally, tail much narrowed, flat on undersurface, possibly somewhat prehensile.

Scales on throat small, granular; on breast and venter, scales larger, juxtaposed, or more or less imbricating, arranged in about 34 rows between two indistinct ventrolateral folds; femoral pores eight, pierced along back edge of somewhat elongated preanal scales; these followed by two rows of scales nearly as large as the pore-scales, and these separated from vent by five rows of smaller scales; base of tail with two strong hemipenial swellings covered with somewhat thickened imbricating scales and with a lateral, greatly enlarged tubercle.

Digits widened, four outer fingers and toes with their distal part compressed each bearing a claw; inner digits lack distal compressed parts as well as claw; lamellae under fingers not divided mesially, twelve or thirteen under third and fourth fingers, fifteen under fourth toe; scales near base of digits small. The compressed portion of digit does not rise free, but extends beyond widened part with a slight web connected to its sides.

Color (in preservative): Ground color buff-brown with darker area on side of snout; rather indefinite brown markings on head and occiput; lighter median stripe with eight small dark spots; sides, arms, and legs variegated with light and dark brown. Tail very indistinctly and irregularly banded (see figure).

Very fine blackish marks about openings of preanal pores, and blackish edges on some scales on underside of base of tail.

Measurements in mm.: Total length, 92; snout to vent, 46; tail, 46; width of head, 10.2; length of head, 13; tip of snout to arm, 17; axilla to groin, 22; arm, 13.2; leg, 17.

Variation: Only the type is known.

Distribution: Known only from the type locality.

Remarks: The reduced number and character of the preanal pores with the absence of femoral pores, the presence of enlarged rows of dorsal tubercles, and absence of large digital webs, amply separates this species from other described forms of this genus. It also differs from the other species in the character of the enlarged chinshields.

The species, collected in 1923, was lost, and rediscovered in 1958 in a jar containing *Hemidactylus frenatus.* The Latin word *amissus,* chosen for the specific name, means *lost.*

Gekko petricolus sp. nov.

Type: EHT-HMS No. 738; collected at Sanoi River Forestry Station, Ubon, Thailand, Feb. 8, 1960, among sandstone boulders, by Edward H. Taylor.

Paratypes: Nos. 34853 (Mar. 23, 1958); Nos. 736-737, 739-742, 744-745, 770 all topotypes taken Feb. 8-11, 1960, by same collector.

Diagnosis: None or only merest remnant of a web between digits; inner digits well developed, lacking claws, the subdigital lamellae undivided; body covered with fine subequal granules, intermixed with somewhat enlarged tubercles forming irregular rows, and separated by from two to five granules; postnasal and frontal areas depressed; rostral entering nostril; venter with about 30 rows of larger cycloid scales, somewhat imbricate; subcaudals widened except at base of tail and at tip; each proximal caudal segment with four enlarged tubercles. Tail slender, depressed; nine or ten preanal pores; no femoral pores. Yellow in life with a lavender-gray head; numerous rounded whitish spots evident.

Description of type: Rostral a little less than twice as wide as high, its upper edge somewhat concave with a Y-shaped median groove; a pair of large supranasals narrowly in contact mesially; nostril surrounded by rostral, supranasal, two postnasals and first supralabial; supralabials twelve, followed by a number of small scales running back to mouth-angle; mental with a labial border equal to that of rostral; ten or eleven infralabials, followed by small scales bordering mouth to its posterior angle; mental followed by two somewhat elongate chinshields; these flanked on each side by

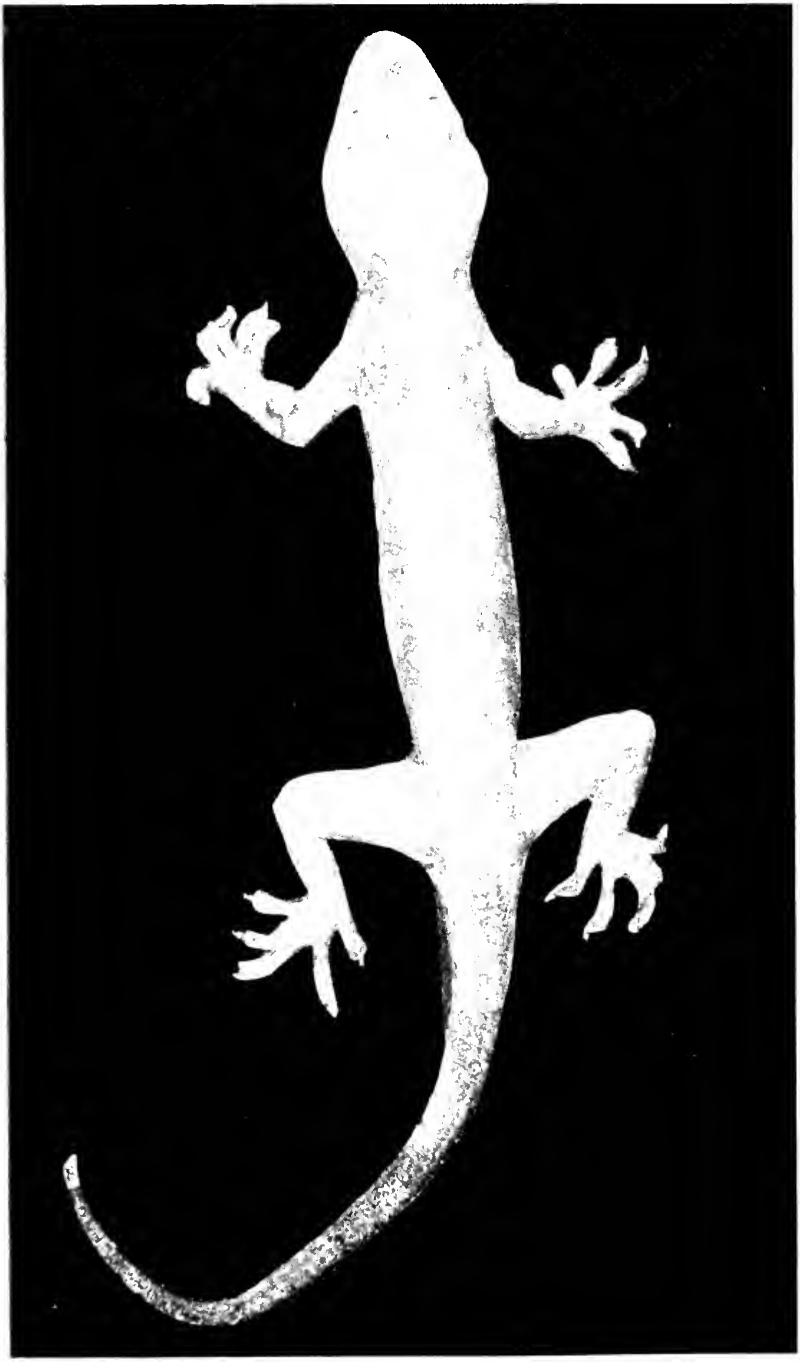

FIG. 7.—*Gekko petricolus* sp. nov. Type. Actual length, 212 mm. Forestry Station, Sanoi River, Ubon, Thailand.

three (or four) enlarged chinshields in contact with infralabials; this enlarged series continues back on each side for several scales, but these scales are separated from infralabials by one or more series of small scales; scales on chin and throat small, cycloid, imbricating, their posterior edges serrate or tuberculate when seen under a lens; an occipital depression somewhat separated by a ridge from the fronto-interorbital depression; area behind nostril somewhat depressed; about 47 scales across snout between seventh labials; eye large, diameter of orbit (7 mm.), much shorter than snout (10.5 mm.); "eyelid" completely surrounding eye, with a short series of spinous scales on its posterior borders; ear-opening moderate, its greatest (diagonal) diameter about three millimeters; the largest scales are on snout on an area anterior to eye and on supraorbital region; interorbital and occipital areas with smallest scales; about 38 scales across head between median edges of upper eyelids. Dorsal scales small, rather uniform, granular, with about 16 irregular rows of larger rounded moundlike tubercles; tail indistinctly segmented, each segment with ten to twelve transverse rows of small scales and with two or more enlarged flattened scales near the posterior part of segment; scales of basal subcaudal region not greatly enlarged; transversely widened median plates under tail for most of its length, extending to near tip of tail, where the widened scales are replaced by rows of small scales. Tail flattened, narrowed, tapering to a fine point.

Arms and legs well developed; digits with scarcely a trace of webs; divided lamellae under digits except at base; elevated terminal joint with claw extending beyond widened part of digit; claw absent on inner finger, which otherwise is well developed. About 20 lamellae under fourth finger and toe, basal ones broken or divided into small scales; hind leg reaches beyond elbow; a somewhat curved series of nine preanal pores, followed by a preanal area covered by seven rows of widened scales; openings of postanal sacs evident just preceding hemipenial swellings.

Color in life: On back, sides of body and tail, yellow with small rather symmetrical yellowish-white marks; some darker flecking visible; head lavender-gray; underside of body and tail yellowish to dirty white. In preservative dull gray, the white spots rather dimly visible.

Variation: The type series, all taken in the same locality, was constant in color save that younger specimens failed to show the yellow coloration and were gray and white in color. The femoral

Table of measurements and data on paratype series of *Gekko petricolus* sp. nov.

Number	732	742	744	737	739	738	745	741	740	770	34853
Sex	♂	♂	♂	♂	♂	♂	♂	♂	♀	♀	♀
Snout to vent	101	98	92	81	95	98	75	75	75	75	62
Tail	102	100	111 (complete)	97	93	114	73	65	62	81	72
Axilla to groin	45	45.5	42	37	43	45	33	34	33	39	27
Head width	22	20.3	19	17.4	20	20	16.2	15	15.4	16	13
Head length	26	25.6	25	21	24	25	21.5	20.5	20	21	17.7
Scales across snout	43	47	46	47	45	47	41	47	46	46	46
Scales between lateral folds	32	28	27	30	30	28	29	30	29	30	29
Subcaudals	......	......	109	110	......	105	reg.	reg.	reg.	reg.	104
Lamellae 4th toe	20	20	20	20	20	20	20	20	19	20	20
Pores	10	10	9	10	9	9	10	9	11	11	10
Supralabials	14	14	14–13	13	12–13	13–13	14–14	12–12	13–15	14–15	13–13
Infralabials	10–11	11–12	11–11	12–12	11–12	10–11	10–12	10–11	11–11	11	10–12
Scales between eyelids	34	41	39	40	40	38	41	41	39	37	40

pores were either nine or ten in number, the exudate from them being glass-clear and projecting strongly from the pores. Variation in number of scales across snout between seventh labials is from 43 to 47; across the middle part of venter between the ventrolateral folds, the number of scales varies between 27 and 32.

Sometimes the supranasals are separated from each other by a single scale instead of two scales. The rostral groove in one specimen is X-shaped.

The subcaudal scale-count from vent to tip of tail varies from about 104 to 110, the basal and terminal ones not enlarged.

The color of the adults varies but little. The yellow color disappears in the fixative within 36 hours. One young specimen differs as follows: above generally gray; head somewhat darker with numerous very small blue-white flecks or spots with slightly larger ones on occiput; a few blacker flecks also present; dorsum lighter gray than head with a row of seven small dashlike black marks along the middle line, these marks alternating with rounded bluish-white spots which continue onto tail; a similar dorsolateral and a lateral row of more indefinite dark spots also interspersed with rounded blue-white spots. Arms and legs gray with numerous whitish flecks and spots sometimes tending to form a reticulum; tail light with twelve broad dark-gray bands reaching to ventral surface; entire undersurface of head and body white or cream-white with some yellowish wash; under a lens some scattered fine pigment can be seen, the pigmentation a little heavier under tail.

Distribution: Known only from the sandstone hills near the border of Thailand and Laos. It probably occurs also in the mountains between Cambodia and Thailand.

Remarks: The weathering of the sandstone exposed along the Laos border leaves boulders and table-rocks in profusion. The species occupies horizontal crevices between the rocks, in which places they were almost invariably found upside down. Eggs are usually placed on ceilings. In certain small overhanging rocks, remnants of dozens of eggs could be seen on ceilings' six or eight feet above the floor. One exception was a pair of eggs placed on a large boulder that offered no crevices. These were on a vertical side of the boulder a few inches from the earth, covered accidentally by a pile of windblown leaves.

The eggs are rather small in diameter (9-11 mm.) and about 8 mm. high. They are somewhat moundlike, the two cemented together and plastered against rock. It is practically impossible to remove them without breaking them.

A single young specimen, No. 34855, was taken at the type locality in 1958. It was found in a pile of discarded boards not far from a group of boulders. Two of the present series were taken in a shelter house built over exposed boulders at the very edge of the Sanoi River.

At no time did I hear them call.

One pair of embryos taken from eggs, measured 45 mm. (22 mm. snout to vent, the tail, 23 mm.).

Sphenomorphus lineopunctulatus sp. nov.

Type: EHT-HMS No. 34852, collected at Forestry Station, Sanoi River, Ubon province, Thailand, Mar. 23, 1958, Edward H. Taylor collector.

Diagnosis: Dark olive-brown above with irregular rows of black dots on back; a broad black lateral stripe punctated at intervals with cream dots beginning on shoulder but preceded by one or two separate spots, bordered above by a line of ground-color and this in turn by a very narrow (often broken) dotted brownish-white line; this stripe bordered below by a broad light line which in turn is bordered below by a dark line from axilla to groin, its lower edge indefinite; no supranasals; frontonasal single; prefrontals separated; no nuchals; eyelid scaly; no postnasal; three pairs of chinshields all touching labials; 38 scalerows around body; ear-opening nearly as large as eye-opening.

Description of type: Rostral large above, not quite reaching level of line between nostrils, forming a broad suture with frontonasal; latter wider than long, broadly in contact with frontal, and bearing a semicircular groove around its anterior part (groove may be accidental or abnormal); prefrontals separated; frontal much longer than its distance from end of snout, slightly longer than combined parietals; frontoparietal divided; interparietal small, enclosed by parietals; nostril in rather large single nasal scale which is separated from its fellow; two loreals, anterior highest and narrowest; large preocular with smaller scale superimposed; two presuboculars, latter partially wedged between fourth and fifth supralabials; ten supraciliaries, first not touching frontal; four large supraoculars, three touching frontal, first touching prefrontal; lower eyelid scaly; seven supralabials, fifth and sixth below eye; two anterior temporals and two larger secondary temporals; ear-opening nearly as large as eye-opening.

FIG. 8.—*Sphenomorphus lineopunctulatus* sp. nov. Type. Actual length, 211 mm. Forestry station, Sanoi River, Ubon, Thailand.

Scales in 38 rows around body; 42 scales around narrowest part of neck; 76 scalerows (transverse) from parietals to above vent; no nuchals; scales on six median dorsal rows transversely widened, especially so on neck; five paired subcaudals basally, followed by a series of 106 single scales (15 regenerated). A pair of enlarged preanals; when limbs are adpressed, toes reach to near elbow; 22 bluntly keeled lamellae under fourth toe; in profile, lamellae forming a strongly serrate row.

Color in life: Above generally dark olive-brown with head a little darker than body; small black spots on posterior edge of frontonasal, frontal, frontoparietals, and interparietal, and two spots on posterior edges of supraoculars; black marks on supralabial sutures and on temporals; light marks on loreals; one or two black spots on shoulder in front of, and above arm-insertion; a black stripe on side, two and a half to three scales wide, continued less distinctly on tail, and bearing series of blue-white punctations; narrow whitish dorsolateral line more or less black-edged above, reaching a point above tympanum; dorsum olive with three indistinct rows of black flecks reduced to single median row of larger spots on base of tail; light grayish-white stripe from above arm to groin, but continued on base of tail as a dim dark-gray stripe; legs and to lesser extent arm with darker reticulation enclosing lighter flecks; sides of neck plumbeous gray; chin, throat, and breast dirty-white with occasional flecks of blackish; venter and subcaudal region white.

Measurements in mm.: Snout to vent, 84; tail, 127; snout to eye, 6.7; snout to ear, 15; head length, 19.8; head width, 13; snout to arm-insertion, 27.5; axilla to groin, 45; arm, 22; leg, 34.5.

Remarks: It is not impossible that this species is related to *Sphenomorphus indicus,* however, the characteristics, especially of the color pattern, are such that it must be regarded as a distinct species rather than as a subspecies of *indicus.*

Sphenomorphus mimicus sp. nov.

Type: B. M. No. 1935.11.5.15, Dong Paya Fai Mts., N. Siam, Malcolm M. Smith, collector (field no. M. S. 5302).

Diagnosis: Small skink, 36 mm. snout to vent; total length 94 mm.; prefrontals in contact, no supranasals, three supraoculars touch frontal; no postnasal; two frontoparietals; parietals enclose interparietal; one pair of nuchals; seven supralabials, the fifth and sixth enlarged; six infralabials, first small; one pair large preanals. Thirty scalerows about body at middle; ventral scales larger than dorsals; subcaudal scales enlarged. Lower eyelid scaly.

Description of species: Very small skink; rostral about twice as wide as high, forming a curved suture with frontonasal; latter much wider than long, touching nasal and first loreal laterally; no supranasals; prefrontals forming a broad median suture; frontal longer than its distance from tip of snout, shorter than its distance to nuchals, the sides straight, the scale much narrowed posteriorly; two frontoparietals, larger than interparietal; latter enclosed by large parietals; pair of nuchals (a small scale broken from that on left side); nostril in single nasal; no postnasal; two loreals, second one

Fig. 9.—*Sphenomorphus mimicus* sp. nov. Type. Actual length, 94 mm. Dong Paya Fai Mts., N. Thailand.

only little larger and equally as high as first; two superimposed preoculars, lower larger; three small presuboculars, third notching supralabial series; this followed by three small suboculars the third of which also notches supraocular series; lower eyelid scaled; four large supraoculars, three touching frontal, fourth followed by a small scale that might be interpreted as a fifth supraocular; fifth and sixth supralabials larger than others, and somewhat elongated; six infralabials, the first about half size of second. Buccal border of mental only slightly larger than that of rostral; large undivided postmental; three well-defined pairs of chinshields; first pair in contact, second pair separated by one scale, third pair by three scales; scales in 30 rows about body, dorsal scales little larger than laterals but smaller than ventral scales; pair of enlarged preanals; subcaudal scales, after tenth, become enlarged, wider and longer than adjoining scales; approximately 61 scales from parietals to point above vent; 86 subcaudals from vent to tip of tail; when arm and leg are adpressed, digits barely touch; third and fourth fingers of equal length, each with eight or nine lamellae; fourth toe longest with 16 lamellae.

Color: Above variegated fawn with clouding or small indefinite spots of brown; a dorsolateral line from snout, broken or at times continuous, and more or less including some small fawn spots most noticable along shoulder region; line continued along side of tail but growing very indefinite and finally lost; supralabials and infralabials each with a dark brown spot; sides of head reticulated with brown; side of neck and sides with fine flecks of brown; arms and legs strongly spotted with brown and fawn; chin, venter, underside of limbs, and subcaudal region cream-white.

Measurements in mm.: Snout to vent, 36; tail, 58; total length, 94; snout to arm-insertion, 13.2; axilla to groin, 18.4; arm, 8; leg, 13.1.

Remarks: This species, known only from the type locality, strongly mimics the small leiolopismas in size, color, and form. Nothing is known of the habits of this particular species.

Sphenomorphus grandisonae sp. nov.

Type: British Museum No. 1935.11.5.13, "Ban Tong Pheung, N. Siam," M. A. Smith, collector.

Diagnosis: Small skink; 34 scalerows around body; six supralabials; five infralabials, median suboculars larger than pre- or postsuboculars, the whole series continuous; temporals, 2 + 3 + 4; no nuchals; dorsal scales smaller than ventrals; subcaudals smaller than

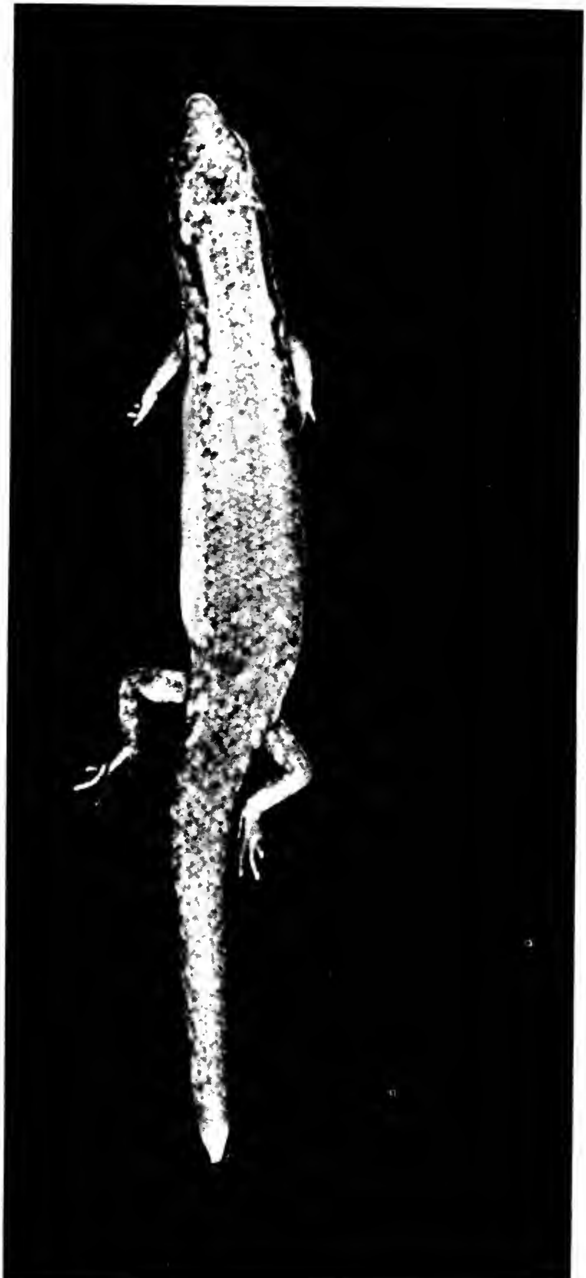

FIG. 10.—*Sphenomorphus grandisonae* sp. nov. Type. Actual length, 51.5 mm. Ban Tong Pheung, N Siam.

lateral caudal scales; dorsolateral markings on side reduced; very slight suggestion of a brown stripe dorsolaterally on tail; digits fail to touch when limbs are adpressed; third finger distinctly longer than fourth, all fingers relatively short. Seventy-one scales in a line from parietals to above vent.

Description of type: Rostral visible, its posterior border convex, forming a suture with frontonasal; frontonasal wider than long; prefrontals moderate, in contact mesially, separated from first supraocular; frontal longer than its distance from tip of snout, much shorter than its distance from posterior end of parietal; two frontoparietals, the interparietal enclosed by parietals; no nuchals; nasal diagonally placed, undivided; two loreals, first higher than second; two preoculars; four supraoculars, the anterior smallest in area; nine supraciliaries; seven or eight pre-, sub-, and postoculars forming a continuous series, none wedged between supralabials; temporals, 2 + 3 + 4; six supralabials, fourth below middle of eye; five infralabials, first largest; mental with larger labial border than rostral; large postmental; three pairs of chinshields touching labials, first pair in contact, second separated by one scale, third by three scales; lower eyelid scaly; tympanum large, superficial; eight scalerows across neck between darker lines; 34 scalerows about middle of body; 24 scales about tail at 14th subcaudal; median subcaudals definitely not larger than adjoining scales, smaller than lateral caudals.

Arm and leg short, toes and fingers separated when legs are adpressed; median finger distinctly longer than two adjoining digits, with six lamellae; twelve lamellae under fourth toe.

Color: Above light brown with some minute flecking on dorsal scales but no series of spots; head with supraorbital sutures darkened as are many other head sutures; lips with dark bars on sutures, separated by cream spots; lighter dorsolateral light line on side of neck and shoulders; a brown stripe below the light stripe reaching to shoulder but not continued along side except as very indefinite, scarcely discernible darker flecking with some lighter dots; indistinct dark and light marks on limbs and tail; white or cream on chin, venter, and underside of tail; tail broken and regeneration begun.

Measurements in mm.: Snout to vent, 30; tail (broken), 21.5; head width, 4.1; head length, 8.2; snout to arm, 12; axilla to groin, 16; arm, 6.5; leg, 9.4.

Distribution: Known only from the type locality.

Remarks: The scales are slightly elevated giving the impression that they are very bluntly keeled. However, they are not keeled.

They are arranged in very straight rows, those on the back are of the same size as those on sides, but smaller than most of the ventral scales.

The failure of any of the subocular scales to form a notch between two supralabials and the presence of a large first infralabial equal in size to second are characters not usually present in *Sphenomorphus.* Usually the first labial is only about half the size of the second.

The species is named for Miss Alice Grandison, Keeper of Reptiles and Amphibians, Department of Zoology, British Museum, who has kindly loaned the specimen for study and description.

Riopa frontoparietalis sp. nov.

Type: EHT-HMS No. 1694, collected in hills near Scout Camp, Sara Buri, Sara Buri, Sept. 26, 1960 by Edward H. Taylor.

Paratypes: Nos. 33339-33342, Nakhon Ratchisima but very close to Muak Lek, Sara Buri; 33391 Muak Lek, Sara Buri; 33392, 33393 Pasadet, Sara Buri, same collector.

Diagnosis: Similar to *Riopa bowringi* except smaller (snout to vent 41), usually darker brown with the frontoparietal single.

Description of the type: Rostral wider than high, visible above; pair of supranasals forming short median suture, touching nasals and anterior loreal laterally, about twice as wide as long; prefrontals quadrangular, widely separated, touching both loreals; frontal truncate anteriorly, longer than its distance to tip of snout, shorter than its distance to nuchal; frontoparietal single, much larger than interparietal, touching three supraoculars; parietals forming a suture behind interparietal; a pair of nuchals; nasal seemingly completely divided without a separate postnasal; two loreals, anterior the higher, posterior slightly larger and subquadrangular; two presuboculars, three postsuboculars connected by a row of tiny scales on lower edge of eyelid; eyelid with several larger scales; two large anterior temporals; three secondary temporals; supralabials, 7-7, fifth below eye; first larger than the three following; seven supraciliaries; mental with an oral border much larger than rostral; one undivided postmental, followed by large pair of chinshields in contact; second pair separated by five scales; six infralabials; ear moderate, the anterior border with two lobules; scalerows about neck, 28; about middle of body, 28.

Scales from nuchal to above vent, 56; when arms and legs are adpressed they are separated by five scales; middle finger extends

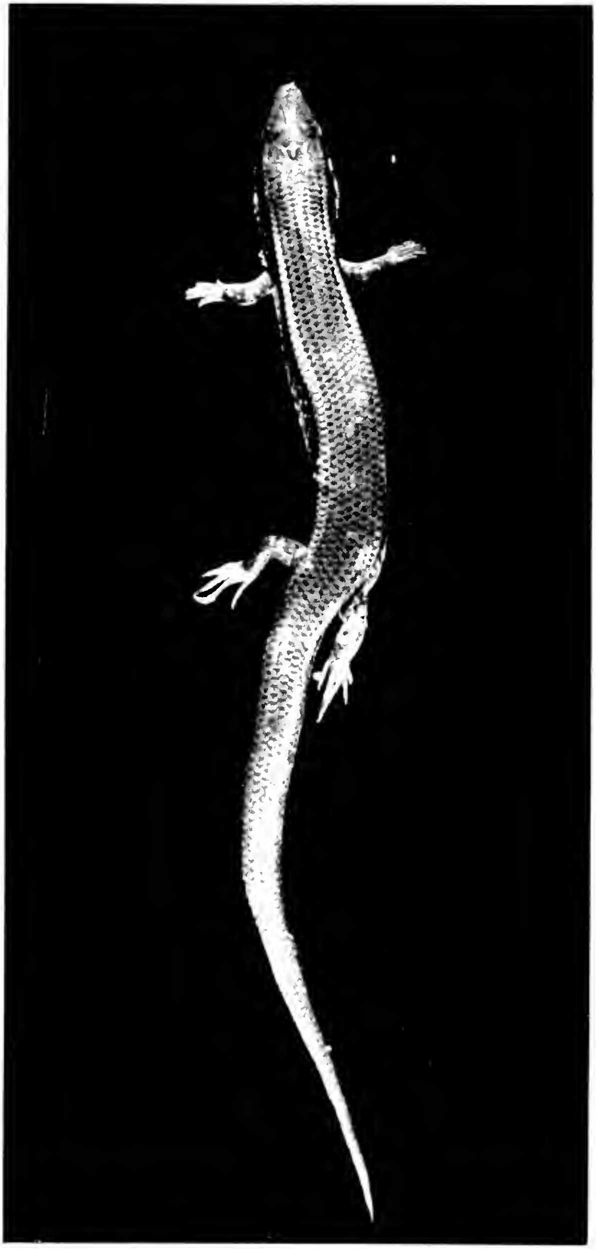

FIG. 11.—*Riopa frontoparietalis* sp. nov. Type. Actual length, 85 mm. Hills near Sara Buri, Sara Buri, Thailand.

a little farther than fourth, the latter with ten subdigital lamellae; fourth toe longest, with 13 lamellae, tubercular proximally, compressed distally; six preanal scales, the two median a little larger than others, and white in color; median subcaudal series of scales slightly enlarged, 78 in all.

Color in life: Above dark brown, head nearly uniformly colored above; a pair of light brown dorsolateral lines covering part of two or one whole and two half rows of scales; six median brown scale-rows each row with a dim dark line. Side with black line bordering the dorsolateral light brown line; below this the side of neck and body covered with irregular vertical rows of dark brown and cream scales. Central part of supralabials with an indistinct cream line. Chin and ventral surface of body dirty white; underside of tail, gray; median anal scales pure white. Palm, sole, and underside of digits blackish.

Measurements and data of *Riopa frontoparietalis* sp. nov.

Number	1694	33341	33342	33391	33392	33393
Snout to vent	38	33	35	41	41	36.2
Tail	47	38	41.5	55	....	42
Head width	6.1	6.5	5.4	6.3	6.4	6
Head length	9.4	8.5	9	10.4	9.3	9.5
Arm	8	6	7	8	8.2	8
Leg	10.3	7.5	9.5	12	11.2	11
Scales, nuchal to vent	56	59	60	57	59	60
Scales around middle	28	30	30	28	28	30

Variation: The scalerows about body vary between 28 and 30.

The type and paratypes are all much the same as regards color and markings.

Distribution: It would appear that this form has originated and is still confined to the central mountains on the eastern part of the Khorat plateau. This range is generally known as the Dong Paya Fai Mts.

This range is also the home of *Riopa koratense; Cyrtodactylus angularis, Phyllodactylus melanostictus, etc.*

Remarks: All the specimens taken in this region, Nos. 33339-33342 Nakhon Ratchisima on border of Sara Buri; 33391 Muak Lek, Sara Buri; 33392-33393 Pasadet, Sara Buri, agree with the type in the presence of a single frontoparietal.

In some hundred specimens of *R. bowringi* this fusion was observed in one specimen in which the frontoparietals, partially fused, were united to the interparietal (probably due to an injury).

Malcolm Smith reports a specimen with a single frontoparietal from the Langbian Plateau, Annam.

Riopa haroldyoungi sp. nov.

Type: EHT-HMS No. 53, collected at the base of Doi Suthep, near Chiang Mai, Chiang Mai province, Sept. 2, 1959 by Harold Young.

Diagnosis: An elongate-bodied skink; distance between tip of snout and insertion of arm contained in axilla to groin measurement about 3⅓ times; arm length in axilla to groin distance about 9 times; ear-opening small distinct; nostril in nasal and almost bordering supranasal; rostral, first supralabial, mental, first infralabial, nasals and supranasals somewhat thickened (bluish to ultramarine in color); first supralabial twice as large as the three subsequent supralabials.

A white band crossing head behind parietals; body with 32 irregular transverse light bands often broken, sometimes tending to form reticulations.

Description of type: Body greatly elongated, adpressed limbs widely separated; head moderately large, scarcely as wide as body in postaxillary region. Tip of snout rounded; rostral large, well visible above, posteriorly forming an angle; internasals completely free from nasal, subtriangular in shape, in contact mesially; frontonasal much wider than long, laterally in contact with anterior loreal; frontal relatively short (4 x 3.7 mm.), the broad contact with frontonasal nearly a straight line; prefrontals small, widely separated, each touching both loreals; a single large frontoparietal, wider than long (5 x 3.5 mm.) mesially notched posteriorly by small interparietal; parietals elongate (6 mm.) diagonally placed, not or barely enclosing interparietal; no distinct nuchals; nostril in a single nasal nearly twice as long as high; two loreals the anterior highest; four supraoculars, the anterior triangular, second largest, fourth barely touching parietal; six supraciliaries; five subocular and preocular scales; upper eyelid greatly reduced; lower lid with at least three rows of small scales.

Nine supralabials anterior twice as large as any other labial, in contact with anterior loreal behind nasal; three rather enlarged temporals border parietal; mental with a larger labial border than rostral, partially fused to first infralabial; nine or ten infralabials, first largest; an azygos postmental; first chinshields in contact, partly

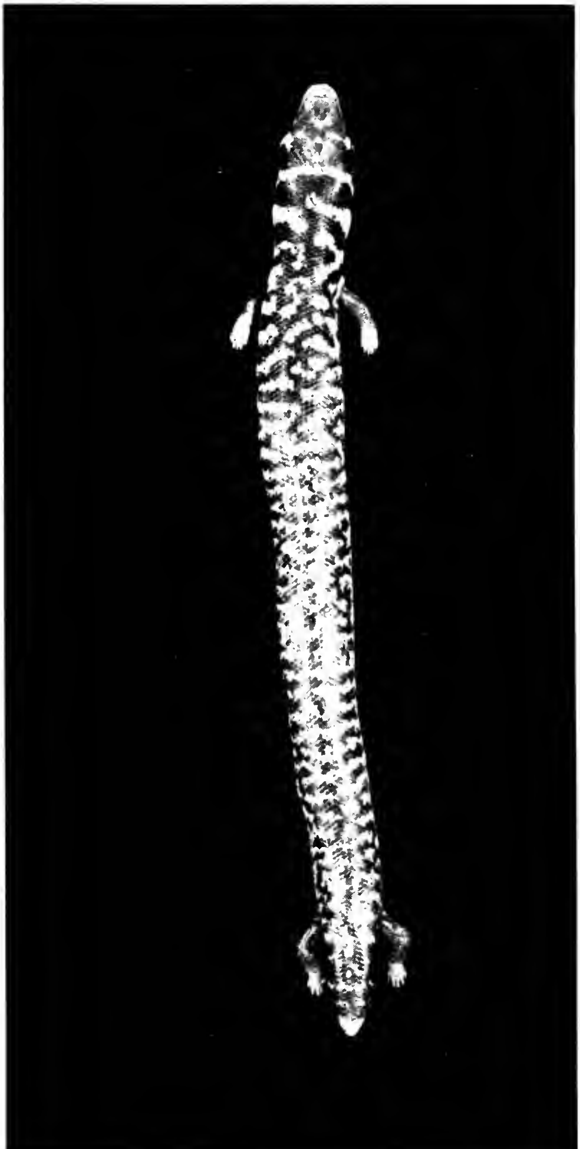

Fig. 12.—*Riopa haroldyoungi* sp. nov. Type. Actual length, 150 mm. Base of Doi Suthep near Chiang Mai, Chiang Mai, Thailand.

fused, touching labials on one side only; second pair of chinshields separated by two or three scales and also separated from labials by one scale; third pair of chinshields scarcely differentiated.

Ear-opening small distinct, upper anterior part partially covered by an overhanging scale or scales; limbs short. Arms short, pentadactyl, clawed, the three median digits subequal, their length with claw, measuring about 1.5 mm., twice length of two outer digits; subdigital lamellae five or six; palm with rounded or somewhat flattened tubercles; four outer toes longer than inner, strongly curving, with strong well-developed claws; six or seven lamellae under longer toes; tympanum very deeply sunk.

Forty-seven smooth scales in a row about neck; 40-42 scalerows about body at middle; vent bordered anteriorly by ten slightly differentiated scales; basal subcaudals not enlarged or differentiated; distal portion of tail missing with regeneration recently begun; 143 scales in row from parietals to point above vent.

Color in life: Generally dull black and yellowish ivory; snout tip rather gray-ultramarine because of thickening of scales; head blackish above with slight clouding of ivory; two ivory marks on chin run back then run up on side of head to eye; this followed by a similar dark band also proceeding to eye; next ivory band reaches front of parietal; followed by a black band, narrow below, but widening on temporal region; next ivory band encircles head behind parietals; from here on, alternating bands are dull blackish and dirty ivory, often broken, sometimes tending to form reticulations; limbs somewhat darker, light flecks indistinct.

Measurements in mm.: Snout to vent, 136; tail broken (regeneration begun), 14; tip of snout to arm-insertion, 29; axilla to groin, 97; arm, 11; leg, 12; width of head, 12; length of head, 18; snout to ear-opening, 16; snout to arm-insertion in axilla-to-groin distance 3.35 times; distance between adpressed limbs equals slightly more than 6.5 times length of arm; greatest body width 13.6.

Remarks: Only the type is known. It was taken at the base of Doi Suthep Mountain by Mr. Harold Young. It was kept alive at his zoo for some days but in trying to escape it fell in a water tank and was drowned.

The species is named for its discoverer.

Leiolopisma pootipongi sp. nov.

Type: EHT-HMS No. 34858; from Forest Station, Sanoi River, tributary of the Moon River; collected Mar. 23, 1958, by Edward H. Taylor.

Diagnosis: A diminutive skink (38 mm.) with frontoparietal single; prefrontals broadly in contact; no transversely enlarged nuchals; dorsolateral whitish line separated from its fellow by six scalerows; lateral dark stripe, its lower edge very irregular with some white dots; 4th toe reaches to wrist when limbs are adpressed; preanals large; 18 lamellae under fourth toe; 30 scalerows about body; posterior subcaudals widened; anterior subcaudals about size of adjoining scales.

Description of type: Rostral large, much wider than high, forming broad suture with frontonasal, separating nasals; frontonasal nearly twice as broad as long touching first loreal laterally; prefrontals large, broadly in contact, touching laterally both loreals and in contact with first supraocular; frontal narrowed to a blunt point posteriorly, touching two oculars, little longer than its distance from tip of snout, shorter than length of combined parietals; four supraoculars, anterior triangular; eight supraciliaries; nasal single; anterior loreal higher and narrower than second; three presuboculars, third wedged between fourth and fifth labials; seven supralabials, fifth and sixth below eye; two temporals between sixth labial and the very large temporal bordering parietal, one between seventh labial and large temporal; lower eyelid with an undivided transparent disc; ear-opening large; six infralabials, first very small; mental with larger labial border than rostral; one large azygos postmental; first chinshields in contact, second pair largest, narrowly separated by one scale; third pair separated by three scales; fourth pair separated by four scales; all four pairs bordering infralabials.

Scales smooth, 30 scalerows around middle of body (one millimeter farther forward the count is 32); eight scalerows on back, those behind occiput somewhat widened; subcaudal scales near base not noticeably enlarged; behind this, distinctly wider than adjoining scalerows; preanals well enlarged; arms and legs overlapping when adpressed, fourth toe reaching to wrist; 18 lamellae under fourth toe; 66 scales from parietals to above vent.

Color in life: Above olive-brown, head, especially in supraocular areas, darker; pair of dorsolateral light lines confined to parts of two scalerows; on middle of back, row of dark spots paired anteriorly; an indefinite darker streak along dorsum of tail with wide dorsolateral stripe bordered laterally by an indefinite darker stripe; dark lateral stripe beginning behind eye passing distinctly above ear, very irregular on its lower edge and bearing several small punctate light spots; dark color widens and extends down almost to arm-insertion and here shows a whitish bordering line; lower flanks, chin, venter, underside of limbs, and subcaudal region immaculate white but subcaudal area somewhat pinkish; labials cream with sutures widely bordered with darker pigment; arms and legs brownish, reticulated, enclosing lighter spots.

Measurements in mm.: Snout to vent, 37.2; tail, 18 (broken); snout to ear, 7.6; head length, 9.4; head width, 5; snout to arm-insertion, 13.7; axilla to groin, 19; arm, 10; leg, 13.8.

Remarks: I do not regard the single frontoparietal as an anomaly. It is a form probably related to the Indian *L. palnicum* Boettger which likewise normally has an undivided frontoparietal.

The species is named for M. R. Pootipong Nupartpat Varavudhi, Instructor in Zoology, Chulalongkorn University, my assistant who obtained many interesting specimens for the collection.

Dibamus alfredi sp. nov.

Type: EHT-HMS No. 1385 ♂, collected Na Pradoo, Pattani, Thailand at base of Bukit Besar, June 8, 1960, by Edward H. Taylor.

Paratypes: Nos. 1386 ♀. Topotype. Same date and collector. Nos. 1374-1375. Topotypes, Nai Prayoon Kananuracks collector, 1961.

Diagnosis: Snout conical, covered with large rostral; a large anterior supralabial fused with rostral anteriorly, but with an entrant suture from ocular on level with eye, extending forward, but not reaching forward to level of nostril; frontal smaller than interparietal; 20 scalerows around body; four preanal pores.

Description of type: Rostral large, rounded anteriorly, and in profile; nostrils lateral, pierced in rostral somewhat back of anteriormost point; snout projecting beyond mouth; posterior border of rostral forming an obtuse entrant angle; small median frontal twice as wide as long, somewhat lens-shaped, bordered behind by a somewhat larger interparietal; latter bordered behind by five scales, shaped somewhat like regular body scales but distinctly larger; an ocular plate borders frontal and interparietal on side; eye covered, but visible in lower anterior part of scale; supralabial scale below ocular. Anterior to ocular at level of eye is an entrant suture extending forward, failing to reach as far forward as vertical level of nostril by a third of length of suture. A large infralabial on each side separated by a trapezoidal mental.

Body scales smooth, subcycloid, or subhexagonal; 24 scalerows around back part of head; 22 on neck, 20 around middle of body and

FIG. 13.—*Dibamus alfredi* sp. nov. Type. Actual length, 94 mm. Na Pradoo, Pattani, Thailand.

preceding vent; 20 around tail; tail short, blunt at tip, not ending in a spine. Legs flattened on ventral surface, covered with three scales at base followed by three pairs of scales and an elongate terminal scale; on dorsal surface covered with about 18 scales; preanal pores two on each side, covered by a pair of somewhat enlarged scales through which elongate pores are visible. Triangular preanal area between folded limbs occupied by two transverse rows of three scales each, and an elongate terminal scale, its posterior half free. No ear-opening; eyes dimly visible through ocular.

Color in life: Generally violet to purplish brown, not or scarcely lighter below on ventral surfaces; underside of snout, a large area about nostril, sides of head and anterior part of chin, cream to ivory-white. Preanal scales and dorsal surface of limbs white. On ventral surface of type, about 50 scattered ivory-white scales.

Measurements in mm. (No. 1386 ♀, 1385 ♂ respectively): Snout to vent, 98, 94; tail, 15.6, 17.2; width of head, 3.1, 3.2; width of body, 4, 3.4; length of leg, —, 3.

Variation: The female taken with the male agrees in most characters. The legs are absent in females. The ocular is bordered behind by two "postoculars"; and there are 20 (or 21 rows) around middle of body, while there are but 16 around middle of tail. There are 178 transverse scalerows on body, and 41 on tail.

At the base of the anal flap, there is a pair of larger scales separated by a smaller scale. Behind this a transverse series of five scales is followed by a transverse series of three, bordering vent. In the female I find only a single preanal pore on each side.

Distribution: B.M. No. 1903.4.13.69, an egg containing a young specimen of a *Dibamus* discovered on Bukit Besar by Robinson (1903), and reported by Boulenger, is in the British Museum. I have examined this specimen but the scale sutures on the head are not discernible. It is to be presumed that it is the same species since the egg was found in the general vicinity where my two adults were taken.

Typhlops khoratensis sp. nov.

Type: No. 3182, collected October 10, 1957, Muak Lek, Friendship Highway, Sara Buri province by Edward H. Taylor.

Paratypes: No. 33325, topotype; Nos. 267-268, Chiang Mai, Chiang Mai province, Thailand; 612 Hua Hin, Prachuap Khiri Khan province; Nos. W.291, 292 (N. M. W.) locality unknown.

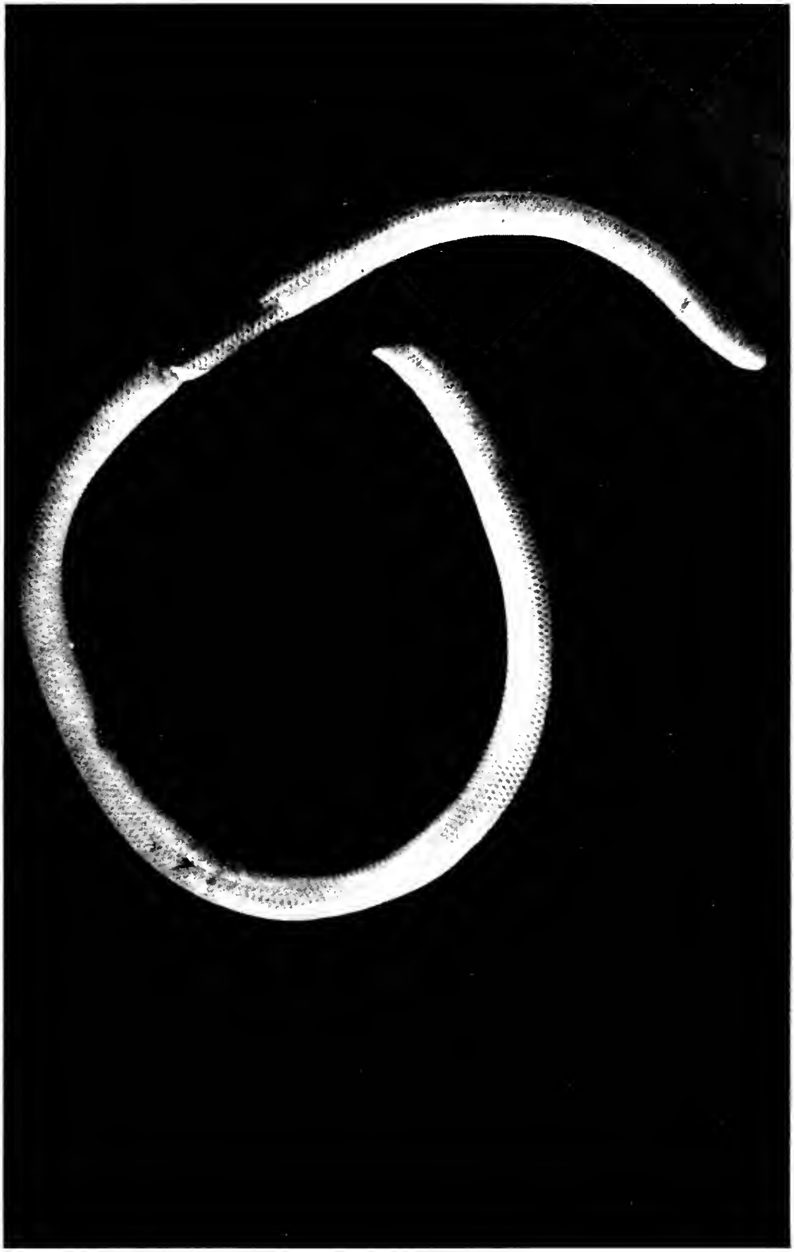

Fig. 13a.—*Typhlops khoratensis* sp. nov. No. M. 268, paratype Chiang Mai, Chiang Mai province, Thailand. Actual length 107 mm. (The dark mark on body is due to an injury.)

Diagnosis: Body width in total length approximately 28-43 times; rostral about ⅓ as wide as head at eye level, failing to reach level of eyes; supralabials and infralabials relatively large; nasal completely divided, the suture from preocular; two pairs of parietals differentiated; prefrontal, frontal, and interparietal large, subequal; 20 scalerows throughout body; transverse scalerows approximately 315-326.

Description of type: Rostral short, about ⅓ as wide as head at eye-level, failing to reach eye-level by a considerable distance; nasals completely divided, the suture arising from preocular; upper nasals not in contact behind rostral; prefrontal relatively large, as large as frontal or interparietal; supraocular only slightly smaller than frontal, its suture with ocular crosses the eye; two pairs of parietals; preocular smaller than ocular, the suture between them not crossing eye; eye only dimly visible; supralabials relatively large and distinct, especially fourth; a single postocular behind ocular between fourth labial and parietal; ocular and preocular relatively small, the preocular largest; infralabials relatively large.

Scales in 20 rows along entire body; transverse scalerows about * 315.

Color: Nearly uniform gray, the scales about mouth and underside of snout whitish.

Measurements and scale-counts of type and paratypes of *Typhlops koratensis* sp. nov.

Number	3183	267	268	612	W.291	W.292	33325
Length, snout to vent	125	103	105	104	119.7	118	100
Tail	3	2	2	2	2.3	3	2
Total length	128	105	107	106	121	121	102
Scalerows at:							
neck	20	20	20	20	20	20	20
middle of body	20	20	20	20	20	20	20
before tail	20	20	20	20	20	20	20
Transverse scalerows	315	320	326	319	321	319	331
Width of head	2.8	2.45	2.5	2.5	2.9	2.8	2.3
Width of rostral	.75	.7	.7	.7	.7	.7	.6
Rostral reaches eye	no	no	no	no	no	no	no
Body width	3	2.8	2.4	2.5	3.6	4	3
Width in length	41.5	37	43.7	40±	33	28	33
Nasal divided	yes	yes	yes	yes	yes	yes	yes
Suture from preocular	yes	yes	yes	yes	yes	yes	yes
Parietals two pairs	yes	yes	yes	yes	yes	yes	yes

* The scales are counted in a row; occasionally there are intercalated scales or the row is incomplete hence the counts are close approximations.

Remarks: This species occurs with and resembles *Typhlops braminus,* especially specimens when they develop a grayish to a silvery-gray color before shedding. The character of the head scales easily separate them and in the case of *T. braminus* the presence of distinct glands following the head sutures is distinctive.

The two specimens from the Vienna Museum kindly loaned by Dr. J. Eiselt without certain locality data, are probably from Laos or Thailand. The data was lost in movement of the collections during the war.

The species is named for the Khorat Plateau area of Central (Eastern) Thailand.

Typhlops trangensis sp. nov.

Type: EHT-HMS, No. 35754; collected at Khao Chong, Forest Experiment Station, Trang province, May 20, 1958, by Edward H. Taylor.

Diagnosis: A short (155 mm.), relatively thick-bodied species, width in length approximately 30 times; 370 transverse scalerows from rostral to tail-spine. Vertebrae, 206; nasal incompletely divided, suture reaching to second labial; 24 longitudinal scalerows; rostral, nasals, oculars, preoculars, prefrontal, frontal, supraoculars, parietals, and perhaps also interparietals cover a distinct pit or depression visible through posterior part of scale; no trace of eye visible; gray to ultramarine above (11 rows), the 13 ventral rows cream-white, the dividing line rather sharply marked.

Description of type: A short, thick-bodied species, the tail ending in a spine and bending down at tip so that terminal spine is on a level with venter; snout rounded, seen from above, equally as wide as body; head width 5 millimeters, greatest dorsal width of rostral 1.65 mm. about one third width of head; rostral forming a suture with prefrontal; suture, partly dividing nasal, ends at second labial, scarcely passing beyond nostril above; prefrontal smaller than frontal; frontal about as large as supraoculars; interparietal a little larger than frontal and notched mesially on posterior border, a little wider than parietals but slightly shorter; preocular about size of ocular, wedged between second and third supralabials; ocular without trace of eye, wedged between third and fourth supralabials, and bordered posteriorly by two postoculars and partly by parietal; four supralabials; snout projecting 1.4 mm. beyond mouth; scales in 24 rows, the anterior median rows largest; vent bordered by five scales, two outer largest; 370 transverse scalerows counted along dorsal midline to spine on tail; (about eleven rows on tail); verte-

FIG. 14.—*Typhlops trangensis* sp. nov. Type. Actual length, 155 mm. Khao Chong Forest Station, Trang, Thailand.

brae, 206, the terminal four or five very small; tail broader than long; a gland under ventral section of nasal; pits (glands)? under major head scales.

Color in life: Ultramarine on eleven dorsal scalerows; lower 13 scalerows cream-white; dorsal head scales lighter than body, the pits beneath them showing a little darker; underside of head cream-white.

Measurements in mm.: Total length, 155; body width, 5.1; tail length, 2.8; tail length in total length about 55 times; body width in total length, 30 times.

Remarks: The relationship of the species is not known; the larger size of the dorsal head scales and the pits appear to separate this species very distinctly from other members of the genus occurring in Thailand. The pits are a significant feature and show with reasonable clarity in the photograph reproduced here.

The specimen was found under a rotting log about 30 meters from the shelter house at the first waterfall at the Khao Chong Forest Experiment Station, Trang province. The species is named for the province (Changwat) of Trang.

Typhlops klemmeri sp. nov.

Type: EHT-HMS No. M176, Koh Phai, near Kuala Lumpur, Malaya.

Diagnosis: A rather thick-bodied species, width contained in length about 28 times; nasal partially divided beyond nostril, nasal suture arising from second labial; width of rostral above, two fifths width of head between eyes; nasals narrowly separated behind rostral; interparietal not or scarcely differentiated; a preocular but no subocular; 23 scalerows around body; about 292 transverse scale-rows from rostral to caudal spine; no gland or pit under imbricating portion of nasal.

Description of type: Rostral reaching back to anterior level of eyes, two fifths as wide above as width of head between eyes; prefrontal small touching rostral and narrowly separating nasals; frontal distinctly wider than prefrontal, a little larger than supraoculars; interparietal not differentiated from body scales; a pair of parietals as wide as frontal but scarcely as large; supraocular suture with ocular above not crossing eye; suture between preocular and ocular crossing eye; nasal suture arising from second supralabial passes slightly beyond nostril, not dividing scale completely; two postoculars between fourth supralabial and parietal; 23 scalerows around body from neck to vent; transverse scalerows 291 or 292 (count on two sides); anal scales not or scarcely differentiated; tail ending in a strong spine directed downward. Width of body in total length about 28 times.

Color: Above medium brown; venter light yellowish brown, the colors without any distinct line of demarcation, with an indistinct median ventral cream line. Subcaudal region as dark as dorsum. Head and nuchal scales have a symmetrical pattern of yellowish glands following sutures.

Measurements in mm.: Total length, 151; tail, 2.5; width of body, 5.2; width of head, 4.3.

Remarks: This species probably is related to the *braminus* group but the body is distinctly stouter and the color of body and pattern of glands on head differs materially in the two forms. In *braminus* the body width in length averages between 35 and 36 times, and the nasal is completely divided. The species is named for Dr. Konrad Klemmer, Curator of Herpetology at the Senckenberg Museum of Frankfurt, in recognition of his many courtesies on my visits to the Senckenberg Museum.

Calamaria fraseri sp. nov.

Type: EHT-HMS No. M. 29; taken on Fraser's Hill, Malaya, elev. 3800 ft. June 28, 1960, by Edward H. Taylor.

Diagnosis: A diminutive species, bluish black above, growing slightly brownish laterally; head somewhat grayish-blue on snout; a cream spot on each side of neck covering six scales, the spots narrowly separated by a single scale on median line; entire venter bright yellow (fading to dull white after a few days in preservative). Four supralabials; no preocular; ventrals and subcaudals reduced; anal single; scalerows, 13.

Description of type: Snout rounded, projecting beyond mouth; rostral well visible above; prefrontals and internasals fused into a pair of large scales as long as, but larger than frontal; frontal regularly hexagonal, about three times width of supraocular, its length equal to its distance from tip of snout; parietals elongate their length about equal to their distance from tip of snout; four supralabials, third (much the smallest) and, second bordering orbit; small postocular; fourth supralabial bordering parietal; rather large secondary temporal behind fourth supralabial bordering posterior part of parietal; nostril pierced in a minute nasal about one tenth size of first labial; five infralabials, first pair in contact behind rather

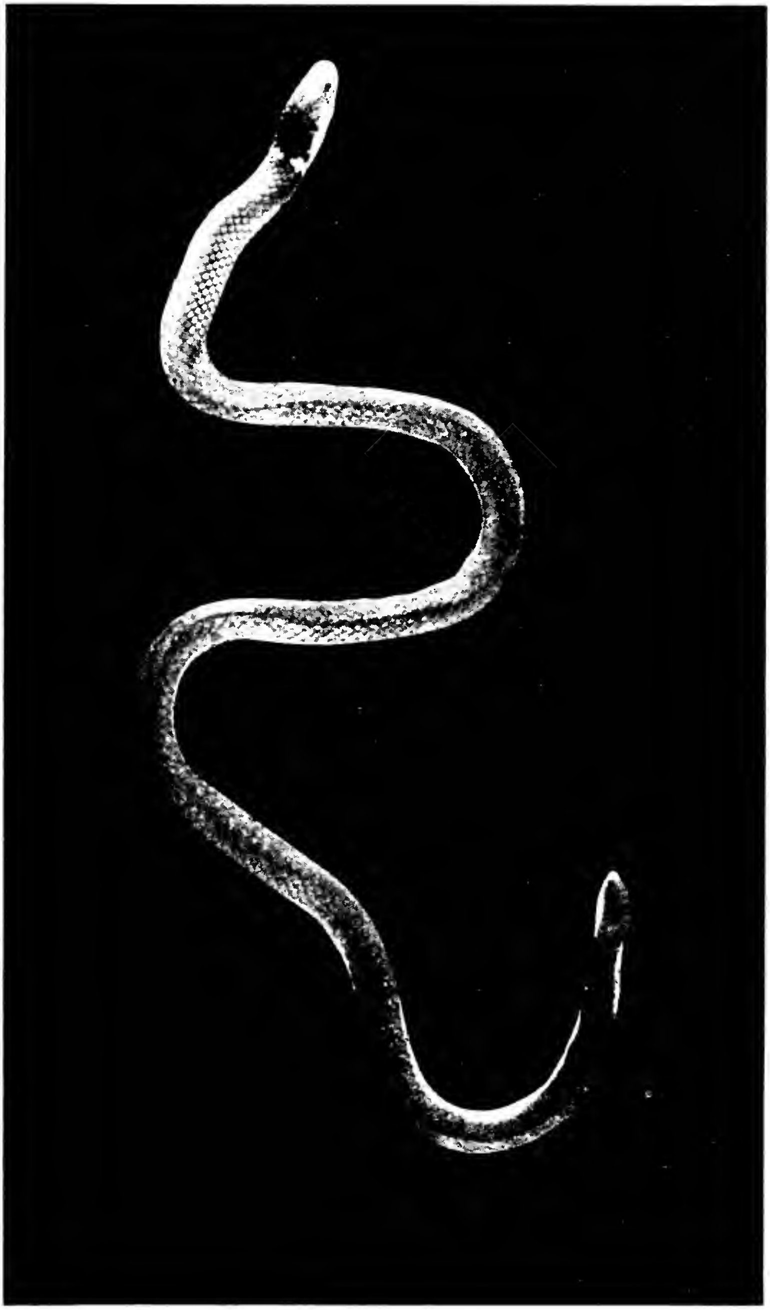

Fig. 15.—*Calamaria fraseri* sp. nov. Type. Actual length, 171 mm. Fraser's Hill, 3800 ft., Malaya.

large mental; first chinshields (touching three infralabials) twice size of second pair which borders fourth and fifth infralabials; scales in 13 rows throughout body, smooth, without apical pits; ventrals, 161; subcaudals, 15; anal single.

Color: Above blackish, with a bluish iridescence, growing lighter and somewhat brownish laterally; venter bright yellow; first and second supralabials gray, third and fourth whitish; entire chin and infralabials yellow; outer scalerow partly yellow; pair of lateral cream spots on neck at 7th transverse scalerow.

Measurements in mm.: Total length, 171; tail, 10.5; width of head, 3.2; length of head, 5.7.

Remarks: This species has seemingly been confused with *Calamaria gimletti.* Thus Tweedie remarks (Snakes of Malaya, 1954, p. 51): "The variable color pattern is a curious feature, and one specimen [*gimletti*] has been recorded with only 165 ventrals, but this is probably best regarded as an abnormality."

Fraseri differs from *gimletti* in lacking the yellow spots on the body, in having a yellow bar on the neck some seven transverse scalerows behind parietals. It likewise differs from that species in having only 161 ventrals, while *gimletti* is reported as having 200-239 ventrals, 9-17 subcaudals. The specimen mentioned by Tweedie as an abnormal *gimletti* is very probably a normal specimen of this species.

Tweedie also mentions a *gimletti* taken from the stomach of *Maticora intestinalis* having 188 ventrals, a count likewise low for that species. This latter may be a female of *fraseri* since the females of certain species of *Calamaria* frequently average twenty more ventrals than the males. However the possibility of a species with the males having only 161 ventrals, and females 239 ventrals, is very remote.

From the Bornean *Calamaria schmidti* Marx and Inger, it differs in having a higher number of ventrals; frontal less wide and definitely not triangular in shape; the third supralabial smallest, less than half size of second; the suture between the combined prefrontals and internasals about half length of scales; the nasal about one tenth the size of the first labial instead of about one half as shown in Marx and Inger's fig. 27. The ventral coloration is uniformly yellow, not purplish posteriorly.

The species may also be compared with a species described by Brongersma from Doerian, an island in the Rhio Linga Archipelago, *Calamaria doerianense.*

Probably the most significant difference is in the coloration; *fraseri* is black above, the scales almost uniformly colored except two outer scalerows anteriorly and single outer scalerow posteriorly which is yellow with some black flecks; the underside of the body is bright yellow throughout except in the subcaudal region. There is a yellow nuchal ring, and the subcaudal region is white lacking a median brown line. The fourth supralabial is very much larger than the second or first, the third is less than half of second.

Calamaria doerianense has each dorsal scale with a dark fleck anteriorly, while posteriorly the scale is whitish. There is a median brown line under the tail. A yellow nuchal collar is lacking. The ventral surfaces are white.

The second and fourth supralabials are subequal in size.

The ventral count given for *doerianense* is 184 with 20 subcaudals, totaling 204 scales (sex?). The count for *fraseri* is 161 ventrals and 15 subcaudals, a total of 176 (male), a difference of 28 scales. This number is significant if the type of *doerianense* is a male. Both species lack a preocular. The second chinshields are strongly in contact in *fraseri:* in *doerianense* they barely touch, and are proportionally smaller. *Doerianense* measures 166 mm., snout to vent, the tail 13 mm. Tail in head-body length, 12.8 times, while *fraseri* measures 171 mm., snout to vent, the tail, 10.5. Tail in head-body length, 16.3 times.

The type of *fraseri,* was obtained somewhat above the village on Fraser's Hill. I was paused, watching some ants migrating across the path, when this tiny snake came crawling out of the short grass into which the ants were disappearing.

The snake has a swelling on the throat that suggests the presence of a disease.

The species is named for the mountain, Fraser's Hill.

Keiometopon gen. nov.*

Type of genus, *Keiometopon booliati* sp. nov.

Diagnosis: Small snake, with a median continuous suture extending from median nuchal to rostral; the left internasal, prefrontal, and left half of frontal fused, as are the scales on right side of suture; parietals large, normal; supraoculars widened; pre- and postoculars present; nostril pierced in a single tiny nasal; five supralabials; a posterior temporal; first labials touching behind mental; two pairs of normal chinshields. Ten maxillary teeth, subequal, each bent at an

* Greek. *Keio,* split; *metopon,* forehead. In reference to the split frontal.

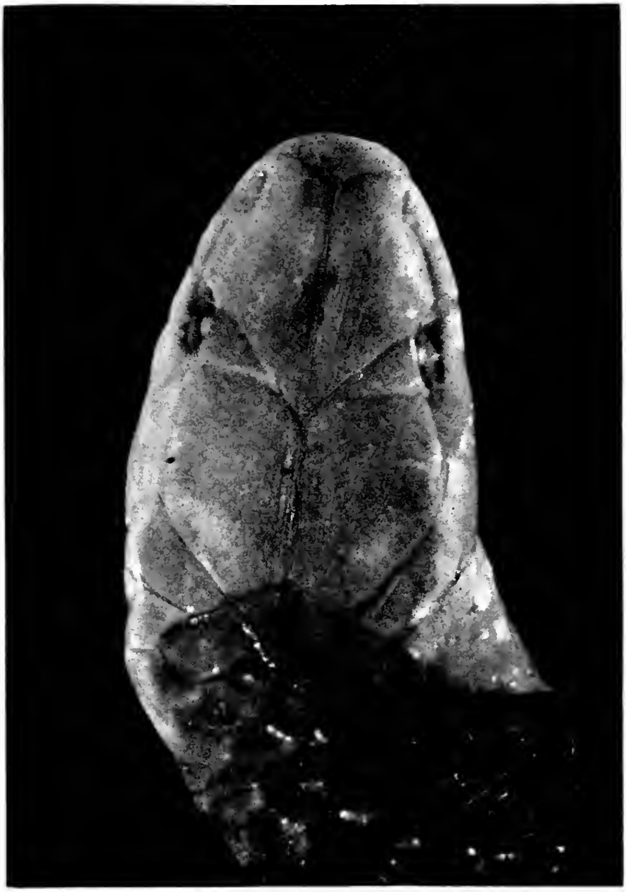

FIG. 16.—*Keiometopon* genus nov. Head of the type-species *Keiometopon booliati* sp. nov., Fraser's Hill, Malaya. Head width, 5.9 mm.

angle; eleven mandibular teeth, becoming smaller posteriorly, teeth not bent at an angle; anal single; subcaudals divided. Scalerows, 10 or 11 as far as 25th ventral; then, 13 to vent.

Keiometopon booliati sp. nov.

Type: EHT-HMS No. M28. Fraser's Hill, Malaya.

Diagnosis: Characters of genus. Tail ending in a point; five supralabials, third and fourth enter eye; eye very small, its diameter (.8 mm.) in snout length (2.8 mm.) three and one-half times. Scales smooth without apical pits; right internasal, right prefrontal and right half of frontal fused into a single scale (same on left side);

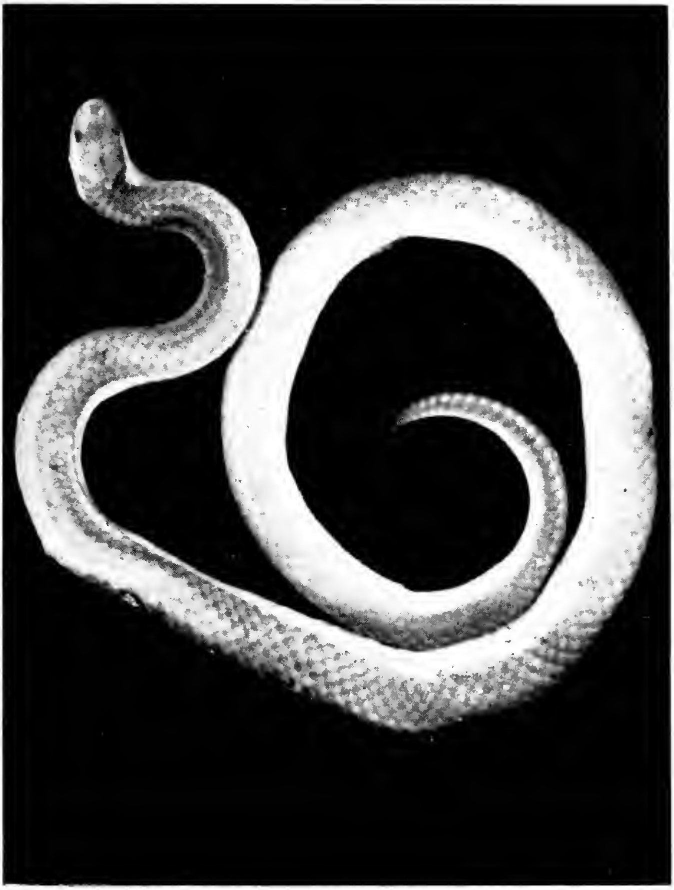

Fig. 17.—*Keiometopon booliati* sp. nov. Type. Actual length, 270 mm. Fraser's Hill, Malaya.

supraoculars much wider than long; three enlarged scales behind parietals.

Description of type: Rostral large, its major portion visible from above, angular posteriorly; large scales (fused internasal, prefrontal, and half of frontal) much longer than wide, ending posteriorly in a sharp point, laterally touching nasal, two supralabials, preocular, supraocular, and anterior part of parietal; parietals large but distinctly shorter than preceding scales, bordered behind by a large secondary temporal and rather large median "nuchal"; supraoculars narrowly separated mesially. Nasal small, scarcely more than a rim about nostril, followed by a depression; a narrow preocular; one (or two) postoculars; no anterior temporal, fifth labial broadly in contact with parietal; five supralabials in following order of size: 1, 4, 3, 2, 5, third and fourth entering eye; five infralabials, first pair in contact with each other behind mental; three anterior touching first chinshields which are longer but about same width as second pair (both pairs in contact with each other); ventrals, 154, anal, single, subcaudals, 25, paired except last. (First ventral is severed longitudinally.) Scale formula: 10-11, 13, 13, without apical pits.

Color: Nearly uniform brown, edges of some scales slightly darker; top of head lighter than body, all ventral surfaces, outer scalerow, and supralabials light, somewhat orange in life.

Measurements in mm.: Snout to vent, 243; tail, 27; total length. 270; width of head, 8.

Remarks: The generic relationship is possibly with *Calamaria.*

The species is named for Mr. Lim Boo-Liat of the Medical Institute, Kuala Lumpur, who generously provided me with numerous herpetological specimens for my study.

Liopeltis baliodeirus Boie (in Boie)

Coronella baliodeira Boie (in Boie) Isis, 1827, 539 (type locality, Java); Schlegel, Essai sur la physionomie des serpents, 1837, p. 64, pl. 2, figs. 9, 10 (including a *var.* in Sumatra); Cantor, Journ. Asiat. Soc. Bengal, vol. 16, pt. 2, 1847, p. 913.

Ablabes baliodeirus Duméril, Bibron, and Duméril, Erpétologie générale . . . 1854, p. 313, Günther, Catalogue of the colubrine snakes in the collection of the British Museum, 1858, p. 29; The reptiles of British India, 1864, p. 224; Flower, Proc. Zool. Soc. London, 1899, p. 673; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 152.

Diadophis baliodeirus Jan, Arch. Zool. Anat. Fis., vol. 2, 1863, 263; Jan and Sordelli, Iconographie générale, livre 15, pl. 5, fig.

Gongylosoma baliodeirum M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 56-57.

Gongylosoma baliodeirum Sworder, Singapore Nat., no. 2, 1922, p. 65, *ibid.*, no. 3, 1921, p. 22 (Singapore).

It is obvious from the variation reported, that several subspecies of this snake exist. Schlegel recognized a *var.* in Sumatra (Schlegel, Atlas, Tableau servant a illustrer la repartition des serpent a la surface du globe). J. A. Fisher described *Ablabes baliodirus* var. *cinctus* (Abh. naturh. Ver. Hamburg, vol. 9, 1886, p. 8, pl. 1, fig. 2), from Nias.

I have not seen specimens of this species from Malaya. It is known in Penang, Province Wellesley and on Bujong Malacca, Perak (*fide* Boulenger, 1912).

Whether these specimens are the same as the form described here, remains to be ascertained.

Liopeltis baliodeirus cochranae subsp. nov.

Type: U. S. N. M. No. 94826 (6343) Khao Soi Dao, Thailand.

Diagnosis: Thirteen scalerows around body; nostril between two nasals, fused above nostril; head scarcely distinct from neck; two preoculars, two postoculars; eight supralabials, the fourth and fifth border eye; 24-25 maxillary teeth; neck with eight or nine dark bands (reaching to ventrals and separated by fawn-colored bands) all except first, third, and fourth interrupted on median dorsal line.

Description of type: Head a little wider than neck; rostral not twice as wide as high, narrowly visible above on snout; internasals wider than long, much smaller and narrower than prefrontals, latter much broader than long, laterally touching loreal, posterior nasal, and upper preocular; frontal shield-shaped, longer than its distance from tip of snout, shorter than parietals; nostril between two nasals that are fused above nostril; the posterior part largest, distinctly higher than anterior nasal; a small loreal; two preoculars, upper not reaching upper surface of head; supraoculars large, not as wide as frontal, two postoculars; a single large anterior temporal followed by two superimposed temporals much shorter than anterior; eight supralabials in the following order of size: 3, 2, 1, 6, 4, 5, 8, 7; the fourth and fifth enter orbit; mental triangular, first labials in contact behind it; seven infralabials, first three touch first chinshields which are much shorter than second pair.

Scalerow formula: 17 (occiput), 13, 13, 13; scales smooth, without apical pits. Ventrals, 118; subcaudals, 72; anal divided.

Color: Head nearly uniform light brown; on side of head very slight dark marks evident along sutures of some labials and a fine dark rim on edges of scales marking outline of orbits; on occiput the brown tends to become blackish in front of first cream bar which is angulate anteriorly and almost broken on side; this followed by a series of eight or nine blackish bars (some of which are broken by a mid-dorsal light line), and separated by dull cream or fawn-colored bars; dark and light bars becoming less distinct posteriorly where they fade into the uniform, finely reticulate pattern of violet brown, each scale with a diamond-shaped light gray-lavender center, a pattern that continues to tip of tail. Outer edge of ventrals and subcaudals with a violet-brown line separating the uniform whitish color of underside of head, body, and tail from the dorsal coloration; a suggestion of black marks along sutures of infralabials, absent in supralabials.

Fig. 18.—*Liopeltis baliodeirus cochranae* subsp. nov. Type. Actual length, 374 mm. Khao Soi Dao, Thailand.

Measurements in mm.: Snout to vent, 256; tail, 118; total length, 374; width of head, 9.1; length of head, 14.

Remarks: Another species of the genus, *Liopeltis scriptus* (Theobald), also occurs in peninsular Thailand and specimens have been taken in the Nakhon Si Thammarat Mountains (Khao Luang and Ronpibon), and on Pulau Panjang (Island), of Phuket.

The differences are considerable in these two forms although both have 13 scalerows about the body. In *baliodeirus* the ventrals are fewer, 118-?137 compared with 126-145; the subcaudals fewer, 58-72, compared with 87-98. There are two instead of three scales bordering orbit; the nasals are partly fused (two separate), and the anterior temporal is wider and somewhat shorter than in *L. scriptus*. The markings also are different in the two forms.

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The Amphibian Fauna of Thailand

BY

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ABSTRACT. The Amphibian fauna of Thailand is reviewed on the basis of collections made in Thailand in 1957-1958 and in 1959-1960, chiefly by the author.

The following forms are described as new:

Leptobrachium minimum, Leptobrachium hendricksoni, Rhacophorus bisacculus, Theloderma stellatum, Theloderma gordoni, and *Microhyla inornata lineata.*

Three generic names have been revived:

Hazelia Taylor has been revived for *Philautus pictus* (Peters) and *Hazelia spinosa* Taylor. *Theloderma* has been revived for certain arboreal Rhacophorids formerly considered under *Rhacophorus* and *Philautus,* species that have a very rough surface. They lay four to eight eggs (perhaps more in some cases) in trees, above cavities containing water. They may or may not have vomerine teeth.

Leptobrachium is revived for certain *Pelobatids* sometimes considered under the genera *Megophrys* (a composite genus) and *Xenophrys.* The four Thai species are *L. hasseltii, pelodytoides, minimum,* and *hendricksoni.*

Frogs formerly regarded as belonging to *Chirixalus* are here treated in the genus *Philautus,* for the reason that the limits of the two genera are as yet not clearly drawn.

The number of species and subspecies treated in the work is 100. However, two are of doubtful validity or of doubtful occurrence.

Practically all forms are described, and illustrated with black and white photographs.

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INTRODUCTION

The work involved in preparing this review of the herpetology of Thailand was undertaken at the specific request of Professor Supachai Vanijuvadhana, Secretary General of Chulalongkorn University, Bangkok, Thailand, who has himself long been interested in the Thai faunas.

The Fulbright Foundation in Thailand, through the kind offices of Professor Supachai, helped to expedite a Fulbright Grant which was made available to me for the period from September, 1957, to June, 1958, and made possible my journey to Thailand. In July, 1958, I found that it was imperative for me to return to America to resume my work at the University of Kansas.

A year later another similar request caused me to apply for a second Fulbright Grant. This was readily made available to me for another ten-months period beginning July, 1959, and was later extended to September, 1960.

Thus a total of 24 months was spent in Thailand. Of this period, approximately 13½ months were devoted to exploration and collecting in various parts of the country.

One is scarcely aware of the size of Thailand from an examination of an ordinary map of Asia, and one is usually surprised to learn that from north to south the country measures over 1,000 miles, and the east-west measurement is more than half this distance. But once realizing the size of the country it becomes evident that no adequate sampling of the fauna could be done in a single year of exploration.

Many areas must be investigated, many mountain tops attained, and much work both day and night must be expended before one might say the sampling was adequate.

The remainder of my time, some ten and a half months, was spent in Bangkok, the time devoted to a study of the collections and the preparation of the manuscripts.

For the most part this publication follows the over-all design for the study agreed upon by Dr. Supachai and the author. While this was not specific in detail it was proposed that the fauna be considered in three groups: first, a volume treating exclusively of the Amphibians; another dealing with the Lizards, Turtles, and Crocodiles; and a third with the Serpents.

M. L. Pootipong Nupartpat Varavudhi—an instructor in Chulalongkorn University—was assigned to accompany me on my earlier journeys of exploration, and proved to be an excellent companion. I have had most excellent help and numerous specimens from Mr. Oliver Gordon Young of Chiang Mai, and his father, Mr. Harold Young.

I also find myself under considerable obligation to Dr. Boonsong Lekagul, Secretary General of the Association for the Conservation of Wildlife, both for his companionship on numerous collecting trips and for numerous specimens.

The design of this work does not permit the inclusion of a very considerable body of notes on the specimens collected. These have in a measure been sacrificed to have space for illustrations, since pictures may be regarded as a universal language substitute. While the illustrations can scarcely be regarded on a par with color photographs, one is more often concerned with the identification of preserved specimens, in which case the illustration in color may be no more serviceable than the black and white illustrations offered here.

No effort has been made to provide complete synonymies or literature lists, the titles listed frequently being works dealing with the species as it occurs in Thailand or adjoining countries. With regard to distribution I have, for the most part, been content to list the changwats or provinces where specimens are known, rather than list all exact localities at which specimens have been taken; although frequently exact localities are given of specimens where this data is pertinent.

Elsewhere more details are given regarding the materials used. On my leaving Thailand Dr. Supachai provided for a division of the collections, giving to me a considerable portion of the collection.

Unless otherwise stated all specimen numbers are those of Chulalongkorn University.

Finally I must offer my sincerest gratitude to the Rector of the University, Air Marshal Muni M. Vejyant-Rangvrisht, and especially to Dr. Supachai Vanijvadhana its Secretary General for the opportunity to undertake this task; for their untiring and prompt concern with my needs; and for their delightful hospitality in this land of Freedom and Smiling.

LAWRENCE, KANSAS.
MAY 1, 1961.

ACKNOWLEDGMENTS

In preparing this work numerous Institutions and numerous individuals associated with them have assisted me greatly by providing space and equipment for work, and the privilege of examining, studying, and describing certain specimens. I am especially obligated to Dr. Heinz Wermuth, Curator of Herpetology in the Berlin Museum; Dr. Josef Eiselt, and Dr. D. Kahsbauer of the Naturhistorisches Museum in Wien; Dr. Enrico Tortonese, Director of the Museo Civico di Genova; Dr. Robert Mertens, Director of the Senckenbergian Museum, and Dr. Konrad Klemmer, Curator of Herpetology in the same Museum. Dr. Giuseppe Scortecci, Director Institute of Biology, University of Genova; Dr. H. Boschma, Director, and Dr. M. Boeseman of the Riksmuseum van Natuurlijke Historie, Leiden; Mr. Hellenius, Curator of Herpetology, Zoologisch Museum, Amsterdam; Miss Alice G. C. Grandison and Mr. J. C. Battersby of the British Museum of Natural History, London; and Dr. Doris Cochran of the U. S. National Museum.

Friends in Thailand and Malaya who have been especially helpful are Prof. Dr. and Mrs. (Dr.) Georg Heuser of Chulalongkorn University, M. L. Pootipong Nupartpat Varavudhi, teacher, Chulalongkorn; Mr. Mann Lilipan, Mr. Vatana Lilipan of Nakhon Si Thammarat; Nai Prayoon Kananuracks, Na Pradoo Kokpho, Pattani; Mrs. Birgit Degerbøl Hansen. Mr. and Mrs. Lynn Noah, Songkhla; Mr. and Mrs. Oliver Gordon Young, and Mr. and Mrs. Harold M. Young, Chiang Mai; Dr. Vichian of Pattani; Dr. Boonsong Lekagul; Nai Sompol Hinchiranan, Asst. Provincial Forest Officer, Ubon; M. R. Chakratong Tongyai, Entomology Specialist, Ministry of Agriculture, Bangkok. Mr. and Mrs. Josef Meyer, Engineer, Siracha Chon Buri; Nai Samrith Junhatitti, Chalermlarb, Chon Buri; Nai Pit Hambaananda, Forest Officer, Royal Forest Department. Sergeant Luan Sincsuwan, Bhetong Police, Dr. and Mrs. Norman Meinkoth, Mr. Donald H. Rochlen, Nai C. D. Suwanarata, Technical Chief and Assistant Director, Na Bon Rubber Estate, Nakhon Si Thammarat. Dr. T. D. Stahlie, Ermelo, Holland; Dr. H. A. Fehlmann; Mr. Lim Boo-Liat; Mr. Mongkol, Banker, Bhetong, Yala. To all of these I am under deep obligation for transportation, for specimens, for photographs, for hospitality, and innumerable courtesies and I offer them my heartfelt gratitude.

TAXONOMIC CONSIDERATION

AMPHIBIA

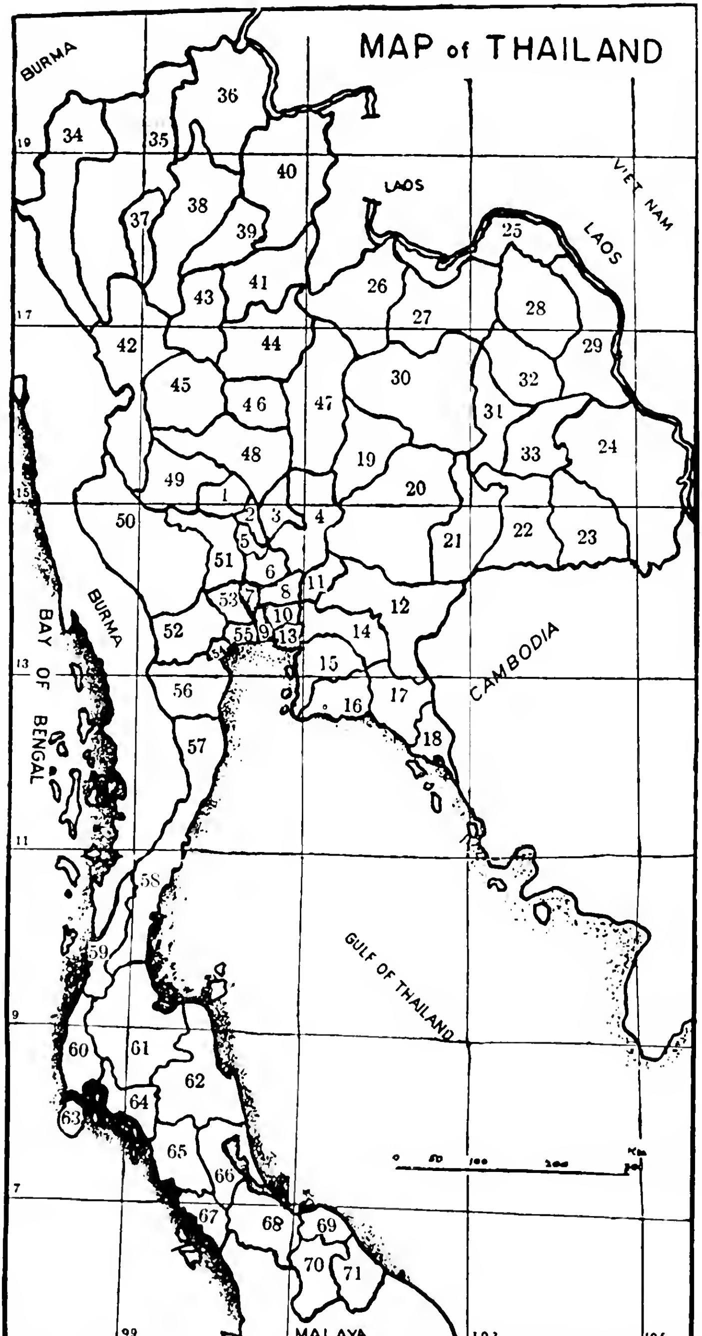
The amphibia, a very early vertebrate group of land animals, are probably less numerous than they have been in the past. Certain orders such as the Labrinthodontia, Phyllospondyli, and Lepospondyli, are extinct.

Three orders of amphibia, however, are living. These are Caudata, Salientia, and Gymnophiona.

The Caudata have retained what we are wont to consider as generalized characters; retention of limbs (rarely lost), retention of the tail, and a moderately elongated body; and the retention of teeth in both jaws (occasionally absent).

The Salientia have, however, become greatly modified and are not generalized. The legs are retained in all cases but the body form has become especially shortened; the number of vertebrae greatly reduced; the legs greatly enlarged in proportion to the arms; the teeth have, with rare exception, been lost in the lower jaw and the tail has been lost in the adult.

Despite this great specialization, these animals must be regarded as plastic and while retaining these specialized characters, may otherwise adapt themselves to many varieties of habitats. They



MAP NO. 1.—Provinces (Changwats) of Thailand. The numbers refer to the numbered list of provincial names, and have no significance in themselves.

LIST OF THAI PROVINCES

(Corrected spellings as used by the U. S. Army Gazetteer, 1944)

1. Chainat
2. Sing Buri
3. Lop Buri
4. Sara Buri
5. Ang Thong
6. Ayutthaya
7. Nonthaburi
8. Pathum Thani
9. Thon Buri
10. Phra Nakhon (Bangkok)
11. Nakhon Nayok
12. Prachin Buri
13. Samut Prakan
14. Chachoengsao
15. Chon Buri
16. Rayong
17. Chanthaburi
18. Trat
19. Chaiyaphum
20. Nakhon Ratchasima (Khorat)
21. Buriram
22. Surin
23. Khu Khan (Sisaket)
24. Ubon
25. Nong Khai
26. Loei
27. Udon Thani
28. Sakon Nakhon
29. Nakhon Phanom
30. Khon Kaen
31. Maha Sarakham
32. Kalasin
33. Roi Et
34. Mae Hong Son
35. Chiang Mai
36. Chiang Rai
37. Lamphun
38. Lampang
39. Phrae
40. Nan
41. Uttaradit
42. Tak
43. Sukhothai
44. Phitsanulok
45. Kamphaeng Phet
46. Phichit
47. Phetchabun
48. Nakhon Sawan
49. Uthai Thani
50. Kanchanaburi
51. Suphan Buri
52. Rat Buri
53. Nakhon Pathom
54. Samut Songkhram
55. Samut Sakhon
56. Phet Buri
57. Prachuap Khiri Khan
58. Chumphon
59. Ranong
60. Phangnga
61. Surat Thani
62. Nakhon Si Thammarat
63. Phuket
64. Krabi
65. Trang
66. Phatthalung
67. Satun
68. Songkhla
69. Pattani
70. Yala
71. Narathiwat

As for the spelling of Thai names, I am using the scheme of transliteration from the Thai alphabet adopted by the Thai Government nearly two decades ago, and likewise used in the U. S. Army Gazetteer of 1944. This often is at variance with spellings encountered in European or older American maps, or in other reports. An effort should be made to stabilize the system of transliteration.

have been very successful and considerable more than two thousand forms are known and doubtless many are still undiscovered.

The life history pattern in many forms has been varied and while normally the amphibian requires a free swimming stage, very many forms pass the larval stage entirely in the egg, the young emerging with arms and legs developed and the tail reduced or lost. There is a world of variety in the life histories of this group. The eggs are deposited in water, in masses of foam, in shrubs and trees, or on the ground in holes in the earth, in pockets on the body, in vocal sacs, in trees above small pockets of water or retained in the "uterine" oviduct where a type of placentation occurs.

A few forms have developed a certain tolerance to sodium chloride, even going into the sea to feed.

The Gymnophiona also have become highly specialized through the loss of both arms and legs, the total, or almost total loss of the tail, the increase in the length of the body, and the development of serpentine locomotion, the transverse folding of the skin and loss or concealment of scales, the reduction of the eye, and the retention of teeth in both jaws (two series in the upper jaw and one or two in the lower).

This group, too, has been successful. It has distributed itself throughout much of the tropical and subtropical areas of the world.

Perhaps as many as 125 species are known and I suspect many are still undiscovered. The fact that at the present time only a single family is recognized, is suggestive that they all originated from and have diversified from a monophyletic group.

CAUDATA

The world-wide distribution of this order of Amphibia follows an unusual pattern. They are wide-spread in the Northern Hemisphere, but completely absent in the Southern Hemisphere except for a few plethodontid salamanders that follow the Andes south to Bolivia and perhaps one species, that has been reported from the Amazon Basin. While present in Siberia, China, and Japan, they are absent in much of southern Asia. None are not known from Arabia, Iran, and India, while in Burma, Thailand, and Indo-China they are known only in the northern parts. They are again absent in Malaya, the Philippines and the Indo-Australian Archipelago.

Only a single genus and species has been found in Thailand. This is *Tylototriton verrucosus* a form entering from the north and as yet known only from high elevation in mountainous areas in the province of Chiang Mai. There is, of course, a possibility of finding other species of salamanders since but little exploration has been undertaken in the higher areas. Yunnan, lying to the north of Thailand, has *Cynops,* another genus represented, while in the Indo-Chinese area another genus, *Paramesotriton,* is present, and *Tylototriton* is represented by a different species, *T. asperrimus.*

A species of *Ambystoma* reported by Gray from Siam in 1859 was found to be actually a mislabeled American species, *A. jeffersonianum.*

While most Caudata have retained the generalized pattern, certain forms have become burrowers with the consequent reduction or loss of digits and limbs; others live entirely in water.

Many forms have become neotenic, attaining sexual maturity and reproducing in the larval state or at least before the complete transformation to a terrestrial form takes place. Sometimes the larval condition retained may be that of external gills. Sometimes it is the fins or the larval condition of the teeth that is retained; and in the case of *Thorius* the bones of the skull appear to remain in the larval condition.

Gymnophiona

The Gymnophiona are less familiar to most persons than are the frogs, since they are subterranean in habitat and often when one is seen it is likely to be regarded merely as an earthworm, which they resemble superficially.

This group has undergone a remarkable evolution since we must postulate that these animals came from four-limbed ancestors as is true of all the terrestrial vertebrates. The loss of digits and limbs are the end result of mutations selected by the burrowing habitat.

The method of locomotion has changed and a curious change has taken place at the surface of the body. This is the "folding" of the skin as if by a system of "tucks." The "seams" are indicated by the small grooves that separate one fold from another and the curious scales, if present, are covered by the fold. The number of the grooves may exceed 400. Sometimes the number of scalerows exceeds 1,000.

An intromittent organ has developed from the posterior part of the gut, an organ that is extruded by infiltrating it with blood, making possible internal fertilization of the eggs. The loss of the tail or almost complete loss of the tail, would permit copulation between male and female even if only the ends of the two bodies were together.

When I have found these animals in burrows the diameter of the burrow is scarcely larger than the diameter of the body and while larger burrows may exist I have found none of a diameter that would permit two animals to copulate when their bodies were parallel side by side. The position in copulation must still be determined.

The inner wall of the male gut is modified posteriorly by thickened areas forming a more or less symmetrical pattern, that at least in many cases, may serve as a distinguishing specific character. In various genera the character may likewise serve to distinguish genera.

The mode of life history varies in the Gymnophiona. Eggs are usually if not universally fertilized internally. They may be deposited in moist places under rocks, in moist burrows near streams, directly in the water, or they may be retained in the oviduct, the young being born in an advanced larval stage.

Most of the species spend a part of their larval life as free swimming larvae, breathing through gills, although a very considerable part of development will have taken place within the egg itself.

In the larval state the lateral-line system may function if the animal is aquatic. It may appear only in the earlier larval stages or it may be retained until the larvae undergo transformation to the adult form. It may be presumed that if so retained the animal is an inhabitant of deeper river water.

One behavioral feature in the sole Thai genus *Ichthyophis* is the parental care bestowed on eggs, at least in certain species. The female of *Ichthyophis youngorum* places the eggs under a rock near the edge of a stream, the eggs being fastened together by threads two or more centimeters in length, like so many diminutive toy balloons. The following illustrates this behavior.

A rock was turned. The female did not attempt escape but remained with the eggs. When the eggs were transferred to a container partly filled with earth the female was picked up gently. Her struggles were negligible and when placed in the container with the eggs she found them and by placing her head under them, turned each egg so that it attained a different position. This was continued perhaps ten or fifteen minutes then she became quiescent.

In this case the eggs contained embryos about 40 mm. long and the movement of the material in the eggs always left the embryo uppermost in the egg regardless of the position in which it was placed; at least the position of the embryo did not change when the egg was rotated.

There is a surprising specific constancy in many of the characters. The arrangement, number, and distribution of the scales; the characteristics of the vent, the number of folds on the tail, its shape and length, and the position of the teeth.

The numbers of the teeth vary from youth to age, and often the larvae will have specialized teeth that are lost during larval existence. Some of these teeth may appear outside the lips and in one case have been reported as serving the larvae in rasping off parts of the uterine surface in order that it may feed upon it.

SALIENTIA

The Salientia, by far the largest living amphibian group, are generally familiar to the people. They have developed a voice and in the case of the males of many species, vocal sacs that open into the mouth through one or two openings.

The sac may be under the skin of the throat and when inflated may form a large pouch on the throat. There may be two sacs that push out through the skin of the floor of the mouth or behind the angle of the jaw on the side of the head.

The openings to the vocal sacs, seen on the inside of the mouth may be elongate slits, short slits or small puckered openings. They may be easily visible in the mouth lying close to the lower jaw, or they may be far back in the mouth near the jaw-angle and difficult to discover. Many species lack the sac in the male. It is not present in females.

Determination of the sex of a specimen is not always easy save by dissection and even then hermaphroditic individuals still offer problems in sexing.

Usually in adults the presence of a vocal sac or sacs or the presence of a nuptial pad on the first finger or specialized groups of spines, which may extend on to second and third fingers, betoken the male.

In most species the female reaches a larger size than the male. Rarely there is a difference in the amount of webbing on the fingers or on the toes. Occasionally marked sexual differences are evident in the two sexes as regards color and marking (see *Pedostibes*).

The nuptial pad of the first finger may be absent. Often glands on the inner part of the arm seem to serve the same purpose as the nuptial pad or groups of spines. If the forms are large and arboreal the male may develop a conspicuous bony spine on the innerside of the first finger that may serve as a safer clasping organ.

For the most part eggs are deposited in the water and are fertilized by the clasping male as the eggs are extruded by the female. Some of the frogs have developed a technique of egg deposition out of the water. In certain tree frogs the eggs are placed on the under side of leaves close to or above water. When the young hatch they fall into water from the eggs. In other cases gelatinlike material extruded with the eggs is churned up by the legs of the male and deposited in the form of a ball of foam in plants, shrubs, or trees, occasionally as much as six meters above water.

ORDER CAUDATA (Salamanders)

Four limbs are usually present, rarely only two; young pass through a larval state in which they breathe by gills, followed by a complete (or partial) metamorphosis. Some forms remain in the larval state throughout life; tail retained, not absorbed at transformation; eggs placed in water for hatching.

Nine families are recognized: Hynobiidae, Cryptobranchidae, Amphiumidae, Ambystomidae, Salamandridae, Desmognathidae, Plethodontidae, Proteiidae, and Sirenidae.

Only a single salamander species is known from Thailand. It is a high mountain dweller, as yet found in Thailand only on isolated mountain peaks, in the northern part of the country.

FAMILY SALAMANDRIDAE

Of the Caudata only the Family Salamandridae is represented in Thailand. A species described from Thailand as *Plethodon persimile* Gray, (1859), was placed in the genus *Ambystoma* family Ambystomidae by Boulenger. It has since been discovered by Noble, (1926), that the specimen so described actually originated in the United States and is a synonym of *Ambystoma jeffersonianum*.

Tylototriton Anderson

Tylototriton Anderson, Proc. Zool. Soc. London, 1871, p. 423; Anatomical and Zoological researches and Zoological results of the Yunnan Expeditions; Reptilia and Amphibia, 1878-1879 (1879), p. 848 (type, *verrucosus*); Boulenger, Catalogue of the Batrachia Gradientia *s.* Caudata and Batrachia Apoda in the collection of the British Museum, 2nd ed., 1882, p. 29.

Tylotriton Boettger, Offenb. Ver. Naturk., vol. 24/25 1885, p. 165 (emendation).

Diagnosis: Tongue small, subcircular, free laterally, and slightly so posteriorly; prevomerine teeth in two oblique series meeting anteriorly; a thick bony frontosquamosal arch; maxillary reaching quadrate; pterygoid applied to maxillary; four fingers; five toes; tail strongly compressed.

Tylototriton verrucosus Anderson

FIG. 0

Tylototriton verrucosus Anderson, Proc. Zool. Soc. London, 1871, p. 423, pl. 76, fig. 6, pl. 77; Anatomical and zoological researches and zoological results of the Yunnan Expeditions; Reptilia and Amphibia, 1878-1879, (1879), p. 848 (type locality Nantin, Momien [Tengyueh] and Hotha valleys, Western Yunnan); Boulenger, Catalogue of the Batrachia Gradientia *s.* Caudata and Batrachia Apoda in the collection of the British Museum, 2nd Ed., 1882, p. 29; Brown, Rec. Ind. Mus., vol. 5, 1910, pp. 193-196; Annandale, Rec. Ind. Mus., vol. 6, 1911, p. 215; Boulenger, Bull. Soc. Zool. France, vol. 45, 1920, p. 98; M. Smith, Rec. Ind. Mus., vol. 26, pt. 4, 1924, pp. 309-310 (Chiang Dao, N. Thailand elev. 5000-6000 ft., larvae); Schmidt, Bull. Amer. Mus. Nat. Hist., vol. 54, 1927, p. 555; Pope, Bull. Amer. Mus. Nat. Hist., vol. 61, 1931, p. 430; Fang and Chang, Cont. Metro. Mus. Nat. Hist. Acad. Sinica, vol. 2, 1932, p. 121; Peking Nat. Hist. Bull., vol. 15, pt. 1, 1940, p. 20; Liu, Fieldiana, Zool. Mem., vol. 2, June 15, 1950, pp. 108-109; Wahlert, Zool. Jahrb. (Anat.), vol. 73, 1953, p. 285 (various other references in paper); Chang, Contribution à l 'étude morphologique biologique et systematique des amphibiens urodeles de la Chine, Paris, 1936, p. 89.

Diagnosis: Maxillary-premaxillary teeth 55, those on the premaxillary largest; vomeropalatine teeth in a continuous series lying parallel anteriorly and diverging posteriorly; tongue circular, free on sides, fastened anteriorly; crown of head flattened, depressed in frontal and interorbital areas; sides of head with bony and glandular areas elevated to level of upper eyelid; nostrils near tip of snout directed forward; body above with two series of rounded knoblike tubercles; tail laterally compressed.

Description of species (from No. 36104; Doi Intanon, Chiang Mai, Thailand, 2000 m.; collected by Mrs. Birgit Degerbøl Hansen): Head bluntly oval almost truncate; strong canthal ridge begins at snout and passes back of eye, terminating in a thickened glandular area (resembling a paratoid gland) the end of which is narrowed and bent somewhat upward. A depression lies between these ridges; eye moderate, its length approximately equal to length of snout; nostrils directed laterally and somewhat forward; prevomerine teeth in two elongate series on inner edges of bones, at first nearly parallel and contiguous, then diverging, their posterior parts somewhat salient. Choanae situated close to orbit, with deep groove directed outwards and somewhat backwards; tongue relatively small; maxillary and premaxillary teeth present.

Dorsum with a median ridge beginning on occiput and continuing to tail where it narrows, becoming continuous with a rather high dorsal fin on tail; beginning above arm, series of rounded dorsolateral knoblike glandular tubercles extend to level of posterior end of vent; a slight ridge distinguishable beyond this, producing a slight thickening far onto tail near its ventral level.

FIG. 0.—*Tylototriton verrucosus* Anderson. No. 36164. Actual total length, 130 mm., Doi Intanon, *circa* 2000 m. elev., Chiang Mai, Thailand.

Arms rather short, with four digits, their tips darkened and rounded; legs pentadactyl, median digit longest; digits somewhat flattened, tips narrowed, somewhat rounded; vent swollen, its inner lips papillate. Tail with well-defined dorsal fin five millimeters high at base; ventral fin obsolete, indicated only by fine median ventral ridge.

Skin of body and tail finely granular; granules present on venter except in median area which has fine transverse folds; granules on underside of digits and on underside of tail.

Color: Above dark brown; glands on side of neck and dorsolateral region lighter brown; tail generally lighter brown than body, becoming cream on ventral surface; area about vent, rusty cream; underside of digits, palms, and soles dull cream; chin, venter, and sides nearly black.

Measurements in mm.: Snout to termination of vent, 68; tail, 62; snout to arm-insertion, 21; axilla to groin, 30; width of head, 16.8; length of head, 16; arm, 20; leg, 21.5.

Variation: The color may be uniform blackish brown, paler on lips, snout, chin, throat, and undersurface of limbs, all of which are of a brownish-olive tinge. The undersurface of the tail may be dull orange.

Distribution: Aside from the single collection of larvae by Dr. Malcolm Smith's collector [on mountain near] Chiang Dao at an elevation of 5000 to 6000 ft., the one recorded here from Doi Intanon, is the only one known from Thailand. Both localities are in Chiang Mai Province. This species has a range from western Yunnan and northern Burma west to Sikkim. It reaches an elevation above 6000 ft.

Remarks: Concerning the development of the larvae, Smith (1924) writes: "The eggs of this newt are large although somewhat variable in size, measuring, when the gelatinous envelope is fully distended by the developing embryo, between 6 and 10 mm. in diameter. The young one on emerging is about 11 mm. long and is provided with well-developed external gills, with a pair of elongated 'balancers' originating from a point behind and below the eye and in a line with the continuation of the mouth backwards, with a crested tail and budding fore-limbs. These latter develop rapidly and all four legs, with their digits, are complete at quite an early stage in life. The 'balancers' apparently soon disappear, although a trace of them often persists in the form of a small tubercle at their point of origin."

There are normally three gills on each side. The Thai specimens tend to lose the gills when they have attained a length of 52 mm. However, some retained the gills when they were 75 mm. in length.

ORDER SALIENTIA

Four limbs are universally present; tail absent in adults (except *Ascaphus*); vertebrae of adults reduced to less than 11; teeth absent from lower jaw (with rare exception), present or absent on maxillary and premaxillary; often absent from vomers. Progression normally made by leaping. A free-swimming stage is normal for larvae, but many frogs pass through the larval stages in the egg and are terrestrial when they leave the egg. Certain ones are known in which the young develop in pockets in the skin, in vocal sacs, or in uteri. In Thailand, the following Anuran families are known: Pelobatidae, Atelopodidae, Bufonidae, Hylidae, Ranidae, Rhacophoridae, and Microhylidae. Only a single species each of the Hylidae and Atelopodidae are known to occur, while approximately 40 species of the Ranidae are known.

KEY TO THE FAMILIES OF SALIENTIA

1. Pectoral girdle arciferal 2
   Pectoral girdle firmisternal 4
2. Terminal phalanges claw-shaped; maxillary (and premaxillary) teeth present; sacral diapophyses expanded; an intercalary cartilage or bone between the two terminal phalanges; arboreal .... Hylidae
   Terminal phalanges not claw-shaped; no intercalated bone or cartilage between two distal phalanges 3
3. Maxillary teeth present; vomerine teeth present or absent; chiefly terrestrial .... Pelobatidae
   No maxillary teeth present; no vomerine teeth; chiefly terrestrial, Bufonidae
4. Maxillary teeth present; usually vomerine teeth also; diapophyses of sacral vertebra cylindrical or at most only very slightly dilated 5
   Maxillary teeth absent (except *Caluella* in Asiatic species); sacral diapophyses expanded 6
5. No intercalated bone or cartilage between last two phalanges on each digit; terrestrial .... Ranidae
   An intercalated cartilage or bone between the two distal phalanges on each digit; arboreal .... Rhacophoridae
6. Slender species, not squat or toadlike; no maxillary or vomerine teeth; coccyx and sternum fused; no intercalary cartilages between distal phalanges, no omosternum; vertebral column procoelous; sternum slender .... Atelopodidae
   Squat toadlike species; without maxillary teeth (in Thai species) except *Calluella;* terminal phalanges simple or T-shaped; sternal apparatus variable. Tadpole without horny mandibles or external teeth, Microhylidae

FAMILY PELOBATIDAE

Amphibians somewhat toadlike in appearance with arciferal pectoral girdle; ends of sacral vertebra strongly widened; vomerine teeth present or absent; coracoids and precoracoids present, curved. A cartilaginous omosternum and sternum entirely cartilaginous or with a bony style.

Vertebrae anomocoelous, (amphicoelous, procoelous, or opisthocoelous), the vertebral discs often not attaching to the centrum. Teeth are present in upper jaw (except *Aelurophryne*); vomerine teeth present or absent.

These primitive amphibians have been treated variously. Noble has proposed the recognition of three subfamilies *Megophryinae*, *Pelobatinae*, and the *Sooglossinae*. The arrangement of the known genera in the subfamily groups follows:

MEGOPHRYINAE	PELOBATINAE	SOOGLOSSINAE
Megophrys Kuhl and van Hasselt	*Scaphiopus* Holbrook	*Sooglossus*
Leptobrachium Tschudi	*Pelobates* Wagler	*Nesomantis*
Nesobia van Kampen	[*Macropelobates*] Noble	
Scutiger Theobald	*Spea*	
Aelurophryne Boulenger		
Leptobrachella M. Smith		
Vibrissaphora Liu		

Boulenger in 1908 (Proc. Zool. Soc. London, pp. 407-430, pls. 22-25) reviewed the Asiatic frogs previously classified under the genera *Leptobrachium* and *Megophrys* (*Megalophrys* of Boulenger since he did not recognize the older name of Kuhl and van Hasselt, which although older [1822], he placed under the synonymy of *Megalophrys* [1824]). He points out that the belief held by Cope and himself that *Megalophrys* had only opisthocoelous vertebrae was untrue. Beddard, studying the anatomy of *M. nasuta* had pointed out that the vertebrae in his specimen had procoelous vertebrae, a statement which Boulenger confirmed. Further he found procoelous vertebrae in some *M. montana*, the type of the genus, and in *M. longipes*. In others of the same species they were opisthocoelous. He states: "It is therefore clear that the character, however important it may appear at first is worthless even as a specific character in these Batrachians."

While it may be regarded as unfortunate that this important vertebral character is not stable enough to be used to separate *Leptobrachium* from *Megophrys* it must be conceded that a number of other differential characters are available for such a separation, and doubtless others will be found when more skeletal material is available for study.

GENUS MEGOPHRYS KUHL

KEY TO THAI GENERA OF PELOBATIDAE

Vomerine teeth absent, tongue broad, notched behind, free for more than half its length; two very strongly distinct metacarpal tubercles, *Leptobrachium*

Vomerine teeth present; tongue not notched behind, not or scarcely free behind; none or only a very indistinct metacarpal tubercle . . *Megophrys*

KEY TO THE THAI SPECIES OF MEGOPHRYS

1. Upper eyelid with long or short pointed dermal appendage, or with one or more pointed tubercles on eyelids 2
   Upper eyelid lacking a dermal "spine" or pointed tubercles 6
2. A dermal appendage on edge of eyelid, also sometimes one on tip of snout; snout projecting beyond mouth 3
   Eyelid with one or several pointed tubercles. Head greatly depressed, 5
3. An elongate dermal appendage on edge of eyelid, one on snout-tip; bony deposits in skin above head and front part of body fusing with bones in adults; tibiotarsal articulation reaching near to commisure of jaws; a vocal sac present. Tympanum dim or hidden; length 125 mm. . . . . *nasuta*
   A short dermal appendage (rarely also one on tip of snout) tympanum more or less distinct 4
4. Old specimens with bony deposits on head; male without a vocal sac; heel reaches to near angle of jaw; snout to vent, 78 mm. . . . . *aceras*
   No bony deposits about head or anterior part of back; heel reaches beyond tip of snout, 65 mm. . . . . *longipes*
5. Eyelid with two to four pointed tubercles near edge; vomerine teeth normally present; heel to shoulder or jaw-angle; skin with bony deposits about head and anterior part of body; a vocal sac and paired elongate glandular folds on back. Male, 123 mm., female, 150 mm. . . . . *carinensis*
   Eyelid with small tubercles, and one much more elongate than others; no longitudinal glandular folds on dorsum; a vocal sac; tibiotarsal articulation reaches near jaw-angle; bony deposits on head; length 106 mm. . . . . *feae*
6. Smaller, snout-vent length to 52 mm.; tibiotarsal articulation reaches to eye or near it; male with nuptial rugosities on first and second finger; a slight rudiment of web on foot . . . . *parva*
   Larger, to 90 mm.; tibiotarsal articulation to near nostril, to tip of snout or beyond; foot about one-fourth to one-third webbed, the web reaching discs as a fringe . . . . *major*

Megophrys nasuta (Schlegel)

FIG. 1

Ceratophryne montana var. Schlegel, Abbildungen neuer oder unvolständig bekannter Amphibien . . . 1837, p. 30.

Ceratophryne nasuta Schlegel, Handl. Dierk, vol. 2, 1858, p. 57, pl. 4, fig. 72 (type locality, Sumatra).

Megalophrys montana (non Kuhl) Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1061; Günther, The reptiles of British India, 1864, p. 413 (*part.*).

Megalophrys montana var. *nasuta* Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1061.

Megalophrys nasuta Günther, Ann. Mag. Nat. Hist., ser. 4, vol. 11, 1873, p. 419; Boulenger, Catalogue of the Batrachia Salienta *s.* Ecaudata in the British Museum, 1882, p. 443; Flower, Proc. Zool. Soc. London, 1900, p. 889; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904, p. 339; Boulenger, Proc. Zool. Soc. London, 1908, p. 413, pl. 22; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 279-280, fig. 77; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, p. 170 ("Tanjong Mas, Patani"); *ibid.*, vol. 2, no. 3, May, 1917, p. 231.

Megophrys nasuta M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 132; Nieden, Das Tierreich, Lief. 46, Anura I, 1923, pp. 54-55, fig. 108; Bourret, Les Batraciens de l'Indochine, 1942, pp. 195-197.

Diagnosis: Head broad, snout with elongate free dermal flap; eyelids with soft hornlike appendages, equal or nearly equal in length to length of eye; usually a fold across back border of occiput; two dorsolateral ridges on back; canthus sharp, loreal region oblique, concave; first finger equal to or shorter than second; white glandular spot on breast below arm insertion; a pair of glandular white spots on posterior face of thigh; tibiotarsal joint extending to between eye and tympanum; latter small, far from eye.

Description of species (from 34666, near Bhetong, Yala Province): Head very large, (41 mm. x 30 mm. measured to back of jaw); head above limited by a curving fold of skin; snout truncate anteriorly, but with a soft hornlike appendage extending from tip; canthus rostralis sharp, loreal region oblique, distinctly concave; sharp, nearly parallel, slightly overhanging folds or ridges from eyes to above tympani; area between this fold and flaring edge of lower jaw shallowly concave; upper eyelid terminating in a dermal spine, strongly projecting, the length of lid and spine together equal to or slightly less than interorbital distance, which is depressed or concave between orbits and canthi; tympanum diagonally placed, rounded below, somewhat angular on upper edge, separated from eye by a distance greater than greatest diameter of tympanum. Choanae rather small, lateral, when palate is viewed directly from below, choanae largely concealed; vomerine teeth on two parallel ridges arising very near inner anterior edge of choanae, scarcely reaching beyond their posterior level, separated from each other by a distance greater than length of one ridge; openings of Eustachian tubes much smaller than choanae; large vocal sac opening through small puckered openings somewhat in front of mouth-angle; palatal glands with a well-defined pair of openings in palate at anterior level of choanae. Tongue small, not or minutely nicked behind, free behind for half or more of its length, largely free on sides; tongue subcircular, attached to front of jaw by a narrow forward projection seven millimeters long.

FIG. 1.—*Megophrys nasuta* (Schlegel). No. 34666 ♂. Actual snout-vent length, 82 mm. Bhetong, Yala, Thailand.

Arm moderate, first finger longer than second; fingers feebly widened at tips, lacking trace of webs; toes with tips similar to those of fingers, but with definite web-remnant (less than one-fourth webbed); digits lacking lateral ridges; no subarticular tubercles, but underside of all digits with low calloused ridges; large inner metacarpal tubercle; elongate inner metatarsal tubercle, no outer; tibiotarsal articulation reaches to tympanum; when legs are folded at right angles to body, heels fail to touch by distance of seven millimeters.

Skin above generally smooth; upper eyelids corrugated, with a median diagonal ridge; a pair of fine longitudinal folds begin at occiput and continue to near groin, the folds closer together anteriorly and posteriorly than on middle of dorsum. A pair of rounded tubercles on shoulders and one on rump; two or three dermal spines near jaw-angle and behind it; a pair of glands on breast below arm-insertion; side with few scattered glandular tubercles; a gland on back face of femur with some indistinct glandules below vent; chin and venter more or less irregularly granulate, especially laterally; some tubercles on legs; diagonal ridges across tibia.

Color: Above brown, darker on sides of head and on snout; a triangular area of lighter brown between eyes; area between folds on back blackish, somewhat mottled, darker than mottled areas on each side; anteriorly this darker area dividing and extending onto eyelids; chin, throat, and breast blackish; venter, underside of arm, and leg whitish with spots or clouding of blackish-brown; region of vent black-brown; back of thigh a brownish network, enclosing numerous whitish flecks and cream-colored glands; large dark spot under foot; tarsus bordered by whitish stripe.

Measurements in mm. of *Megophrys nasuta*

Number	34666	34667	34664	M 137	M 80
Sex	♂	♂	♂	♂	♀
Snout to vent	82	72	75	77	135
Width of head	41	37	36.2	37	61
Length of head	30	28	28	29	43
Interorbital width	12.5	10.5	11.5	12.5	18
Length of eye	9	8	8	9	12.5
Arm	52	46	51	48	67
Leg	94	95	94.4	88	126
Tibia	31	27.5	29	28	42.5
Foot and tarsus	44.5	41	41	39	57

Megophrys aceras (Boulenger)

FIG. 2

Megalophrys montana Flower, Proc. Zool. Soc. London, 1899, p. 914 (type locality, Perak, Malaya); Laidlaw, *ibid.*, 1900, pp. 889; Butler, Journ. Bombay Nat. Hist. Soc., 1904, p. 399; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 22; Boulenger, Proc. Zool. Soc. London, 1908, p. 411 (*part.*); A vertebrate fauna of the Malay peninsula . . . Reptilia and Batrachia, 1912, pp. 277-278 (*part.*); Nieden, Das Tierreich, Lief. 46, Anura I, 1923, pp. 52-54 (*part.*).

Megalophrys montana aceras Boulenger, Fasciculi Malayenses; Zoology, vol. 1, 1903, p. 131, pl. 5, fig. 1.

Megalophrys montana M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, p. 170 (Khao Wang Hip, upper camp, 800-900 m. NE "Tung Sawang," Nakhon Si Thammarat); *ibid.*, vol. 2, no. 3, May, 1917, p. 231; *ibid.*, vol. 2, no. 4, Dec., 1917, pp. 271-272 (Doi Nga Chang, N. Siam).

Megophrys aceras M. Smith, Proc. Zool. Soc. London, 1926, pp. 983, 987, 988 (a species separate from *montana*, the latter not occurring in the Malay peninsula); Bull. Raffles Mus., 1930, pp. 132-133 (Pattani); Bourret, Les Batraciens de l'Indochine, 1942, pp. 192-194, fig. 37.

Diagnosis: Tongue entire or feebly notched posteriorly; interorbital distance greater than width of eyelid; interorbital region distinctly concave; canthus sharp; tympanum present, far from eye; first finger not, or but slightly longer than second; subarticular tubercles lacking; belly with small tubercles; male without vocal sac; vomerine teeth present; a pair of dorsolateral glandular folds and transverse fold behind occipital region; very short dermal "horn" on eyelid.

Description of species (from Boulenger 1912): Head very much widened, one and one-half to one and three-quarter times as wide as long; usually a transverse fold behind occipital region; snout truncate, or somewhat obtusely pointed, projecting beyond lower jaw, as long as or a little shorter than eye; canthus rostralis sharply defined; loreal region vertical anteriorly, somewhat oblique posteriorly, the region concave; interorbital distance one and one-half to twice width of upper eyelid, the region distinctly concave; tympanum not distinct, rarely hidden, its diameter one-half to two-thirds times that of eye; vomerine teeth in small widely separated groups, just behind level of choanae; tongue entire or feebly nicked behind; no vocal sac in males.

Fingers obtuse or slightly swollen at tips; first finger as long as or a little longer than second; no subarticular tubercles or distinct metacarpal tubercles; toes short, obtuse, feebly swollen at tips with mere rudiment of web, or at most one-fourth webbed; no subarticular tubercles, but a flat indistinct metatarsal tubercle; tibiotarsal articulation extending to shoulder, angle of jaws, or temporal area; tibia three-eighths to one-half snout-to-vent length; foot as long as or shorter than tibia.

Skin above smooth, or with some scattered conical warts or tubercles. Old specimens with bony deposits on head and anterior part of back; strong fold extending from eye above tympanum to shoulder; sometimes more than one fold on each side; usually one on each side of back; upper eyelid with short horn not exceeding two-thirds diameter of eye; limbs usually with oblique transverse glandular ridges; venter with small tubercles.

Fig. 2.—*Megophrys aceras* (Boulenger). EHT-HMS No. 6232. Actual snout-vent length, 53 mm. Mts., Nakhon Si Thammarat, Thailand.

Color: Uniform olive-brown above, or variously marked with darker or lighter shades; large triangular dark spot more or less distinct between eyes, base forward; dark oblique bar below eye; transverse dark bars on limbs more or less distinct; lower parts pale brown, spotted and marbled with blackish; white gland on each side of breast.

Measurements in mm.: Snout to vent, 88.

Distribution: The species is known from southern peninsular Thailand. Known also in Malaya.

Remarks: I have followed Smith and Bourret in recognizing *aceras* as a distinct species. It has been found at considerable elevation in the mountains. The light spot (tubercle) mentioned by Boulenger is a gland.

Postfemoral glands are present, and a pair of glands on breast; *M. aceras* and *nasuta* occur in the same territory.

Megophrys longipes (Boulenger)

FIG. 3

Megalophrys longipes Boulenger, Proc. Zool. Soc. London, 1885, p. 850, pl. 55 (type locality, "mountains of Perak, Straits of Malacca, 3300 ft."); Günther, Ann. Mag. Nat. Hist., ser. 5, vol. 20, 1887, p. 316; Butler, Journ. Bombay, Soc. Nat. Hist., vol. 15, 1904, p. 400; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 29; Boulenger, Proc. Zool. Soc. London, 1908, p. 415 (revision of genus); A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 280 (mountains of Perak, 3000-4500 ft., and Gunong Angsi, Negri Sembilan, 2600 ft.); Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 282 (Fraser's Hill).
Megophrys longipes Smith, Bull. Raffles Mus., no. 3, 1930, p. 132.

Diagnosis: A small soft spine on outer edge of upper eyelid; vomerine teeth present; snout projecting beyond jaw; toes with slight rudiment of web; tibiotarsal articulation reaching beyond tip of snout; gland on posterior surface of thigh; vocal sac in male.

Description of species (from type description): Tongue pyriform, indistinctly nicked posteriorly; vomerine teeth in two small groups just behind line of posterior borders of choanae; head broader than long, much depressed; snout very short, obliquely truncate, concave above and on sides, with strong canthus rostralis; nostril equally distant from eye and middle of rostral extremity; interorbital space concave, a little broader than upper eyelid; tympanum distinct, oval, its distance from eye exceeds its greatest diameter. Arm long and slender, the first finger extending beyond second. Leg very long, the extremity of femur reaching shoulder; tibiotarsal articulation reaching far beyond tip of snout; toes slender, swollen at tips

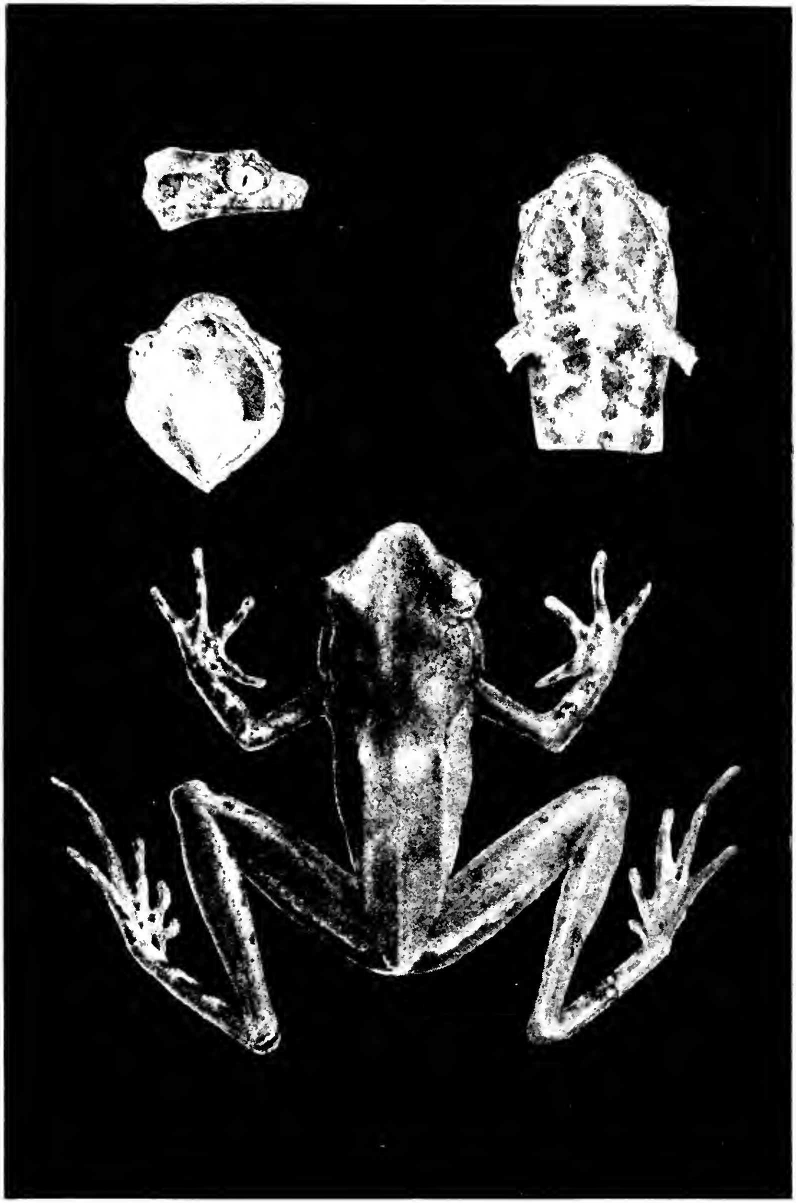


Fig. 3.—*Megophrys longipes* (Boulenger). Type. From Boulenger, Proc. Zool. Soc. London, 1885, p. 850, pl. 55. Actual length, 60 mm. Mountains of Perak, Malaya.

with a slight rudiment of a web. Subarticular tubercles lacking; no metatarsal tubercles.

Skin smooth above, with small warts on flanks, and two pairs of delicate oblique folds converging posteriorly on the scapular region; fold extending from eye above tympanum to shoulder; upper eyelid with small hornlike tubercle on outer edge; lower surfaces smooth.

Color: Olive-brown above, sides of head speckled with blackish, and with oblique yellowish vertical bars; digits with yellowish cross-bars; on hinder side of thighs upper half reddish brown, lower part blackish brown, the two colors sharply separated; lower surface pale reddish brown, largely marbled and spotted dark brown.

Measurements in mm. (male and female, respectively, from Boulenger, 1908): Snout to vent, 47, 65; length of head to occiput, 14, 19; width of head, 17, 23; length of snout, 4, 6; diameter of eye, 5, 6; arm, 31, 43; leg, 83, 118; tibia, 27, 38; foot, 22, 33.

Distribution: In Thailand specimens have been captured on Khao Luang, Nakhon Si Thammarat, at 4000 feet elevation. In Malaya it has been taken at the type locality, Mountains of Perak, where it is common.

Variation: The first finger may equal or exceed length of second.

Remarks: "Mr. Butler has observed it to be the commonest frog on the hills above 3000 ft., and to be entirely nocturnal, being found in the daytime under logs, rocks, or in holes in banks, and in densely shaded spots among dead leaves . . . When seized in the hand they frequently open their mouths wider for some seconds. Mr. Butler has never seen this frog enter water of its own accord and he suspects very large ova (⅛-inch in diameter) containing tadpoles with the hind limbs and tail well developed, which he found under damp moss in tree-trunks, to belong to it." (Boulenger, 1908.)

Megophrys carinensis (Boulenger)

FIG. 4

Leptobrachium carinense Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 7, 1889, p. 748 (type locality, western slopes of the Karen Hills, east of Toungoo Burma, elevation 2500 ft.); *ibid.*, vol. 8, 1892-1893, p. 345, pl. 12, (in separate, p. 42); Sclater, Proc. Zool. Soc. London, 1892, p. 347 (vomerine teeth present); Boulenger, The fauna of British India including Ceylon and Burma; Reptilia and Batrachia, 1890, pp. 511-512.

Megalophrys carinensis Boulenger, Proc. Zool. Soc. London, 1908, pp. 427-428; Barron, Journ. Nat. Hist. Soc. Siam, vol. 3, no. 1, Nov. 1918, p. 45 (Me Taw a tributary of the Me Wang some miles west of Lakon, Lampang, elev. 700-800 ft.).

Diagnosis: A very large pelobatid toad; female with snout-to-vent length of 150 mm.; eyelid with three sharp-pointed flattened tubercles; tympanum hidden; straight diagonal fold from eye to above arm-insertion; arm and leg short; toes about one-third webbed; tongue free posteriorly for half its length, free on sides; vomerine teeth present on two small elevations between choanae but extending behind their posterior level, separated by a distance equivalent to four times length of one; no subarticular tubercles.

Description of species (from No. 20 ♀; collected at Chang Kin, Doi Suthep, Chiang Mai, by Oliver Gordon Young): Head extremely flat, wide, length three-fourths of width; snout very short, its length in front of level of eyes, 12 mm.; distance between nostrils, 11 mm.; canthus rostralis sharp; loreal region strongly diagonal; eyelid elevated, projecting, bearing three or more sharp compressed tubercles; total width of eyelid and tubercles contained in interorbital distance two and one-half times; depth of head, eleven millimeters at base of snout; depth at occiput 15 mm. Tongue broad, free behind for at least half its length, free on sides; fastened to a triangular thickening in front of tongue; choanae partly concealed by maxillary shelves; vomerine teeth present on two elevations between choanae, their posterior level behind choanal level, separated by a distance nearly four times length of one elevation: palatal glands opening through two circular apertures between choanae, widely separated from each other. Arm rather long in proportion to leg; first finger shorter than second; second and fourth extending forward to same point; legs relatively short, tibiotarsal articulation reaching to back of skull; toes about one-third (or less) webbed; a large flat inner metatarsal tubercle, longer than first toe; no tarsal fold but seemingly a thickened rounded ridge on tarsus; digits with indistinctly widened tips; a more or less distinct ridge on sides of toes; heels fail to meet by a distance of about 13 mm. when legs are folded.

Skin above generally smooth with strong straight fold from edge of eyelid to above arm-insertion; back with pair of curving ridges from head to shoulders; a second pair of elevated dorsolateral ridges and a pair of irregular ridges above groin, with some scattered small ridges and tubercles between, not symmetrically arranged; pair of conical symmetrical tubercles in front of shoulders; two indefinite rows of sharp ridges and tubercles on sides, below which are some flattened tubercles; on upper surface of thigh small light-topped tubercles tending to form transverse rows; tibiae with two or three elongate irregular transverse ridges on black bands; back of thigh with a pair of outer diagonal yellowish spots and a few other more

FIG. 4.—*Megophrys carinensis* (Boulenger). No. 36008. Actual snout-vent length, 124 mm. Kaeng Pang Tao, Chiang Mai, Thailand.

or less symmetrically arranged white spots; a pair of cream glandules on breast, suggesting mammae.

Color in life: Top of head smoky fawn; two broad dorsolateral areas of light fawn; area under and back of eye darkened; underedge of supratympanic fold black from eye to arm-insertion; a dim brownish line follows canthus rostralis; an arched series of small light brownish spots cross between anterior parts of eyes, and a second continuous line crosses between middle of eyelids; two prominent rounded black spots on shoulders; most ridges on back and sides bordered with black, limbs with indistinct darker bands; numerous white punctations on thighs; chin blackish, breast mottled with gray; venter and underside of limbs dirty light brown; palms and soles dark.

Measurements in mm.: Snout to vent, 112; width of head, 60; length of head, 45; arm, 59; leg, 130; tibia, 43; tarsus and foot, 60.

Variation: Very little significant variation has been noted. The vomerine teeth may be absent (condition in the type), but this condition has not been observed in other specimens.

Distribution: This species occurs in the northwestern part of Thailand, especially in Chiang Mai and Lampang provinces. Elsewhere it is known only in Burma and Yunnan, China.

Remarks: The species was calling on Doi Suthep, and at Kaeng Pang Tao, 61 km. north of Chiang Mai, during the latter half of June and the first part of July while I was visiting these areas. The call they make can be heard easily at a distance of a quarter of a mile on the Doi. It is introduced on a querulous note followed by a loud raucous call repeated five or six times with slight pauses between. If disturbed by one's presence, the toad may remain quiet for three-quarters of an hour. Ordinarily the call is repeated every ten to fifteen minutes. The animals were usually found ensconced among rocks in a stream, one however, was traced to a perch on the stream's bank. Only four were heard in the two mentioned localities and four were taken. Two other specimens were acquired from Mr. Harold Young and Mr. Oliver Gordon Young. On Doi Suthep they were found at an elevation of 3500 feet; farther north at Kaeng Pang Tao they were taken at an elevation under 500 feet.

The only previous record of this species in Thailand is that of Barron (1918) who obtained a single specimen in Lampang at an elevation of 700 to 800 feet.

Megophrys feae (Boulenger)

FIG. 5

Megalophrys feae Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 4, 1887, p. 512 (type locality, Kakhien Hills, Burma); *ibid.*, vol. 5, 1887, p. 423, pl. 5; Boettger, Ber. Senckenb. Ges., 1888, p. 166; Müller, Verh. Ges. Basel, 1892, p. 200; Boulenger, Proc. Zool. Soc. London, 1908, pp. 411, 428-429; Beddard, *ibid.*, 1911, p. 393 (anatomy); Mell, Arch. Naturg., vol. 88A, 10, 1922, p. 129; Nieden, Das Tierreich, Lief. 46, Anura I, 1923, pp. 63-64, fig. 118 (fig. from Boulenger).

Leptobrachium feae Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 7, 1889, p. 750; The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 512-513 ("Kakhyen" Hills); Sclater, Proc. Zool. Soc. London, 1892, p. 348.

Leptobrachium carinense (not of Boulenger), Boulenger, Ann. Mag. Nat. Hist., ser. 7, vol. 12, 1903, p. 186 (*fide* Boulenger 1908).

Megophrys feae Gee and Boring, Peking Nat. Hist. Bull., vol. 4, pt. 2, 1929-1930, pp. 20, 40; Bourret, Annexe au Bull. Inst. Pub., no. 4, 1937, p. 20; *ibid.*, 1939, pp. 43, 45, 46; *ibid.*, 1939, p. 58; Les batraciens de l'Indochine, 1942, p. 218-220.

Diagnosis: Very large toads, snout-to-vent measurement 135 mm.; vomerine teeth present. Head very large, depressed, nearly twice as broad as long; snout not projecting beyond lower jaw; canthus rostralis distinct; interorbital distance twice width of upper eyelid; first and second fingers equal; skin with bony deposits on head and anterior part of body; no longitudinal glandular folds. Male with vocal sac. Upper eyelid with a soft dermal projection.

Description of species (from Boulenger, 1908): Tongue feebly nicked behind; vomerine teeth usually present in two widely-separated small groups just behind level of choanae; head very large and extremely depressed, once and three fourths to twice as broad as long; snout rounded, hardly as long as eye, not projecting below lower jaw; canthus rostralis distinct; loreal region very oblique, slightly concave; nostril equidistant from eye and from end of snout; interorbital space slightly concave, twice as broad as an upper eyelid; tympanum completely hidden. Fingers short, blunt, first and second equal, two thirds length of third; no subarticular tubercules; metacarpal tubercles indistinct; toes short, blunt, nearly free or with a mere rudiment of a web at base; no subarticular tubercles; a very large flat oval inner metatarsal tubercle. Tibiotarsal articulation reaching axilla, shoulder, or commissure of jaws; tibia one third to two fifths of the snout-to-vent length; foot longer than head.

Skin with bony deposits on head and anterior part of body; a strong transverse fold defines head behind; a strong glandular fold from eye to shoulder; upper eyelid with tubercles, one of which is larger and conical and may be developed into a rather long hornlike appendage in adult. Body and limbs above with scattered small smooth warts; no longitudinal glandular folds; lower parts smooth.

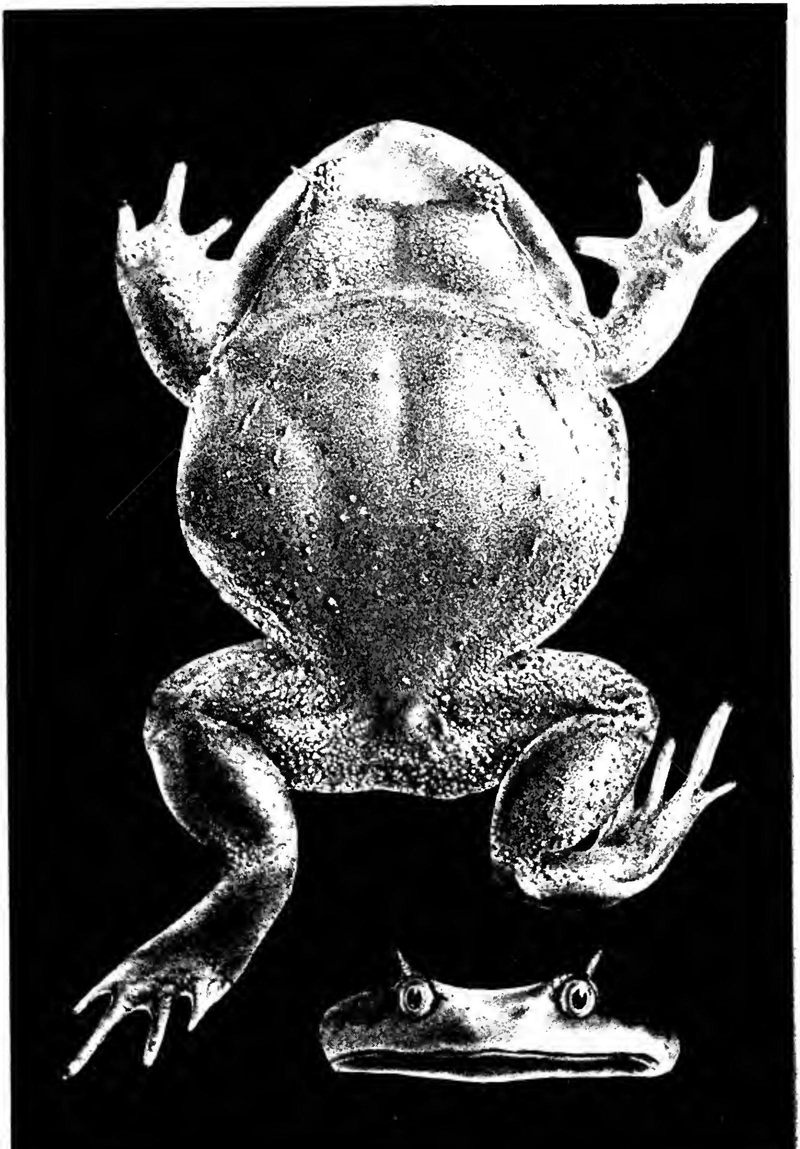


FIG. 5. *Megophrys feae* (Boulenger). After Boulenger (1887) fig. of topotype, snout-vent length, 135 mm.? Kakhien Hills, Burma.

Color: Olive-brown above; a T- or Y-shaped darker marking on head, the transverse branch between eyes, often dividing the head into a lighter anterior and a darker posterior portion; a dark temporal band, the lip below it yellowish; lips, eyes, and some of the larger warts on body edged with blackish; some warts whitish; lower parts dirty white to dark brown; throat sometimes spotted dark brown. Male with an internal vocal sac.

Measurements in mm.: Sex ♂ and ♀. Snout to vent, 82, 106; length of head (to occiput), 25, 31; width of head, 46, 57; length of snout, 8, 10; diameter of eye, 9, 10; interorbital width, 13, 16; arm, 45, 55; hand, 24, 28; leg, 98, 130; tibia, 31, 39; foot, 31, 41.

Distribution: The species is known in northern Burma, and in Viet Nam (Tamdao). It has been reported in Thailand, perhaps incorrectly, but it most probably occurs in the mountains of northern Thailand.

Remarks: Boulenger has reported a specimen from the Man Son Mountains as lacking vomerine teeth and with a feebly developed tubercle or "horn" above eyelid. This was obtained at an elevation of from 3000 to 4000 ft.

Bourret (1937, and 1939) reports other specimens from Tonkin and states: "Dents vomériennes habituellement présent."

The following notes were made from a topotypic specimen: The tympanum is completely concealed. There is a slight circular fold across the occiput. On the edge of upper eyelid there is one elongate soft spine and several short tubercles. The skin on dorsum shows two indistinct diagonal rows of small tubercles, discontinuous on sides; a few other scattered tubercles are present. On sides and legs there are also scattered tubercles of varying size.

The vomerine teeth are in two parallel groups directed backwards. The tongue is large (26 mm. x 26 mm.), slightly nicked behind. There is a transverse palatal ridge behind choanae, and another in front of the Eustachian tubes.

The fingers are without subarticular tubercles, the first finger shorter than second, the second and fourth equal. There is a well-defined metacarpal tubercle at base of first finger, and a large one at base of outer finger. A strong inner metatarsal tubercle but no outer, the toes slightly webbed at base. The tibiotarsal articulation reaches the tympanic depression.

The specimen is now violet-lavender with a trace of a dark bar between the eyes. An area about jaw-angle is light colored.

Megophrys parva (Boulenger)

FIG. 6

Xenophrys monticola Günther, The reptiles of British India, 1864, p. 414, pl. 26, fig. H (type locality, Sikkim, Himalayas and Khasi Hills. The name already preoccupied by *Megophrys monticola* Kuhl 1822 for another species).

Xenophrys monticola (part.) Anderson, Proc. Zool. Soc. London, 1871, p. 200; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, p. 441.

Leptobrachium monticola (part.) Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 7, 1889, p. 720; The fauna of British India . . . Reptilia and Batrachia, 1890, p. 510.

Leptobrachium parvum Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 344, pl. 9, fig. 2 (type locality, Karin Hills, Upper Burma).

Megalophrys parva Annandale, Rec. Ind. Mus., vol. 2, 1908, p. 305; Boulenger, Proc. Zool. Soc. London, 1908, pp. 419-420; ? Annandale, Rec. Ind. Mus., vol. 8, pt. 1, 1912, pp. 28, 29, pl. 4 (tadpole); Nieden, Das Tierreich, Lief. 46, Anura I, 1923, pp. 51, 57; Hora, Journ. Proc. Asiat. Soc. Bengal, vol. 18, 1922, p. 9-15; Rec. Ind. Mus., vol. 30, 1928, p. 139.

Megophrys parva Bourret, Les Batraciens de l'Indochine, 1942, pp. 203-204, fig. 41.

Diagnosis: Related to *Megophrys major* but differing in being much smaller (largest known specimen 54 mm. snout to vent) and in lacking black stripe on side of head and the elongate light mark below it. Toes with only a web-remnant, lacking fringes on sides of toes; fine dorsolateral ridges dim; tongue not notched behind; tip of snout slightly elevated; no spine over eye; eye longer than snout; tympanum distinct, vomerine teeth distinct; tibiotarsal articulation reaches between eye and nostril.

Description of species (from No. 35950 ♀): Head short; snout rounded, obliquely truncate, tip turned up slightly at edge; canthus rostralis sharp; loreal region slightly oblique, somewhat concave behind nostril; distinct fold extending back from eye, forming upper border of tympanum, and terminating above arm; tympanum distinct, its diameter about two fifths length of eye, and separated from eye by distance slightly less than its diameter; width of eyelid a little greater than interorbital width.

Tongue rounded posteriorly, not notched, free for about one fifth of its length or less; vomerine teeth on parallel elevations, terminating in two beadlike prominences, beginning at upper level of choanae but the rounded elevation lies chiefly behind choanae; elevations separated from each other by distance slightly less than diameter of swollen area. (Male with vocal sac; vocal slits small, on level with angle of mouth.)

Skin appearing nearly smooth but minutely roughened or corrugated under a lens; sides with few glandular pustules; thigh with four or five very fine transverse irregular ridges; few small glandular

Fig. 6.—*Megophrys parva* (Boulenger). Upper figure, No. 35951 ♂. Actual snout-vent length, 41 mm. Lower figure, No. 35950 ♀, length, 48 mm. Both Doi Suthep, *circa* 3500 ft., Chiang Mai, Thailand.

pustules about vent; well-defined yellow glandular spot on back of thigh closer to tibia than to vent; a hairfine angular ridge limits interorbital dark mark; a second pair of fine ridges extend back from each eye and meet on middle of back, then separate; a hairfine ridge from a point back of tympanum to lumbar region.

Hand with first finger a little longer than second; a slight swelling on base of first finger but no distinct metacarpal tubercles; no subarticular tubercles or ridges; a few pustules under forearm; leg slender, tibiotarsal articulation reaching front of eye; toes with mere remnant of web, without lateral ridges or fringes; no subarticular tubercles; no distinct inner or outer metatarsal tubercles; when legs are folded at right angles to body, heels overlap 3.5 millimeters.

Color: Dorsum light brown with a light-edged olive triangular mark between eyes; narrow olive-brown marks follow the fine ridges on back; slight olive lines follow ridges on thighs; black marks on hand and fingers; chin and anterior part of venter clouded; two yellow glandular spots on breast; lips barred with olive and dull cream; posterior part of venter and underside of thighs cream with minute powdering of darker pigment; underside of foot and tarsus blackish; black marks on forearm and on sides of tibia.

Measurements in mm. of *Megophrys parva*

Number	36582	35950	35951	33610	36611
Sex	♀	♀	♂	♂	♂
Snout to vent	54	49	40	38	37
Width of head	18	18	15	14	13
Length of head	19	18	14.5	14.6	13.1
Arm	30.5	32	26	23.5	24
Leg	80	76	64	59	55
Tibia	26	27	20	20	19.5
Foot and tarsus	35.5	35	27.5	26.5	23

Variation: The largest female (No. 36582) is darker than the specimen here described, and has some small blackish marks on snout, sides, and rump. The side of the head is dark brown, except that the snout-tip has some cream spots. The anterior part of the venter is brownish, while the posterior part and the groin are yellow, as is the underside of the tibia. Underside of the digital tips whitish.

Two males, Nos. 33610, 33611, are dark olive with the side of head, lower side of snout-tip, breast, and the anterior part of venter, blackish. The skin is distinctly more corrugated than in the described specimen and there are some fine dorsal pustules. As regards the webbing of the toes, and the character of the fine dorsal ridges, they agree well. The males have vocal sacs.

Distribution: In Thailand the species has been taken in the province of Chiang Mai. Elsewhere the species has been collected in Sikkim and Burma. In the latter country the range extends far south into Tenasserim.

Remarks: Both females examined have ovarian eggs. The described female specimen was taken from a branch in a small shrub about five feet from the ground. She was carrying a clasping male, that would call occasionally. They were about 15 meters from a tiny rivulet.

Without careful examination, this species may be mistaken for the young of *Megophrys major.*

Megophrys major Boulenger

FIGS. 7, 8

Xenophrys gigas (non Blyth) Jerdon, Proc. Asiat. Soc. Bengal, 1870, p. 85 (type locality, Darjeeling and Khasi Hills).

Xenophrys monticola (part.) Boulenger, Catalogue of the Batrachia Salientia s. Ecaudata in the collection of the British Museum, 2nd Ed., 1882, pp. 441-442.

Leptobrachium monticola (part.) Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 7, 1889, p. 720; The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, pp. 510-511; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 343 (Thao, District of Karin Bia-Po, Burma).

Megalophrys major Boulenger, Proc. Zool. Soc. London, 1908, pp. 416-417, pl. 23; Annandale, Rec. Ind. Mus., vol. 6, 1911, p. 215; *ibid.*, vol. 8, 1912, p. 29, pl. 4, fig. 9 (tadpole); Nieden, Das Tierreich, Lief. 46, 1923, p. 56, fig. 110 (foot); M. Smith, Proc. Zool. Soc. London, 1926, p. 988; Rec. Ind. Mus., vol. 31, 1929, p. 79.

Megalophrys longipes (non Boulenger), Mell, Arch. Naturg., vol. 88, A. 10, 1922, p. 129.

Megophrys longipes (non Boulenger), Gee and Boring, Peking Nat. Hist. Bull., vol. 4, 2, 1930, pp. 20, 37, 39.

Megophrys major Gee and Boring, Peking Nat. Hist. Bull., vol. 4, 1930, pp. 20, 29; Pope and Boring, *ibid.*, vol. 15, 1940, p. 28; Bourret, Les Batraciens de l'Indochine, 1942, pp. 199-202, fig. 40 (specimen from Mao Son, Tonkin).

Megophrys longipes maosonensis Bourret, Annexe au Bull. Inst. Publ. no. 4, 1937, p. 12, fig. 4; *ibid.*, no. 6, 1939, pp. 15, 28; *ibid.*, no. 4, 1939, pp. 45, 46; *ibid.*, no. 4, 1939, p. 58 (type locality Mao Son, Tonkin) (synonymized by Bourret).

Diagnosis: A medium-large species (snout to vent, male, 77; female, 94 mm.); vomerine teeth present; interorbital distance equal to or larger than width of an upper eyelid; first finger equal to or a little shorter than second; tibiotarsal articulation to tip of snout. Tongue feebly nicked behind; snout projecting beyond lower jaw; male with vocal sac.

Description of species (from No. 36554): Head wider than long

FIG. 7.—*Megophrys major* (Boulenger). No. 36554 ♀. Actual snout-vent length, 91 mm. Doi Pna Kao, near Doi Inthanon, Chiang Mai, Thailand.

(30.5 mm. x 27.5 mm.); interorbital and frontal areas depressed, concave; canthus rostralis distinct, loreal region slightly oblique; concave; nostril equidistant between eye and tip of snout; outline of snout seen from above rather angular, the tip bluntly pointed, extending beyond lower jaw, then sloping backwards and downwards to mouth. Tympanum distinct, oval, its upper portion covered by fold of skin arising from eye and terminating behind jaw-angle; tympanum separated from eye by distance one and a third times the longest diameter of tympanum; interorbital distance slightly greater than width of upper eyelid; tongue not or scarcely nicked or emarginate behind, free for one third of its length; vomerine teeth on two parallel ridges arising behind upper level of choanae; ridges somewhat bulbous posteriorly, separated by a diastema nearly equal to length of one ridge, and from choanae by a similar distance; choanae rather small, concealed when palate is viewed from below; openings of palatal glands on each side of palate at about level of choanae.

Skin generally smooth showing some minute corrugations under a lens; a diagonal fold from eye across upper part of tympanum to above arm-insertion; hair-fine ridges from upper eyelids run back diagonally, meet and continue back on median line some distance; another pair of fine ridges, arising behind eyes, extending diagonally meet and fuse on shoulders; this ridge then extends posteriorly to lumbar region and divides, the branches extending back and outwards, becoming lost on sides. A pair of hair-fine dorsolateral glandular folds from near level of tympanum to groin; some slight ridges across femora and tibiae; lateral skinfold indicated; chin, breast, venter, and underside of limbs smooth; well-defined gland, cream in color on back of thigh, nearer tibia than to vent; similar gland on breast near arm-insertion; irregular row of fine lateral glands, white in color, on side.

Digits of hand widened slightly and swollen at tips; first finger as long as second (left hand) (much smaller abnormally on right); no web or lateral ridges on fingers; flat inner metacarpal tubercle at base of first finger, outer indistinct; no subarticular tubercles; toes flattened, tips widened into small discs without peripheral grooves; toes about one-fourth to one-third webbed, with indication of lateral ridges on some toes; low inconspicuous inner metatarsal tubercle, no outer; no subarticular tubercle; tibiotarsal articulation to nostril or slightly farther; when legs are folded at right angles to body, heels overlap 8 millimeters.

Fig. 8.—*Megophrys major* (Boulenger). No. 36133 ♂. Actual snout-vent length, 65 mm. Doi Suthep, 3000 ft. elev., Chiang Mai, Thailand.

Color: Dorsum generally lavender-brown on head, back, and sides; a triangular, dark brown or black-bordered mark between eyelids; sides of head olive-brown; lower eyelid white; an elongate light spot extending below nostril to mouth-angle where it joins the light coloration on sides of neck; lower jaw and chin light brownish-gray with dark-edged cream spots on lip; a dark spot under point of arm-insertion; dark spots under forearm; row of black spots or partly continuous dark line low on sides; strong dark markings at knee and on underside of tibia, tarsus and foot; transverse dark mark with upper sinuous edge across back of thigh enclosing two large cream glandular spots, and numerous cream flecks; side with row of five small white spots; chin and breast brownish gray; underside of thighs and part of underside of tibiae cream-white.

Measurements in mm. of *Megophrys major*

Number	36554	36553	33726	36613
Sex	♀	♀	♀	juv.
Snout to vent	91	87	85	54
Width of head	30.5	35	30	20
Length of head	27.5	27	25	16
Arm	50	44	49	33.5
Leg	131	131	132	83
Tibia	40	44	43	29
Foot and tarsus	59	56	60	36

Number	30	46	47	66	36553
Sex	♂	♂	♂	♂	♂
Snout to vent	76	75.3	79	68	83
Axilla to groin	36	36	31	33.1	43
Width of head	29	28.5	30	26	31.4
Length of head	26	25.3	26	23	26
Arm	47	46	44	44	45.4
Leg	126	120.4	120	114	126
Tibia	45	40	40.2	37	44
Foot and tarsus	53.7	50	52	48	56

The males (here measured) from Doi Suthep, (about 3000 ft.) differ from females taken farther north in the character of the feet. In these the digits are distinctly wider and fringed. Also the body is shorter in proportion to the width of the head, than in female specimens listed. At first I suspected I was dealing with a different species. Since each group contains but a single sex I conclude that the differences are sexual. The pattern of coloration and to some extent the ridges on back are similar. Figures are given of both male and female specimens.

Genus LEPTOBRACHIUM Tschudi

Leptobrachium Tschudi, Classification der Batrachier mit Berücksichtigung der fossilen Thiere dieser Abtheilung der Reptilien, 1839, (1838?), p. 81 (type of the genus *Leptobrachium hasseltii*).

Diagnosis: Small pelobatids with vomerine teeth absent; snout not extending beyond lower jaw; tongue broad posteriorly and strongly notched, free behind for a half or more of its length; legs proportionally short; arms slender and proportionally elongate; two well-developed, elevated metacarpal tubercles; vertebrae procoelian; one condyle for articulation with coccyx; omosternum cartilaginous, outer metatarsals united; sternum with a bony style; vocal sac present or absent.

Since Boulenger (1908) found variation in the characters of the vertebrae of *Megophrys* it is not wholly certain that all the presumed generic skeletal characters of *Leptobrachium* listed are invariable. The vocal sac may be absent. How much weight this latter character must be given I canont say, since the same is true in *Megophrys.*

The following key to the species of Thai *Leptobrachium* will distinguish the various species:

KEY TO THAI SPECIES OF LEPTOBRACHIUM

1. Snout angular in profile sloping forward to lip; two very strong metacarpal tubercles subequal in size 2
   Snout somewhat rounded in lateral profile; metacarpal tubercles strong, inner tubercle several times larger than outer 3
2. A rather large axillary gland; one or two glands on posterior face of femur; no gland on breast; sides and venter white, speckled with small subequal black spots; back without spots, venter not granular .... *hendricksoni*
   A smaller axillary gland, ocellate; ventral surface of chin and venter granular or areolate; gland on back of femur diffuse or indistinct; venter reticulated with blackish brown; back with rather large numerous irregular spots, more or less distinct .... *hasseltii hasseltii*
3. Tympanum moderately distinct; a conspicuous gland above insertion of arm, one on breast near insertion of arm, and one on posterior face of femur. Scattered tiny glandules on sides .... *pelodytoides*
   Tympanum larger, round, very distinct; no gland above arm-insertion; a ventrolateral gland or glandular fold extending more than half way between axilla and groin; a white gland and a large blackish area on back face of femur .... *minimum*

Leptobrachium hendricksoni sp. nov.

FIGS. 9, 10

Type: No. 34749, collected, Bhetong, Yala, Thailand, Jan. 26, 1957, by Edward H. Taylor.

Paratypes: Nos. M.198, M.199, Kuala Tahan, King George V Nat. Park, Pahang, Malaya, Mar. 23, 1956, Dr. J. R. Hendrickson, collector, Mar. 12, 1957.

Diagnosis: A medium species, known maximum size, 63 mm., snout-to-vent length; head broader than body; tongue ample with a V-shaped notch behind, free posteriorly for half its length, free on sides. Male with vocal sac, the slits opening far back near jaw-angle; no vomerine teeth; choanae entirely visible from below; first finger equal or slightly longer than second; unicolor lavender brown above; venter, chin, side, groin, and limbs speckled with small black spots, the largest ones on legs.

Description of type: Head broad; very sharp canthus rostralis; loreal region oblique, shallowly concave; nostrils just below level of canthus, the area about them swollen, with slight depression between swollen areas, snout sloping obliquely forward to lip in front of them; distance of nostril from eye (6 mm.) equal to its distance from median point on upper lip (6 mm.); length of eye (8.5 mm.) a little shorter than length of snout (9.5 mm.); tympanum very distinct, its greatest (diagonal) diameter (5 mm.), greater than its distance from eye (3 mm.); a sharp skinfold from eye curves down behind tympanum and stops just behind jaw-angle; interorbital distance (9 mm.) wider than upper eyelid, (6.2 mm.).

Tongue broad with a V-shaped notch behind, its width (19 mm.) less than length (23 mm.), free behind for half its length, free on sides, considerably narrowed anteriorly at attachment (6 mm.); choanae clearly visible from below, somewhat angular; just anterior to their forward level, a pair of subtriangular pits marking openings of palatal glands; openings of Eustachian tubes equally as large or larger than choanae, no dermal fold between them.

Arm elongate, slender; more than half of forearm extends beyond tip of snout when laid forward; first finger a little longer than second, fifth minutely longer than second; no trace of web, but lateral ridges on some fingers; no subarticular tubercles, but fingers with some elongate callous ridges; a pair of very strongly developed elevated metacarpal tubercles. Legs relatively short, tibiotarsal articulation reaching to tympanum when legs are stretched forward; when legs are folded at right angles to body, heels separated by a distance of

FIG. 9.—*Leptobrachium hendricksoni* sp. nov. No. 34749 ♀. Actual snout-vent length, 63 mm. Bhetong, Yala, Thailand.

four millimeters; distinct web between toes, four joints of fourth toe free; three inner digits with lateral ridges; distinct elongate callous ridges under second, third, and fourth toes; a distinct inner metatarsal tubercle, its length half its distance from tip of first toe; no outer tubercle or tarsal fold; tips of all digits slightly swollen, but bluntly pointed.

Skin generally smooth above with fine indistinct veinlike reticulation; a little less smooth low on sides, with indistinct tuberculation evident; chin and breast smooth; posterior part of venter with indistinct flat tubercles; pair of larger postfemoral glands nearer insertion of tibia than vent; between these and vent a smaller pair; a well-defined pair of axillary glands.

Color: Above lavender brown on head, back, upper part of femur, tibia, and arms; very indistinct, darker-edged mark between eyes and lighter vertical dark-edged mark on tip of snout; black line below canthus, and narrow black line curving under eye; narrow black line follows supratympanic fold; tympanum brownish black; groin area, front and back of femur, concealed parts of tibia, and upper part of foot and tarsus speckled with black; chin breast, venter, and underside of arms finely speckled with black on cream to gray-white ground color; chin and posterior part of venter dusted with fine pigment; grayish behind and below vent; tips of digits cream.

Measurements in mm. of *Leptobrachium hendricksoni*

Number	34749	M198	M199
Sex	♀	♂	♂
Snout to vent	63	46	45
Width of head	27	14	15
Length of head	26	20	19
Arm	40.5	33	34
Leg	69	56	53
Tibia	23	16.5	17
Foot and tarsus	31	23	14.4

Variation: The males have the head markings partly absent, or very indefinite. In one specimen the first finger appears to be scarcely equal to second. The larger postfemoral glands are present on both males; both however, lack the inner smaller pair as described in the female.

FIG. 10.—*Leptobrachium hendricksoni* sp. nov. Tadpole. No. 34739A. Actual snout-vent length, 49 mm. Kuala Lumpur, Malaya.

Distribution: This species is known from the type locality in Thailand. In Malaya the species has been taken in King George V Park, Pahang, Malaya, and at Kuala Lumpur and environs.

I have seen many of the easily recognized larvae taken by Dr. Hendrickson and myself on the campus of the University at Kuala Lumpur.

Remarks: The tadpoles of this form are being studied by Dr. Hendrickson. It is quite probable that in the past this species has been mistaken for *Leptobrachium hasseltii* which also occurs in Malaya and Thailand.

Leptobrachium hasseltii hasseltii (Müller in Tschudi)

FIGS. 11, 12, 13

Leptobrachium hasseltii Müller, in Tschudi, Classification der Batrachier . . . 1838, p. 81 (attributed to Müller M. S.; type locality, Java); Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 441; The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, p. 511; Proc. Zool. Soc. London, 1890, p. 37; Butler, Journ. Nat. Hist. Soc. Bombay, vol. 15, 1904, p. 397.

Megalophrys hasseltii van Kampen, Natuurk. Tidsch. Ned. Ind., vol. 69, 1909, p. 27, pl. 2; Boulenger, Proc. Zool. Soc. London, 1908, p. 425, pl. 25, fig. 3; A vertebrate fauna of the Malay Peninsula, from the Isthmus of Kra to Singapore including the adjacent islands; Reptilia and Batrachia, 1912, pp. 282-283; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, pp. 170-171; Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, p. 153, pl. 6; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 3, May, 1917, p. 23 (Hill country of peninsular, western, and northern Thailand); *ibid.*, no. 4, Dec. 1917, p. 274; Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, June 13, 1934, p. 287 (Chiang Mai). Taylor, Phil. Journ. Sci., vol. 21, 1922, pp. 184-185, pl. 4, fig. 1.

Megophrys hasselti hasselti Bourret, Les Batraciens de l'Indochine, 1942, pp. 211-213; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1077-1079, fig. 14 (photograph). (Na Haeo, Dan Sai, Loei Province).

Diagnosis: Head as wide or wider than body, one to one and one-fifth times as wide as long; canthus rostralis sharp; arms proportionally long, legs weak, slender; tibiotarsal articulation reaching between shoulder and eye; no palpebral appendages or spines; no vomerine teeth; male with a vocal sac; inner metatarsal tubercle present, no outer.

Description of species (from EHT-HMS No. 31762 Na Haeo, Loei Province): Head about as wide as long; canthus sharply defined; loreal region oblique, concave; snout in front of nostrils sloping obliquely; interorbital width once and three fourths width of an eyelid; tympanum small, its diameter less than half length of eye-opening, upper part covered by a sinuous fold from eye to angle of jaw. Eyes prominent.

Posterior two thirds of tongue free, notched behind; two large slitlike openings to vocal sac far back near mouth-angle; choanae large; no vomerine teeth; two distinct openings to palatal glands lying between inner level of choanae, but slightly in advance of choanae.

Skin on dorsum minutely granular or pustular, pustules larger and more prominent on sides; chin with small granules; entire venter with larger granules or areolations; underside of thighs smooth ex-

FIG. 11.—*Leptobrachium hasseltii* Müller in Tschudi. EHT-HMS No. 31762 ♂, Na Haeo, Loei, Thailand. Actual snout-vent length, 46 mm.

cept for a few proximal granules; few granules about vent; more or less distinct fold on each side, anteriorly touching, but not continuous with, the supratympanic fold.

Arm slender; first finger a little longer than second; latter longer than fourth, third double length of second; digits with terminal discs not wider than digits; undersurface of digits with some broken elongate callous ridges that may incorporate any subarticular tubercles that may be present; inner fingers and inner edge of outer fingers with narrow lateral fringe or ridge, but no web; two very prominent metacarpal tubercles; toes short, one-third to one-half

Fig. 12.—?*Leptobrachium hasseltii* Müller in Tschudi. EHT-HMS No. M200. Actual snout-vent length, 44 mm. Singapore Island.

Fig. 13.—*Leptobrachium hasseltii* Müller in Tschudi. Upper figure No. 36609. Actual snout-vent length, 49 mm. Lower figure, No. 36605, length, 54 mm. Both from Whe Tat Village, Chiang Dao, Chiang Mai, Thailand.

webbed on inner toes, but web continued as a fringe or ridge to the terminal digital swelling; a well-defined inner metatarsal tubercle; no outer tubercle; no tarsal fold or ridge; when legs are folded at right angles to body heels fail to meet; an elongate ridge on underside of third and fourth toes, barely indicated on second; tibiotarsal articulation reaches to near tympanum.

Color: Above lavender with darker lavender or purplish; numerous darker irregular blotches or spots on dorsum and sides; a dark longitudinal interorbital line joining a transverse interorbital mark; loreal region and lip with three or four black spots; a dark line from nostril to eye, and from eye along supratympanic fold, widening on tympanum; arms and legs banded dark lavender above; venter and chin yellowish with clouding of lavender, or numerous flecks of brown or lavender tending to touch each other and forming a reticulation.

Measurements in mm. of *Leptobrachium hasseltii hasseltii*

Number	36606	36605	36608	36609	36607	31762
Sex	♂	♂	♂	♂	♂	♂
Snout to vent	56	56	51	50	48	46
Head width	27	27	24	22.7	21.5	21.5
Head length	21.5	21	19	18	17	21.5
Arm	37	37	30.5	31	30.5	29
Leg to vent	61	60	54	52	53	49
Tibia	20	19	17.2	16.6	16	16.5
Foot and tarsus	28	27	25	23.5	24	22

Variation: The populations now included in the species *L. hasseltii* show very considerable variation. The range is great, the species occurring in Borneo, Sumatra, Burma, Thailand, Tonkin, and Hainan. Two subspecific forms have been designated. These are *hasseltii pullus* by Malcolm Smith (1921, p. 440); and *hasseltii chapaensis* by Bourret (1937, p. 18, fig. 6) both from Indo China. The population from northwestern Siam probably merits subspecific designation. Another form occurring in Thailand and illustrated here may or may not be typical of the Javan (type) form as I have designated it. Until some worker can review material from this very great range and directly compare it with the Javan form, relationships of the various populations will be uncertain. The three specimens illustrated give some indication of differences, especially in the shape of the head and body.

Distribution: In Thailand specimens are known from Chiang Mai, Loei, Trang, and Chumphon provinces.

Leptobrachium pelodytoides Boulenger

FIG. 14

Leptobrachium pelodytoides Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, pl. 11, fig. 3 (type locality, Karin Hills, east of Toungoo, Burma, at Thao and Karin Bia-Po); Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903 (1904?), p. 397 (Perak).

Megalophrys pelodytoides Boulenger, Proc. Zool. Soc. London, 1908, pp. 423-424; A vertebrate fauna of the Malay Peninsula, . . . Reptilia and Batrachia, 1912, p. 282; M. Smith, Journ. Nat. Hist. Soc. Siam, II, 1917, p. 272, fig. (tadpole); Nieden, Das Tierreich, Lief. 46, Anura I, 1923, pp. 60-61.

Megophrys pelodytoides M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 133; Pope, Bull. Amer. Mus. Nat. Hist., vol. 61, 1931, pp. 447-450, fig. 4; Boring, Mem. B. A. China Rept., 1932, p. 102; Bourret, Annexe au Bull. Inst. Publ., no. 4, 1937, p. 17; Pope and Boring, Peking Nat. Hist. Bull., vol. 15, 1940, p. 30; Bourret, Les Batraciens de l'Indochine, 1942, pp. 208-211, fig. 45.

Diagnosis: A small species (snout-to-vent length, 54 mm., ♀), snout not projecting beyond lower jaw; two metacarpal tubercles, inner large, outer smaller; tibiotarsal articulation reaches to between eye and nostril; vomerine teeth absent; tongue strongly notched behind; first and second fingers equal; toes of males one-third to one-fourth webbed; a subgular vocal sac; no fine dorsal ridges.

Description of species (from cotype, Genova, No. 27845B): Head moderate, about as long as wide; snout rounded, scarcely projecting beyond lower jaw, a little shorter than length of eye; canthus rostralis distinct, curving inwards somewhat, loreal region oblique and distinctly concave; nostril distinctly closer to eye than to mid-point on upper lip; interorbital distance equivalent to width of an upper eyelid; tympanum moderately distinct, its greatest diameter a little more than half length of eye, separated from eye by a distance slightly less than its own diameter; a distinct fold from eye to above arm-insertion.

Vomerine teeth absent; when palate is viewed from below choanae not concealed by palatal shelf; tongue large (12 mm. x 9 mm.), strongly nicked behind, free behind for two fifths of its length; two strongly defined somewhat circular openings for palatal glands, lying between anterior edges of choanae or a little farther forward.

Fingers slightly swollen at tips, first a little shorter than second (equal in type description); second and fourth fingers about equal; very strongly defined inner metacarpal tubercle, and distinct outer, much smaller than inner. No subarticular tubercles; leg moderate, tibiotarsal articulation reaching to eye; when legs are folded at right angles to body, heels fail to touch by a distance of two or three millimeters; no subarticular tubercles, but elongate callous areas

FIG. 14.—*Leptobrachium pelodytoides* Boulenger. Paratype, Mus. Civ. Genova, No. 27845B. Actual snout-vent length, 30 mm. Karin Bia-Po, Burma.

under toes; a small distinct inner metatarsal tubercle; digits somewhat widened at tips, lacking or with only trace of web, and indications of lateral ridges on sides of inner fingers. No tarsal fold.

Skin smooth above with small smooth pustules, more distinct laterally; ventral surfaces of body and limbs smooth except for fine indistinct granules on chin; a pair of small light-colored glands on breast near point on insertion of arm; gland on back of femur, closer to tibia than to vent; gland on side of rump above groin; sides with several small whitish glands.

Color: Olive above with some darker spots or marbling on head, dorsum, and sides; dark marks between eyes preceded by a lighter bar and this bordered anteriorly by another darker bar; upper lip with some dark vertical bars, or posteriorly, diffuse spots or clouding; arms, legs, and foot, strongly barred with dark brown; whitish on venter, the brown color on sides encroaching on venter, while most of surface is dusted with cinnamon pigment; on chin, very numerous tiny whitish flecks.

Measurements in mm. (two cotypes): Snout to vent, 30, 37; length of head, (to occiput), 10, 13; width of head, 10, 15; length of snout, 3.5, 4.6; diameter of eye, 3.5, 4.3; interorbital width, 3, 4; diameter of tympanum, 2, 2; distance between eye and tympanum, 1.5, 1.8; arm, 19, 23; hand, 8, 10; leg, 46, 51; tibia, 15, 16.3; foot, 15, 21.

Distribution: Megophrys pelodytoides has been reported from Doi Nga Chang, N. Siam by Malcolm Smith who states: "Not uncommon above 1000 meters." It is known from Burma, the type locality being the Karin Hills. Boulenger (1908) has referred to this species a series of specimens and states that they differ from the types in having less web between the toes (only a rudiment in the female, and none of the males has the toes more than one-fourth webbed).

Variation: It may be noted that the cotype specimen I have here described has the web reduced to a mere remnant. Boulenger's specimens from Tonkin averaged larger, the females reaching a size of 42 millimeters. Malcolm Smith obtained tadpoles which he referred to this species. They measured 60 mm. total length, and 21 mm. snout to vent length.

Leptobrachium minimum sp. nov.

FIG. 15

Type: No. 34020, Doi Suthep, *circa* 1000 m. elevation Chiang Mai, Chiang Mai province, Thailand; Edward H. Taylor, coll., Dec. 21, 1957.

Paratypes: Nos. 22 and 35980, topotypes, same collector.

Diagnosis: Tongue oval, nicked behind; no vomerine teeth; canthus rostralis angular; toes with remnant of web; two metacarpal, tubercles, inner very large, outer smaller; no subarticular tubercles on hand; first finger shorter than second; on foot subarticular tubercles present only under second and third toes; a small yellow ventrolateral glandular ridge or fold; a yellow gland above arm-insertion and one on breast in front of arm-insertion, an elongate black spot under thighs with a white or cream gland on its posterior

FIG. 15.—*Leptobrachium minimum* sp. nov. No. 34020 ♂. Actual snout-vent length, 27 mm. Doi Suthep, Chiang Mai, Thailand.

edge; an inner but no outer metatarsal tubercle; black spots on sides and in groin. Maximum length, 29 mm.

Description of type: Snout short, canthus rostralis rounded; nostril slightly nearer eye than to tip of snout; snout projecting two millimeters beyond mouth; distance between nostrils about equivalent to interorbital distance; tympanum distinct, its diameter slightly more than half diameter of eye; a strong curving fold above tympanum, terminating at a gland above arm insertion.

Tongue notched behind, free on sides and for two thirds of its length; no vomerine teeth; choanae nearly lateral. Two small vocal sacs, the openings small, puckered, behind mouth-angle. Arm rather short; a pair of small glands on breast near arm-insertion; first and second fingers of about equal length; a very large inner metacarpal tubercle and a smaller outer tubercle; four small tubercles under forearm in a longitudinal row; fingers (and toes) without subarticular tubercles, their tips truncate, slightly enlarged; toes with a web-remnant at base, having a ridge or fringe on lateral edges of toes continued to near tip; tips slightly enlarged; a strong inner metatarsal tubercle but no outer; no trace of a tarsal fold; when legs are folded at right angles to body, heels touch; tibiotarsal articulation reaching eye; pupil vertically elliptic, appearing almost round.

Skin rather smooth, with very small or microscopic rugosities and tubercles; a row of widely spaced tubercles above thigh, tibia, and tarsus; chin and venter smooth; anterior part of thigh smooth, posterior part granular, bearing on posterior surface a round cream-colored gland; several symmetrically placed glandular tubercles in anal region.

Color in life: Above generally olive-brown on head and body; side of head dull cream with two dim darker spots on upper lip; tympanum brown; supratympanic fold blackish; sides cream with several black spots on sides and smaller black flecks in ventrolateral regions; a salmon glandular spot above arm-insertion; forearm with two dark transverse bands; a cream lateral fold, or row of glandules, moderately distinct; thigh with two or three transverse dark bands above; posterior part of tibia with three transverse dark bands on ventral side, separated by cream; black spots under tarsus; a large black area under thigh, extending up somewhat on posterior surface; a prominent glandular cream spot, surrounded by black, on distal part of posterior surface of thigh; black under heel and tarsus, the sole lighter.

Measurements in mm. of *Leptobrachium minimum* sp. nov.

Number	22	34020	35980
Sex	♂	♂	♂
Snout to vent	23	27	28.6
Width of head	9.4	11	11
Length of head	8.2	11.8	10
Arm	16	18	18.5
Leg	37	38	43
Tibia	13	12	14
Foot and tarsus	16	18.5	19.3

Distribution: Known only from the type locality.

Remarks: The type specimen was found in a small mountain stream on Doi Suthep, near Chiang Mai, at an elevation of about 900 meters, in 1957. Several were seen but only one was taken on my first visit. They were hidden among groups of small rocks surrounded by water. When disturbed they were especially active, escaping as soon as the rocks were moved, diving into the fast-moving water under which they would conceal themselves for a short time, then regain the opposite bank.

Two specimens were taken in late September, 1958, when I paid a second visit to the mountain. These were found in a similar habitat at an elevation of about 1090 m. In 1959 a fourth specimen was taken near the type locality.

This species would seem to be close to *Leptobrachium oshanensis*, a Chinese species, which appears to differ chiefly in having a single, rather than paired, vocal sacs; and in lacking an elongate ventrolateral gland. The coloration also is different.

Family Bufonidae

This family of amphibians is nearly world-wide in distribution in temperate and tropical zones, some species even penetrating into the arctic zone. It is, however, absent on the great island, Madagascar.

Southeastern Asia and the Archipelago have representatives of six bufonid genera: *Bufo, Ansonia, Pseudobufo, Ophryophryne, Pelophryne,* and *Pedostibes.* In Thailand only three of these are represented, *Bufo* by four species; *Ansonia* and *Pedostibes,* each represented by a single known species. One other genus, *Pelophryne* should be looked for in the southern part of peninsular Thailand, since *Pelophryne guentheri* occurs in nearby Malaya. It is a small species living along mountain streams and may be easily overlooked.

The species most frequently seen in Thailand is the ubiquitous and widespread *Bufo melanostictus*. It might well be regarded as a domestic species, since it is to be found in and about dwelling places throughout the country. It hides usually during the day, emerging at night to forage on insects attracted by lights. In cities one may often find it moving about on the ground under electric lights.

Breeding choruses are well known in the klongs and ponds of the city of Bangkok. Choruses that begin at night may often continue through the following day. Some lively stories dealing with "battles between large and small frogs" have appeared in Thai newspapers written by reporters who have lacked training in Zoology and who have misinterpreted the observations made. The small frogs are the males, the large ones females and what appears to be battle is the attempt of one or more males to clasp the females.

Genus BUFO Laurenti

Bufo Laurenti, Specimen medicum, exhibens synopsin reptilium emendatam cum experimentis circa venena et antidota reptilium austriacorum Viennae 1768, p. 25 (type of genus *Rana bufo* Linnaeus).

Diagnosis: Tongue oval, elliptic not notched, free behind; no vomerine or maxillary teeth. Tympanum distinct or hidden by skin, rarely absent; web absent on fingers; toes usually with a thickened web and not on but slightly widened digit-tip. Outer metatarsal united; usually only a single slit enters vocal sac; omosternum usually absent, but of cartilage where present; a cartilaginous or bony sternum. Pupil horizontal; parotoid gland present and conspicuous.

These are the animals commonly known as toads. They have a distribution that is cosmopolitan extending near to if not reaching the Arctic Zone in Alaska. They are present on Madagascar but absent in Australia. They are omnipresent in Thailand.

KEY TO THE THAI GENERA OF BUFONIDAE

1. No parotoids present; cranial crests absent; webs between digits membranous . . . . *Ansonia*
   Parotoids present, cranial crests present or absent, webs usually thickened 2
2. Fingers partly, toes almost completely webbed; tips of digits widened into discs; arms and legs longer . . . . *Pedostibes*
   Fingers unwebbed, tips not distinctly widened; body with numerous spiny tubercles and warts; arms and legs shorter . . . . *Bufo*

KEY TO SPECIES OF BUFO IN THAILAND

1. Cranial crests or ridges absent; parotoid glands low; diameter of tympanum equal to length of eye or slightly less; snout to vent 55 mm., *macrotis*

   Cranial crests or ridges present; parotoid glands distinct, elevated; tympanum variable 2

2. Crests when present sharply distinct, variable in number; web on foot not reaching digital tips; large or small 3

   Ridges or flat crests on head often rather indistinct; web on foot reaching discs on toes; diameter of tympanum about one third length of eye. Very large toads, snout to vent 215 mm. . . . . *asper*

3. Small toads, supraorbital and parietal crests continuous, forming curves extending to or near back of occiput; diameter of tympanum two thirds to three fourths length of eye. Snout to vent, 50 mm. . . . *parvus*

   Large toads with a full set of cranial crests except parietal (rarely indicated), the crests covered with black horn; snout to vent, 97 mm.; diameter of tympanum about two thirds of length of eye, *melanostictus*

Bufo macrotis Boulenger

FIG. 16

Bufo macrotis Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 5, 1887, pp. 422-423, pl. 4, fig. 3 (type locality, Kakhien Hills, Burma); *ibid.*, vol. 13, 1892-1893, p. 40 (Palon, Burma); The fauna of British India . . . Reptilia and Batrachia, 1890, pp. 502-503; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, pp. 169-170; *ibid.*, vol. 2, no. 3, May 1917, p. 230 (Krabin, eastern Siam; Sai Yoke, Kanchanaburi province, western Siam; Pattani, Pattani province, southern Siam); Barron, *ibid.*, vol. 3, no. 3, Aug. 1919, p. 230; Nieden, Das Tierreich, Anura I, Lief. 46, 1923, p. 88, fig. 158; M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 30 (Muang Sai, Pattani); Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 8 (Nong Ri, Nakhon Nayok province).

Diagnosis: Head lacking crests; parotoid glands low, little larger than eyelid; tympanum large, equal to or little less than eye; body covered with very numerous tubercles of varying sizes, those on head smallest; no tarsal fold but row of larger tubercles on tarsus; distinct inner and a smaller outer metatarsal tubercle; large rounded palmar tubercle; first finger longer than second; subarticular tubercles on hand often bifid or trifid.

Description of species (from No. 36564 collected by Gordon Young, on top of Doi Hkram, Mong Haut, Chiang Mai, at an elevation of about 7000 ft.): Head rather flat, eyes elevated slightly; no cranial crests; parotoid glands flat (approximately 6.5 by 6.5 mm.); tympanum large, clearly defined, almost size of eye; tongue narrow, elongate, free for four fifths of its length; seen directly from below only inner edges of choanae are visible.

Arm moderate, first finger longer than second; large rounded

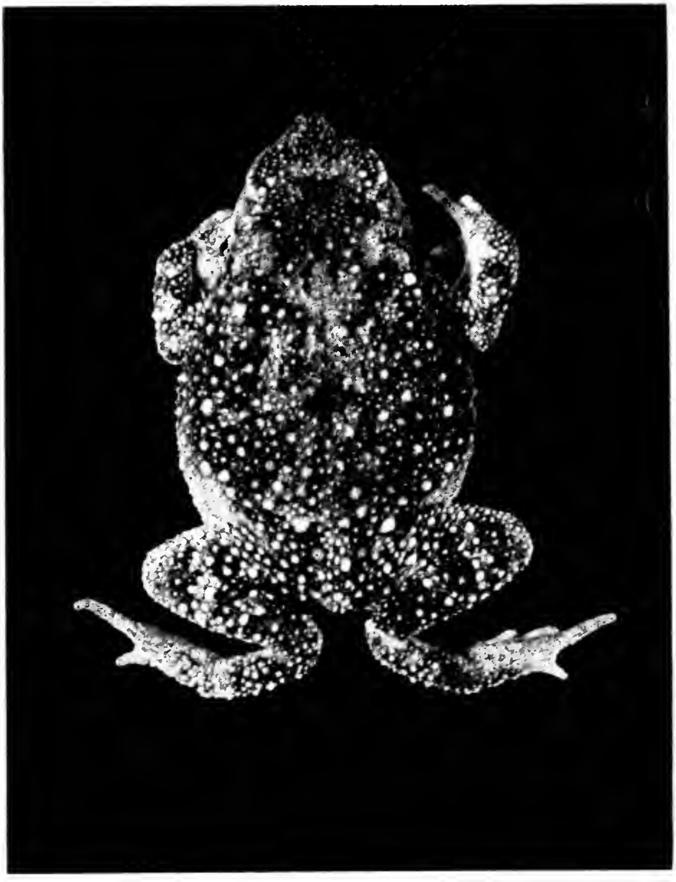


FIG. 16.—*Bufo macrotis* Boulenger. No. 36564. Actual snout-vent length, 55 mm. Doi Hkram "approx. 7000 ft." Chiang Mai, Thailand.

palmar tubercle; subarticular tubercles bifid (or trifid) with a row of enlarged tubercles from wrist to elbow; leg rather short, tibiotarsal articulation reaching tympanum. An elevated oval inner metatarsal tubercle and a small outer tubercle; small web between toes; no tarsal fold, but an inner and an outer row of enlarged tubercles; when legs are folded at right angles to body heels fail to meet. Entire body covered with tubercles or warts of varying size, often spiny; few enlarged tubercles at sides of vent.

Color: Above light brown with more or less symmetrical darker areas on snout and between eyes; a Λ-shaped mark in front of shoulders and dark spot near middle of back; sides dark, mottled; limbs with indefinite dark marks; tympanum uniformly dark; edge of upper lip white. Venter, chin, and concealed parts of limbs dirty yellowish-white. Dorsal tubercles on body cream; tubercles on limbs and subarticular tubercles cream to yellow.

Meaurements in mm.: Snout to vent, 55; snout to arm-insertion, 20; axilla to groin, 26; width of head, 20; length of head, 18.2; arm, 34; leg (from vent), 66; tibia, 20; foot and tarsus, 29.

Distribution: The species has been taken in western Thailand in the provinces of Chiang Mai, Nakhon Nayok, Kanchanaburi, and Pattani. Elsewhere it is known in Burma.

Remarks: Barron, *loc. cit.* has given an account of the breeding of this toad in July and August. He states:—"when the skin of the male becomes smooth and changes from dark brown to quite a bright yellow color, the female retains her normal characteristics They are to be found in large numbers in pools in or near small forest streams, the males invariably preponderating" . . . "if the males are separated from the females they very soon resume their normal coloring, but although I kept them for several days their skin did not become warty, as it is out of the breeding season."

This change during the breeding season in the characteristic of the skin (*i. e.*, the loss of the warty tubercles) is not usual in toads! Sometimes they are known to be less conspicuous in gravid females distended with eggs.

Bufo asper Gravenhorst

FIG. 17

Bufo asper Gravenhorst, Deliciae Musei Zoologici Vratislaviensis continens Chelonios et Batrachia, fasc. 1, Lipsiae, 1829, p. 58 (type locality, Java); Schlegel, Abbildungen . . . Amphibia, 1837-44, p. 63, pl. 20, fig. 1; Günther, The reptiles of British India, 1864, p. 423; Stoliczka, Journ. Asiat. Soc. Bengal, 1873, p. 113; Boulenger, Catalogue of the Batrachia Salientia s. Ecaudata in the British Museum (Natural History), 1882, p. 313; The fauna of British India . . . Reptilia and Batrachia, 1890, p. 507; Flower, Proc. Zool. Soc. London, 1896, p. 912, pl. 44, fig. 3; *ibid.*, 1899, p. 910; Laidlaw, Proc. Zool. Soc. London, 1900, p. 888; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904, pp. 396-397; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 271-272; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 3, May, 1917, p. 230 peninsular and western Siam); Journ. Federated Malay States Mus., vol. 10, 1922, p. 282; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, pp. 82-84; Nieden, Das Tierreich, Lief. 46, Anura I, 1923, p. 119, fig. 168; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 8 (Nakhon Si Thammarat); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 131 (Tasan, Isthmus of Kra; Nakhon Si Thammarat Mountains); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1075-1076, fig. 13.

Phrynoidis asper Fitzinger, Systema Reptilium, vol. 1, 1843, p. 32.

Nectes obscurus Barbour, Proc. Biol. Soc. Washington, vol. 17, 1904, p. 51 (type locality, Sarawak).

Bufo obscurus Barbour, Mem. Mus. Comp. Zool. Harvard College, vol. 44, no. 1, 1912, p. 75, pl. 6, fig. 20.

Diagnosis: Very large toads without parietal crests; orbital ridges flattened, indistinct; canthal ridges distinct in younger specimens; supratympanic ridge strong, thickened, touching small distinct parotoid gland; fingers free, toes about three-fourths webbed,* webs touching discs on outer side of three inner fingers and inner side of fifth; two distal joints of fourth toe free; a strong tarsal fold; digital tips swollen, somewhat widened; two metacarpal tubercles, outer largest; two metatarsal tubercles, inner largest; tibiotarsal articulation reaches to tympanum or eye; tympanum small, its diameter about one third that of eye.

Description of species (from No. 152 Na Bon, Nakhon Si Thammarat): Head relatively narrow; canthus rostralis distinct, angular, loreal region practically vertical, not or scarcely concave; nostrils lateral; tip of snout obliquely truncate; eyes prominent, edge of upper eyelid thickened; canthal crests distinct with depression between them; orbital crests flat, widened, not continuous with canthal crest; postorbital or parietal crest not evident; very strong, widened supratympanic crest touching upper eyelid and parotoid gland; latter small, slightly diagonal, somewhat longer than wide; width of an eyelid distinctly less than distance between orbital crests; interorbital region concave; length of eye about equal to length of snout. Tympanum about one third diameter of eye.

Choanae strongly narrowed, followed behind by a high bony ridge; tongue broadly oval, free behind for two thirds of its length; (males with a pair of vocal slits back near angles of jaws).

Skin of entire surface covered with larger and smaller warts and granules; dorsum with numerous large warts rounded or flattened; larger warts on legs pyramidal, surmounted by one or more small spines; granules vary in size on chin, breast, venter, and underside of limbs, smaller than dorsal warts, each with small central spine and with very numerous minute spines; tarsal fold nearly straight, its edge surmounted by brown tubercles; (first finger of males with an area covered with minute horny nuptial spines that extends nearly to tip on inner side; horny spines also present on second finger); first finger not or but very little longer than second (many specimens have them same length); inner edge of first three fingers and outer edge of fourth with a longitudinal ridge or fold; subarticular tubercles single, well developed on hand and foot; web on toes reaches

* Boulenger (1912, p. 272), says, "toes completely webbed." I have seen no specimens in this condition. A specimen from Kuala Lumpur agrees with the specimens from southern Thailand.

FIG. 17.—*Bufo asper* Gravenhorst. No. 34541. Actual snout-vent length, 152; Bhetong, Yala, Thailand.

discs of three inner toes on their outer side, and fifth toe on its inner side; elsewhere web may form a narrow fringe or ridge that reaches disc except on fourth toe which has two distal joints free.

The tibiotarsal articulation reaches to posterior edge of eye; when legs are folded at right angles to body, heels very narrowly separated.

Color: Above light olive to olive-brown nearly uniform; venter brownish white with indistinct darker spotting or mottling.

Measurements in mm. (No. 152, 1573 [Bhetong, Yala Province], respectively): Snout to vent, 137, 110; width of head, 50, 40; length of head, 38, 29; eye length, 15, 11; length of snout, 15, 12; arm, 86, 68; leg, 178, 152; tibia, 60, 50; foot and tarsus, 83, 72.

Variation: There is much variation in the general coloration. Specimens may be light clay, olive, blackish or occasionally (probably in the breeding season) may be spotted with orange or crimson.

Young specimens and males may be yellowish white or cream on venter, while the chin and breast may be covered with smoky black flecks, dots, or marblings.

Distribution: The species is known in peninsular and western Thailand, specimens having been taken in the provinces of Yala, Trang, Nakhon Si Thammarat, and Chumphon. How far north the species extends has not been determined.

In Malaya the species occurs from sea level to an elevation of 4500 feet. It has been taken in caves deep in the mountains. It has also been taken in southern Burma, Sumatra, Borneo, and Java.

Remarks: The species usually remains close to small streams. At Bhetong numerous specimens were acquired from clumps of bamboo growing in the edge of a small stream. The toads were perched among low branches and were easily seized. However, many escaped by plunging into the water.

One popular legend regarding this species is that thieves burn the dried toad skins permitting the smoke to enter a room where persons inhaling the smoke enter a deep sleep, and will not awaken while the room is being robbed.

Bufo parvus Boulenger

FIG. 18

Bufo parvus Boulenger, Ann. Mag. Nat. Hist., ser. 5, vol. 19, 1887, p. 346, pl. 10, fig. 3 (type locality, Malacca); Flower, Proc. Zool. Soc. London, 1899, p. 911; Laidlaw, Proc. Zool. Soc. London, 1900, p. 888; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 274; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, pp. 42, 170, fig. —; Journ. Federated Malay States Mus., no. 3, 1930, p. 131; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 8.

Diagnosis: A small toad with supraorbital and parietal bony ridges forming a straight or slightly curved line; a small supratympanic ridge; pair of rather small, somewhat rounded paratoids; snout extending beyond mouth; tibiotarsal articulation reaching to front of tympanum; tympanum distinct, its diameter a little more than two-thirds length of eye; interorbital space broader than an eyelid; first finger extending beyond second.

Description of species (from No. 35764, Khao Chong, Trang, May 19, 1958): Canthus rostralis sharp; snout narrowed and projecting considerably beyond mouth, truncate anteriorly; pair of supraorbital ridges continued as strong parietal ridges in straight or somewhat curving lines; edge of eyelid projecting somewhat; a pair of strong but short supratympanic ridges which project outwards; upper eyelid about equal to interorbital width; small slightly diagonal parotoid longer than wide touches supratympanic ridge; loreal region nearly vertical, edge of jaws not visible from above, area slightly concave; tympanum large, close to eye, its greatest diameter nearly three fourths length of eye; tongue slender, elongated, free for half its length; choanae almost completely visible from below; (males with a subgular vocal sac; vocal slit (slits) may be dextral, sinistral, or both).

Arms and legs relatively elongate, slender; tibiotarsal articulation reaching front level of eye; first finger longer than second; subarticular tubercles single, prominent. Two palmar tubercles, outer very large; toes slightly less than half webbed; subarticular tubercles small, indistinct, except on fourth toe; a prominent inner metatarsal tubercle, a smaller outer; no tarsal fold, but an irregular row of somewhat larger spiny tubercles on edge of tarsus; when legs are folded at right angles to body heels do not, or barely, touch.

Head, except interorbital and loreal areas, dorsum, sides, and upper surfaces of limbs covered with various larger, and smaller spiny tubercles producing a very rough surface; chin, breast, venter, and undersurface of limbs with small rounded granules most of which have a small center spine surrounded by several still smaller ones.

Color in life: Light brown above, slightly darker on sides; arms and legs dimly banded with darker brown; lower surfaces very indistinctly marked.

Measurements in mm. (Nos. 35764, 35766, 34740, respectively): Snout to vent, 47, 42, 35; width of head, 15, 14, 12.6; length of head, 15.3, 14, 12; arm, 33, 27, 25.2; leg, 60, 55, 49; tibia, 19, 17, 15; foot and tarsus, 26, 24.5, 21.

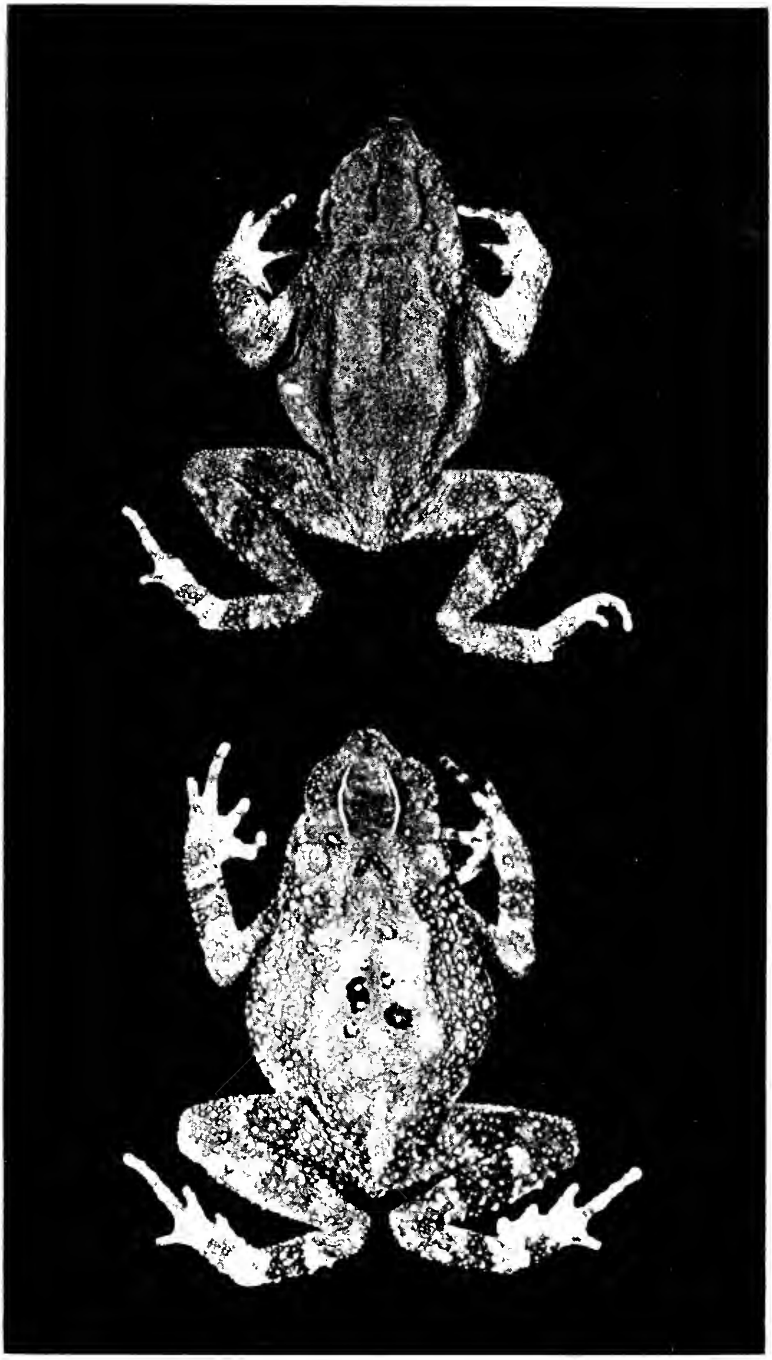


Fig. 18.—*Bufo parvus* Boulenger. Upper figure, No. 34735 ♂; actual snout-vent length, 35 mm. Lower figure, No. 34733 ♀; length, 39 mm. Both from Bhetong, Yala, Thailand.

Variation: There is some variation in the length of leg; the tibiotarsal articulation may reach beyond the eye. Males have a subgular vocal sac which may have a sinistral or dextral vocal slit. One specimen shows two slits. Many specimens have some of the larger dorsal tubercles surrounded with black and occasionally the larger tubercles seem to form a symmetrical pattern. In many males the chin and throat are uniformly blackish olive while the buff or fawn venter is speckled or reticulated with olive.

Distribution: The species is well-known in southern Thailand, specimens having been taken at several places in the province of Nakhon Si Thammarat and in "Patiyu [= Prachuap Khiri Khan province], at Bhetong, Yala and Khao Chong, Trang. The species has been reported by Malcolm Smith, on the basis of larval forms, on Khao Sebab, Chanthaburi province. It is widely distributed in Malaya in southern Burma, and it has also been taken in Sumatra.

Remarks: The species was found breeding May 19-23 in a tiny rivulet that had accumulated a few pools after having been dry for some time. Specimens were taken at one pool on three different nights. Other specimens were found hopping about in open forest.

Malcolm Smith reports that he introduced the species into Bangkok (before May 1917). I have found no specimens or records of its having been taken since. However, no especial effort has been made to discover it.

Bufo melanostictus Schneider

FIG. 19

Bufo melanostictus Schneider, Historiae amphibiorum naturalis et literariae . . . fasc. primus 1799, p. 216 (type locality "Ex India orientali"); Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1063; Günther, The reptiles of British India, 1864, p. 442; Boulenger, Catalogue of the Batrachia Salientia, *s.* Batrachia Ecaudata in the collection of the British Museum, 1882, p. 306; The fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 505, fig.; Flower, Proc. Zool. Soc. London, 1896, p. 911, pl. 44, fig. 3; *ibid.*, 1899, p. 910; Laidlaw, Proc. Zool. Soc. London, 1900, p. 888; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, p. 395; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 272-274, fig. 76; Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 133; Stejneger, Bull. U. S. Nat. Mus., vol. 58, 1907, p. 72, figs. 58-61; Barbour, Mem. Mus. Comp. Zool. Harvard College, vol. 44, no. 1, 1912, p. 73; Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 4, Dec. 1915, p. 249 (Koh Chang); *ibid.*, vol. 2, Dec. 1916, p. 17, (Pattani, and Nakhon Si Thammarat): *ibid.*, vol. 2, May 1917, p. 230 ("Common almost everywhere" [in Thailand]); *ibid.*, vol. 2, Dec. 1917, pp. 274-275; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, pp. 80-81; Nieden, Das Tierreich, Anura I, Lief. 46, 1923, p. 116, fig. 167; Taylor and Elbel, Univ. Kansas Sci. Bull. vol. 38, 1958, pt. 2, p. 1076; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 131.

Bufo meranostictus (*sic*) Stejneger, Journ. Coll. Japan, vol. 12, p. 216.

Diagnosis: Medium large toads (snout-to-vent 11.5 mm.); strong canthal, supraorbital, postorbital (pretympanic), supratympanic, and preorbital crests; strong depression between orbital crests; length of orbit slightly greater than snout length; snout rather pointed; parotoids large, much longer than wide, above level of tympanum; body with very numerous warts surmounted by one large and numerous smaller spines; first finger longer than second; subarticular tubercles bifid, often divided rather than single; tibiotarsal articulation to middle of parotoid; toes about one-third webbed.

Description of species (♀ specimen, from Chiang Mai, Thailand): Body relatively short; snout rather pointed; canthal crest from above nostril continuous with orbital crest; supratympanic crests and postorbital (pretympanic) crests present; loreal region sloping somewhat obliquely, shallowly concave; eyelid narrower than distance between supraorbital crests; no parietal crests; supratympanic crest short, thickened; tympanum large (8 mm.) more than half size of eye; parotoid large (25 by 10 mm.), separated from its fellow by a distance of 15 millimeters; deep concavity between crests continued to between parotoids, widest at anterior level of parotoids; pair of prominent rounded warts between anterior part of parotoids; an indistinct horny ridge below eye paralleling ridge on edge of jaw; choanae circular, completely visible from below; ridges behind choanae not meeting mesially; tongue narrowed anteriorly, widened posteriorly, free posteriorly for half its length; (male with nuptial asperities on first and second fingers, and indicated on edge of third); vocal slit either sinistral or dextral (rarely both slits present); a pair of tubercles between parotoids, and two irregular parallel rows of enlarged tubercles on back; these usually capped with horn; warts on side with a larger median and several smaller horny spines; dorsal spines on arms smaller than those on legs.

Digits with horny tips, slightly dilated; large outer and much smaller inner metacarpal tubercle; first finger longer than second; subarticular tubercles of hand partly bifid or double, some single. Toes usually one-third webbed or less; a strong inner metatarsal tubercle and smaller outer; no tarsal fold but in its place a straight row of tubercles; tibiotarsal articulation reaches to midway on parotoid; when legs are folded at right angles heels fail to touch.

Color: Above light brown with some reddish brown between parotoids; crests of head, parotoids, and most tubercles covered

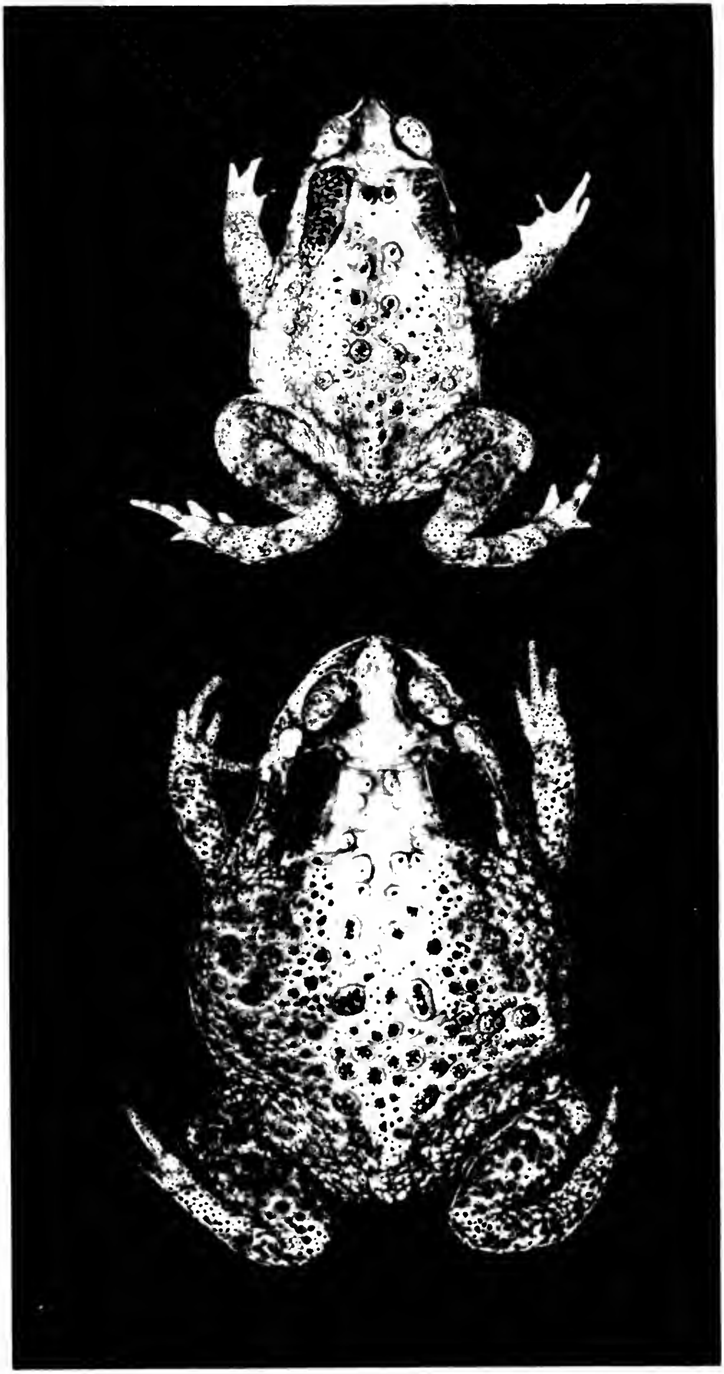


FIG. 19.—*Bufo melanostictus* Schneider. Upper figure, No. 34112. Actual snout-vent length, 71 mm. Lower figure, No. 33722. Length, 101 mm. Both Chiang Mai, Chiang Mai, Thailand.

or topped with black horn; venter fawn, the small spines horn-colored.

Measurements in mm.: Snout to vent, 105; width of head, 40; length of head, 29; length of eye, 11; length of snout, 11; diameter of tympanum, 7; length of parotoid, 25; width of parotoid, 13; arm, 60; leg (from vent), 120; tibia, 40; foot and tarsus, 58.

Variation: An examination of a large series of specimens from various parts of Thailand showed some minor differences in the populations. Thus, specimens from Muak Lek, Sara Buri province, and Ang Hin, Chon Buri have slightly wider fingers and a median tubercle between the two usual metatarsal tubercles. Also the tympanum is somewhat larger. Certain specimens from southern Thailand have longer more slender fingers and toes with subarticular tubercles less developed than in more northern specimens. A few northern specimens show traces of a parietal crest.

The two tubercles between the parotoids are almost invariably present, more may be present and in a large number of individuals the larger warty tubercles tend to form two parallel rows on each side of the median line of the back; these, however, are rarely regular.

The length of the parotoids varies considerably. The amount of horny material on crests and tubercles varies seasonally and it would appear that this is shed at times, since some individuals have the dark horny material absent from both tubercles and crests.

The color may be light tan dorsally, and some females are light fawn below on chin and venter (Chiang Mai) while females from the central plains (Chon Buri and Sara Buri), may have the chin and breast more or less heavily marked with blackish.

Certain specimens from Renong have the venter largely bright yellow; and the diameter of the tympanum equal to about four fifths of eye-length.

Distribution: In Thailand this species has been taken in a large number of provinces, and it probably occurs in every province. Outside of Thailand it has been found in India north to the Himalayas, Burma, S. China, Indo-China, Malaya, and the Indo-Australian Archipelago.

Pedostibes Günther

Pedostibes Günther, Proc. Zool. Soc. London, 1875, pp. 576-577 (type of genus *Pedostibes tuberculosus,* from Malabar India).

Nectophryne, Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 1882, p. 279.

The brief generic description reads: "Differing from *Callula* in its physiognomy and habit which resembles Bufo. Palate concave, without any transverse ridges."

This genus was presumably thought by Günther to belong to the Microhylidae since his generic description compares it with *Kaloula* (*Callula*). The genus was later thrown into the synonymy of *Nectophryne* by Boulenger (1882).

Barbour (1938) has resurrected this genus to include certain species heretofore regarded as *Nectophryne: hosii*, Borneo and the Malay Peninsula; *everetti*, Mt. Kinabalu and Mt. Penrisen, Borneo; *altitudinis*, Mt. Kinabalu 7000-10000 ft. altitude; and *kempi*, Garo Hills, Assam.

In Thailand only *Pedostibes hosii* has been taken.

Pedostibes hosii (Boulenger)

FIGS. 20, 21

Nectophryne hosii Boulenger, Proc. Zool. Soc. London, 1892, p. 508, pl. 30, fig. 2 (type locality Mt. Dulit, Sarawak, Borneo); Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 19; Roux, Proc. Zool. Soc. London, 1906, vol. 1, p. 59, pl. 2, fig. 1; van Kampen, Amphibien des indischen archipels . . . 1907, p. 413; Barbour, Mem. Mus. Comp. Zool. Harvard Coll. 1912, vol. 44, p. 175; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 268-269; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 67; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 129.

Pedostibes hosii Barbour, Proc. Biol. Soc. Washington, vol. 51, 1938, p. 192.

Diagnosis: A toadlike amphibian with long arms and legs, hand and foot webbed; digits dilated at tips into discs. Pupil horizontal; tongue elliptical without a notch behind; well-developed inner finger; male with an internal subgular vocal sac; outer metatarsals united.

Description of species (from M. S. No. 7675, "Setun River, Siam"): Head somewhat concave above, snout narrow truncate; canthus distinct, swollen in front of eye, loreal region concave, oblique; nostrils lateral, close to tip of snout; tympanum distinct preceded, behind eye, by a slight bony elevation; supratympanic ridge somewhat swollen, considerably above and overhanging tympanum; diameter of tympanum scarcely more than half length of eye; interorbital space depressed, twice (or a little more) as wide as upper eyelid.

Tongue narrow, elliptical, free behind; no vomerine teeth; choanae partly concealed when observed from below.

Skin minutely granular on head with a few tubercles above on eyelid; few small scattered warts on dorsum; undersurface of chin, venter, and thigh, granular or areolate; short but distinct parotoid

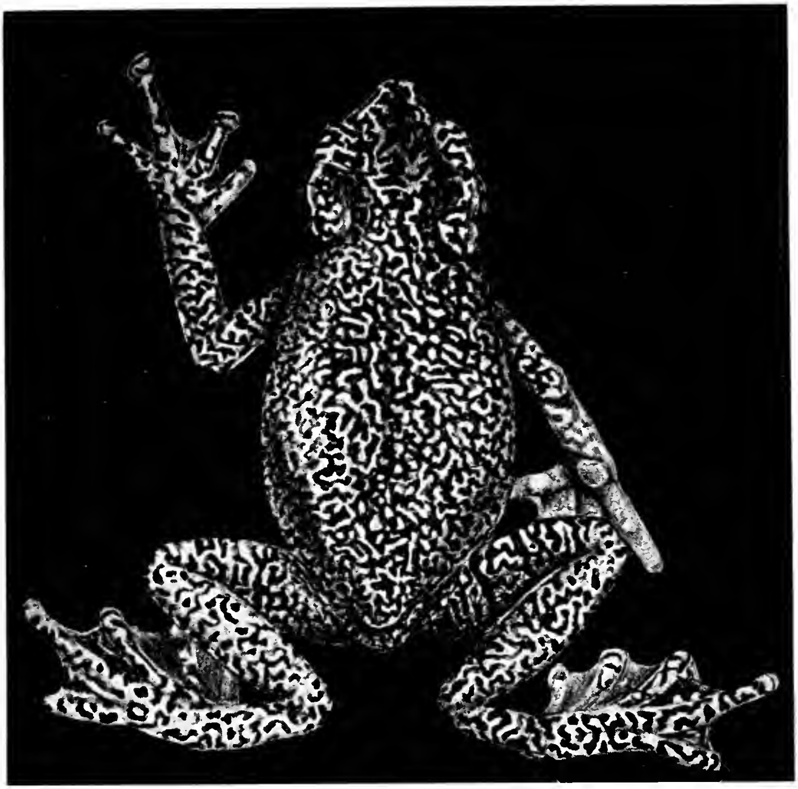


FIG. 20.—*Pedostibes hosii* (Boulenger) After Roux. Female. Proc. Zool. Soc. London, vol. 1, 1906, pl. 2, fig. 1. Borneo.

gland. Arms long, slender, fingers much depressed, webbed at base, web extending as slender margins to widened terminal discs; first finger shorter than second; toes moderate, flattened, almost completely webbed, tip of digits widened into truncate discs slightly smaller than those on fingers; subarticular tubercles small, feebly prominent; two flat metatarsal tubercles, inner larger; a tarsal fold; tarsometatarsal articulation reaches tip of snout.

Color: Uniform brown with some indications of darker markings across legs, and some reticulation on back of thigh.

Measurements in mm.: Snout to vent, 63; width of head, 21.6; length of head, 21; arm, 55; leg, 97; tibia, 28; foot and tarsus, 43.

Variation: The males and females differ so much in size (females reach a snout-vent length of 100 mm.), in the development of the digital pads, and especially in coloration, that it is scarcely possible to believe they are of the same species.

FIG. 21.—*Pedostibes hosii* (Boulenger) After Boulenger. Male. Proc. Zool. Soc. London, 1892, p. 508, pl. 30, fig. 2. Borneo.

The male may have some indistinct spots on the limbs and the throat may be black. Others may be dark brown with light brown markings which form indistinct coarse vermiculations while the limbs are yellowish brown with indications or transverse bands (Lawas, Brunei).

The females examined have a ground color of black with spots or vermiculations of yellow on head, dorsum, sides and on upper parts of limbs. The concealed parts of the body are dull dirty gray or uniform yellowish. There are yellow spots on lower lip. The females have fewer and perhaps less conspicuous tubercles. The limbs of both sexes may vary in length, the tibiotarsal articulation sometimes reaching to or near to tympanum, to eye or slightly beyond. There is a tarsal fold present.

The eggs are laid in long strings typical of *Bufo*.

Distribution: The inclusion of this species in the Thai fauna is on the basis of a single collection in the province of Satun,* which borders on the State of Perlis, Malaya.

Malcolm Smith (1930) writes: "My native collector found this toad common in the vicinity of the Setun River (lat. 7° 40′ N.) and obtained a large series. He was attracted to the spot after dark by the voices of the males as they were clambering about on bushes and small trees."

The species was originally discovered in Sarawak, Borneo and has been found subsequently in several other places. In Malaya it has been taken in the state of Selangor.

Remarks: This species was long included in the genus *Nectophryne,* an African genus. Barbour (1938) with the help of H. W. Parker of the British Museum examined the skeletal and other characters and both agreed that *hosii* and other Asiatic "*Nectophryne*" should be placed in a different genus.

Genus ANSONIA Stoliczka

Ansonia Stoliczka, Proc. Asiat. Soc. Bengal, 1870, p. 152, (type of genus, *Ansonia penangensis*).

A small toadlike amphibian. Fingers elongate, well developed; toes almost completely webbed, the web not thickened; cranial crests absent; tympanum absent. No parotoids glands. A single slit opening into vocal sac.

One species recognized in Thailand.

Ansonia penangensis Stoliczka

FIG. 22

Ansonia penangensis Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 152, pl. 9, fig. 4, (type locality, Penang I.).

Bufo penangensis Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 287; Flower, Proc. Zool. Soc. London, 1896, p. 911; *ibid,* 1899, p. 908, pl. 60, fig. 3; Butler, Journ. Nat. Hist. Soc. Bombay, vol. 15, 1904, p. 395; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 270-271, (Penang, 2000 ft. Perak, 2000-3000 ft.); Journ. Federated Malay States Mus., vol. 10, 1922, p. 282, (Kuala Teku and Fraser's Hill, Malaya); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 129, fig. 6, (Tasan, Isthmus of Kra; and "Benang Star," Yala; mountains of Nakhon Si Thammarat).

* Often spelled Setul, Satul, or Setun.

Diagnosis: A small species (snout to vent, 40 mm.); no bony ridges on head; body slender; parotoid glands very small or absent; tibiotarsal articulation to eye, or between eye and tip of snout; two metatarsal tubercles; no tarsal fold. Fingers rather long with feebly swollen tips, first shorter than second. Dark brown above with fine

FIG. 22. *Ansonia penangensis* Stoliczka, EHT-HMS 81. Actual snout-vent length, 22 mm. (M. S. 3328), Tasan, Chumphon, Thailand.

white or yellow spots; brownish beneath, speckled yellow or with brown marbling.

Description of species (from M. S. No. 3328 (F 81); Tasan, Thailand): Top of head without elevated ridges; snout short obliquely truncate; canthus rostralis rounded, loreal region nearly vertical but slightly concave; snout projecting beyond mouth; nostril nearer median point of snout than to eye; length of eye a little greater than length of snout; tympanum distinct, its vertical diameter little more than half length of eye, separated from eye by a distance less than half its diameter; small parotoid above tympanum; small gland below tympanum. Tongue elongate, free for nearly three fourths of its length; a long longitudinal slit opens into vocal sac on right side, none on left; choanae visible when palate is viewed from below. Skin on dorsum with unequal-sized warts, the largest arranged dorsolaterally; upper eyelids, sides of neck, sides of body, limbs, and venter covered with granules; chin relatively smooth.

Arms and legs slender; fingers rather long, slender, tips more or less swollen; hand without web; subarticular tubercles absent or indistinct; first finger shorter than second. Toes short, more than half webbed, with indistinct subarticular tubercles and two flat metatarsal tubercles; no tarsal fold; tibiotarsal articulation reaches to near eye.

Color: Dark brown above, head a lighter shade than dorsum; a distinct median yellowish spot on shoulders and a few yellow flecks scattered on back and sides; chin, venter, and underparts of limbs deep brown enclosing numerous irregular yellow spots.

Measurements in mm.: Snout to vent, 22; width of head, 7.6; length of head, 7.2; arm, 12; leg, 33; tibia, 11; foot and tarsus, 17.

Variation: The markings may be brown and white; the tibiotarsal articulation may reach almost to nostril.

Distribution: In Thailand the species, so far as known, occurs from the Isthmus of Kra south to Malaya, having been taken in the provinces of Pattani, Nakhon Si Thammarat, and Chumphon.

Elsewhere it occurs in Malaya (Penang and Perak) and Borneo.

FAMILY ATELOPODIDAE

A small toadlike amphibian, originally named *Hylaplesia borbonica* by Boie (1826), was later referred to the genus *Bufo* by Cope, 1867, and Boulenger (1882). Here it remained until van Kampen (1923) placed it in the genus *Nectophryne*. Davis, (1935) in a study of the form proposed the genus *Cacophryne*. He pointed out that its relationship was not with the *Bufonidae* but with the South American family *Atelopodidae*.

One other member of this family has been recognized in Asia by Brongersma.

Cacophryne Davis

Cacophryne Davis, Zool. Ser. Field. Mus. Nat. Hist., vol. 20, no. 12, May 5, 1935 (type of genus *Hylaplesia borbonica* Boie).

Diagnosis: Vertebral column procoelous. Pectoral girdle completely firmisternal; sternum slender and cartilaginous; omosternum absent; sacral diapophyses widely expanded; coccyx and sacrum fused; maxillary and vomerine teeth lacking; prevomer small, ethmoid entire, palatine present. Ear complete; no palatal folds; Eustachian tubes present. Terminal phalanges simple, no intercalary cartilages. Pupil horizontal. Narrow inconspicuous parotoid glands present. Habitus slender with elongated limbs.

Davis calls attention to the apparent distributional anomaly in having in Asia, a monotypic genus referable to a South American family Atelopodidae. He points out another similar case, that of *Nothopsis,* a new world representative of a subfamily represented elsewhere only in Southeastern Asia.

Cacophryne borbonica (Boie)

FIG. 23

Hylaplesia borbonica Boie (Kuhl and van Hasselt in Schlegel), Isis, vol. 20, 1826, p. 294 (*nomen nudum*); Schlegel, Bull. Sci. Nat. Férussac, vol. 9, 1826, p. 239 (*nomen nudum*); Tschudi, Mem. Soc. Sci. Nat. Neuchâtel, vol. 2, 1839, p. 70; Peters, Monatsb. Acad. Wiss. Berlin, 1863, p. 81.

Bufo borbonicus Cope, Journ. Acad. Nat. Sci. Philadelphia, vol. 6, 1867, p. 193; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 1882, p. 286 (*part.*); Horst, Notes Leyden Mus., vol. 5, 1883, p. 236; Mocquard, Arch. Mus. Paris ser. 3 vol. 2, 1890, p. 122; Boettger, Katalog der Batrachier-Sammlung im Museum der Senckenbergischen naturforschenden Gesellschaft, 1892, p. 33; van Kampen, Zool. Jahrb., Java, vol. 22, 1905, p. 713; Amphibiens des Indischen Archipels . . . 1907, p. 413; Robinson and Kloss, Journ. Federated Malay States Mus., vol. 8, 1920, p. 306; Bourret, Les batraciens de l'Indochine, 1942, pp. 167-169, fig. 24.

Bufo borbonica M. Smith, Sarawak Mus. Journ., vol. 3, 1925, p. 30; Bull. Raffles Mus., no. 3, 1930, p. 130.

Nectophryne borbonica van Kampen, Notes Leyden Mus., vol. 34, 1911, p. 75; The Amphibia of the Indo-Australian Archipelago, 1923, p. 20, fig. 7.

Nectophryne sumatrana van Kampen, Naturk. Tijdschr. Ned.-Ind., vol. 69, 1910, p. 19, pl. 1, fig. 1.

Bufo jerboa Boulenger, Proc. Zool. Soc. London, 1890, p. 328, pl. 25, fig. 3; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 271; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 76; Noble, The Biology of the Amphibia, 1931, p. 502, fig. 161 (reprinted 1954).

Cacophryne borbonica Davis, Field Mus. Nat. Hist. Zool. Ser., vol. 20, 1935, pp. 87-92.

Diagnosis: A small slender species, head without bony ridges; canthus angular; leg long, tibiotarsal articulation reaching nearly to

FIG. 23.—*Cacophryne borbonica* Boie. From Boulenger, Proc. Zool. Soc. London, 1890, p. 328, pl. 25, fig. 3, "Bufo jerboa." Actual snout-vent length, 30 mm. SE Borneo.

tip of snout; toes half webbed; paratoids small, two on each side; blackish or brownish with white spots; marbled brown below.

Description of species (from Boulenger's description of *Bufo jerboa* 1912. This has been synonymized with *Cacophryne borbonica.* It must appear that, if this is fact, the southern Thai specimens should resemble more the population described as *jerboa* since Boulenger identifies specimens from Gunong Inas, northern Perak as belonging to *jerboa.* Perak borders Thailand on the south): Body very slender; head lacking trace of crests or bony ridges; snout obliquely truncate, strongly projecting beyond mouth; loreal region vertical; interorbital space as broad as or a little narrower than upper eyelid; tympanum distinct one half to two thirds diameter of eye, and close to latter. Fingers long and slender, with feebly swollen tips, first as long as or a little shorter than second; toes short, one-third to one-half webbed with very prominent subarticular tubercles; two small but prominent metatarsal tubercles; a tarsal fold; tibiotarsal articulation reaches far beyond tip of snout; tibia about two thirds length of head and body. Upper parts with granules and very small warts; venter granulate; paratoids, if at all distinct, very narrow.

Color: Brown above, with dark and light spots or symmetrical markings, often forming an X-shaped figure in front of sacral region; a yellowish dorsolateral streak sometimes present; dark bars on limbs and on lips; yellowish or pale brownish beneath, throat and breast dark brown or much mottled with dark brown.

Measurements in mm.: Snout to vent, 50.

Distribution: In Thailand the species has been taken in the province of Trang and at Kuan Nieng, southwest of Phatthalung, Phatthalung province.

It was originally found in Java, while the type of *Bufo jerboa* came from southeastern Borneo (first mentioned by Fisher, Arch. Nat., 1885, p. 43 as *Bufo leptophis*).

FAMILY HYLIDAE

This great family, comprising chiefly arboreal frogs is very poorly represented in Asia. On the other hand Australia, South America, and North America have numerous species. They are absent or rare in Africa.

A single species is known from Thailand, a species much better known in Burma.

The Hylidae may be described as follows: Arboreal or secondarily terrestrial frogs. Vertebrae procoelian, lacking free ribs; coccyx attached to sacrum by paired condyles; sacral diapophyses dilated except in terrestrial species; an arciferal pectoral girdle. Coracoids and precoracoids connected by an arched cartilage, that on one side overlapping that of the other; omosternum and sternum of cartilage. Upper jaw with teeth; terminal phalanges claw-shaped, separated from penultimate phalanx by an intercalated cartilage. A frontoparietal fontanelle.

A single genus Hyla, is represented.

Genus HYLA Laurenti

Hyla Laurenti, Specimen medicum, exhibens Synopsin Reptilium emendatam cum experimentis circa venena et antidota Reptilium Austriacorum, 1768, pp. 32, 33 (type of genus, *Hyla viridis*).

Diagnosis: Characters of family. Sternum a cartilaginous plate; outer metatarsals almost completely united; fingers free or more or less webbed; toes webbed, tips dilated into larger or smaller discs; pupil horizontal; tongue entire or notched behind; vomerine teeth usually present. Tympanum distinct or hidden.

A single species is present in Thailand.

Hyla annectens (Jerdon)

Polypedates annectens Jerdon, Proc. Asiat. Soc. Bengal, 1870, p. 84 (type locality, Khassya Hills, N. India).

Hyla annectens Günther, Proc. Zool. Soc. London, Nov. 16, 1875, p. 576 (closely allied to *Hyla chinensis*); Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, p. 382; Ann. Mus. Civ. Genova, ser. 2, vol. 6, 1888, p. 593; The fauna of British India. . . . Reptilia and Batrachia, 1890, p. 509; Sclater, Proc. Zool. Soc. London, 1892, p. 348; Boulenger, Ann. Mus. Civ. Genova, 1893, ser. 2, vol. 13, pp. 311, 343; Fea, *ibid.*, ser. 2, vol. 17, 1897, p. 476; Nieden, Das Tierreich, Lief. 46, Anura I, Subordo Aglossa und Phaneroglossa Sectio I Arcifera, 1923, pp. 201-202; Vogt, Zool. Anz., Leipzig, 1924, p. 343; Parker, Ann. Mag. Nat. Hist., ser. 9, vol. 15, 1925, pp. 305; Gee and Boring, Peking Nat. Hist. Bull., vol. 4, pt. 2, 1930, pp. 24, 39; Pope, Bull. Amer. Mus., vol. 61, 1931, p. 474; Bourret, Annexe. Bull. Inst. Publ., No. 4, 1939, Dec., p. 58; Pope and Boring, Peking Nat. Hist. Bull., vol. 15, 1, 1940, p. 37; Bourret, Les Batraciens de l'Indochine, 1942, pp. 222-223.

Diagnosis: A member of the *Hyla arborea* group; a strong, tubercular fold from eye to shoulder; black spots along flanks.

Description of species: Tongue circular, slightly nicked and free behind; vomerine teeth in two groups on level with posterior edge of choanae; head broader than long; snout short, rounded; canthus rostralis distinct; interorbital space as broad as upper eyelid; tympanum distinct, about half diameter of eye. Fingers webbed at base; toes two-thirds webbed, discs well developed. Tibiotarsal articulation reaches tympanum or eye; skin smooth above, granular on ventral surface; strongly tuberculated fold from eye to shoulder; male with vocal sac; black nuptial excrescences on first finger of male.

Color: Green above; a light-edged dark lateral streak terminates posteriorly in two or three black spots, separated or confluent on groin, which is bright yellow; sides of thighs with deep black spots on a bright yellow ground; two outer fingers and two outer toes green; beneath, whitish immaculate.

Measurements: Snout to vent approximately 50 mm.

Distribution: The species is known from northwestern Thailand at Mae Hong Son. It occurs also in Burma.

Remarks: Pope (1931) has shown the close relationship between the Asiatic mainland species of *Hyla.* Two forms that presumably differed, *Hyla albotaeniata* Vogt and *Hyla bambusicola* Barbour have been shown to be species of the genus *Rhacophorus,* and consequently in a different family.

The arborea group of *Hyla* also occurs in America. A species group in Mexico (including *euphorbiacea, cárdenasi, eximia, arboricola, lafrentzi,* and *wrightorum*) must be regarded as members of the *arborea* group. Some populations of *arborea* are so similar to *lafrentzi* that they can be separated only with considerable difficulty, if at all.

Family Ranidae

Four genera of this family are recognized as occurring in Thailand. They may be identified by the following key:

KEY TO THE THAI GENERA OF THE FAMILY RANIDAE

1. No vomerine teeth ... 2
   Vomerine teeth present ... 3
2. Tongue elongated, narrow, pointed behind ... *Ooeidozyga*
   Tongue rounded behind without notch ... *Phrynoglossus*
3. Small species, tongue narrow not divided posteriorly; vomerine teeth present ... *Elachyglossa*
   Small and large species; tongue divided posteriorly; vomerine teeth present (rarely absent) ... *Rana*

Genus OOEIDOZYGA Kuhl and van Hasselt

Ooeidozyga Kuhl and van Hasselt, Isis, 1822, p. 475 (type of genus, *O. lima*); M. Smith, Proc. Zool. Soc. London, 1927, p. 202.

Diagnosis: Small frogs; tympanum covered with skin; pupil of eye horizontal; fingers with web-remnant; toes fully webbed; subarticular and metacarpal tubercles somewhat titlike; tongue pointed behind; no vomerine teeth; lateral-line (neuromast) system retained in adults; skin even on palms and soles, covered throughout with pearly, often spinous, tubercles; slightly widened terminal discs on toes or none; three metacarpal and two metatarsal tubercles; tarsal fold indicated; outer metatarsals separated by web; a small spine-covered process near posterior underside of tarsus. Omosternum with a bony style; tips of digits simple without intercalated bone or cartilage between two terminal phalanges.

Ooeidozyga lima Kuhl and van Hasselt

FIG. 24

Ooeidozyga lima Kuhl and van Hasselt, Isis, 1882, p. 475 (type locality, Java); M. Smith, Proc. Zool. Soc. London, 1927, p. 202; Bull. Raffles Mus., no. 3, 1930, pp. 92, 135; Pope, Bull. Amer. Mus. Nat. Hist., vol. 61, Aug. 29, 1931, pp. 481-484; M. Smith, Bull. Raffles Mus., no. 5, 1931, p. 16, Boring, Mem. B. A. China Rep., 1932, p. 104; Taylor, Lingnan Sci. Journ., vol. 13, 1934, p. 304; Bourret, Les Batraciens de l'Indochine, 1942, pp. 398-401, figs. 131-132 (literature list); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1048-1049 (Nakhon Phanom).

Oxyglossus lima Tschudi, Classification der Batrachier . . . 1838, p. 85; Günther, The reptiles of British India, 1864, p. 401; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 5; The fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 436; Flower, Proc. Zool. Soc. London, 1899, p. 886; Laidlaw, *ibid.*, 1900, p. 884; Boulenger, Fasciculi Malayenses., Zoology, pt. 1, 1903, p. 134; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 225; Vogt, Sitzungsb. Ges. Nat. Berlin, 1911, p. 143; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, p. 164 (Klong Wang Hip, Nakhon Si Thammarat); *ibid.*, pp. 172-175, pl.; *ibid.*, vol. 2, no. 3, May, 1917, p. 227.

Oxydozyga lima Stejneger, Proc. U. S. Nat. Mus., vol. 66, 1925, p. 33.

Diagnosis: Small aquatic frogs, maximum size about 39 mm.; tongue elongate, extensively free, pointed behind; fingers acutely pointed, first equal to second; two or three distinct metacarpal tubercles; two metatarsal tubercles, and a strong tubercle on end of tarsus; skin very rough, tubercular or spiny; linear series of warts, marking lateral line (neuromast) organs, on venter, sides, and chin; male with internal vocal sac; continuous dark and light transverse stripes on back of thighs; fingers with slight web; toes fully webbed (see also generic characters).

Description of species (from female specimen Bangkok): Small species (about 40 mm. females); snout short, a rather pointed oval; canthus rostralis not indicated; nostrils on two elevated swellings raised above level of snout, distance between them (1.5 mm.) less than interorbital distance (1.8 mm.); loreal region oblique with slight depression or concavity behind nostril; tympanum large distinct, covered with skin, its greatest diameter (2.9 mm.) less than

FIG. 24.—*Oocidozyga lima* Kuhl and van Hasselt. Upper figure, No. 1053 ♂. Actual snout-vent length, 29 mm. Chon Buri. Lower figure, No. 33201 ♀. Length, 35 mm. Polo Field, Bangkok.

length of eye (3.7 mm.); width of eyelid (1.7 mm.) about equal to interorbital distance.

Tongue terminating posteriorly in a point, free behind for two thirds of its length; choanae at anterior end of palate partly overhung by median part of premaxillary shelf; no trace of palatal gland openings; (males with a vocal sac, the openings near jaw somewhat in advance of jaw-angle).

Arms short with elongate pointed digits; proximal subarticular tubercles somewhat distinct, titlike; small distal one on third finger only. Fingers about one-fourth webbed, webs continuing to near tips as narrow fringes; two (occasionally three) metacarpal tubercles; legs short, tibiotarsal articulation reaches to tympanum; toes pointed, subarticular tubercles distinct; two strong metatarsal tubercles, inner largest, compressed, elevated; toes fully webbed, only extreme tips of fingers free; outer metatarsal separated by web; small tarsal fold, and in line behind this a tarsal tubercle covered with small spines and tubercles.

Skin everywhere with pearly tipped tubercles or spines, even on undersurface of soles, palms, and digits; lateral-line system represented by a series of organs on wartlike elevations beginning on side near axilla, continuing back across groin to underside of femur, a narrow Λ-shaped series on throat, and one or two vertical series in groin, each elevation bearing from one to four pores.

Color: On dorsal surfaces, dark olive with dark spots or flecks scattered thickly on back, sides, and limbs; snout darker olive; tympanic area brown; on middle of side an indefinite black line below which is an indefinite greenish-cream line, distinct in region of groin; deep-black elongate spot under arm; two dark lines begin on breast, extend forward to tip of chin and meet; chin, breast, and venter cream with a fine powdering of blackish brown; black line from axilla to groin below cream line; black line from groin onto undersurface of thigh forming an angle; deep black stripe continuous across posterior surface of femora with numerous pearly dots; cream line both above and below black stripe; upper line again bordered by a blackish broken line outlined narrowly in cream; strong black line from upper end of tarsus to tip of outer toe.

Measurements in mm. (from 33204 ♀, and 33203 ♂, Bangkok): Snout to vent, 36, 30; width of head, 12, 11; length of head, 11, 10; arm, 18.2, 18; leg, 50, 49; tibia, 16, 14; foot and tarsus, 21, 23.

Variation: The markings of the described female agree with those of several other gravid female specimens and a few males. Certain others from the same locality differ in having the back uniform olive, the sides without lines, the venter very lightly pigmented and the ventral lines entirely absent or only dimly indicated; the posterior markings on the thighs are usually present.

A series of specimens from Kanchanaburi taken near the city of the same name are light gray-brown and cream-white below. Under a microscope one can discern the typical markings of the venter outlined in minute pigment dots. The lateral-line system is very clearly defined in these.

Many specimens have a slight fold across back of head.

Distribution: In Thailand the species has been obtained in lowlands where collections have been made and probably it occurs in all the provinces. Outside of Thailand it occurs in Burma, Indo-China, Hainan, Malaya, and Java.

Remarks: The tadpole of the species described by Pope (1931) is very different from most Ranid tadpoles in lacking the external teeth about the mouth.

Genus PHRYNOGLOSSUS Peters

Phrynoglossus Peters, Monatsb. K. Akad. Wiss. Berlin, 1867, pp. 29-30 (type species *Phrynoglossus martensii* Peters); Malcolm Smith, Bull. Raffles Mus., no. 3, 1930, p. 135; and *ibid.*, no. 5, 1931, p. 135.

Oreobatrachus Boulenger, Ann. Mag. Nat. Hist., ser. 6, vol. 17, May 1896, p. 401 (type of genus, *O. baluensis* Boulenger); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 135; *ibid.*, no. 5, 1931, pp. 3-32.

This genus was proposed by Peters for a frog which was similar to *Ooeidozyga lima* but which differed from it chiefly in the character of the tongue; seemingly it was generically related to *Ooeidozyga laevis* which species was also placed in the new genus. Peters' name in turn was placed in the synonymy of *Ooeidozyga* (or one of its synonyms) where it remained until M. Smith (1931) pointed out that *Phrynoglossus* was a legitimate genus.

Inger (1954) has proposed to place *Micrixalus diminutiva* Taylor in the genus *Ooeidozyga* but it would appear that this should stand as *Phrynoglossus diminutivus.* Since he does not discuss the presence or absence of the lateral-line system one suspects that he is unaware that it occurs in *laevis* but is not evident in *Phrynoglossus.* His whole discussion of the genus and its Philippine variants is obscured by his display of mathematics.

Phrynoglossus magnapustulosus (Taylor and Elbel)

FIG. 25

Micrixalus magnapustulosus Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1066-1068, fig. 9 (type locality Ban Na Phua, Kan Luang, Nakhon Phanom province, elev. 200 m.).

Diagnosis: Related to *Phrynoglossus martensii* but with a series of relatively very large pustules each surmounted by a single tiny rounded pearly tubercle. Similar tubercles but smaller above tibia and tarsus; tongue oval, wider posteriorly than anteriorly, and free behind for one third its length; no vomerine teeth, eye longer than snout; tympanum covered with skin its outline partly discernible; toes four-fifths webbed, a distinct web-remnant between first and second fingers.

Description (from type description): Tip of snout broadly oval, nostrils slightly elevated, situated about an equal distance from eye and from median point on edge of upper lip, separated from each other by a distance equal to or very slightly less than median length of snout; width of an eyelid equal to or slightly less than interorbital distance; tympanum moderately distinct, covered with skin, its diameter (1.5 mm.) much less than length of eye-opening (2.2 mm.); a sinuous fold from eye extends back for a short distance behind mouth-angle; no canthus rostralis; loreal area slightly convex rather than excavated; snout extends beyond mouth for about half a millimeter; eye large, strongly elevated, its length greater than median length of snout, but equal to a line from eye to middle point on upper lip.

Tongue a little longer than wide (3 x 2.7 mm.) free posteriorly for about one third of its length, and free laterally; no tongue papilla, but surface minutely granular; choanae small, nearly lateral, not concealed by maxillary shelf when seen from below; no trace of vomerine teeth; openings of Eustachian tubes smaller than choanae; no evidence of vocal slits. Symphysis of lower jaw without distinct denticulate elevation.

Arm short, only fingers reaching beyond tip of snout; first finger very little longer than second; a distinct vestige of a web, edges of digits not or but slightly ridged on sides. Three small palmar tubercles, inner and outer a little more distinct than middle one, outer elongated and completely separated from middle one; four distinct subarticular tubercles.

Leg short, toes four-fifths webbed, tibiotarsal articulation reach-

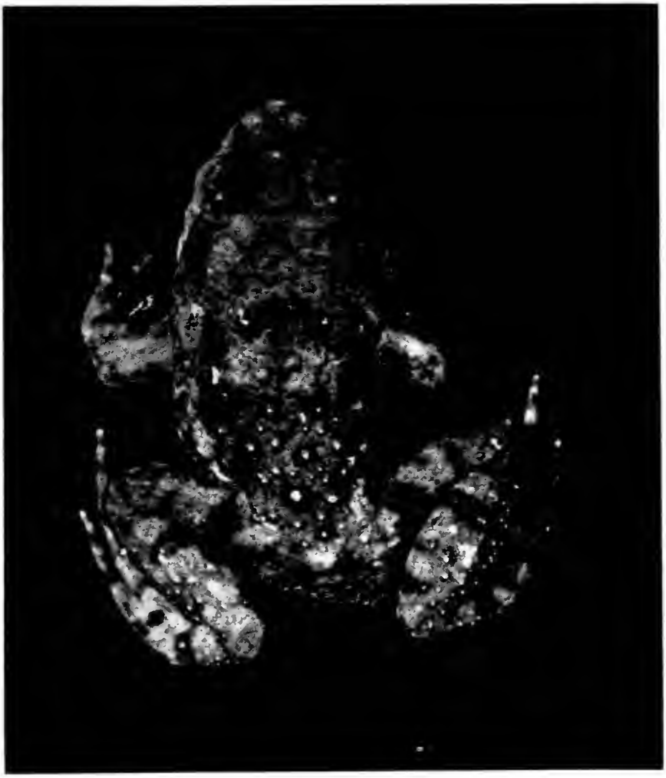


FIG. 25.—*Phrynoglossus magnapustulosus* (Taylor and Elbel) EHT-HMS No. 31838 ♂. Actual snout-vent length, 16 mm. Ban Na Phua, Kan Luang, Nakhon Phanon, Thailand.

ing middle of eye; toes with only slight development of terminal discs; web reaching discs on one or more toes; well-defined, somewhat compressed, elongate inner metatarsal tubercle; very tiny outer tubercle situated at terminus of slight pustular ridge along outer toe; well-developed subarticular tubercles; a short diagonal tarsal fold extending less than half length of tarsus; when legs are folded at right angles to body heels fail to touch.

Skin on snout and interorbital area with a very indistinct elevation across head between anterior edges of eyes (the "eyespot" included); body with large craterlike pustules, the sides of which are excavated by numerous "valleys"; pustules pearl-tipped; between larger pustules there are tiny pustules; sides with less distinct pustules; legs with numerous smaller pearl-tipped pustules tending to form longitudinal rows; chin nearly smooth; venter without distinct granules; underside of thighs smooth except on posterior part; posterior face of thighs with very few scattered granules.

Color in preservative: Generally brown above with two vague lighter areas on middle of back preceded and followed by slightly darker areas or lines; upper side of upper arm fawn-brown, forearm banded with brown. Leg including tarsus, and foot, with narrow bands; below, chin and throat brownish with some lighter flecks; venter and part of underside of thighs nearly immaculate; soles dark lavender; posterior part of thighs brownish.

Measurements in mm. (Type): Snout to vent, 16; width of head, 7; length of head, 6; arm, 8; leg, 22.5; tibia, 7; foot, 7.7.

Variation: This form has been taken in several localities in eastern, northern, and northwestern Thailand. All of the specimens show the presence of the short web between the first and second fingers. This is quite unusual since in most species where the hand has a web-remnant the outer fingers (third and fourth) will more often display the remnant; usually in such cases the web is lacking between the first and second fingers or it is negligible. When compared with *martensii* in southeastern Thailand, the heads are proportionately narrower. There also is some differences evident in the front of the palate when this and *martensii* are compared.

Distribution: In Thailand known only from Nakhon Phanon, Ubon, Loei, and Chiang Mai provinces.

Phrynoglossus laevis (Günther)

FIGS. 26, 27

Diagnosis: A small frog; tongue oval, rounded behind free for about one fourth its length, somewhat free on sides; tympanum covered with skin, dimly visible, a little more than half diameter of eye; first finger shorter than second; second and third fingers with partial fringe most distinct on second finger; tibiotarsal articulation reaches slightly in front of eye; heels overlap strongly; distinct discs on toes, their upper surface usually divided by deep grooves; terminal phalanx blunt at tip; toes almost fully webbed; strong compressed inner metatarsal tubercle, very small outer; a tarsal fold; lateral-line system retained in adult.

Description of species: (From No. 34752 Pattani, Pattani). Head flattened, snout oval, not or only slightly projecting beyond lower jaw; no canthus rostralis; loreal region broadly oblique; nostril dorsal, closer to anterior tip of snout than to eye; snout rounded in lateral profile; slight diagonal ridge suggested in back part of loreal region

FIG. 26.—*Phrynoglossus laevis* (Günther). No. 34752. Actual snout-vent length, 26 mm. Pattani, Pattani, Thailand.

behind which lies a slight depression which touches eyelid; width of upper eyelid greater than interorbital width; tympanum (2.1 mm.) little more than half length of eye (3.6 mm.); length of snout (3.65 mm.) about as long as eye; slightly tubercular fold from lower eyelid, crosses upper third of eyelid; fold from mouth-angle back to behind jaw-angle.

Choanae rather large, on anterior part of palate, not concealed when palate is viewed from below; tongue oval, rounded behind, free for about one-fourth of its length, somewhat free on sides; no trace of vomerine teeth.

Arm short, if brought forward only tips of fingers reaching tip of snout; first finger not extending as far forward as second; fringe on second finger extending part of distance on each side; fringe on inner side of third finger; tips of fingers swollen a little; proximal subarticular tubercles moderately well developed; distal ones on third and fourth fingers obsolete; two distinct metacarpal tubercles, inner larger, median obsolete.

Toes rather elongate, digital tips forming somewhat elongate discs with deep groove dividing its upper surface; terminal phalanx blunt at tip; no groove across under surface of disc; subarticular tubercles small, distinct; large compressed elevated inner metatarsal tubercle; outer small, at end of fold along outer edge of fifth finger. Toes five-sixths webbed; well-defined inner tarsal fold half length of tarsus; an indistinct outer fold suggested also. Tibiotarsal articulation reaches to just beyond eye. When legs are folded at right angles to body heels overlap.

Skin on snout smooth; on occiput and back finely corrugate; two indistinct dorsolateral lines begin behind eye and are lost on shoulder; sides of body with glandular tubercles; skin on legs, especially exposed surfaces, with fine pearl-capped tubercles, the tubercles extending onto sole of foot. Skin of chin, breast, venter, and much of concealed surface of limbs, smooth.

Color: Above olive-brown to brown, with two darker lines following dim dorsolateral folds; a dark and a light transverse line across head between eyes; two or three cloudy areas on back; arms light brown, flecked with darker brown; flecks of brown on thighs; tibia, tarsus, and foot with dark-brown bars; entire undersurface of body and limbs uniform white or with few scattered punctate spots on breast and numerous larger dark-brown spots on underside of legs; a slightly lighter area on side of head from eye to arm-insertion.

FIG. 27.—*Phrynoglossus laevis* (Günther) EHT-HMS No. M145 ♀. Actual snout-vent length, 33 mm. Pahang, Malaya.

Measurements in mm. (from No. 34752, Pattani, Pattani; and No. M. 145, Pahang, Malaya): Snout to vent, 26, 33; width of head, 12, 14.2; length of head, 11.4, 12; arm, 14, 16; leg, 40, 49.5; tibia, 14, 17; foot and tarsus, 17, 21.5.

Variation: The specimen from Pahang has the lip and the loreal region darkened. There is a light olive bar between the eyes, bordered behind by a black line and an indistinct darker line in front. The occiput and front of shoulders are uniform gray-olive. The fold curving back and down from the eye is dark; a tiny broken dorsolateral ridge gives the body a decidedly angular appearance; some black flecks on back. A distinct fold in front of breast; and a somewhat lunate dark spot in groin preceded by a curved series of small glandular tubercles.

The pattern of the lateral-line system of *laevis* differs somewhat from that of *lima.* The tubercles on the Pahang specimen are more distinct than in the described specimen.

The tubercles with pores are distributed as follows: two parallel rows of three on the throat; a row of four on each side just preceding the breast fold; two or three near angle of jaws; four above arm-insertion; a series of five in axilla; four in a curved vertical row on side in front of groin; a series of six or eight beginning above vent cross the base of the femur, perhaps a part of the lateral series immediately preceding it.

In the described specimen the lateral-line pore bearing tubercles are less distinct but with care they can be found in about the same numbers and in the same position. Besides these, there are numerous glandular tubercles with small pearly tips. If the pearly portion is shed or removed these too may appear to have a pore. Some tubercles have only a single pore, others may have three or four.

A specimen from Singapore M. 146, differs in being deep brown on all dorsal surfaces except the snout which is uniform white, and there are a few scattered black spots.

The tubercles are wanting (or flattened) but the pores can be seen clearly under a lens. Their arrangement is as follows: there are four groups discernible under the eye, four behind the eye following the supratympanic fold, five above arm-insertion, eight in a longitudinal lateral row, eight or nine across base of femur and to above vent, four in axilla, three in a posterior lateral vertical series, two or three in a transverse series on throat, two or three at jaw angle, and a pair on back of chin. A few show some elevation and the number of pores varies from one to four, but most of the tubercles are completely flattened and only pores are discernible.

Distribution: This species is known to occur only in the southern part of Thailand, and presumably throughout Malaya. There is no certainty that this is specifically identical with Günther's *Oxyglossus laevis* from the Philippines, or with the form so called from the Indo-Australian Archipelago. Larger collections may show that the Singapore specimen discussed merits specific recognition if the characters are constant.

Remarks: The Singapore specimen has an oval tongue showing a tiny posterior notch. This may be accidental but may suggest still another difference from the Pattani and Pahang forms. The discs on the toes are somewhat larger, elongate oval in shape. Under no circumstances can one consider *martensii* a subspecies of this form. Examination of various Philippine populations show differences in the detailed characters of the lateral-line system.

Phrynoglossus martensii Peters

FIG. 28

Phrynoglossus martensii Peters, Monats. Akad. Wiss. Berlin, 1867, p. 29 (type locality, Bangkok, Siam).

Oxyglossus martensii Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd ed. 1882, p. 6; Flower, Proc. Zool. Soc. London, 1899, p. 887; M. Smith, and Kloss, Journ. Nat. Hist. Soc. Siam, vol. 1, pt. 3, 1915, p. 248.

Oxydozyga martensii Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 2.

Ooeidozyga laevis (*part.*) Bourret, Les Batraciens de l'Indo-Chine, 1942, p. 401-404, fig. 134.

Diagnosis: Differs from *Phrynoglossus laevis* in having very small terminal discs on tips of digits, lacking dorsal longitudinal grooves. Distinctly smaller than *laevis*.

The two species occur together in southern Thailand.

Description of species (from No. 35876, Khao Chong, Trang, southern Thailand): Head rather flattened, oval in outline; no canthus rostralis; nostril a little nearer corner of eye than to anterior median point on snout; width of an eyelid greater than interorbital distance; nostril surrounded by a distinct swelling; tympanum covered with skin, but most of the outline distinct, separated from the eye by a distance equal to about half diameter of tympanum; a fold beginning at posterior corner of eye passes down and back diagonally across tympanum to near arm; a small indistinct fold from mouth-angle passing back to a point in front of arm-insertion; tongue rounded behind without notch, sides nearly

FIG. 28.—*Phrynoglossa martensi* Peters. Left figure, No. 1225 ♂. Actual snout-vent length, 27 mm. Right figure, No. 35794 ♂. Actual length, 26 mm. Khao Chong, Trang.

parallel, free behind for one fourth or less of its length; choanae visible seen directly from below, not concealed by jaw.

Arm short, first finger longer than second; second and fourth of same length, third finger longest; distinct inner and outer metacarpal tubercles, the middle somewhat obsolete; no trace of a web between first and second fingers; leg moderate in length, tibiotarsal articulation reaching eye; toes with terminal discs not or scarcely larger than those on fingers; toes three-fourths to four-fifths webbed, the webs somewhat incised between digits; a large projecting shovellike tubercle more than half length of first toe; a small distinct tarsal fold; no outer tubercle; a slight ridge of skin on outer edge of outer toe; skin with a few small scattered tubercles posteriorly on dorsum, nearly smooth on anterior part of dorsum and head; on posterior half of tibia and on tarsus numerous small tubercles; chin, venter and underside of thighs smooth; a suggestion of a fold across breast, and a faint fold across head behind orbits.

Color: Head brownish gray, clouded or flecked with darker; indefinite lighter spots on tip of snout and along upper lip; ground color of dorsum brownish gray; a broad brownish stripe on back arising on occiput, fading on rump, flanked by two broad stripes of ground color; an indefinite dorsolateral line from eye along side becoming wider posteriorly; venter and underside of limbs yellowish-white to flesh-white, but with a fine peppering of darkish pigment, somewhat denser on chin and throat, and outer parts of the underside of thighs; pigment dense on underside of foot, less so on hand; arms indistinctly spotted or barred; legs with more distinct brown bars.

Measurements in mm.: Snout to vent length, 25.5; width of head, 9; length of head, 9; arm, 12; leg, 36.

Variation: The chief observable variation has to do with the details of the markings. Some specimens are covered with scattered brown spots and the pattern as described is obsolete. An occasional specimen may have a narrow median cream line.

Distribution: The species occurs throughout peninsular Thailand and probably also throughout the central part of the country.

Remarks: The relationship of this form is with *magnapustulosus* a form as yet not well established. Further work is being undertaken to determine the true relation of these forms.

Genus ELACHYGLOSSA Andersson

Elachyglossa Andersson, Kungl. Svenska Vetensk.-Akad. Hand; Band 55, no. 4, 1916, p. 13.

Diagnosis: "This new genus of the family *Ranidae* is nearly allied to *Oxyglossus,* but differs in having vomerine teeth, tympanum distinct, a large head, depressed body and differently shaped hind feet. The diagnosis of the genus may be as follows: Sternal apparatus of the firmisternian type; upper jaw very distinctly toothed; diaphyses of sacral vertebra not dilated. Pupil horizontal. Tongue free, narrow and entire. Vomerine teeth present. Tympanum distinct. Fingers free, toes webbed, the fourth toe much the longest; tips of fingers and toes feebly dilated into very small disks. Outer metatarsals separated by web. Omosternum with a bony style, sternum a cartilaginous plate. Terminal phalanges of fingers transversely dilated; no intercalary ossification between the distal and penultimate phalanges."

Elachyglossa gyldenstolpei Andersson

FIG. 29

Elachyglossa gyldenstolpei Andersson, Kungl. Svenska Vetensk.-Akad. Hand., Band 55, No. 4, 1916, pp. 13-14, 2 figs. in text (type locality, Bang Hue Pong village southern slope Koon Tan mountains, northern Siam).

Diagnosis: See characters of the genus.

Description of species (type description): "Vomerine teeth in two rather long oblique series behind the small choanae. Tongue very small, narrow, extensively free, and bluntly pointed behind, very

FIG. 29.—*Elachyglossa gyldenstolpei* Andersson. After Andersson, Kungl. Svenska Velensk-Akad. Hand. Band 55, 1916, fig. 2 in text. "Bang Hue, Pong Koon Tan Mountains," N. Siam. Actual length, 23 mm.

small in proportion to the wide mouth. Head large, broad, and flattened; the greatest breadth of the head equal to the distance between the tip of the snout and the hind margin of the tympanum. Snout rounded, a little longer than the diameter of the eye; canthus rostralis indistinct. Loreal region oblique, deeply concave. Interorbital space broader than the upper eyelid. Nostril nearer the tip of the snout than the eye. Tympanum distinct, three fifths diameter of eye. Fingers free, rather long, the first not quite reaching the tip of the second; toes nearly entirely webbed, the web reaching the disks, except in the 4th toe, two joints of which are free; the web of the other toes as well is deeply emarginate; the 4th toe considerably longer than the 3rd and 5th; tips of fingers and toes with very small disks; terminal phalanges of fingers somewhat dilated, those of toes pointed; subarticular tubercles very distinct, especially on the fingers; a single, compressed inner metatarsal tubercle, no outer; if the dimension of the tibia is marked off from the knee forwards along the body, it reaches the tip of the snout.

"Skin very finely chagreened above, and provided with some irregular warts, smooth below.

Color: "Above dark greyish brown with irregular black dots; between the eyes a light transverse band, bordered behind by black;

limbs reddish, transversely barred with dark; inner side of tibia uniform pale flesh-coloured; below dirty whitish yellow, the limbs reddish."

Measurements in mm.: "Total length, 23; width of head, 10.5; length of head (from the hind margin of tympanum), 10; length of snout, 4.5; diameter of eye, 3.4; diameter of tympanum, 2; length of humerus, 4.2; from elbow to tip of third finger, 10.2; length of femur, 12.2; length of tibia, 12.1; length of tarsus with fourth toe, 17.

Remarks: "One specimen from Bang Hue Pong, a small village on the southern slopes of the Koon Tan Mountains in Northern Siam, 7/5/1914."

This species has not been rediscovered. I have not seen the type. One might suspect that did the specimen prove to have the lateral-line system developed, it represents a close relative of *Phrynoglossus laevis* differing chiefly in the presence of vomerine teeth.

Genus RANA Linnaeus

Rana Linnaeus Systema Naturae . . . Ed. 10, vol. 1, 1758, p. 210 (type of genus, *temporaria*).

Diagnosis: Large and small frogs, with a horizontal pupil, maxillary and vomerine teeth; tongue free, deeply notched posteriorly. Tympanum usually visible, often hidden under skin; fingers unwebbed with pointed or dilated tips. Outer metatarsals usually separated by a web. Omosternum and sternum with a bony portion.

This is the most populous group of the Salientia in Thailand and while recognized as being composite is treated as a single genus. Thirty-four species are recognized. I have included *Rana scutigera* but suspect this may belong in another genus.

The following key will be of assistance in recognizing most species at least the males. In certain cases it is difficult to separate the females.

KEY TO THAI FROGS OF THE GENUS RANA

1. Lateral-line system retained in adults, indicated by a series of pores; two external vocal sacs opening through two slits below corners of mouth; toes pointed; no dorsolateral fold; no outer metatarsal tubercle . . . . *cyanophlyctis cyanophlyctis*
   Lateral-line system not present in transformed frogs or if present tongue not notched behind 2
2. Skin of head partly ossified and fused to skull bones; no dorsolateral line (possibly a *Rhacophorus*) . . . . *scutigera*
   Skin of head not partly ossified and fused to bones of the skull 3

3. No dorsolateral glandular fold (sometimes suggested in young of *Rana cancrivora* and *Rana macrodon*) 4
A dorsolateral glandular fold usually present, varying in width . . 22
4. Tips of digits rather pointed or somewhat swollen at tips; sexual dimorphism not strongly marked 5
Tips of digits with terminal discs, with or without peripheral grooves, 14
5. Digit tips pointed, no prominent toothlike processes from lower jaw, 6
Digits swollen at tips; prominent toothlike processes arising from lower jaw (males) 10
6. A small outer metatarsal tubercle present; tibiotarsal articulation reaching to between eye and nostril; males with paired internal vocal sacs and a pair of black spots on chin . . *limnocharis limnocharis*
No outer metatarsal tubercle 7
7. No vocal sacs in males; smaller frogs, snout to vent length to 70 mm.; no paired black spots on chin; venter and chin white; tympanum distinct (crab eaters; salt tolerant) . . . . *cancrivora*
Vocal sacs in males; larger frogs, 85-160 in length 8
8. Large frogs 121 mm. snout to vent, with numerous large discrete dark spots on head and body; 30-40 small dark spots on throat and breast; a pair of black spots in males marking externally position of vocal sacs . . . . *raja*
No black spots on chin marking the vocal sacs; tibiotarsal articulation to near eye 9
9. Large frogs, 160 mm.; lips with vertical bars of black; a tarsal fold, *tigerina pantherina*
Somewhat smaller frogs . . . . *rugulosa*
10. Tympanum hidden 11
Tympanum distinct 12
11. Aquatic frogs, skin largely smooth except strong tubercles on tibia; strong sexual dimorphism; male head flattened and much larger and wider than female; large, to 100 mm. . . . . *kuhlii*
Aquatic frogs, skin with short ridges, wrinkled longitudinally; venter glassy smooth; vomerine tooth ridges scarcely separated mesially behind choanae; smaller, to 40 mm. . . . . *laticeps*
12. Terrestrial frog; chin of males with strong folds but no vocal slits in mouth; sometimes trace of a dorsolateral fold; direct transformation; small, to 32 mm. . . . . *hascheana*
Aquatic frogs; no vocal slits or sacs; very large frogs, 100 to 240 mm. snout-to-vent 13
13. Head broader than long, wider than body in adults; with or without a fine median dorsal line from tip of snout to vent, and a fine line running length of femur and tibia . . . . *macrodon*
Head longer than wide usually not wider than body; a broad median light band usually present. Large frog to 240 mm. . . . . *blythii*
14. Head not enlarged; no toothlike projections in lower jaw; no postorbital flap or process; little obvious sexual dimorphism; maximum known size, 50 mm. . . . . *doriae*

Head more or less enlarged; sexual dimorphism strong; with or without postorbital bead or flap; with or without bony processes in lower jaw of male; if without processes, vomerine teeth weak or absent or skin very fragile ... 15

15. Toothlike processes in lower jaw of male ... 16
No toothlike processes in lower jaw of male ... 19

16. No free process or flap in postorbital area ... 17
A free flap or process in postorbital area ... 18

17. Only a slight swelling on the head, maximum size 42 mm. ... *kochangae*
A very distinct postorbital swelling reaching the level of anterior border of tympanum; heels overlapping; maximum length 58 mm. ... *macrognathus macrognathus*

18. Postorbital swelling flaplike the edges free laterally and posteriorly; its width in adult distinctly greater than interorbital width; larger to 64 mm. ... *pileata*
Postorbital swelling, small rounded bead or process, one to two millimeters in length; body with numerous longitudinal folds; smaller, to 43 mm. ... *plicatella*

19. Vomerine teeth poorly developed or more frequently absent; head broader than long; canthus rostralis obtuse, concave loreal region; tympanum one half of eye diameter; first finger shorter than second; tibiotarsal articulation to between eye and tip of snout; toes webbed at base; no outer metatarsal tubercle; small to 28 mm., no vocal sac ... *tenasserimensis*
Vomerine teeth well developed ... 20

20. First finger shorter than second; toes half webbed; canthus obtuse, loreal region oblique concave; tympanum very distinct, one half to three fifths of diameter of eye; tibiotarsal articulation near to tip of snout; no outer metatarsal tubercle; a glandular network of fine folds on body; the skin fragile ... *tasanae*
First finger longer than second ... 21

21. Canthus distinct, tympanum distinct, three fifths to three fourths of the eye diameter; internal vocal sacs in male; round outer metatarsal tubercle; oval gland on arm and a pad on first finger in male; yellowish or reddish dorsolateral lines ... *signata*
Canthus obtuse, indistinct, or absent ... 21a

21a. Skin smooth; small outer metatarsal tubercle; no vocal sac or pad on first finger in male; head depressed; reddish or chocolate brown, *luctuosa*
Skin on body completely covered with large flat granules; a dorsolateral fold may be indicated by linear arrangement of glandular granules; males with vocal sacs and large oval gland on inner part of arm ... *glandulosa*

22. Dorsolateral fold broad ... 23
Dorsolateral fold narrow ... 24

23. First finger longer than second; a small outer metatarsal tubercle; gland on arm in male ... *nigrovittata*
First finger equal or shorter than second; no outer metatarsal tubercle; dorsolateral light stripes ... *erythraea*

24. A humeral gland present ... 25
No humeral gland present ... 28

25. External vocal sac opening below jaws; diagonal ridges on back; a strong swelling on first finger of male .... *miopus*
Internal vocal sacs present 26
26. A gland on breast and one on inner side of arm; canthus strong, loreal region oblique, deeply concave; tympanum nearly as large as eye; no peripheral groove around digital disc .... *cubitalis*
No gland on breast; humeral gland present 27
27. A peripheral groove about small digital discs; canthus distinct; a small outer metatarsal present; throats of males blackish with a longitudinal light line .... *nicobariensis nicobariensis*
No digital discs; no peripheral groove about slight terminal digital swelling; canthus distinct. No median light line on dark chin and throat .... *lateralis*
28. Discs feebly expanded with peripheral groove. Head much longer than broad; body slender with three to five longitudinal golden or yellowish lines; first and second fingers equal .... *macrodactyla*
Discs strongly expanded with peripheral groove, no longitudinal golden lines on body 29
29. External vocal sacs; first and second fingers about equal 30
Internal vocal sacs; first and second fingers variable in length 31
30. Finger discs large, equal to tympanum; canthus rostralis obtuse; tibiotarsal articulation reaches beyond tip of snout; no outer metatarsal tubercle; toes webbed to discs .... *livida*
Finger discs much smaller than tympanum; toes entirely webbed . . *jerboa*
31. A small outer metatarsal tubercle; first finger longer than second. An indistinct brown lateral stripe; legs long and slender reaching tip of snout or beyond tip of snout; terminal discs smaller than tympanum .... *alticola*
No lateral stripe 32
32. Digital discs longer than wide, often pointed at tips; smaller, to 66 mm. .... *chalconota*
No outer metatarsal tubercle; large frogs, 100 mm.; discs large, largest equal to tympanum; tibiotarsal articulation to far beyond tip of snout; dorsolateral glandular fold distinct anteriorly .... *hosii*

Rana cyanophlyctis cyanophlyctis Schneider

FIG. 30

Rana cyanophlyctis Schneider, Historiae Amphibiorum naturalis et literariae fasc. 1, 1799, p. 137 (type locality, oriental India); Peters, Mon. Berlin Akad., 1863, p. 78; Günther, The reptiles of British India, 1864, p. 406; Steindachner, Reise der osterreichischen Fregatte Novara. . . . Amphibia, 1867, p. 20; Stoliczka, Proc. Asiat. Soc. Bengal, 1872, p. 102; Boulenger, Catalogue of the Batrachia Salientia *s.* Batrachia Ecaudata. . . . in the British Museum, 1882, p. 17; The fauna of British India Ceylon and Burma; Reptilia and Batrachia, 1890, p. 442; Anderson, Proc. Zool. Soc., London, 1895, p. 660, pl. 37, fig. 2; Ferguson, Journ. Bombay Soc. Nat. Hist., vol. 15, 1904, p. 500; Boulenger, A vertebrate fauna of the Malay Peninsula. . . . Reptilia and Batrachia, 1912, pp. 228-229 (doubtful report of the species by Cantor at Penang, Malaya); Annandale, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 91 (Inland Sea, Singgora = [Songkhla]); Mem. Asiat. Soc. Bengal, vol. 6, 1917, p. 145 (Phatthalung province. Same specimens as preceding reference.); Annandale and Rao, Rec. Ind. Mus., vol. 15, 1918, p. 30, fig.; M. Smith, Rec. Ind. Mus., 1929, vol. 31, p. 77; Bull. Raffles Mus., no. 3, 1930, pp. 92, 95; Bourret, Les Batraciens de l'Indochine, 1942, pp. 237-239.

Rana bengalensis, Gray, Illustrations of Indian Zoology, 1834, p. 77.

Rana leschenaultii Duméril and Bibron, Erpétologie Générale . . . vol. 8, 1841, p. 342; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1059.

Diagnosis: Rather large frogs (to 100 mm.); three or more paired series of lateral-line pores on body; no canthus rostralis; tympanum large, distinct; male with small, widely separated, external vocal sacs; toes fully webbed.

Description of species (from EHT-HMS No. 31094): Large frogs to 100 mm. snout-vent length; head rather small, snout oval; canthus rostralis indistinct, loreal region sloping obliquely, slightly concave; eye length shorter than length of snout; tympanum distinct, large, its diameter three fourths eye length, separated from eye by distance little less than half diameter of tympanum; upper eyelid wider than interorbital space.

Vomerine teeth very few, on small elevations between choanae, but widely separated from them, close together, barely extending

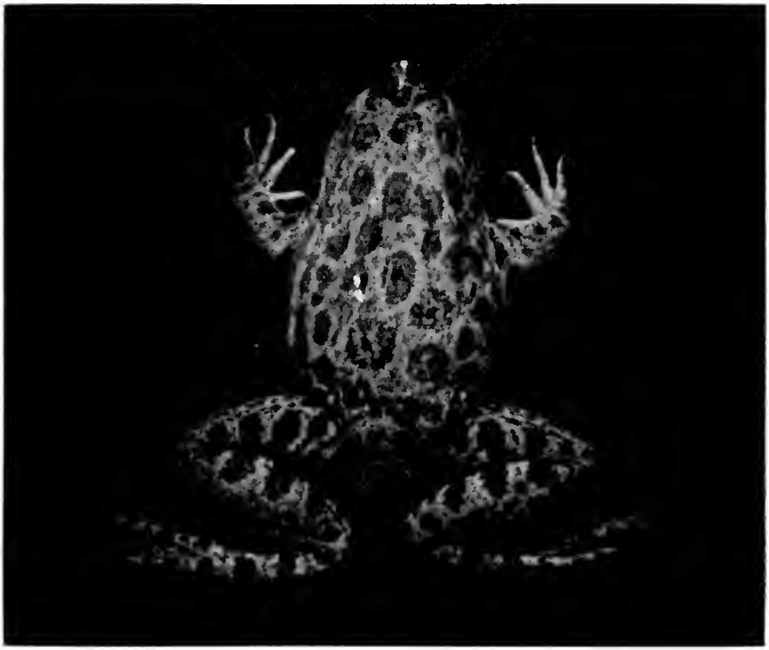


FIG. 30.—*Rana cyanophlyctis cyanophlyctis* Schneider. EHT-HMS No. 31094 ♂. Actual snout-vent length, 58 mm. Trincomalee (12 mi. N.) Ceylon.

back of posterior level of choanae; palatal glands opening in distinct curved groove midway between vomerine teeth and front end of palate; tongue long, with two long posterior horns, free for about one third of its length. Pair of small external vocal sacs extruded close to each jaw on chin; vocal slits in mouth posteriorly placed.

Skin with small granular tubercles varying in size on dorsum and upper surface of head and limbs; a dorsolateral row of pores extending from eye to groin; a ventrolateral row meeting posteriorly and outlining venter but extending anteriorly above arm-insertion;* two other short curving rows one on either side of the breast and a line across breast, meeting its fellow on sternal area.

Fingers somewhat swollen at tip but not widened; fingers slender with very tiny web rudiment and lateral ridge extending to near tip on inner edge of three outer fingers; first finger as long as second, or slightly longer; subarticular tubercles prominent; metacarpal tubercles small, rather indistinct; toes swollen and widened slightly, completely webbed, webs reaching discs on all toes; subarticular tubercles distinct; inner metatarsal tubercles elongate, compressed terminal portion free and slightly pointed; no outer tubercle; distinct skin-fold on outer side of first and fifth toes; small tarsal fold; leg rather short, tibiotarsal articulation reaching just beyond level of eye; when legs are folded at right angles to body heels fail to meet by several millimeters.

Color in life: Above and on sides olive or brown-olive with numerous dark-olive spots of varying sizes somewhat symmetrically placed; arms and legs strongly barred or spotted with dark olive; chin, venter, and under limbs, yellowish with greenish or small olive dark marks; back part of thigh, dark olive reticulated with gray; a more or less continuous transverse, white line behind thighs below which is a similarly broken olive line; web of foot spotted olive.

Measurements in mm.: Snout to vent, 58; width of head, 21; length of head, 17; arms, 31; leg from vent, 83; tibia, 25; foot and tarsus, 38.

Distribution: In Thailand the species has been reported from the Tale Sap, Inland Sea, by Annandale. An older report from Penang, Malaya has been questioned. It is obvious that this species is rare, and one might suspect its presence in Phatthalung province as the result of an accidental introduction into the area, and perhaps a recent one if the Penang record is to be discounted.

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* These pores are difficult to distinguish, however some of the specimens have each of the pores infested with a small cestode (?) worm, black in color that causes the pores to be conspicuous. It is presumed that these pores represent remains of the neuromast [lateral line] system of the larval amphibians and fishes. These pores are retained in adults of certain other aquatic species such as *Ooeidozyga lima*. Some glands as well as pores are present above vent.

The species is otherwise distributed from South Arabia, Baluchistan and India to Ceylon.

Remarks: The specimen here described is from Ceylon where it is very common. It has the habit of hopping on the surface of water, often making a dozen leaps before sinking.

I observed a moderately large pool, in a partly dry stream bed. with a population of perhaps more than a hundred frogs. When I approached all took off and every frog found refuge in the same hole in the bank several feet above the waters edge before I reached the place. This same thing happened on three different occasions save that I approached under cover and came very close before they were disturbed.

Rana tigerina Daudin

Rana tigerina Daudin, Histoire naturelle des rainettes, des grenonilles et des crapaud. 1802 (an XI), p. 42, pl. 20 (type locality, Bengal India).

The frogs of this group, since there is more than a single subspecies, have been confused in literature. Boulenger and Annandale have considered the facts and have been able to separate *cancrivora* as a separate species, but they have failed to agree on all points. The form most commonly encountered at and near Bangkok is the very large one originally named *Hydrostentor pantherinus,* by Fitzinger in 1861, with Hong Kong the type locality.

Rana tigerina pantherina (Fitzinger)

FIG. 31

Hydrostentor pantherinus Fitzinger, Sitz. Kais. Akad. Wiss. Wien., Band 42, 1861, p. 414 (type locality, Hong Kong).

Rana tigrina pantherina Steindachner, Reise der österreichischen Fregatte Novara in. 1857, 1858, 1859: Amphibien, Zool. Theil., Bd. 1, 1867, p. 17, pl. 1, figs. 14-17; Boulenger, Rec. Indian Mus., vol. 20, June, 1920, p. 17.

Rana tigerina pantherina Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1050-1052.

Rana tigrina (part.) Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 234; Robinson and Kloss, Journ. Federated Malay States Mus., vol. 5, 1915, p. 155 (Koh "Pa-ngan").

Rana tigrina Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1060; Boulenger, Catalogue of the Batrachia Salientia, *s.* Ecaudata in the British Museum, 1882, p. 26 (*part.*); Flower, Proc. Zool. Soc. London, 1896, p. 901; *ibid.*, 1899, p. 891, pl. 59, fig. 2; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 197.

Diagnosis: Large species 160 + mm. in length. Differs from the typical form in a somewhat shorter leg reaching between shoulder and eye, heels not or scarcely overlapping when folded. Inner metatarsal tubercle blunt; dark and light bars on lips; lower parts may be spotted, or with a streak on throat.

Description of species (from No. 993 ♀, Chalermlaub, Siracha, Chon Buri): Head much widened, considerably wider than long; canthus rostralis obtuse, loreal region strongly oblique, shallowly concave; nostril much nearer tip of snout than to eye; eye length about equal to its distance from nostril; tympanum large, its diameter (8 mm.) equal to nearly two thirds of eye length (11 mm.); tympanum largely directed upwards, separated from orbit by a distance little greater than half its diameter; eyelid a half wider than interorbital width; a strong supratympanic fold curving from eye above and behind tympanum.

Vomerine teeth on two elongate oblique ridges practically continuous with anterior rim of choanae, running back behind level of choanae, narrowly separated mesially; openings of palatal glands in a curved median row closer to front of palate than to anterior level of choanae; males with two lateral vocal sacs, rather small, evidenced by external folding of skin on under side of head; vocal slits in mouth are far back near mouth-angle and likely to be overlooked.

Arm moderate, fingers slightly swollen at tips with a fleshy lateral fringe on inner side of first finger, less strong on distal half on outer side; on distal half of third finger, fold or ridge strong on inner side only; leg moderately long, tibiotarsal articulation reaching front of eye; when legs are folded at right angles to body, heels touch but barely overlap; toes with small terminal swellings, five-sixths webbed to fully webbed, membranes reaching discs, but somewhat excised between digits. A strong compressed elongate inner metatarsal tubercle; no outer; a skin-flap on outer side of fifth toe; a tarsal fold; subarticular tubercles of hand rounded, of toes more elongate.

Skin of front of head smooth; dorsum and dorsal surface of legs heavily covered with smaller tubercles and larger pustular warts; tubercles on limbs often pearl-capped; elongate glandular ridges from one to twelve millimeters in length; on tibia tubercles may form elongate rows connected by low ridges; entire ventral surface smooth.

Color: Above olive-brown (greenish-olive in life) with numerous small black spots; lips with large dark spots separated by cream; sides and front of thighs yellow-cream mottled with darker; back of thighs black reticulated with cream or white, and with dark flecks

FIG. 31.—*Rana tigerina pantherina* (Fitzinger). No. 33532 ♀. Actual snout-vent length, 140 mm. Samut Sakhon, Thailand.

and a few small peripheral spots; venter and undersurfaces of limbs white; soles and palms blackish.

Measurements in mm.: Snout to vent, 120; width of head, 53; length of head, 46; arm, 59; leg, 186; tibia, 55; foot and tarsus, 80.

Distribution: Butler writes (1903) "I am inclined to think this frog must be rather local in its distribution in the Peninsula and probably more abundant in the Siamese States than in the South."

I have specimens from Chon Buri, and Bangkok. The subspecies *pantherina* ranges from Burma through Thailand to Indo-China and Formosa. (See Boul. Rec. Ind. Mus.) Reports of the subspecies from Madras may be the results of artificial introductions.

Rana rugulosa Wiegmann *

Fig. 32

Rana rugulosa Wiegmann, Nova Acta Acad. Leopold . . . vol. 17, p. 258, pl. 21, fig. 2 (type locality, cape Syng-more, Macao): Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, pp. 126-127, pl. 5, fig. 3, 3a, 3b (Burma, Yunnan; Bangkok and Lop Buri, Siam); Boulenger, Rec. Ind. Mus., vol. 15, 1918, pp. 52-55; Annandale, *ibid.*, vol. 15, 1918, pp. 60-61; Cochran, Proc. U. S. Nat. Mus., vol. 77, p. 3, 1930; Pope, Bull. Amer. Mus., no. 61, 1931, p. 487, fig. VI; Taylor, Lingnan Sci. Journ., vol. 13, 1934, p. 472.

Rana tigrina Anderson, Anatomical and Zoological Researches . . . vol. 1, 1878, p. 837 (*part.*).

Rana tigerina Stejneger, U. S. Nat. Mus. Bull., vol. 58, 1907, p. 139, figs. 127-131.

Rana burkhilli Annandale, Rec. Ind. Mus., vol. 5, 1910, p. 79.

Rana tigrina rugulosa Bourret, Les Batraciens de l'Indochine, 1942, pp. 242-245, figs. 55-57 (*part.*); Tchang and Boring, Peking Nat. Hist. Bull., vol. 14, 1939-40, p. 228; Pope and Boring, *ibid.*, vol. 15, 1940, pp. 48, 49.

Diagnosis: A frog reaching a length of approximately 85 mm.; arms and legs moderately short. Toes nearly fully webbed; digit without discs, tips of toes slightly swollen at tip, no outer metatarsal tubercle; about ten rows of warts and ridges on back. Interorbital space much narrower than upper eyelid.

Description of species (from No. 34889, Ubon, Ubon): Snout oval, canthus distinct, loreal region oblique, concave, concavity with slight median longitudinal elevation; jaw forming slight shelf below eye; nostril much nearer eye than median tip of snout; two small lateral swellings below nostrils; tympanum covered with skin, distinct with a small central circular elevation, its distance from eye about one third its diameter (4.8 mm.); length of eye (6.5 mm.) shorter than snout (9.8 mm.); width of upperlid (5.9 mm.) more than twice interorbital distance (2.3 mm.).

Vomerine teeth in two elongate ridges arising from upper anterior edge of choanae, extending diagonally, very narrowly separated mesially; line of pores across palate near its anterior end mark the openings of palatal glands; choanae small, not concealed when viewed from below but somewhat overhung by vomerine ridges; tongue large, free for two fifths of its length, broadly attached anteriorly.

* Without an examination of the materials on which many reports of the presence of *rugulosa* and *tigerina* (*tigrina*) are based, it is impossible to place them properly in synonymy.

Arm short; first finger longer than second, second and fourth extend forward same distance; first finger with a distinct nuptial pad not extending onto distal joints; subarticular tubercle large, flat, no trace of web but some lateral ridges indicated on inner edge of second to fourth fingers; inner metacarpal tubercles moderately distinct; outer practically indiscernible.

Leg short, tibiotarsal articulation to front of eye; subarticular tubercles small; rather small inner metatarsal tubercle; no outer;

Fig. 32.—*Rana rugulosa* Wiegmann. No. 34889, Ubon, Ubon. Actual length, snout to vent, 66 mm.

toes five-sixths to fully webbed, slightly excised; outer metatarsal separated by web. Faint tarsal fold indicated. All digits rather pointed, without small discs.

Skin rugose on sides and dorsum with nine or ten irregular rows of elongate warts or ridges; upper eyelids rugose; arms smooth above; leg and foot with small pearly tipped tubercles tending to form lines on tibiae; skin of ventral surfaces smooth; few small pearly tipped tubercles about vent; strong fold from eye curving around behind tympanum.

Color: On back of head brownish olive, somewhat lighter on sides; side of head with four black spots separated by small cream spots. Arms and legs indistinctly barred with dark olive; numerous indefinite black spots on sides and larger ones on dorsum; front of thigh with a row of black spots; on back of thigh numerous black spots in lighter reticulum; very slight indefinite gray marks on chin.

Measurements in mm. of *Rana rugulosa*

	Ubon	Bang Saen	Doi Suthep
Number	34889	821	36581
Sex	♂	♀	♀
Snout to vent	68	85	82
Width of head	28	38	33
Length of head	22	30	35
Tympanum	4.8	7	6
Eye length	6.5	10	7
Snout length	9.8	12.5	12
Arm	31	41.3	38
Leg	97	119	105.6
Tibia	31.5	39	35
Foot and tarsus	49.2	58	53

Rana raja M. Smith

FIG. 33

Rana cancrivora raja M. Smith, Bull. Raffles Museum, no. 3, 1930, pp. 96-97 (type locality, Pattani, Pattani, Thailand).

Diagnosis: A large species, female reaching a length of 121 mm. snout to vent; canthus rostralis rather distinct; skin of back with a few longitudinal warts or folds, without or rarely with median stripe; first finger longer than second, tips slightly narrowed just back of slight terminal swelling; skin-flap on outer side of fifth toe; a small compressed, anteriorly pointed metatarsal tubercle; toes about three-fourths webbed or a little more; vomerine teeth ridges arising directly against or near anterior internal border of choanae, narrowly separated mesially; small openings into two lateral vocal sacs, near inner edge of lower jaw.

Description of species (from B. M. 1947, 2.3.88 ♀, Pattani, Pattani province, Thailand): Head oval, distance between canthi small; canthi distinct, obtuse, nostril situated little closer to eye (9.5 mm.) than to median point on upper lip (10.1 mm.); width of eyelid greater than interorbital distance; diameter of tympanum (7.2 mm.) less than length of eye (10.5 mm.); length of snout, 15 millimeters; distance between tympanum and eye, 5 millimeters; loreal region broadly oblique, somewhat concave. Palatal glands open into transverse groove nearly midway between front of palate and anterior level of choanae; vomerine teeth on ridges arising at anterior inner edge of choanae, extending back obliquely, narrowly separated mesially; tongue large, free behind for little more than one third of its length; (male with small vocal slits opening into vocal sacs); openings of Eustachian tubes larger than choanae.

Skin with a few folds varying in length on back, and with few small tubercles; distinct fold from eye to above tympanum bending down behind tympanum to above arm-insertion; limbs rather smooth above and below; chin and venter smooth; few indistinct warts or flat tubercles about vent.

Tips of digits very slightly swollen at tip; inner metacarpal tubercle elongate, two outer fused, flattened; first finger longer than second; toes about three-fourths webbed; two distal phalanges of fourth toe without web; a small metatarsal tubercle, its length slightly less than half its distance from tip of inner toe; when legs are folded at right angles to body, heels barely touch; tibiotarsal articulation reaches to eye.

Color: Broad clay-gray median stripe from lip to vent; back gray-brown to brown, some folds edged with black or black-brown with few rather larger blackish spots; thighs with dark bars; back of thigh black, reticulated with cream; tibia, feet, and arms with blackish spots; dark loreal line; lip, chin and lower jaw with dark brown spots separated by cream spots; spots on venter and underside of thighs cream-white; a light area under tibia; brownish on underside of foot.

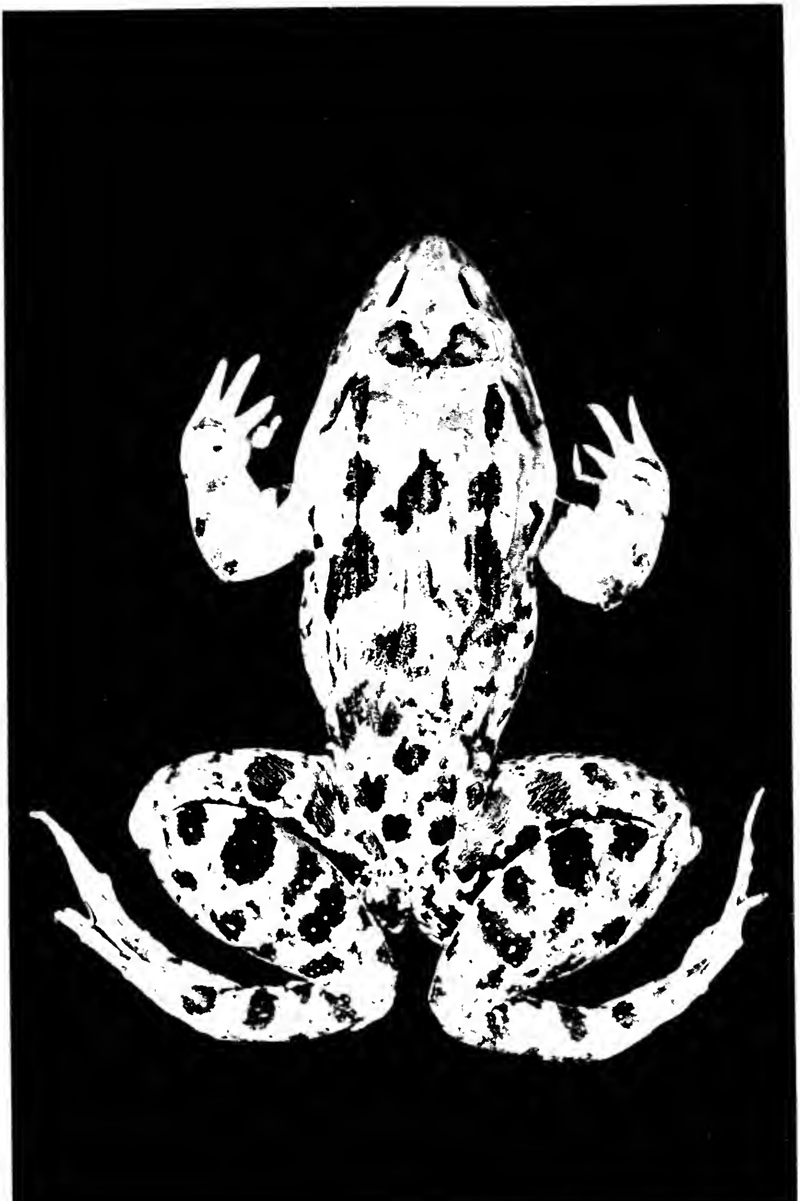

Fig. 33.—*Rana raja* M. Smith. No. 34839 ♂. Actual snout-vent length, 84 mm., near Phatthalung, Phatthalung, Thailand.

Measurements in mm. *Rana raja*

Number	34839	34836	34837	34838	MS No. 4395	MS No. 7442
Sex	♂	♀	♀	♀	♀	♂
Snout to vent	84	109	113	98	119.5	88
Width of head (tympanum)	31	46	47	36.2	46	32
Length of head to jaw-angle	30	41	41	35	42	31
Length of eye	8	9.8	10.8	10	......	......
Length of snout	11.6	17	15	16.3	......	......
Eye to tympanum	4.1	4.5	5	4.8	......	......
Tympanum diameter	5	6.8	7	7	......	......
Arm	44	57	58	51	53	43.5
Leg	122.6	159	168	163	162	126
Tibia	40	57	60.5	53	55	40
Foot and tarsus	60	81	83	77	77	58

Variation: The specimens above (Nos. 34836-39) were taken at Phatthalung in fields of rice about two kilometers from the Tale Sap (Sea of Singgora).

The male has well-developed vocal sacs with large black spots covering them on the throat; the vocal slits in the mouth are small but distinct and back near the angle of the mouth. The females are gravid.

Females have about ten large spots along lower jaw, while the chin, throat, and front of breast is nearly covered with thirty or forty dark spots and flecks separated by areas of yellowish-white color. In No. 34838 these markings are dim to obsolete. The venter is yellowish white in all. The web is rather deeply excised in all the specimens and the terminal swellings vary slightly.

I have examined the type series in the British Museum. The largest paratype (cotype) ♀ measures 121 mm., and a male 62 mm. snout to vent. Both lack a median stripe. My measurements of two of the types differs slightly from those published by Dr. Smith.

Distribution: Known from Pattani, Songkhla, and Phatthalung in Thailand. I have examined specimens of this species from Kuala Lumpur.

Remarks: The species *cancrivora* is highly specialized with regards salt toleration. It is usually to be found in the vicinity of the seashores or mouths of rivers. The species here considered seemingly is not so confined in its distribution and there is no evidence that either adult or tadpole is salt tolerant. There are no vocal sacs in *cancrivora*, however, two are present in this species.

Rana cancrivora Gravenhorst

FIG. 34

Rana cancrivora Gravenhorst, Deliciae Musei Zoologici Vratislaviensis continens Chelonios et Batrachia, fasc. 1, Lipsiae, 1829, p. 41 (type locality, Java); Annandale, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, 1916, pp. 91, 96; Mem. Asiat. Soc. Bengal, vol. 1, 1917, pp. 121, 128, pl. 5, fig. 4; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, p. 228; *ibid.*, 1917, p. 256; *ibid.*, 1917, p. 264 (Chumphon); Annandale, Rec. Ind. Mus., vol. 18, 1918, p. 63, figs. 3, 3a; Boulenger, Rec. Ind. Mus., vol. 15, pt. 2, no. 7, Apr. 1918, pp. 55, 65-67; Rec. Ind. Mus., vol. 20, 1920, p. 23; Robinson and Kloss, Journ. Federated Malay States Mus., vol. 8, 1920, p. 305; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, pp. 170-172; Sworder, Singapore Naturalist, no. 5, 1925, p. 99; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1929, p. 3; Bourret, Les Batraciens de l'Indochine, 1942, pp. 245-248, figs. 58-59 (nearly complete synonymy, and literature list).

Rana tigrina (sic) (part.), Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 234.

Rana cancrivora forma *typica* * M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 97.

Diagnosis: Nostrils directed upward; the interorbital width about one half width of an eyelid; nostril nearer tip of snout than eye; loreal region oblique, concave; tympanum distinct; first finger longer than second; tibiotarsal articulation to eye; when legs are folded, heels touch; fringe on outer side of outer toe; slight tarsal fold; inner metatarsal tubercle; no outer; numerous dorsal folds; dorsolateral fold suggested, composed of numerous short ridges in line; vomerine teeth oblique extending much behind small choanae; toes about three-fourths webbed; small eye-spot in middle of frontal area.

Description of species (from No. 34294, ♀ Ang Hin, Chon Buri province, Thailand): Snout pointed oval; nostril a little closer to median tip of snout than to eye; canthus rostralis not indicated, loreal region oblique somewhat depressed, concave, with few small smooth warts; width of eyelid greater than interorbital distance; small supratympanic fold extending diagonally to above tympanum then bending downward and backwards behind tympanum but not obscuring tympanic ring; diameter of tympanum little greater than distance between tympanum and eye; yellowish gland at angle of mouth touching tympanum.

Internal nares small; vomerine teeth on two narrow diagonal ridges beginning on anterior inner edge of choanae, extending backwards; distance between ridges equal to transverse diameter of one ridge; palatal glands opening in sinuous discontinuous groove, between, but somewhat anterior, to choanae; tongue large, strongly

* M. Smith has described a frog from the peninsular part of Thailand as *Rana cancrivora raja*. I do not believe the form to be a subspecies of *cancrivora*. Dunn (1928) has placed *verrucosa* also as a subspecies of *cancrivora*. This is a very doubtful relationship.

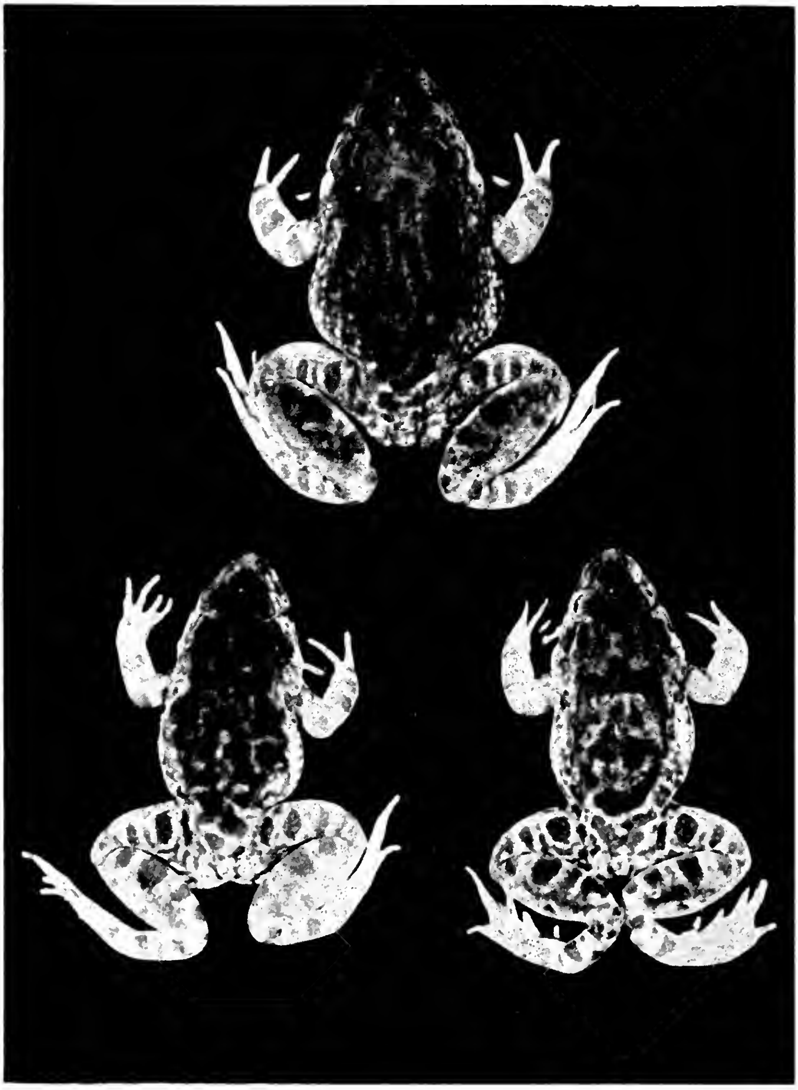

FIG. 34.—*Rana cancrivora* Gravenhorst. Upper figure, No. 34294 ♀. Ang Hin, Chon Buri. Actual snout-vent length, 68 mm. Lower figures, unnumbered, natural size, males, Ang Hin, Chon Buri, Thailand.

notched behind, free for three fourths of its length (no vocal slits or vocal sacs in males).

Skin above with numerous glandular warts, some forming elongated ridges others small tubercles; more or less conspicuous row of rounded tubercles border side. Skin of chin, venter, and underside of thighs smooth; some inconspicuous tubercles on posterior face of thigh; arm short, digits without webs, their tips swollen into small dilations; first finger slightly longer than second; subarticular tubercles distinct; two rather flat metacarpal tubercles scarcely distinguishable; toes perhaps three-fourths webbed; distinct skin-flap along outer toe; prominent inner metatarsal tubercle; no outer tubercle; subarticular tubercles well developed; limbs short, tibiotarsal articulation reaching front edge of eye; when limbs are folded at right angles to body, heels touch.

Color in life: Above gray to brownish gray with irregular gray-black spots; spots on arms and legs; outermost row of small warts on sides, and gland at mouth-angle, cream; chin, venter, and concealed parts of arms and legs cream; undersurface of foot lavender, tips of toes and fingers cream; some fine diffuse pigment on chin.

Measurements in mm.: Snout to vent, 68; width of head (at tympanum), 27; length of head, 23; arm, 36; leg (from vent), 86.

Variation: The markings on the body vary considerably. Some individuals may be nearly uniformly colored; in others the spotting is strongly defined. Occasionally individuals are found in which the spots are arranged symmetrically. A chevron-shaped spot is almost always discernible in the supraorbital area and a transverse shoulder mark appears in many specimens.

Distribution: In Thailand the species is known to occur in Bangkok, Petriu (near Bangkok), Chon Buri, Songkhla, and Chumphon. Outside of Thailand the species is known in Malaya, the Indo-Australian Archipelago and has been reported as far east as the Philippines. It is probably rare in Malaya. There is a report of a specimen from Singapore.

Remarks: This species has strong tolerance for salt water. A large series was obtained on the beach at night at Ang Hin, from numerous tide pools at low tide. The frogs were feeding in these pools on crabs and other crustaceans. During the day-time the frogs were hidden among the rocks forming the foundation of a pier. There were fresh-water or brackish-water pools nearby, where the species laid eggs and the young developed. Some, but not all of these pools were well above the high tide mark.

Rana limnocharis limnocharis Gravenhorst

FIG. 35

Rana limnocharis Gravenhorst, Deliciae Musei Zoologici Vratislaviensis continens Chelonias et Batrachia, fasc. 1, Lipsiae, 1829, p. 42 (type locality, Java); Wiegmann, Nova Acta Acad. Leopoldina-Carolinae Ger. Nat. Curio., vol. 17, pt. 1, 1835, p. 255; Stoliczka, Proc. Asiat. Soc. Bengal, 1872, p. 102; Journ. Asiat. Soc. Bengal, vol. 42, 1873, p. 116; Flower, Proc. Zool. Soc. London, 1899, p. 893; Laidlaw, *ibid.*, 1900, p. 885; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903; Ferguson, *ibid.*, vol. 15, 1903, p. 502; Boulenger, Spolia Zeylanica, vol. 2, 1904, p. 73; Stejneger, Bull. U. S. Nat. Mus., Bull. 58, 1907, p. 127, figs.; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 236; Robinson and Kloss, Journ. Federated Malay States Mus., vol. 5, 1913-15, p. 155; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, pp. 165-166; *ibid.*, vol. 2, pt. 3, Dec. 1917, pp. 228-260; Annandale, Mem. Asiat. Soc. Bengal., vol. 6, 1917, p. 133, text figs. pl. 5, fig. 6; M. Smith, vol. 2, pt. 3, Dec. 1917, pp. 228, 265; Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, p. 133, fig. 2, pl. 6; Journ. Federated Malay States Mus., vol. 7, 1917, p. 108.

Rana limnocharis limnocharis Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1051-1053, fig. 2.

Rana gracilis (*non* Gravenhorst) Wiegmann, Nova Acta Acad. Leop-Carol., vol. 17, pt. 1, 1835, p. 255; Günther, The reptiles of British India, 1864, p. 409; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 28 (*part.*).

Diagnosis: Tips of digits slightly swollen, not or scarcely wider than digit; first finger extending beyond second; toes one-half to two-thirds webbed; outer metatarsals separated by a web; a compressed inner and a small outer metatarsal tubercle. Back with warts or numerous longitudinal glandular folds; vocal sacs, in male, black externally.

Description of species (from No. 82, Chiang Mai): Head rather low, the snout a pointed oval, about as long as orbit; canthus rostralis obtuse; interorbital space narrower than upper eyelid; loreal area oblique, area behind nostril concave; a tympanic fold crosses upper edge of tympanum which is approximately three fifths diameter of eye, separated from eye by a distance equal to three fifths its diameter.

Vomerine teeth on two oblique ridges beginning near inner anterior border of choanae at end of slight ridge that passes above choanae; openings of palatal glands in a curved row about midway between upper edge of vomerine ridges and front of palate (males with two external vocal sacs, opening into mouth through puckered slits back near angle of mouth); tongue moderate, free behind for a third of its length, and free on sides.

Arm short; fingers short, pointed at tips or with a very slight swelling, first finger longer than second; no lateral ridges or fringes on fingers; subarticular tubercles well-developed; three distinct palmar tubercles, median largest, outer very small; an indistinct

FIG. 35.—*Rana limnocharis limnocharis* Gravenhorst. EHT-HMS No. 31778 ♀, Phu Phan, Sakhon Nakhon, Thailand. Actual snout-vent length, 41 mm.

row of tubercles along outer face of forearm; (male with a large nuptial gland on first finger, extending from base to distal phalanx); legs moderate, tibiotarsal articulation reaching front level of eye; toes about three-fourths webbed (or less), their tips pointed or very slightly swollen; partial skin-fringe on outer side of fifth; somewhat compressed, anteriorly elevated, inner metatarsal tubercle and small outer; small tarsal fold; subarticular tubercles smaller than those on fingers; when legs are folded at right angles, heels overlap five millimeters or more.

Skin minutely granular with numerous longer and shorter glandular folds and pustular warts sometimes tending to form rows on sides; an area low on sides somewhat areolate; chin, breast, and most of venter smooth; posterior part of venter areolate as is much of the posterior half of undersurface of thigh and much of posterior face of thigh on sides of vent; an indistinct ventrolateral fold from axilla to groin, and an indistinct fold indicated across breast; small fold indicated from jaw angle across anterior point of insertion of arm.

Color in life: Above generally olive, variegated with darker, somewhat symmetrical markings; three dark bars on upper and lower lips; a canthal mark; an interrupted bar across orbital and interorbital areas; broad median orange-brown stripe from tip of snout to end of coccyx; spot covering upper part of tympanum, leaving a lighter diagonal bar from eye to jaw angle; lighter brownish diagonal bar from shoulder to groin, its anterior part a rounded brownish spot, posterior part in groin nearly yellow white; limbs barred with dark brown; chin, venter, and underside of limbs yellowish white to cream. (Males with black areas on chin over vocal sacs or entire chin may be black).

Measurements in mm. (Nos. 82 and 36344, Chiang Mai province): Snout to vent, 62, 42; width of head, 23, 18; length of head, 19, 13.2; arm, 30.3, 22.2; leg, 92.3, 61; tibia, 30, 20.2; foot and tarsus, 43, 30.

Variation: Owing to the fact that this species is ubiquitous in lowlands and numerous specimens are available from many localities, it is possible to discern geographic populations showing differences in size, in the general rugosity of the body and in color patterns, so that from a mixed lot it is often possible to separate them at sight. Thus a group from Kaeng Pang Tao northern Chiang Mai province have the tubercles and ridges more pronounced than elsewhere, none seemingly showing the median light stripe.

About Chiang Mai (city) a large proportion of the female specimens have an orange-brown stripe and a dim diagonal lateral stripe beginning with a rounded brown spot. In the southeastern part of the country the specimens are gray and blackish often with a clay-colored median line (appearing usually in females).

The shape of the vomerine ridges, and their proximity to the choanae varies also. The males differ in having a diffuse gland over two sides of the venter. This comprises most of the venter, except posteriorly, the surface being closely covered with minute tubercles. The ventrolateral folds, and the sinuous fold across the breast together form a "ventral disc" evident on many Leptodactylid frogs, and not typical of *Rana*. A glandular patch is present on the front of the chin. A fold anterior to the breast marks the posterior limit of the vocal sacs. The area external to the sacs is deep black in all adult males. The ventral fold just in front of arm-insertion is often very distinct, occasionally not apparent if the arms are stretched backwards.

Distribution: The subspecies probably occurs in lowlands everywhere in Thailand. It ascends some distance into the mountains.

Outside of Thailand the species is very widespread in India, Ceylon, Formosa, China, and Japan. It occurs also in Malaya and the Indo-Australian Archipelago. The complete range of this, the presumed typical subspecies is still undefined.

Remarks: This small amphibian is significantly important in Thailand. It furnishes considerable food for human consumption and serves more than other amphibians as the chief food for certain animals. I believe it to be the major food for many of the terrestrial lowland snakes that utilize cold-blooded animals for food.

Rana macrodon Kuhl, in Tschudi

FIG. 36

Rana macrodon Kuhl, in Tschudi, Mem. Soc. Sci. Neuchâtel, vol. 2, 1839, p. 80 (type locality, Java); Duméril and Bibron, Erpétologie Générale . . . vol. 8, 1841, pp. 382-384; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 1882, p. 24, pl. 1, fig. 4; *(part.)*; Flower *(part.)* Proc. Zool. Soc. London, Dec. 1, 1896, pp. 898-901, plate 45, fig. 1 (excellent figure in color of *Rana macrodon*); Laidlaw, Proc. Zool. Soc. London, 1900, p. 885 *(part.)*; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 233-234 *(part.)*; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 2, 1915, p. 130; *ibid.*, vol. 1, no. 3, 1916, p. 156; *ibid.*, vol. 3, 1916, p. 165; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, pp. 174-176 *(part.)*; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 98 *(part.)*.

Diagnosis: Large frogs, differing from *Rana blythii* in having a relatively shorter head in proportion to length, tympanum separated from eye by a distance less than diameter of tympanum; snout

FIG. 36.—*Rana macrodon* Kuhl, in Tschudi. No. M. 41. Actual snout-vent length, 90 mm. Kuala Lumpur, Malaya.

shorter in front of level of nostrils; eye proportionally shorter; tibiotarsal articulation to level of eye.

Description of species (from No. M 41, Kuala Lumpur): Head broad (43 mm.), not or but slightly greater than its length (39.6 mm.); canthus not or scarcely indicated, the loreal region strongly oblique, very shallowly concave; nostrils very much closer to midpoint on lip than to eye; width of an eyelid (7.9 mm.) slightly wider than interorbital distance (7.5 mm.); distance between nostrils five millimeters, nostrils narrow, slitlike; jaw forming a shelf below eye; tympanum large, diameter (7.2 mm.) greater than its distance from eye (5 mm.) and slightly less than eye length (8.9 mm.); an indistinct fold indicated across head behind eyes; a fold from edge of upper eyelid passes above tympanum, then extends down and terminates behind angle of jaw; vomerine teeth on two sharp ridges arising at anterior inner edge of choanae and extending diagonally backwards toward mid-line, to some distance beyond posterior level of choanae; strong transverse ridge behind choanae almost touching vomerine tooth ridges; no openings from palatal glands evident; no vocal sac or vocal openings; tongue elongate, broadened and notched behind, free for nearly half its length; pair of strong bony processes from ends of mandibles extending backwards and fitting into well-defined depressions in upper jaw when mouth is closed.

Arm moderate, fingers unwebbed without lateral ridges; subarticular tubercles distinct, tips of fingers swollen, first finger much longer than second, reaching nearly as far as third; second and fourth equal; a prominent inner metacarpal tubercle, outer flat, scarcely discernible.

Leg short, tibiotarsal articulation reaches forward to a point two millimeters beyond eye; toes about four-fifths webbed, the web extending to swellings at tip as narrow fringes; an elongate metatarsal tubercle; subarticular tubercles distinct, no tarsal fold.

Skin above generally smooth over body and limbs; posterior half of eyelid with well-defined tubercles, one or two almost titlike; the sides with minute pavement-like granules with a few very indefinite tubercles dorsolaterally. Chin with a fine subcutaneous ridge, forming a fine reticulum; breast, venter, thigh, smooth but with fine vertical wrinkling and immediately posterior to vent fine vertical grooves.

Color: Above generally light brown with chocolate brown shading and indistinct markings including a darker chevron on shoulders; a dark line follows the supratympanic fold; darker flecks on tympanum; some indistinct black spots along lower edge of upper jaw and upper edge of lower jaw. Throat, breast, and anterior part of venter light brown with fine flecking of cream.

Arms and legs with indistinct brown bars; back part of thighs blackish with some fine vermiform flecks and reticulations. A hair-fine median cream line from snout to end of rump and touching a similar fine transverse line running across back of femora. Underside of foot dark chocolate.

Measurements in mm.: Snout to vent, 90; width of head, 43; length of head, 39.6; arm, 50; leg, 136; tibia, 45; foot and tarsus, 62.

Distribution: This species originally described from Java is known to occur also in the Malay Peninsula and has been reported from Thailand by Malcolm Smith and Flower.

This species and *Rana blythii* occur together and should not be regarded as subspecies.

Rana blythii Boulenger

FIGS. 37, 38

Rana fusca Blyth, Journ. Asiat. Soc. Bengal, vol. 24, 1885, p. 719 (type locality?) (preoccupied); Stoliczka, *ibid.*, vol. 42, 1873, p. 115.

Rana macrodon Boulenger (*part.*), Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 1882, p. 21, pl. 1, fig. 4; Blanford, Proc. Zool. Soc. London, 1881, pp. 225-226, pl. 21, fig. 4, 4a; Flower, Proc. Zool. Soc. London, 1889, p. 888, pl. 59, figs. 1, 1a (tadpole); Laidlaw, Proc. Zool. Soc. London, 1900, p. 885, (*part.*); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, pp. 1053-1054 (Nakhon Si Thammarat).

Rana blythii Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 40, 43-45 (new name for *Rana fusca* [non Meyer] Blyth); van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, pp. 174-176 (*part.*).

Diagnosis: Very large frogs reaching a length of nearly 260 mm. snout to vent. Tips of digits swollen or somewhat dilated, without peripheral groove; outer metatarsal separated by web for all or most of its length; dorsolateral fold absent; no vocal sacs; no nuptial pad on first finger, which is much longer than second; tympanum distinct, widely separated from eye by a distance much more than its diameter; male lacking vocal sacs; large toothlike bony projections from front of lower jaw of males (very low in females); eye large; a rather distinct canthus rostralis and oblique loreal region.

Description of species (from No. 151, Na Bon, Nakhon Si Thammarat): Head oval, longer than wide; canthus rostralis not distinguishable; loreal region very oblique, somewhat concave, nostril nearer tip of snout than to eye; upper eyelid wider than interorbital space; tympanum distinct, its greatest diameter about three fifths of length of eye, separated from eye by a distance considerably greater than its diameter. Snout longer than eye; a supratympanic fold curving down behind tympanum to above arm.

Choanae posteriorly placed in palate; pair of elongate oblique ridges bearing vomerine teeth begin near inner anterior edge of choanae but separated by distance equal to less than one fourth of

Fig. 37.—*Rana blythii* Boulenger. No. 34546. Actual snout-vent length, 228; La Doo Tin Mine, Yala, Thailand.

their length and converge toward median line considerably behind choanae; palatal glands open into mouth through several separate openings midway between front of palate and anterior level of choanae; tongue large, prominently notched behind. Arms and legs moderately long, finger tips swollen, scarcely as wide as finger; first finger much longer than second; subarticular tubercles moderately large; lateral fleshy ridge on sides of third finger and a short one on second; three palmar (metacarpal) tubercles, the two outer flat, more or less fused together; leg with tibiotarsal articulation reaching nostril; foot completely webbed; digit tips dilated; inner metatarsal tubercle somewhat compressed, elongate, more than half length of first toe beyond tubercle; no outer tubercle; subarticular tubercles large; a prominent skinfold on outer side of fifth toe; a tarsal fold.

Skin generally smooth (under lens minutely corrugated); a few small scattered pearl-tipped tubercles on legs; chin, venter, as well as undersurface of limbs, smooth; granules in area about vent scarcely discernible.

Color: Head, dorsum, and sides blackish brown with narrow cream median line from end of coccyx to tip of snout; upper and lower lip with large black spots, those on lower jaw bordered by yellow; limbs brownish with large black bands; back of thigh with a transverse hair-fine cream line; below this, thigh brownish, reticulated with cream; chin, venter, and underside of limbs whitish or yellowish white with shadowy dark spots on front of breast; dark lavender on palms of hands and soles of feet.

Measurements in mm. (No. 151, and No. 34546): Snout to vent,* 110, 228; width of head, 40, 90; length of head, 41, 85; arm, 54, 102; leg, 180, 339; tibia, 58, 113; foot and tarsus, 75, 152.

Variation: The second specimen measured, No. 34546, from Bhetong, Yala, is very large, but still falls short of the maximum size. One larger specimen in the collection not at the moment available, is approximately an inch longer, and specimens still larger have been reported.

In color the specimen is dark brown, nearly uniform, somewhat lighter laterally. The banding on the limbs can be seen if the specimen is submerged in clear liquid. The entire chin and breast is smoky brown, the spots on lower lips blackish. The venter and underside of limbs are dirty whitish; undersurface of hands and feet dark lavender.

* In most cases the vent is terminal or nearly so; measurement is made on mid-line to posterior median part of thigh when this extends beyond vent.

FIG. 38.—*Rana blythii* Boulenger. No. 151. Actual snout-vent length, 110; Na Bon, Nakhon Si Thammarat, Thailand.

The tympanic region as well as tympanum concave, overhung by a fold from eye to arm; a distinct fold across head at level of the posterior edge of orbits. The eyelid (16 mm.) much narrower than interorbital distance (22 mm.).

A series of young specimens taken on a small mountain near Haadjai, Songkhla, 52 to 71 mm. in length have the head and dorsum finely and distinctly granular intermixed with tubercles and small warts. Most of the series have a broad orange stripe. Below, the specimens were uniform yellowish. These were perched on rocks near pools in a rivulet at an elevation of about 300 meters.

Another series from Kuala Lumpur are somewhat lighter olive in color, the eyes averaging a little larger.

Distribution: While it is difficult to be certain from the literature descriptions of *Rana macrodon* which species is involved, it appears fairly certain that both *macrodon* and *blythii* are included in the materials collected by Dr. Malcolm Smith in southern Thailand. I have taken only *blythii.*

Rana doriae Boulenger

FIG. 39

Rana doriae Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 5, 1887, pp. 482-483, pl. 8, fig. 1 (type locality, Tenasserim); Anderson, Journ. Linn. Soc., Zool., vol. 21, 1889, pp. 336, 349; Boulenger, The fauna of British India, including Ceylon and Burma; Reptilia and Batrachia, 1890, pp. 447-448; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, pp. 328-329, pl. 8, fig. 1, 1a; Butler, Journ. Nat. Hist. Soc. Bombay, vol. 15, 1904, p. 196; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 231; M. Smith and Kloss, Journ. Nat. Hist. Soc., Siam, vol. 1, no. 4, Dec. 1915, p. 249 (S. E. Siam, Koh Chang, Koh Mehsi, Koh Kut); *ibid.,* vol. 2, no. 2, Dec. 1916, p. 165 (Khao Wang Hip, Nakhon Si Thammarat province); Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, p. 133; Boulenger, Rec. Ind. Mus., vol. 20, 1920, p. 49; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 3, no. 3, May 1917, p. 228; *ibid.,* vol. 4, no. 4, Jan. 25, 1922, pp. 217-218, pl. 9, fig. 1; Bull. Raffles Mus., no. 3, 1930, p. 98.

Diagnosis: Head in males without toothlike projections in lower jaw; no flap or knoblike prominence in interorbital or occipital regions, but this area convex in males; tympanum in males varies; in some its diameter equals eye-length, in others only three fourths of eye-length; fingers and toes with small discs; no vocal sac in male. Head normal in females, somewhat enlarged in old males.

Description of species: Canthus rostralis distinct but rounded; interorbital space as wide as an upper eyelid, the region in males convex; tympanum distinct, its diameter three fourths to full diameter of eye, largest in adult males; vomerine teeth in two diagonal fasciculi beginning near posterior edge of choanae and extending back; lower jaw without toothlike prominence from near symphysis.

Fig. 39.—*Rana doriae* Boulenger. After Boulenger, pl. 8, fig. 1, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1892-93. Actual length, approximately 57 mm. Palon, Karin Hills, Burma.

Fingers and arms moderate, first finger longer than second, tips dilated into small discs; toes more than four-fifths webbed; tips of toes with small discs wider than those on fingers; subarticular tubercles moderately large; fringe on outer side of outer toe; an elongate inner metatarsal tubercle two thirds length of inner toe; no outer metatarsal tubercle; indistinct tarsal fold; leg moderately long, heel reaching to near nostril; top of head and occipital region smooth; back with longer or shorter glandular tubercles; an indistinct fold between posterior corners of eyes; a fold beginning behind eye runs above tympanum to near arm-insertion.

Skin smooth or with irregular glandules on back; a more or less distinct fold across head behind upper eyelids; a strong glandular fold from eye to shoulders.

Color: Above olive-brown to dark-brown with more or less symmetrical darker markings bordering slightly swollen area on occiput; W-shaped mark on shoulders; snout lighter with a dark band between eyes; upper thigh, tibia, tarsus, and foot strongly barred with dark blackish-brown; back of thigh, dark, reticulated with yellow; lip with vertically placed dark-brown bars; yellowish white beneath, on chin, venter, and concealed parts of limbs, in females (chin and throat of males dark, marbled with blackish brown).

Measurements in mm. (from M. Smith No. 5922): Snout to vent, 50 mm., length of head, 18; width of head, 19; snout, 8; eye, 5; interorbital width, 4; tympanum, 4; arm, 26; leg, 80; tibia, 27; foot, 25.

Variation: The sexual variation in this form is somewhat less than in related forms, since the head of the male does not become greatly enlarged and there are no toothlike projections from the front of the lower jaws. There is no vocal sac in the male; no occipital swellings developed.

The tibiotarsal articulation may reach as far as the tip of the snout or may extend somewhat beyond this point. The form that occurs on the Andaman Islands differs in numerous particulars. The vomerine teeth are farther forward, the web between toes more emarginate, and a distinct outer metatarsal tubercle is present.

Males have the throat spotted or marbled with brown.

Distribution: The species is known only in the peninsular part of Thailand, specimens having been taken in Prachaup Khiri Khan, and Chumphon provinces. The species is known also in Tenasserim, Burma, and it has been taken in Malaya.

Rana kohchangae M. Smith

FIG. 40

Rana doriae Smith and Kloss, Journ. Nat. Hist. Soc. Siam, vol. 1, Dec., 1915, p. 249.

Rana macrognathus (part.) Boulenger, Rec. Ind. Mus., vol. 20, 1920, p. 51.

Rana kohchangae Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, no. 4, July 25, 1922, pp. 223-225, pl. 9, fig. 5 (type locality, Koh Chang, Gulf of Siam).

Diagnosis: The least-modified member of the *Rana doriae* group. Head somewhat enlarged with a pair of fanglike bony processes on front of lower jaws; canthus rostralis obtuse; distance between nostrils greater than interorbital width which is greater than width of upper eyelid. First finger as long as second; one metatarsal tubercles; well-marked tarsal fold; no flap in interorbital or occipital area; latter region not or but slightly swollen.

Description of species (from M. S. No. 6055. Koh Chang I. EHT-HMS 29857): Head moderate, broader than long, snout oval rather pointed; canthus rostralis obtuse, loreal region somewhat concave; nostril nearer tip of snout than to eye; interorbital width greater than that of upper eyelid; tympanum distinct, its diameter three fifths of eye length, separated from eye by distance equal to two thirds its diameter; strong fold from eye, curves back above tympanum and down to arm-insertion; snout projecting slightly beyond mouth; vomerine teeth on two oblique subtriangular ridges beginning near inner sides of choanae but extending much behind their posterior level, narrowly separated mesially, each ridge larger than a choanal opening; palatal glands open in a transverse series at upper level of choanae; tongue free for nearly half its length (male with internal vocal sac; a pair of fanglike triangular bony projections from lower jaws).

Arms short, first finger as long as second; three metacarpal (palmar) tubercles; subarticular tubercles, strongly developed; some traces of lateral ridges on inner digits; tips swollen into small discs; leg moderate, tibiotarsal articulation reaching to anterior edge of eye; when legs are folded at right angles heels overlap a little; toes almost completely webbed, tips dilated into discs each with a peripheral groove; strongly compressed inner metatarsal tubercle, nearly half length of inner toe; no outer metatarsal tubercle.

Skin above with numerous short folds or rounded tubercles scattered rather regularly on back; supratympanic fold; two diagonal folds on shoulder; arms and legs with scattered tubercles; chin venter and underside of limbs smooth, except ventroposterior face

FIG. 40.—*Rana kochangae* M. Smith, EHT-HMS No. 29857 ♀. Actual snout-vent length, 35 mm. Koh Chang I, Gulf of Siam.

of thigh and region on both sides of vent covered with more or less regular granules; well-defined tarsal fold.

Color: Above generally olive-brown with some lighter and darker markings usually along short glandular folds; arms and legs barred with brown; lips with brown spots; all lower surfaces yellowish white.

Measurements in mm.: Snout to vent, 35; width of head, 16; length of head, 14.6; arm, 21.5; leg (from vent), 57; tibia, 18; foot and tarsus, 26.

Variation: Malcolm Smith reports that the tibiotarsal articulation may reach as far as nostril, and that the tympanum (presumably) of males may equal area of eye; the first finger may be slightly longer than second. Rarely a broad yellow stripe is present. The maximum (snout-vent) size is about 42 millimeters.

Distribution: The species has been found on Koh Chang, Koh Kut and Koh Mehsi and on the mainland at Ok Yam.

It is not known elsewhere.

Remarks: It has been pointed out by Smith that it is practically impossible to separate the females of this group of species since, the specific differences are to be found in secondary sexual characters of the males. One might suppose that the relations are more of a subspecific than specific nature. However in several places two distinct forms have been found occurring together, each maintaining its own characters. In the case of *kohchangae* its occurrence on the mainland suggests that it may occupy the same territory as *Rana pileata* known to occur only 125 kilometers from Ok Yam. These frogs are usually encountered along small streams.

Rana macrognathus macrognathus Boulenger

FIG. 41

Rana macrognathus Boulenger, Ann. Mag. Nat. Hist., ser. 8, vol. 20, 1917, p. 414 (type locality, Karen Hills, Burma); Rec. Ind. Mus., vol. 20, 1920, p. 51; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, 1922, pp. 216, 218, pl. 9, fig. 2; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 98-99; Boulenger, Rec. Ind. Mus., vol. 20, 1920, p. 51; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1039, fig. 3.

Diagnosis: * A small *Rana,* males reaching a length of 40 mm.; head enlarged; swelling on occipital region and low swelling just back of interorbital area but without free flap; tympanum as large as or larger than eye; head thickened posteriorly; jaws swollen; skin

* Malcolm Smith (1922) calls attention to the confusion formerly existing in Boulenger's descriptions of certain species of this group. This has been corrected by Boulenger (1920). In this same paper Smith corrects further listings made by Boulenger in his monograph on South Asian Ranae.

below jaw somewhat plicate; tibiotarsal articulation to tip of snout; arms short, first finger longer than second; lower jaw with two distinct toothlike projections; tips of digits with distinct discs; toes about four-fifths webbed.

Description of species (from M. S. No. 6330. Nakhon Si Thammarat): Head enlarged, canthus somewhat rounded; loreal region concave, oblique; snout scarcely extending beyond mouth; nostril

FIG. 41.—*Rana macrognathus macrognathus* Boulenger. No. 215. Actual snout-vent length, 50 mm. ♂, Na Bon, Nakhon Si Thammarat, Thailand.

nearer tip of snout than to eye; upper eyelid considerably narrower than interorbital distance; tympanum distinct, large, its area equal or greater than eye, separated from eye by distance equal to half its diameter; vomerine teeth on two sharply elevated ridges that arise about level of middle of choanae and extend behind their posterior level, separated mesially by distance equal to about half length of one ridge; choanae visible from below; tongue free posteriorly for little more than a fourth of its length, and free on sides; no vocal sac or slits.

Skin on head and dorsum relatively smooth with few small warts on sides and on rump; under lens one sees occipital swollen area covered with minute regular granulations not present on slight interorbital swelling; no free skin-flap; narrow fold from eye passes above tympanum to arm-insertion; few small warts on upper eyelid; legs with few elongate, narrow ridges; granules on back of thigh and area about vent; chin and venter smooth; few narrow elongate folds on dorsum.

Arm short, fingers slightly swollen at tips; first finger longer than second; subarticular tubercles distinct; three palmar (metacarpal) tubercles, median smallest; narrow ridges of skin along inner sides of middle digits. Toes almost completely webbed; tips of digits widened into small but distinct discs; an elongate somewhat compressed inner metatarsal tubercle more than half as long as first toe; no outer tubercle; distinct tarsal fold; when legs are folded at right angles to body heels overlap five millimeters; tibiotarsal articulation reaches tip of snout.

Color in life: Olivaceous green or brown above with darker markings; throat white; belly and under surface of thighs pale yellow, the two colors usually clearly limited by fold across throat; lips and limbs with dark bars and pale narrow band between eyes; broad yellow stripe from median tip of snout to vent, its sides darker brown, indistinct lateral yellowish mark with brown spots both above and below it.

Measurements in mm.: Snout to vent, 55; width of head at tympanum, 26; length of head, 28; arm, 28; leg, from vent, 88; tibia, 30; foot and tarsus, 35; diameter of tympanum, 7.5; length of eye, 6.

Variation: Age variations are rather striking and the sexual variation is greater than in most frogs. In females the head does not become enlarged and the swelling in the occipital and interorbital regions is lacking. There may or may not be a median dorsal light line, and this may vary in width when present. In the specimen figured, the mouth is actually small.

Distribution: The species originally described from the Karen Hills of Burma has been traced south into the northern part of the Malay Peninsula to the mountains of Nakhon Si Thammarat.

Smith (1930) reports specimens from De Lisle Island and Pulo Rawi off the coast of peninsular Thailand and from the Me Taw forest of West Raheng.

Rana pileata Boulenger

FIG. 42

Rana pileata Boulenger, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, pp. 103-105, pl. —, figs. A to E (type locality, "Khao Cebab, Chantabun" = Chanthaburi province, Thailand); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 3, 1917, p. 228; Boulenger, Rec. Ind. Mus., 1920, vol. 20, pp. 52-53; Rao, Journ. Bombay Nat. Hist. Soc., vol. 27, 1920, p. 119; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, no. 4, July 25, 1922, pp. 222-223, pl. 9, fig. 4; Bourret, Annexe au Bull. Pub. Inst. no. 7, 1939, p. 58; Les Batraciens de l'Indochine, 1942, pp. 268-270, fig. 69.

Rana macrognatha macrognatha Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, no. 13, Mar. 20, 1958, pp. 1054-1056, fig. 3 *(part.)*.

Diagnosis: Strong sexual dimorphism. Adult males with heads swollen, jaws expanded, interorbital and part of postorbital area with median tonguelike flap, free-edged behind; no canthus rostralis; eye smaller than tympanum which is separated from eye by distance equal to length of eye; tibiotarsal articulation reaches to near nostril; foot three-fourths webbed, tips of toes dilated into small but distinct terminal discs; first finger longer than second; two small toothlike processes from front of lower jaws; heel to front of eye.

Description of species (from No. 34951, Phu Kading, Loei province): Head distinctly wider than body, wider than long; snout oval seen from above; no distinct canthus rostralis; loreal region sloping obliquely to lip; not concave; nostril nearer tip of snout than to eye; lips, loreal region, and top of head glassy smooth; flap on head extending six millimeters behind level of eyes; width of upper eyelid (4 mm.) contained twice in interorbital distance (8 mm.); tympanum large, distinct, its diameter a fifth longer than eye; a strong fold beginning behind eye passes above tympanum then turns down to point above arm-insertion; occipital area swollen on each side; tympanum separated from eye by distance greater than length of eye.

Tongue notched behind, free for half its length, free laterally; vomerine teeth on two elevated ridges lying between and largely behind level of choanae, separated by a distance equal to their distance from choanae; pair of toothlike processes in front part of

FIG. 42.—*Rana pileata* Boulenger. No. 36569 ♂. Actual snout-vent length, 57.5 mm. Doi Pna Kao near Mt. Inthanon, Chiang Mai, Thailand.

lower jaw; choanae as large as openings to Eustachian tubes; no vocal sac (males). Palatal groove nearer anterior level of choanae than to front of palate.

Arm short, first finger as long as, or a little longer than second; three distinct palmar tubercles; tips of fingers swollen a little, wider than digits; subarticular tubercles strong. Leg long, tibiotarsal joint reaching to or near to nostril; foot three-fourths to four-fifths webbed; tips of toes dilated into small but distinct discs; web reaching terminal disc on inside of toe, but rather deeply excised; subarticular tubercles present; an elongate, somewhat beanshaped, inner metatarsal tubercle; no outer; a free flap of skin along outer toe; outer metatarsals separated from others by web; a small tarsal fold; no outer metatarsal tubercle.

Skin on head smooth; back with numerous irregular warts; skin low on sides, on chin, venter, and on greater part of undersurface of thigh smooth; posterior part of thigh finely granular; leg with fine tubercles intermixed with larger tubercles, many of which are pearl-tipped.

Color: Dark dull-olive growing somewhat brown on rump and lighter on limbs; chin gray; breast and venter white; underside of thigh white; underside of foot and tarsus plumbeous; arm and leg dimly barred with darker.

Measurements in mm. (of Nos. 34951 and 34959, respectively): Snout to vent, 60, 51; width of head, 31, 27; length of head, 28, 23; arm, 37, 30; leg, 96, 81; tibia, 31, 27; tarsus and foot, 43.5, 37.

Variation: In females the differences are considerable, since they lack the fanglike processes in lower jaw, their heads are not swollen, and the jaws are not widened. The interorbital region is narrower, only a little broader than an eyelid, and the head-flap is absent. The tympanum is three fourths to four fifths the diameter of the eye. Young males have only a small flap or a semicircular fold indicated.

The color of the females and young vary considerably. They may be olive or brown above, rarely green, with irregular mottling or spotting. A yellow band, dark-edged behind, may be present between the eyes; the lips are black spotted with lighter areas between spots. Below pale yellow, immaculate, or rarely with spots on the throat. Rarely a middorsal cream line is present.

It is difficult to distinguish the females of the various species of this *doria* group, which includes *doria, pileata, macrognatha, koh-changae,* and *tournenoffi,* etc. They are very similar indeed. The males, however, are easily differentiated.

Distribution: This species is not uncommon in southeastern Thailand at the type locality, Khao Sebab, and at Hup Bon, Siracha, in Chanthaburi province. In northern Thailand it has been taken at Doi Suthep, Doi Pna Kao (Amphur Cawm Tawng 7200 ft.), Camp Mae Ka (Stream, Amphur Mong Hawt, *circa* 4200 ft.), Whey Tat (Amphur Chiang Dao, elev. *circa* 6000), all in the province of Chiang Mai; Phu Kading, Loei province; Phu Phan (Mt.), Sakhon Nakhon; Nong Bua Lumpoo, Udorn Thani; Khao Pleung, Uttaradit; and the Me Song Forest, Phrae.

Outside of Thailand there are no records available to me.

Remarks: This species is the most strikingly modified species of the *doriae* group. The females, however, except on the basis of size can only be doubtfully separated from females of other members of the group.

The widening and thickening of the head is strictly an adult character. Malcolm Smith (1922) points out that the age at which the head of the male reaches maximum development is not always commensurate with the size of the frog. In my collection a specimen 66 millimeters in length has the head much as occurs in females save for the small flap, while in No. 36566, 50.5 mm. in length, the head is much thickened and widened and the flap is larger with two considerable swellings on the occipital area. This variation in size at which this flap develops caused Taylor and Elbel to consider one of the large immature specimen of *pileata* to be a *Rana macrognathus*.

Rana pileata is a hill and mountain species, occurring from 100 to above 2000 meters elevation.

Rana plicatella Stoliczka

FIGS. 43, 44

Rana plicatella Stoliczka, Journ. Asiat. Soc. Bengal. vol. 42, 1883, p. 116, pl. 11, fig. 1 (type locality, Penang or Province Wellesley); Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata . . . 1882, p. 26; Flower, Proc. Zool. Soc. London, 1899, p. 890; Laidlaw, Proc. Zool. Soc. London, 1900, p. 885; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 196; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 231-232; Rec. Ind. Mus., vol. 20, 1920, pp. 53-54; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, no. 4. Jan. 25, 1922, pp. 227-228, fig. (head of *plicatella*).

Diagnosis: A member of the *Rana doriae* group. A strong fold across head behind eyes; about eleven elongate glandular ridges covering back; pair of fanglike processes arising from front part of lower jaws (not distinct in female or young); toes about two-fifths webbed; first finger longer than second; elongate, oblique vomerine tooth elevations beginning on inner posterior edge of choanae and extending considerably behind their back level; discs on toes small but distinctly widened; no vocal sac; maximum length, about 43 mm.

Description of species (from No. 34717, 15 km. NE Bhetong, Yala province): Snout oval seen from above; top of head rather flattened; nostrils far apart, distance between them one and one-half times interorbital width; canthus rostralis barely indicated; loreal region slightly concave, sloping obliquely to lip; snout longer than eye; length of eye greater than its distance to nostril; tympanum distinct,

FIG. 45.—*Rana plicatella* Stoliczka. No. 34717 ♀. Actual snout-vent length, 26. 15 km. NE Bhetong, Yala, Thailand.

little more than half diameter of eye. A strong skinfold curving from above arm-insertion across head close behind eyes; no distinct supratympanic fold.

Tongue notched behind, free behind for about one third of its length, also free on sides; vomerine teeth in two oblique elevated ridges beginning near inner posterior part of choanae, separated from each other by distance equal to their distance from choanae. Seen from directly below the choanae partially concealed by maxillary shelf.

Arm moderate, tips of fingers only slightly widened; first finger longer than second; subarticular tubercles well developed; leg long, tibiotarsal articulation reaches three millimeters beyond tip of snout; when leg is folded, heels overlap nearly three millimeters; toes approximately two-fifths to one-half webbed; tips dilated into moderately enlarged discs; narrow elongate inner metatarsal tubercle from

FIG. 44.—*Rana plicatella* Stoliczka. EHT-HMS No. 30249 ♂. Actual snout-vent length, 34 mm. Kuala Lumpur, Malaya.

which continues a well-defined tarsal fold; unwebbed part of toes with narrow fringes to discs; no, or at most, only a very indistinct outer metatarsal tubercle.

Skin smooth on top and sides of head; dorsum heavily lineated with ten to twelve, often discontinuous, longitudinal folds; no dorsolateral fold discernible; sides with indistinct small tubercles; venter, chin, and underside of limbs smooth; posterior part of thigh granular; dorsum with warts and tubercles.

The discs on toes show a thin anterior edge, usually dark in color.

Color in life: Above variegated olive to olive-brown; large area on top of head gray-brown bordered laterally by dark line from snout to eye; supraorbital area black; row of indefinite irregular marks across shoulders, with dorsolateral series of irregular cream marks; arm barred with dark and light; thigh with three brown-black bars with other less distinct bars between them; edge of tibia and tarsus with black bars or spots; chin, venter, and underside of thighs ivory white; under surface of feet nearly black; back of thigh flecked minutely with brown (nearly uniform).

Measurements in mm. (from Nos. 34717, and 30249, Kuala Lumpur, Malaya): Snout to vent, 26, 34; width of head, 11.2, 15.8; length of head, 11, 15.2; arm, 18, 20; leg, 49.5, 59; tibia, 16, 19; foot and tarsus, 22, 25.

Variation: The adult differs from the described specimen in having a proportionally larger head, especially in males. The canthus is rounded and just back of the interorbital space is a small knoblike prominence or projection. The width of an upper eyelid is less than the interorbital width. The tympanum is distinct, its diameter equal to or larger than length of eye.

Two fanglike prominence arise from front of jaws in males. The upper eyelid is tubercular and a strong supratympanic fold is present. The interorbital area may be somewhat convex.

Distribution: The species has been taken in Thailand about 15 km. northeast of Bhetong, and at the La Doo Tin Mine, Benang Stah. Both localities are in Yala province.

In Malaya specimens are known from Penang, Perak, Selangor and Singapore. It has been found up to 4000 ft. elevation.

Remarks: Of the two specimens whose measurements are given only the one described was found in Thailand. It is, I believe, the first record for the country. It was taken along a small rivulet in low mountains in the southern part of the province of Yala, about

15 kilometers northeast of Bhetong. It was routed out from under leaves near the edge of a stream. The Malayan specimen was taken by me near the Batu Caves in Selangor. The latter is an adult male.

The specimen from the La Doo Mine came from an elevation of about 3200 feet. I found it ensconsed under a slab of fallen bark near a small, slow-flowing stream.

The largest male specimens reach a length of 43 mm. Malcolm Smith reports a female specimen from Selangor, 29 mm. in length, with ripe ova. Tadpoles were taken in June.

Rana laticeps Boulenger

FIG. 45

Rana laticeps Boulenger Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 1882, p. 20, pl. 1, fig. 1 (type locality Khassya, India); The fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 444; Flower, Proc. Zool. Soc., London, 1896, p. 897; *ibid.*, 1899, p. 888; Butler, *ibid.*, 1902, p. 190; Boulenger, Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 172; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 196; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 23; Boulenger, A vertebrate fauna of the Malay Pensinsula . . . Reptilia and Batrachia, 1912, p. 230; Rec. Ind. Mus., vol. 20, p. 67; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1927, p. 271 (Wray's Camp, Tahan River; Fraser's Hill, Malaya); Journ. Sarawak Mus., vol. 3, 1925, p. 18 (Borneo); Bull. Raffles Mus., no. 3, 1930, pp. 93, 98; *ibid.*, no. 10, 1935, p. 62; Bourret, Les Batraciens de l'Indochine, 1942, pp. 282-284, fig. 76.

Diagnosis: A small frog (40 mm.); strong fold across head behind eye; dorsal skin with numerous short ridges; fold from eye to shoulder; tympanum hidden; first finger longer than second; skin strongly wrinkled longitudinally; venter glassy smooth; heel reaches to midway between eye and nostril; strongly developed toothlike projections on lower jaws; vomerine tooth ridges oblique, extending considerably behind choanae, and scarcely separated mesially.

Description of species (from No. 34720. 18 km. NE Bhetong, Yala province): Snout oval, moderately pointed; canthus rostralis scarcely evident; loreal region oblique, somewhat concave behind nostril; tympanum hidden completely; a skinfold beginning near angle of mouth runs across head behind orbits; interorbital space little wider than an eyelid; pair of strongly developed toothlike processes in mouth arising from near symphysis of jaw; choanae small, the vomerine teeth on two elongate ridges extending obliquely from back edge of choanae, almost meeting on midline of palate at point considerably behind choanae.

Arm moderate, first finger equal or a little longer than second; subarticular tubercles well developed, metacarpal tubercles not well

FIG. 45.—*Rana laticeps* Boulenger. Upper figure, No. 34732 yg. Actual snout-vent length, 20.5 mm. Lower figure, No. 34720 ♂. Length, 35 mm. Both from near Bhetong, Yala, Thailand.

defined; fingers moderately long, first slightly shorter than second, discs moderately large; leg moderate, tibiotarsal joint reaching nearly midway between eye and nostril; when legs are folded, heels overlap four millimeters; toes little less than half webbed, inner with short web; digits dilated into small discs larger than those on fingers; elongate inner metatarsal tubercle; distinct tarsal fold.

Skin of head dorsally and laterally with very fine ridges and corrugations; few pustules on posterior part of back; skin on chin strongly wrinkled, with a slight fold across breast; venter glassy smooth as is entire underside of thigh and region about vent; very dim fold from eye to arm-insertion.

Color in life: Above fawn to light tan with brown markings on upper jaw, smaller ones on lower jaw; small brown line follows canthus; brown band between eyes; a W-shaped mark on shoulders and dorsolateral series of irregular brown marks; two bands of brown on thigh, tibia, and tarsus; chin yellowish, with brown flecks; venter flesh-white; fine flecking on underside of thigh and other concealed parts of limbs.

Measurements in mm.: Snout to vent, 35; axilla to groin, 13; width of head, 18; length of head, 16; arm, 20; leg, 60; tibia, 19; foot and tarsus, 23.

Variation: Considerable differences in the color pattern obtains. The smaller specimen figured has much less marking than the female pictured below. The male has no vocal sac. There is a conspicuous nuptial pad on the first finger.

Distribution: In Thailand the species has been collected in Chumphon and Yala provinces (and at Mamoh, near the Isthmus of Kra). Outside of Thailand it is known in the Malay States of Selangor, Malacca, Pahang, and Perak; also in Burma, Bengal and Borneo.

Remarks: The species has been found chiefly along small rivulets. At night it sits in shallow water or forages there for food. When approached it is likely to remain motionless rather than to attempt escape.

In the daytime it is usually found under stones at the edge of small rivulets. When disturbed it usually makes one leap into the shallow water then remains motionless in the water where it is easy to capture it.

Rana kuhlii Schlegel, in Duméril and Bibron

FIGS. 46, 47

Rana kuhlii Schlegel in Duméril and Bibron, Erpétologie générale . . . vol. 8, 1841, p. 384 (type locality, Java); Günther (*part.*), Catalogue of the Batrachia Salientia . . . of the British Museum, 1858 (1859), p. 8, var. A & C; Reptiles of British India, 1864, p. 404, pl. 26, fig. A (but not fig. B); Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 20; Ann. Mus. Civ. Genova, ser. 2, vol. 5, 1887, p. 482; The fauna of British India Ceylon and Burma; Reptilia and Batrachia, 1890, p. 443; Flower, Proc. Zool. Soc. London, 1899, p. 887; Boulenger, *ibid.*, 1899, p. 166; Journ. Bombay Nat. Hist. Soc. vol. 15, 1903, p. 195; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 229-230; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, 1917, p. 227; *ibid.*, no. 4, Dec. 1917, pp. 262-263, pl.-fig. 1; Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 62-66; M. Smith, Bull. Raffles Mus., no. 3, 1930; pp. 97-98; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1057-1058, fig. 4 (Loei province); Bourret, Les Batraciens de l'Indochine, 1942, pp. 278-282, fig. 74.

Rana corrugata Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, June 13, 1934, pp. 281-282 (Chiang Mai province).

Diagnosis: A very aquatic frog found usually along rivulets in hills and mountains; strong sexual dimorphism, males with very broad heads, lacking vocal sac and toothlike prominences on lower jaws; no canthus rostralis; tympanum hidden; first and second fingers equal; tibiotarsal articulation reaching to near eye; dark bar across interorbital area, light-bordered behind.

Description of species (from No. 33933 Doi Suthep, 1000 m. elev., Chiang Mai): Adult male with head greatly widened, its width exceeding its length; canthus rostralis indicated, loreal area oblique, somewhat concave; jaw much thickened; distance between nostrils about equal to interorbital width; upper eyelid equal to or a little wider than interorbital width; tympanum not visible; fold from eye curving back behind jaw-angle to near insertion-point of arm; jaw forming small shelf below eye; occipital area somewhat swollen; nostril about equidistant between eye and tip of snout; eye length less than snout length.

Vomerine teeth on two small diagonal ridges, each somewhat smaller than choana, beginning near inner edge, but extending for most part behind posterior level of choanae, the ridges separated mesially by distance half length of one ridge; pair of elongate bony mandibular processes in lower jaw directed upwards and backwards fitting into two deep pockets in front of palate; no vocal sac; tongue large, its posterior horns moderate.

Arms and legs short; finger tips swollen a little but not or scarcely wider than digit; three metacarpal tubercles median largest, flat, rather indistinct; subarticular tubercles distinct; two middle fingers

FIG. 46.—*Rana kuhlii* Schlegel, in Duméril and Bibron. No. 36556 ♂. Actual snout-vent length, 95 mm. Doi Pna Kao, near Doi Inthanon, Chiang Mai, Thailand.

with lateral skin-ridges or fringes present for a greater or lesser distance; first finger equal to length of second, or a little less; leg short, thick, tibiotarsal articulation reaching eye; toes widened into small but distinct discs lacking a peripheral groove; toes fully webbed; a fine skin-fold along outer edge of outer toe; a well-defined tarsal fold; inner metatarsal tubercle elongate, compressed.

Skin above slightly corrugated on head and anterior part of back; sides with small glandular warts; limbs above, especially on back part of tibia and tarsus, with strong, pearl-tipped spines; chin, venter, front and most of undersurface of thighs smooth; a pair of short, poorly defined dorsolateral lines, moderately distinct anteriorly in young, indistinct in adult specimens.

Color in life: Olive-brown above on dorsum; a black, light-edged interorbital bar; back with some rounded or irregular darker spots usually with small lighter centers; arms and legs barred with brown; a light mark from eye back to jaw angle; upper lip and jaw darker, with some blackish marks; lower jaw clouded or spotted with brown. Chin and venter yellowish, as is much of the underside of thigh; brownish on sole and palm.

Measurements in mm. (Nos. 33933 ♂, and 34905 ♀ [Phu Kading, Loei]): Snout to vent, 93, 80; width of head, 47, 32; length of head, 44, 29; arm, 48, 42; leg, from vent, 116, 107; tibia, 39, 35; foot and tarsus, 53, 48.

Variation: The obvious variation in the species is sexual. The heads of the males are greatly widened and often the occipital region shows two well-marked swellings. The heads of the females are narrower without any obvious swelling. They lack the bony processes in the front of the lower jaws. Neither sex has a vocal sac or slits. In both males and females a well-defined fold may be present across the head at the posterior level of the orbits. In many specimens this is not in evidence. A few specimens, both males and females, have a median cream-yellow stripe, usually somewhat wider on head than elsewhere. While most specimens show no external trace of a tympanum, in several the inferior part of the tympanum can be discerned. Very young specimens, and occasionally older specimens show two rows of rounded dark spots on the back, each spot with a tiny light-colored tubercle in its center. The black and light bars in the interorbital region are always present, the light bar wider and preceding the other. Specimens from Southern Thailand and Malaya are especially rugose on the upper surface of the femur and tibia.

Fig. 47.—*Rana kuhlii* Schlegel, in Duméril and Bibron. No. 34014 ♀. Actual snout-vent length, 57 mm.; Doi Suthep, 3000 ft. elev., Chiang Mai, Thailand.

Distribution: In Thailand, specimens have been taken or reported from the provinces of Chiang Mai, Phrae, Loei, Narathiwat, Nakhon Si Thammarat and Yala. It has been taken in Malaya in the states of Perak, Selangor, and Negri Sembilan. It also occurs in Southern China and Formosa.

Remarks: This is an aquatic frog that is almost never seen outside of water. Usually the frogs are partly submerged among rocks or debris in rivulets or streams in mountains up to 1400 meters and perhaps higher. When disturbed the animal takes refuge under a submerged stone, hides in soft mud, or enters holes of fresh-water crabs which are usually available. While younger specimens seem plentiful, fully adult specimens are more rarely taken.

Rana hascheana (Stoliczka)

FIG. 48

Polypedates hascheanus Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 147, pl. 9, fig. 3 (type locality).

Rana gracilis var. *andamanensis (part.)* Stoliczka, *ibid.*, 1870, p. 142.

Rana hascheana Sclater, Proc. Zool. Soc. London, 1892, p. 344; Flower, Proc. Zool. Soc. London, 1899, pp. 894-895; Laidlaw, Proc. Zool. Soc. London, 1900, p. 885; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 197; Boulenger, A vertebrate fauna of the Malay Peninsula from the Isthmus of Kra to Singapore . . . Reptilia and Batrachia, 1912, pp. 232-233; Rec. Ind. Mus., vol. 20, 1920, pp. 54-55. M. Smith, Rec. Ind. Mus., vol. 31, 1929, p. 77; Bull. Raffles Mus., no. 3, 1930, pp. 100-101.

Rana limborgii Sclater, Proc. Zool. Soc. London, 1892, p. 344, pl. 24 (type locality, Tenasserim); Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 56-57; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, p. 165 (Maprit and Klong Bang Lai, Prachuap Khiri Kahn); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 3, May, 1917, p. 228 (peninsular and northern Siam).

Diagnosis: A small frog, maximum length of females about 38 mm. snout to vent; of males about 35. No vocal slits or vocal sac evident in males; series of dim elongate dorsolateral tubercles that sometimes suggests a broken dorsolateral fold; tongue small, bifid, free posteriorly for one fourth of its length; sides of throat wrinkled longitudinally in males; tibiotarsal articulation to front of eye; diameter of tympanum (2.9 mm.) smaller than eye length (3.6 mm.); first finger shorter than second or equal in length; toes one-third or less webbed, tips scarcely dilated; eggs large, few, unpigmented, three millimeters in diameter.

Description of species (from No. 36110, Doi Suthep, about 3000 ft. elevation): Head rather pointed oval; canthus rostralis distinct, rounded; eye small, its length little greater than its distance from nostril; latter only slightly closer to tip of snout than to eye; interorbital space considerably greater than width of eyelid in males,

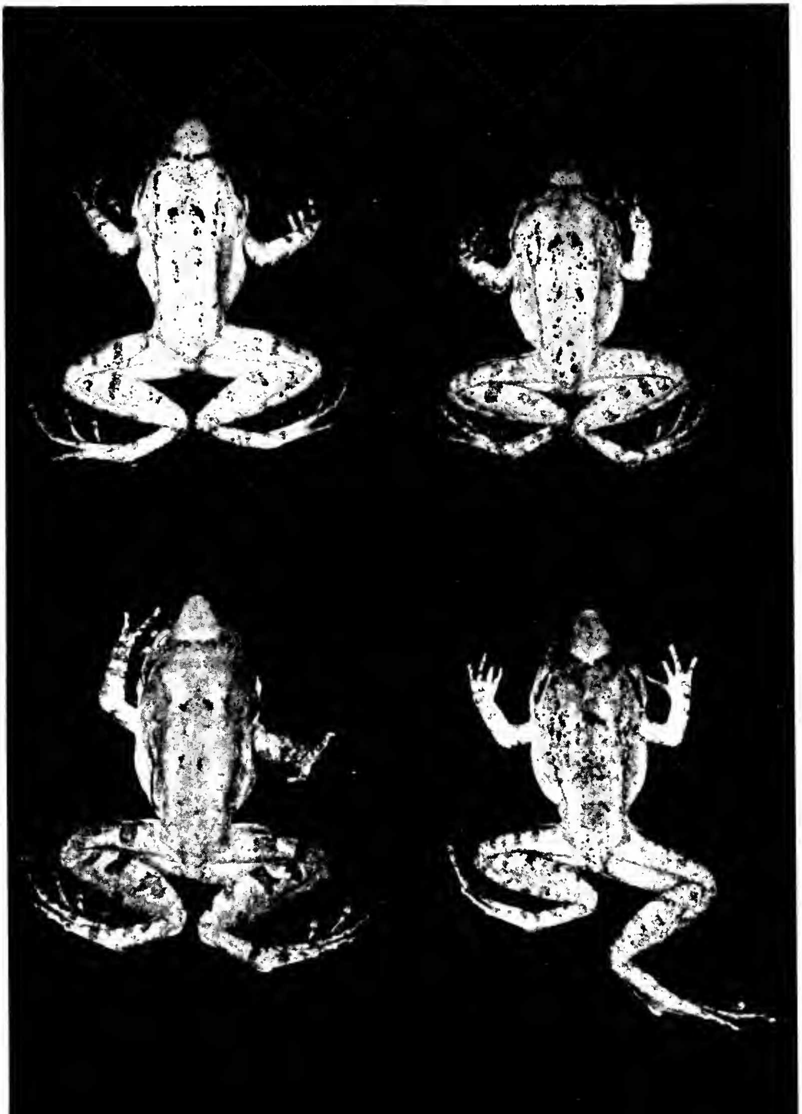

FIG. 48.—*Rana haschcana* (Stoliczka). Upper left, No. 35968. Actual snout-vent length, 33 mm. Upper right, No. 35969, length, 31 mm. Lower left, No. 35920, length, 34.5 mm. Lower right, No. 36106, length, 33 mm. All from Doi Suthep, elevation *circa* 3000-3500 feet, Chiang Mai, Thailand. (All males.)

less in females; occipital region slightly swollen; well-defined curved supratympanic fold from eye to near arm-insertion passing along edge of tympanum; loreal region oblique, then rounding under upper jaw; snout projecting one and one-half millimeters beyond mouth; tympanum somewhat smaller than eye.

Vomerine teeth in two oblique ridges extending back from line within hinder edge of choanae, separated from its fellow by distance nearly equal to length of one ridge; openings of palatal glands very close to front edge of palate; space between front of choanae and palate small, strongly vertical; tongue rather small, bifid, free behind for one fourth of its length; apparently no vocal sacs or slits, however, skin under jaws longitudinally wrinkled. Arm short, fingers reaching beyond tip of snout; first and second fingers equal or first slightly less; digits not or scarcely widened at tip; leg with tibiotarsal joint reaching slightly in front of eye; slight tarsal fold; prominent strong inner metatarsal tubercle; no outer; subarticular tubercles weak; tips of toes with small discs; toes less than one-third webbed.

Skin on top of head, occipital region, and sides of head smooth; back with a dorsolateral row of elongate tubercular ridges suggesting a broken dorsolateral fold; pair of tubercles just back of occiput, and other tubercles scattered on back; sides with smooth flat granules; small fold on breast limiting throat folds; venter with transverse wrinkles; front and underside of thighs smooth, except mesially where there is a large patch of flat granules lateral to and behind vent. A few scattered black-topped tubercles on tibia.

Color in life: Body usually yellowish or yellowish brown; an area on snout lighter than occiput; an indistinct band between eyes; side of snout blackish, with three spots more or less separated by yellow-cream areas; area in front of tympanum light, with dark spot above tympanum; lower jaw indefinitely marked with darker spots; venter and chin yellow; under thighs and concealed parts of limbs yellowish or cream; a faint dark mark (often W-shaped) on shoulders with other dark brown or blackish flecks on dorsum; thigh and tibia barred with brown, spots not continuous when leg is folded; sole of foot and tarsus purplish.

Variation: The four specimens figured suggest the variation in markings that obtains in this species. I have followed Malcolm Smith in regarding *Rana limborgii* Sclater a synonym.

Distribution: In Thailand the species is known from Chiang Mai, and Chumphon provinces. It is probably much more widely spread

Measurements in mm. of *Rana hascheana*

Number	36110	36109	36107
Sex	♂	♂	♂
Snout to vent	34	34	32
Snout to arm-insertion	18	18	14
Axilla to groin	13	13	11.5
Width of head	16.8	16	13.5
Length of head	14.8	14	13.8
Arm	19	20	18.2
Leg	54.3	56	50
Tibia	19	19.3	16.2
Foot and tarsus	24	24	22

but the solitary habits and the fact that it occurs at high elevation makes it rather difficult to obtain.

The species occurs in India, Burma, Malaya, and Viet Nam.

Remarks: In 1958 I found this frog plentiful on Doi Suthep, Chiang Mai during the month of June. Males were calling through the forest, their cry sounding very much like a crow-call, *caw-caw*, the syllable repeated twice. The animal is actually on the ground under leaves, but the sound they make seems to come from everywhere. It was indeed first mistaken for the call of a crow, and thought to be in the forest trees.

The frogs are very shy and the least noise seems to cause them to stop their calling for some time. When a specimen is finally located in some limited area one has to move the leaves carefully, for when uncovered the frog usually escapes with long rapid leaps. The males usually are found to be calling from shallow pits, often with rims above the surrounding surface, which they have dug out and rounded. In several cases a second cup was in the immediate vicinity in which were found freshly laid eggs, older eggs with tadpoles, or young transformed frogs of very small size sitting on the edge of the cup.

This species of *Rana* has what amounts to direct transformation, since the tadpole stage is undergone in the egg, and there is no free swimming stage.

A set of relatively freshly-laid eggs were left on May 28 with Mrs. Birgit Degerbøl Hansen at the Forest Experimental Station on Doi Suthep near Chiang Mai, who kindly agreed to watch their behavior since I was scheduled to leave Thailand. The mud cup in which the eggs were laid was transferred to a glass container. At this time the eggs consisted of round masses of unpigmented yellow yolk in large round clear masses of jell, each more than a centimeter in diameter. Concerning the lot Mrs. Hansen * has made the following notes:

"June 2. There are small thin yellow larvae to be seen riding on top of the yolk like thin threads, which can move a little when touched. One fixed in formalin and later transferred to alcohol.

"June 4. Larvae still small compared to the mass of yolk which is now covered with visible blood vessels. Small knotlike processes present that show beginning of limbs behind the head, and at the site of future legs.

"June 7. Noticeable growth of larvae. The tail is elongated and can be beaten vigorously. The hind leg protuberances are now distinct. One fixed at this stage.

"June 12. Legs are growing but as yet are not leg-shaped.

"Between June 12 and June 20 we were away from headquarters. On our return the tadpoles were quite dry (still in the earth cup in the glass jar) except for the 'egg slime'. As soon as a little water was added they began moving their elongate tails rather rapidly. They now have both the front and hind legs, that is, they now have the shape and appearance of true legs; there is still the long tail and much of the yellow yolk is present. They move usually only when disturbed and all remain still in the cup.

"June 21. Limbs growing fast, the tail now diminishing. The unpigmented yolk, partly surrounded, now looks like a big yellow stomach.

"June 25. Now three of them have only a small curved tail which is not used for body movements. They can now hop about. One fixed.

"June 28. Tail now almost gone. One fixed (it is less than one centimeter long). One was found dead. This was preserved.

"July 8. The last two frogs were found dead. These were preserved."

Another species, *Rana opisthodon* Boulenger belonging to the subgenus *Discodeles*, is reported as dispensing with the ordinary type of life history, the young emerging from the eggs, which are laid in moist crevices of rocks close to the water, in perfect condition with limbs and without a vestige of a tail. The eggs measure 6 to 10 millimeters in diameter.

The species *Rana hascheana* Stoliczka has always been regarded as belonging to *Rana, sensu strictu*. If this association is correct

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* I wish to express my keen appreciation to Mrs. Hansen for having made these important observations on this erratic *Rana* species.

this mode of life history has probably been developed quite independently.

Rana erythraea (Schlegel)

FIGS. 49, 50

Hyla erythraea Schlegel, Abbildungen neuer oder unvolständig bekannter Amphibien . . . 1837, p. 27, pl. 9, fig. 3 (type locality, Java).

Limnodytes erythraeus Duméril and Bibron, Erpétologie Générale . . . vol. 8, 1841, p. 511, pl. 88, fig. 1; Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1062.

Hylarana erythraea Tschudi, Mem. Soc. Sci. Nat. Neuchâtel, vol. 2, 1839, pp. 37, 78; Günther, The reptiles of British India, 1864, p. 425; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 1882, pp. 65-66, fig. a; The fauna of British India, Ceylon, and Burma; Reptilia and Batrachia, 1890, pp. 460-461; Flower, Proc. Zool. Soc. London, 1896, p. 902, pl. 45, fig. 2; *ibid.*, 1899, p. 895; Laidlaw, Proc. Zool. Soc. London, 1900, p. 885; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 198; Van Kampen, Nat. Tijdschr. Ned.-Indie, vol. 69, 1909, p. 35; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 241-242; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 4, Dec. 1915, p. 249; (Klong Yai and Ok Yam, Trad province); *ibid.*, vol. 2 no. 2, Dec. 1916, p. 167 (Nakhon Si Thammarat and Narathiwat provinces): *ibid.*, vol. 2, May, 1917 (Bangkok); *ibid.*, vol. 2, no. 4, Dec. 1917, p. 267; Boulenger, Rec. Ind. Mus., vol. 20, 1920, p. 152; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 108; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1064, fig. 8 (Loei province).

Diagnosis: Rather large frogs (78 mm.) usually green with broad dorsolateral fold covered with yellow stripe; broad dark stripe on sides of head and body; snout pointed and projecting; fingers slender, first little shorter than second; toes nearly entirely webbed; small discs on digit tips; tibiotarsal articulation to tip of snout; no cross-bars on limbs but often marks paralleling leg present; vocal sac absent; well-defined nuptial pad on first finger of male.

Description of species (from No. 34715, Bhetong, Yala): Body elongate, slender; head longer than wide, snout nearly on level with back; canthus rostralis obtuse, loreal region slightly concave, oblique; eyelid width about equal to interorbital width; length of eye only slightly less than length of snout; tympanum distinct, its diameter equal to five eighths of length of eye, separated from eye by distance equal to about half its diameter.

Choanae rather small, posteriorly placed in palate, visible from below; vomerine teeth in two nearly transverse ridges lying between choanae, separated from them by slightly shorter distance than that between the two ridges; openings of palatal glands in broken groove between front of palate and vomerine teeth but closer to latter; tongue elongate, notched rather deeply behind (male without vocal sacs).

FIG. 49.—*Rana erythraea* (Schlegel). No. 35680. Actual snout-vent length, 67 mm. Ronpibon, Tonka Harbour Tin Mine, Nakhon Si Thammarat, Thailand. (Variety.)

Arm and legs moderately slender. Digits tips widened into small elongate discs each with peripheral groove; first finger not extending beyond second; subarticular tubercles rather large; three metacarpal tubercles, median smallest, three or four supernumerary tubercles on palm; fingers with lateral ridges or skinfolds; legs with tibiotarsal articulation reaching nostril; when legs are folded at right angles to body, heels overlap several millimeters; toes four-fifths webbed, webs reaching discs only as narrow fringe on inner side of digits; small inner metatarsal tubercle, a small rounded outer; no tarsal fold.

Skin above minutely corrugated (seen under a lens); sides with few flattened warts; strongly defined, rather wide, dorsolateral glandular fold from eye to end of rump, distinctly above tympanum,

Fig. 50.—*Rana erythraea* (Schlegel). Upper figure, No. 33424. Actual snout-vent length, 62 mm., Bangkok, Thailand. Lower, No. 35818, length, 64 mm., Khao Chong, Trang, Thailand.

which has no tympanic fold; a second broken glandular fold begins behind tympanum and extends short distance on side; separate gland below and behind tympanum; chin, venter, and part of underside of thighs smooth; part of ventral and most of posterior surface of thigh granular.

Color in life: Above bright green on head and back, the color less intense posteriorly; yellowish stripe from eye covers dorsolateral fold, bordered on each side by blackish line; dark greenish line from tip of snout follows loreal region and side of body to near rump, widening on side. Tympanum brown with somewhat lighter center; upper and lower jaw cream; lateral stripe cream-white; all lower parts pure white; legs grayish or greenish gray with indistinct longitudinal markings indicated; undersurface of foot light lavender.

Measurements in mm.: Snout to vent, 75; width of head, 22.5; length of head, 25.8; arm, 45; leg from vent, 121; tibia, 40; foot and tarsus, 57.

Variation: Young specimens usually fail to show the brilliant green coloring of the adults. Males are much smaller than females, usually under 55 millimeters in length, and the tympanum is slightly larger proportionally. There is some difference discernible in the width of the dorsolateral gland and stripe, and in the length and distinctness of the lateral glandular fold. Males have a flat gland on inner lower surface of arm, while the chin, breast, and part of venter has glandular skin, the minute glandules appearing as flecks of yellowish white below the surface of the transparent skin.

Distribution: The species is widely distributed in Thailand, in the lowlands. I have taken it in the following provinces, always in the immediate vicinity of water: Chiang Mai, Nong Khai, Loei, Ubon, Phatthalung, Nakhon Si Thammarat, Trang, and Yala.

It has been reported from Trad and Narathiwat; also Bangkok. It is known also in Burma, Malaya, and in the Indo-Australian Archipelago; Negros and Panay in the Philippine Islands.

Remarks: Adults are usually to be found in water, the top of the head showing. Occasionally I have found specimens in shrubs beside pools. At one such place the frogs seemed to be reluctant to leave the shrub and hopped about in the branches rather than jump into the water.

The species is probably related to *Rana macrodactyla.*

Rana macrodactyla (Günther)

FIG. 51

Hylorana macrodactyla Günther, Catalogue of the Batrachia Salientia, 1858 (1859), p. 72, pl. 2, fig. C (type locality, Hong Kong [restricted]); The reptiles of British India, 1864, p. 424.

Rana trivittata Hallowell, Proc. Acad. Nat. Sci. Philadelphia, 1860, p. 504 (type locality __________).

Hylorana subcaerulea Cope, Proc. Acad. Nat. Sci. Philadelphia, 1868, p. 140. (type locality, Rangoon, Burma).

Rana macrodactyla Boulenger, Catalogue of the Batrachia Salientia s. Ecaudata, in the British Museum, 1882, p. 54; The fauna of British India, Ceylon, and Burma; Reptilia and Batrachia, 1890, p. 455; Flower, Proc. Zool. Soc. London, 1899, p. 895; Laidlaw, Proc. Zool. Soc. London, 1900, p. 885; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, pt. 2, Oct., 1903, p. 198; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 238-239; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec., 1916, p. 167 ("Bangnara, Patani" [= Narathiwat, Narathiwat]); *ibid.*, vol. 2, no. 3, May, 1917, p. 228 (widely distributed not uncommon, found in Bangkok); *ibid.*, vol. 2, no. 4, Dec., 1917, pp. 265-266, pl. figs. 3, 3a, 3b; Boulenger, Rec. Ind. Mus., vol. 20, 1920, p. 155; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 108; Cochran, Proc. U. S. Nat. Mus. vol. 77, 1930, p. 5 (Bangsoon, near Chumphon); *ibid.*, Metcalf, vol. 87, 1940, p. 540 (Trang).

Diagnosis: A very slender frog, the digits elongate, first finger not longer than second; pair of narrow white or cream stripes following narrow dorsolateral glandular fold; tympanum distinct, nearly as large as eye; toes and foot elongate, half webbed; two metatarsal tubercles; no vocal sacs; a glandular lateral fold.

Description of species (from No. 34925, Ubon): Body slender, foot large elongate; head slender pointed; nostril much closer to tip of snout than to eye; canthus rostralis rounded, loreal region oblique somewhat concave behind nostril; tympanum large, its greatest diameter (4.5 mm.) less than length of eye (5 mm.); tip of snout extending beyond mouth; width of eyelid less than interorbital width.

Choanae rather large, situated posteriorly, close to orbits, visible when seen from below; vomerine teeth on oblique ridges beginning near inner anterior edge, and lying almost completely between and anterior to posterior level of choanae; palatal glands opening in a straight groove equidistant between front of palate and anterior level of vomerine tooth ridges; tongue elongate, well-notched behind; vocal sac absent.

Arm slender, fingers long, first distinctly shorter than second; three metacarpal tubercles, median largest; subarticular tubercles well developed; tips of fingers swollen into small discs lacking peripheral groove; legs long and slender; tibiotarsal articulation reaches beyond tip of snout; when legs are folded at right angles

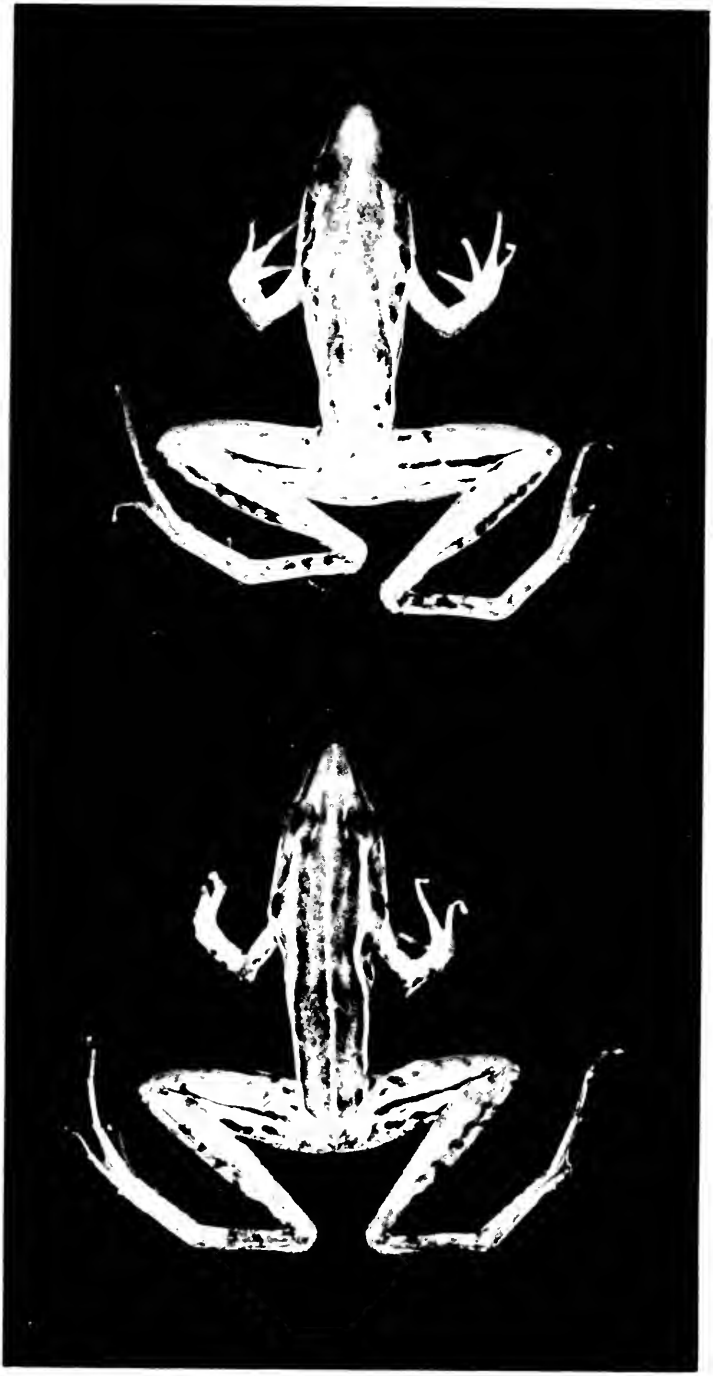

FIG. 51.—*Rana macrodactyla* (Günther). Upper, No. 34926 ♀. Actual snout-vent length, 39 mm. Lower, No. 34925 ♀. Actual snout-vent length, 39 mm. Ubon, Ubon, Thailand.

heels overlap five millimeters; toes with small discs bearing peripheral grooves; toes about one-half webbed, web reaching to near discs as fine fringe on some of inner fingers; outer metatarsal separated by web; small inner metatarsal tubercle and smaller outer; no tarsal fold; subarticular tubercles well developed.

Skin smooth on head, dorsum, and upper part of limbs; chin and venter smooth; sides with few flat warts; median ventral and posterior face of thigh with regular granulation or areolation; dorsolateral glandular fold, and a broken lateral fold beginning behind tympanum extends along sides to near groin.

Color: Above olive to bronzy-brown with narrow median light-cream line, and dorsolateral cream lines from eye to groin covering dorsolateral glandular folds; on sides numerous small brownish spots, the lateral fold below them white; arms and legs light brownish with transverse cream line on thighs bordered above and below with a transverse brown line; below this line brown spots often coalescing; tibia brown with spots of darker brown on anterior face; tympanum light-brown with lighter center; dark band from tip of snout to eye crossing loreal region.

Measurements in mm. (Nos. 34925-34926, Ubon): Snout to vent, 39, 39.5; width of head, 11, 11.3; length of head, 16.2, 16; arm, 22, 22; leg, 76, 75.5; tibia, 23, 24; foot and tarus, 33, 36.3.

Variation: Most of the differences that obtain are color variations. However, most of the specimens conform to the described pattern.

Distribution: The species which is usually a lowland form, has been taken in Chiang Mai, Loei, Nong Khai, Ubon, Chon Buri, Chumphon, Phatthalung, Narathiwat, and Trang provinces.

Specimens were taken by me in Loei Province on the summit of Phu Kading at about 5000 ft. elevation. Elsewhere, I have found them only in lowlands.

Remarks: The species is most commonly found in rice fields and swampy places. It is especially active and capable of making long leaps, thus difficult to catch. M. Smith (Dec., 1917) states: "I know of some half dozen spots [around Bangkok] from where I can obtain as many specimens as I wish, but the rest of the country, although not differing apparently in any way, seems to be entirely devoid of them."

I propose to restrict the type locality to Hong Kong.

Rana cubitalis M. Smith

FIG. 52

Rana cubitalis M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, p. 277 (type locality, "Doi Nga Chang, Thailand, 1600 ft. elev."); Boulenger, Rec. Ind. Mus., vol. 20, June 1920, pp. 138; 139 (redescription of type?); M. Smith, Rec. Ind. Mus., vol. 26, 1925, p. 138 (tadpole); * Bull. Raffles Mus., no. 3, 1930, pp. 94, 103-104, fig. 5 (Nakhon Si Thammarat; Karen Hills, Burma); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1058-1060, fig. 5 (Na Haeo, Dan Sai, Loei province, Thailand).

Rana (Hylarana) cubitalis Bourret, Les Batraciens de l'Indochine, 1942, pp. 316-317, fig. 92.

Diagnosis: Moderately slender, elongate frogs, reaching a length of approximately 75 mm. in females; narrow dorsolateral glandular fold; toes about four-fifths webbed, webs not reaching discs on inner sides of second, third, and fourth toes; digits with small but distinctly widened discs; tibiotarsal articulation reaches two to five millimeters beyond tip of snout; strongly defined brown diagonal spot covers tympanum; dark line borders canthus; vomerine teeth on two ridges diagonally placed between large choanae. Male with large nuptial gland on inner face of forearm; a flat conspicuous gland in front of arm-insertion.

Description of species (from No. 31748, Na Haeo, Dan Sai district, Loei province): Snout obtusely pointed, slightly longer than eye; sharp canthus rostralis; loreal region nearly vertical above jaw, distinctly concave; nostril much nearer tip of snout than to eye; jaw below eye and tympanum with distinct elevation or ridge; width of upper eyelid equals interorbital width; tympanum distinct its diameter (6.2 mm.) distinctly less than eye length (8 mm.), its distance from eye about equal to its diameter.

Choanae rather large, vomerine teeth on two oblique ridges between choanae, but extending behind their posterior level, separated from each other by distance equal to their distance from choanae; tongue large, with two prominent posterior horns, free for little more than half its length; (males with vocal sac, the openings small, in floor of mouth behind level of tongue).

Skin finely granular with few small scattered tubercles above posteriorly; sides similar, but with an irregular row of larger granules; distinct narrow dorsolateral fold beginning behind eye runs to near level of vent; chin and venter smooth; skin of upper arm coarsely granular; underside of thighs coarsely and regularly granular; posterior face of thigh with larger and smaller granules intermixed; front face of thighs smooth.

* Malcolm Smith states that Boulenger's redescription (Records Indian Museum, vol. 20, 1920, pp. 138-139), is not of the type (Smith No. 2836, B. M. No. 1919.3.28.5), but of another specimen.

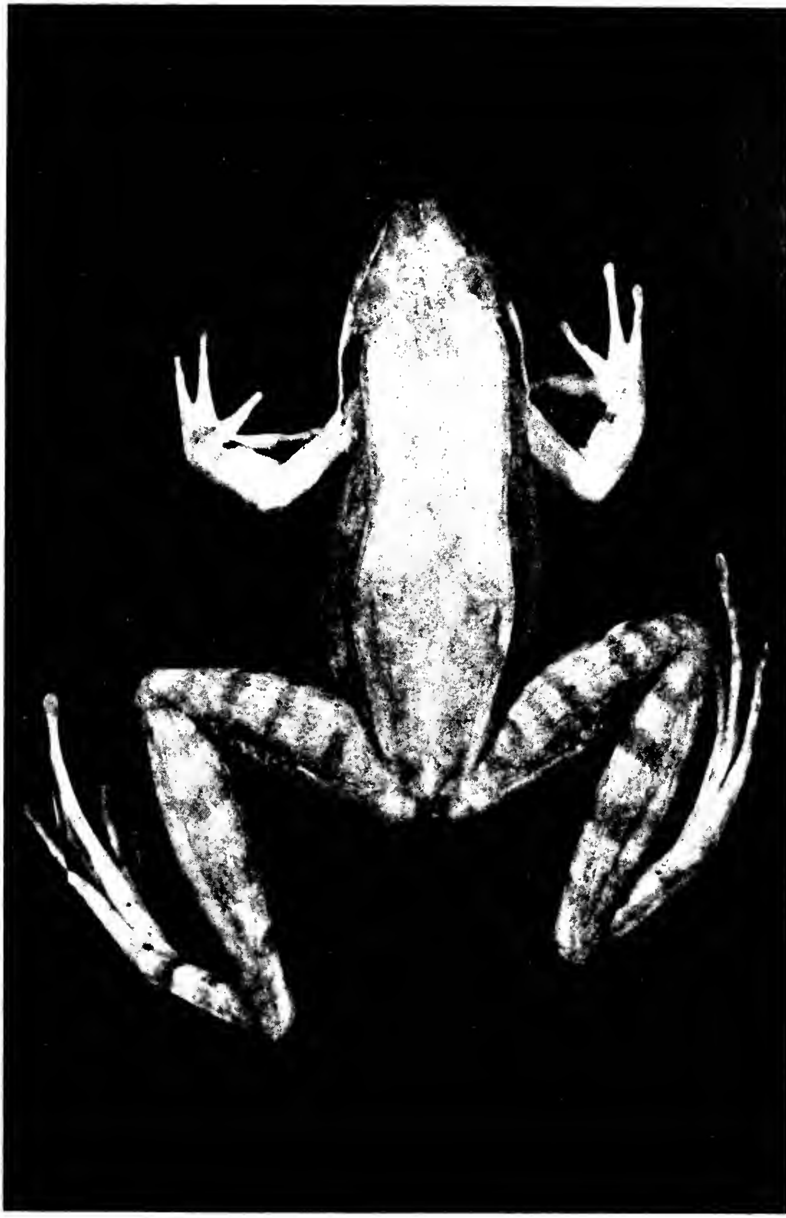

Fig. 52.—*Rana cubitalis* M. Smith. EHT-HMS No. 31748 ♀. Ban Na Muang, Na Haeo (village), Dan Sai (district), Loei (province), Thailand. Actual snout-vent length, 76 mm.

Arms and legs long, slender; digit tips expanded into small but distinct discs, each disc with peripheral groove; hand with three metacarpal tubercles, inner largest; first finger distinctly longer than second; subarticular tubercles distinct; toes about four-fifths webbed, web not reaching discs on inner side of second to fourth toes; outer metatarsal separated by web; tibiotarsal articulation reaches a centimeter beyond tip of snout; compressed inner metatarsal tubercle and well-defined low conical outer tubercle; subarticular tubercles prominent; when legs are folded at right angles to body heels overlap strongly.

Color: Above light fawn, nearly uniform on head and on body between dorsolateral folds; strongly defined dark diagonal mark behind eye including tympanum (but tympanum medium brown rather than black); dark line from eye to eye around front of snout below canthus rostralis; a few brown flecks on jaws and diagonal dark mark below arm-insertion (where, in the male, there is a well-defined gland); some dark marks on underside of arm; legs with light-brown bars, the bars continuous when legs are folded; dark mark about vent; four blackish spots under tibia and several along front of thighs; undersurface of tarsus and foot dark purplish lavender.

Measurements of *Rana cubitalis*

Number	31748	31747	32062
Sex	♀	♀	♀
Snout to vent	73	74	62
Width of head	24.4	23.2	21
Length of head	26	26	23.1
Arm	41.5	41	36
Leg (from vent)	126	137	103
Tibia	44	43.2	36
Foot and tarsus	54.2	62	44

Variation: In younger specimens the black marks on the body are more sharply defined. The upper eyelids are rugose posteriorly and the tympanum is proportionally a little larger.

The males have internal vocal vesicles. There is a nuptial pad on the first finger extending as a broad band along the inner side of the forearm and expanding into a large rounded gland on inner side of elbow. An oval flat gland is present on each side of the breast in front of the base of arm.

The color of the type is described as being light olive (grayish in alcohol) above and on sides with an irregular chain of small black spots along each flank. The limbs have dark crossbars, and the posterior surface of thighs are marbled with dark brown, the venter being whitish. A dark streak is present along the canthus rostralis, and there are dark spots on the lips. The tympanum is dark brown.

Distribution: Besides the type locality, the species is known from Na Haeo, Dan Sai district, Loei province, which is the source of the three measured specimens. It has been taken also in the Karen Hills of Burma, and in the mountains of Nakhon Si Thammarat.

Remarks: The species is said to be most closely related to *Rana guentheri* Boulenger. In profile it resembles strongly an Indian species *Rana leptoglossa* Cope.

Rana miopus Boulenger

FIG. 53

Rana humeralis * M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, pp. 148, 167 (not of Boulenger); *ibid.*, vol. 2, no. 3, May, 1917, p. 229 (Nakhon Si Thammarat).

Rana miopus Boulenger, Journ. Nat. Hist. Soc., Siam, vol. 3, no. 1, Nov., 1918, pp. 11-12 (type locality, Khao Wang Hip, Nakhon Si Thammarat); Rec. Ind. Mus., vol. 20, 1920, pp. 148-149; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 273 (Pahang, Malaya); Bull. Raffles Mus., no. 3, 1930, pp. 105-106 (Kuala Tembeling and Kuala Tahan, Pahang; Chikus Forest Reservoir, Perak).

Rana lateralis (non Boulenger) Laidlaw, Proc. Zool. Soc., London, 1900, p. 886, pl. 67, figs. 1, 2 (Kwala Aring, Ulu Kelantan); Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Amphibia, 1912, pp. 239-240 (*part.*); Butler, Proc. Zool. Soc., London, 1902, p. 189; Boulenger, Fasciculi Malayenses, Zoology, 1903, p. 172 ("Biserat, Jalor, Siam"); Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 201; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 24.

Rana (Hylarana) miopus ** Bourret, Les Batraciens de l'Indochine, 1942, pp. 326-327, fig. 92 ("Biserat, Jalor, Siam").

Diagnosis: Body slender, the head slightly wider than body; strong dorsolateral folds; tympanum distinct, as large as eye in male; strong humeral glands; external vocal sac; first finger longer than second; no lateral band on side of head; elongate, somewhat widened discs on digits; toes at least three-fifths webbed; fine diagonal glandular ridges (left to right) on back.

Description of species (from EHT-HMS No. 136 Kuala Tahan, King George V National Park, Pahang): Length of head little greater than width; snout with distinct, somewhat rounded canthus rostralis extending forward beyond nostrils; tip rather pointed,

* The record of *Rana humeralis* Boulenger published by M. Smith must be eliminated from the Thai fauna. The specimen on which the record was based has been made the type of *Rana miopus*.

** The specimen figured fails to show the distinct diagonal lines of *miopus*, mentioned in the text.

FIG. 53.—*Rana miopus* Boulenger. EHT-HMS No. 136. Actual snout-vent length, 71 mm. Kuala Tahan, King George Nat. Park, Pahang, Malaya.

then sloping back and downwards to mouth; snout reaching two millimeters beyond mouth; loreal region sloping obliquely, concave; width of an eyelid a little greater than interorbital width; tympanum large, its diameter (7.2 mm.) slightly less than length of eye (7.8 mm.); two external vocal sacs behind and below mouth-angles, indicated externally by numerous short folds.

Vomerine teeth in two diagonal ridges arising from anterior inner edge of small choanae, directed obliquely backward behind level of choanae and separated by a distance little less than length of one ridge; palatal glands open into mouth through four small openings in middle of palate, about equidistant from level of choanae and front of palate; tongue large, strongly forked behind, free for two fifths of its length; vocal slits small, puckered, back near angle of mouth.

Arms strong, first finger distinctly longer than second with noticeable nuptial pad on upper surface of first finger, and another above strong inner metacarpal tubercle; latter larger than median or outer metacarpal tubercles; subarticular tubercles distinct; no supernumerary tubercles; terminal discs scarcely developed, legs moderately long, tibiotarsal articulation reaches a little in front of eye; when legs are folded at right angles to body heels overlap five millimeters; toes with terminal discs somewhat widened and elongated, rather pointed, with peripheral grooves on sides of discs; subarticular tubercles strong, somewhat elongated; strong inner metatarsal tubercle and small outer; sole with a few small granules; inner toes about three-fifths webbed, a little more on third and fifth toes; fourth toe elongate, slightly less than length of tibia.

Skin above with very numerous fine pearl-tipped pustules, nearly smooth on snout; pair of well-developed dorsolateral folds from eyes to groin; several fine diagonal ridges running across back; sides smooth except in area posterior to tympanum; venter and part of underside of thigh smooth, with indication of small breast fold; posterior part of underside of thigh and much of posterior surface with minute regular granules; on dorsal surface granules pustular, and a little longer.

Color: Above gray-olive on head and body with some indefinite darker streaks following diagonal ridges; sides dirty yellowish-white, but olive behind tympanic area; arms lighter, dimly barred; legs dimly barred; on back of thigh, a fine dark reticulation on a yellowish ground color; sole and underside of tarsus and toes dark lavender. Entire under surface yellowish white.

Measurements in mm. of *Rana miopus*

Number	136	135	Type
Sex	♂	♀	♀
Snout to vent	71	67	73
Head length	26	25.6	25
Head width	25	23	25
Arm	44.2	41	46
Leg	115	104	108
Tibia	38	34	35
Foot and tarsus	53	47.2	....
Fourth toe	36	32.3	....

Variation: Boulenger gives the color of the type as: "grayish above with pink patches on the back, sides, and limbs and with large blackish blotches on the limbs with indistinct cross-bands; hinder side of thighs black, speckled and vermiculated with white."

The second specimen (No. 135) also a female, differs in coloration in having the loreal and tympanic areas dark-olive with a black line from eye above tympanum which widens into a diagonal black blotch behind tympanum. A black mark in the position of the humeral gland of male, and some small black spots in the groin. The limbs are rather distinctly barred. There is a black area about the vent and very dark discrete spots on back of tibia. The thighs are black posteriorly. On the back there are some diagonal markings; the tibiotarsal articulation reaches about halfway between the eye and nostril. The vomerine teeth-ridges are very slightly diagonal.

Distribution: The species is known only from the type locality in Nakhon Si Thammarat, Thailand. In Malaya, specimens have been taken in the states of Pahang and Perak.

Remarks: The presence of diagonal ridges on the bodies of these frogs is unusual since it represents a marked asymmetry.

Rana nicobariensis nicobariensis (Stoliczka)

FIG. 54

Hylorana nicobariensis Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 150, pl. 9, fig. 2 (type locality, Nicobar Islands).

Rana nicobariensis Boulenger, Ann. Mag. Nat. Hist., ser. 5, vol. 16, 1885, p. 389; The fauna of British India, Ceylon, and Burma; Reptilia and Batrachia, 1890, p. 459; Ann. Mag. Nat. Hist., ser. 6, vol. 8, 1891, p. 291; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 20; Boulenger, Journ. Federated Malay States Mus., vol. 3, 1908, p. 62; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia (*part.*), 1912, pp. 240-241; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 108 (Nakhon Si Thammarat); Boulenger, Rec. Ind. Ind. Mus., vol. 20, 1920, pp. 162-165.

Rana javanica Annandale, Journ. Federated Malay States Mus., vol. 7, 1917, pp. 108, 109 (Jalor Caves, Biserat, peninsular Siam).

Rana erythraea var. *elongata* Werner, Jahresb, Nat. Ver. Magdeburg, 1892, p. 253 (type locality, Nias).

Rana lemniscata Boettger, Zool. Anz., 1893, p. 337.

Rana nicobariensis nicobariensis Inger, Fieldiana Zool., vol. 33, 1954, pp. 331-334 (*part.*)

Diagnosis: A small slender frog (55 mm.); very fine dorsolateral glandular fold; dorsal skin very finely granular (sometimes nearly smooth in gravid females); canthus rostralis distinct; width of interorbital space greater than width of upper eyelid. Tympanum distinct; small but distinct discs on digits; first finger longer than second; inner and outer metatarsal tubercle present; heel to tip of snout; dark stripe on side of head and body; uniform white, or brown spotted on venter.

Description of species (from M. Smith No. 6163 [F 44], Nakhon Si Thammarat): Head longer than broad, snout more or less pointed, equal or longer than diameter of orbit; canthus rostralis distinct, side of head nearly vertical, loreal region somewhat concave; tympanum distinct, its diameter (3 mm.) two thirds to three fourths that of eye, separated from eye by distance equal to about one third diameter of tympanum; nostril nearer tip of snout than to eye.

Choanae rather large, elongate, with vomerine teeth on two diagonal ridges beginning near upper level of choanae but not reaching beyond their posterior level, separated from each other by a distance equal to length of one ridge; tongue elongate, slender, free for about one fourth of its length; (male with vocal sac and flat oval gland on inner side of arm); skin shagreened above on head and dorsum; sides with coarser granules; fine dorsolateral glandular fold from eye to above groin; sides of shoulders, chin, venter, and underside of limbs smooth; limbs slender, all digits widened at tips into distinct discs with a groove around periphery; fingers slender unwebbed, first finger longer than second; all fingers with slight lateral ridges extending to discs; two metacarpal tubercles; toes at least two-thirds webbed, web continuing as very narrow fringe to discs; compressed elevated inner metatarsal tubercle, small rounded outer; no tarsal fold; tibiotarsal articulation reaches between eye and nostril; when legs are folded at right angles to body heels overlap about five millimeters.

Color: Above grayish to reddish brown, nearly uniform on head; back with indistinct darker and lighter markings; dark-brown stripe from snout along side of head covering tympanum and reaching some distance on side; labial region yellowish, with fine dusting of

FIG. 54.—*Rana nicobariensis nicobariensis* (Stoliczka). M. S. No. 6163 ♀. Actual snout-vent length, 41 mm. Nakhon Si Thammarat, Thailand.

pigment; three yellow glands behind lower level of tympanum; sides, chin, venter, and underside of limbs with indistinct darker marks formed of fine pigment flecks; arms and legs barred; underside of foot dark.

Measurements in mm.: Snout to vent, 41; width of head, 11; length of head, 15; arm, 25; leg, 67; tibia, 22.5; foot and tarsus, 34.

Distribution: In Thailand the species has been found in the province of Nakhon Si Thammarat, the described specimen being from this locality. Outside of Thailand the species is known in the Nicobar Islands, Malaya, and the larger and some small islands of the Indo-Australian Archipelago. It is replaced in the Philippines by two related forms: *suluensis* and *sanchezi*. A subspecies occurs in Java. Its presence on small islands suggests that it may have considerable tolerance to salt-water.

Rana chalconota (Schlegel)

FIG. 55

Hyla chalconota Schlegel, Abbildungen neuer oder unvolständig bekannter Amphibien, 1837, p. 24, pl. 9, fig. 1 (type locality, Java).

Lymnodytes chalconotus Duméril and Bibron, Erpétologie Générale . . . vol. i, 1841, p. 513.

Hylarana chalconota Günther, Catalogue of the Batrachia Salientia . . . 1858 (1859), p. 73.

Rana chalconota Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata . . . 1882, p. 66; Rec. Ind. Mus., vol. 20, 1920, p. 201; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 274 (Kuala Teku, Malaya); van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 217; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 109 (unites *chalconota* and *labialis*), (Khao Ram, Nakhon Si. Thammarat); Tasan and Mamoh, Chumphon province.

Rana labialis Boulenger, Ann. Mag. Nat. Hist., ser. 5, vol. 19, 1887, p. 345, pl. 10, fig. 1 (type locality, Malacca); Ann. Mus. Civ. Genova, ser. 4, vol. 14, 1894, p. 617; Flower, Proc. Zool. Soc. London, 1896, p. 903, pl. 45, fig. 3; Peracca, Rev. Suisse Zool., vol. 7, 1899, p. 329; Laidlaw, Proc. Zool. Soc. London, 1900, p. 886; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 199; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 242-243; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 168 (Nakhon Si Thammarat); *ibid.*, vol. 2, no. 3, May 1917, p. 229; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 220; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 5 (Khao Luang, Nakhon Si Thammarat).

Diagnosis: Head longer than broad; body slender with fine distinct even granulation on dorsum; posterior part of venter and underside of thigh with somewhat larger regular granules; toes with widened discs, nearly entirely webbed; discs of fingers larger; dorsolateral glandular fold distinct anteriorly; outer metatarsals separated by web; tibiotarsal articulation to beyond tip of snout; snout longer than eye.

FIG. 55.—*Rana chalconota* (Schlegel). Upper figure, No. 34721 ♀. Actual snout-vent length, 40 mm. Lower figure, No. 34436, length, 44 mm., 15 km. NE Bhetong, Yala.

Description of species (from No. 392 Khao Chong, Trang): Head slender, flattened, body slender, snout pointed, elongate; loreal region nearly vertical, strongly concave; canthus strong, obtuse; nostrils much nearer to tip of snout than to eye; diameter of tympanum four fifths length of eye, which is shorter than snout. Vomerine teeth in two short oblique ridges beginning some distance from inner edge of choanae but extending behind their posterior level, separated mesially by a distance about equal to length of one ridge; choanae large; no vocal sac.

Arm moderate, outer fingers elongate, with strong terminal discs half as large as tympanum; inner fingers short, first less than second. (A pronounced swelling at outer base of first finger in male; another farther forward on first finger, probably nuptial swellings.) Toes four-fifths webbed; discs smaller than on fingers; small inner and smaller outer metatarsal tubercle; no tarsal fold, subarticular tubercles well developed, stronger on hand than on foot; supernumerary tubercles on hand; tibiotarsal articulation reaches half centimeter beyond tip of snout. When legs are folded at right angles to body, heels overlap strongly.

Skin of head and back covered thickly with very small regular granules, those on sides somewhat larger; distinct dorsolateral glandular fold, stronger anteriorly, continuous with straight supratympanic fold; several glandules below and behind tympanum; posterior part of upper jaw somewhat thickened; chin and breast smooth; back part of venter with aerolate granules, greater part of ventral and posterior face of thigh with similar granules; upper surface of limbs nearly smooth; elongate glandular area low on sides.

Color in life: Above olive to olive-brown, darker on top of head; lighter on arms than on legs; narrow blackish mark from tip of snout bordering canthus; chin, venter, and underside of limbs with spots of finely powdered pigment; palms lightly pigmented; soles and web heavily pigmented; back of thigh light-brown with lighter flecking; banding on limbs not discernible; a fine olive reticulation on back of thigh enclosing yellowish flecks.

Measurements in mm. of No. 392 ♀ and 34725 ♂, respectively: Snout to vent, 43.5, 31; axilla to groin, 20, 13.5; snout to eye, 7, 5.6; diameter of tympanum, 4, 3.75; eye length, 6, 4; width of head, 13.8, 10; length of head, 17, 12; arm, 25.5, 21; leg, 71, 56.5; tibia, 25, 19; foot and tarsus, 31.5, 25.

Variation: In the series at hand, the color in life varied from occasional green to greenish olive to bronze-brown above, the sides dull brownish, the tympanum light-brown. The spotting on venter was often very dim, sometimes stronger. The dorsolateral glandular fold is often dim and rarely extends as far as rump.

The largest specimens measure about 55 millimeters snout to vent.

Distribution: In Thailand records for *chalconota* (and *labialis*) are confined to the peninsular part of the country. The species occurs in the following provinces: Prachuap Khiri Khan, Nakhon Si Thammarat, Trang, Phatthalung, Songkhla, and Yala.

Outside of Thailand, the species occurs in Malaya and the Indo-Australian Archipelago.

Remarks: Specimens are usually found during the day sitting along banks of small forest rivulets or streams while at night they are often seen perched on leaves of low plants or in shrubs in wet places.

The vocal sac, in the males, opens through small puckered openings back at the level of the mouth-angle.

Boulenger (1920) says: "I now regard *R. labialis* from the Malay peninsula, as a variety of the typical *R. chalconota* from Java, from which it differs in the usually shorter foot as compared with the tibia, the rather more slender hind limbs, and the smaller sizes; but intermediate specimens completely connect the two extreme forms."

Rana chalconota may easily be confused with the males, especially young males of *Rana hosii.* The resemblance is great.

Rana glandulosa Boulenger

FIG. 56

Rana glandulosa Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 2nd Ed., 1882, p. 73, pl. 7 (type locality, Sarawak); Ann. Mag. Nat. Hist., ser. 6, vol. 8, 1891, p. 291; *ibid.*, ser. 6, vol. 14, 1894, p. 87; Flower, Proc. Zool. Soc. London, 1896, p. 905; Butler, Journ. Federated Malay States Mus., vol. 3, 1905, p. 63 (Kuala Lipis, Malaya, 200 ft. elev.); Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 236-237; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 2, Dec. 1916, p. 167 ("Bangnara, Patani" (=Narathiwat, Narathiwat]); *ibid.*, vol. 2, no. 3, May, 1917, p. 228; Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, p. 146; Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 181-182; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 272 (Fraser's Hill, Malaya); Bull. Raffles Mus., no. 3, 1930, p. 102 (Langsuan, Chumphon).

Diagnosis: Rather large frogs (65 mm.); eyes very large, interorbital distance less than width of upper eyelid; first finger extending beyond second; toes about two-thirds webbed; two metatarsal tubercles; tibiotarsal articulation to eyes or tip of snout. Back and sides covered with large flat glandules; paired vocal sacs; large oval gland on inner side of arm.

Description of species (from No. 1522, Bhetong, Yala): Head rather flat, smooth, without tubercles or glandules except on back of occiput; snout rounded; canthus rostralis distinctly obtuse, loreal region wider than interorbital distance (4.6 mm.); length of eye (8 mm.) equal to snout length (8.05 mm.); tympanum distinct, its greatest diameter (4.6 mm.) less than length of eye; separated from eye by a distance (3 mm.) less than its diameter.

Choanae small visible when palate is viewed from below; vomerine teeth on two short elevated ridges near inner edge of choanae extending somewhat behind level of choanae, separated by a distance equal to length of one ridge; tongue large, bifid posteriorly, free for little more than one third of its length; openings of paired vocal sacs into mouth small, rounded, somewhat puckered; glands of palate open into a short groove slightly in advance of anterior level of choanae.

Arm well developed, when brought forward wrist and part of forearm reaches beyond snout; digits slender, tips dilated into very small discs, only two outer with a peripheral groove; no transverse groove on under surface of disc; subarticular tubercles well developed; four distinct supernumerary tubercles and three larger well-defined metacarpal tubercles, inner largest. A strongly defined gland on front face of upper arm; fingers without trace of web or trace of lateral ridges; first finger distinctly longer than second, slightly larger than fourth, and reaching to base of disc on fourth.

Legs long, tibiotarsal articulation reaching tip of snout or slightly beyond; when legs are folded at right angles to body, heels overlap seven millimeters; first and second toes with only a web remnant, second and third, one third webbed, three outer toes a little less than half webbed; discs a little larger than those on fingers, all with a peripheral groove; two well-developed metatarsal tubercles, outer only little smaller than inner; no tarsal fold; subarticular tubercles large; outer metatarsal separated by web for much of its length; web forming small ridges extending to near discs on most toes.

Skin of head smooth; shoulders, back, sides, upper surfaces of femora, tibiae, and tarsus with very numerous large flat pitted pustules or granules, largest and almost continuous on shoulders and above arm-insertion. Chin, breast, arms, outerpart of under-

FIG. 56.—*Rana glandulosa* Boulenger. No. 1522 ♂. Actual snout-vent length, 62 mm. Bhetong, Yala, Thailand.

side of femur and its anterior face, underside of tibia, and tarsus glassy smooth; skin of venter transversely wrinkled, posterior and undersurface of femur with flat pavementlike irregular granules.

Color in life: Above lavender-gray, with rather indistinct flecking and spotting with dark gray or black. Arms and legs somewhat brownish with dark bands; sides with some whitish flecks; lips with three dark spots separated by brownish-cream vertical marks; chin purplish lavender with some lighter flecks; venter and much of underside of limbs grayish with marbling or reticulation of dark lavender; a lighter median area under femora; posterior face of femora blackish lavender spotted with cream. Eye red.

Measurements in mm. of *Rana glandulosa*

Number	1522	34713	34712
Sex	♂	♀	♀
Snout to vent	62	55	55
Width of head	24.8	20	21
Length of head	25	22.1	22
Arm	41	36	38
Leg	101.4	87	90
Tibia	32	30	29.4
Foot and tarsus	49	41	39

Variation: In most frogs the females are larger than males. It is possible that the female of this species does not reach as large a size as the male since the largest male in the British Museum series is 92 mm., the largest female, 83 mm. Some specimens are reddish brown above in life, while the ventral surface may be whitish or buff, uniform or spotted.

Distribution: In Thailand I have taken specimens in Trang and Yala provinces. It has been reported from "Bangnara, Patani" [= Narathiwat, Narathiwat], and Langsuan, Chumphon province by Malcolm Smith. Elsewhere it is known in Malaya and Borneo.

Remarks: Boulenger (1912) states that: "This is one of the creatures found in the Batu Caves, Selangor, Malaya in total darkness."

The call of this species is very loud, perhaps louder than the calls of other ranas taken in Thailand. I have observed the frog in the act of calling and the vocal sac seemingly is not large. During the day the specimens have been taken from under old stumps or logs.

The specimens I have studied from Thailand have the dorsal and lateral glandular areas much more pronounced than in Boulenger's figure (1882) and the femora and tibia are distinctly barred with black. The legs, too, would appear longer, the tibiotarsal articulation reaching the tip of snout or beyond.

Rana nigrovittata (Blyth)

FIG. 57

Limnodytes nigrovittatus Blyth, Journ. Asiat. Soc. Bengal, vol. 24, 1855, p. 718 (type locality, Mergui, Tenasserim, Burma).

Rana nigrovittata Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 334, pl. 8, fig. 3; Flower, Proc. Zool. Soc. London, 1899, p. 896; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 20; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 242; Smith and Kloss, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 4, Dec., 1915, p. 249. (Two specimens reported from Koh Chang; both unusually large, one measuring 72 mm. snout to vent.); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 1; June, 1916, pp. 37, 42, 43, pl., upper fig.; *ibid.*, pt. 2, Dec. 1916, p. 168 (Klong Bang Lai, Prachuap Khiri Khan); M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 274; Bull. Raffles Mus., no. 3, 1930, pp. 94, 107 (mountains of Nakhon Si Thammarat); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1060-1063, figs. 6, 7.

Diagnosis: A medium-sized frog (average full-grown adult about 60 mm. occasionally reaching 75 mm. *vide infra.*) Tips of fingers swollen into small discs, two outer at least with a peripheral groove; toes with distinct discs, all with a peripheral groove; toes four-fifths webbed; two metatarsal tubercles; supernumerary tubercles and three large palmar tubercles on hand; first finger longer than second; dorsolateral fold thick, distinct; males with gland on outer front base of arm.

Description of species (from No. 12740 ♂, Nakhon Nayok): Snout oval, projecting but little beyond mouth; canthus rostralis somewhat rounded, loreal region slightly oblique, somewhat concave behind nostril; length of eye shorter than length of snout; tympanum large, distinct, its diameter about five eighths of length of eye; separated from eye by distance equal to half its diameter; interorbital width slightly less than width of upper eyelid; occipital region slightly swollen; vomerine teeth in two small elevated groups between choanae, each group about size of choanae, widely separated from choanae and each other, extending somewhat behind hind level of choanae; tongue moderately notched, free behind for little more than one fourth of its length; palatal glands opening into transverse groove between vomerine teeth and front of palate; internal vocal sac, opening (in this specimen) on left side only, back behind level of mouth angle.

Fig. 57.—*Rana nigrovittata* (Blyth). No. 1274 ♂. Actual snout-vent length. 59 mm. Nakhon Nayok, Thailand.

Fingers moderate, first longer than second, tips swollen into small discs, two outer at least, with peripheral groove; three large subequal palmar tubercles and five supernumerary tubercles on outer palm; subarticular tubercles well developed; scarcely a trace of lateral ridges on fingers.

Toes with small well-developed terminal discs, each disc with peripheral groove; toes four-fifths webbed, web failing to reach discs on inner side of second and third toes; well-developed, slightly compressed, inner metatarsal tubercle and small rounded outer; no tarsal fold; subarticular tubercles well developed; no supernumerary tubercles; when legs are folded at right angles to body, heels overlap two millimeters; tibiotarsal articulation reaches slightly beyond tip of snout.

Skin on head nearly smooth; on body fine tubercular granules, intermixed with a few larger tubercles; lateral tubercles large, flat; thick dorsolateral glandular fold passes back from eye to above thigh, not touching tympanum; two glands below and behind tympanum; gland on front base of upper arm (males only). Chin, venter, and underside of limbs smooth; middle and posterior part of undersurface of thigh with fine granules that extend up along side of vent; legs and to a lesser extent arms, with fine tubercular granules.

Color in life: Above olive-brown; head with some darker marbling; some indistinct darker flecks on back; black stripe from snout to eye; tympanum dark, area behind it black, extending to groin as narrow black line on outer edge of dorsolateral glandular fold; sides greenish and grayish white; chin and breast gray-white; underside of thighs with slight yellowish wash; back of thighs yellow-olive with reticulum of black; both limbs more or less banded with olive; webs blackish.

Measurements in mm. (Nos. 1274 ♂, 31772 ♂, 1005 ♀, respectively): Snout to vent, 59, 70, 59; width of head, 24, 31, 22; length of head, 22, 27, 21; arm, 34, 42, 36; leg, 93, 113, 95; tibia, 30.5, 38, 32; foot and tarsus, 42, 51, 42.

Variation: Specimens for the most part follow the scheme of markings here recorded, except that the larger proportion of both males and females have chin, venter, and underside of limbs dark. The outer metatarsal is separated by a web almost to the tarsus.

The expected size of fully grown specimens is about 60 millimeters but occasionally considerably larger specimens appear. M. Smith (Dec., 1915) reports a specimen measuring (snout to vent)

72 millimeters in length; and Taylor and Elbel figure a specimen measuring 70 mm.

Distribution: In Thailand this species is known from the following provinces: Chiang Mai (Doi Suthep); Loei (Phu Kading, 1045 m. elev.); Sakhon Nakhon, (Knok Phu, and Phu Phan, 500 m. elev.); Ubon, (Sanoi River); Nakhon Sayok (mountain near); Chon Buri, near Siracha; Chumphon, (Tasan, near Isthmus of Kra); Nakhon Si Thammarat (mountains).

Outside of Thailand the species occurs in Tenasserim, Burma, Viet Nam, and northern Malaya.

Remarks: This species has been taken along the edge of the lake near Siracha, Chon Buri. A few specimens were found in a small pool at a spring a few yards away from the Sanoi River in Ubon, and others were heard calling during the dry season from rather inaccessible crevices among river boulders. One was captured among rocks in a small stream near the Forest Station in Nakhon Nayok.

In the described specimen the vocal sac had only a single, rather than a double opening into the mouth. This condition is certainly an anomaly.

Rana lateralis Boulenger

FIG. 58

Rana lateralis Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 5, 1887, p. 483, pl. 8, fig. 2 (type locality, Kokarit, east of Moulmein, Tenasserim); The fauna of British India . . . Reptilia and Batrachia, 1890, p. 457; Boulenger, The fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 239-240 (on basis of Laidlaw's report of a specimen from Kelantan, This specimen actually is *R. miopus* fide. M. Smith); Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 3, May, 1917, p. 228; Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 4, Dec., 1917, pp. 266-267, pl.-fig. 1, 1a, 1b, tadpole; Boulger, Rec. Ind. Mus., vol. 20, 1920, p. 96-98.

Diagnosis: A distinct, moderately thick dorsolateral fold; tympanum large, equal to or slightly less than area of eye; upper jaw thickened with white stripe, becoming slightly elevated posteriorly; strong posttympanic tubercle behind mouth-angle; heel to front of eye; eyelid width greater than interorbital width; well-developed gland on arm of males; a pair of well-separated oblique vomerine teeth-ridges betweeen choanae; male with vocal sac and small posterior vocal slits; digits slightly swollen at tips; toes three-fifths webbed; first finger much longer than second.

Description of species (from No. 33817, Doi Suthep, Chiang Mai): Head narrow, longer than wide; snout acuminate much longer than eye, extending beyond lower jaws for two millimeters; loreal region

FIG. 58.—*Rana lateralis* Boulenger. Upper figure, No. 36176 ♂. Actual snout-vent length, 49 mm. Lower figure, No. 36031 ♀. Length, 59 mm. Both from Kaeng Pang Tao. Chiang Mai, Thailand.

oblique, concave. Nostril a little closer to tip of snout than to eye; canthus rostralis sharply defined; diameter of tympanum (5 mm.) slightly less than length of eye-opening, scarcely separated from eye; strongly defined dorsolateral fold beginning behind eye; slight posttympanic fold extends from dorsolateral fold diagonally down behind tympanum crossing its upper posterior border; lower jaw surface thickened posteriorly surface being somewhat elevated behind jaw; behind this a separate tubercle.

Vomerine teeth on two short transverse ridges rising from posterior inner edge of choanae, separated mesially by distance nearly equal to length of one ridge; palatal glands open into short transverse groove, closer to anterior level of choanae than to front of palate; tongue strongly notched behind, free posteriorly for half its length; choanae completely visible when seen directly from below.

Arm with moderately distinct fold or glandular ridge on underside of forearm, first finger longer than second, with indistinct metacarpal tubercles; subarticular tubercles strong; tips of digits slightly swollen at tips but scarcely wider than digits; toes half to two-thirds webbed; very strong, compressed, shovellike inner metatarsal tubercle, and small outer; rather indistinct tarsal fold or glandular thickening on tarsus; tibiotarsal articulation to eye; when legs are folded at right angles to body heels touch but do not overlap. Skin, seen under a lens, finely and evenly roughened by minute corrugations; posteriorly on dorsum, lateral area below dorsolateral line, and upper surface of thigh, with some very small tubercles; tibia with some fine elongated ridges; chin and venter, smooth, or slightly wrinkled; posterior- and undersurface of thigh covered for most part with equal-sized granules.

Color: Above greenish or olive in life becoming light-brown in fixative; sides somewhat darker with dark stripe below canthus rostralis; black diagonal stripe behind posttympanic fold; side darker than dorsum with blackish-edged dark brown spots low on side and in groin; dark stripe or row of black marks on front edge of thigh and tibia; tympanum dark brown; light stripe on upper jaw.

Chin and breast with suggestion of a median light mark; remainder of underside strongly clouded with darker; venter and side of limbs yellowish; hands below light; undersurface of foot and tarsus blackish; dim bands on limbs; black spot near point of arm-insertion where in male a gland occurs; back of thigh dark brown with a few dim light marks.

Measurements in mm.: Snout to vent, 55; length of snout, 9; length of eye, 6; width of head, 22; length of head, 20; arm, 28.5; leg, 75; tibia, 24.5; foot and tarsus, 35.

Variation: No. 33821 is a male with two well-defined black glands on front of arm near insertion; the first finger has two rather well-defined nuptial asperities, one at base the other reaching forward to level of the subarticular tubercle. The thighs are dark brown with white dots or vermiculations; a pair of rounded slits open into the vocal sacs, the slits very far back near corners of mouth.

A female specimen figured shows a black line following the dorsolateral glandular fold for some distance.

Distribution: The species is to be found in northern Thailand, most of my specimens having been taken in Chiang Mai province. A specimen was taken in Kanchanaburi Province near the city of that name. None has been reported from Peninsular Thailand, and it is unknown in Malaya. M. Smith (1917) reports it in central, southeastern and eastern Thailand.

Remarks: I found the species breeding in a recently flooded rice paddy area at Kaeng Pang Tao, Northern Chiang Mai province, June 16, 1958.

Rana aenea M. Smith

FIG. 59

Rana aenea M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, no. 4, July 25, 1922, pp. 210-212, pl. 8, fig. 1 (type locality, Doi Chang, N. Siam, elev. 1500 meters altitude).

Diagnosis: A small species, 38 mm. snout to vent; no bony prominences in lower jaw; canthus distinct; interorbital width less than width of eyelid; tympanum indistinct; first finger as long as second; tibiotarsal articulation reaching beyond snout; toes about two-thirds webbed; no tarsal fold, one metatarsal tubercle only; skin smooth; fine dorsolateral glandular fold beginning behind eyelid, converging towards its fellow on shoulder.

Description of species (from type description): Head broader than long; snout rounded, slightly projecting beyond mouth, as long as orbit; canthus rostralis distinct, loreal region oblique, slightly concave; nostril equidistant from eye to tip of snout; distance between nostrils twice interorbital width, which is less than that of upper eyelid. Tympanum indistinct, less than half diameter of eye, one and one-half times its distance from latter.

Vomerine teeth in small, slightly oblique series, commencing

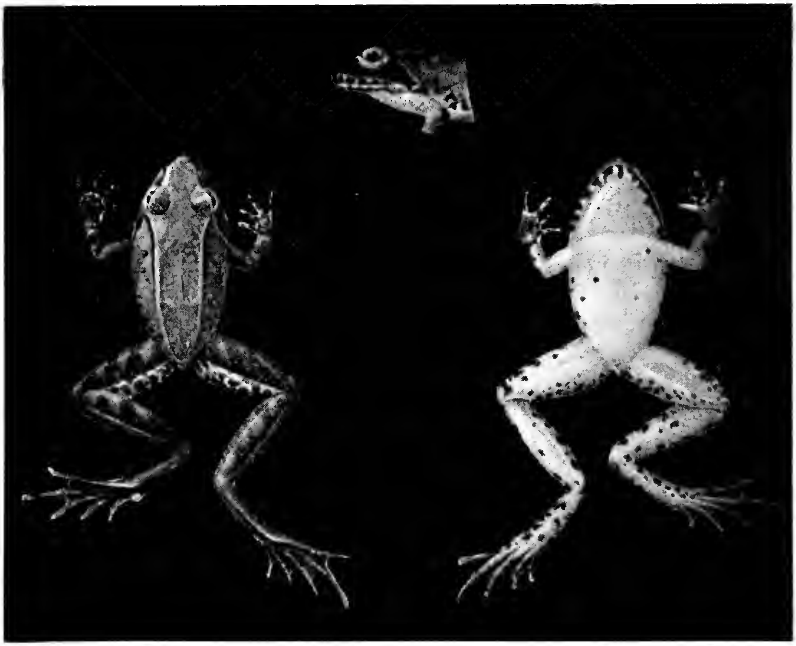

Fig. 59.—*Rana aenea* M. Smith. M. S. No. 5821 ♀. Actual snout-vent length, 35 mm. Doi Chang, Chiang Mai, Thailand, elev. 1500 m.

from level of posterior borders of choanae, equidistant from them and from each other; no bony prominences on lower jaws in males.

Fingers moderate, tips slightly swollen, first as long as second, third shorter than snout; subarticular tubercles moderate. Leg long, tibiotarsal articulation reaching well beyond snout; heels strongly overlapping when limbs are folded at right angles to body; toes moderate, tips dilated into small but very distinct discs, two-thirds webbed, nearly three phalanges of fourth toe free; no groove on discs separating upper from lower surfaces; no tarsal fold; subarticular tubercles moderate, inner metatarsal tubercle moderate, three-fifths length of inner toe; no outer tubercle.

Skin quite smooth; posterior half of upper eyelid warty; a glandular fold from eye to shoulder; a fine glandular dorsolateral fold beginning behind upper eyelid, converging towards its fellow on shoulders and extending to hip.

Color: Brownish or grayish-black above, sides with small rounded, jet-black spots; dorsolateral fold indicated by a thin whitish line edged outside with black on forepart of body; supratemporal fold with similar markings; black band including tympanum; lips black with white spots, limbs with black crossbars. Below yellowish white, throat finely speckled with black; belly and limbs with larger black spots.

Measurements in mm. (type and paratype, respectively): Snout to vent, 35, 38; length of head, 12.5, 14; width of head, 14.5, 15.5; snout length 6, 6.5; eye, 5, 5; interorbital width, 2.5, 3; tympanum, 2, 2; arm, 20, 22; leg, 65, 74; tibia, 22, 25; foot, 20, 22.

Variation: A second female (No. 5822) collected in the same locality differs in having the vomerine teeth slightly more prominent, the tympanum more distinct, and the dorsolateral fold present only halfway down the back.

Distribution: The species is known only from the type locality, Doi Chang, N. Siam.

Remarks: M. Smith regards *Rana aenea* as being nearest to *R. palavanensis* Boulenger from the Malay Archipelago. It differs from it in the smaller and less distinct tympanum, in the smaller digital discs and shorter first finger, in the convergence of the dorsolateral folds and in coloration (compared with two specimens from N. Borneo). Characters of the male are not known.

Rana signata (Günther)

FIG. 60

Polypedates signatus Günther, Proc. Zool. Soc. London, 1872, p. 600; pl. 40, fig. C (type locality, Borneo).

Rana signata Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 71; Werner, Zool. Jahrb., Syst. Band 13, 1900, p. 493; Laidlaw, Proc. Zool. Soc. London, 1900, p. 886; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 237-238; Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 177-179; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 227 (*picturata* = *signata*); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 103 (Tasan, Isthmus of Kra).

Rana obsoleta Mocquard, Nouv. Arch. Mus., ser. 3, vol. 2, 1890, p. 147.

?*Rana picturata* Boulenger, Rec. Ind. Mus., vol. 20, 1920, p. 179; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 272 (Pahang).

Rana signata Inger, Fieldiana. Zoology, vol. 33, 1954, p. 312 (*part.*).

Diagnosis: Medium small frogs, digits with small discs; outer metatarsals separated by web; dorsolateral fold; toes two-thirds webbed; two metatarsal tubercles; skin smooth or finely granular above; male with internal vocal sac; length of eye greater than length of snout; dark olive, brownish or black above; white or yellowish line from snout-tip on side of head and continued dorsolaterally on body. Numerous whitish or reddish spots on back; limbs barred with whitish, cream, or red.

Fig. 60.—*Rana signata* (Günther), EHT-HMS, No. M.153a, Kuala Lumpur, Selangor, Malaya. Actual snout-vent length, 35 mm.

Description of species (from EHT-HMS, M153a, Kuala Lumpur): Head rather narrow, snout rounded or slightly truncate anteriorly, nostrils nearer snout than eye; interorbital width greater than width of upper eyelid; canthus rostralis distinct, loreal region strongly concave; length of eye equal or slightly greater than length of snout; tympanum distinct, its diameter about half length of eye, separated from eye by a distance less than half its diameter.

Choanae large, vomerine teeth in two oblique groups wholly between choanae, but not reaching their posterior level, separated from each other by distance nearly equal to length of one group; an internal vocal sac present.

Arm moderate, first finger distinctly longer than second; small nuptial swelling at base of first finger (in male); tibiotarsal articulation reaches somewhat beyond tip of snout; small inner metatarsal tubercle and small outer; no tarsal fold; subarticular tubercles strong on fingers, somewhat smaller on toes; digits with tips widened into discs; toes from between one-half to two-thirds webbed.

Skin smooth over most of body; a few tubercles on thigh below vent.

Color: Above violet or lavender brown (probably dark olive in life) with yellow-cream line across tip of snout passing along sides of head, continued on dorsolateral region to groin (partly broken into spots); sides, back, head, and limbs with numerous cream spots; entire lower surface of body and limbs heavily powdered with black giving skin a dirty brownish-gray cast.

Measurements in mm.: Snout to vent, 35; axilla to groin, 16; head width, 12; head length, 13; arm, 27; leg, 64; tibia, 20.5; foot and tarsus, 28.

Variation: The tibiotarsal articulation may reach only to nostril; occasionally the upper surface of body is completely but finely granular. The species may reach a length of 60 millimeters. Another specimen taken by me near Kuala Lumpur had red spots and a red dorsolateral stripe.

Distribution: In Thailand the species has been taken only at Tasan, Isthmus of Kra in the province of Chumphon. It is probably rare, otherwise its conspicuous coloration would have permitted it to be seen and taken more frequently. Elsewhere the species occurs in Malaya and the Indo-Australian Archipelago.

Rana luctuosa (Peters)

FIG. 61

Limnodytes luctuosa Peters, Monatsb. Akad. Wiss. Berlin, 1875, p. 579 (type locality, Borneo); Ann. Mus. Civ. Genova, vol. 3, 1872, p. 43, pl. 6, fig. 1.

Rana luctuosa Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 1882, p. 68; Ann. Mag. Nat. Hist., ser. 6, vol. 7, 1891, p. 341; Flower, Proc. Zool. Soc. London, 1896, p. 904, pl. 46; *ibid.*, 1899, p. 896; Hanitsch, Journ. Straits Asiat. Soc., vol. 34, 1900, p. 73; Boulenger, Fasciculi Malayenses, Zoology, 1903, p. 172; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 199; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 24; van Kampen, Amphibien des Indischen Archipel . . . Leiden, 1906, p. 411; Barbour, Mem. Mus. Comp. Zool. Harvard College, vol. 44, 1912, p. 169; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 238; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 273 (Fraser's Hill, Malaya); van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 196; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 94, 103; *ibid.*, 1931, p. 16.

Rana (Limnodytes) luctuosa Mocquard, Nouv. Arch. Mus. Paris, ser. 3, vol. 2, 1890, p. 122.

Rana decorata Mocquard, Le Natur., 1890, p. 155; Nouv. Arch. Mus., ser. 3, vol. 2, 1890, p. 145, pl. 10, fig. 1, 1a, 1b; Boulenger, Ann. Mag. Nat. Hist., ser. 6, 1891, p. 341.

Rana (Hylorana) luctuosa Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 183-184.

Diagnosis: Medium-sized frogs, snout to vent length ♀ 60, ♂ 45 mm.; snout bluntly rounded; canthus obtuse; snout projecting somewhat beyond mouth; first finger longer than second; second and third fingers with lateral dermal ridges; toes with web only at base; tips of digits widened into small discs, each with a peripheral groove; heel to or little beyond tip of snout; narrow dorsolateral white or yellow line borders red or red-brown color of back; male lacking vocal sac and slits.

Description of species (from No. 6527, Khao Ram, Nakhon Si Thammarat): Snout broadly rounded anteriorly; distance between lateral nostrils one and a half times interorbital width, which in turn is wider than an upper eyelid; snout rather flattened at tip extending beyond mouth; canthus broadly rounded, loreal region slightly concave, nearly vertical; tympanum large, its greatest diameter equal to four fifths of length of eye; eye length shorter than snout; distance between tympanum and eye less than half diameter of tympanum.

Vomerine teeth on two small elevations between choanae, widely separated from choanae and from each other, neither group as large as a choana; latter concealed when viewed directly from below; small group of openings of palatal glands in middle of palate not far from anterior level of choanae; tongue free for a third of its length and free on sides; male lacking vocal sac and

FIG. 61.—*Rana luctuosa* (Peters). M. S. No. 6527. Actual snout-vent length, 46 mm.; Khao Ram, Thailand.

slits; skin of head and dorsum shining smooth; skin of side generally smooth with minute pits (seen under a lens); chin, venter, and underside of limbs smooth; about half of posterior surface of thigh granular, especially area around vent.

Arms smooth, fingers moderately long, first longer than second; three metacarpal tubercles, that at base of first finger largest; sides of fingers with fine folds of skin extending from discs to base of middle digits.

Toes less than one-third webbed, but webs bordering sides of digits as small free flaps to discs; flat inconspicuous inner metatarsal tubercle, smaller rounded outer tubercle; tips of all digits widened into small discs, each with a peripheral groove; subarticular tubercles moderately developed.

Color: Above reddish brown to magenta, bordered dorsolaterally with whitish line that crosses edge of eyelid and surrounds the tip of snout; sides of head and body brownish to brownish black, with few whitish flecks; tympanum light-brown with darker center; whitish elongate gland below tympanum; limbs brown indistinctly marked with transverse darker bars separated by whitish dots or lines; back of thigh and underside of tibia dark-brown with numerous whitish flecks; throat dark; venter dirty brownish buff with some lighter flecks.

Measurements in mm. (M. S. Nos. 6614, and 6527): Snout to vent, 42, 46; width of head, 15.1, 15; length of head, 16.2, 18; arm, 25, 24; leg, 74, 73; tibia, 23, 24; foot and tarsus, 33, 33.

Variation: The toes may be one-third webbed, but it is usually less. Boulenger's description (1912) states that the outer metatarsal tubercle is absent, and the tibiotarsal articulation may not reach the tip of the snout; the vomerine teeth in No. 6614 are better developed than in the one described, and the choanae are not hidden when seen from below.

Distribution: The species in Thailand seems to be confined to the southern part of the peninsula coming as far north as the province of Nakhon Si Thammarat. It is known outside Thailand in Malaya where it is common on Penang Island at elevations of 2000-2200 feet; and in the Larut Hills Park at an altitude of 4000 ft. It is also known in Borneo where it was first taken. The described specimen is from Nakhon Si Thammarat.

Rana alticola Boulenger

FIG. 62

Hylorana tytleri (*non* Theobald) Stoliczka, Journ. Asiat. Soc. Bengal, vol. 39, 1870, p. 148, pl. 9.

Rana tytleri (*non* Theobald), (*part.*) Boulenger, The fauna of British India, Ceylon, and Burma; Reptilia and Batrachia, 1890, p. 458.

Hylorana pipiens Jerdon, Proc. Asiat. Soc. Bengal, 1870, p. 83.

Rana alticola Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, pp. 62-63, fig. (type locality, Khasi Hills; Sikkim; Moulmein); Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 334; Annandale, Rec. Ind. Mus., vol. 8, 1912, pp. 8, 22, pl. 4, fig. 1; vol. 26, 1924, p. 138, fig.; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, pt. 2, Dec. 1916, p. 167; *ibid.*, vol. 2, pt. 3, May, 1917, p. 228 (Patiyu = Prachuap Khiri Khan); Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, p. 140, 144; Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 166-169; M. Smith, Rec. Ind. Mus., vol. 26, 1924, p. 138, fig. tadpole; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 106-107.

Rana nigrovittata Sclater, Proc. Zool. Soc. London, 1892, p. 345 (*part.*).

Rana leptoglossa (not of Cope), Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, 140, fig.

Diagnosis: Medium-small frog (52 mm.); a narrow dorsolateral fold present; tibiotarsal articulation to tip of snout or beyond; limbs very slender; males with internal vocal sacs; no gland on arm; first finger longer than second; large very prominent subarticular tubercles; outer metatarsals separated by a web almost to tarsus; two metatarsal tubercles; skin smooth.

Description of species (from M. S. No. 3612 ♀ (756) "Siam"): Head little longer than broad, depressed, body slender; snout obtusely pointed or rather truncate anteriorly, longer than eye; canthus

FIG. 62.—*Rana alticola* Boulenger. B. M. No. 1916.6.22.29 ♀ (248). Actual snout-vent length, 52 mm. Klong Bang Lai, Prachuap Khiri Khan, Thailand.

rostralis well defined but rounding; loreal region nearly vertical, concave; width of interorbital space slightly greater than width of upper eyelid; nostril nearer to end of snout than to eye; tympanum large, distinct, its diameter slightly more than three fifths length of eye, separated from eye by distance about one third its diameter.

Vomerine teeth on short oblique ridges beginning between choanae but extending behind level of their posterior borders, separated from choanae by distance equal to length of one ridge, and from each other by a greater distance; (males with internal vocal sacs); tongue free posteriorly for about one third of its length, deeply notched behind.

Skin smooth above; narrow (in young specimens rather indistinct) dorsolateral fold from near eye to above groin; dim fold from eye to shoulder behind tympanum; chin, venter, and limbs smooth. Arms slender, tips of digits widened into strong discs each with peripheral groove; first finger a little longer than second; third little longer than snout; subarticular tubercles large and strongly prominent. Legs long, very slender, tibiotarsal articulation reaching slightly beyond tip of snout; when limbs are folded at right angles to body, heels overlap five or more millimeters; toes slender, with discs; toes webbed to discs of third and fifth digits, two phalanges of fourth free; outer metatarsals separated by web almost to tarsus; large subarticular tubercles; prominent inner metatarsal tubercle and small more or less distinct outer.

Color: Light brown above nearly uniform; sides somewhat darker brown; light vertebral mark above urostyle; dorsolateral fold light-edged with darker on outer side; upper lip lighter with dark margin; bars on limbs not or barely indicated; chin and venter whitish, throat dimly clouded brownish, with a white median line.

Meaurements in mm.: Snout to vent, 39; width of head, 11; length of head, 15; arm, 22; leg, 55; tibia, 18; foot and tarsus, 20.

Variation: The tibiotarsal articulation may just reach the tip of snout or it may reach several millimeters beyond the tip.

The distinctness of the dorsolateral glandular fold varies and if the specimen is somewhat desicated it may not be discernible. Occasionally there is a black line bordering the light-colored fold. The back as well as the chin and throat may have some dark-brown spots. Sometimes the lip is pink and often a white line is present on throat. The largest female specimens measure about 52 millimeters.

Distribution: In Thailand the species is known from Prachuap Khiri Khan, Chumphon, and Nakhon Si Thammarat provinces. Elsewhere it ranges in Assam and northern Indo-China. I believe that it has not been taken in the southern part of the Malay Peninsula.

Remarks: Alticola appears to be spotty in its distribution. From the character of the digital pads it is probably arboreal. I have not found the species in northern Thailand where the species is to be expected.

This species has a curious tadpole bearing two large paratoidlike glands on the front of the back, and a third elongate medial gland on back of rump. These glands are present also in newly-transformed young. The tail is much thickened near its base and ends in an acute point.

The name *Rana alticola* is a substitute name for *Hylorana pipiens* of Jerdon, which is preoccupied in *Rana*.

Rana tasanae M. Smith

FIG. 63

Rana pullus (not of Stoliczka 1870) M. Smith, Journ. Federated Malay States Mus., vol. 10, 1921, p. 197, pl. 2.

Rana tasanae M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 4, 1921, p. 193 (change of name); Bull. Raffles Mus., no. 3, Apr. 1930, p. 101 (Tasan and Mamoh near the Isthmus of Kra).

Diagnosis: Small frog (40 mm.); no dorsolateral fold; head as broad as long; canthus rostralis obtuse; tympanum present; first finger shorter than second; heel to near tip of snout; toes half webbed; inner metatarsal tubercle present, no outer. Gray or blackish above; below whitish speckled except on venter; no vocal sac; fine network of minute glandular folds on dorsum. Skin fragile.

Description of species (from B. M. No. 1947.22,2 (M. S. No. 3293): Small species (snout to vent, 39 mm. ♀); width of head (19 mm.) greater than length (17.2 mm.); snout oval seen from above, the nostrils separated by distance (4.3 mm.) slightly greater than interorbital distance, and this slightly greater than width of upper eyelid; canthus rostralis distinct, loreal region oblique with elongate concave area extending to and somewhat under eye; tympanum distinct, its greatest diameter (3.1 mm.) approximately half length of eye (6.05 mm.) and half snout-length (6.15 mm), separated from eye by half its diameter; skin fold extends straight back from eye then at posterior level of tympanum it extends down and back to above arm-insertion; strongly defined elongate glandular

FIG. 63.—*Rana tasanae* M. Smith. B. M. No. 1947.2.2.82. Actual snout-vent length, 39 mm. Chumphon, Thailand. (Paratype.)

tubercle at angle of mouth extending downwards; choanae moderate in size, clearly visible seen from below, their anterior edge forming a straight line; vomerine teeth on two elevated ridges, separated from choanae by length of one ridge, extending diagonally from posterior level of choanae, separated mesially by half length of a ridge; palatal glands open through a transverse row of pores at anterior level of choanae; tongue strongly notched behind, free for about one third of its length; (male without vocal sac but with enlarged nuptial pad on first finger); fingers moderately long, first little shorter than second, tips with moderately large discs, with a deep transverse groove across front, separating the upper from the lower surface, the under part extending distinctly farther forward than upper part; no web remnant, but lateral ridges are indicated at least on inner parts of second and third fingers; subarticular tubercles distinct, no supernumerary tubercles; strong inner metacarpal tubercle; median and outer tubercles fused, notched above and slightly elevated; leg rather short, the tibiotarsal articulation reaching front edge of eye; toes with dilated discs grooved like fingers, somewhat smaller; outer toes nearly half webbed, inner toes one-third webbed; the webs reaching discs as narrow fringes; strong subarticular tubercles; an elongate inner metatarsal tubercle; a tarsal fold; outer finger with a narrow outer fringe. Skin smooth above and below, but under skin a pronounced reticulum that leaves imprint on skin.

Color: Nearly uniform brown above with indication of lighter marks on upper lip, separated by darker brown; venter, upper lip, and chin with brown and cream reticulation; back part of venter cream-white. Brown under limbs with some slight flecks of cream; uniform brown under feet and tarsi.

Measurements in mm. (B. M. Nos. 1947.22.72, 1947.22.82): Snout to vent, 39, 24; width of head, 19, 12; length of head, 17.6, 12; arm, 24, 15; leg, 59.5, 41; tibia, 20, 14; foot and tarsus, 25.5, 19.

Variation: In the smaller measured specimen the vomerine ridges are smaller, closer together, and in consequence, farther from the choanae.

Distribution: Known only from the type locality, Tasan and Mamoh (near the Isthmus of Kra), Chumphon and Renong provinces, respectively. Not known from elsewhere.

Remarks: The relationship of the species is said to be with *Rana oeddomii.* I suspect a relationship with *Rana tenasserimensis.*

The females reach a size of 40 mm.; the males 33 mm. The tympanum of male is proportionally larger than in female.

Dr. Smith comments "The skin of this frog is unusually tender. There is not a single example in the series in which the skin is not torn or damaged in some part of the body. The glandular reticulations referred to are possibly not so prominent in life as in spirit specimens."

The remarkable fact is that the species has not been found save at the type locality of Tasan, "25 miles SW of Chumporn," with the exception of a single specimen taken at Mamoh, Renong. A series of 46 were taken at the type locality.

Smith remarks: "The eggs large, few, unpigmented, the vittilene sphere measuring 2 mm. in diameter."

Rana tenasserimensis Sclater

FIG. 64

Rana tenasserimensis Sclater, Proc. Zool. Soc. London, 1892, p. 345, 348, pl. 24, figs. 4, 4a (type locality, Tenasserim, Burma); Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, pp. 310, 331; Proc. Zool. Soc. London, 1894, p. 641; Fea, Ann. Mus. Civ. Genova, ser. 2, 1897, p. 476 (Karin Hills); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 102 (Khao Ram and Khao Ronpibon, Nakhon Si Thammarat).

Micrixalus tenasserimensis Myers, Proc. Biol. Soc. Washington, vol. 55, 1942, p. 79.

Cornufer tenasserimensis Boulenger, Ann. Mag. Nat. Hist., ser. 9, vol. 1, 1918, p. 373; Bourret, Les batraciens de l'Indochine, 1942, p. 378.

Diagnosis: A small frog (25 mm.); vomerine teeth normally absent; tympanum distinct, half of eye diameter; first finger shorter than second. Toes webbed at base; outer metatarsals bound together; feeble inner metatarsal tubercle; usually dorsolateral light stripes from eye; skin everywhere glassy smooth; digital discs large, without a transverse groove; tongue bifid behind.

Description of species (from M. S. 6258. B. M. No. 1927.4.21.1-4): Small frogs with short broad snout; nostril little nearer median point on snout than to eye; tip of snout projecting little beyond lower jaw; canthus rostralis obtuse, loreal region nearly vertical, concave; distance between nostrils distinctly greater than interorbital width, which is distinctly greater than width of an upper eyelid; tympanum distinct, its diameter equal to about half length of eye, separated from eye by distance equal to one third its diameter; indistinct fold from eye curves above tympanum, terminating, somewhat thickened, above arm-insertion; a small glandular fold beginning below tympanum turns down in front of arm-insertion terminating near its lower level.

FIG. 64.—*Rana tenasserimensis* Sclater. B. M. No. 1927.4.21.1-4 (M. S. 6258). Actual snout-vent length, 24 mm. Khao Ronpibon, Nakhon Si Thammarat, Thailand.

Palate high, choanae rather small, largely, if not entirely hidden when palate is viewed directly from below; no trace of vomerine teeth; tongue rather large, strongly notched behind with small posteriorly directed lobule (pigmented) just below notch; apparently distinct transverse fold just behind level of Eustachian tubes; openings of tubes distinctly larger than choanae; openings of palatal glands medial, between choanae. Arms rather short, wrists not reaching tip of snout; fingers elongate with well-developed terminal discs, width of those on outer fingers more than half diameter of tympanum; transverse terminal groove on discs but no transverse groove on face of disc. Two rather large, flat metacarpal tubercles; no supernumerary tubercles; first and second fingers equal or second slightly longer; no trace of web, and no trace of lateral folds or ridges on sides of fingers. Toes with widened discs, some almost if not entirely as large as those on fingers; trace of web between toes, but no folds or lateral ridges; small low inner metatarsal tubercle, no outer; a fine scarcely distinguishable fold follows behind tubercle, and a fine fold along outer metatarsal which may extend somewhat on tarsus; outer metatarsal united with others throughout its length; tibiotarsal articulation extends two millimeters beyond tip of snout; when legs are folded at right angles to body heels overlap one or two millimeters; subarticular tubercles on all digits rather large, flat, indistinct.

Skin smooth without trace of tubercles, warts or granules on body; under lens one may observe a very fine elevated reticulum of smooth folds covering dorsal surfaces of head, body, and limbs (in some specimens it is heavier and more distinct and may be seen without lens).

Color: Above gray or grayish brown with entire dorsal surface of snout uniform light-gray; a blackish-brown mark across head covering posterior half of upper eyelids; a pair of gray-white stripes from corner of eyes running back to near groin widening a little on sides of rump; area between stripes flecked or with small brownish blotches; brown canthal stripe; upper jaw with conspicuous brown and cream spots; sides of head, neck, and sides with small flecks and blotches of brown; legs and arm barred above with brown; back surface of thighs brownish; below gray-white with brownish dots or flecks on lower jaw and chin.

Measurements in mm. of *Rana tenasserimensis*

Number	6258	6259	6103	6267
Sex	♀	♀	♀	♀
Snout to vent	24	23	25	24
Width of head	10	9.6	10	9.6
Length of head	8.8	8.2	8.3	8
Arm	15.4	14.2	13	14.9
Leg	44	41	38	41.6
Tibia	14.4	13.9	13	14
Foot and tarsus	19.2	17.1	16	19

Variation: The type of the species is figured as having vomerine teeth. There is no trace of teeth in the four females here examined.

In color and markings, No. 6259 is similar but the dorsal spotting is more intense, the markings emphasizing two dorsal spots and one between eyes; the dorsolateral light lines are interrupted; Nos. 6103 and 6267 are distinctly brownish with deep-brown markings.

Distribution: This species is known in Thailand from a collection made at Khao Ram and Khao Ronpibun, Nakhon Si Thammarat by Dr. Malcolm Smith. Elsewhere the species is known in Burma.

Remarks: The breeding habits of this species are not known. The ovaries of each female studied contained either two or three large, presumably nearly mature eggs measuring about 2.5 millimeters in diameter. In the same ovaries were several eggs of about half this size and still others somewhat smaller. It suggests that only very few eggs are deposited at one time and that perhaps there are two or more layings in one season.

I did not discover the species while collecting in this area. The numbers given are those of Malcolm Smith; the group number being B. M. 1927.4.21.1-4. There has been considerable difficulty in placing this small frog generically. Sclater described it as a *Rana;* Boulenger considered it as a member of the genus *Cornufer;* Myers has suggested (with a ?) that it is *Micrixalus.* M. Smith has placed it in a subgenus *Discodeles* in *Rana.* In this I follow Smith since I do not have sufficient comparative material at hand to make an independent decision.

Rana jerboa (Günther)

FIG. 65

Hylorana jerboa Günther, Proc. Zool. Soc. London, 1872, p. 599, pl. 40, fig. B (type locality, Matang, Sarawak, Borneo).

Rana jerboa Boulenger, Catalogue of the Batrachia Salientia *s.* Ecuadata in the British Museum, 1882, p. 67; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 335; Proc. Zool. Soc. London, 1893, p. 526; Flower, *ibid.*, 1899, p. 916; Butler, Journ. Nat. Hist. Soc. Bombay, vol. 15, 1903, p. 199; van Kampen, Natuurk. Tijdschr. Ned.-Ind., vol. 69, 1909, p. 39, pl. 2, figs. 3-6; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 244-245; Boulenger, Rec. Ind. Mus., vol. 20, 1920, p. 196; Mertens, Arch. für Hydrob. Suppl. Band, 12, 1934, p. 685 (Sumatra); van Kampen, the Amphibia of the Indo-Australian Archipelago, 1923, p. 208 (Siam); M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 109; Metcalf, Proc. U. S. Nat. Mus., vol. 87, 1940, p. 568 (Siam).

Rana masonii Boulenger, Ann. Mag. Nat. Hist., ser. 5, vol. 13, 1884, p. 397.

Staurois jerboa Bourret, Les Batraciens de l'Indochine, 1942, pp. 382-385, figs. 123, 124.

Diagnosis: Large frogs reaching a snout-to-vent length of 102 mm.; nostril equidistant between eye and end of snout; discs of fingers and toes smaller than tympanum; first and second fingers nearly equal; tibiotarsal articulation reaches more than centimeter beyond tip of snout; tip of femur reaches tympanum; pair of small vocal sacs near jaw-angles; toes nearly fully webbed; two metatarsal tubercles, no tarsal fold.

Description of species (from EHT-HMS No. F. 1045, Java): Head longer than broad, body relatively slender; snout rather obtusely pointed; canthus rostralis distinct; loreal region concave,

FIG. 65.—*Rana jerboa* (Günther). Type (after Günther 1872). Actual snout-vent length, approximately, 51 mm., Matang, Borneo.

sloping obliquely to lip; nostril midway between eye and tip of snout; tympanum very distinct, slightly sunken; strong rims about tympanum, which stands very close to eye; diameter of tympanum about two thirds length of eye; eyelid considerably wider than interorbital distance; choanae large, vomerine teeth on two oblique ridges almost completely between choanae, separated by a distance about equal to their distance from choanae; palatal glands open into straight groove between anterior edges of choanae; male with internal vocal sacs; tongue free for about a third of its length.

Skin on dorsum finely granulate or corrugate; a dorsolateral glandular fold from eye to end of rump; small fold running from above tympanum to point near arm-insertion; undersurfaces smooth except mesial portion of femur and area about vent granulate.

Digit-tips expanded into discs which are smaller than tympanum; first finger little longer than second; much enlarged tubercle at base of first finger; two other rather rounded smaller metacarpal tubercles. Toes almost fully webbed to discs; subarticular tubercles well developed on hand and foot; outer metatarsals separated by a web; an inner metatarsal tubercle; no outer; no tarsal fold; tibiotarsal articulation reaches far beyond tip of snout; length of tibia nearly four fifths of head-body length.

Color: Generally brownish with some darker marbling; sides dark brown including a light streak along upper lip; limbs with indistinct dark crossbars; ventral surfaces whitish, nearly uniform.

Measurements in mm.: Snout to vent, 35; width of head, 13; length of head, 16.5; arm, 29; leg, 91; tibia, 29; foot and tarsus, 38.

Variation: The vomerine teeth may extend behind level of choanae; the interorbital width may exceed the width of an upper eyelid and the first two fingers may be of equal length. Some specimens have the chin, breast, and venter spotted.

Distribution: The inclusion of this species in the Thai fauna is based on two "records." Van Kampen mentions Siam as part of its range (based on what record?) and Metcalf reports a parasite from a specimen of *Rana jerboa* from Trong [= Trang] Lower Siam.

Elsewhere the species is known in Burma, Malaya, and the larger East Indian islands of Borneo, Java, and Sumatra.

Remarks: I have examined the type in the British Museum. The specimen measures 55 mm. It is a female with eggs. The first finger is longer than second. The loreal region is nearly vertical, but somewhat concave, the discs on digits are slightly pointed rather than rounded. When the leg is adpressed forward the knee reaches the front of tympanum, and the tibiotarsal articulation reaches beyond the tip of the snout a distance equal to half the length of the femur.

Günther describes the color: "Upperside of the head and back red, side of the body and head black, upper lip and glandular folds greenish white, legs marbled with brown; lower side of foot and tarsus black; abdomen whitish."

All trace of the red and greenish color is now absent.

Rana hosii Boulenger

FIG. 66

Rana hosii Boulenger, Ann. Mag. Nat. Hist., ser. 6, vol. 8, 1891, p. 290 (type locality Borneo, Mt. Dulit); Journ. Federated Malay States Mus., vol. 3, 1908, p. 62; van Kampen in Weber, Zool. Ergeb. Reise Nied. O-Ind., vol. 14, 1907, p. 398; Bull. Dept. Agric. Ind. Neerl., vol. 25, 1909, p. 2. Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 243-244; van Kampen, Notes Leyden Mus., vol. 36, 1914, p. 260; Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 199-200; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 274 (Gunong Tahan Mt., Malaya); van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, pp. 215-216, fig. 25 (the drawing seemingly shows the snout too pointed).

Rana durheimi Baumann, Zool. Jahrb., Syst., vol. 34, 1913, p. 275, text figs. D and E.

Rana cataracta M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 274 (Nakhon Si Thammarat, Thailand; Fraser's Hill, Malaya); Bull. Raffles Mus., no. 3, 1930, p. 110 (places *cataracta* in the synonymy of *hosii*).

Hyla chalconotus (*part.*) Schlegel, Abbildungen neuer oder unvollständig bekannter Ampibia 1837-44, p. 23, pl. 9, fig. 1.

Diagnosis: A large frog (snout to vent 97 mm.); tympanum less than half diameter of eye; first finger longer than second; discs on two outer fingers as large as tympanum; foot fully webbed except on fourth toe; low elongate inner metatarsal tubercle; no outer tubercle; tibiotarsal joint reaching to a point considerably beyond tip of snout; white stripe on upper lip; dorsolateral fold distinct; tympanum with median dark spot surrounded by lighter circle. Back may be black spotted or green.

Description of species (from No. 33816 ♀ Doi Suthep, 4000 ft. elev., Chiang Mai): Snout subacuminate as long as orbit, projecting slightly beyond mouth; nostrils separated by an interval equal to interorbital space, slightly nearer tip of snout than to eye; canthus rostralis evident but obtuse or rounded; loreal region deeply concave, sloping obliquely to lip; tympanum sharply delineated, diameter (5 mm.) less than half length of eye (11.5 mm.), separated from eye by distance equal to its diameter; eyelid (8.5 mm. wide)

FIG. 66.—*Rana hosii* Boulenger. No. 33816 ♀. Actual snout-vent length, 96 mm. ♀. Doi Suthep, *circa* 4000 ft. elevation, Chiang Mai, Thailand.

about equal to interorbital distance; frontal, interorbital, and occipital areas slightly depressed or concave.

Vomerine teeth on two strongly elevated oblique ridges beginning near inner anterior edge of choanae and extending half their length behind posterior level of choanae; openings of palatal glands in transverse line closer to front of palate than to anterior level of choanae; tongue large, wide, strongly bifid behind, free for one third of its length.

Arm long; first finger longer than second; all digits moderately long, tips widened into large terminal discs each with peripheral groove but without a groove across ventral surface of disc; discs of outer fingers as large as tympanum; upper part of disc larger than lower, rather pointed; subarticular tubercles well developed. Leg very long, toes webbed to widened discs; an elongate inner metatarsal tubercle more than a third length of inner toe; no outer tubercle; tibia two thirds of snout-vent length. Subarticular tubercles on toes, distinct, elongate. A feeble tarsal fold. Heels overlap considerably when legs are folded at right angles to body. Skin of head, dorsum, and sides slightly granulate; limbs, chin, and venter smooth; dorsolateral folds distinct; a few large granulations on sides of vent and on median area of underside of thigh.

Color: Upper surface of head dark olive, dorsum and sides brown; lighter low on sides with few rounded brown spots more or less outlined in dull cream; arms and legs with bands separated by narrow lines of yellow-brown; back of thigh brown with veriform cream or yellowish-brown marks; chin, venter, and underside of limbs cream-white; whitish or cream line on upper lip; whitish spot behind angle of jaws; underside of web on foot dark brown; tympanum fawn with dark brown center.

Measurements in mm.: Snout to vent, 96; width of head, 35; length of head, 37; axilla to groin, 38; arm, 58; leg, 194; tibia, 62; foot and tarsus, 76.

Variation: The male of the species has internal vocal vesicles, and a nuptial pad on the first finger. Malcolm Smith described his *Rana cataracta* (which he later placed in the synonymy of *R. hosii*) as verdant green above in life, grayish in spirits. The sides of the head and body a little darker than back. Upper lip and glandule behind it, white. The lower parts white.

A specimen from Tahan River, Malaya has the tibia exactly the length of the head and body. The eye length is nearly equal to the length of the snout in adult specimens. Females are very considerably larger than males, the largest specimen recorded measuring 104 millimeters from snout to vent. Boulenger (1912) states "first finger not extending beyond second," and "tibia not two thirds the length of head and body."

Distribution: The specimens here recorded are presumably the first taken in northern Thailand. This record extends the range in Thailand some 900 km. northward.

In southern Thailand the species has been taken on Khao Ram in Nakhon Si Thammarat (*Rana cataracta*) and at Tasan, Chumphon province. In Malaya it has been taken on Gunong Tahan and at Fraser's Hill. It is known also from Borneo, Java, and Sumatra.

Remarks: M. Smith states that the voice of the male, heard only at night is a short whistling cry, sometimes almost a scream. My own experience shows them to be extremely shy. They are perched on rocks or low shrubs along mountain rivulets or streams and dive into water to escape, taking temporary shelter under submerged rocks or perhaps as frequently entering holes in the banks.

Differences in the populations may be indicative of subspecies; however the material available does not permit me to make judgment on the matter. The males and the young specimens look similar to *Rana chalconota* and may be easily mistaken.

Rana livida (Blyth)

FIG. 67

Polypedates lividus Blyth, Journ. Asiat. Soc. Bengal, vol. 24, 1855, p. 718 (type locality, Eastern Himalayas).

Polypedates chloronotus Günther, Proc. Zool. Soc. London, 1875, pp. 569-570, pl. 65, fig. A (entire animal in color) (type locality, "Darjeeling").

?*Polypedates smaragdinus* Jerdon, Proc. As. Soc. Bengal, 1870, p. 83; Anderson, Proc. Zool. Soc. London, 1871, p. 208.

Rana chloronata Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum 1882, p. 69, Werner, Abb. Bayer. Akad. Wiss., Ed. 22, Heft. 2, 1903, pp. 369, 376.

Rana livida Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 5, 1887, p. 484; The fauna of British India . . . Reptilia and Batrachia, 1890, p. 462 (Assam, Tenasserim and Hongkong); Butler, Journ. Nat. Hist. Soc. Bombay, vol. 15, 1903, p. 201 (Larut District, Perak); Boulenger, The fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 244-245; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, May, 1917, p. 229 (Doi Nga Chang, N. Siam); Boulenger, Rec. Ind. Mus., vol. 20, 1920, pp. 214-216; M. Smith, Proc. Zool. Soc. London, 1921, p. 437; Bull. Raffles Mus., no. 3, 1930, p. 110 (Nakhon Si Thammarat mountains; Believes *graminea* Boulenger a synonym).

Rana graminea Boulenger, Proc. Zool. Soc. London, 1899, p. 958, pl. 67, fig. 1.

Rana (Hylarana) livida Bourret, Instr. Publ., Hanoi, no. 22, 1941, p. 31.

Diagnosis: Tips of digits moderately dilated, first finger longer than second, much swollen at base; pair of vocal sacs in front of arms; tympanum large, distinct, toes four-fifths to fully webbed; small elongate inner metatarsal tubercle, no outer; back of thigh black with numerous white spots.

Description of species (from No. 34958): Head oval, depressed but not concave; canthus rostralis somewhat obtuse; loreal region slightly oblique, distinctly concave; nostril equidistant or slightly nearer tip of snout than to eye. Upper eyelid distinctly wider than interorbital space, snout longer than eye; tympanum large, distinct, its diameter (5 mm.) little more than half of eye-length (9 mm.).

Tongue very slender, elongate, notched behind, free for about a

Fig. 67.—*Rana livida* (Blyth). No. 34957 ♂. Actual length, snout-vent, 71 mm. Phu Kading, Loei, Thailand.

fourth of its length; vomerine teeth on two ridges beginning between choanae that extend back diagonally to a point somewhat behind choanae, separated mesially by a distance much less than their distance from inner side of choanae; palatal glands open through a series of discernible parallel tubes into a sinuous groove anterior to level of choanae but closer to them than to anterior limit of palate; a curved or sinuous vocal slit near mouth-angle opens into each lateral external vocal sac which is situated directly in front of arm; openings of Eustachian tubes considerably larger than choanae.

Forearm thickened; first finger equal or a little longer than second, its base much swollen with a large patch of nuptial asperities covering swelling; tips of digits widened into discs equal to about half width of tympanum; largest 3 mm. wide, with deep groove about periphery but none on ventral surface; second and third fingers with trace of lateral ridge or fringe; no trace of basal web; legs elongate, tibiotarsal articulation reaching about ten millimeters beyond tip of snout; toes four-fifths to fully webbed; outer metatarsal separated completely by web; when legs are folded at right angles to body, heels overlap about eight millimeters; subarticular tubercles distinct under fingers and toes; two outer metacarpal tubercles faintly outlined; a small elongate inner metatarsal tubercle, no outer; no tarsal fold.

Skin smooth above, below, and on sides; a slight glandular ridge follows from eye to behind jaw-angle thickening into a distinct gland, followed by a second gland above arm; an indistinct dorsolateral fold; patch of flat granules on underside of femora and about vent. No trace of dorsal granulation or lateral tubercles or warts.

Color in life: Entire dorsal surface bluish green; sides black with some white marks especially in groin; ventral surfaces gray-white. A whitish line on upper jaw, becoming yellowish cream posteriorly; inner finger gray-white; arm with dim banding above, its underside with some whitish spots or flecks; femora and tibia banded brown, with lighter interspaces; front and back faces of femora, and part of upper surfaces black; undersurface of tibiae blackish, with scattered small rounded or vermiform white spots; side of foot blackish.

Variation: The three males listed above, all from Phu Kading,* Loei Province, are larger than any in the series of male specimens in the British Museum (males, 45-51 mm., females, 84 to 100 mm.) as measured by Boulenger (1920).

The size of the digital discs is considerably smaller than suggested for *R. livida* by Boulenger (1920): "very large discs as long as broad, as large or a little smaller than the tympanum."

It is possible that specimens from this isolated mountain top should be regarded as a subspecies of *livida.*

Distribution: The species originally described from northern

* Phu Kading = Mountain of the cowbell, *i. e.*, shaped like a cowbell.

Measurements in mm. of *Rana livida*

Number	34956	34957	34958
Sex	♂	♂	♂
Snout to vent	70	71	65
Width of head	24	27	22.8
Length of head	24	25	21
Length of snout	10	10	9
Eye	9	9	8.7
Arm	45	45	43
Leg	131	126	125
Tibia	47	42	42
Foot and tarsus	57	55.5	54
Diameter of largest disc	3	2.6	2.95

India has been found in Chiang Mai (Doi Nga Chang), and in Loei province (Phu Kading).

Outside of Thailand the species is known in northern India (eastern Himalayas), Assam, Burma; Perak, Malaya; ?southern China; and Indo-China.

Remarks: There has been considerable confusion concerning this species, and a recent treatment by Bourret has placed in its synonmy, *Rana graminea* Boulenger, from Hainan, *Rana leporipes* Werner, and, with a question, Ahl's *Rana (Hylorana) sinica,* from southern China. It is evident that there are certain differences in these populations referred to *R. livida* in the area from Assam east to Hainan and south to Perak. Whether they merit taxonomic designations must await a careful review of the types and materials available.

Rana scutigera Andersson

Rana scutigera Andersson, Kungl. Svenska Vetensk-akad. Hand., Band 55, no. 4, 1916, pp. 15-17 (type locality, Hat Sanuk, Siamese Malaya, near Tenasserim border); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, May 1917, pp. 229 (near Koh Lak, S. W. Siam?); Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, 1958, p. 1039 (listed).

Diagnosis: Small frog, snout to vent, 49 mm.; vomerine teeth between choanae not extending behind them; skin on head partly ossified with large square plate between eyes, extending to level of posterior edge of tympanum; a plate on side of snout and a small one above tympanum.

Description of species (type description): "Vomerine teeth in two very distinct oblique series between the choanae, not reaching behind the posterior edge of the latter; the space between the groups of teeth larger than their distance from the choanae. Head depressed, as broad as long; snout rounded, a little longer than diameter of eye; canthus rostralis distinct; loreal region oblique, concave nostril much nearer the tip of the snout than the orbit; interorbital space broader than an upper eyelid; tympanum very distinct, two-thirds the diameter of the eye. Fingers and toes slender with well-developed discs; disc of the first fingers considerably smaller than those of the other fingers; first finger not reaching the tip of the second, toes broadly webbed, the formula being 1, 2/1, 2/1, 2/2, 1 (the figures indicate the joints free from web, above the line on the inner, below the line on the outer side, counting from the first toe). A small inner metatarsal tubercle, no outer. If the dimension of the tibia is marked off from the knee forwards along the body, it reaches the tip of the snout. Skin above partly ossified, *viz.*, a large square plate between the eyes, extending from their anterior margin to the level of the posterior edge of the tympanum, two semicircular plates on the snout, forming canthi rostrales, and two very small plates, one above each tympanum. A narrow glandular fold from the eye above the tympanum to the anterior part of the side of the body, where it disappears; remaining upper surfaces smooth; belly coarsely, under surfaces of thighs moderately granulate.

"When alive this frog was pretty yellow; when caught it grew rapidly paler, and the yellow nearly disappeared. In spirit the ground color is whitish gray with faint dark markings on the back and more distinct ones on the sides; immediately behind the interorbital osseous plate a large angular spot, the branches of which vanish before the middle of the bar; on the sacral region of the back some small distinct black spots. A blackish brown band from the tip of the snout bordering the canthus rostralis, extends along the edge of the upper eyelid of the tympanum, and of the glandular fold to behind the axil; behind the tympanum this band is rather broad, sharply limited above and below; on the loreal region only its upper margin is well defined, while the lower fades into the light margin of the upper lip; on the sides of the body some small distinct rounded black spots. The hind limbs with faint dark cross bands; the hinder side of the thighs reticulated with dark and light. Lower parts uniform dirty yellowish white, the chin white. The toes are blackish brown.

"One specimen, a male from Hat Sanuk the Siamese Malaya near Tenasserim boundary, 12/2/15, caught on a cactus, dermal fold above axil possibly indicate outer vocal vessicles."

Measurements in mm.: "Total length (from snout to vent), 48 mm. Breadth of head, 17; Length of head to hind margin of tympanum, 17.5; Length of snout, 7.8; Diameter of eye, 6 mm.; Diameter of tympanum, 4.2; Length of humerus, 10; Elbow to tip third finger, 24; Length of femur, 27; Length of tibia, 27; Length of tarsus and 4th toe, 3.5.

"In spirit this specimen corresponds very well with the figure of *Rana graminea* Boul. from Hainan (PZS London, 1899, pl. 67) and evidently this new species is nearly allied to that one as well as *Rana labialis* Boul. from the Malay Penn. It is, however, easily distinguished by the bony shields, the coloration, the strongly granulate keel, etc."

Remarks: The description of this frog parallels so closely the characters of *Rhacophorus leucomystax* that I cannot but fear that the two are the same. Thus a specimen of *leucomystax* measuring 48 mm. (the length of the type of *Rana scutigera*), was compared with the measurements given for *scutigera*. The individual measurements differed about one to two millimeters.

The presence of the granular vent and the rapid changing of colors suggest *Rhacophorus* rather than *Rana*.

Anyone having access to this type specimen should ascertain whether it is *Rana* or *Rhacophorus* and if the latter, compare it with young male specimens of *leucomystax*.

Genus STAUROIS Cope

Staurois Cope, Nat. Hist. Rev., 1865, p. 117 (Cope states: "Embraces *Ixalus natator*, *Ixalus guttatus* and *Hyperolius plicatus* of Günther." Boulenger (1918) designates the first, *Ixalus natator* as the type): Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata . . . British Museum, 1882, p. 7; Ann. Mag. Nat. Hist., ser. 9, vol. 1, 1918, pp. 374-375; Noble, Ann. New York Acad. Sci., vol. 30, Oct. 31, 1927, pp. 107-108, fig. 27; The biology of the Amphibia, 1931 (reprint 1954) pp. 65 (fig. 23), 521-522.

Amolops Cope, Nat. Hist. Rev., 1865, p. 117 (type of genus *Polypedates afghanus* Günther.

Diagnosis: Outer metatarsus webbed to base; terminal phalanges slender with short transverse limb; tongue with median inferior prominence; no dorsolateral folds; vomerine teeth; ethmoid widely separating prefrontals, and these from frontoparietals.

Cope defined *Amolops:* "Terminal phalanges short; transverse limb long; tongue without median inferior prominence; no dorsolateral glandular folds; vomerine teeth."

Boulenger synonymized these genera with *Rana* in 1882 where they remained for some decades. Boulenger in 1918 redefined the genus. The characters designated were: Vomerine teeth present or absent; tympanum small; finger discs large, broader and larger than those on toes with a half-disc within the disc on the lower surface; toes fully webbed involving the base of discs; outer metatarsals separated to base. He included *Staurois larutensis* Boulenger, *Staurois natator* Günther, *Staurois nubilus* Mocquard, *Staurois tuberilinguis* Boulenger, and *Staurois guttatus* Günther.

Noble in 1931 reviewed the group and in a measure reinterpreted the genus. He says: "It is, therefore, advisable to redefine the genus *Staurois* in order that it may include all species having this same distinctive tadpole." Besides the forms listed above, Noble includes *Rana whiteheadi, livida, cavitympanum, hosii, jerboa, afghana, ricketti, hainanensis,* and perhaps others.

It is indeed difficult to decide on the limits of the genus *Staurois*. I am aware that there is no more reason why two different genera might not have tadpoles with the suction discs as described for *Staurois* than to have two different genera lacking the suction disc, provided they differed also in other characters.

Since specimens of both groups are dealt with in this work I am considering *larutensis* and *afghana* as representing the genus *Staurois*. It is possible that *livida* and *hosei*, among Thai species, should be considered with *Rana* as has been done by Malcolm Smith (Bull. Raffles Mus., no. 3, 1930, pp. 110-111). He points out that suckers have developed on tadpoles in other genera in other parts of the world. He seems to suspect that some tadpoles of these Asiatic frogs may have been incorrectly identified.

KEY TO SPECIES OF STAUROIS IN THAILAND

Vomerine teeth on two strong diagonal ridges between and partly behind back level of choanae; no groove across the under face of the dilated discs of fingers and toes .... *afghana*

Vomerine teeth in two small low rounded patches between and extending behind choanae; a deep groove across undersurface of digital discs, *larutensis*

Staurois afghanus (Günther)

FIG. 68

Polypedates afghana Günther, Catalogue of the Batrachia Salientia in the collection of the British Museum 1858 (1859), p. 81 (type locality Afghanistan *ex errore?*); Fauna of British India, 1884, p. 432.

Amolops afghanus Cope, Nat. Hist. Rev., 1865, p. 117.

Rana afghana Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, pp. 69-70; Ann. Mus. Civ. Genova, ser. 2, vol. 5, 1887, p. 485; Annandale, Rec. Ind. Mus., vol. 8, 1912, p. 24, pl. 4, fig. 3 (tadpole).

Rana latopalmata * Boulenger, Catalogue of the Batrachia Salientia . . .

* Boulenger's persistent refusal to use Günther's name *afghanus* is very probably on the grounds of inappropriateness. The type specimen did not come from Afghanistan.

1882, p. 464 (type locality, Tenasserim); The fauna of British India . . . 1890, pp. 462-463; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 337; Proc. Zool. Soc. London, 1893, p. 526, pl. 43, fig. 3; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 5 (Doi Angka, Thailand. This is the first Siamese record for this species).

Staurois afghanus Pope and Boring, Peking Nat. Hist. Bull., vol. 15, 1940, pt. 1, p. 47; Liu, Fieldiana Zool. Mem., vol. 2, 1950, pp. 358-359.

Diagnosis: Large *Staurois,* toes fully webbed, webs reaching onto terminal discs; discs of fingers widened, those on outer fingers larger than those on inner; discs on toes large, outermost smallest; first finger little shorter than second; a strong nuptial gland on first finger and a gland on inner side of elbow in male. Vocal sac present, the small rounded openings of sacs on floor of mouth back at level of mouth-angle; vomerine teeth lying between and behind small choanae; tongue very large, free for half its length, and on sides.

Description of species (from No. 71 Mai Salat, 4000 ft. northern Chiang Mai province): Snout short, canthus rostralis strongly defined, loreal region slightly concave, nostril about midway between eye and tip of snout; tip of snout rounded in profile; eyes elevated, width of an eyelid little greater than interorbital width; tympanum small, rather indistinct, its diameter about one fourth length of eye (9.8 mm.); eye very nearly equal length of snout; small fold from eye runs diagonally to near arm-insertion.

Vomerine teeth on two diagonal ridges beginning at about level of choana but separated from choanae by distance equal to three-fifths length of one series, the two series narrowly separated mesially; palatal glands open into straight but short groove near anterior level of choanae; tongue very large, wide, notched behind, free for half its length as well as along sides (male with small puckered vocal openings, on level with mouth-angle); top of head rather flattened. Skin of dorsum finely granular or shagreened; venter generally smooth as is ventral and posterior part of thigh; a few granules on posterior and dorsal faces of thigh; tibia with some fine elongated ridges.

Fingers moderately long widened into large discs with groove around periphery but no groove on undersurface of disc; first and second fingers equal; slight fringe on distal portions of two middle fingers; toes fully webbed, web reaching sides of digital discs. Outer metatarsal separated by web; subarticular tubercles well developed, elongate; flat inner metatarsal tubercle; no outer tubercle; tibiotarsal articulation reaching six millimeters beyond tip of snout; when legs are folded at right angles heels overlap five millimeters.

FIG. 68.—*Staurois afghanus* Günther. Upper, No. 33807 ♀, snout-vent length, 76 mm. Lower, No. 33805 ♀, 77 mm. Both, Doi Suthep, Chiang Mai, Thailand, 2300-4000 ft. elevation.

Color in life: Greenish olive with light reticulation enclosing darker areas; arms, hands (partly) banded with whitish; narrow light line and dark stripe on underside of forearm; legs with lighter bars which are themselves spotted black; back of thigh black with whitish reticulation; underside of foot and tarsus, and web between toes blackish; underside of discs gray. Venter yellowish cream.

Measurements in mm. of *Staurois afghanus*

Number	71	33805	33807	73	72
Sex	♀	♀	♀	♂	♂
Snout to vent	77	77	76	42.5	42.5
Width of head	29	30.5	29	17	17
Length of head	24	27	25	15	15
Snout	11	11.6	10.8	5.9	5.8
Arm	49	50	48	29.5	32
Leg (from vent)	132	133	128	73	75
Tibia	42	45	45.3	24	25
Foot and tarsus	56.2	55	55	31	32

Variation: Although much smaller, the two males seem to be mature since the nuptial pads on first fingers are large and the arm glands are well-developed. The granulation of the back and sides is conspicuous and there is more granulation on the limbs than in females.

Distribution: The first record of the species for Thailand is that by Dr. Doris Cochran in 1930, for Doi Angka (Doi Intanon), Chiang Mai province. This is the highest mountain in the country.

Elsewhere the species is known in Burma, Sikkim and Yunnan.

Staurois larutensis (Boulenger)

FIG. 69

Rana larutensis Boulenger, Ann. Mag. Nat. Hist. ser. 7, vol. 3, 1899, p. 273, pl. 11, fig. 1 (type locality, Larut Hills, Perak); Flower, Proc. Zool. Soc. London, 1899, p. 898; Laidlaw, Proc. Zool. Soc. London, 1900, p. 886, pl. 57, figs. 3 and 4; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 200; Boulenger, Journ. Federated Malay States Mus., vol. 3, 1908, p. 63; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 245-246; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 277; Bull. Raffles Mus., no. 3, 1930, pp. 110-111, fig. 6 (Tapli and Tasan, Isthmus of Kra; Ban Chanaha and Bhetong, Yala).

Diagnosis: A large species reaching 75 mm. snout-to-vent length; skin finely granular with some larger pustules on dorsum and about vent; eyes large, elevated upper lid wider than interorbital space; tympanum small (occasionally hidden), first finger shorter than second. Toes completely webbed; very large terminal discs, those of fingers largest, tending to be triangular rather than rounded. Vomerine teeth in groups between choanae but each much smaller than choana. Heel to beyond tip of snout. Above pale green, strongly spotted with black.

Description of species (from M. S. No. 61 "Patani, Siam"): Head rather short, about as long as broad, snout somewhat rounded, subacuminate, and shorter than eye; loreal region nearly vertical, concave; nostril equidistant from tip of snout and eye; canthus rostralis

FIG. 69.—*Staurois larutensis* Boulenger. No. 61 ♂. Snout-vent length, 41 mm. Pattani, Thailand.

with sharp edge; interorbital space equal or little less than width of upper eyelid; tympanum well developed, its diameter equal to one third length of eye, not encroached upon by supratympanic fold, separated from eye by distance equal to two thirds its diameter.

Vomerine teeth in small elevations between and almost entirely behind posterior level of choanae; tongue free for at least one fourth its length; two small vocal vesicles, openings back near level of mouth-angle; openings of palatal glands in a short curved groove between choanae.

Skin with fine granulations with some flat enlarged pustules on sides; venter largely covered with granules or areolae; part of ventral and posterior faces of thigh with irregular granules or pustules; chin, throat and breast smooth.

Fingers with tips dilated into large discs which are considerably larger than tympanum; peripheral grooves, and groove across face of disc present; first finger shorter than second bearing large nuptial pad at base of first (males only); toes very broadly webbed, web reaching terminal discs, which are little smaller than those on fingers; an elongate but flattened inner metatarsal tubercle and small distinct rounded outer tubercle.*

Tibiotarsal articulation reaches beyond tip of snout; when legs are folded at right angles to body, heels overlap three to four millimeters; very indistinct dorsolateral fold beginning behind eye can be traced to near groin.

Color: Above pale greenish (brown in fixative) with a reticulum of cream enclosing darker areas; arms and legs with transverse bars of darker color; underside of head and body whitish to yellowish white; limbs greenish to grayish; hands and feet purplish, the web nearly black.

Measurements in mm. (Nos. 61 ♂ and 1336 ♀): Snout to vent, 41, 54; width of head, 14, 18.8; length of head, 14.2, 18.2; arm 24.6, 36.5; leg, 67, 99; tibia, 23, 32.5; foot and tarsus, 29, 43.

Variation: The female of the species reaches a length of 70 millimeters, while the male is much smaller (45 millimeters). The tympani of the female specimens are definitely less than a third the length of the eye, and their diameter is less than their distance from eye. The vomerine teeth are more distinct and the outer metatarsal tubercle is distinctly developed in the female specimens.

Distribution: The species is known from Pattani, Yala, and

* Boulenger (1912) description of this species says "no outer metatarsal tubercle."

Chumphon provinces, peninsular Thailand. It has been found to be common along mountain streams in northern Malaya, and has been taken at an elevation of about 1800 meters. It has also been reported from Borneo.

Remarks: The second measured specimen is from Kuala Lumpur, Malaya.

FAMILY RHACOPHORIDAE

Until further studies have been made on the arboreal ranid frogs I propose to retain the Rhacophoridae as a family group despite suggestions to the contrary.*

Four genera are recognized in Thailand. These are *Philautus*, *Theloderma*, *Rhacophorus*, and *Hazelia*. That it is not always easy to assign species to their proper genus is readily admitted. Certain herpetologists have abandoned all or a part of these except the genus *Rhacophorus*.

Chirixalus is separated from *Philautus* on the character of the hand. The two inner digits are separated from the other two and tend to be opposite to the two outer digits. In preservation, unless the hand has been spread, this character may not be at all obvious but nevertheless it is real. It is probable that this genus should also be recognized.

Species of *Philautus* often appear to be miniature *Rhacophorus* but in all cases *Philautus* lacks vomerine teeth (a few presumed *Rhacophorus* may lack them also). In the genus *Theloderma*, I am associating frogs having rough warty skins, and an arboreal life history. It includes species that have been assigned to various genera including *Rhacophorus* and *Philautus*.

Each of the above is discussed further under the generic discussions.

Genus RHACOPHORUS Kuhl

Rhacophorus Kuhl, in Schlegel, Isis, 1827, vol. 20, p. 294, type of the genus? (leucomystax).

This group has in common the habit of depositing the eggs out of water, in trees, shrubs, plants or in the absence of all these on the ground near the water's edge. However, they tend to choose plants that are growing from water or that have branches overhanging water. They may be placed on tree branches as much as thirty feet from the water, or they may be on plants only a few inches above the water surface.

* See Laurent, Rev. Zool. Bot. Afr., vol. 45, I, 1951, pp. 116-122. In this paper he proposes to reduce the Rhacophoridae to subfamily rank and elevate certain other African and Madagascar frogs to a family group, Hyperoliidae.

As the eggs are being laid by the female in a place she has chosen, carrying the male with her, the male by movements of his legs churns up the liquid and gelatinous matter extruded with and about the eggs, into a mass of sticky foam. The outer surface of this mass dries and shrinks somewhat forming a crust. It may have the form of a ball with a diameter of from three to four inches. The crust prevents loss of moisture. The young hatch and the foam tends to liquidate forming within the mass a small body of water. Eventually this water breaks through the crust of the mass, and falls with the young larvae to the pool of water below.

Often the eggs may be deposited over shallow rain pools which, by the time the young are ready to take up life in water, will have disappeared by draining or evaporation, in which case the young die after falling.

If, however, the water remains the young on reaching it tend immediately to seek the edges of the pool where they may congregate. Here perhaps they find better protection among the plants growing near the edges than in deeper water.

Almost invariably the laying of the eggs begins after the first rains of the season and usually temporary rain pools are chosen rather than streams or larger ponds, presumably because they are more likely to be free of fish. I have, however, found the egg masses along mountain rivulets capable of accommodating small to tiny fish in areas where no temporary rain pools are apparent.

This habit of depositing eggs away from the permanent bodies of water would seem to have considerable survival value, since it occurs in many if not all species of *Philautus,* and *Rhacophorus,* the family Centrolenidae, many genera of the Leptodactylidae, the genus *Agalychnis, Phyllomedusa* certain species of *Hyla* and perhaps other genera in the Hylidae. In the case of some Leptodactylidae the transformation of the larvae is direct and without a free swimming period. This is true also of certain species of *Rana.*

KEY TO THAI SPECIES OF RHACOPHORUS

1. Fingers strongly webbed (more than half to completely webbed) 2
   Fingers not webbed or with only a trace 5
2. A well-defined dermal flap above vent 3
   No dermal flap above vent 4
3. A well-defined dermal flap on outerside of forearm and on heel; length, to 100 mm. .... *nigropalmatus*
   No dermal flap on outer edge of forearm or at heel; length, to 82 mm., *robinsoni*

4. A dermal flap above vent; black (or blue) spots present behind axilla; tibiotarsal articulation to tympanum; 55 mm. . . . . *bimaculatus*

   A very prominent dermal flap above vent; no axillary black spots; tibiotarsal articulation to tip of snout or beyond. Green in life, cream in preservative with often fine black dots on back; 68 mm., *dulitensis prominanus*

5. Small species; a scalloped fringe on posterior (outer) edge of tarsus and foot; paired vocal sacs present; 30 mm. . . . . *bisacculus*

   Large species; no scalloped fringe on posterior side of tarsus and foot; a single vocal sac 6

6. Part of skin on head with bony deposit, fused to skull bones; 82 mm., *leucomystax*

   Skin on head not attached to skull; 75 mm. . . . . *colletti*

Rhacophorus nigropalmatus Boulenger

FIG. 70

Rhacophorus nigropalmatus Boulenger, Ann. Mag. Nat. Hist., ser. 6, vol. 16, 1895, p. 170 (type locality, Sarawak); Flower, Proc. Zool. Soc. London, 1899, p. 899; Werner, Zool. Jahrb., Syst., vol. 13, 1900, p. 496, pl. 34, fig. 8; Boulenger, Fasciculi Malayenses., Zool., vol. 1, 1903, p. 137, pl. 6, fig. 1; A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 251, fig. 71; Anderson, Svenska. Ak. Handl. vol. 55, no. 4, p. 17; van Kampen, Amphibia of the Indo-Australian Archipelago, 1923, p. 267.

Rhacophorus (R.) *nigropalmatus* Ahl, Das Tierreich, Lief. 55, Anura III, 1931, pp. 166-167.

Rhacophorus nigropalmatus nigropalmatus Wolf, Bull. Raffles Mus., no. 12, 1936, p. 200.

Diagnosis: A large species reaching a length of 100 mm. snout to vent. Arms, vent, heel, and tibia with dermal folds; fingers entirely webbed; toes entirely webbed; black spots on webs of hands and feet; loreal region oblique.

Description of species (from No. 20725 collection of Dr. Boonsong Lekagul, Ban Bang Non, Ranong): Head as broad or broader than body; interorbital distance greater than width of an eyelid; loreal region oblique; canthus rostralis scarcely indicated except immediately behind nostril; loreal region slightly concave; snout sloping obliquely to lip; tympanum large, its diameter (7 mm.), nearly equal to length of eye (7.6 mm.); tympanum separated from eye by a distance equal to about one third diameter of tympanum; choanae moderate; vomerine teeth on ridges arising at anterior inner edge of choanae extending back diagonally, curving slightly, but separated from each other by a gap equal to half length of one series; tongue large, free for more than half its length.

Arms long, two other fingers fully webbed; between first and second fingers, web fails to reach discs; discs of fingers large, those of two outer fingers larger than tympanum; terminal phalanges of

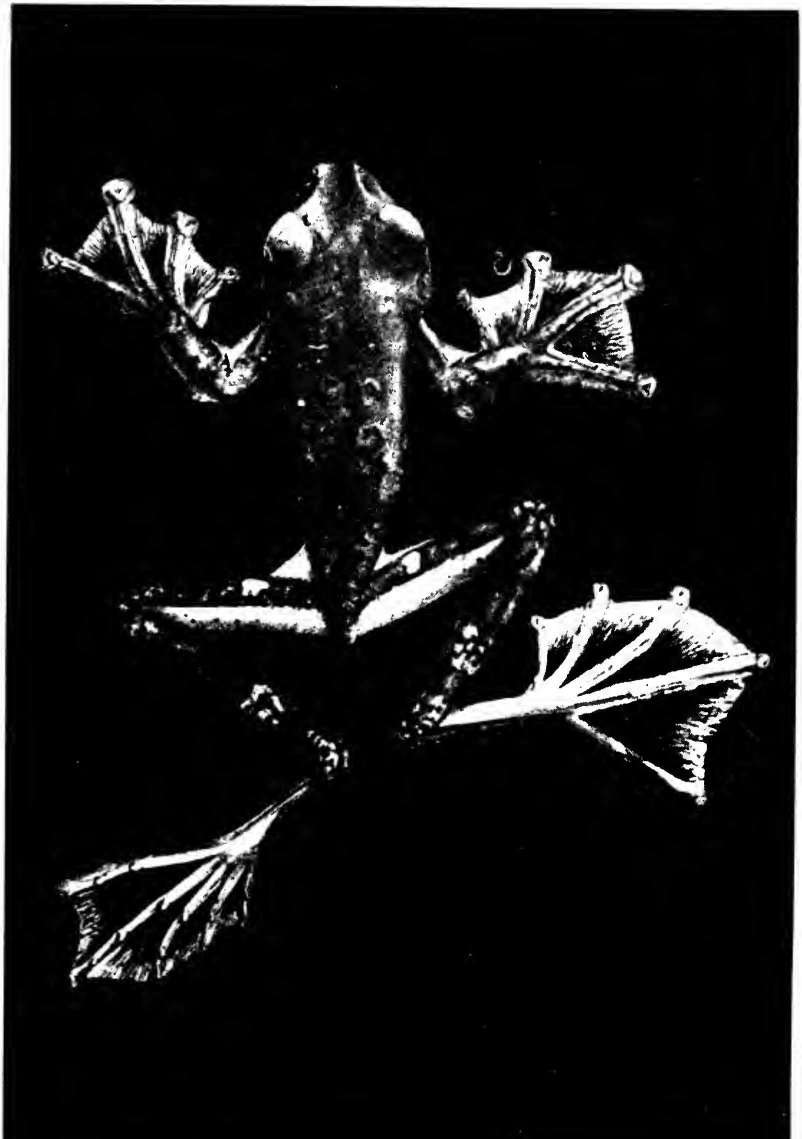

Fig. 70.—*Rhacophorus nigropalmatus* Boulenger. From Boulenger 1903, pl. 6, fig. 1. About natural size.

fingers Y-shaped, branches of Y, forming short ridges on upper surface of discs, each branch two millimeters long; a narrow skin-fold along outer edge of outer finger continued to elbow, widening along radioulna. Outer subarticular tubercles moderate, proximal ones small; metacarpal tubercles, except inner, not well differentiated; numerous small palmar granules.

Leg large, the tibiotarsal articulation reaching little more than halfway between eye and nostril; a projecting normal fold on tibiotarsal joint connecting with a slight fold on outer edge of outer toe. Toes fully webbed, terminating in discs smaller than those on fingers; subarticular tubercles small; some small granules on sole; inner metatarsal tubercle small; no outer tubercle.

Skin nearly smooth along upper part of sides, and on dorsal and lateral surfaces of limbs, but under a lens, minute granulation present. Breast, venter, part of underside and part of posterior face of femur strongly granular or areolate; a strong transverse fold of skin above vent.

Color: Above, green in life, the color in preservative (formalin) lively lavender to violet with a few scattered elevated glandular white spots; venter, chin, and underside of limbs whitish; webs on feet somewhat orange with large black areas between toes and between three outer fingers; large ink-black spots behind axillae.

Measurements in mm.: Snout to vent, 101; width of head, 33; length of head, 34; arm, 63; width of largest disc, 7.5; leg, 149; tibia, 50; foot and tarsus, 69.

Variation: Relatively few specimens of this species have been found. There are, however, certain known variations. The webs on the hand may reach the discs of the first and second finger and the hand is then fully webbed. Boulenger (1912) states that the tympanum is one half to two thirds the diameter of the eye; in the described specimen it is relatively larger; the tibiotarsal articulation may reach the tip of the snout. The color was described by Boulenger (1912): "Color in life green above, powdered with white or with lichen-like white markings; one or two conspicuous white spots on the upper surface of the thigh; flanks yellow or orange, veined with black; interdigital membranes black at the base, yellow or orange veined with black towards the border; throat and chest cream-colour, belly and lower surface of limbs salmon-pink, sometimes dotted over with yellow."

Distribution: In Thailand the species is known from "Mabek, Jalor, Pattani"; Ban Bang Non, Ranong; and "extreme north of Siam."

The species was originally described from Sarawak. Since then it has been taken in Sumatra and Malaya.

Remarks: Boulenger 1903 suggests that this species may be the "flying frog" reported by Wallace from Borneo. Gadow (1909), however, believes the species to have been *Rhacophorus pardalis,* a much smaller frog, and identifies Wallace's specimens with that species, the largest of which has a length of about 65 mm. He computes the total surface of hands and feet to be 18.8 square centimeters instead of 78 square centimeters as was erroneously reported by Wallace.

Rhacophorus robinsoni Boulenger

FIG. 71

Rhacophorus robinsoni Boulenger, Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 136, pl. 5, fig. 2 (type locality, Bukit Besar, 2500 ft., Pattani, Thailand); Journ. Federated Malay States Mus., 1908, vol. 3, p. 63; A vertebrate fauna of the Malay Peninsula. . . . Reptilia and Batrachia, 1912, pp. 249-250.

Rhacophorus R. robinsoni Nieden, Das Tierreich, Lief. 55, Anura III, Mar. 1931, p. 157.

Rhacophorus pardalis robinsoni Wolf, Bull. Raffles Mus., no. 12, 1936, p. 208.

Diagnosis: Fingers nearly entirely webbed, discs as large as tympanum; toes fully webbed; skin smooth above; no dermal flaps on heel or above vent; vomerine teeth on elongate ridges beginning close to anterior edge of choanae.

Description of species (from B. M. No. 1906.2.28.7, Kuala Teku, Pahang, Malaya, 500 ft., adult female): Snout obtusely pointed, a little longer than orbit; nostril about equidistant between eye and tip of snout, very slightly nearer latter; canthus rostralis distinct; loreal region nearly vertical, somewhat concave; top of head rather concave; strong fold from eye continuing back, covering upper edge of tympanum and extending to point above and behind level of arm-insertion; tympanum large, its diameter (5.3 mm.) little more than half length of eye (10 mm.), separated from eye by distance less than one fourth its diameter.

Vomerine teeth on two elongate slightly curving ridges, arising from anterior inner edge of choanae, separated mesially by a distance about two fifths of length of one ridge; palatal glands opening in a transverse sinuous, more or less continuous groove on palate close to anterior level of choanae; tongue free behind for more than two fifths of its length.

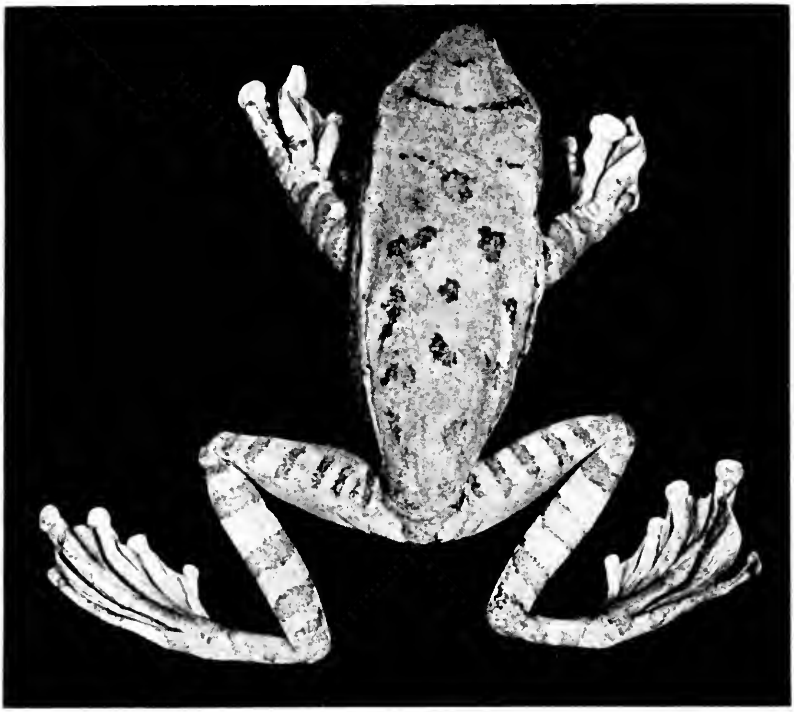

FIG. 71.—*Rhacophorus robinsoni* Boulenger. B. M. No. 1906.2.28.47. Actual snout-vent length, 59 mm. Kuala Teku, Pahang, Malaya.

Arm well developed without fringe, fingers with widened terminal discs, width of three outer ones equal to diameter of tympanum; on three outer fingers webs extend to base of discs, but only halfway to disc on first finger; subarticular tubercles small; inner metacarpal tubercle large projecting; legs moderate, tibiotarsal articulation reaching forward to beyond eye; legs folded at right angles to body, heels overlap four millimeters; toes with widened discs smaller than those on fingers, completely webbed, the webs attaching to sides of discs; a very small inner metartarsal tubercle, no outer; no tarsal fold; prominent skin-fold along edge of outer finger, a smaller one on outer toe; subarticular tubercles under toes small; very small supernumerary tubercles on soles and palms.

Skin above smooth; skin on head free; above arm and less distinctly on sides, skin finely grooved or wrinkled; chin and breast smooth, venter strongly granular; skin on exposed part of arm and leg smooth; inner posterior part of ventral surface of thigh and an area on posterior surface below vent with fine granules.

Color: In preservative, pinkish to rusty brown with narrow dark bar crossing head in supraorbital region; scattered spots of black on dorsum, some with brown centers; arm banded with black; five short bands on thigh and tibia, three median much wider than corresponding bands on thigh; entire posterior side of thigh dark gray with some darker mottling; webs dark to black; side of head dark lavender with some lighter flecks; cream spot close below eye (left side), and small white spot on lip below eye (right side); chin and breast cream with scattered brownish flecks; venter strongly spotted or reticulated with brown; brown spotted on underside of thighs and tibia.

Measurements in mm.: Snout to vent, 59; width of head, 29; length of head, 24; arm, 49; leg, 123; tibia, 38; foot and tarsus, 57.

Variation: This is, I believe, the second specimen known. It is larger but differs but little from type save in some details of coloration and marking. Boulenger (1912) states: "Pinkish brown or pale coffee colour above, bluish gray on sides of body and limbs; sides of head darker, purplish gray to blackish, which shade is sharply defined on the canthus rostralis; more or less defined dark spots on the back; limbs with grayish brown crossbars; interdigital webs blackish with light veins; whitish beneath, throat spotted or mottled, belly marbled with gray.

"The type measured 82 mm. from snout to vent."

Distribution: The type came from Bukit Besar, a mountain in the present provinces of Pattani, Songkhla and Yala. It is most probable that the exact type locality is in the province of Pattani.

Outside of Thailand a specimen has been taken at Kuala Teku, Pahang, at 500 feet. This specimen forms the basis of this description.

Remarks: It would appear that *Rhacophorus robinsoni* differs so markedly from *Rhacophorus pardalis* that I cannot accept Wolf's suggestion of placing it as a subspecies of the latter.

Rhacophorus bimaculatus Boulenger

FIG. 72

Rhacophorus reinwardtii Jerdon, Proc. Asiat. Soc. Bengal, 1870, p. 84 (not of Kuhl).

Rhacophorus maculatus Anderson, *ibid.*, 1871, p. 27 (not of Gray).

Rhacophorus bimaculatus Boulenger, Catalogue of the Batrachia Salientia s. Ecaudata in the collection of the British Museum, 2nd Ed., 1882, pp. 90-91 (type locality Khassya and Assam); The fauna of British India . . . Reptilia and Batrachia, 1890, p. 472; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 202; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 250; Annandale, Rec. Ind. Mus.

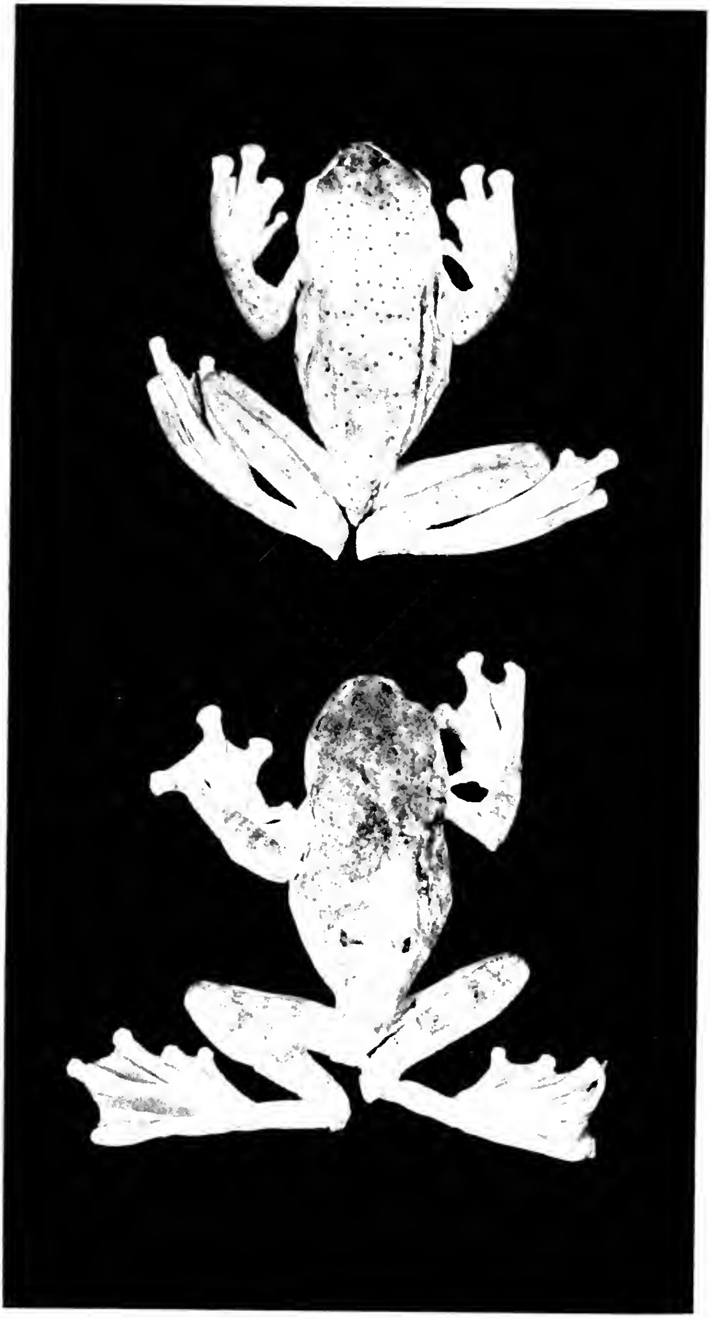

FIG. 72.—*Rhacophorus bimaculatus* Boulenger. Upper figure, No. 36012 ♀. Actual snout-vent length, 47 mm. Doi Suthep, Chiang Mai, Thailand. Lower figure, No. 36279 ♀. Length, 46.5 mm., Kaeng Pang Tao, Chiang Mai, Thailand.

vol. 8, p. 12; M. Smith, Journ. Federated Malay States Mus., vol. 10, 278; Bull. Raffles Mus., no. 3, Apr. 1930, p. 114 (Nakhon Si Thammarat Mts.).

R[hacophorus] (R.) bipunctatus Ahl, Das Tierreich, Lief. 55, Anura III, Mar. 1931, pp. 168-169; Sitzb. Ges. Fr. Berlin, 1927, p. 46.

Rh[acophorus] reinwardti bipunctatus Wolf, Bull. Raffles Mus., no. 12, 1936, p. 214; Bourret, Les Batraciens de l'Indochine, 1942, p. 446.

Diagnosis: Digits of hand with broad terminal discs, outer as large or larger than tympanum; outer fingers four-fifths webbed; toes webbed to discs except on fourth; strong fringe along outer finger and forearm; fringe along outer toe to tarsus forming one or two free flaps on tibiotarsal joint; a preanal flap; males with vocal sac; pair of axillary spots, rarely two spots on each side. Green or gray above, rarely red-brown with black dots; pure white or yellowish on venter.

Description of species (from No. 33730 ♀ Doi Suthep near Chiang Mai, Chiang Mai province): Head rather broad, interorbital space equal or slightly exceeding width of an eyelid; top of head flat, but from nostrils snout slopes down to terminal point on upper lip; nostril closer to eye than to tip of snout; canthus rostralis rounded, scarcely indicated; tympanum distinct, its diameter (3.4 mm.); shorter than length of eye (5.2 mm.); eye to tip of snout nine mm. Vomerine teeth on two transverse ridges that begin on inner edge of choanae; separated mesially by a distance equal to length of single ridge; palatal glands open in median groove closer to anterior level of choanae than to front of palate. Tongue large, strongly bifid posteriorly, free for more than half its length posteriorly, and free on sides. (Males with vocal sac and elongate vocal slits). Arm rather short, permanently (?) flexed at elbow with small prebrachial web; fingers with broad terminal discs, outer ones equal to size of tympanum, inner one small; three outer fingers about four-fifths webbed; subarticular tubercles small, distinct; toes webbed to discs on outer toes, while on inner side of first three, web scarcely reaches discs; a small indistinct inner metatarsal tubercle; a fringe on outer finger which reaches elbow (widening somewhat); fringe on outer toe reaches tarsus forming there a free flap; tibiotarsal articulation reaches to tympanum.

Skin above minutely corrugated (under lens); skin of chin and breast minutely wrinkled; entire venter, lower sides, and most of undersurface of thighs regularly granular or areolate. A few granulations on posterior face of thigh behind vent; well-defined sinuous transverse flap above vent.

Color in life: Generally lavender brown above; back very indefinitely marked, with dark line between eyes; faint X-shaped mark on shoulder discernible when submerged in clear liquid; webs of hand and foot orange. Sides and all undersurfaces white with a slight ivory cast; black spot on side in axillary region.

Measurements in mm. of *Rhacophorus bimaculatus*

Number	33730	67	68	69	70
Sex	♀	♂	♂	♂	♂
Snout to vent	54	35.2	36	37	36.5
Snout to eye	9	6	6.1	5.8	5.6
Length of eye	6.2	5.3	5	4.8	5
Diameter of tympanum	3.5	2.6	2.5	2.35	2.3
Axilla to groin	31	21	18	19	19
Width of head	20	13.5	12.9	13	14
Length of head	16.5	13	12.2	12.2	13.2
Arm	33	23	22	23	23.8
Leg	73	54	55.6	57	57
Tibia	23.5	17	18	19	18.6
Foot and tarsus	31	22	22	24	24

Variation: A series of males from Northern Chiang Mai province shows some variation in the markings.

No. 68 is dark lavender above, and pure white below. Darker markings on the dorsum (dark bar across eye, indefinite X-shaped markings on shoulders and the transverse marks on back and on limbs) are scarcely discernible unless submerged in clear liquid. An axillary black mark present, followed by one or two others. An orange web on foot and between two outer fingers.

No. 67. This is dark maroon to magenta above, the dark markings indistinct; a black axillary mark, followed on each side by three rounded white spots, more or less outlined in black, extends to the groin. Some black flecks are present on chin.

No. 69. The dark dorsal marks are distinct and the X-shaped mark is widened to form a large blotch. Only a narrow stripe of color is present above the white thigh. The darker bars on arms and limbs are distinct.

No. 70. The dorsal markings are distinct and there is a single axillary spot.

In the described specimen there is only a narrow line of pigment along the upper surface of upper arm and along the upper part of the femur. The specimen described (No. 33730) has become nearly uniform dark lavender on the dorsal surface.

A very brilliantly-colored specimen from Fraser's Hill, Malaya, in preservative one month, is coffee-brown above with minute fleckings and reticulations of black; the bars on the limbs are moderately distinct. Chin, sides, venter, and underside of limbs, formerly bright chrome-yellow, are now pure white. The sides are white with a large axillary blue spot followed by an equally large lateral spot and paired spots on sides of venter with two small ones on each side of the anal area. All the blue spots are speckled with very numerous minute white dots. When first captured, the specimen was very light clay color above. Within an hour it was grass green, later turning coffee-brown. With its orange and yellow hands, red-orange feet, it was one of the most brilliantly-colored amphibians I have seen.

Distribution: The species has been taken in Nakhon Si Thammarat, and in the province of Chiang Mai at elevations of about 800 ft.

It has been taken in Malaya (Fraser's Hill, and Larut, Perak). It is known also in Assam and Burma.

Remarks: A female, found about midday at Paeng Kang Tao in bushes near a swampy area, was attached to a leaf and appeared to be in a deep sleep.

Rhacophorus dulitensis prominanus M. Smith

FIG. 73

Rhacophorus prominanus M. Smith, Journ. Federated Malay States Mus., vol. 9, pts. 3 and 4, March, 1924, pp. 185-186, figs. A and B (type locality, Jor, Batang Padang, Perak, altitude 600 meters); Bull. Raffles Mus., no. 3, Apr. 1930, pp. 114-115 (Banang Star, Patani = Bendang Stah, Yala).*

R[hacophorus] (R.) prominanus Ahl, Das Tierreich, Lief. 55, Mar. 1931, p. 165.

Rhacophorus dulitensis (part.) Wolf, Bull. Raffles Mus., no. 12, 1936, pp. 210-211.

Diagnosis: A medium-sized species of the genus (snout to vent, 68 mm.); head except in young, broader than long, depressed; diameter of tympanum five sixths of eye length; vomerine teeth present; interorbital width greater than width of an eyelid; fingers broadly webbed; toes fully webbed, discs of all digits much widened, the largest equal to tympanum; tibiotarsal articulation to tip of snout; strong skin-fold along outer side of arm and hand and along foot, terminating at heel; anal region with very prominent cutaneous flap, the vent in middle of its undersurface. Green in life with numerous small brown spots; yellowish white below.

Description of species (from EHT-HMS No. M. 149 ♀, Kuala Tahan, King George V, National Park, Pahang): Head depressed, its width (15.2 mm.) slightly greater than length (14 mm.); canthus

* Sometimes spelled Banang Stah or Benang Star.

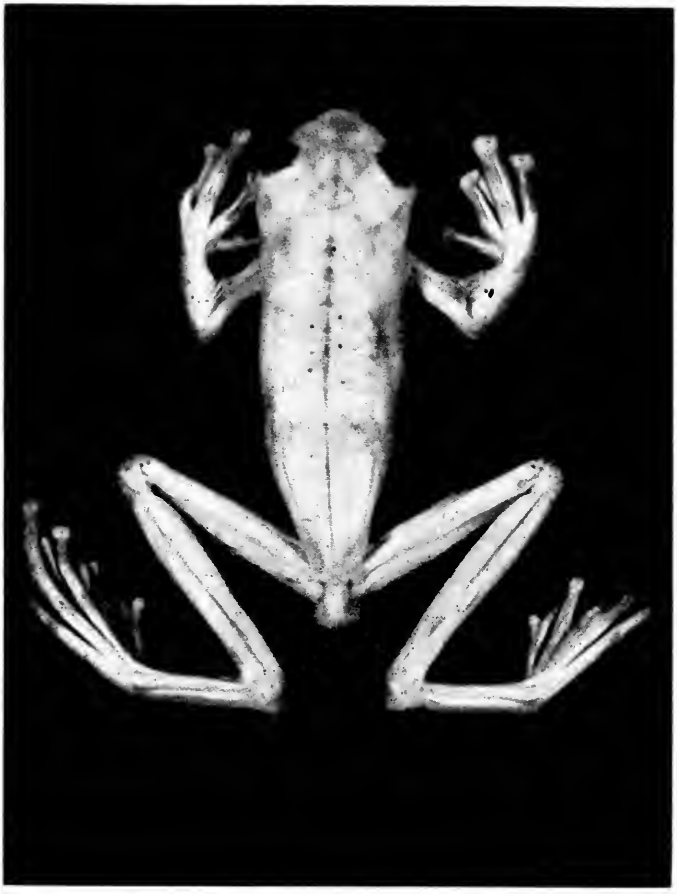

FIG. 73.—*Rhacophorus dulitensis prominanus* (M. Smith) EHT-HMS No. M. 149 ♀. Actual snout-vent length, 42 mm. Kuala Tahan, Pahang, Malaya.

rostralis angular, loreal region slightly oblique not or scarcely concave; snout rather pointed, projecting somewhat beyond mouth; nostril nearer tip of snout than to eye; tympanum distinct, its diameter less than eye length, very narrowly separated from eye; width of eyelid in interorbital width about one and one-fourth times; tongue large, notched behind, free for about two fifths of its length; vomerine teeth on two elevated ridges set in from choanae, not extending to their posterior level, and separated from each other by distance much greater than length of one elevation.

Arm short, digits broad, flattened, tips widened into discs, outer ones as wide as diameter of tympanum; outer fingers fully webbed, inner fingers, half webbed; large inner metacarpal tubercle, median and outer small; subarticular tubercles distinct, single; palm with numerous granules; fringe on outer side of hand continuing to elbow; very slight but distinct axillary web; small web in front of arm opposite elbow. Legs moderately long, tibiotarsal articulation reaches tip of snout; toes completely webbed; very small inner metatarsal tubercle; no outer; subarticular tubercles moderate; metatarsals completely separated by web. A fringe along outer toe continued along tarsus to end of heel; distinct flap slightly notched in middle projects above anus, the vent opening in middle of underside of flap.

Skin, seen under a lens, finely corrugated above; sides nearly smooth; chin and breast with minute granules; breast and venter with flat granules or areolae; underside of thigh with similar granules intermixed with an irregular transverse row of larger elevated granules or tubercles; posterior face of thigh smooth (under a lens minutely wrinkled).

Color: In life bright green with some fine brown spots; in preservative very light yellow brown (nearly cream) with a few brown dots above; canthus and tip of snout brownish; black spot on eyelid; entire ventral surface of body and limbs yellowish or cream, with trace of an orange spot on outer web membranes of foot.

Measurements in mm. (Nos. 148 and 149, respectively): Snout to vent (end of flap), 50.5, 42; width of head, 15.2, 12.6; length of head, 14, 13.5; arm, 30.6, 25; leg, 74, 59; tibia, 26.5, 21; foot and tarsus, 34.2, 27.5.

Distribution: In Thailand this form has been found only at "Benang Star" in Yala, a relatively short distance from the Malayan border. In Malaya it has been taken in Perak (the type series); and in Pahang (King George V National Park).

Remarks: The anal flap occurs also in *Rhacophorus bimaculatus* but is rarely so well-developed as in *prominanus.* This flap is greatly reduced in *dulitensis dulitensis.*

M. Smith records the living colors: "deep green in life with numerous small dark brown spots; below yellowish white, uniform. Supraorbital region and anal projection ochreous yellow, web of fingers greenish yellow, web of toes yellow at the base, carmine at the margin."

Rhacophorus bisacculus sp. nov.

FIG. 74

Type: No. 34960. Collected March 14, 1958, Phu Kading, Loei province, at an elevation of 3800 ft., by Edward H. Taylor.

Paratype: No. 34959. Topotype. Same date and collector.

Diagnosis: Vomerine teeth weak, in two transverse rows between choanae, widely separated mesially; snout pointed at tip; all fingers with web remnants; chin, venter, and underside of femora granulate; paired lateral vocal sacs at mouth angles; toes at least three-fourths webbed; a row of tubercles on underside of arm, and a similar row on tarsus, continuing onto outer digits. Vocal sacs present.

Description of type: Snout triangular in outline, terminating in a small "nose" extending beyond lower jaw, then sloping backwards and downwards to lip; canthus rostralis not or scarcely indicated; loreal region sloping obliquely, shallowly concave; area about nostrils swollen, elevated somewhat, distance between nostrils slightly greater than interorbital distance which is narrower than width of an upper eyelid; tympanum large, well defined, its diameter (2 mm.) a little less than half length of eye (4.6 mm.); snout practically as long as eye.

Tongue strongly notched behind, free for little more than a third

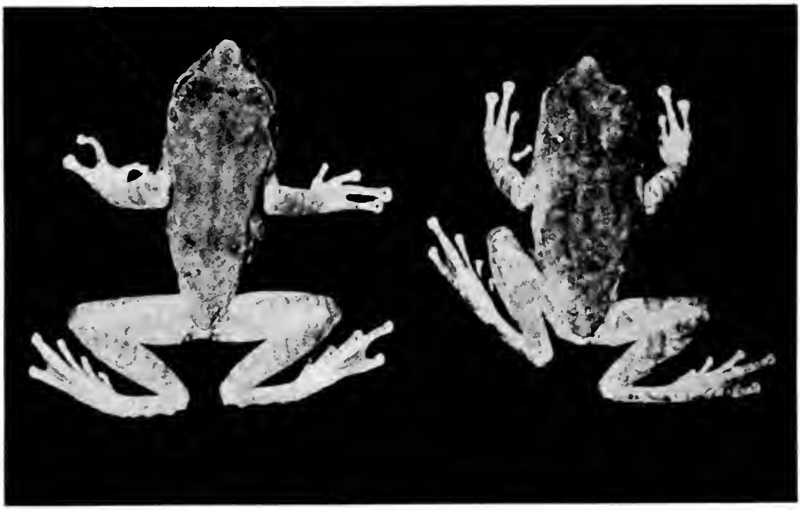

FIG. 74.—*Rhacophorus bisacculus* sp. nov. Left figure, No. 34960 ♂. Type. Actual snout-vent length, 30 mm. Right figure, paratype, No. 34959 ♀. Length, 29 mm. Both, Phu Kading, Loei, Thailand.

of its length; vomerine teeth on two low ridges arising near inner edges of choanae, running transversely and somewhat diagonally, separated mesially by distance greater than length of one series.

Male with vocal sacs, situated near angle of mouth, opening into mouth through two small puckered openings just back of level of mouth-angle.

Arm moderate; first finger very small, with basal swelling and large nuptial patch covered with asperities; metacarpal tubercles distinct, largest at base of first finger; distinct remnant of web between fingers, continuing on sides of fingers as fine ridges; distal subarticular tubercles distinct, large, proximal ones much smaller; tips of digits dilated into discs, each with peripheral groove, outer ones more than twice width of inner; somewhat broken fleshy fold on outer edge of fourth finger, continued on forearm to elbow as a linear series of tubercles. Leg moderately long, tibiotarsal articulation reaching to a point near halfway between eye and nostril; legs folded at right angles to body heels overlap two millimeters. Toes about three-fourths webbed except first and second which are less than half webbed; discs of toes smaller than those on fingers; subarticular tubercles distinct, distal ones larger than proximal ones; some granules on sole; an inner metatarsal tubercle, no outer; a broken fringe on outer toe continued along tarsus with a series of conspicuous tubercles. Skin with some scattered flat tubercles on head, eyelids, and occiput; fewer tubercles on dorsum, numerous, and a little larger on sides, finely granular on rump. Some prominent tubercles on end of tibia; chin finely granular, breast nearly smooth; venter and lower part of sides strongly and uniformly granular. Most of underside of femur and anal region granular. Strong fold from eye above tympanum to above arm-insertion.

Color: Dorsum dark brown with a darker somewhat triangular area on occiput; a pair of dark lines from eye curving back and becoming lost on sides; darker band between eyes and some indefinite marks on sides of head and on lips; tympanum brownish; narrow pigmented stripe along dorsal part of femur showing darker banding; front and back of femur light with thinly scattered nearly uniform pigment; chin clouded blackish; throat, breast, venter, and undersides of limbs whitish or yellowish-white; underside of feet dark. Region about vent blackish preceded by an irregular pair of lavender spots.

Measurements in mm. (type ♂ and paratype ♀, respectively): Snout to vent, 30, 29; width of head, 12, 11.6; length of head, 11.4, 10; arm, 19, 19.2; leg, 44.4, 44; tibia, 15, 15; foot and tarsus, 19, 19.6.

Variation: The tubercles on tarsus are more conspicuous in the type (see figure) than in the paratype. The pattern on the paratype is less distinct than that of the type.

Distribution: Known only from the type locality.

Remarks: I believe this species is related to *Rhacophorus appendiculatus,* and *chaseni.* I do not, however, regard it as a subspecies of either of those forms. *R. chaseni* has been reported in Malaya. This is approximately 800 miles south of the Thai locality from which *bisacculus* is known.

The two specimens were taken at night from plants growing in the edge of a tiny rivulet on the side of Phu (mountain) Kading. The latter is something more than 5000 ft. in elevation. The top is relatively flat, with several slow-flowing streams and covered by a splendid coniferous forest.

Rhacophorus leucomystax leucomystax (Kuhl, in Gravenhorst)

FIGS. 75, 76

Hyla leucomystax Kuhl, in Gravenhorst, Deliciae Musei Zoologici Vratislaviensis, . . . fasc. 1, 1829, p. 26 (type locality, Java).

Polypedates leucomystax Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1063.

Polypedates maculatus (part.) Günther, The Reptiles of British India, 1864, p. 428.

Polypedates rugosus Duméril and Bibron, Erpétologie générale . . . vol. 8, 1841, p. 520 (*part.*).

Rhacophorus maculatus (part.) Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata, in the British Museum, 1882, p. 83.

Rhacophorus leucomystax Boulenger, The fauna of British India . . Reptilia and Batrachia, 1890, p. 474; Flower, Proc. Zool. Soc. London, 1896, p. 905, pl. 44, fig. 2; *ibid.*, 1899, p. 898, pl. 59, fig. 3; Laidlaw, Proc. Zool. Soc. London, 1900, p. 887; Butler, Journ. Nat. Hist. Soc. Bombay, vol. 5, 1903, p. 202; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 248-249; van Kampen, Zoologische Ergebnisse einer Reise in Niederländisch Ost-Indien, Bd. 4, 1907, pp. 399, 411; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 1, no. 3, Mar. 1915, p. 156 (Sai Yoke, Kanchanaburi province); *ibid.*, vol. 2, no. 2, Dec. 1916, p. 168; *ibid.*, p. 229; *ibid.*, p. 267 (tadpoles); Journ. Nat. Hist. Soc. Siam, vol. VI, no. 2, Oct. 1923, p. 211 (Hainan).

Rhacophorus leucomystax leucomystax Wolf, Bull. Raffles Mus., no. 12, 1936, pp. 178-181; Bourret, (*part.*) Les Batraciens de l'Indochine, 1942, pp. 426-430 (large synonymy and literature list, up to 1942).

R[hacophorus] R. leucomystax Ahl, Das Tierreich, Anura III, Lief. 55, 1937, pp. 134 (*part.*). (Not fig. 83.)

Diagnosis: A large species (75 mm.) characterized by having much of the skin on head involved with nasal and frontoparietal bones; vocal sac present in male; interorbital space wider than upper eyelid; tympanum distinct; fingers with very small web. Toes

FIG. 75.—*Rhacophorus leucomystax leucomystax* Kuhl in Gravenhorst. KU No. 40194. Actual snout-vent length, 60 mm. Khon Kaen, Thailand.

two-thirds or more webbed; digital discs smaller than tympanum; tibiotarsal articulation to between eye and nostril or to tip of snout; well-developed vomerine teeth; hourglass-shaped figure on head and occiput reaching shoulders.

Description of species (from No. 1140, Siracha, Chon Buri): Head subtriangular, its width (26.5 mm.) slightly wider than long (25 mm.); canthus rostralis distinct, rounded, loreal region oblique, slightly concave; at level of nostrils snout turns down and ends in point slightly in advance of mouth; snout longer than eye; tympanum large, its diameter about seven eighths of length of eye.

Vomerine teeth on two elevated ridges, continuous with a slight ridge along upper border of choanae, slightly diagonal but not reaching back level of choanae, separated mesially by a narrow space; choanae moderately large; tongue free for two fifths of its length. (Male with vocal sac; vocal slits small, near angle of jaws).

Fingers moderate, first shorter than second; terminal discs widened, two outer largest but these little more than half area of tympanum; subarticular tubercles single, well developed; inner metacarpal tubercle flat; a beadlike median, and a small outer metacarpal tubercle; supernumerary tubercles on palm. Leg moderate tibiotarsal articulation reaching nostril; when heels are folded at right angles they overlap three millimeters. Foot two-thirds webbed, terminal discs smaller than those on outer fingers; subarticular tubercles well developed; small inner metatarsal tubercle and smaller outer; dim granulation on sole. Skin above generally smooth, but under a lens appearing finely granulated; skin covering nasal bones and that on frontoparietals with a bony surface; a small triangular bony area above tympanum; a fold from eye runs above tympanum and reaches point above arm; chin vaguely granular on sides; breast smooth; venter and much of ventral and posterior surface of thighs with small granules.

Color: Head light amber-brown; body generally fawn with gray markings and clouding. An indistinct dark band below canthus rostralis; a dim band between eyes; an hourglass-shaped mark on back of head and neck, extending on shoulders; some irregularly placed darker marks on back and rump; limbs with dim darker bands; back of thigh enclosing numerous rounded gray-white dots; web of foot dusky. Back of thigh brown with cream-white spots.

Measurements in mm.: Snout to vent, 75.5; width of head, 26.5; length of head, 25; arm, 45.5; leg, 114; tibia, 40; foot and tarsus, 49.

Variation: There is remarkable variation in color in the living

FIG. 76.—*Rhacophorus leucomystax leucomystax* Kuhl, in Gravenhorst. No. 1140. Actual snout-vent length, 66 mm. Chalermlaub Royal Forest, Siracha, Chon Buri, Thailand.

animal since it is able to change its color in a short time. Green is rather unusual, but brown, gray, fawn and yellow are common.

The size of the tympanum varies, some populations having tympani a fourth to a third smaller than the one described here.

Eggs are laid in masses of foam that is churned up by the male as the eggs are deposited. These may be placed in shrubs several feet above water or they may be placed in trees on branches more than twenty feet above water. If no trees or shrubs are available the eggs may be placed at the edge of a pool or directly in the water on floating trash. The species usually chooses to lay eggs in temporary pools that have no fish.

A breeding population was found at Chalermlaub in the Royal Forest east of Siracha. Most of the individuals captured were heavily covered with fine pustules studded with small pearly spinules. This was evident on both males and females.

Distribution: This form occurs throughout Thailand in suitable places and it could doubtless be found in every province. Outside of Thailand the species occurs throughout southeast Asia and the Malay Peninsula and also in certain islands of the Indo-Australian Archipelago. However, in most of the latter areas a four- or six-lined form occurs.

Rhacophorus leucomystax sexvirgatus (Reinwardt, in Gravenhorst)

FIG. 77

Hyla sexvirgata Reinwardt in Gravenhorst, Deliciae Musei Zoologici Vratislaviensis . . . fasc. 1, 1829, p. 26 (type locality, Java).

Hyla quadrilineata Nova Acta Acad. Caes. Leop-Carol. Nat. Cur., vol. 17, 1835, p. 260, pl. 20. fig. 1 (type locality, Manila, restricted).

Polypedates quadrilineatus Günther, Catalogue of the Batrachia Salientia in the collection of the British Museum, 1858 (1859), p. 79; The Reptiles of British India, 1864, p. 429; Steindachner, Reise der Osterreichischen Fregatta Novara . . . Zoologischen Theil, Amphibien, 1867, p. 49; Anderson, Proc. Zool. Soc. London, 1871, p. 207; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, pp. 84-85 (Singapore, Java, Philippines, Formosa, and Indo-Australian Archipelago).

Rh[acophorus] leucomystax leucomystax Wolf, Bull. Raffles Mus., no. 12, 1936, pp. 178-180 (*part.*).

Diagnosis: This subspecies occurring in southern Thailand differs from the preceding chiefly in having four dorsal dark stripes, and a longer or shorter stripe from tympanum along side.

Description of species: In this form there is usually a dark mark near tympanum followed by a few dark spots as in *leucomystax*, or the spots may become a stripe that extends for a longer or shorter distance along sides. This is present in the "*quadrilineatus*" form to a greater or lesser degree and in *sexvirgatus* it is usually present as a continuous stripe to groin. (*fide* Van Kampen.) The disposition of the four dorsal stripes is much the same in both nominal forms.

The material I have examined largely from southern Thailand. suggests that the four- and six-lined forms differ only in the distinctness of the lateral stripe. If one regards them as the same form then the earlier name *sexvirgatus* Reinwardt in Gravenhorst will take precedence over *quadrilineatus*.

Distribution: I have found the lined form only in southern Thailand in the province of Yala. This may be an area of intergradation since typical *leucomystax* were taken at the same locality.

Remarks: I do not distinguish differences in behavior between

FIG. 77.—*Rhacophorus leucomystax sexvirgatus* Reinwardt in Gravenhorst. Fig. from van Kampen (1923), p. 249, fig. 27.

Rhacophorus l. leucomystax and *l. sexvirgatus.* It is difficult to say whether the latter should have the status of a subspecies or a color variety. I am treating it as the former.

Rhacophorus colletti Boulenger

FIG. 78

Rhacophorus colletti Boulenger, Proc. Zool. Soc. London, 1890, p. 36 (type locality, Langkat, Sumatra); Werner, Zool. Jahrb., Syst. vol. 13, p. 494, pl. 32, fig. 4; van Kampen, Amphibia of the Indo-Australian Archipelago, 1923, p. 250; M. Smith, Proc. Zool. Soc. London, 1924, p. 225 (Pattani); Bull. Raffles Mus., no. 3, Apr. 1930, pp. 112-113 ("Bangnara Patani" = Narathiwat Narathiwat).

R[hacophorus] (R.) colletti Ahl, Das Tierreich, Lief. 55, Anura III, 1931, p. 121.

FIG. 78.—*Rhacophorus colletti* Boulenger. No. 1311 ♀. Actual snout-vent length, 75 mm. La Doo Tin Mine, Benang Stah, Yala, Thailand.

Rhacophorus leucomystax leucomystax (*part.*) Wolf, Bull. Raffles Mus., no. 12, 1936, pp. 178-179.

Diagnosis: A large species (75 mm.); vomerine teeth between large choanae; canthus rostralis angular; interorbital space broader than eyelid; eyes large, tympanum distinct, finger discs large but smaller than tympanum; tibiotarsal articulation to beyond tip of snout; skin of head free, not involved with skull bones; anal region blackish with a light edge above. Web rudiment on hand. Toes webbed.

Description of species (from No. 1311 La Doo Tin Mine near Malay border of Kedah just northwest of Bukit Bubus): Head subtriangular, eyes strongly elevated; canthus rostralis bluntly angular, loreal region oblique, concave; in front of nostrils snout turns down to mouth; snout longer than eye, rounded at tip; head (in large female) a little broader (27.7 mm.) than long (25 mm.); eyelid equal or slightly less than interorbital width; nostril much nearer tip of snout than to eye; tympanum large, its vertical diameter (5.5 mm.) less than length of eye (8.2 mm.), separated from eye by very narrow distance. Straight fold from eye runs across upper edge of tympanum and straight back terminating on shoulder; skin of head not fused with skull bones.

Vomerine teeth on two elevated diagonal ridges arising on anterior inner edge of choanae and extending beyond their posterior level, separated from each other by a distance equal to more than half length of one ridge; tongue large, free for two fifths of its length; (male with two small puckered vocal slits opening into vocal sac back near level of mouth-angle; the choanal openings larger, and the vomerine ridges smaller and farther apart).

Arms large, fingers long, digital discs with as great a diameter as tympanum but with smaller area; first finger equal or slightly shorter than second; vague web-rudiments continued as ridges along sides of fingers; discs wider than long; subarticular tubercles large, single; a strong elongate somewhat compressed inner metacarpal tubercle; an elongate median tubercle and a small outer; several supernumerary tubercles on palm; an indistinct row of small tubercles on under posterior part of arm. Leg elongate, toes about four-fifths webbed; discs subequal, smaller than those on fingers; a flat inner metatarsal tubercle, a small outer; subarticular tubercles well developed; small tubercles on sole indicated; tibiotarsal articulation to five millimeters beyond snout; when heels are folded at right angles to body, the heels overlap about six millimeters.

Skin generally smooth but under a lens finely granular, the granules equal, close set; very small indistinct granules or areolae under chin; breast smooth; venter, most of underside and part of posterior part of thigh, as well as lower sides, with granules or areolae; a few enlarged white tubercles bordering anal region.

Color: Above mottled grayish brown; sides of body somewhat lighter, with a few scattered small black spots in lumbar region; a V-shaped mark terminating on inner side of eyelids; arms and legs dimly barred; anal region dark, more or less edged with white; two small but conspicuous tubercles on upper edge of a small anal flap.

Measurements in mm. of *Rhacophorus colletti*

Number	1311	1300	1301	1302
Sex	♀	♂	♂	♂
Snout to vent	75	51	51	53
Width of head	27.7	17.2	17.4	18
Length of head	25	17.6	19	18
Length of snout	10.2	7.6	7.8	8
Length of eye	8.2	6.8	7	7.3
Arm	53	35	33.3	34
Leg	130	89	83	91.5
Tibia	44	30.6	28	30
Foot and tarsus	56	37	35.5	38.1

(All from same locality. No. 1302 was clasping a female.)

Variation: There is some variation in dorsal markings. The V-shaped mark is more or less evident in all specimens. Some show black flecks or spots that are absent in others. Two have a dim bar across the eyelids. The lip is not white. The skin on top of head is loose in all.

The males have rather more pointed snouts than the female and the head width and length is equal or perhaps slightly longer than wide. The tibiotarsal articulation reaches beyond the tip of the snout in all, some not so far as in the female. The eyelid equals the interorbital width in two specimens. The female has a peppering of pigment on chin and throat. The web on the foot is blackish. Males may have two slight elevations in the interorbital area.

Distribution: In Thailand, specimens have been taken in Narathiwat and Yala. So far as I know none has been taken in Malaya. Otherwise known in the Indo-Australian Archipelago.

Remarks: This species has been mistaken for *leucomystax*, and Wolf (1936) has erroneously placed it in the synonymy of that species.

The two are definitely distinct since in *leucomystax*, ossification of the dorsal head skin is not a variable character. The two species are found together in southern Thailand and presumably throughout the remainder of the range of *colletti*. Neither Malcolm Smith (1930) nor Boulenger (1912) report the species in Malaya. It must occur there since my specimens were taken close to the Malayan border.

The female clasped by one of the males was beginning to deposit eggs when taken. The eggs were in a mass of foam. *R. leucomystax* was present in a nearby pool, and seemingly much more numerous than *colletti*.

Genus HAZELIA Taylor

Hazelia Taylor, Philippine Journ. Sci., vol. 16, 1920, p. 292 (type of genus *H. spinosa* Taylor).

Diagnosis: No vomerine teeth; tongue bifurcate (or notched) behind; pupil horizontal; digits with dilated tips, an intercalated element between two distal phalanges; terminal phalanges bifurcate; fingers entirely free, without lateral ridges; toes webbed; body and limbs with numerous spiny tubercles; very small metacarpal tubercles; a moderately distinct fold across palate between Eustachian tubes followed by a second less distinct; two well-defined bony ridges from canthus rostralis to back edge of occiput; bony ridges above tympanum; skin of head adherent to bones of skull and at least partially ossified.

I have revived this genus to contain *Hazelia spinosa* Taylor (the type species), and *Ixalus pictus* Peters. The latter species has been found in southern Thailand, while *spinosa*, so far as known, is confined to Mindanao and certain adjoining islands.

I do not doubt that other species, now recognized in the genus *Philautus* will be found to belong in this genus. Two that are suspects are *Rhacophorus anodon* van Kampen and *Ixalus flavosignatus* Boettger. The former at least, has the skin of head adherent to the skull.

Both *H. picta* and *H. spinosa* appear to have the same type of life history. Eggs are placed above holes or cavities in trees containing water. The rain or gravity brings the eggs or hatchlings into the water pockets. Very few eggs are laid. This would appear to be an adaptation to limited food supply in the water cavities.

Although in the type of *H. spinosa* I did not discern distinct ridges on palate in front of esophagus several specimens show one distinct fold followed by a second distinct fold between Eustachian tube openings.

Wolf (Bull. Raffles Mus., no. 12, 1936), has placed *Hazelia spinosa* as a subspecies of *Rhacophorus leprosus* (*sic.*), a disposition that suggests the author's lack of experience with the Amphibia, and an inclination to indiscriminate lumping.

Ahl has placed *Hazelia spinosa* as a species under *Philautus* which he considers a subgenus of *Rhacophorus.* Inger (1954) follows him (except he maintains *Philautus* as a genus). The tadpoles attain large size before transformation.

Hazelia picta (Peters)

FIG. 79

Ixalus pictus Peters, Monatsb. Akad. Wiss. Berlin, 1871, p. 580 (type locality, Sarawak, Borneo); Ann. Mus. Civ. Genova, vol. 3, 1872, p. 44, pl. 6, fig. 2; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 99; Fischer, Arch. Naturg., vol. 51, 1885, p. 43; Mocquard, Nouv. Arch. Mus. Paris, ser. 3, vol. 2, 1890, p. 122; Boulenger, Proc. Zool. Soc. London, 1894, p. 642; Flower, *ibid.*, 1896, p. 908; *ibid.*, 1899, p. 900; Boulenger, Fasciculi Malayenses, Zool., 1903, 172; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 203; Robinson, Journ. Federated Malay States Mus., 1905, vol. 1, pp. 24, 30; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 255.

Philautus pictus Barbour, Mem. Mus. Comp. Zool. Harvard Col., vol. 44, 1912, p. 171; M. Smith, Journ. Federated Malay States Mus., vol. 10, 1922, p. 280; van Kampen, Amphibia of the Indo-Australian Archipelago, 1923, p. 269-270; M. Smith, Ann. Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 78; Bull. Raffles Mus., no. 3, 1930, p. 116 ("Banang Star," Pattani); Bull. Raffles Mus., no. 5, 1931, p. 19; Bourret, Les Batraciens de l'Indochine, 1942, p. 455.

Rhacophorus (Philautus) pictus Ahl, Das Tierreich, Lief. 55, Anura III, 1931, p. 84.

Diagnosis: A diminutive form (35 mm., snout to vent); interorbital space wider than eyelid; a pair of low bony ridges on each side of interorbital region extending onto occipital region; ridges above tympani; latter distinct; sharp canthus rostralis; fingers completely without web; toes webbed; tongue notched behind; no vomerine teeth; snout narrowed, truncate, extending somewhat beyond lower jaw; skin above covered with granular and spiny tubercles; green in life with cream or orange spots along canthus, neck, and on upper surfaces of arms and legs.

Description of species (from B. M. No. 1929.12.24.2 ♂, Bhetong, Yala province): Head rather broad, snout narrowing anteriorly, obtuse or truncate at tip, not sloping forward, extending beyond lower jaws and sloping down and backwards to lip; canthus rostralis sharply defined, nearly vertical; loreal region, slightly concave; nostril almost directly above anterior level of lower jaw very much

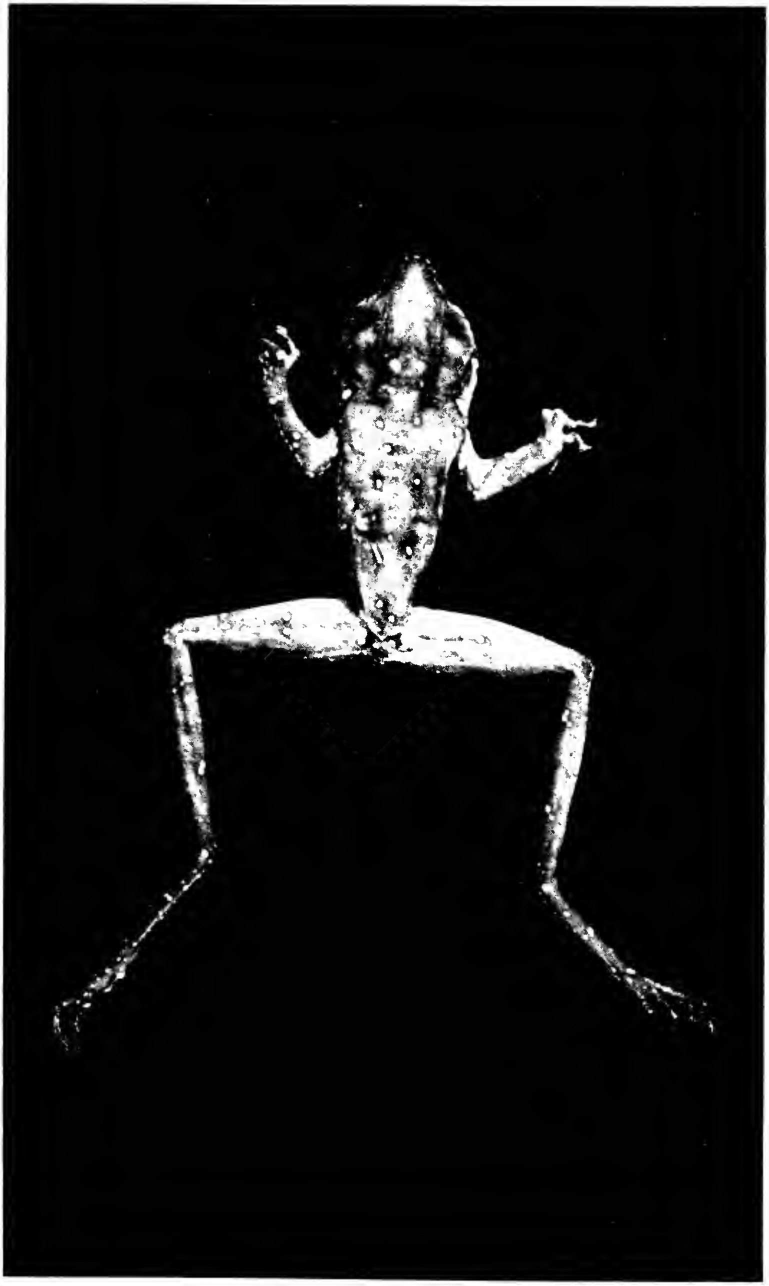

FIG. 79.—*Hazelia picta* (Peters). B. M. No. 1929.12.24.2 ♂. Actual snout-vent length, 30.5 mm. Bhetong, Yala, Thailand.

closer to tip than to eye; interorbital distance (4.2 mm.) distinctly wider than an upper eyelid (2.7 mm.); two low bony ridges from about front level of eyes along borders of interorbital area to near back end of occiput; small low bony ridge above tympanum; diameter of tympanum (3 mm.) a little less than length of eye (3.35 mm.); back border of eyelid forming a slight curving flap.

Choanae lateral, large, concealed largely when palate is viewed from point directly below; Eustachian tube openings as large as choanae. Tongue slender, strongly notched behind, free for two fifths of its length; a distinct dermal fold across palate between openings of Eustachian tubes; no vocal sac in male.

Arms moderate; digits elongate, flattened, without trace of web or lateral ridges; first finger shorter than second; all with widened terminal discs with peripheral grooves; width of largest outer discs (1.2 mm.) a little more than a third of diameter of tympanum; distal subarticular tubercles large; proximal ones small; three small metacarpal tubercles; swelling at base of first finger covered with fine nuptial asperities. Legs slender, elongate, tibiotarsal articulation reaching about six millimeters beyond tip of snout; digits with discs smaller than those on fingers; small subarticular tubercles; outer digits about one-third—inner about one-fourth webbed; distinct metatarsal tubercle less than half length of first toe.

Skin on top and side of head, dorsum and to a lesser extent upper surfaces of arms and legs, with rough, scattered granular or spiny tubercles; skin on head especially on dorsal surface adherent to skull bones; skin on chin, breast, sides, undersurface of arms and legs, anterior and part of posterior faces of femur, smooth; no supratympanic fold. Venter with large, somewhat irregularly shaped granules; some granules also in region of vent.

Color: In preservative, very light brown on head and dorsum, slightly darker on tip of snout and on rims of the cream or orange spots; a number of small yellow spots on dorsum along canthus rostralis, eyelid, sides of head, neck, and sides of body; on forearm spots arranged in transverse diagonal rows and to a lesser extent the same is true on leg; numerous small cream or yellowish spots on back of thighs and anal region; chin fawn-brown with minute yellow flecks; venter with a brown reticulum enclosing large irregular cream spots; hand, foot, and tarsus with yellow or orange spots.

Variation: The tongue may be free for nearly half its length. In the two specimens measured above (from "Valley Contour Path, Measurements in mm. of *Hazelia picta*

Number	2784	2792	1929.12.24.2
Sex	?	?	♂
Snout to vent	29	28	30.5
Width of head	11	10.2	10.9
Length of head	12	12	10.9
Arm	21	19.5	19.2
Leg	45	50	52
Tibia	17.5	17.8	17.5
Foot and tarsus	18.6	20.2	21

Bukit Timali, Singapore Island") the spots assume a more ocellus-like appearance. They may be orange or cream in color.

One of the specimens was captured on a tree near a small pocket of water, suggesting that this type of habitat may serve as breeding place for the species. The tympanum may be a little smaller in the Singapore specimens than in the single Thai specimen seen (about three fourths as large as eye) and the discs of fingers may be slightly more than half the diameter of the tympanum.

Distribution: In Thailand the species has been captured only in the southernmost province of Yala. It is known in Malaya, Borneo and the Mentawi Islands.

Remarks: The pupil of the eye is unusual in character. It is a horizontal opening; the upper rim forms a convex line, while the lower rim is strongly sinuous with a pair of elevations on its border.

I have placed this form in *Hazelia* because of numerous characters that set them apart from most other forms of *Philautus*. I have no doubt that certain other forms now regarded as *Philautus* will eventually be placed in this genus. I have suspected that *Philautus anodon* of van Kampen may be such a form. Another that is a suspect is *Philautus flavosignatus* Boettger. I have not examined specimens of these forms.

Genus THELODERMA Tschudi

Theloderma Tschudi, Classification der Batrachier . . . (printed separately) and in, Mem. Soc. Neuchâtel, vol. 2, 1939, pp. 32, 73 (type of genus *leporosa*).

I am reviving this name, long in synonymy, for a group of frogs now assigned to *Rhacophorus* and *Philautus*.

Diagnosis: Oriental tropical frogs, with very numerous larger or smaller warts studded with ivory-colored tubercles; widened discs on digits; distinct tympanum, usually without vomerine teeth (present in *leporosa*); tongue variable; toes usually half to fully webbed; fingers with remnant of web to one-half webbed; reduced number of large eggs placed above cavities or holes in trees, filled with water.

Certain of the species develop only four or eight eggs in each ovary, and it may be a characteristic of all the species. Eggs are laid in trees usually on branches or holes above small cavities or pockets of water. Rain or gravity carries the egg or the hatchlings into the water where they develop.

Accounts of this behavior has been reported for certain of the forms, and it is believed to be common to all.

Boulenger quotes the following with the type description of *Ixalus horridus* Fasciculi Malayenses, Zool., vol. 1, 1903, p. 139: "A considerable number of adults of this species inhabited a tree in the jungle near our camp on Bukit Besar occasionally manifesting their presence by low grunts or croaks, uttered singly at intervals. The tree was one of those from the lower parts of whose trunk large buttresses projected and in its case these buttresses had coalesced in pairs so as to form cavities which contained several gallons of rain water and dead leaves. The frogs deposited their spawn on the trunk in frothy masses about the size of a cricket ball, a foot or two above the surface of the water in these cavities, which was of a deep brown colour. The masses resemble those produced by *Rhacophorus leucomystax* but were smaller and paler in color. I found that if they were not washed down by rain into the water within two or three days the froth dried up and the ova perished. The cavities were haunted by a snake *Tropidonotus chrysargus* two specimens of which were taken feeding on the spawn despite the froth in which it was imbedded."

Under *Theloderma stellatum* I describe the place of deposition of the eggs of that species. The tadpoles taken there developed for some time after being taken back to Bangkok. The eggs taken hatched in the laboratory having been kept in water from the cavity in which they have developed.

Theloderma gordoni was taken on the bole of a tree in northern Chiang Mai province. Mr. Young who collected the type specimen on a tree trunk did not observe any water pockets near by.

I regard the following species as probably referable to *Theloderma.*

1. Vomerine teeth present, tongue notched posteriorly, no vocal sacs.	*corticalis* Boulenger *leporosum* S. Müller *bicolor* Bourret *gordoni* sp. nov.
Vomerine teeth absent	2
2. Vocal sac present.	*stellatum* sp. nov. *horridum* Boulenger
Vocal sac absent	*asperum* Boulenger

Boulenger described the genus *Phynoderma* largely on the basis of a tongue said to be feebly nicked behind. I have examined the type with Miss Grandison. We agree that at the present time we could not describe the tongue as even feebly nicked. There is no trace of the condition despite the statement and figure given by Boulenger.

This makes it doubtful that this species should be associated with anyone of the three genera, *Philautus, Rhacophorus,* or *Theloderma.*

The species *Phrynoderma moloch* described by Annandale may or may not belong to *Phrynoderma* Boulenger (not of Fitzinger). No description has been given for the tongue, nor detail of the other characters. He states:

"This species differs from *Phrynoderma asperum* Boulenger, the only one hitherto known, in several important characters, notably in the much more pronounced nature of the asperities on its back."

Wolf, 1936, has placed both *moloch* and *asperum* as subspecies of *Rhacophorus leporosus,* evidence of somewhat indiscriminate lumping.

KEY TO THAILAND SPECIES OF THELODERMA

1. Vomerine teeth present; chin and throat rough .... *gordoni*
   No vomerine teeth; chin and throat smooth 2
2. Fingers with web 3
   Fingers without web, canthus feebly distinct; snout as long as orbit; tympanum nearly as large as eye; finger discs large, but smaller than tympanum; blackish above with ashy-gray dots or with a large square, or triangular, dark mark on back .... *asperum*
3. Interorbital space narrower than eyelid; tympanum as large as eye; vocal sac in male .... *horridum*
   Interorbital space equal to eyelid; canthus rostralis obtuse; tympanum much smaller than eye; no vocal sac in male .... *stellatum*

Theloderma gordoni sp. nov.

FIG. 80

Type: No. 33741. Doi Suthep, above 4000 ft., Chiang Mai, Chiang Mai province; Gordon Young, collector.

Diagnosis: Dorsal and lateral parts of body with very numerous large warts covered with small pearly granular asperities; sharp canthus rostralis; interorbital distance at least once and a half times width of eyelid; fingers entirely free, toes little less than two-thirds webbed; tips of all digits dilated but all considerably smaller than tympanum; vomerine teeth present; tongue notched behind; an oval inner metatarsal tubercle; no outer tubercle apparent; snout to vent, 4.8 millimeters.

Description of the type: Head flat on top; canthus rostralis well defined; loreal region nearly vertical, concave; length of snout (8 mm.) considerably longer than eye (5.2 mm.); eye to nostril, 5.15 millimeters; nostrils elevated, much nearer end of snout than to eye; tip of snout rounding in lateral profile, extending about one millimeter beyond mouth. Tympanum large, distinct, about four millimeters in diameter, its distance from eye less than half its diameter; width of an eyelid (4.8 mm.), much narrower than interorbital distance; eyes very moderately elevated.

Choanae lateral; vomerine teeth on two ridges beginning near anterior inner border of choanae, directed diagonally, not extending behind choanae, separated from each other by distance greater than length of one group; palatal glands open into distinct transverse groove, closer to anterior level of choanae than to front of palate; tongue a little longer than broad, notched, free behind for half its length, free on sides.

Arm brought forward wrist reaches beyond mouth; fingers free with well-developed discs much smaller than tympanum; fourth finger distinctly shorter than third; three rather large metacarpal tubercles situated at bases of first, third, and fourth fingers; subarticular tubercles well developed, distal ones larger than proximal; toes nearly two-thirds webbed, web reaching terminal discs by narrow fringes; discs surrounded by peripheral groove; prominent oval, moderately large, inner metatarsal tubercle; no outer tubercle, or if present covered with granules as are other surface tubercles in that area and not distinguishable; subarticular tubercles on three outer toes; discs on tips of toes a little smaller than those on fingers; leg brought forward, tibiotarsal articulation reaches eye. Dorsal surface of head, dorsum, dorsal surfaces of arms and legs, with large and small irregular tubercles covered with granules, very rough to the touch; chin, front of breast, and sides with similar but smaller granules; venter and underside of thigh with smooth

FIG. 80.—*Theloderma gordoni* sp. nov. No. 33741. Actual snout-vent length, 48 mm. Doi Suthep, "Above 4000 ft.," Chiang Mai, Thailand.

granules or areolae; smooth areas in groin, axillary region, and underside of tibia.

Color in life: Dark wood-brown with darker spots on head; granules on tubercles light gray or cream; an irregular darker area in groin; venter lavender with dark lavender flecks and reticulations, and some larger spots under limbs and on front of thighs; tubercles under digits cream to flesh.

Measurements in mm.: Snout to vent, 48; width of head, 20.3; length of head, 21; arm, 33; leg, 67; tibia, 21; foot and tarsus, 29.5.

Remarks: The described species is probably most closely related to *Theloderma leporosus.* It differs in having the toes scarcely more than half webbed (not nearly "completely webbed"), the discs about three-fourths the size of tympanum. The inner metatarsal tubercle is rather large, rather than "very small." The tibiotarsal joint reaches to eye rather than to between eye and the tip of the snout. *Theloderma leporosa* is described as "jet black beneath, marbled with pale bluish gray." This also differs from the light lavender-flesh ventral ground-color, with its varied fleckings and reticulations of dark lavender or purplish. Examination of the figure given shows that there is a more or less definite symmetry in the distribution of the dark markings on head and body.

The specimen was captured on a tree trunk in the forest on Doi Suthep. It is named for Mr. O. Gordon Young of Chiang Mai, Thailand, who discovered the specimen.

Theloderma stellatum sp. nov.

FIG. 81

Type: No. 35441. Khao Sebab (mt.), *circa* 18 km. NE of Chanthaburi (town) near "the waterfall"; Edward H. Taylor, collector.

Diagnosis: Body with very numerous tubercles covered with granular asperities; fingers about one-third webbed, toes about four-fifths webbed; digits with large terminal discs, those on fingers as large as tympanum; canthus not distinct; eye as long as snout; eyelid a little wider than interorbital distance; tibiotarsal articulation reaches to near tip of snout; throat smooth; tympanum distinct, much smaller than eye; subarticular tubercles small. Male with a large pad on dorsal surface of first finger; no vocal sac in male; venter brown mottled and reticulated with cream.

Description of the type: Snout seen from above a rather pointed oval; nostrils round, directed upward, area surrounding them forming two slight elevations with a slight depression between them;

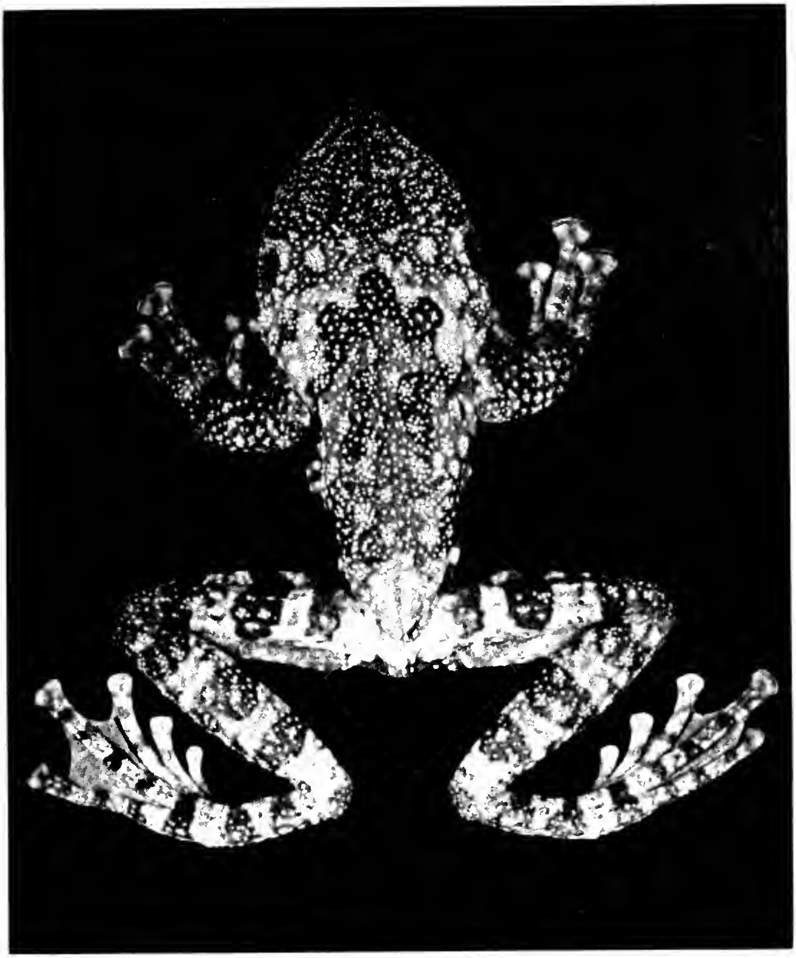

Fig. 81.—*Theloderma stellatum* sp. nov. No. 35441. Type. Actual snout-vent length, 34 mm. Khao Sebab, Chanthaburi, Chanthaburi, Thailand.

loreal region slightly concave; in profile snout rounded, projecting about one millimeter beyond mouth; eye large, strongly elevated, as long as or slightly longer than snout. Interorbital distance nearly equals width of eyelid (6 mm.); tympanum large (3 x 2½ mm.), its distance from eye equal to about a third of its width.

Choanae lateral, openings of palatal glands between choanae near their anterior level, not forming a conspicuous groove; tongue as long as wide, deeply notched behind, free for nearly half its length, and free on sides; arms short, wrist not reaching beyond snout; limb "fixed" in position and cannot be moved forward easily; fingers about one-third webbed with broad terminal discs wider than long; sides of digits with thickened lateral ridges; subarticular tubercles small; palmar (metacarpal) tubercles three, a very small one under first finger and widely separated from this are two contiguous tubercles at base of two outer metacarpals; linear ridge on back edge of forearm; leg laid forward tibiotarsal joint reaches to nostril; toes about four-fifths webbed with a well-developed, rather elongate, oval inner metatarsal tubercle; very small, rather indistinct outer; heels overlap about two millimeters when legs are folded at right angles to body.

Dorsal surface of head and body, sides of head, upper side of forearm, upper surface of tibia, and tarsus, with smaller or larger tubercles covered with granular asperities; thickened paratoidlike swelling above arm-insertion behind eye. Upper surface of femora, with small tubercles, arranged in linear fashion; throat, breast, underside of arms, hands, sides of body, anterior and posterior surface of thigh, undersurface of tibia and tarsus smooth; venter, undersurface and part of posterior surface of thigh with rounded flattened granules, lacking asperities.

Color in life: Above brownish or lavender gray, cream-speckled; black spots on snout and one or two between eyes; a trifoliate spot across shoulders, followed by four or five smaller dark spots; a strong black groin spot and one less distinct behind axilla partially visible from above; thigh, tibia, tarsus, and foot with transverse purplish bars contiguous when limb is folded; a purplish spot about vent; underside of chin dark lavender or purplish with numerous tiny whitish flecks; venter and underside of thighs cream with purplish-brown flecks or spots, partially reticulated; terminal discs on digits slightly pinkish; metacarpal and metatarsal tubercles flesh-white; iris with indistinctly radiating lines of black and dark gold; eye with horizontal pupil.

Measurements in mm.: Snout to vent, 34; width of head, 14; length of head, 16.4; arm, approx. 20; leg, 51; tibia, 18; foot and tarsus, 22.

Remarks: Eggs of this species were found in two masses attached to the trunk of a forest tree, about two feet from the ground, some five inches directly above a small hole in the trunk containing a quantity of black-brown water, colored by rotting wood and leaves. I placed the masses in water and they separated into two groups of eight individual components, each egg 3½ to 4 mm. in diameter. The eggs absorbed some water, and when measured were from six to seven millimeters in diameter. From the same pocket of water I recovered some tadpoles hatched from a previous laying.

Eggs and tadpoles were placed in a container and taken to Bangkok together with a quantity of the water from the hole. I hatched the eggs in the laboratory. The young remained in the egg capsules for four or five days. When hatched, the tadpoles remained near the bottom most of the time. They were fed on fragments of dried biscuit.

The absence of a vocal sac would appear to be significant. Where the sac is present, usually a loud voice obtains, which is the means of calling together a breeding group. In this case, there is an extremely limited supply of water and one pair may be the maximum number that can be accommodated.

Distribution: The species is known only from the type locality.

Theloderma horridum (Boulenger)

FIG. 82

Ixalus horridus Boulenger, Fasciculi Malayenses, Zoology, vol. 1, 1903, p. 139, pl. 6, fig. 2 (type locality, Bukit Besar, Pattani); Robinson, Journ. Federated Malay States Mus., 1905, p. 24; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 256-257; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, May 1917 ("Pattani, peninsular Siam").

Philautus horridus M. Smith, Ann. Mag. Nat. Hist., ser. 9, vol. 18, 1926, p. 80 (Mentawi Islands); Bull. Raffles Mus., no. 3, 1930, pp. 116, 118.

R[hacophorus] P[hilautus] horridus Ahl, Das Tierreich, Lief. 55, Amphibia, Anura III, 1931, p. 65.

Diagnosis: Prominent irregular warts studded with granular asperities; fingers half webbed; toes fully webbed; tibiotarsal articulation to between eye and tip of snout; tympanum as large as eye; webs of hands and feet black; venter blue-gray, marbled with black; male with vocal sac. Eggs laid in masses of foam on trees above pockets of water *fide* Boulenger. No vomerine teeth.

Description of type (after Boulenger): Very similar in general appearance to *Rhacophorus leporosus*, Schlegl. and *R. corticalis*, Blgr.; head rather strongly depressed, obtusely pointed, snout a little longer than diameter of orbit; canthus rostralis obtuse; loreal region concave; nostrils close to end of snout; interorbital space a little narrower than upper eyelid; tympanum distinct, as large as eye. Fingers half webbed, with large terminal discs, which are broader than long; width of discs on outer fingers equals diameter of tympanum; toes webbed to discs, which are smaller than those of fingers; terminal phalanx bifurcates; subarticular tubercles of fingers and

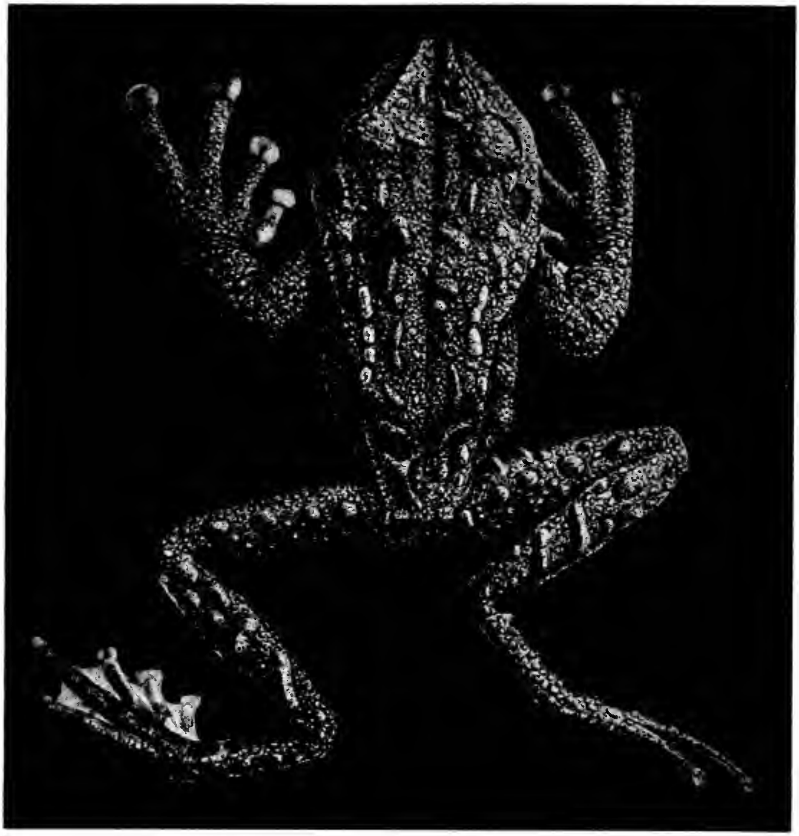

Fig. 82.—*Theloderma horridum* (Boulenger). Type. Actual snout-vent length, 40 mm. Bukit Besar, Pattani, Thailand.

toes very small; small oval inner metatarsal tubercle. Tibiotarsal articulation reaches between eye and tip of snout. Upper parts with very prominent, irregular large warts, themselves studded with granular asperities in adult; throat, breast, lumbar region, anterofemoral region, and lower surfaces of limbs, smooth; belly and anal region with large flat granules. Male with large soft nuptial pad on inner side of first finger, and an internal vocal sac.

Color in life: Dark warm-brown above with rather indistinct blackish spots on body and regular crossbars on limbs; granular asperities grayish; large black lumbar spot; webs blackish; lower parts white (bright blue-gray in life) largely spotted and marbled with black.

Measurements in mm.: Snout to vent, 40 mm.

Distribution: Known only from southern Thailand in the province of Pattani. It probably occurs in Malaya also.

Remarks: "The resemblance, both above and below, between this species and *Rhacophorus leporosus,* known from the mountains of Perak, is very close indeed, and is probably an instance of adaptive resemblance or 'convergence,' though the two frogs belong to closely allied genera, seeing that they both differ widely in appearance from the typical members of their respective genera. Their habits appear to be identical, and it is probable that a very close resemblance also exists between their larvae, which live under very similar conditions, but it is not known whether the species are found together. It would almost seem as if there were a physiological connection in these genera between a warty barklike dorsal surface, and a blue-gray belly, mottled with black, as it is most improbable, in consideration of conditions under which these frogs live, with their bellies closely pressed against the bark of trees, that the conspicuous coloration of the ventral surface is an advertisement to enemies." (Quoted by Boulenger, as notes of the collector.)

Theloderma asperum (Boulenger)

Fig. 83

Ixalus asper Boulenger, Proc. Zool. Soc. London, 1886, p. 416, pl. 39, fig. 1 (type locality, Larut Hills, Perak, 3300 ft. elev.); Sclater, *ibid.,* 1892, p. 347 (Hills between Burma and Siam); Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, pp. 7(310), 37(340); Flower, Proc. Zool. Soc. London, Dec. 1, 1896, p. 908; *ibid.,* 1899, p. 900; Boulenger, Fasciculi Malayenses Zool., 1903, p. 172; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1903, p. 204; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 24; Annandale, Rec. Ind. Mus., 1912, pp. 7, 16; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, pp. 255-256; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, p. 229 (Hills, western Siam).

Philautus asper M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 116, 117 (northern Siam and Annam); Bourret, Annexe au Bull. Inst. Publ., no. 4, 1937, p. 60.

Philautus asperrimus Bourret, Les Batracians de l'Indochine, 1942, pp. 465-467, fig. 165.

Rhacophorus asperrimus Ahl, Sitzb. Ges. Fr. Berlin, 1927, p. 37, 116.

Rhacophorus philautus asperrimus Ahl, Das Tierreich, Lief. 55, Anura III, 1931, p. 74, fig. 52.

Diagnosis: Small frogs (snout to vent, 35 mm.); canthus rostralis not distinct; interorbital distance wider than upper eyelid; tympanum distinct, nearly as large as eye; fingers, with discs, without webs; toes three-fourths (or more) webbed; tibiotarsal articulation to tip of snout. Skin with rough granular tubercles, venter strongly

FIG. 83.—*Theloderma asperum* (Boulenger). Upper figure, B. M. No. 93.10.9.31. Actual snout-vent length, 23 mm. Karin Hills, Burma. Lower figure, B. M. No. 1904.7.19.26, length, 32 mm. Bukit Itam, Selangor, 3000 ft.

granular or areolate; a large dark marking on back. Venter marbled black and bluish gray.

Description of species (from B. M. No. 1904.7.19.26, Bukit Itam, Selangor, Malaya): Head broader than body; snout oval, nostril much nearer tip of snout than eye; canthus poorly marked, loreal region oblique, slightly concave; distance between nostrils (2.4 mm.) much less than interorbital distance; length of eye (4 mm.) less than length of snout (4.8 mm.); width of an eyelid (3.1 mm.) less than interorbital width; tympanum large, its diameter (3.15 mm.) less than length of eye, situated very close to eye. No fold from eye above tympanum.

Tongue short and broad, notched strongly behind, free behind for two fifths of its length; choanae moderate, very much smaller than Eustachian tube openings; palatal glands open in a chevron-shaped groove (more or less continuous), just anterior to front level of choanae; choanae not concealed when palate is viewed from below; vocal sac present, the openings small, puckered, near angle of mouth. Arm moderate, but difficult to straighten; fingers with large discs, not as large as tympanum; a web remnant at base of fingers with slight fringes or ridges reaching to discs; a groove across face of disc; first finger shorter than second; subarticular tubercles distinct; supernumerary tubercles present; three distinct metacarpal tubercles, two outer nearly contiguous; toes, with discs smaller than those on fingers, about three-fourths webbed; single small inner metatarsal tubercle; no tarsal fold; subarticular tubercles strong; leg moderate, tibiotarsal articulation reaches more than midway between eye and nostril; when legs are folded at right angles to body heels overlap four millimeters.

Skin on dorsal and lateral surfaces with fine pearly-tipped tubercles sometimes in linear arrangement, sometimes forming vermiform lines, sometimes scattered; ventral surfaces of chin nearly smooth, venter with large granules or areolae, underside of thighs and femora smooth; a few tubercles about vent.

Color: Dorsal surface of head and body grayish or bluish gray with a small brown line between eyes and some indefinite brown marking on occiput; a darker area under eye extending on to tympanum; an elongate brown spot from shoulder level to rump where it divides, terminating on each side near level of venter, followed behind by a gray area dividing and terminating on base of femora; latter generally brownish, barred with brown, bands with lighter centers, reaching venter level on front of femora but not posteriorly;

some fine cream vermiform flecks. Tibia barred with dark brown tending to encircle limb; tarsus and foot barred; ventral surface of chin nearly uniform brown with a few minute whitish flecks. Venter cream, strongly marbled with brown, brownish on underside of arms and limbs.

Measurements in mm. (of B. M. Nos. 1904.7.19.26 and 93.10.9.31, latter from Karin Hills): Snout to vent, 32, 23; width of head, 13.2, 9.3; length of head, 12.3, 9; arm, 20.4, 14; leg, 49.2, 34.3; tibia, 17, 12; foot and tarsus, 22, 14.3.

Variation: The second specimen measured, from the Karin Hills, differs from the one described in certain characters which may be largely due to the fact that it is a younger specimen. The tubercles are more elevated and fewer. Seemingly the pearly tips are shed and when lost the wartlike tubercles suggests a crater.

The web-remnant on the hands is somewhat less distinct, the gray color is lighter and the dark mark on side of head surrounds the eye and tympanum and extends back beyond axilla; the marks are all deep chocolate-brown.

Distribution: Occurs in western Thailand. (M. Smith says northern Thailand also.)

Elsewhere it occurs in Burma, Selangor and Perak in Malaya, and in Indo-China.

Remarks: The smaller specimen was collected in the Karin Hills by L. Fea. The larger specimen, a male, has a large nuptial pad on the first finger.

The life history of this species is as yet undescribed. It is presumed that eggs are placed in cavities containing water, in trees.

Genus PHILAUTUS Gistel

Philautus Gistel, Naturgeschichte des Thierreichs . . . 1848, p. 10 (not seen).

Diagnosis: Pupil horizontal; tongue notched behind; vomerine teeth usually if not universally absent; fingers free or webbed at base; outer metatarsals separated by a groove or narrow web; a small intercalated bone or cartilage between last two phalanges in digits.

The difficulty of separating *Philautus* from *Rhacophorus* has been recognized by many workers but most have agreed that *Philautus* must be recognized as a generic group.

The recognition of species within the genus also presents problems, as is evidenced by two recent works: the treatments of the species in the Philippines by Inger 1954 and those in Ceylon by

Kirtisinge 1957. Both works seemingly are somewhat unsatisfactory, either because of unwarranted synonymyzing or the describing of new forms without giving them names. In both cases the authors, at the time their studies were made, had had no adequate field experience with this difficult group or with the tropical fauna in general. I, too, have encountered difficulty chiefly from inadequate material. A specimen of a form of *Philautus* in the U. S. National Museum from Khao Sebab, Chanthaburi, not in the best condition, may represent another species of the genus in the Thai fauna.

KEY TO SPECIES OF THAI PHILAUTUS

1. Small species, 20 mm. or less in total length; snout shorter than orbit; tympanum hidden; males with large vocal sac evidenced by ample skin folds under chin . . . . *parvulus*
   Larger species 24-35 mm. snout to vent length 2
2. Color pattern of dark transverse spots or blotches; arms and legs barred 3
   Color pattern with parallel cream, yellow, or white dorsolateral lines that may be edged with darker color; no transverse dark bars 4
3. Head distinctly broader than body; eyes protuberant; tibiotarsal articulation to tip of snout or beyond; bar between eyes, one across neck, one behind shoulder another across rump; conspicuous cream spot below eye; snout to vent 35 . . . . *bimaculatus*
   Head not or at most only slightly wider than body, tibiotarsal articulation reaches eye or a little farther; toes three-fourths to four-fifths webbed; canthus angular; tympanum distinct . . . . *nongkhorensis*
4. Three dim or distinct darker parallel lines on dorsum rarely also trace of dorsolateral lighter lines; tympanum distinct; a slight tarsal fold; 32 mm. . . . . *doriae*
   A pair of yellow, cream, or whitish dorsolateral lines 5
5. Smaller (to 24 mm.); snout pointed; tibiotarsal articulate, reaching beyond tip of snout; scarcely discernible web between fingers; toes about two-thirds webbed; vocal sac present, the slits elongated, *hansenae*
   Larger to 32 mm. outer two fingers one-fifth webbed; openings to vocal slits short puckered, foot one-half webbed . . . . *vittatus**

Philautus parvulus (Boulenger)

FIG. 84

Ixalus parvulus Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1892-1893, pp. 339-340, pl. 10, fig. 4 (type locality, Karin Hills).
R[hacophorus] P[hilautus] parvulus Ahl, Das Tierreich, Lief. 55, Anura III, Polypedatidae, 1931, pp. 70-71, fig. 48.

Diagnosis: Snout shorter than diameter of orbit; loreal region oblique, concave; interorbital region wider than an upper eyelid;

* I have not been able to examine the type of *vittatus* and am not wholly convinced of the specific distinctness of the two forms, *hanseni* and *vittatus*. Presumably there is a very considerable difference in size.

tympanum hidden; toes webbed at base; tibiotarsal articulation to eye (or to snout-tip); discs large on digital tips. Venter granular; male with large vocal sac.

Description of species (from No. 62 ♀ Mai Salat, stream, 4000 ft. elev. headwaters Muang Khawng, Ampur, Me Pang, Chiang Mai): Head a little wider than body, its width about equal to its length; snout about as long as eye; canthus rostralis very obtuse; loreal region sloping obliquely, not or but shallowly concave; width of interorbital space one and one-third times width of an eyelid; nostril about equidistant between eye and tip of snout; fold indicated from eye to point above arm-insertion; tympanum barely indicated, covered with skin.

Choanae lateral when viewed directly from below, more than half visible; tongue free behind for two fifths of its length, free on sides; (males with very ample vocal sac indicated by heavy folds below on chin; opening into mouth through moderately long vocal slits).

Skin smooth above on head, dorsum, and upper surfaces of limbs; chin smooth (granular in males); venter, lower part of sides, and underside of femur, granular or areolate.

Arms short, digits without webs, tips dilated, two outer large, innermost scarcely wider than digit; first finger fails to reach base of disc of second; distal subarticular tubercles moderate; proximal tubercles not or scarcely indicated; inner metacarpal tubercle distinct, median well defined, nearly as large as inner; palm and sole of foot not granular. Leg short, digits dilated, discs smaller than

Fig. 84.—*Philautus parvulus* (Boulenger). Left figure, No. 36159a. Actual snout-vent length, 17.2 mm. Right figure, No. 36159 ♂. Length, 18 mm. Doi Suthep, 3000-4000 ft., Chiang Mai, Thailand.

those on hand; proximal and distal subarticular tubercles distinct; three outer digits about one-fourth webbed or less, inner ones with web remnant; inner metatarsal tubercle, no outer; no tarsal fold; tibiotarsal articulation to back edge of eye; when legs are folded at right angles to body, heels barely touch; outer metatarsals completely bound to other metatarsals.

Color: Above gray, with an indefinite subtriangular blotch covering part of interorbital area and occiput; two curving lines begin behind eyes extending to middle of back; a black spot on side of rump, with a light area touching it. Arms and legs banded with darker; a dark spot below eye preceded and followed by slightly lighter area. Chin yellowish, flecked with darker; venter and sides darkly pigmented, enclosing small light flecks; underside of arms, legs, hands, and feet, with much pigment except on discs and tubercles.

Measurements in mm. of *Philautus parvulus*

Number	62	36144	36148	36150	36151
Sex	♀	♂	♂	♂	♂
Snout to vent	21	18	18	19.6	18
Head width	8.3	7	6.5	7	7
Head length	8.6	7	7	6.7	7.1
Snout length	3	2.8	2.5	2.3	2.1
Eye length	3	2.6	2.6	2.3	2.2
Arm	12	12	11.2	11.5	11
Leg	29	28.2	26	28	27
Tibia	10	9.2	8	9	9
Foot and tarsus	12	13	12	11	12

Variation: I recently captured a specimen of *Philautus larutensis* on Fraser's Hill in Malaya. I have compared this specimen (a male) with the above males. The measurements are as follows: No. M 30, male; snout to vent, 23; head width, 10.6; head length, 10.5; snout length, 4; eye length, 3.5; arm, 17; leg, 42, tibia, 15; foot and tarsus, 19.

Since the female reaches a length of 35 millimeters, it will be obvious that *larutensis* is quite a different species from the form treated here. The head width and length is much greater (one-third), the arms and legs much heavier and longer proportionally; the webbing of the feet is considerably greater. The shape of the palate differs and the choanae are completely visible seen from below. There is no external evidence of a large vocal sac on chin. The skin on the chin of the male is strongly but finely granulate.

On the venter and under the thighs the granules or areolae are large. In the female described the throat is completely smooth, the underside of the thighs smooth, while the granulation is scarcely visible on venter.

Distribution: In Thailand the described species has been taken only in the province of Chiang Mai.

Remarks: The specimens which I found on Doi Suthep were in low trees, shrubs, low plants, or occasionally on the ground probably having been dislodged from a higher perch. They are especially common from 3000 to 5000 ft. elevation on the mountain. These are often so far from water that one suspects that the species does not have a free swimming tadpole stage. However, I have not found the eggs and do not know where they are placed. Ovarian eggs are relatively large. I have never taken a specimen near water.

I noted that there were two distinctive calls and considered two species were involved. In the field I was presumably able to separate the material into two lots. Unfortunately at the present time all the specimens are not available for study. Two forms may actually be represented. There is a possibility that this is the species reported from Thailand by authors as *P. petersi.*

Philautus hansenae Cochran

FIG. 85

Philautus hansenae Cochran, Proc. Biol. Soc. Washington, Dec. 2, 1927, vol. 40, pp. 181-182 (type locality, Nong Khor, southeastern Thailand); Proc. U. S. Nat. Mus., vol. 77, 1930, p. 6 (Nong Khor and Ban Sadet).

R[hacophorus] C[hirixalus] hansenae Ahl, Das Tierreich, Lief. 55, Anura III, Polypedatidae, 1931, pp. 103-104.

Chirixalus hansenae Bourret, Les Batraciens de l'Indochine, 1942, pp. 475-476.

Diagnosis: Diminutive species (males to 24 mm.); tympanum equal to one third or less of length of eye; snout pointed, reaching farthest forward at level of nostril, extending beyond mouth; chin and breast smooth; scarcely discernible web between fingers; largest finger discs larger than tympanum; feet about two-thirds webbed; heel reaches to eye; openings of vocal sac elongate slits; row of glandules across anal flap.

Description of species (from 36208 ♀ Paeng Kang Tao): Head moderate, eyes prominent, their length about equal to length of snout; latter bluntly pointed extending about one millimeter beyond mouth; canthus rostralis obtuse; loreal region slightly oblique, somewhat concave; width of upper eyelid little less than width of interorbital space; fold from eye runs diagonally back across upper edge of tympanum, terminating somewhat above arm-insertion; tympanum distinct, its diameter slightly less than half length of eye.

Choanae lateral at least half visible when viewed directly from below; tongue rather elongate, free behind for two fifths of its length, free on sides; no papilla. Faintly visible ridge extending diagonally inward from near upper edge of choanae.

Skin practically smooth on dorsum, upper part of sides and on limbs; below, throat glassy smooth; breast smooth; venter and underside of thigh granulate, largest granules on underside of thigh; small median groove extending down from vent.

Arm short, first finger shorter than second (reaching only to disc); discs on two outer fingers much enlarged, at least equal to diameter of tympanum; none or but slightest web-remnant between fingers; distal subarticular tubercles moderately developed, proximal ones cannot be distinguished from granules on palm; inner metatarsal tubercle moderately distinct, others practically indistinguishable from granules of palm. Leg short, tibiotarsal articulation reaching between eye and nostril; toes with discs, largest equal or less than

FIG. 85.—*Philautus hansenae* Cochran. No. 1021 ♂. Actual snout-vent length, 21.5 mm. Chalermlaub, Siracha, Chon Buri, Thailand.

that on second finger; toes about three-fourths webbed; small inner metatarsal tubercle; no tarsal fold; when legs are folded at right angles to body, heels overlap about two millimeters.

Color: Dorsum with rather distinct cream dorsolateral stripe bordered on each edge with two violet to lavender streaks, the lower violet streak extending to tip of snout, widening behind eye; a median stripe from occiput to rump; dim darker line on head crossing upper eyelids; between stripes ground color light lavender.

Measurements in mm. of *Philautus hansenae*

Number	36208	36219	26209	36228	36315	34962	1021
Sex	♀	♀	♀	♂	♂	♀	♂
Snout to vent	24	23	24	24	21.5	23	21.5
Snout length	3.4	3.3	3.3	3	3	3.4	3
Eye length	2.95	3	3	3	3.1	3.1	3.3
Width of head	7.7	7.4	6.8	6.1	6	7.2	7.8
Length of head	8.3	8.3	8	7.2	7	8	6.8
Arm	14	14	14.3	11.4	12	13	12
Leg	37	38	34.5	32.9	34	35.3	33
Tibia	12.0	12	11.8	10.4	10.8	12	10.5
Foot and tarsus	16	16	16	14.2	14.3	16	14

No. 34962, Phu Kading, 3000 ft. Loei Prov. No. 1021 Chalermlarb, Chon Buri. All others from Kaeng Pang Tao, Chiang Mai prov.

Variation: Some of the specimens from Chiang Mai are brownish rather than violet or lavender. No. 36221 is brown, the area from occiput to rump with thickly scattered small white-topped pustules. These are not evident in any other specimen. No. 34962 is only faintly colored above, the stripes scarcely evident. The tips of the fingers and toes are a little smaller than in the other specimens. In Nos. 36226, 36228 (Chiang Mai) the darker lines tend to be broken and the area between them has numerous darker flecks.

Distribution: The species is known from Chanthaburi, Chon Buri (Chalermlarb); Loei (Phu Kading); Chiang Mai (Nong Pu'ng and Kaeng Paeng Tao). Most of the specimens were taken from small rain pools or ponds chiefly in lowland forest. One exception is a specimen taken at Phu Kading at an elevation of about 2800 ft.

Remarks: This species superficially looks like *Philautus doriae*, however, the following differences would seem to preclude its being regarded as the same species: Distinctly smaller; proportionally larger eyes; sharper snout coming to a "point" at a higher level; a slightly smaller tympanum; reduction of the webbing between fingers; the absence of the rows of glandules on anal flap and the more elongate openings of vocal sacs into the mouth.

Three of the females are gravid. Specimens taken at Chalermlarb were in the same pool as *Philautus nongkhorensis*. The small "blue spots" near end of rump are small masses of dark material below the skin (not impossibly pigment and refuse resulting from absorption of the larval tail). It is not superficial, and when dissected it may easily be removed in the form of a small nodule. The eggs are relatively large.

I examined the types in the United States National Museum. Of the paratype series Nos. 70110-70116, only two female specimens remain, both containing numerous eggs. In one the snout is pointed, the nostril practically equidistant between the eye and the nostril. The black dorsal spots are present near end of rump.

No. 70135, is from Ban Sadet, with large eggs. The "nose" is shorter, the nostril nearer the tip of the snout than to the eye. When the palate is seen from below, the choanae are largely concealed

Philautus vittatus (Boulenger)

Ixalus vittatus Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 5, 1887, p. 421, pl. 4, fig. 2 (type locality, Bhamo, Burma); The fauna of British India, Ceylon and Burma . . . Reptilia and Batrachia.

Philautus vittatus M. Smith, Rec. Ind. Mus., 1924, vol. 26, p. 141, pl. 7, fig. 4.

R[hacophorus] (P.) vittatus Ahl, Das Tierreich, Anura III, Lief. 55, 1931, pp. 90-91.

Diagnosis: Body rather slender, elongate (snout to vent, 32 mm.); eyes prominent, outer finger less than one-fifth webbed; terminal discs of third finger larger than others, equal in size to tympanum; foot about one-half webbed, first finger smaller than second; eyelid about equal to interorbital distance; tympanum distinct; body brown or grayish violet with two lateral and three dorsal gray or violet stripes; snout as long or longer than eye.

Description of species (from No. 36206 ♀, Kaeng Pang Tao, Chiang Mai): Head not wider than body, snout pointed, little longer than eye; canthus rostralis obtusely rounded, loreal region slightly oblique, not or scarcely concave; tympanum distinct, its diameter (2 mm.) about half length of eye, separated from eye by less than half its diameter; fold from corner of eye runs back diagonally across upper part of tympanum and terminates some distance above arm-insertion.

Choanae lateral, not visible when palate is viewed directly from below; tongue free for two fifths of its length and on sides; (male with a vocal sac opening into mouth by two small narrow puckered vocal slits).

Skin smooth without dorsal or lateral tubercles on body and limbs; chin and underside of limbs with fine granulation; venter and under thigh with larger granules or areolae; transverse row of glandules on anal flap a little above vent; median groove extends down from vent; breast nearly smooth.

Arms rather short, finger tips dilated into large discs, that on fourth finger as large as tympanum. First finger shorter than second, two outer fingers less than one-fifth webbed; vague remnant of web between second and third; no web between two inner fingers; distal subarticular tubercles large, proximal ones small; metacarpal tubercle at base of first finger rather indistinct; other tubercles scarcely distinguishable from granules on palm; toes with discs smaller than those on outer fingers, about three-fourths webbed; small inner metatarsal tubercle, no outer; subarticular tubercles moderately distinct, outer metatarsals not separated except a little anteriorly; no tarsal fold; tibiotarsal articulation reaches to front level of eye; when legs are folded at right angles to body, heels overlap about two millimeters.

Color: Above violet-brown with a series of three rather indistinct violet stripes, median arising near tip of snout, dorsolateral ones from eyes; lateral stripes from snout through eye to near groin; chin, venter, breast, and concealed parts of limbs cream-yellow with a vague scattering of pigment on chin and back part of thighs.

Variation: Occasional specimens show a tendency toward secondary stripes between the major ones, while in some others they fade out leaving the specimen a dull fawn with very little cloudy pigmentation.

Measurements in mm. of *Philautus vittatus*

Number	36204	36206	36210	36203	36214	36229
Sex	♀	♀	♂	♂	♂	♂
Snout to vent	32	31	28	27	27	26
Eye length	4.1	4	4.5	4	4	3.8
Snout	5	4.4	4	4	4	3.5
Width of head	10.3	10	9.6	8.8	9	9
Length of head	12	10.5	11	10	10	10
Arm	19.6	17.6	17	15	15.2	15.2
Leg	50.4	48.3	42	42.3	42	40
Tibia	17	16.7	15.4	14.7	14	14.2
Foot and tarsus	22.2	22	19	18	16.6	17

Philautus nongkhorensis Cochran

FIG. 86

Chirixalus doriae (not of Boulenger) M. Smith, Proc. Zool. Soc. London, 1924, p. 226.

Philautus nongkhorensis Cochran, Proc. Biol. Soc. Washington, vol. 40, Dec. 2, 1927, pp. 179-181 (type locality, Nong Khor, southeastern Thailand; Proc. U. S. Nat. Mus., vol. 77, p. 6.

R[hacophorus] C[hirixalus] nongkhorensis Ahl, Das Tierreich, Lief. 55, Anura III, Polypedatidae, 1931, p. 107.

Rhacophorus (Chirixalus) striatus Ahl, Zool. Anz., Leipzig, vol. 87, 1930, p. 229 (type locality, Karin Hills, Burma); Das Tierreich, Lief. 55, Anura III, Polypedatidae, 1931, 103 (*fide* Bourret).

Philautus nongkhorensis Bourret, Les Batraciens de l'Indochine, 1942, pp. 473-474.

Diagnosis: Moderately large (snout to vent 38 mm.). Head generally wider than body (gravid females excepted); eye large protruding, longer than snout; canthus rostralis angular; outer fingers two-thirds webbed; toes nearly entirely webbed, their discs smaller than fingers; inner metatarsal tubercle, no outer; skin generally with fine rounded tubercles; belly and much of concealed part of thigh granular; male with a vocal sac.

Description of species (from No. 1073, Chalermlarb in Royal Forest, Siracha, Chon Buri): Eye large, its length (4.8 mm.) a little greater than snout length (4.6 mm.); loreal region somewhat oblique, shallowly concave; tip of snout with a very small rounded "nose" little above median notch in upper lip; canthus distinct, nostril nearer tip of snout than to eye; interorbital distance (4 mm.) greater than width of an upper eyelid; strong fold from eye running straight back diagonally, covering upper edge of tympanum and terminating some distance above arm-insertion; tympanum entirely distinct except upper edge, its diameter (2.15 mm.) less than half of eye length; choanae lateral, when viewed from directly below, largely concealed by maxillary shelf; palate strongly arched; tongue large, deeply forked, without papilla, free for little more than half its length; (males with vocal sac opening through elongate slits into mouth). Arm rather short, fingers flattened, tips widened into strong discs, those of two outer fingers largest, equally as large as tympanum; two outer fingers scarcely more than one-third webbed; a basal remnant only between second and third, and first and second fingers; first and second fingers equal or second slightly longer; large inner metacarpal tubercle; other tubercles scarcely distinguishable from granules on palm; distal subarticular tubercles large, proximal ones much smaller; two inner fingers at least partially opposable to outer two. Leg short, tibiotarsal articulation reaching

FIG. 86.—*Philautus nongkhorensis* Cochran. Upper figure, No. 1069. Actual snout-vent length, 31 mm. Lower figure, No. 1076, length, 35 mm. Chalermlarb, Siracha, Chon Buri, Thailand.

middle of eye; toes three-fourths to four-fifths webbed, discs all smaller than those on outer fingers; an inner metatarsal tubercle, no outer; faint lateral tarsal fold (or thickening of skin) along edge of tarsus; subarticular tubercles moderately developed; sole granular; when legs are folded at right angles to body, heels overlap three millimeters.

Skin appearing rather smooth, but with small scattered tubercles especially about head, behind jaw angle, and on posterior face of arm; chin very finely tuberculate; venter and entire underside of thigh (to knee) granulate; granules large, pavementlike, on venter, largest just back of breast.

Color: Light lavender-brown with triangular spot on eyes and occiput; an indefinite blotch on middle of back with fine black flecks; dim mark surrounding back of rump; chin with slight pigmentation on jaws; venter white without pigment; sole of foot with some pigment but none on palm; side of head violet; lip somewhat lighter but without distinct cream or white spots.

Measurements in mm. and data of *Philautus nongkhorensis*

Number	1073	1075	902	1066	1069	1133
Sex	♀	♀	♀	♂	♂	♂
Snout to vent	35	36.4	36	32	31	29
Width of head	12	12.2	12.2	10	10	9
Length of head	13.4	13.3	11.2	9.7	10.2	10
Length of eye	4.8	4.9	4.8	4.9	4.6	4.1
Length of snout	4.6	5.3	4.9	4.5	4.3	4.1
Arm	18.2	23.1	23.2	17.5	15.2	16
Leg	54	58	55.5	45	45	45
Tibia	18	20	20	15.1	16	15
Foot and tarsus	24.8	25.2	25	19	18.3	20
Heel to—	eye	eye	eye	eye	eye	eye

Variation: There is variation in the details of the distribution of pigment on the back, and in the distinctness of the spots.

No. 902 ♀. In this specimen there is a small black mark across the snout before the eyes, connecting with dark violet-brown spots (or stripes) on side of the snout. A band between the eyes is connected with a mark extending from the interorbital region onto occiput and in turn connecting with a dark figure enclosing a diamond-shaped lighter violet area. This connects with a large blotch back of the shoulders and has a continuing narrow median stripe to rump where it widens. A narrow streak crosses back of rump. The legs and arms are strongly barred.

It will be seen from the table of data that the head is nearly as long as wide, perhaps longer in females and slightly shorter in males. The head-width measurements do not include the eyes which stick out beyond the outline of the head.

Distribution: All of my specimens are from southeastern Thailand taken at a large logging camp at Chalermlarb, Siracha, Chon Buri.

Remarks: No. 902, a female, was taken, clasped by a male, as she was depositing eggs in a foamy mass at the water surface while clinging to a small partly submerged stick. Most specimens were found perched in shrubs and weeds about the periphery of rain pools.

Philautus bimaculatus (Peters)

Fig. 87

Leptomantis bimaculatus Peters, Monatsb. Akad. Wiss. Berlin, 1867, p. 32 (type locality, upper reaches of the Agusan River, Mindanao, Philippine Islands).

Ixalus bimaculatus Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, p. 106.

Ixalus bimaculatus Boulenger, Proc. Zool. Soc. London, 1898, p. 475; Boettger, Ber. Senckenb. Ges., 1886, p. 123; Abh. Ber. Mus., Dresden, 1898-1899, no. 1, p. 3.

Philautus bimaculatus Stejneger, Proc. U. S. Nat. Mus., vol. 28, 1905, p. 347; Barbour, Mem. Mus. Comp. Zool. Harvard Col., 1912, p. 171; Taylor, Phil. Journ. Sci., vol. 16, 1920, pp. 296, 305; van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 269; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 116-117, fig. 8 (Setun, SW of Phatthalung, and Tasan, Chumphon); Inger, Fieldiana Zool., vol. 33, no. 4, 1954, pp. 399-401 (*part.*).

Rhacophorus (Philautus) bimaculatus Ahl, Das Tierreich, Lief. 55, Anura III, 1936, p. 64.

Diagnosis: A medium-sized *Philautus;* head broad, well defined; arms short, tibiotarsal articulation to tip of snout; sides and groin dark purplish-lavender with numerous cream flecks; back of thigh and underside of tibia dark lavender with cream flecks; outer fingers about three-fourths webbed; no tarsal fold.

Description of species (from B. M. 1927, 4, 21, 10 "Setun." Thailand): Head width 12.6 mm. greater than length (11 mm.); canthus rostralis distinct, the loreal region somewhat oblique, shallowly concave; in front of nostrils snout bends down with a distinct rimmed depression at tip; upper eyelid distinctly narrower than interorbital area; tympanum small (2 mm.) less than half of eye length (4.3 mm.); straight diagonal fold from eye to above arm becoming widened and terminating in a prominent glandular enlargement behind angle of jaws; no vomerine teeth; choanae large, lateral, when palate is viewed directly from below the outer part of choanae concealed by maxillary shelf; tongue rather elongate, very

Fig. 87.—*Philautus bimaculatus* (Peters). B. M. No. 1927. 4.21.10 ♂. Actual snout-vent length, 32 mm. "Setun" = ?Setul, Thailand.

strongly bifid posteriorly and free for more than half its length; vocal sac present, the openings elongate (or at least skinfold covering opening) half length of jaw; palatal roof high; distinct openings of palatal gland not evident.

Arm short when brought forwards, fingers reach beyond snout; first finger opposes other three, actually longer than second but when placed side by side they reach same distance; discs of three outer fingers large, equal to or slightly larger than tympanum; fingers one and two, one-fourth webbed; two and three, one-half webbed; two outer fingers nearly three-fourths webbed, the webs continuing as slight fringes or ridges to discs; strong subarticular tubercles; strong inner metacarpal tubercle, two other much smaller tubercles, outer at termination of a fold along outer finger; several supernumerary tubercles. Toes about three-fourths webbed, web continuing to discs as narrow fringes, discs smaller than those on fingers; a distinct fold along outer toe; a small inner metatarsal tubercle, none or only a very indefinite outer; no tarsal fold; discs with a deep peripheral groove with a strong groove across face of disc; tibiotarsal articulation reaching three millimeters beyond tip of snout; legs folded at right angles, heels overlap four millimeters; subarticular tubercles and some indefinite supernumerary tubercles. Skin smooth on head, eyelids, dorsum, sides and limbs; chin and breast with a very elaborate reticulation of grooves; venter and part of underside of thigh granulate or areolate, the individual granules varying much in size.

Color: Front half of head and snout buff; a cinnamon brown narrow bar between eyes; dorsum darker gray-brown with a light-edged brown bar across neck, one behind shoulder and a third across rump; lower part of sides, front and back of thigh, underside of tibia, lavender-violet with cream or yellow flecks; dorsal part of leg brownish-gray with four or five brown bars on femur, three on tibia; bars indefinite on foot and tarsus. Chin gray-white, venter yellowish white, growing darker posteriorly; underside of femur indefinite brownish flesh with a few cream dots below vent. Very conspicuous cream spot below eye.

Measurements in mm.: Snout to vent, 32; width of head, 12.6; length of head, 11; arm, 18.2; leg, 58; tibia, 19; foot and tarsus, 26.

Variation: It is difficult to ascertain the variation occurring in the species. Dr. Inger has synonymized *Philautus zamboangensis* with this species. This is a doubtful association as shown by the differences mentioned. The arm, especially, is shorter * and the coloration of *zamboangensis* differs materially.

Distribution: It would appear that the species occurs in the southern part of peninsular Thailand from the Isthmus of Kra south. It has been reported from Tasan, Chumphon, and "Setun, SW Phattalung" (perhaps now in the province of Setul?). It has been reported from Sarawak, Borneo, and Mindanao.

* Inger's elaborate argument for placing the species in synonomy contains at least one gross error. It appears that Inger did not see my type or a single specimen of *bimaculatus*. He states: "Two remaining points cited by Taylor involve characters that exhibit sufficient variation in other species of *Philautus* to account for the differences between the two types. These are the amount of webbing on the foot and the distance between the nostrils. The final distinction of the forelimb appears to be wholly unfounded, for Peters did not mention this character at all"[!] If Dr. Inger had had someone translate the type description for him he would have found that Peters *did mention* the forelimb. He gives the measurement of the forelimb as 25 mm.; of the hind limb, 62 mm.

Philautus doriae (Boulenger)

FIG. 88

Chirixalus doriae Boulenger, Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1892, p. 34, pl. 10, fig. 5, 5a (type locality, Karin Bia Po, and Thao Karin Hills); Proc. Zool. Soc. London, 1894, p. 642; Fea, Ann. Mus. Civ. Genova, ser. 2, vol. 17, 1897, p. 96 (476); Schenkel, Vehr. Ges. Basel, vol. 13, 1901, p. 150; Annandale, Rec. Ind. Mus., vol. 8, 1912, pp. 7, 18; M. Smith, Proc. Zool. Soc. London, 1924, pt. 1, p. 226 (Nong Khor, Thailand, Ban Khen, Me Wang Forest, N. Siam).

Rhacophorus (Chirixalus) doriae Ahl, Das Tierreich, Lief. 55, Anura III, pp. 105-106, fig. 67.

Philautus doriae Pope, Bull. Amer. Mus., vol. 61, 1931, p. 582, fig. 34 (Nodoa, Hainan); Pope and Boring, Peking, Nat. Hist. Bull., vol. 15, 1940, pp. 49, 72.

Diagnosis: Small species (35 mm.); pupil horizontal; tongue free, deeply notched behind; no vomerine teeth; tympanum distinct. Fingers webbed at base, the two inner opposed somewhat to two outer; toes webbed; digit tips dilated into large discs. Outer metatarsals separated by a web; canthus obtuse; tibiotarsal articulation to eye.

Description of species (from No. 29426 B, Karin Bia Po, cotype): Small frogs (35 mm.); snout obtusely pointed, tip extending very slightly beyond mouth; eye large (4 mm. long), its length greater than length of snout (3.3 mm.); canthus obtuse; loreal region vertical, slightly concave; distance between nostrils (2.85 mm.) less than interorbital distance (3.85 mm.); width of eyelid (2.2 mm.) smaller than interorbital distance; tympanum distinct, close to eye, its diameter (1.7 mm.) more than half length of eye; straight skinfold from eye runs across tip of tympanum and terminates behind level of arm-insertion; choanae moderately large, lateral, concealed by maxillary shelf when palate is viewed from below; no vomerine teeth; palatal glands open mesially at anterior level of choanae; tongue very strongly notched behind, the "horns" elongate, tongue free for nearly half its length; openings of vocal sac puckered, beside angle of mouth; openings of Eustachian tubes as large as choanae; skin smooth on head, dorsum, and on limbs; chin and throat corrugated or finely granular. A distinct fold across breast; venter and underside of thighs strongly and uniformly granular or areolate; row of glandular tubercles above vent; few indefinite ones about vent.

Arm moderate, digits with widened tips, with peripheral grooves; a small web between two outer fingers; two inner fingers opposed to two outer; subarticular tubercles large; a large but rather indistinct inner metacarpal tubercle, outer ones not distinguishable; diameter of largest discs nearly equal to diameter of tympanum;

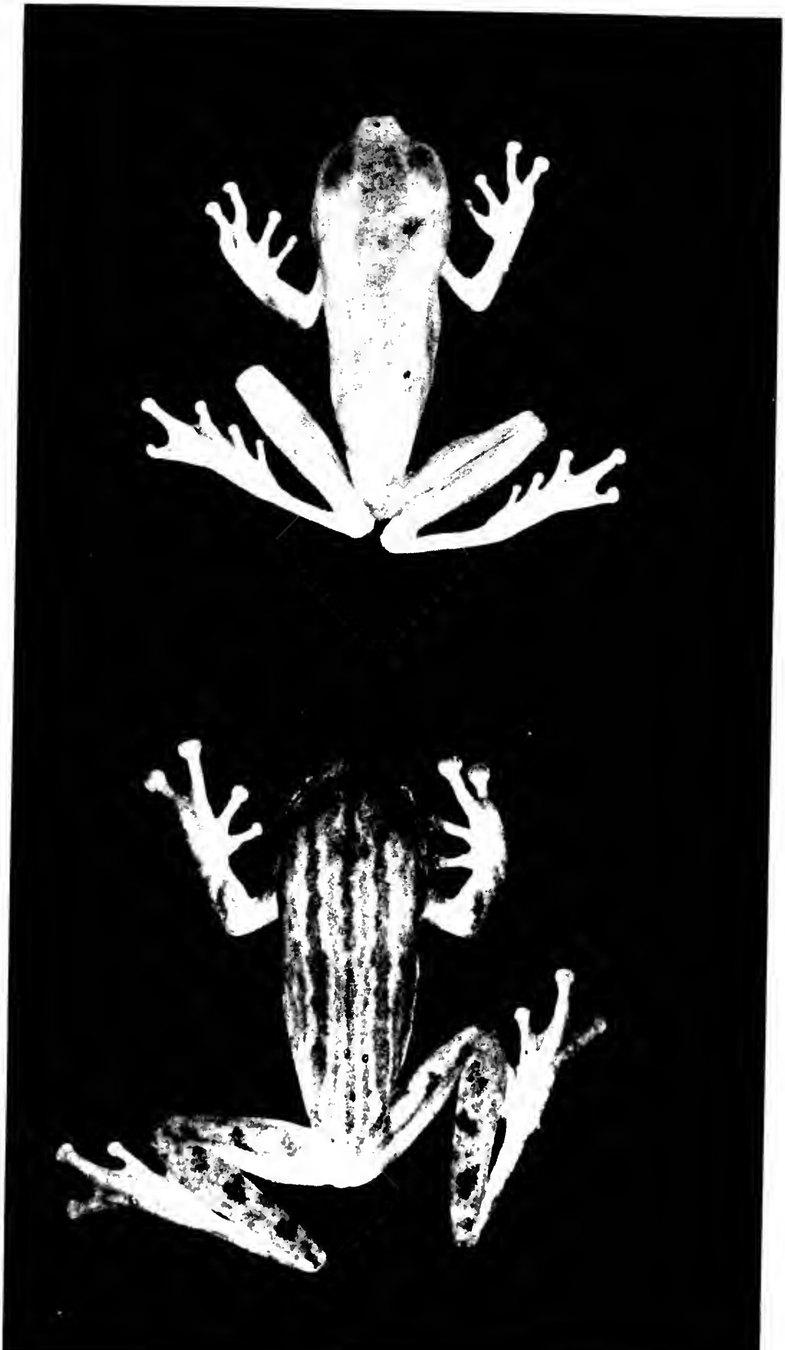

FIG. 88.—*Philautus doriae* (Boulenger). Upper figure, No. 33135. Ang Hin, Chon Buri. Lower figure, No. 33234. Ang Hin, Chon Buri, Thailand.

leg rather short, tibiotarsal articulation reaches slightly in advance of eye; when legs are folded at right angles to body, heels overlap three millimeters; outer toes a little more than half webbed, only a remnant between first two; subarticular tubercles well developed; a small but distinct inner metacarpal tubercle; a slight lateral tarsal fold or ridge indicated; discs on toes smaller than those on fingers.

Color: Purplish-gray above, nearly uniform with three dim stripes from tip of snout (median) and eyes (dorsolateral); loreal and tympanic region about same shade as dorsal stripes. A narrow yellow line on edge of upper jaw; chin, breast, venter, and underside of limbs yellowish to yellowish white; row of glands above vent creamy white.

Measurements in mm.: Snout to vent ♂, 26; width of head, 9; head length, 8.2; arm, 15.3; leg, 40; tibia, 8.8; foot and tarsus, 17.

Variation: A series of specimens taken at Kaeng Peng Tao, northern Chiang Mai province agree in detail with the descriptions of the cotypes. Two are females and two are males. Their snout-to-vent measurements are, 29, 32, and 26, 28 millimeters, respectively. Specimens from Phu Kading likewise agree in essential details.

Distribution: In Thailand the species is known from Chiang Mai province and from Phu Kading, Loei province. Malcolm Smith's report of the species from southeastern Thailand (Nong Khor, 1924) is most probably Cochran's *hansenae* from the same locality.

FAMILY MICROHYLIDAE

Genus MICROHYLA Tschudi

Microhyla Tschudi, Mem. Soc. Sci. Neuchâtel, vol. 2, 1839, pp. 28, 71 (type of genus *Hylaplesia achatina* Boie, = *Microhyla achatina* Tschudi); Parker, Monograph of the Microhylidae, 1934, pp. 123-127.

Diagnosis: "Prevomer divided, postchoanal portion lost; palatine present or absent. No clavicles, procoracoids or omosternum; sternum cartilaginous. Vertebral column diplasiocoelous. Terminal phalanges simple, or T-shaped.

"Pupil circular. Tongue oval, entire or free behind. One or two dermal ridges across the palate in front of the pharynx, smooth or crenulate. Digits with or without terminal dilations." (Parker.)

The American and Asiatic species of these small microhylids have been united under the single genus *Microhyla* by Parker (1934). It is a prolific genus and at least eight species are recognized in our territory. For the most part the species are lowland forms, but some at least reach an elevation above 5000 ft.

The frogs of the genus *Microhyla*, because of their small size appear to be difficult to classify, since it is usually necessary to have a lens or microscope in order to see many of the characters clearly. The variable color and pattern likewise tend to confuse. The following key, however, will separate most if not all Thai specimens into their proper species.

KEY TO SPECIES OF MICROHYLA IN THAILAND

1. One metatarsal tubercle (inner) ... 2
   Two metatarsal tubercles (inner and outer) ... 5
2. Toes webbed ... 3
   Toes without webs ... 4
3. Toes two-thirds to three-fourths webbed; leg very long, the tibiotarsal articulation reaching much beyond tip of snout; digits with well-developed discs each having a dorsal notch and groove; very small species, 18 mm. snout to vent ... *annectens*
   Toes three-fourths webbed; leg moderate, the tibiotarsal articulation reaching tip of snout; discs with a notch and cleft above. Grayish with an angular blotch in middle of back ... *annamensis*
4. Larger species, 31 mm.; leg shorter, tibiotarsal articulation fails to reach eye; tips of digits swollen but not widened into discs. Normally with well-rounded spots or nearly uniform gray; outer metacarpal tubercle behind the median; supernumerary tubercles on palm, *inornata inornata*
   Similar to the above but a little smaller with three straight continuous or broken lines on back ... *inornata lineata*
5. Tips of digits swollen, without discs, the upper surface not notched or grooved; no peripheral groove about disc ... 6
   Tips of digits widened into discs which are notched above, with a median cleft, and peripheral groove ... 7
6. Two metacarpal tubercles, outer large; toes about one-third webbed, *pulchra*
   Three metacarpal tubercles, the median smallest, the inner and outer usually touching behind median ... *ornata*
7. Toes less than one-third webbed, with sharp lateral fringes; a continuous black stripe along side of body; a pair of small black marks in middle of back ... *heymonsi*
   Toes one-third to fully webbed ... 8
8. Toes at least one-third webbed, the toes with lateral fringes to discs, the tibiotarsal articulation reaches to nostril; small species, 23 mm., *butleri*
   Toes four-fifths to fully webbed, discs large; tibiotarsal articulation to tip of snout or a little beyond; large species, 35 mm. ... *berdmorei*

Microhyla annectens Boulenger

Microhyla annectens Boulenger, Ann. Mag. Nat. Hist., ser. 7, vol. 6, 1900, p. 188 (type locality, Larut Hills, Perak, Malaya, 4000 ft. elev.); Butler, Proc. Zool. Soc. London, 1902, p. 189; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904, pp. 389-390; Boulenger, Fasciculi Malayenses, Zoology, 1903, p. 172; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 23; Boulenger, A vertebrate fauna of the Malay Peninsula, . . .

Reptilia and Batrachia, 1912, p. 262 (*part.*); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 169; *ibid.*, 1917, p. 230; Barbour, Occ. Papers Mus. Michigan Univ., no. 76, 1920, p. 3 (*part.*); van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 156 (*part.*); Nieden, Das Tierreich, Lief. 49, Anura II, Engystomatidae, 1926, pp. 28, 32 (*part.*); Parker, Ann. Mag. Nat. Hist., ser. 10, vol. 2, 1928, p. 482; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 126, 127; Smedley, Bull. Raffles Mus., no. 5, p. 109; Parker, Monograph of the frogs of the family Microhylidae, 1934, p. 129; Bourret, Les Batraciens de l'Indochine, 1942, pp. 511-512.

Diagnosis: A small species, snout to vent, 20 mm.; a median groove on upper surface of digital discs; snout equal to or a little longer than eye; leg very long, tibiotarsal joint reaching beyond tip of snout; toes nearly three-fourths webbed; inner metatarsal tubercle, no outer; first finger less than half length of second.

Description of species: Snout rounded, its length equal or little longer than orbit; canthus rostralis obtuse; loreal region vertical or nearly so, not concave; width of upper eyelid contained in interorbital width 1.75 times; tympanum concealed; digits with widened discs, their upper surface bearing a median groove; inner finger very short, about half length of second; toes nearly two-thirds webbed, membrane midway between third and fourth, reaching level of distal tubercle on third toe, which is longer than fifth; an oval inner but no outer metatarsal tubercle; subarticular tubercles moderately large; tibiotarsal articulation reaching well beyond tip of snout; skin smooth both above and below.

Color: "Brown above, with an oblique black bar from above shoulder, along flanks towards groin; a light streak, sometimes black-bordered posteriorly, from below eye to fore-limb; a symmetrical dark marking on back commencing between eyes where it connects upper eyelids, narrowing behind occiput, widening between shoulders, narrowing again and then becoming indistinct; an oblique dark cross-bar on femur, tibia, and tarsus; a black spot on anterior aspect of knee and another in region of vent; head, from level of center of eyes to tip of snout may be green, with a triangular black spot on lip in front of eye. Lower surfaces lighter, closely marbled with brown" (after Parker, 1934).

Measurement in mm.: Snout to vent, 20.

Variation: Males have an ample vocal sac.

Distribution: The species has been reported by M. Smith as occurring at "Patiyu just north of the Isthmus of Kra" now Chumphon province. I am not aware of its having been collected elsewhere in Thailand.

Outside of Thailand the species has been taken in Malaya (Larut Hills, Perak, and Selangor).

Microhyla annamensis M. Smith

FIG. 89

Microhyla annamensis M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 6, no. 1, 1923, pl. 5, fig. 2 (type locality, Sui Kat, 1000 meters altitude, Langbian Plateau, S. Annam.); Parker, Ann. Mag. Nat. Hist., ser. 10, vol. 2, 1928, p. 483; Monograph of the frogs of the Family Microhylidae, 1934, p. 130.

Diagnosis: Body moderately slender; tympanum not visible; interorbital space wider than upper eyelid; digital discs relatively large, with median cleft; toes three-fourths webbed; small inner metatarsal tubercle; no outer tubercle; tibiotarsal articulation to tip of snout.

Description of species (after type description): Habit moderately slender, snout obtuse, little longer than eye; interorbital space broader than upper eyelid; fingers moderately long, with well-developed discs except first which is extremely short with blunt tip; second finger half length of third; toes with discs larger than those of fingers, digits three-fourths webbed; two phalanges of fourth toe free; upper surface of discs of digits with median cleft; feeble inner metatarsal tubercle, no outer; tibiotarsal articulation reaches tip of snout; tibia more than half length of head and body. Skin

FIG. 89. *Microhyla annamensis* M. Smith. From M. Smith, 1923, pl. 5, fig. 2, about natural size. Langbian plateau, Annam.

with numerous pustules and tubercles on dorsal surface; ventral surfaces smooth except for patch of granules below vent.

Color: Grayish above, with large dark angular blotch in middle of back; black spot above arm, and one above groin; dark crossbars on limbs; below whitish, thickly speckled with gray.

Measurement in mm.: Snout to vent, 20; arm, 11.5; leg, 34.

Variation: The tibiotarsal articulation may reach beyond the tip of the snout, in some males, considerably beyond the tip. The webbing on the toes may be less than in the type. The warty pustular condition of the skin is always present in some degree. The dark dorsal blotch may have a faint white edge. The male has a subgular vocal sac and is smaller than the female.

Remarks: The species was caught on swampy ground among dense undergrowth. Many females are full of ripe pigmented eggs.

On the basis of the webbing it is most closely allied to *M. berdmorei* Blyth, the two having more webbing than other members of the genus. It differs, however, in less webbing, and the absence of an outer metatarsal tubercle. The discs of the fingers are larger, the skin more warty, the size smaller, and the coloration different. The type is a female.

Distribution: Known from Khao Sebab in Thailand; and from the type locality on the Langbian Plateau, south Annam.

Microhyla inornata inornata Boulenger

FIG. 90

Microhyla inornata Boulenger, Proc. Zool. Soc. London, 1890, p. 37 (type locality, Deli, Sumatra); Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 342; Boettger, Zool. Anz., 1893, p. 430; Flower, Proc. Zool. Soc. London, 1899, p. 905; Laidlaw, Proc. Zool. Soc. London, 1900, p. 887; Werner, Zool. Jahrb., Syst., vol. 13, 1900, p. 502; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904, p. 388; van Kampen, Zool. Jahrb., Syst., vol. 12, 1905, p. 713; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 259; M. Smith, Journ. Nat. Hist., Soc. Siam, vol. 2, 1916, p. 109; van Kampen, Amphibians of the Indo-Australian Archipelago, 1923, p. 153; M. Smith, Rec. Ind. Mus., vol. 26, 1924, p. 141; Nieden, Das Tierreich, Lief. 49, Anura II, Engystomidae, 1926, p. 33; M. Smith, Bull. Raffles Mus., no. 3, April 1930, p. 129; Parker, Ann. Mag. Nat. Hist., ser. 10, vol. 2, 1928, p. 498; A monograph of the frogs of the Family Microhylidae, 1934, pp. 144-145 (synonymy).

Microhyla stinegeri (sic) Boulenger, Ann. Mag. Nat. Hist., ser. 8, vol. 4, p. 494 (type locality, Kanshirei, Formosa).

Microhyla stejnegeri Stejneger, Proc. U. S. Nat. Mus., vol. 38, 1910, p. 92, 95; Nieden, Das Tierreich, Lief. 49, Anura II, Engystomatidae, 1926, p. 935.

Diagnosis: Small species (to 31 mm. ♀); snout shorter than orbit; first finger shorter than second; tympanum more or less distinct; toes entirely free, tips with very small discs; a single metatarsal tubercle; male with an internal vocal sac; body grey or brown above spotted or marbled with black; heel to near back of eye; three metacarpal tubercles, inner very small, median almost directly in front of outer which occupies position farther back than in other species; strong supernumerary tubercles on palm; skin smooth everywhere save for some dim granulation indicated above vent.

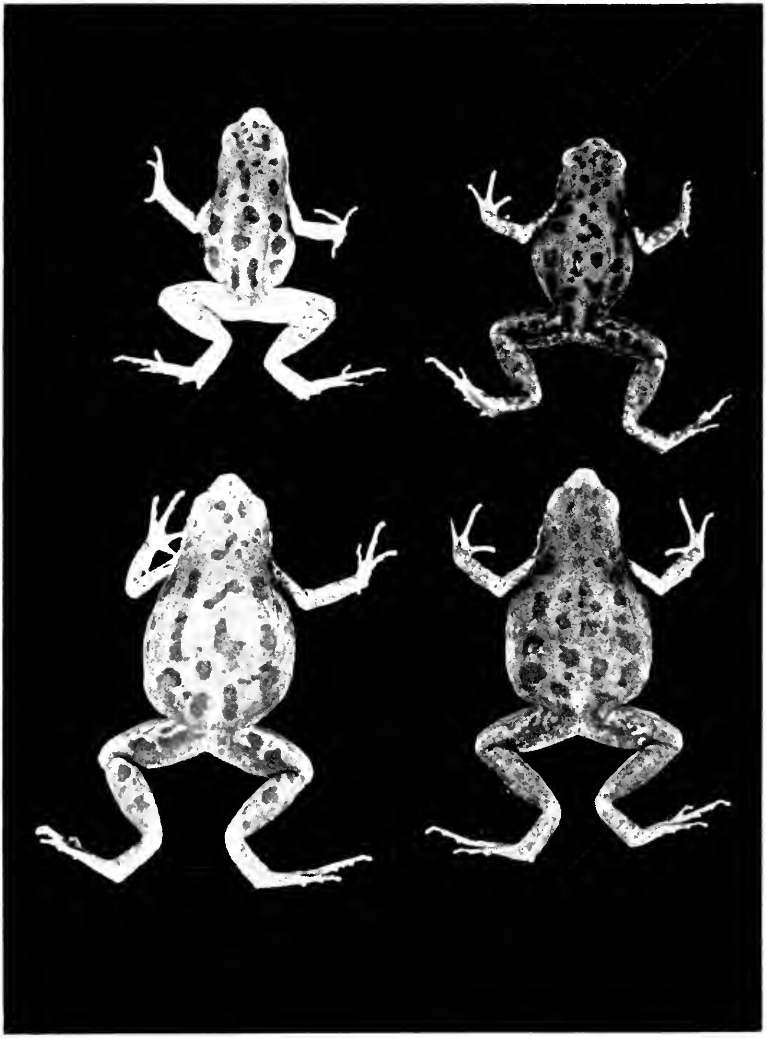

FIG. 90.—*Microhyla inornata inornata* Boulenger. Upper figures, males. Snout-vent length, *circa*, 23 mm. Lower figures, females. Length, *circa*, 30 mm. All from Chiang Mai, Chiang Mai, Thailand.

Description of species (from No. 1017 ♀, Chalermlarb, Chon Buri): Head and body rather flattened, loreal area almost vertical, not concave; canthus rostralis not, or but scarcely indicated; length of snout equal or slightly shorter than eye length; snout rounded in lateral profile, extending one millimeter beyond mouth; tympanum covered with skin, only upper edge overhung by fold beginning behind eye curving back to front of arm, separated from eye by distance equal to half its diameter; choanae rather large, half concealed when viewed from below; tongue free for about half its length, free on sides; males with an internal vocal sac opening through elongated slits into mouth.

Arms moderate, fingers with very small swollen discs, first finger much shorter than second (but considerably longer than distance to first subarticular tubercle of second); subarticular tubercles large; supernumerary tubercles on hand; metacarpal tubercles three, inner very small, median also small standing in advance of large outer; no lateral ridges on digits; legs short, toes entirely free with a slight ridge indicated on inner side of fourth toe; a single small inner metatarsal tubercle; no outer tubercle; tendon forming elevation on both ends of tarsus; subarticular tubercles well developed, smaller than those on hands; no supernumerary tubercles on sole; tibiotarsal articulation to back of tympanum; when legs are folded at right angles to body, heels touch or barely overlap.

Skin everywhere smooth (gravid female distended with eggs): the fold from eye rather dim.

Color in life: Gray-olive with deep black spots beginning on frontal region and scattered irregularly on back and sides; some spots on sides contiguous or fused; body becoming lighter low on sides; arms and legs light fawn with small scattered spots rather than bars; venter whitish cream with a peppering of pigment, enclosing small rounded pigmentless areas except on posterior part which is immaculate; some pigment on undersides of hands and feet; side of head with grayish reticulum enclosing small light spots or flecks.

Measurements in mm. (No. 1017 ♀ and No. 1019 ♂): Snout to vent, 25.5, 21; width of head, 8.1, 7.2; length of head, 7.5, 6.9; length of snout, 2.8, 2.3; length of eye, 3, 2.7; arm, 17, 15; leg, 36.2, 30; tibia, 11, 9.2; foot and tarsus, 16, 14.8.

Variation: Males and spent females show small pustules on the back and somewhat larger ones on the sides. Certain of the specimens are almost devoid of black spots. In these, the side of head and body are darker and the light spots on the side of the head and on lips are discrete, usually yellowish-cream in color. Often, too, there are yellow spots low on the sides.

In the southern part of Thailand the population that seemingly belongs to this species presents an appearance so different as regards marking that I propose to distinguish it as a subspecies: The markings are arranged longitudinally forming continuous or broken lines.

Distribution: The spotted form is known from Chiang Mai (city), from low elevation on Doi Suthep, and Chalermlarb, Chon Buri.

Microhyla inornata lineata subsp. nov.

FIG. 91

Type: No. 35534 ♀, 10 km. west of Nakhon Si Thammarat, collected by Edward H. Taylor, April 30, 1958.

Paratypes: Nos. 445, 35822, Khao Chong, Trang; 34793-94, Na Pradoo, Pattani; 35531-35533, 35535, topotypes (all same collector).

Diagnosis: Spots elongate arranged in lines on back; more or less distinct continuous stripe from tip of snout to above shoulder (often

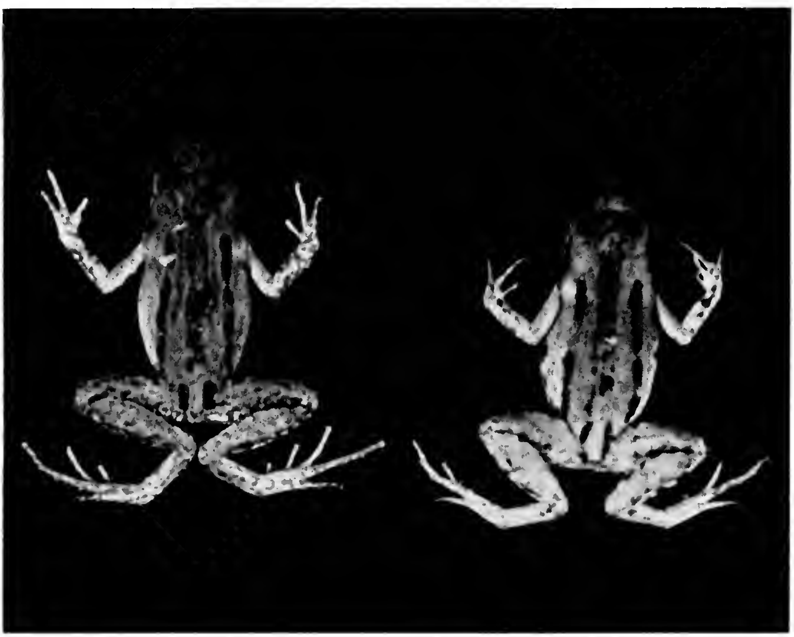

FIG. 91.—*Microhyla inornata lineata* subsp. nov. Right figure, type. No. 35534 ♀. Actual snout-vent length, 19.2 mm. Left figure, paratype. No. 35531 ♂. Length, 20 mm. 10 km. W Nakhon Si Thammarat, Thailand.

continued to groin); spots on lip tend to form a continuous irregular white line, and this may be continued across neck as a series of whitish spots; broken dorsolateral line.

Description of type: Body rather flattened; no canthus rostralis; snout depressed between nostrils, directed somewhat downward to tip, extending beyond mouth .8 millimeter; loreal region vertical, slightly concave behind nostril; snout distinctly shorter than eye-length; tympanum covered with skin but distinctly outlined; fold from eye across upper edge of tympanum to arm; choanae seen from below almost completely visible; tongue free behind for at least half its length, also free on sides.

Arm short; digits slightly swollen at tips, first much shorter than second; three metacarpal tubercles, inner small, outer placed almost directly behind median; supernumerary and subarticular tubercles well developed; leg with tibiotarsal articulation reaching eye; toes entirely free; an inner metatarsal tubercle, no outer tubercle.

Skin smooth, fold from eye to arm scarcely discernible.

Color in life: Brownish gray on dorsum; limbs light tan to fawn above; black stripe of irregular width from tip of snout along side of head to near groin, narrowed posteriorly; below this on side of head a cream stripe of irregular width from tip of snout to arm where it tends to cross breast as a series of light indistinct spots; below lateral stripe an indefinite light stripe; dorsolateral stripe from shoulder to groin; median stripe beginning on eyes as two lines that extend back diagonally and coalesce on median line; widening, it continues as moderately distinct line to back of lumbar area; two strong black marks at extreme end of rump; dark flecks and reticulation on posterior face of arms and front face of thigh and tibia; few flecks on dorsal part of limbs; chin and lower lip with numerous cream spots enclosed in reticulum of darker; scattering of pigment on breast and underside of thigh; most of ventral surface immaculate.

Variation: It will be noted that No. 34793 has short legs. It would appear that these specimens average smaller than the spotted forms of *inornata inornata* which occurs in the north. No. 34794, a gravid female, is the largest specimen seen; while several females of the spotted form are 30 or 31 mm. in length.

Distribution: Specimens are at hand from Pattani, Trang and Nakhon Si Thammarat.

Measurements in mm. of *Microhyla l. lineata*

Numbers...	35534	34794	35535	34793
Sex...	♀	♀	♂	♂
Snout to vent...	19.2	22	19	19.2
Width of head at tympanum...	6.25	7	7.1	6.1
Length of head...	5.3	6.7	6.2	6
Eye...	2.35	2.35	2.25	2.2
Snout...	2	2.15	2	1.9
Arm...	13	13.2	13	12
Leg...	30	29.2	30	25
Tibia...	9	8	9	7.2
Foot and tarsus...	15	14	14	9

Microhyla pulchra (Hallowell)

FIG. 92

Engystoma pulchrum Hallowell, Proc. Acad. Nat. Sci. Philadelphia, 1860, p. 506 (type locality "Between Hong Kong and Whampoa").

Diplopelma pulchrum Günther, The reptiles of British India, 1864, p. 417; Steindachner, Reise . . . Novara, Amphibia, 1867, p. 36, pl. 2, figs. 15-18; Tirant, Notes sur les reptiles et les batraciens de la Cochinchine et du Cambodge, 1885, p. 96.

Microhyla pulchra Boulenger, Catalogue of the Batrachia Salientia . . . in the collections of the British Museum, 2nd Ed. 1882, p. 165; Boettger, Ber. Offen. Ver. Nat., 1885, p. 50; Flower, Proc. Zool. Soc. London, 1899, p. 905; Werner, Abh. Bayer. Akad. Wiss., ser. 2, vol. 22, 2, 1903, p. 370; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, p. 39; *ibid.*, vol. 6, no. 2, 1923, p. 211; Parker, Ann. Mag. Nat. Hist., ser. 9, vol. 15, 1925, pp. 301, 304; Nieden, Das Tierreich, Lief. 49, Anura II, 1926, p. 31, fig. (synonymy); Pope, Bull. Amer. Mus. Nat. Hist., vol. 61, 1931, p. 599, fig. 39; Parker, A monograph of the frogs of the Family Microhylidae, 1934, pp. 137-138 (extensive synonymy).

Microhyla hainansis Barbour, Bull. Mus. Comp. Zool. Harvard College, vol. 51, 1908, p. 322 (type locality Mt. Wuchi, Central Hainan).

Microhyla melli Vogt, Sitzb. Ges. Naturf. Fr. Berlin, 1914, p. 101 (type locality "environs of Canton").

Microhyla boulengeri (*non* Vogt), Mell, Arch. Naturg., vol. 88, 1922, p. 130.

Microhyla major Ahl, Sitzb. Ges. Naturf, Fr. Berlin, 1930, p. 317 (type locality, Yao-Shan Mts. Kwangsi [1500 m.] China).

Diagnosis: A moderately large *Microhyla;* snout short and approximately equal to length of eye; first finger very much shorter than second; toes one-third to one-half webbed; tibiotarsal joint reaches to tip of snout, or slightly less; length of eye about equal to snout length; tips of digits not dilated, and without median cleft above; two very large metacarpal tubercles; strong inner metatarsal tubercle; small outer tubercle; when legs are folded at right angles to body, heels overlap.

Description of species (from No. 36287, Kaeng Pang Tao, 65 km.

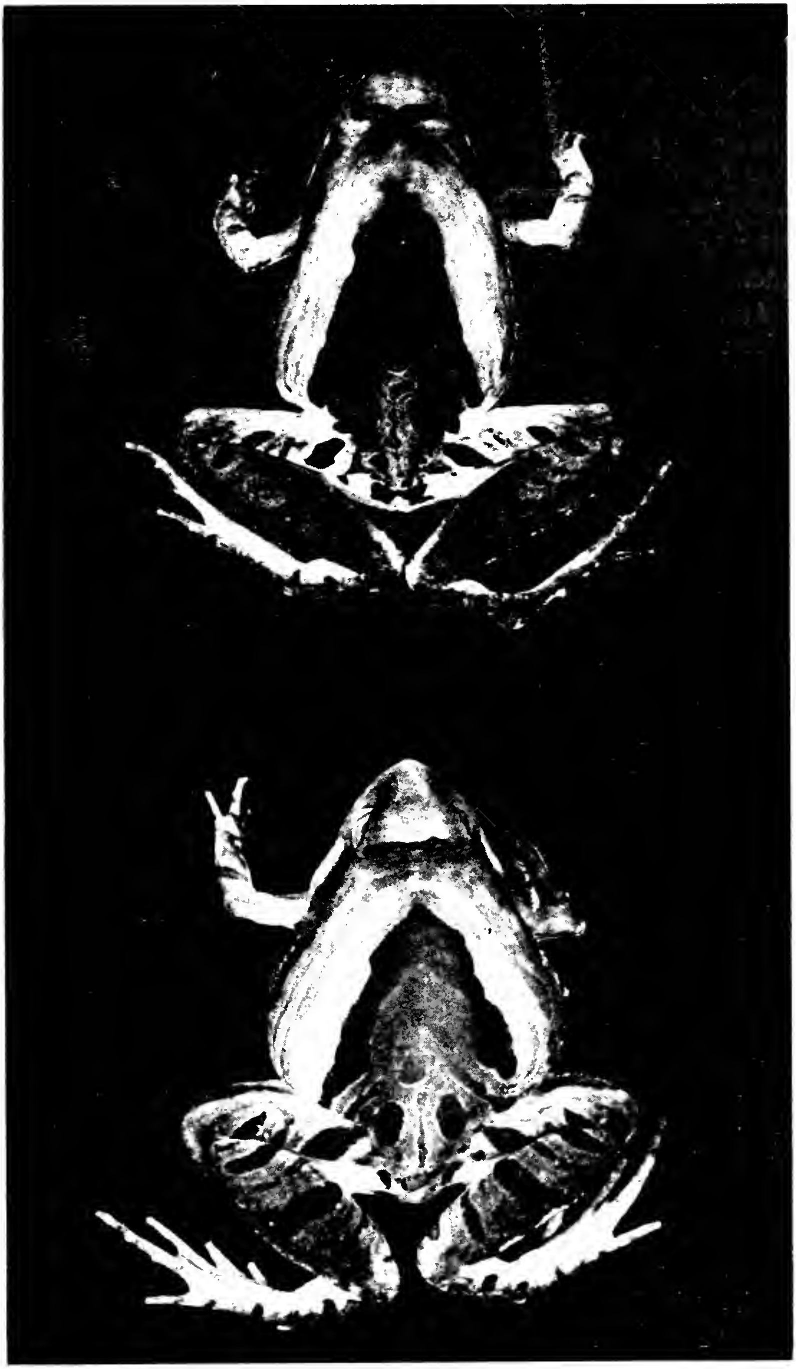

FIG. 92.—*Microhyla pulchra* (Hallowell). Upper figure, No. 36260 ♀. Actual snout-vent length, 29 mm. Lower figure, No. 36257 ♀. Snout-vent length, 30 mm. Both from Kaeng Pang Tao, Chiang Mai, Thailand.

N. Chiang Mai, Thailand): Body subtriangular in shape, snout rather acuminate, short, about equal to length of eye; interorbital space distinctly wider than an eyelid; canthus rostralis absent, loreal region slightly oblique, area not concave; tympanum hidden; a postorbital fold more or less distinct; tongue narrow, oval, free behind for about two fifths of its length; no vomerine teeth; seen directly from below choanae partly concealed by maxillary shelf; palatal glands open in two groups of four pores in front of choanae; internal vocal sac with pair of elongate vocal slits lateral to tongue.

Arm weak; a pair of strong metacarpal tubercles; subarticular tubercles strong; first finger very much smaller than second; toes one-third to one-half webbed; digital tips not wider than digits; pair of metatarsal tubercles, outer relatively large; no tarsal fold; when legs are folded at right angles, heels overlap five millimeters or more; tibiotarsal articulation reaches little beyond tip of snout.

Skin of front part of head smooth; slight fold crosses head behind orbits; fold indicated behind eye bending down and continuing to near arm-insertion; back with numerous smaller and larger flat tubercles, only a few on limbs; skin of chin finely wrinkled; venter nearly smooth, with some indication of ventral disc; area below vent transversely wrinkled.

Color: Above varicolored; black band across interorbital area; behind this two broad light diagonal bands diverge and continue to groin; a Λ-shaped mark on dorsum its apex between scapulae, its extremities in groin; dark canthal stripe; limbs with numerous wider and narrower bands, somewhat irregular; chin and chest more or less mottled with brown. In diagonal lateral areas fine parallel darker lines; black spots or more or less continuous black line extending along sides; groin, venter, and underside of limbs bright yellow. Chin black in male.

Measurements in mm.: Snout to vent, 29; axilla to groin, 11.5; width of head, 11.4; length of head, 8.7; arm, 14; leg, 49; tibia, 18; foot and tarsus, 21.

Distribution: The species has been taken in the following Thai provinces: Chiang Mai, Sara Buri, Nakhon Nayok, Phrae, Krabi, Chumphon, Nakhon Si Thammarat, and Chon Buri.

Outside of Thailand the species is known from Hongkong, China, Hainan, Tonkin, Cambodia and Viet Nam.

Remarks: I found this species breeding at Chalermlarb, Chon Buri, April 23, 1959.

One peculiarity in their calling is that the male population seem to start calling at the same instant, and they likewise all seem to cease calling on the same note. The signal to begin is given usually by a single individual.

This is, I believe, the handsomest species of the genus.

Microhyla ornata Duméril and Bibron

Fig. 93

Engystoma ornatum Duméril and Bibron, Erpétologie Générale . . . vol. 8, 1841, p. 745 (type locality "côte Malabar").

Diplopelma ornatum Günther, The reptilia of British India, 1864, p. 417.

Microhyla ornata Boulenger, Catalogue of the Batrachia Salientia *s.* Batrachia Ecaudata in the British Museum, 1882, p. 165; The fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 491; Flower, Proc. Zool. Soc. London, 1899, p. 901, pl. 60, fig. 1; Laidlaw, Proc. Zool. Soc. London, 1900, p. 887; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, part 3, 15th Feb. 1904, pp. 387-388 (Penang, Kedah, Kelantan); Boettger, Ber. Off. Ver. Nat., 1892, pp. 98, 102; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 1, June 1916, p. 38, *ibid.*, vol. 2, no. 4, Dec. 1916, p. 169 (Maprit, Klong Bang Lai, Prachuap Khiri Khan); *ibid.*, no. 3, May 1917, p. 230; *ibid.*, vol. 2, no. 4, Dec. 1917, pp. 264-268; Parker, Ann. Mag. Nat. Hist., ser. 10, vol. 2, 1928, p. 493; M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 129; Parker, A monograph of the frogs of the Microhylidae, 1934, pp. 139-141. (Extensive literature list and synonymy).

Microhyla fissipes Boulenger, Ann. Mag. Nat. Hist., ser. 5, vol. 13, 1884, p. 397 (type locality, Taiwan-fu, S. Formosa); Stejneger, Proc. U. S. Nat. Mus., vol. 58, 1907, p. 88; Nieden, Das Tierreich, Lief. 49; Anura II, 1926, p. 35.

Microhyla eremita Barbour, Occ. Papers Mus. Zool. Michigan, no. 76, 1920, p. 3 (type locality, Nanking); Stejneger; Proc. U. S. Nat. Mus., vol. 66, 1925, p. 11.

Diagnosis: A medium-sized species (28 mm. snout-to-vent length); tips of toes swollen, without discs; toes with only rudiment of web; two metatarsal tubercles; tibiotarsal articulation reaches side of neck, sometimes nearly to eye; three metacarpal tubercles, median usually smallest, inner and outer in contact behind median; fold on breast (in males); an area of flat irregular granules on back part of venter and in an area behind anal region. Male with vocal sac.

Description of species (from No. 36477 ♂ from Kaeng Pang Tao, Chiang Mai): Body not slender, but squat and generally triangular; tip of snout rounded, extending beyond mouth for 1.3 millimeters; no canthus rostralis, loreal region oblique, not concave; snout length greater than length of eye; interorbital space greater than width of upper eyelid; fold from behind eye extends across tympanic area and runs above arm-insertion; tympanum hidden; nostril lateral, directed outward.

Choanae viewed from below partially concealed by maxillary shelf; tongue free for half its length, and free on sides; vocal sac opens to mouth through two very elongate slits.

FIG. 93.—*Microhyla ornata* Duméril and Bibron. Showing variation in markings. Upper figures, *circa*, 24 mm. Lower figures, *circa*, 27 mm. All from Kaeng Pang Tao, Chiang Mai, Thailand

Arm short, fingers somewhat swollen at tips; first finger about one-half length of second; subarticular tubercles strong; lateral ridges on fingers indicated on inner side; three metacarpal tubercles, median smallest, wedged between inner and outer which are touching each other behind median. Legs relatively short, tibiotarsal articulation reaches back of eye. Toes somewhat flattened, tips slightly swollen; tiny web rudiment continued as fringe or ridge on sides of digits, more distinct on inner sides; subarticular tubercles large; two metatarsal tubercles, outer on elevated area of tendon almost as large as inner; when legs are folded at right angles to body, heels overlap one or two millimeters.

Skin with numerous large tubercles or pustules on dorsum; indication of row back of eye to shoulder; largest above arm-insertion; trace of hair-fine median ridge (broken); femur and tibia with numerous pustules above and few on arm near insertion; fold across front of breast (very strong in breeding males); patch of flat irregular granules on back part of venter and similar area behind and below vent.

Color: Various shades of gray-brown, with symmetrical brownish figure beginning on occipital region widening on shoulders, and growing gradually wider on rump where it loses some of its definition; outer edges somewhat darker than middle; diagonal stripe bordering this more grayish and lighter than the figure; on this stripe faint suggestions of darker parallel lines; sides of head little darker behind eye; dark elongate spot widening above arm-insertion then narrowing and disappearing about midway on side; legs banded; chin and throat blackish (males); under arms dull whitish; venter and under thighs cream; stripe on tarsus and sole, dark.

Measurements in mm. of *Microhyla ornata*.

Number	36477	36412	36416	36407
Sex	♂	♂	♀	♀
Snout to vent	27	25	28	28
Width of head	9	9	9	9
Length of head	7.7	7.4	7.4	7.2
Snout length	3	3	3	3
Eye length	2.85	2.8	3	3
Arm	14	14	12.3	11.9
Leg	40	41.05	39	42
Tibia	12.2	13	13	13
Foot and tarsus	20.5	20	18.2	19

All from Kaeng Pang Tao, Chiang Mai.

Variation: The apparently shorter arm of gravid females is perhaps due to the presence of the ovarian eggs which distend the body, thus also removing most evidence of pustules on the skin of dorsum, and the granulation of the posterior part of the venter. A fold across the front of the breast is scarcely indicated. A few specimens show the lower part of the tympanum, and although covered with skin, nearly a third of it may be visible. There are no supernumerary tubercles present on the palm; rarely a specimen may show a trace of a tarsal fold continuous with the inner metatarsal tubercle.

Specimens are often red-brown or smoky gray. The lighter diagonal area outside of the dorsal figure may have a series of fine lines, sometimes conspicuous.

Distribution: I have found this species in Thailand more frequently than any other *Microhyla.* It was especially common in northern Chiang Mai at Kaeng Pang Tao; also at Nong Khai and along the banks of the Mekong river for a distance of 50 kilometers where collections were made at intervals. The species is known from the two provinces mentioned, and the following: Udon Thani, Sara Buri, Kanchanaburi, Nakhon Si Thammarat, Trang, and Chumphon. I suspect it occurs in all the provinces of Thailand.

Elsewhere it is known in India (including Kashmir), Ceylon, Southern China, Indo-China, Formosa, and Malaya.

Microhyla heymonsi Vogt

FIG. 94

Microhyla achatina (part.) Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 261 (localities in Malaya); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 196, p. 39, fig. (tadpole); *ibid.*, vol. 2, no. 2, Dec. 1916, p. 169 (Patiyu and Pattani); Robinson and Kloss, Journ. Federated Malay States Mus., vol. 5, 1915, p. 155 ("Koh Pennan," Thailand); Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 6.

Microhyla heymonsi Vogt, Sitzber. Ges. Naturf. Fr., Berlin, 1911, p. 181 (type locality, Formosa); Parker, Ann. Mag. Nat. Hist., ser. 10, vol. 2, 1928, p. 487; Nieden, Das Tierreich, Lief. 49, Anura II, 1926, p. 32 (*part.*); M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, pp. 127-128; Pope, Bull. Amer. Mus. Nat. Hist., vol. 61, 1931, p. 593, fig. 38; Parker, Monograph on the Microhylidae, 1934, pp. 134-135.

Microhyla fissipes (*non* Boulenger) Boulenger, Ann. Mag. Nat. Hist., ser. 8, vol. 4, p. 495.

Diagnosis: A small microhylid (snout to vent, 22 mm.); body flattened nearly uniform gray or brown above, with usually a hair-fine median line and one or two very small median black spots on back; side of head and body with black band reaching to near groin; tympanum hidden; three large well-defined metacarpal tubercles, subequal in size, median wedged between inner and outer,

FIG. 94.—*Microhyla heymonsi* Vogt. No. 1031. Actual snout-vent length, 22 mm. Chalermlarb, Siracha, Chon Buri, Thailand.

but extending farther forward; two metatarsal tubercles, outer larger; slight web remnant; tips of digits widened into small discs.

Description of species (from No. 1032, Chalermlarb, Chon Buri): Head very small, flattened, snout rounded or bluntly pointed then directed obliquely backwards to mouth; canthus rostralis not indicated; loreal region oblique, perhaps slightly convex rather than concave; snout (2.7 mm.) little longer than length of eye (2.3 mm.); tympanum hidden; slight skin-fold from eye reaches arm-insertion; snout projecting .8 mm.; nostril closer to tip of snout than to eye.

Choanae nearly lateral, partially concealed when palate is viewed directly from below; palate strongly arched; tongue large, rounded behind, free for one fourth its length; (male with an internal vocal sac, vocal slits parallel to jaw, much elongated).

First finger very short, reaching to level of front of subarticular tubercle of second finger; three very prominent oval metacarpal tubercles, median little farther forward than others; tips of digits widened into small discs; subarticular tubercles well developed; supernumerary tubercles on palm; leg short, tibiotarsal articulation reaching front of eye; when legs are folded at right angles to body, heels overlap three millimeters; toes rather flattened; trace of web between toes, continued along sides of digits as lateral ridges; tips widened into small discs; strong subarticular tubercles; two metatarsal tubercles, outer larger; tendon enlarged, forming elevations at both ends of tarsus; outer metatarsals bound together.

Skin smooth generally but under lens some fine corrugation may be seen posteriorly and on sides; trace of median ridge; skin-fold begins back of eye and curves down to lower level of arm; chin glassy smooth, venter wrinkled; part of back and undersurface of thighs and back part of venter, granular.

Color in life: Above light gray to dusky gray along central parts of dorsum; darker on top of head; faint median light line with two fine black spots in middle of back; dark stripe from tip of snout through eye to near groin, lower edge indefinite becoming gray; limbs with indistinct bands; black triangular anal spot; some fine black spots on back of thigh, on back of tibia, and a black line on back of tarsus; entire ventral surface yellowish-cream with fine peppering of pigment on chin and throat.

Measurements in mm. (Nos. 1032 ♀ and 1023 ♂): Snout to vent, 22, 18; width of head, 7, 6.4; length of head, 6.5, 5.9; eye length, 2.3, 2.1; snout, 2.6, 2.3; arm, 11.2, 9; leg, 36, 29.6; tibia, 12, 10.3; foot and tarsus, 18, 14.

Variation: The general color pattern is maintained but the color may have a decided reddish tinge or may be brownish; most specimens are gray. Males usually have the chin and sometimes both chin and throat blackish, at least in the breeding season. Often the median light line (cream, yellow, or light gray) may be bordered with equally fine dark lines. The black spots in middle of the back may partially coalesce leaving a whitish center. In most specimens the transverse bands or lines on limbs are more distinct than in the described specimen. In some specimens there is a dim V-shaped spot beginning on the eyes and meeting back of the occiput, which may join a dim cloudy area that divides into two long, posteriorly directed, parallel limbs. Traces of this can be discerned if specimens are submerged in clear liquids.

Distribution: The species has been taken in the following provinces: Chiang Mai (several localities); Udon Thani, Loei, Chon Buri, Bangkok (Phra Nakhon), Chumphon, Pattani, Trang, and "Koh Pennan" (island). From these records one presumes that the species is distributed throughout the country.

The species was formerly confused with the Javan species *Microhyla achatina* and this accounts for the latter species having been reported from Thailand.

Remarks: While this is one of the smallest Microhylid species, it is one of the most easily recognized. It is very shy and difficult to capture. Both measured specimens are from Chalermlarb.

Microhyla butleri Boulenger

FIG. 95

Microhyla butleri Boulenger, Ann. Mag. Nat. Hist., ser. 7, vol. 6, 1900, p. 188 (type locality, Larut Hills, Perak, Malaya, 4000 ft.); Butler, Proc. Zool. Soc. London, 1902, p. 189; Journ. Bombay Nat. Hist. Soc., vol. 15, 1904 (second part of the article), pp. 388-389 (Larut Hills); Boulenger, Fasciculi Malayenses; Zoology, vol. 1, 1903, p. 172; Robinson, Journ. Federated Malay States Mus., vol. 1, 1905, p. 23; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 261; Vogt, Sitz. Ges. Nat. Berlin, 1913, p. 223 (Hainan); M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, p. 230 ("widely distributed" [in Thailand]); *ibid.*, vol. 4, no. 4, 1922, p. 214; *ibid.*, vol. 6, no. 2, Oct. 31, 1923, p. 212 (Hainan, Kiung-Chao and the "Hummocks"); Nieden, Das Tierreich, Lief. 49, Anura II, 1926, p. 31; Parker, Ann. Mag. Nat. Hist., ser. 10, vol. 2, 1928, p. 483; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 6 (Nong Khor, Siam); Gee and Boring, Peking, Nat. Hist. Bull., 4, 2, 1929-1930, pp. 26, 39; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 126-127; Parker, A monograph of the frogs of the Family Microhylidae, 1934, pp. 131-132 (Siam localities, Ta Rua, Central Siam, Den Chai, N. Siam, Nong Khor, S. E. Siam; Maa Yome, N. of Prae; Paknam, Chumphon; and numerous Malayan localities; Hainan; Saigon; Szechwan, China); Bourret, Les Batraciens de l'Indochine, 1942, pp. 514-516, figs. 187-188.

Microhyla boulengeri Vogt. Sitz. Ges. Natur. Fr. Berlin, 1913, pp. 222, 227, 229 (type locality, Hainan).

Microhyla latastii Boulenger, Ann. Mag. Nat. Hist., ser. 9, vol. 6, 1920, p. 107 (type locality, Saigon).

Microhyla hainanensis (*non* Barbour) Mell, Arch. Naturg., vol. 88, 1922, 10, p. 131.

Microhyla grahami Stejneger, Occ. Papers Boston Soc. Nat. Hist., vol. 5, 1924, p. 119 (type locality, Sui-fu Sze-chwan, China).

Microhyla sowerbyi Stejneger, Occ. Papers Boston Soc. Nat. Hist., vol. 5, 1924, p. 119 (type locality, near Yenping-Fu, Fukien, China).

Diagnosis: A medium-sized species (26 mm.); tips of toes with distinct small discs bearing median notch and cleft on upper surface of disc; a peripheral groove; two metatarsal tubercles; toes about one-third webbed; dark mark on back usually distinct or broken into symmetrical spots, outer ones outlined in lighter color; usually light line from eye to arm-insertion with several more or less distinct glandules or glandular tubercles. A short tarsal fold following inner metatarsal tubercle.

Description of species (from EHT-HMS No. M.160 from Singapore Island): Body rather slender, snout rounded, as long as eye, extending .9 mm. beyond mouth; no canthus rostralis; snout rounded

FIG. 95.—*Microhyla butleri* Boulenger. EHT-HMS No. 162 (3337). Actual snout-vent length, 26 mm. Kuala Tahan, Malaya.

in lateral profile; loreal region oblique, not concave; tympanum hidden; fold from eye to level of arm; (in male a row of distinct glandules from eye follow groove to angle of jaw, scarcely distinguishable in female); interorbital distance a little greater than width of an upper eyelid; nostril equidistant from eye and tip of snout, directed nearly straight upward on dorsal part of snout.

Choanae viewed directly from below not hidden by palatal shelf; tongue long, free for two fifths of its length, as well as free on sides; vocal sacs opening into mouth through two very elongate slits; sides of throat (in males) with series of very fine diagonal longitudinal folds marking position of vocal sacs.

Limbs with digits widened into distinct discs, larger on toes than on fingers, each with peripheral groove (at least on toes) and on dorsal surface of disc, a forward notch followed by cleft; fingers with well-developed subarticular tubercles, no supernumerary tubercles; first finger reaches subarticular tubercle of second; three metacarpal tubercles, outer largest, narrow, more or less fused with median; toes about one-third webbed, flattened, with ridge or fringe on outer and inner edges extending to discs, which are larger than those on fingers; two metatarsal tubercles, both small, inner slightly elongated, and followed by very short tarsal fold. The tendon of tarsus not conspicuously enlarged. When limbs are folded at right angles to body, heels overlap two millimeters; tibiotarsal articulation reaches to nostril. Skin smooth but with some rather large smooth flattened pustules on front part of dorsum; skin on sides of throat finely plicate; venter, breast, chin, and underside of limbs smooth.

Color: Gray to brownish-gray on back; sides showing some lighter flecks (probably red in life); rather large, more or less symmetrical blackish mark on dorsal areas which is deep black often surrounded with a fine lighter line (cream or red in life); in life red or scarlet spots on sides; cream line from eye to arm-insertion and light area on tip of snout; whitish to cream below on venter, chin clouded with dusky (males) less so in females; some flecks along sides of venter; limbs irregularly barred with dark marks.

Measurements in mm. (EHT-HMS Nos. M. 160 ♂ -161 ♂, Singapore; No. 36604 ♀, Whey Tat, Chiang Dao, Chiang Mai, respectively): Snout to vent, 21.4, 23, 22.5; width of head, 7, 7.2, 7; length of head, 7, 7.1, 6.8; eye, 2.8, 2.7, 2.7; snout, 2.8, 2.8, 2.7; arm, 12, 12.5, 11.5; leg 36, 37, 34; tibia, 11.5, 12.2, 11.2; foot and tarsus, 17.2, 18, 17.2.

Variation: There is considerable difference in general appearance depending upon the intensity of the dark coloration. Sometimes part of the dorsal figure lacks definition, the emphasized portions appearing as distinct spots; occasionally the general outline is lost altogether and symmetrical spots result.

The specimen from Chiang Mai is typical of this latter coloration. Of the two Singapore specimens, one has the toes a little less than a third webbed. The slight tarsal fold may be easily overlooked unless sought with a lens.

Distribution: The species has been taken in the following provinces in Thailand: Chiang Mai, Loei (Phu Kading, 5000 ft. elev.), Phrae, Chumphon, and Chanthaburi.

Outside of Thailand the species is known in Malaya, Burma (south Shan States), Hainan, and Tonkin.

Remarks: The tadpoles are nearly transparent, and usually have some scarlet or reddish brown on the tail, according to Malcolm Smith.

Specimens I collected were ensconsed under small bits of turf and leaves near a small pool at Phu Kading. The males were calling and the cry sounded like nothing so much as the gritting of human teeth!

Microhyla berdmorei (Blyth)

FIG. 96

Engystoma berdmorei Blyth, Journ. Asiat. Soc. Bengal, vol. 24, 1856, p. 720 (type locality, Pegu, Burma).

Diplopelma berdmorei Günther, Zool. Rec., 1868, p. 146; Proc. Zool. Soc. London, 1868, p. 479; Anderson, Proc. Zool. Soc. London, 1871, p. 202; Stoliczka, Proc. Asiat. Soc. Bengal, vol. 39, 1872, p. 109.

Microhyla (Engystoma) berdmorei Boulenger, in Mason's Burma, vol. 1, 1882, p. 500; Theobald, *idem.*, vol. 1, p. 292.

Microhyla berdmorii Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the British Museum, 1882, p. 166; The fauna of British India, . . . Reptilia and Batrachia, 1890, p. 492; Sclater, Proc. Zool. Soc. London, 1892, p. 348; Flower, *ibid.*, 1896, p. 908; *ibid.*, 1899, p. 906; Fea, Ann. Mus. Civ. Genova, ser. 2, vol. 17, 1897, p. 476; Laidlaw, Proc. Zool. Soc. London, 1900, p. 888; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904; Boulenger, A vertebrate fauna of the Malay Peninsula . . . Reptilia and Batrachia, 1912, p. 263; Barbour, Mem. Mus. Comp. Zool. Harvard College, vol. 44, 1912, p. 173; M. Smith and Kloss, Journ. Nat. Hist. Soc. Siam, 1915, vol. 1, no. 3, p. 249 (Klong Yai, SE Thailand); M. Smith, *ibid.*, vol. 2, 1916, p. 169 (Maprit, Klong Bang Lai); van Kampen, The Amphibia of the Indo-Australian Archipelago, 1923, p. 158; Nieden, Das Tierreich, Lief. 49, Anura II, Engystomatidae, 1926, p. 33; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1070-1072, fig. 11 (Loei province).

Microhyla berdmorei M. Smith, Rec. Ind. Mus., vol. 26, 1924, pp. 141-142, pl. 7, fig. 1 (Phan Rang, Annam); Parker, Ann. Mag. Nat. Hist., ser. 10, vol. 2, 1928, p. 479; M. Smith, Bull. Raffles Mus., no. 3, 1930, p. 127, fig. 13; Cochran, Proc. U. S. Nat. Mus., 1930, vol. 77, p. 7.

Callula natatrix Cope, Journ. Acad. Nat. Sci. Philadelphia, 1867, ser. 2, vol. 6, p. 199 (type locality, Rangoon, Burma).

Microhyla fowleri Taylor, Proc. Acad. Nat. Sci. Philadelphia, vol. 86, 1934, pp. 284-286, pl. 17, fig. 2, text fig. 1 (type locality, Chiang Mai, Thailand).

Microhyla malcolmi Cochran, Proc. Biol. Soc. Washington, vol. 40, 1927, p. 182 (type locality, "Pak Jong, Siam").

Diagnosis: Snout subacuminate, as long as orbit; first finger shorter than second; toes elongate, webbed to tips which are widened into broad discs, the upper surface of which are divided by a groove. Tibiotarsal joint to snout-tip or beyond; male with vocal sac; back usually with an hourglass-shaped spot (sometimes broken) often partly outlined in whitish. Outer and inner metatarsal tubercles; strong fold across neck in male.

Description of species (from No. 49, Doi Suthep, Chiang Mai): Head slender, snout acuminate; loreal region nearly vertical, not concave; interorbital width equal to width of an eyelid; tympanum indistinct, covered with skin; length of eye (3.5 mm.), shorter than snout, (5 mm.); tongue slender, rounded, free behind for one half or more of its length; palatal glands discharge through openings near upper anterior edge of choanae; vocal sac indicated externally by strong fold across breast; vocal sac present. Two vocal slits along sides of tongue; no vomerine teeth.

Fig. 96.—*Microhyla berdmorei* (Blyth). K. U. M. N. H. No. 40187 ♀. Actual snout-vent length, 39 mm. Phu Kading, 1045 m., Loei, Thailand.

Arms slender; tips of fingers widened into small discs, and with slight lateral ridges and a mere web-remnant. First finger much shorter than second (first finger abnormal on right hand); inner metacarpal tubercle rather large, outer tubercle larger, somewhat bifid; well-developed subarticular tubercles; toes webbed to widened terminal discs; distinct inner and small outer metatarsal tubercle; tibiotarsal articulation reaching beyond tip of snout; outer metatarsal united; when legs are folded at right angles to body, heels overlap five millimeters. Discs with median groove above, separating two swellings.

Skin above with smaller and larger tubercles, most strongly developed laterally; skin on throat somewhat wrinkled; venter and lower surface of thighs smooth or minutely wrinkled; some tubercular granulation below vent.

Color: Above grayish or brownish-gray, with a butterfly-shaped dark mark between eyes, extending to shoulders, narrowly joined to large somewhat indefinite spot on dorsum that extends back on rump, partially outlined with lighter edges; limbs with dim blackish bars. A few deep black spots on tarsus, foot, back side of tibia, and on forearm; front of femur with light diagonal band with very small vermiculations of darker color and some larger darker spots near knee; back of thigh similarly marked, and with deep black arch above vent; some blackish marks behind axilla; a diagonal light line from eye to arm-insertion. Web of front foot dark, blackish under tarsus; chin dark.

Measurements in mm. of *Microhyla berdmorei*

Number	49	40	51	52	14
Snout to vent	37	36	36.4	37.5	38
Axilla to groin	14	14	15	14	15
Width of head	17	16	16.2	16.3	17
Length of head	11.5	11.4	12	13.2	13.8
Arm	20	20	20	21.5	22
Leg	64	66	66	66	70
Tibia	23	24	24	23.5	25.3
Foot and tarsus	26	27.5	28	28	28.3

Variation: Specimens from the Chiang Mai region seem to show more tuberculation than more southern ones, some of which may be nearly smooth. The legs vary in length, since in some the heels overlap 10 millimeters. The dorsal pattern varies greatly in distinctness and detail. The type of *Microhyla malcolmi* has more webbing on the hand than most other specimens.

Distribution: The species is widely distributed in Thailand. Specimens are known from the following provinces: Chiang Mai (Doi Suthep), Phrae, Chon Buri, Loei (Phu Kading), Chanthaburi, Trad, Chumphon (Maprit), Nakhon Si Thammarat, Phatthalung, and Yala (Bhetong).

Outside of Thailand the species occurs in Pegu and Tenasserim in Burma; Annam, Malaya, and Sumatra.

Remarks: I collected a series of *Microhyla berdmorei* from a large rainpool on the side of Doi Suthep, Chiang Mai province (elevation, about 1000 ft.) at eleven o'clock in the morning of September 12, 1959. I first heard the breeding chorus from a point more than a quarter-mile away. The pool had filled early the previous evening during a heavy rain. I do not know when the chorus began but at this time it seemed unabated, and was continued at least until late afternoon when I left the vicinity. A number of pairs of frogs were seen clasping and the surface showed many groups of floating eggs spread about on the surface; but the pairs seemed remarkably wary, diving and escaping. No females were taken.

Most of the eggs were centered about bits of grass, floating chips, or twigs emerging from the water.

Only one other species frog was heard calling, presumably a single male specimen of *Rana pileata.*

Genus Kaloula Gray

Kaloula Gray, Zoological Miscellany, 1831, p. 38 (type of genus *Kaloula pulchra*).

Palatine bones forming a ridge across palate; no precoracoids, no omosternum, sternum cartilaginous; diapophyses of sacrum moderately dilated. Pupil round, tongue entire or nicked behind; two dermal ridges across palate in front of esophagus; tympanum hidden. Fingers free, toes more or less webbed; tips of digits pointed or, more or less dilated. Outer metatarsals united.

Two species occur in Thailand, the common, *Kaloula p. pulchra,* and the rare, *K. mediolineata.*

Key to Species of Kaloula in Thailand

1. Digits distinctly widened at tips, truncate, slight web at base of toes, *Kaloula p. pulchra*

   Digits pointed at tips, toes of adult more than half webbed, *Kaloula mediolineata*

Kaloula pulchra Gray

This species has two or more subspecies of which the typical one is present in Thailand.

Kaloula pulchra pulchra Gray

Fig. 97

Kaloula pulchra Gray, Zoological Miscellany, 1831, p. 38 (type locality "China"); Günther, Catalogue of the Batrachia Salientia . . . 1858, (1859), p. 123; The reptiles of British India, 1864, p. 437; Steindachner, Reise der Osterreichischen Fregatte Novara . . . Amphibien, pp. 68-69 (Ceylon); Cochran, Proc. U. S. Nat. Mus., vol. 77, pp. 7-8.

Callula pulchra Boulenger, Catalogue of the Batrachia Salientia s. Ecaudata in the collection of the British Museum, 1882, p. 170; The fauna of British India . . . Reptilia and Batrachia, 1890, p. 494; Flower, Proc. Zool. Soc. London, 1896, p. 908; *ibid.,* 1899, p. 906; Laidlaw, *ibid.,* 1900, p. 888; Butler, Journ. Bombay Nat. Hist. Soc., vol. 15, 1904, p. 390; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 1, June 1916, pp. 40-42, pl., figs. B 1, 2, 3; *ibid.,* vol. 3, no. 3, May 1917, p. 230; Annandale, Mem. Asiat. Soc. Bengal, vol. 6, 1917, p. 152, fig.; Nieden, Das Tierreich, Lief. 49, Anura II, 1926, p. 22, fig.; M. Smith, Bull. Raffles Mus., no. 3, Apr. 1930, p. 121, fig. 10.

Hylaedactylus bivittatus Cantor, Journ. Asiat. Soc. Bengal, vol. 16, 1847, p. 1064.

Kaloula pulchra pulchra Bourret, Les Batraciens de l'Indochine, 1942, pp. 487-490, fig. 175-176 (good literature list).

Diagnosis: Digits widened, especially at tip, and truncate; entire dorsum brown with two dark-edged light brown, yellowish, or pink stripes from eye to groin. No median stripe; web remnant on toes.

Description of species (from No. 1091 ♀, Chon Buri): Body subtriangular in shape with limbs involved in body skin leaving less than a third of femora free; canthus rostralis scarcely indicated; loreal region sloping obliquely, not concave; nostril nearer tip of snout than to eye; width of interorbital area (8 mm.) much greater than width of an upper eyelid (5 mm.); tympanum concealed; faint fold across occiput from eye to point of arm-insertion; snout extends little (1.3 mm.) beyond mouth.

Choanae transversely widened, irregularly shaped, not concealed when palate is viewed from below; pair of transverse elevated ridges from outer level of choanae run behind them, but separated mesially by diastema; an elevated ridge anterior to outer part of choanae; fleshy fold arches across palate behind orbits preceding a straight transverse denticulate fold; tongue free for a little less than half its length; (males with an ample subgular vocal sac, opening through rather short vocal slits, partly covered by skin folds; a large external fold on chin marks vocal sac externally.

Arms rather long; fingers long, gradually widened at tips, terminally truncate and lacking peripheral groove, or transverse groove on wider portion; first finger shorter than second; subarticular tubercles very moderate; three metacarpal tubercles, outer longest, median smallest; no supernumerary tubercles on palm.

Leg very short, foot slightly longer than hand; toes much narrower than fingers, tips slightly swollen but not widened, with web remnant; subarticular tubercles distinct; fifth toe shorter than second and not extending as far forward; two metatarsal tubercles, inner shovel-shaped with free edge; outer smaller, rounded, separated from inner; no tarsal fold; tibiotarsal articulation reaching to point above arm-insertion; when legs are folded at right angles to body, heels separated by distance of 10 millimeters.

Skin finely granular with some scattered pustular tubercles; skin of chin, sides, venter, and underside of thigh granulate, granules or areolae small, irregular, usually not rounded, but angulate.

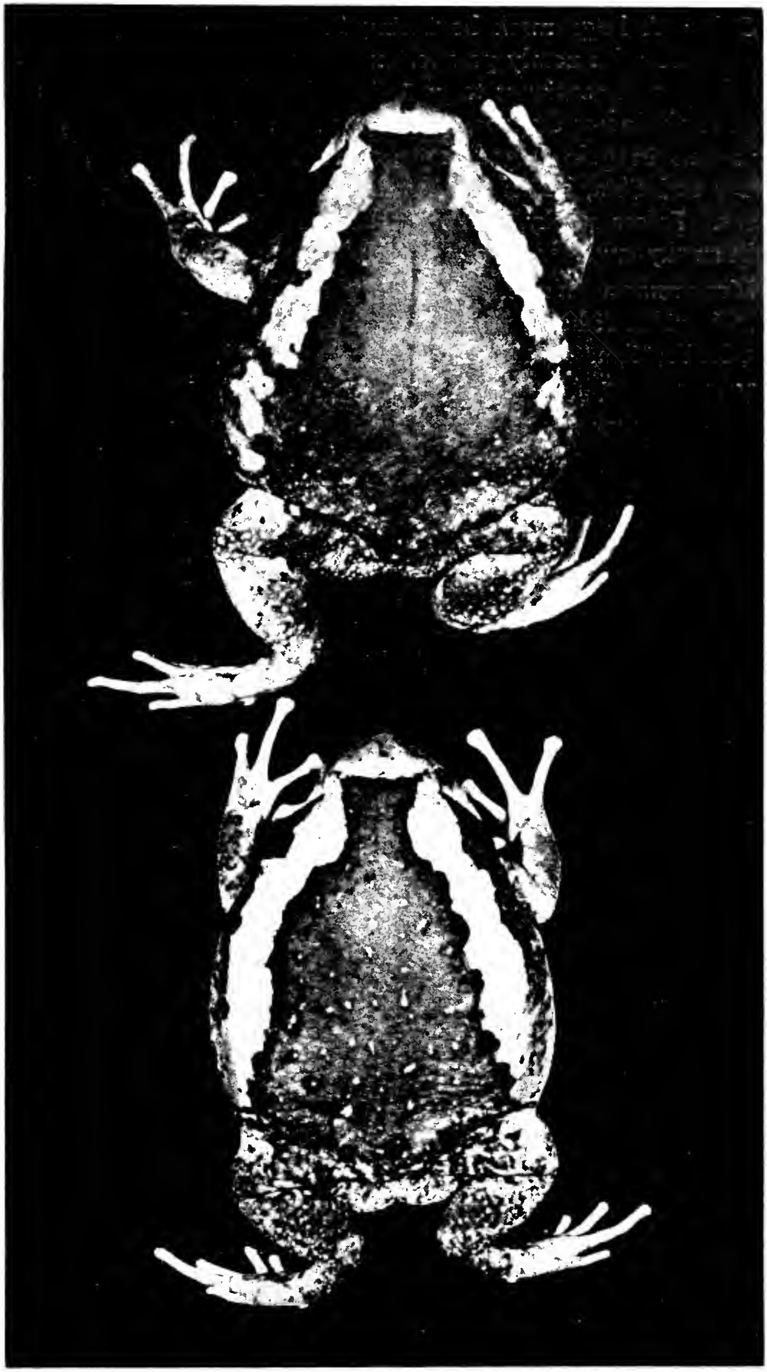

FIG. 97.—*Kaloula pulchra pulchra* Gray. Upper figure, No. 1091 ♀. Actual snout-vent length, 70 mm. Lower figure, No. 1106 ♂. Length, 65 mm. Both from Chalermlarb, Chon Buri, Thailand.

Color: A large mark beginning in interorbital region extends back, with sides nearly parallel on occiput; it begins widening on shoulders and continues to posterior edge of body. An irregular-edged light brown diagonal stripe from eye to groin, bordered below by a dark irregular-edged stripe; an interrupted light band crosses femur and tibia, which are indefinite black with some fine white flecks. Below smoky, darker under chin; venter reticulated with light smoky-lavender inclosing small lighter areas.

Measurements in mm. (No. 1091 ♀ and 1106 ♂): Snout to vent, 70, 65; width of head, 25, 24; length of head, 15, 14; arm, 49, 44.2; leg, 86, 76; tibia, 26.2, 24; foot and tarsus, 39, 39.

Variation: The general pattern changes but little, but the shades of color vary greatly. No two specimens, seemingly, have the same exact color. The lateral stripes may be whitish, greenish, fawn, yellowish-orange, gray, brown, or pink.

Distribution: This species is widespread throughout the country in lowlands and probably occurs in every province in Thailand.

Outside of Thailand it is known in Malaya. In Ceylon and in part of India it is replaced by another subspecies.

Remarks: This narrow-mouthed toad has a very loud low-pitched voice that can be heard for a considerable distance. Since there are many hundreds of ponds or klongs in Bangkok, each apparently with at least a few individuals of this species, most, if not all, city dwellers are familiar with their noise and have had an opportunity of lying awake at night listening to their booming cries.

The toads inflate their bodies with air, fill the subgular vocal sac and float, spread out on the surface of the water.

Kaloula mediolineata M. Smith

FIG. 98

Callula mediolineata M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, no. 3, May 1917, pp. 224-225, pl., fig. 2 (type locality, Prachuap Khiri Khan); *ibid.*, vol. 2, no. 3, May, 1917, p. 230 (Nong Pling, Central Siam, Ubon, Prachuap Khiri Khan); Parker, A monograph of the frogs of the family Microhylidae, 1934, pp. 81-82 (Paknampo, Korat, Ubon, Prachuap Khiri Khan); Bourret, Les Batraciens de l'Indochine, 1942, p. 485.

Diagnosis: Toes pointed, about half webbed. Dark above with broad light-yellow or light brownish marks from upper eyelid to groin; similar median stripe from middle of back to near vent; two large compressed metatarsal tubercles, outer smaller.

Description of species: Head elevated in occipital region, snout lower, short, rounded; no canthus rostralis, nostril closer to eye than

Fig. 98.—*Kaloula mediolineata* M. Smith, No. 34177. Actual snout-vent length, 56 mm. Ang Hin, Chon Buri, Thailand.

to median point on tip of snout; length of eye twice length of snout; interorbital distance distinctly wider than an eyelid; tympanum hidden; a fold from eye across tympanic area. A rather wide, somewhat denticulated ridge across palate in front of esophagus; this preceded by an arched dermal fold lying between orbits; choanae crowded between eyeballs and front of palate; tongue oval, slightly nicked posteriorly; tongue free behind, no vomerine teeth; large vocal slits connecting with subgular vocal sac.

Arms short, fingers free, with indistinct lateral ridges, first much shorter than second; three metacarpal tubercles, inner largest, median rounded and close to outer tubercle; four supernumerary tubercles present; subarticular tubercles rather small; two very large metatarsal tubercles, the inner shovel-shaped, outer smaller, thicker, narrowly separated from inner tubercle; subarticular tubercles small; no supernumerary tubercles visible. Tibiotarsal articulation fails to reach to arm-insertion; when femora are at right angles to body lateral skin reaches to knee. A distinct fold across breast; a slight axillary web; some indistinct granules on back; venter smooth.

Color: A narrow dark-brown line across eyelids; broad brown dark-edged stripe from head, widening posteriorly and bifurcating posteriorly; brown lateral stripe from eye to groin; light-brown stripe from eye terminating in groin, and similar stripe from vent to rump; one broad dark band across thigh and tibia; arm above light brown; chin (♂) blackish brown; entire venter yellowish white.

Measurements in mm.: Snout to vent, 56; width of head (tympanic region), 20; length of head, 17; arm, 32; leg, 61; tibia, 22; foot and tarsus, 31.5.

Variation: The species was described from young specimens, the largest being 38 mm. in length. It is probable that the females reach a length somewhat greater than that recorded for the male above (56 mm.).

The dorsolateral light stripe may be broken into elongate spots, and the light median stripe varies in length. In two young specimens, the median is barely indicated.

Distribution: This species, known only in Thailand, has been found in Korat, Ubon, "Nong Pling near Paknampo," Chon Buri (Ang Hin); and at the type locality, Prachuap Khiri Khan.

Remarks: Information regarding the life history of this species is greatly to be desired. It is to be found in or near the same pools with *Kaloula pulchra pulchra, Glyphoglossus molossus* and *Caluella* *guttulata.* However, even after having been described for 45 years it is still comparatively unknown.

At Ang Hin where one adult and two young have been taken, dozens of *Kaloula pulchra pulchra* have been found. Their calls may be heard after almost every heavy rain during August and September. I have never detected the call of *mediolineata.*

Genus CALLUELLA Stoliczka

Calluella Stoliczka, Proc. Asiat. Soc. Bengal, 1872, p. 146, figs. 3, 4 (types of genus *Megalophrys guttulata* Blyth); Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, p. 181.

Dyscophina van Kampen, Zool. Jahrb., Syst., vol. 22, 1905, p. 708 (type of genus *Dyscophina volzi*).

Diagnosis: Burrowing frogs, maxillary and vomerine teeth present; prevomer large, almost surrounding choana, in contact with its fellow mesially, ankylosed to palatine and bearing teeth; clavicles and procoracoids present; sternum cartilaginous, large; terminal phalanges simple. Pupil of eye circular. Tongue large, oval, entire, and somewhat free behind. Two dermal ridges across palate. Tips of digits slightly widened, toes webbed.

Three species are recognized; one is from Sumatra, one from Yunnan; a single species enters Thailand and Burma.

Calluella guttulata (Blyth)

FIG. 99

Megalophrys guttulata Blyth, Journ., Asiat. Soc. Bengal, 1855, vol. 24, p. 717 (type locality, Pegu, Burma).

Callula guttulata Günther, Proc. Zool. Soc. London, 1868, pp. 479, 490, pl. 40, fig. 1.

Calluella guttulata Stoliczka, Proc. Asiat. Soc. Bengal, 1872, p. 146; Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, p. 181; The fauna of British India . . . Reptilia and Batrachia, 1890, p. 498; Ann. Mus. Civ. Genova, ser. 2, vol. 13, 1893, p. 348 (in separate p. 7); Fea, Ann. Mus. Civ. Genova, ser. 2, vol. 17, 1897, p. 476; Boulenger, Ann. Mag. Nat. Hist., ser. 7, vol. 13, 1904, p. 44; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, pp. 225, 230 (widely distributed in Siam in suitable places); Nieden Das Tierreich, Lief. 49, Anura II, 1923, p. 8; Bourret, La faune de l'Indochine, Vertébrés, 1927, p. 262; Cochran, Proc. Zool. Soc., Washington, vol. 77, 1930, p. 8; M. Smith, Bull. Raffles Mus., no. 3, 1930, pp. 119-120, fig. 9; Parker, A monograph of the frogs of the Family Microhylidae, 1934, pp. 28-29, fig. 3 (numerous Thai records); Bourret, Les Batraciens de l'Indochine, 1942, pp. 481-482, figs. 172, 173.

Diagnosis: Maxillary teeth present; transverse rows of vomerine teeth; tympanum hidden; choanae far forward on palate. Digits bluntly pointed.

Description of species (from No. 1007 ♀, Chalermlarb, Chon

FIG. 99.—*Calluella guttulata* (Blyth). No. 33728 ♂. Actual snout-vent length, 40 mm. Doi Suthep, Chiang Mai, Thailand.

Buri): Body roughly triangular in shape; snout rather rounded, extremely short (3.35 mm.), less than length of eye (4.2 mm.); no canthus rostralis; loreal region oblique, not concave; nostril nearer tip of snout than to eye; interorbital width (4.5 mm.), much wider than an upper eyelid (3.1 mm.); tympanum not visible. A fold from eye runs diagonally across tympanic region terminating above arm.

Choanae against front of palate, partially visible when viewed directly from below; vomerine teeth on two straight transverse ridges, originating behind choanae and beyond their outer edges, separated by a short mesial diastema; tongue wide and thick anteriorly, narrower and slightly nicked posteriorly, free for half its length; (male with a large subgular vocal sac opening into mouth through elongate lateral slits, covered more or less by fold of skin); curved thickened fold across palate behind orbits, and longer somewhat denticulated transverse fold or ridge behind it.

Arm short; digits completely free, bluntly pointed at tips; first finger shorter than second; subarticular tubercles moderately developed; three metacarpal tubercles, outer longest, median small somewhat in advance of other two; two or three small supernumerary tubercles on palm. Legs short, toes pointed, webbed at base for about one third of their length, webs continued distally as narrow fringes on each side of digits; subarticular tubercles moderate; large, somewhat shovellike inner metatarsal tubercle; small conical outer tubercle; tibiotarsal articulation reaches to level of angle of jaws; when legs are folded at right angles to body heels fail to touch by two or three millimeters.

Skin seen under lens minutely granulate with larger tubercles scattered on sides of neck and shoulders and on rump; tubercles evident on thigh and tibia; on head in interorbital area, two larger pustular tubercles, and on occiput a curving series of four, that may continue diagonally on sides with smaller pustules; pair of tubercles on shoulders that mark wide point on a dark figure; side of head rather corrugated with some glandules near mouth-angle; some tubercles on sides of chin; a slight transverse curving skin-fold in front of breast; venter and underside of thighs without tubercles or granules; few tubercles on sides of vent.

Color in life: Dorsal parts of body brownish with dark diagonal mark following supratympanic fold; dark marks begin on upper eyelids, extend back and meet mesially, then again diverge as far as two enlarged tubercles, then again converge behind these, the pattern indefinite; two rather definite spots in groin; transverse black mark on back of thighs, widening to include area about vent; this bordered anteriorly by a cream or fawn line; area about jaw-angle amber; inner fingers whitish; chin finely flecked and reticulated with brown; venter and undersides of thighs whitish; soles of feet dark lavender; indefinite marks on sides; limbs indefinitely barred with blackish.

Measurements in mm. (Nos. 1007 ♀, 1011 ♂, respectively): Snout to vent, 50, 43; width of head, 20, 19; length of head, 16, 13.5; arm, 28.5, 28; leg, 68, 62; tibia, 22, 19.5; foot and tarsus, 33, 30.

Variation: The skin of the anterior part of the venter on males is thickened and glandular, and the vocal sac is evidenced by heavy folds of skin.

The tongue in most specimens is rounded or somewhat truncate behind without a notch. A skinfold may be present across the head between the eyes. The choanae in males are more exposed than in females.

The details of the color pattern vary much. Many specimens have reddish blotches. The general color may be olive-gray, greenish or even yellowish, the dark spots on the back often being outlined in light reddish, whitish, or cream. The external surface of vocal sac of the male is deep black during the breeding season. The population in Thailand differs from that in Malaya, in having the inner metatarsal tubercle proportionally larger, and the webbing of the feet very distinctly less.

A review of the various populations of *Calluella guttulata* may point to the necessity of distinguishing these considerable variations as subspecies.

An adult gravid female from Kuala Tahan, Pahang, measures 38 mm. snout to vent, and a male from the same locality is 34 mm. This suggests a size difference in the populations.

Distribution: In Thailand the species has been taken in Bangkok and in the provinces of Chiang Mai, Chon Buri, and Chumphon. It appears to be a lowland species probably not reaching high elevations in the mountains.

Outside of Thailand, the species occurs in Burma (type locality, Pegu), and Malaya.

Genus KALOPHRYNUS Tschudi

Kalophrynus Tschudi, Mem. Som. Sci. Neuchâtel, vol. 2, 1838, p. 86 (type of the genus *Kalophrynus pleurostigma*).

"Prevomer divided, the postchoanal portion absent; palatine absent; ethmoids minute or absent. Clavicles and procoracoids present, well developed, reaching the mid-line of the girdle and scapulae; omosternum small, cartilaginous; sternum large cartilaginous. Vertebral column diplasiocoelous. Terminal phalanges T-shaped.

"Pupil horizontal; tongue oval or subcircular, entire and half free behind. A strongly denticulated ridge across the palate in front of the pharynx, preceded by a shorter, curved, nearly smooth one; a smooth ridge behind each choanae; digits not dilated distally; skin thick and glandular." Parker, 1934.

Kalophrynus pleurostigma pleurostigma Tschudi

FIG. 100

Kalophrynus pleurostigma Tschudi, Mem. Soc. Sci. Neuchâtel, vol. 2, 1838, p. 86 (type locality, Sumatra); Günther, Catalogue of the Batrachia Salientia in the collection of the British Museum, 1858 (1859), p. 54; Smith, Bull. Raffles Mus., no. 3, 1930, p. 123.

Kalophrynus pleurostigma pleurostigma Parker, A monograph of the frogs of the Family Microhylidae, 1934, pp. 97-98, figs. 39-40 (*part.*); Inger, Fieldiana Zool., vol. 33, no. 4, July 23, 1954, pp. 416-420 (*part.*).

Calophrynus pleurostigma Boulenger, Catalogue of the Batrachia Salientia *s.* Ecuadata in the collection of the British Museum, Ed. 2, 1882, p. 158; The fauna of British India, Ceylon and Burma; Reptilia and Batrachia, 1890, p. 490 (*part.*); Flower, Proc. Zool. Soc. London, 1896, p. 908; *ibid.*, 1899, p. 900 (*part.*); Butler, Journ. Bombay Nat. Hist. Soc., vol 15, 1904, p. 387; Boulenger, A vertebrate fauna of the Malaya Peninsula . . . Reptilia and Batrachia, 1912, 258; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1916, p. 168; Nieden, Das Tierreich, Lief. 49, Anura II, 1926, p. 16 (*part.*). Parker, Monograph of the Microhylidae, 1934, pp. 97-98, figs. 39-40.

Diagnosis: Body squat, covered usually with very numerous small horny spines tipped with ivory; more or less distinct or diffuse parotoid gland; oval inner metatarsal tubercle, outer absent or indefinite; vocal sac in male. Third toe longer than fifth; second longer than fourth; toes one-third webbed or a little more; nuptial pads on inner fingers.

Description of species (from EHT-HMS No. 30264): Body squat; head flat somewhat wedge-shaped; snout little shorter than eye length; interorbital width about one and a half times width of upper eyelid; canthus rostralis obtuse; loreal region nearly vertical, not or but slightly concave; tympanum moderately distinct, covered with skin, close against eye, its diameter (3.5 mm.) more than half length of orbit (4.8 mm.); a skinfold from top of eye extends down, curving above tympanum then down to arm-insertion then back and up above arm, becoming lost on side; dorsolateral fold begins at eye and extends back diagonally to groin.

Choanae entirely concealed when palate is viewed from below; palatal glands empty into distinct curving groove which runs from upper edge of choana across palate; tongue slender, small, free behind for half its length, free on sides, not notched; an elevated dermal ridge curves across palate behind orbits; just behind this denticulated dermal ridge crossing palate; subgular vocal sac opening into mouth through two slits beginning behind angle of mouth then curving forward.

Skin thick, glandular, over upper surface of body, covered with small tubercles or pustules, each with an ivory tip, becoming a little larger, pyramidal, or spinose, laterally. Tubercles present on legs, a few above femur, many on tibia, present but less distinct on foot;

FIG. 100.—*Kalophrynus pleurostigma pleurostigma* Tschudi. EHT-HMS, No. 30264, Patiyu, Prachuap Khiri Khan, Thailand.

chin and to lesser extent breast with fine tubercles; venter, much of undersurface, and posterior surface of thighs granulate, the granules or areolae somewhat variable in size.

Arms short; fingers small, tips slightly swollen, distal and proximal subarticular tubercles strongly developed; two metacarpal tubercles, outer very large, flat; three large supernumerary tubercles; nuptial pads on dorsal surface of three inner fingers; legs short, toes half webbed, webs reaching swollen tips as narrow fringes; inner and smaller outer metatarsal tubercles; strong subarticular tubercles; no tarsal fold; tibiotarsal articulation reaches tympanum.

Color: Above uniform violet brown, tips of tubercles ivory to cream; a faint lighter dorsolateral line bordered by darker below. Chin and throat smoky; underside of thigh, chin, breast, and anterior part of venter yellowish; small ocelli where the larger tubercles exist.

Measurements in mm.: Snout to vent, 40; width of head, 17; length of head, 14.5; diameter of tympanum, 4; arm, 28.5; leg, 53; tibia, 18; foot and tarsus, 22.

Variation: The specimens occurring in Thailand and Malaya seem to agree with the Sumatran form. It is possible that more than a single form occurs in Borneo. A second species has been described from Malaya.

Distribution: In Thailand the species has been taken only in the southern part, several specimens having been acquired by Dr. Malcolm Smith from Patiyu = Prachuap Khiri Khan. The species occurs in Malaya and the Indo-Australian Archipelago. A handsome species *K. stellatus* occurs in the Philippines.

Genus GLYPHOGLOSSUS Günther

Glyphoglossus Günther, Proc. Zool. Soc. London, 1868, p. 483 (type of genus, *Glyphoglossus molossus*); Boulenger, Catalogue of the Batrachia Salientia s. Ecaudata in the British Museum, 2nd. ed., 1882, p. 175.

Diagnosis: "Head very short, crown convex; mouth transverse, very narrow; limbs short, eye small; space between and behind the inner nostrils is even without papillae; one papilla in the median line of the hinder part of the palate. Tongue long, free, and notched behind and in front, divided into two lateral halves by a deep groove. Tympanum hidden; openings of Eustachian tubes small. Toes broadly webbed; metatarsus with a large, compressed, cutting shovel-like prominence." Günther (1868).

The following characters also obtain: "prevomer undivided, the post-choanal portion overlying the palatine region, and bearing, mesially one or two knob-like prominences; no clavicles, procoracoids, or omosternum; sternum cartilaginous; vertebral column diplasiocoelous. Terminal phalanges simple" . . . "A fimbriated ridge across palate in front of pharynx preceded by a median papilla; an indefinite, pigmented dermal ridge behind each choana." Parker, 1934.

It has been pointed out by Parker and others that the genus is closely related to *Uperodon* Duméril and Bibron, and it might be well to unite the genera. However, he maintains them both in his monograph. The species *Uperodon globosum* has an undivided prevomer and this agrees with *Glyphoglossus.* It might be that this form should be placed in the genus *Glyphoglossus.* Material is not at hand for such a study.

Glyphoglossus molossus Günther

FIG. 101

Glyphoglossus molossus Günther, Proc. Zool. Soc. London, June 25, 1868, p. 483, pl. 38, fig. 1 (type locality, Pegu, Burma); Boulenger, Catalogue of the Batrachia Salientia *s.* Ecaudata in the collection of the British Museum, 2nd Ed., 1882, p. 175 (Pegu); The fauna of British India . . . Reptilia and Batrachia, 1890, p. 497; Sclater, Proc. Zool. Soc. London, 1892, p. 348; Fea, Ann. Mus. Civ. Genova, ser. 2, vol. 17, 1897, p. 473; M. Smith, Journ. Nat. Hist. Soc. Siam, vol. 2, 1917, p. 230; *ibid.*, 1917, pp. 269-270; Nieden, Das Tierreich, Lief. 49; Amphibia, Anura II, Engystomatidae, 1926, p. 21; Cochran, Proc. U. S. Nat. Mus., vol. 77, 1930, p. 8 (Sikiu near Khorat, Nakhon Ratchasima, Thailand); Noble, The biology of the Amphibia, 1931, p. 533, fig. 174; Parker, A monograph of the Microhylidae, 1934, pp. 72-73, fig. 30 ("Paknampo, N. E. Siam; Ta Rua, Central Siam"); Bourret, Annexe au Bull. Inst. Publ., no. 4, 1937, p. 55; *ibid.*, no. 4, 1939, p. 60 (Takeo, Cambodia); Les Batraciens de l'Indochine, 1942, p. 493-495, fig. 179; Taylor and Elbel, Univ. Kansas Sci. Bull., vol. 38, pt. 2, Mar. 20, 1958, pp. 1072-1075, fig. 12.

Diagnosis: See diagnosis of genus.

Description of species (KUMNH, No. 33519 ♂, Rat Buri, Thailand): Large burrowing frogs, snout and lower jaw very strongly truncate; canthus rostralis not indicated; eye very small, much shorter than distance between eye and tip of snout; upper eyelid heavy, overhanging lower; head strongly convex above; occipital region highest, sloping gradually forwards and downwards to tip of snout; a small fold usually present across head behind eyes, reaching laterally to angle of mouth; choanae diagonally elongate, partly divided by fleshy process from anterior edge; vomerine teeth absent, but two small boletoid bony processes behind, but slightly mesial to choanae, somewhat resembling vomerine teeth; rounded median papule lies immediately in front of, and contiguous with broad transverse fold lying across palate some distance in front of

Fig. 101.—*Glyphoglossus molossus* Günther. KU Mus. No. 40018 ♀. Actual snout-vent length, 73 mm. "Thailand."

esophageal opening; tongue rounded and thickened with a suggestion of an anterior notch, and on each side a distinct lateral thickening, leaving strong median depression or groove; these thickenings narrow posteriorly, leaving two diverging fingerlike ridges that fail to reach back edge of tongue; posterior part of tongue free for one fourth of its length; openings of Eustachian tubes large, circular; a vocal sac; two slitlike lateral openings to vocal sac on each side of tongue, near anterior part of mouth; externally transverse folds show position of median vocal sac, which has two extensions running back above arm to shoulder.

Fingers with lateral ridges (or fringes) along their inner sides and with small web-remnant between second and third. Four subarticular tubercles followed by three small tubercles on palm and two large (metacarpal) tubercles, outer elongate extending to back border of palm, inner shorter but more distinct than outer; toes fully webbed, tips somewhat swollen into small terminal discs; three subarticular tubercles; very large free-edged shovel represents inner metatarsal tubercle; small outer tubercle present; when leg is carried forward shovel reaches tip of snout. Skin of face, snout, eyelids, anterior part of lower jaw, and lips covered with tiny firm rounded or spinose tubercles; body skin wrinkled, sometimes showing indistinct granulation. Venter smooth, not granulate.

Color: Color generally blackish- to grayish-brown with dorsal and lateral areas of body and limbs with very numerous small to minute light flecks or spots; most of ventral surfaces of chin, body, and limbs whitish to cream, partially clouded.

Measurements in mm.: Snout to vent, 60; arm, 31; leg, 81; tibia, 25; foot and tarsus, 36; shovel, 9.

Variation: Some specimens have the skin granular on the anal region; in others the front part of the head and chin are beset with numerous small regular pustules; the occipital fold may or may not be present; sometimes the general coloration above is purplish.

Distribution: In Thailand specimens have been taken in Chon Buri, Chanthaburi, Rat Buri, and Ayutthaya. Outside of Thailand it has been taken in Burma.

Remarks: This species is widespread in Thailand. It is one of the amphibians commonly found in markets, available for human consumption. Several of these are placed on a spit and roasted to a crisp—this without removing the skin or viscera.

Young specimens were found during the dry season burrowed into a sandy bank near a swampy area in Chon Buri.

ORDER GYMNOPHIONA

This group was formerly called Apoda, an excellent name for the group but unfortunately the name was used earlier for certain eel-like fishes, and cannot be used for these creatures.

The group may be briefly described as follows: Body wormlike or snakelike, lacking arms, legs, and internal parts of pelvic and pectoral girdles; palatine bones fused to maxillaries; frontals, nasals, parietals, and prefrontals distinct; tail absent or rudimentary; squamosal in contact or not with parietal; eye usually under skin, sometimes under bones of skull. Males with terminal part of gut modified, so that when exserted it serves as an intromittent organ for internal fertilization. Young usually transform from an aquatic, larval, water-breathing condition to an adult air-breathing state.

The species of this Order at the present time are regarded as belonging to a single family, Caeciliidae, and are commonly referred to as the Caecilians.

This group of animals is not well-known and on first seeing them one is more likely to associate them with worms or snakes rather than with amphibians.

The caecilians, unlike their relatives the frogs and toads do not announce their presence by singing loudly. These are very secretive, silent animals, living underground most of their lives. Most species place their eggs near water, and these, when they hatch, permit the young to enter water and live like fishes. They take their oxygen from the water through gills at first. Later they lose their gills, leave the water, and become burrowing animals. These creatures, like most vertebrate animals living under the ground, have lost their arms and legs; their eyes have become changed and perhaps nonfunctional, and the animal has learned a new method of locomotion similar to that of snakes or legless lizards.

The caecilians have become still further modified. Not only have the arms and legs disappeared but even the bones within the body that normally support the arms and legs have disappeared. The tail has become reduced in size so that it is sometimes less than one-half millimeter long in certain Indian species (which may be said to lack tails), or three to seven millimeters long in certain Thai species.

Another curious characteristic of the caecilians is that in many species there are scales present; but unlike fishes, lizards and snakes in which the scales are on the surface of the body, the scales in these animals are hidden below the surface in skin-folds that pass around the body. In all species where they occur they are completely or practically concealed. In some species the scales may be absent from all or a part of the body while in the posterior part of other species there may be as many as five to nine scalerows in a single fold. In various parts of the body the scales may vary in size from tiny ones less than one fourth of a millimeter in size to larger ones 3 millimeters in diameter, and various sizes may occur in the same specimen, sometimes in the same fold. The number of rows around the body may total more than a thousand, in some cases perhaps nearer two thousand.

The skin of the body contains a very large number of glandules that produce secretions of mucus on the body. The largest of these may be two to three millimeters in length, lying nearly horizontal and forming a closely-packed row around the body in (or between) each fold.

The folds tend to make circles around the body, and are separated by fine grooves. In most of the species known in Thailand the folds are very numerous (250 to 380). They curve forward on the upper surface of the body and on the sides are directed downwards, while on the under surface they curve backwards and meet on the middle line of the body in a rather sharp angle throughout most of the body. However, in the posterior part of the body, the folds run straight across the ventral surface.

The anal opening, in Thailand species, is a narrow longitudinal slit into which several grooves enter. The back part of the intestine in the males is thickened with some especially developed organs. The intestine may be extruded and may serve as an intromittent organ for fertilizing the eggs of the female internally. This organ does not occur in either the Salientia (frogs, toads, etc.) or the Caudata (salamanders).

The eye is usually visible in the Thailand species although it is covered with skin and other tissues which may be partly transparent. It does not seem possible for the eye to serve the animal other than to determine light intensity. Anterior to the eye, and variously placed between the eye and the nostril is a small organ, the tentacle, which may be everted and retracted. It is usually shaped like a minute cone, and one or two millimeters long when extruded and doubtless serves the animal as a sense organ of some kind. The nostrils are placed far forward near the tip of the snout.

The teeth are important in differentiating caecilian species. There are four sets of teeth. In the upper part of the mouth the maxillary-premaxillary series forms a line around the edge of the upper jaw, associated with the maxilla and the premaxillary * bones. Just behind the first row is a second series, the vomeropalatine, which is associated with the prevomer and palatine bones but usually forms a continuous series.

The lower jaw has a series of teeth bordering the mandible (or dentary); and behind this is a series of splenial teeth associated with the splenial bone. In certain caecilians including some Asiatic species, the splenial teeth may be entirely absent. In others the number may be reduced to only two median teeth while in other species the number may reach or exceed 50 teeth.

The tongue is fastened on all sides, sometimes covering the splenial teeth. It cannot be extruded from the mouth.

It is difficult to determine (except with a skeleton at hand) the exact length of the head, since the region back of the head is wider than the skull. This is caused by two large folds that are called the first and second collar. Usually there is a groove at the front and back part of each of these collars but often the grooves are dim and may not completely surround the collars. Sometimes the collars may be divided above by grooves marking folds; as many as three may be present in certain species in the second collar, one or two in the first. In other species no grooves or folds are evident.

Occasionally there may be a dorsolateral ridge on each side of the body. Since this may be the result of contraction of muscles after death, it may not be a permanent character. The nature of this fold is not known at present.

The larvae, before they hatch from the eggs, develop three dendritic gills that may grow to a length of from ten to twenty millimeters. These may be retained for a few weeks then they are reabsorbed and one pair of gill opening (or in some species two) may remain until the animal transforms into its adult form, at which time the gill openings close, and the caudal fin is lost.**

The size of the larvae varies greatly. In some species the transformed larva may be as small as 130 millimeters in total length. In one Thailand species the larvae transform after they have reached a length of 240 millimeters.

The lateral-line sensory organ (neuromast organs) well known in fishes is present in larvae caecilians. Usually it can be discerned on the heads of very young specimens only. In other species it appears visible and presumably functional during the entire larvae life.

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* This bone may be fused with the nasal bones.

** One South American species remains in the water all its life and the fin, which runs the length of the body is retained during life.

FAMILY CAECILIDAE

The family Caecilidae comprises some twenty recognized genera as follows:

Amphiumophis	*Gymnopis*	*Rhinatrema*
Boulengerula	*Herpele*	*Scolecomorphus*
Cthonerpeton	*Hypogeophis*	*Schistometopum*
Caecilia	*Idiocranium*	*Siphonops*
Dermophis	*Indotyphlus*	*Typhlonectes*
Geotrypetes	*Ichthyophis*	*Uraeotyphlus*
Gegeneophis	*Praslina*	

Of these *Ichthyophis* occurs in Asia wherever caecilians are to be found. *Indotyphlus, Gegeneophis,* and *Uraeotyphlus* are endemic to India and not known elsewhere. *Herpele,* an African genus has been included in the Asian fauna on the basis of a single specimen of a species named *Herpele fulleri* by Alcock, discovered at Cachar in Assam.

In a recent preliminary study * I have recognized some 24 forms of *Ichthyophis,* and realized the necessity of recognizing others when certain data were made available on the Linnaean type of *I. glutinosus.*

Although all the 24 forms were treated as full species it is entirely possible that certain of them may more profitably be regarded as subspecies when a greater material is available for study.

At the present time I am engaged in further exploration and study of the Asiatic and other Caecilians with a hope of clarifying these relationships.

Diagnosis: The characters of the family Caecilidae may be regarded as being the same as those of the order (*vide supra*).

Genus ICHTHYOPHIS Fitzinger

Ichthyophis Fitzinger, Neue Klassification der Reptilien nach ihren natürlichen Verwandschaften. Nebst. einer Verwandschafts-tafel und einem Verzeichnisse der Reptilien-Sammlung des k.k. Zoologischen Museum's zu Wien, 1826, p. 36. Type of genus *Caecilia glutinosa* (by monotypy).

Diagnosis: Squamosals in contact with parietals. One or two series of teeth in lower jaw, splenial series sometimes absent; a tentacle near lip, closer to eye than to nostril; scales imbedded in skin, present in all known species but variable in number and position on body; number of folds, 240-416 (the primary and secondary folds cannot be easily differentiated).

Vertebrae from 102-123; orbit of eye circular, complete, or broken by tentacular groove.

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* Taylor, Univ. Kansas Sci. Bull., vol. 40, Apr. 20, 1960, pp. 37 to 120.

In Thailand only a single genus, *Ichthyophis* has been found. It is represented by at least four species.

KEY TO THE SPECIES OF ICHTHYOPHIS IN THAILAND

1. No lateral cream or yellow stripe from head to tail 2
   A cream or yellow lateral stripe on body 3
2. Larvae reaching a large size (240 mm.); tranverse folds, dorsal count, 314-325.* Body width in length 16-17.5 times. Scales absent in the anterior third of body, reduced to a single row when present. Tooth formula; maxillary-premaxillary 21-22, vomeropalatine 21-22; mandibular 20-20; splenial, 12-12 . . . . *youngorum*
   Larvae transforming at from 200-205 mm. in length. Body width in length 20 times; two rows of scales in a fold where present; transverse folds, 315-332; maxillary-premaxillary teeth, 25-25; vomeropalatine, 26-27; mandibular, 25-24; splenial, 22-22; snout acuminate . . . . *acuminatus*
3. A narrow cream or yellow stripe. In adult tail length in total length 102 times; body width in body length approximately 30.6 times; head width 9.2 mm., head length, 13 mm. Total length 306 mm.; teeth, maxillary-premaxillary, 31-32; vomeropalatine, 27-27; mandibular, 8-6; splenial 18-18. Folds vary between 306 and 322. . . . *supachaii*
   A broad cream or yellow stripe; mandibular teeth not reduced in number 4
4. Transverse folds 289-320; maxillary-premaxillary teeth in adults (300 mm. or more in length), 20-24 on each side; vomeropalatine 20 to 22 on each side; mandibular 20-21 on each side; splenial, 12-14 on each side; tail in total length about 79 times; body width in total length approximately 20 times . . . . *kohtaoensis* subsp.?
   Cream or yellow lateral stripe widening on back part of head, one short branch bordering lower jaw, the other terminating below eye. Transverse folds 362-366; maxillary-premaxillary teeth, 22-23; vomeropalatine, 22-23; mandibular, 21-20; splenial, 17-18; tail length in total length, 60-66; width in length 23 times . *kohtaoensis kohtaoensis*

Ichthyophis acuminatus Taylor

FIG. 102

Ichthyophis acuminatus Taylor, Univ. Kansas Sci. Bull., vol. 40, Apr. 20, 1960, pp. 98-101, figs. 32, 33 (type locality, Me Wang Valley, northern Chiang Mai province, Thailand).

Diagnosis: Large form (known length, 300 mm.); head acuminate; tentacle near lip, twice as close to eye as to nostril; eye visible, very small; splenial teeth in transformed specimens 15-22 in each side of jaw; tail short without orange or yellow spot at vent; scales present in posterior part of body; absent or greatly reduced in anterior part; body width in total length (in adults), about 20 times; dorsal count of transverse folds on body and tail, 315-332; on venter,

* Ventral counts average 29 lower. Tooth totals in larvae are lower.

297-320; vertebrae, 109-110; larvae transform at length of about 200 millimeters.

Description of species (from type, American Mus. Nat. Hist., No. 20875): Body thick, head acuminate, rather elongate, when seen from above rather triangular; eye visible, very small, .7 mm. in diameter; tentacle minute, conical, the opening somewhat horseshoe-shaped, near edge of mouth, but closer to eye (1.7 mm.) than to the nostril (3.8 mm.); width between eyes—measured in a straight line, 7 mm.; length of snout from eyes forward, 5.8 mm.; the snout tip extends 1 mm. beyond mouth. Width of head, 11.6 mm.; head length to first groove 14 mm.; first nuchal groove preceding first collar well defined on sides of head and under chin; second between collars distinct ventrally and laterally; third groove behind second collar scarcely indicated.

Primary and secondary folds cannot be differentiated, but a number of presumed secondary folds do not reach ventral surface so that dorsal counts of folds are greater than lateral or ventral. Folds meeting on ventral surface at an angle; in posterior part of body they pass straight across venter without an angle. Total folds counted dorsally, 315; on venter, 303. Scales absent or very small and few in anterior half of body; posteriorly there are one or two usually complete rows in each fold; longitudinal anal vent interrupts six folds; tip of tail pointed, flat ventrally and somewhat compressed laterally.

Tongue rather pointed, not free, covering large series of splenial teeth, many of which seem not to have completely penetrated gums.

Teeth: maxillary-premaxillary, 24-25 on the two sides of the upper jaw; vomeropalatine, 26-27; mandibular (dentary) 25-24; splenial, 22-22, smaller than other teeth.

Color: Somewhat violet-lavender, nearly uniform above tending to be somewhat lighter on throat and chin; no cream or yellow spot at vent; a cream area about tentacle; lips light cream.

Measurements in mm.: Total length, 295; tail, 7 (from front of vent); head width at first groove, 11.6; head length, 14; body width, 14.6; body width in length, 20 times.

Variation: Specimens long preserved may be dull slate or sometimes brownish in color. The number of teeth is smaller in the larvae and recently transformed specimens; the splenials vary from 15-15 to 22-22; the folds vary between 315-330 on dorsum; 297 to 300 in the ventral counts. The vertebrae (2 specimens) are 109-110. The larvae transform at a length of about 205 millimeters

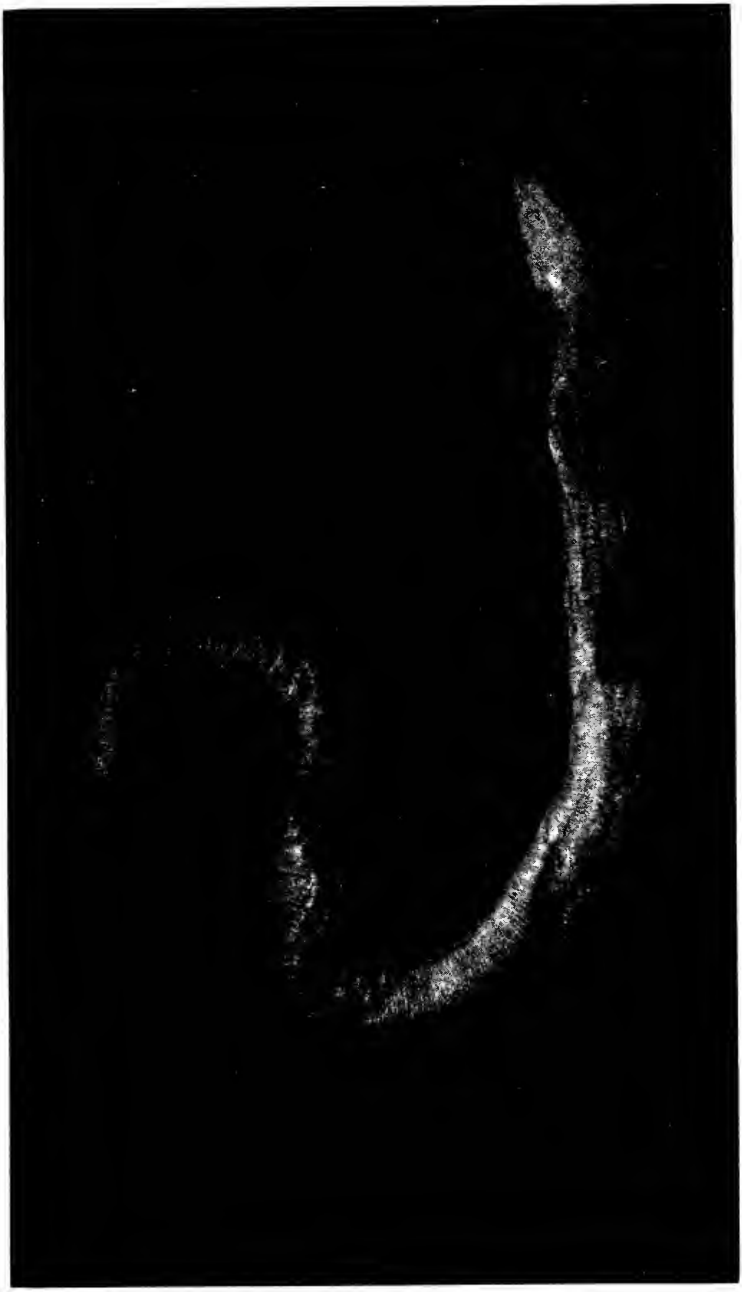

FIG. 102.—*Ichthyophis acuminatus* Taylor. Type. Me Wang Valley, Chiang Mai (province) Thailand. Actual length, 295 mm.

since of three specimens examined of this length, two were transformed and one was still larval.

Distribution: The species has been taken only in northern Thailand at "Muang Liep" and at Pa Meang in the Me Wang Valley, in the province of Chiang Mai.

It has not been taken elsewhere.

Ichthyophis supachaii Taylor

FIG. 103

Ichthyophis supachaii Taylor, Univ. Kansas Sci. Bull., vol. 40, 1960, pp. 107-110, figs. 36, 37 (type locality, 10 km. W Nakhon Si Thammarat, Nakhon Si Thammarat province, Thailand).

Diagnosis: A relatively-slender elongate species, largest known 306 mm. long; a rather narrow lateral cream stripe broken on neck, and, in the adult type, numerous white or cream spots both on dorsum and venter; body width in length, 30.6 times; tail in total length, 102 times; mandibular teeth reduced in number, splenials 18-18, relatively prominent; transverse folds, 313-332. Larvae transform at small size (before 125 mm. is reached).

Description of species (from type specimen): Head seemingly a little more flattened proportionally than in other Thai species, height 32 mm.; head width, 9.2 mm.; head length, 13 mm.; distance between eyes (6.2 mm.) greater than length of snout in front of eyes (5 mm.); tentacle rather conical, the opening lunate, closer to eye (1.8 mm.) than to nostril (3.5 mm.); tip of snout to first nuchal groove, 13 mm.; to second, 16.4, to third, 20. Total number of transverse folds, 322, of which 4-5 are on tail. Grooves separating folds fail to cross the back either dorsally or ventrally, except posteriorly; folds form a posteriorly directed angle on venter. Scales absent on anteriormost folds; when they begin to appear they are small (one-half millimeter in diameter) and do not form a complete row around body. More posteriorly, three to five complete rows of distinctly larger imbricating scales in each fold.

Teeth: Maxillary-premaxillary, 31-32; vomeropalatine, 27-27; mandibular, 8-6; splenial, 18-18; tongue oval, narrowed anteriorly, not covering (perhaps not reaching) splenial teeth.

Color in life: Above dark plumbeous-lavender; gray-slate below; a dark collar around neck preceded on side by a cream spot near angle of mouth and a second spot on side of neck. A cream stripe begins at third nuchal groove and runs along sides, continues to point in front of level of vent; numerous flecks and small spots of cream both dorsally and ventrally. Eye with an incomplete ring

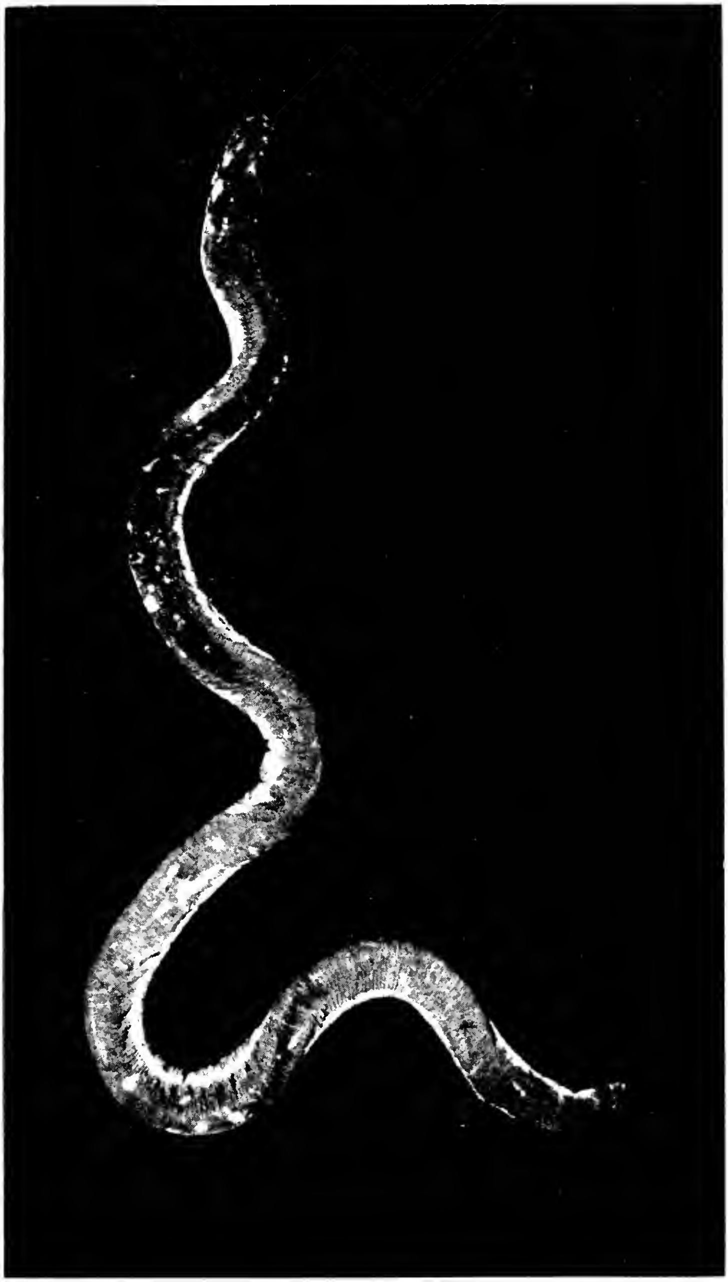

FIG. 103.—*Ichthyophis supachaii* Taylor. Type. 10 km. W Nakhon Si Thammarat (city), Thailand. Actual length, 305 mm.

of cream; cream spot at tentacle and vent; a small median cream spot on occiput.

Measurements in mm.: Total length, 306; tail length, 3; width of body, approximately, 10; width of head, 9.2; length of head, 13; width in length, 30.6 times; tail in total length, 102 times.

Variation: One of two small specimens measuring each 125 mm. taken at the same place as the type specimen presumably has transformed recently from the larval state, since there is still a trace of the caudal fin at the end of the tail. The transverse folds number 313. The teeth foreshadow the condition in the adult. All the series are greatly reduced. I count only five maxillary-premaxillary teeth on each side and seven in the vomerine series. Of the mandibular series there is a tiny median pair, then three widely spaced enlarged teeth with a single tooth in the posterior part of the jaw on one side, two on the other.

Distribution: Certain other larvae were taken near Trang, at the Khao Chong Forest Station, and in Nakhon Si Thammarat at the Tonka Harbor Tin Mine near Ronpibon. A transformed specimen was taken at a point, 18 kilometers northeast of Bhetong.

Further collections will probably show a greater range for the species.

Ichthyophis youngorum Taylor

FIGS. 104, 105

Ichthyophis youngorum Taylor, Univ. Kansas Sci. Bull., vol. 40, 1960, pp. 84-91, figs. 23-27 (type locality, Doi Suthep (Sutep) about 1000 m. elevation, near Chiang Mai, Chiang Mai Province, Thailand).

Diagnosis: A medium-sized species reaching a known length of 220 mm. for adults; 240 mm. for the largest larva; transverse body folds, 310-326 (dorsal count), six on tail; 276-304 ventral count; body width in total length, 16-17.5 times; tail length in total length approximately 40 times, head not acuminate, and anteriorly somewhat broader proportionally than *acuminatus.* Larvae transforms at a length of about 240 mm. Scales apparently absent or rare in anterior one third of body; when they first appear, they are very small, transversely widened; posteriorly there is a single row in each fold.

Description of species (from type): A somewhat cylindrical body, 210 mm. long; the width (12 mm.) contained in length 17.5 times; eye distinct; tentacle from lip, .35 mm.; from eye, 1.3 mm.; from nostril, 2.6 mm.; head width at first nuchal collar, 9 mm.; head

FIG. 104.—*Ichthyophis youngorum* Taylor. Type. No. 35946; Doi Suthep, Chiang Mai, Thailand. Elev., 3900 ft. Actual length, 210 mm., dorsal view.

length from same, 12 mm.; distance between eyes, 4.9 mm.; snout length, 4.3 mm.; tentacle cone-shaped, opening lunate.

First groove (preceding first nuchal collar) dimly visible on throat; second groove well visible on throat and sides of neck; third groove behind the second collar, dim even laterally; a median longitudinal groove on chin extending to throat; tip of snout to third groove measured laterally, 16.5 mm.

Primary and secondary folds 324 (dorsal count) generally not distinguishable one from the other, but many secondaries fail to reach the venter so the dorsal, lateral, and ventral count of folds are progressively smaller; lateral count, 304; ventral count, 280, four folds interrupted by vent; six folds on tail; a pair of dorsolateral ridges partly indicated; body folds curve slightly forward on dorsum then curve back and meet on the ventral surface at an angle, except posteriorly where they pass directly across venter; vertebrae, 107.

Scales absent in anterior part of body; present at least in latter two thirds; where they first appear they are very small, transversely widened; posteriorly they form a single overlapping row in each fold.

Teeth: Maxillary-premaxillary series, 21-22; vomeropalatine, 21-22; mandibular, 20-20; splenial, 12-12.

Color in life: General color, violet to lavender above, more lavender ventrally; grooves between folds, partly due to glands in the skin, appear light gray; chin brownish black; head dark plumbeous; a gray-white spot in front of eye more or less connected with a gray spot around tentacle; a slightly distinct light area about nostril; edges of vent are gray-flesh with two small glands apparent on each side of anterior end.

Measurements in mm.: Total length, 210; tail, 5.2; body width, 12; head length, 12; head width, 9.

Variation: Another specimen, an adult topotypic paratype is almost an exact counterpart of the type. It measures 220 mm. in length, 12.2 mm. in body width. The dorsal count of transverse folds is 328, the lateral count, 292, the ventral, 285. There are 106 vertebrae. Most other characters are very similar to the type.

The known habitat of this species is a mountain rivulet on Doi Suthep. All were taken in gravel and mud, under rocks in very shallow water. Numerous larvae were taken. The large size of the larvae suggested that they might be neotenic; however, I found no internal evidence that this might be true in specimens dissected.

FIG. 105.—*Ichthyophis youngorum* Taylor. Type. No. 35946, ventral view. Actual length, 210 mm., ventral view.

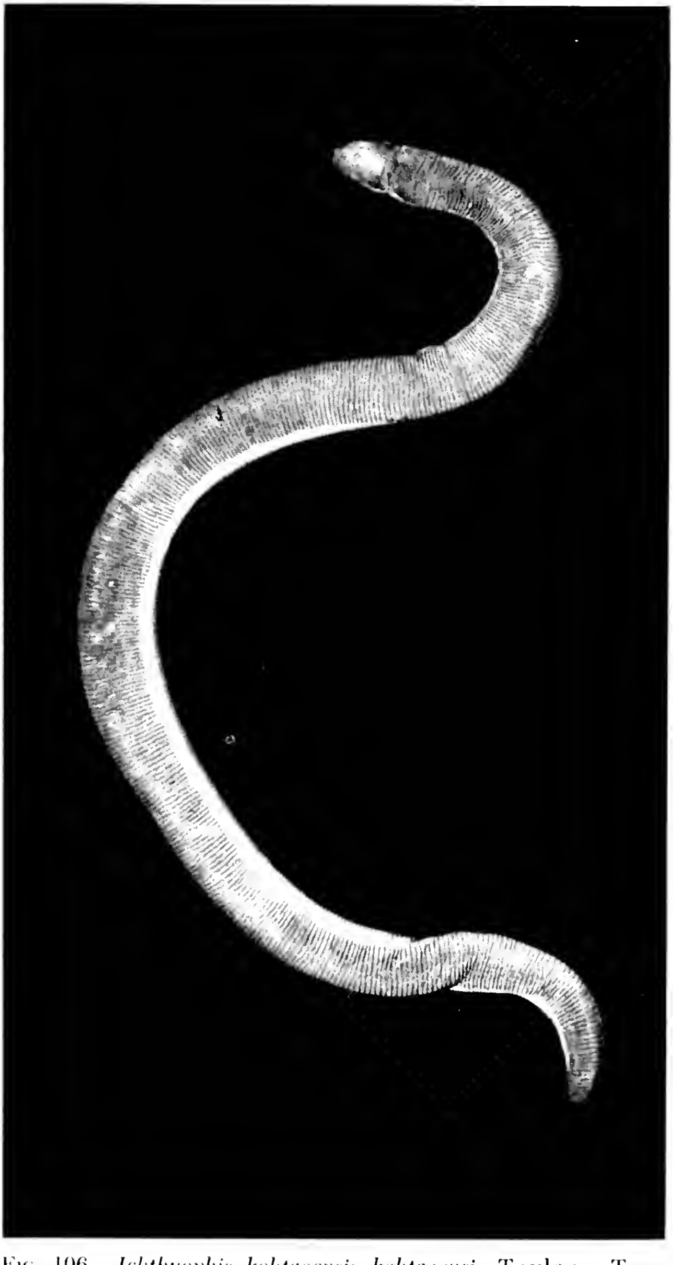

FIG. 106.—*Ichthyophis kohtaoensis kohtaoensis* Taylor. Type. Koh Tao (island), Gulf of Siam. Actual length, 280 mm.

Ichthyophis kohtaoensis kohtaoensis Taylor

FIG. 106

Ichthyophis kohtaoensis Taylor, Univ. Kansas Sci. Bull., vol. 40, 1959, pp. 110-113, fig. 38 (type locality, Koh Tao island, western part of Gulf of Siam, Thailand).

Diagnosis: A species having a wide lateral cream stripe, a well-developed series of splenial teeth, 17-18 in older specimens; mandibular teeth, 22-23; vomeropalatine teeth very small, scarcely penetrating gums. Transverse folds, 362-366; width in length about 24 times.

Description of species (from type): Head rather narrow, the region behind head (1st and 2nd collars) wider than head; head width at first groove, 8.7 mm., head length, 12.1 mm.; width between eyes approximately 5.6 mm. measured in a straight line; snout length (level of eyes to snout-tip) 4.4 mm.; tentacular opening small, curved, near edge of lip, closer to eye (1.7 mm.) than to nostril (3 mm.). Eye distinct, surrounded by a narrow cream ring. First nuchal groove distinct below and on sides; second, strong below reaching laterally above cream lines; third groove bordering second collar cannot be traced except ventrally; second collar divided by three transverse folds.

Transverse folds, 362-366, curving somewhat forward dorsally, ventrally turned back and forming a distinct angle mesially except posteriorly; grooves between folds fail to cross venter except posteriorly where folds cross venter in a straight line; vent interrupts four of six folds confined to tail.

Scales present anteriorly (probably some present on folds on collar); at first only one or two small scales can be found; gradually they increase in number and size and posteriorly at least four imbricating rows are present in each fold extending around body.

Teeth: Maxillary-premaxillary, 22-23; vomeropalatine, 22-23; mandibular, 20-21; splenial, 17-18. Vomeropalatine teeth small, scarcely penetrating the gums.

Color: Generally lavender brown, grooves slightly lighter than elsewhere; broad lateral cream stripe bifurcates at mouth angle, branch going on lower jaw soon becoming brownish, that on upper jaw extends to eye; stripe extends posteriorly to a point somewhat in advance of the vent. A cream spot at tentacle, nostril, and vent; tip of snout lighter than remainder of head. A narrow cream ring about eye.

FIG. 107.—*Ichthyophis kohtaoensis* subsp?

Measurement in mm. (Type and paratype): Snout to vent, 280, 192; tail, 4.2, 3.3; head width, 8.7, 6.9; length of head, 12.1, 9.6; width of body, 12.2, 8.2; width in length (times), 23, 23.4; tail length in total length (times), 66.6, 60.

Variation: The paratype has a pair of tiny triangular spots on the sides of the vent, a shade lighter than the spot at vent. There are 366 folds. Because the cotype is a younger specimen, the teeth are fewer as is generally typical of younger specimens.

Ichthyophis kohtaoensis subsp?

A population of *Ichthyophis* whose identification could not be completed when I pursued my study in 1960, owing to lack of data on the type species *Ichthyophis glutinosus,* is being treated elsewhere by me and is mentioned here as assurance that it has not been forgotten. This is a common form of *Ichthyophis* in Thailand, at least from Bangkok to northern and eastern Thailand.

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Some Observations on the Flow of Blood in Certain Veins in the Turtle, *Pseudemys scripta troosti*

BY

PAUL J. GARDNER and IRWIN L. BAIRD

ABSTRACT: The direction of flow of blood in several veins in the turtle, *Pseudemys scripta troosti*, has been demonstrated by a radiographic technique. Under the conditions of these experiments, it was found that: (1) with the exception of the flow from the anterior intercostal vein, the entire return from the vertebral venous system may normally pass through a renal portal system to the posterior vena cava; (2) the renal portal vein is primarily concerned with the transport of blood from the posterior part of the vertebral venous system, and a part of the blood from the posterior portion of the external iliac vein, to the renal portal system; and (3) excepting that from the tail and dorsal pelvic area, all venous blood from the posterior somatic structures of the body is returned to the liver by the ventral abdominal veins. It seems probable that the direction of flow in the renal portal vein is, under some conditions, subject to reversal and allows for part of the blood from the vertebral venous system to be drained via the ventral abdominal veins.

INTRODUCTION

Although the development and morphology of the vascular system in adult chelonians have been rather thoroughly investigated and reported in the literature, many remarks concerning the patterns of circulation of the blood in these animals appear to consist largely of speculations based solely upon anatomical observations. This is particularly true of comments concerning the flow of blood in those veins of dorsal and posterior somatic structures of the body which are directly or indirectly related to the so-called renal portal vein and the venous system of the kidney. Studies by De Martino (1841) and Jourdain (1859) treat with the structure and function of the renal portal system in reptiles, but remarks pertaining directly to chelonians are limited. More recently, De Ryke (1926) has demonstrated that there is, at least anatomically, a renal portal system in *Chrysemys marginata*, and an effective by-pass, which takes the form of a direct anastomosis between the renal portal vein and the posterior vena cava, in *Chelydra serpentina*. A survey of the literature has, however, disclosed no objective information concerning the direction of venous flow in vessels of the renal portal system in turtles, or in vessels tributary to that system. This investigation was undertaken for the purposes of determining whether or not studies of venous flow *in vivo* could successfully be made in turtles and, if so, providing experimental data concerning the direction of movement of blood in vessels tributary to the renal portal system.

MATERIALS AND METHODS

Eighteen specimens of *Pseudemys scripta troosti*, with carapace lengths of from seven to eight inches, were used in this study. Pertinent parts of the venous system of one specimen were injected with vinyl acetate and corroded with a strong solution of potassium hydroxide; seventeen specimens were used in radiographic procedures.

Hypaque Sodium [1] (3,5-diacetamide—2,4,6-triiodobenzoate, 50% in aqueous solution) was selected as the radiographic contrast medium, primarily because of its high radiopacity and, secondarily, because of the reported low incidence of side effects, such as vascular spasm, resulting from its use in other animals (Bodner, Howard and Kaplan, 1955; Root and Strittmatter, 1955). No experiments designed to test side effects of the agent in turtles were performed.

Experimental animals were anesthetized by intraperitoneal injections of 1-1.5ml of veterinary pentobarbital sodium, and necessary surgical procedures, such as partial or complete removal of the plastron and/or partial removal of the carapace, where carried out. After this initial preparation, a radiograph was made of each animal to serve as a reference and control film. Following this, the chosen vessel was cannulated and, during continuous injection of the contrast medium, radiographs were made at intervals of five seconds. The contrast medium was forced, by air pressure, from a reservoir through a length of rubber tubing to the cannula; injection pressure only slightly exceeding venous pressure was sufficient to provide a flow adequate for good visualization of vessels. Relatively high injection pressures were deliberately applied at several sites, but these did not bring about any considerable increase in the number

1. Courtesy of Winthrop-Stearns, Inc.

of vessels visualized, nor did they significantly change patterns of flow, except as noted below.

Figure 1 shows a diagrammatic representation of the larger vessels considered in this study. In all cases, except that of the posterior vena cava, vessels were cannulated and injected in the direction that blood was observed to flow in the vessels selected.

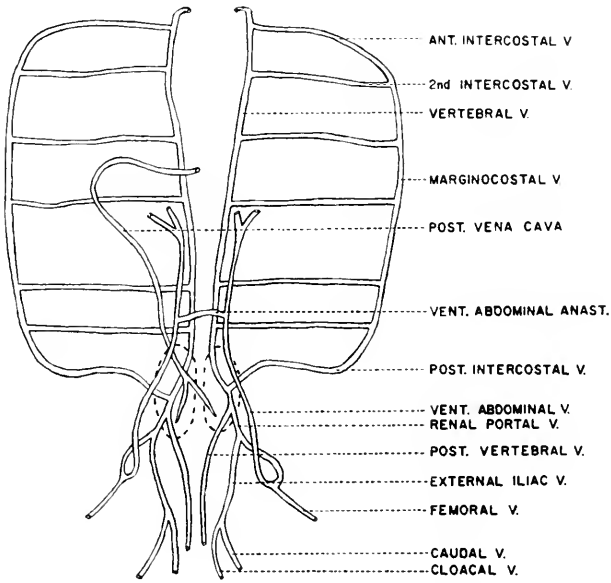


Fig. 1.—Diagrammatic representation of the major veins of dorsal and posterior somatic structures of *Pseudemys;* relationships to the kidneys and posterior vena cava are shown from the ventral aspect.

RESULTS

Femoral vein: When the femoral vein is injected just proximal to the knee, the contrast medium passes cephalad to the external iliac vein and thence to the ventral abdominal vein of the same side. The major flow in the latter is directly to the liver, but the opaque material also traverses the ventral abdominal anastomosis and courses forward in the contralateral ventral abdominal vein. Thirty seconds after injection is begun, filling of small venous channels in the liver is first noted, and after 45 seconds a distinct shadow of the heart is visualized; at the latter stage, small vessels in the liver are only moderately opaque. This pattern of flow in the ventral abdominal veins and the sequence of formation of liver and heart shadows are essentially similar in all cases cited below.

External iliac vein: Injection of the external iliac vein immediately anterior to the union of the caudal and cloacal veins results in visualization of the homolateral ventral abdominal vein in the radiograph taken five seconds after initiation. The renal portal vein may be visualized after 10-15 seconds of injection (Fig. 2) and, after 45 seconds of injection, the shadow of the kidney achieves moderate density as a result of filling of small vessels within it. The posterior vena cava is not visualized, even after injections have been continued for five minutes.

Posterior vena cava: Retrograde injection into the posterior vena cava produces immediate bilateral filling of the renal veins and venules (Fig. 3), but retrograde flow through the kidney to the renal portal vein and vertebral venous complex is not visualized. Neither lengthy periods of injection nor high injection pressures alter these facts, although the latter results in passage of the contrast medium to the pelvic viscera, and both procedures produce extreme density in the heart and vessels of the anterior regions of the lungs. In no case was it possible to achieve passage of the contrast medium beyond the levels reached by vinyl acetate injected into the same area.

Posterior vertebral vein: Ten seconds after injection of the posterior vertebral vein is begun, the renal portal vein and anterior part of the external iliac vein can be visualized, and numerous small vessels within the kidney can be seen. After 30 seconds, the renal veins and posterior part of the posterior vena cava may be identified, and the shadow of the kidney is clearly visible because of extensive filling of small vessels in that organ. Within one minute, the homolateral ventral abdominal vein is visualized, and there is some opacity in the hypogastric vein and some of its tributaries.

Intercostal veins: When contrast medium is injected medially into the third intercostal vein (Figs. 4 and 5), there is immediate filling of the anterior vertebral vein posterior to the point at which it is joined by the injected vessel; slight anterior filling is frequently noted. Within ten seconds, tortuous small vessels are visible within the kidney and, at the end of twenty seconds, the renal portal vein and posterior part of the posterior vena cava, filling by way of the renal veins, are visible (Fig. 4). After 30 seconds of injection (Fig. 5) the shadow of the kidney is extremely dense, the posterior vena cava may be traced to its termination, and the homolateral renal portal, external iliac (anterior part) and ventral abdominal veins are clearly visible. Injections administered with considerable pressure show the same sequence of events, but the amount of contrast medium traversing the renal portal vein and reaching the liver is, proportionally, much greater. Injections made at other intercostal sites result in essentially similar patterns of flow, except that contrast medium introduced into the anterior intercostal vein (anterior part of the marginocostal vein) passes anteriorly into the jugular vein and thence to the heart.

DISCUSSION

It has been suggested by various investigators (Jourdain, 1859; Stromsten, 1905; and others) that, in turtles, venous return from posterior somatic areas of the body takes place along two routes; (1) via the renal portal vein to the posterior vena cava, either by way of direct communication or a portal system of some sort within the kidney; and (2) via the ventral abdominal veins to a system of sinusoids within the liver and thence to the heart. Results of these experiments indicate that an extremely small part of the venous blood from the posterior region of the body is returned by way of a renal portal route; that part is carried only by the posterior tributaries of the external iliac vein and some of the veins of the vertebral system draining the posterior part of the carapace. Under the conditions of these experiments, only a small part of the flow from the external iliac vein enters the renal portal system; conversely, most of the flow from the vertebral vessels normally traverses the portal system.

Findings resulting from the injection of intercostal veins and vertebral system indicate that, except for blood carried by the anterior intercostal vein, the entire venous return from the carapace passes via a renal portal system to the posterior vena cava. Visualization, first of a series of small veins undergoing arborization within the kidney, followed by considerable diffuse density in that organ, complements the findings of DeRyke (1926) in that there is no evidence, in this species, of direct communication between veins leading to the kidney and the posterior vena cava. The rate of filling of the posterior vena cava suggests that there may be some communications of a size larger than capillaries, but certainly there can be nothing resembling the direct inosculation described in *Chelydra* by that author. This is further supported by the failure of radiopaque material and vinyl acetate to appear in any major ves-

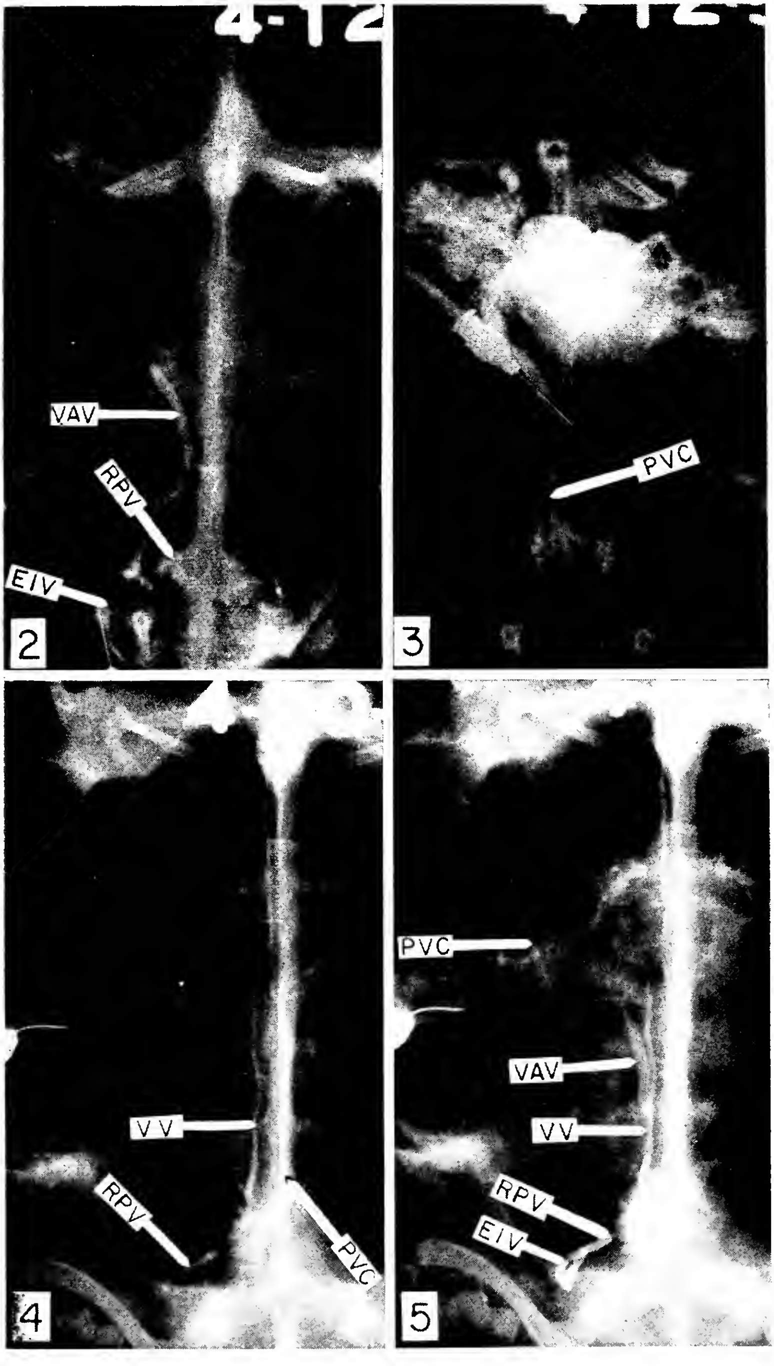
PHLEBOGRAMS OF CERTAIN VEINS IN *Pseudemys scripta troosti*

FIG. 2.—Radiograph taken 15 seconds after beginning of injection of the external iliac vein (EIV). Note opacity in renal portal vein (RPV) and contralateral ventral abdominal vein (VAV).

FIG. 3.—Retrograde injection of the posterior vena cava (PVC). Note differences in venous shadows within the kidney from those shown in following figures.

FIG. 4.—Radiograph taken twenty seconds after beginning of injection of the third intercostal vein. Note vessels within the kidney and shadows of the posterior vena cava (PVC) and renal portal vein (RPV). VV = vertebral vein.

FIG. 5.—Same specimen after 30 seconds of injection. Note completion of shadow of posterior vena cava and filling of external iliac (EIV) and ventral abdominal (VAV) veins.


4-12
VAV
RPV
EIV
2
PVC
3
VV
RPV
PVC
4
PVC
VAV
VV
RPV
EIV
5

sels associated with the kidney, except the renal vein and its tributaries, when these substances are injected into the posterior vena cava in a retrograde direction.

These experiments seem to support the suggestions of Jourdain (1859) and Stromsten (1905) concerning variability in the direction of flow in the renal portal vein. It would appear that the renal portal vein may be primarily concerned with the transport of venous blood from the posterior vertebral veins and posterior portion of the external iliac vein and its tributaries to a portal system in the kidney. When a contrast medium is introduced slowly into the vertebral venous system, relatively little of the agent passes to the ventral abdominal veins; more rapid flow of the material into the system brings little change in the renal and caval shadows but noticeably increases the density of the shadow of the ventral abdominal veins. This suggests that a constant rate of flow through the portal system is maintained. It is conceivable that, under certain conditions of temperature and bodily activity, a larger venous flow than could successfully traverse the kidney might well develop in the vertebral venous system and bring about shunting of excess blood through the renal portal vein to the ventral abdominal vein. This would mean that, under these conditions, all external iliac venous return would, of necessity, be via the abdominal veins.

There would appear to be some doubt concerning the termination of the ventral abdominal vessels wholly in sinusoids in the liver. The negligible delay between the time of first appearance of the radiopaque medium in the liver and the time of its appearance in the heart suggests a series of small direct communications between branches of the ventral abdominal veins and the hepatic veins. Such communications would certainly not be numerous enough to accommodate the entire flow of the ventral abdominals. This interpretation finds support in the fact that prolonged injection of radiopaque material results in continuously increasing density of the liver shadow despite the appearance of heart and pulmonary arterial shadows early in the course of such injection.

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A Comparative Limnological Survey of Leavenworth County and Nemaha County State Lakes, Kansas

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This paper reports the first extensive study of the limnological characteristics of lakes in Kansas. Stene (1946) reports the location, date of impoundment, area, depth and other data of 21 state lakes. Nineteen of the state lakes were surveyed in 1947 and 1948 (Andrews and Bruekelman, 1952). In the present study, Nemaha County State Lake was visited 22 times and Leavenworth County State Lake, 23 times between November 7, 1957, and May 29, 1958.

The study was supported by a grant from The University of Kansas research fund. Mr. Jerry C. Tash provided technical assistance in collecting samples and analyzing water.

DESCRIPTION OF THE LAKES

Nemaha County State Lake (Fig. 1), located near Seneca, was impounded in 1938. It has a surface area of about 144 hectares. Although the maximum depth was about 10 meters in 1947 (Andrews and Bruekelman, 1952), it was about 3.8 meters during this study. The lake drains approximately 8,498 hectares. The lake was consistently turbid (Fig. 9), probably because of wind action on the exposed, shallow water and of sediments carried into the lake after rain.

Leavenworth County State Lake (Fig. 2), located near Tonganoxie, was impounded in 1931. The dam was placed below the confluence of two streams, which now form the two arms of the lake. It was drained in 1947 and refilled in 1948. It has a surface area of about 70.8 hectares. The maximum depth was 14 meters, somewhat less than the 17 meters reported in 1948 (Andrews and Bruekelman, 1952). The lake drains about 1,011 hectares. It is one of the few state lakes of Kansas with a wooded shoreline.

METHODS

During each visit to each lake, water samples were taken at various depths with a Kemmerer bottle, temperature was determined with a Whitney thermometer at meter intervals from the top of the bottom of the lake, light penetration was measured with a Secchi disc, and plankton samples were collected at meter intervals from top to the lowest feasible depth with an uncalibrated Clarke-Bumpus sampler with a No. 25 mesh net.

At Nemaha County State Lake samples of water and plankton were collected at depths of one, two and three meters. At Leavenworth County State Lake, nine samples distributed between one and 11 meters were collected for the determination of oxygen and carbon dioxide. Plankton was sampled at meter intervals through the first nine meters of water. Four samples of water for further chemical analysis were collected at various depths between one and 13 meters.

Dissolved oxygen was determined immediately after the collection of the samples. All other chemical analyses were made at the Laboratory of Aquatic Biology of The University of Kansas. The water was preserved by the addition of 5-10 cc. of chloroform.

The hydrogen ion concentration was measured with the Hellige colorimetric comparator.

Free carbon dioxide was determined according to procedures in Welch (1948, p. 213).

Because all other analyses followed standard procedures (Standard Methods, 1955), only a designation of the chosen method will be given.

Dissolved oxygen was determined by means of the Rideal-Stewart modification of the Winkler method.

Alkalinity was measured titrimetrically with phenolphthalein and methyl orange indicators and 0.02N sulfuric acid.

Sulfate was determined titrimetrically with tetra-hydroxyquinone indicator and standard barium chloride solution.

The Mohr method was used to measure chloride.

Phosphate, ammonia, nitrate and nitrite were measured colorimetrically with a Fisher Colorimeter. The diazotization method was used for nitrite; the phenoldisulfonic acid method, for nitrate; direct nesslerization, for ammonia and aminonapthol-sulfonic acid, for phosphate.

Plankton was killed with 95% alcohol, which was diluted to 70% for preservation. In the laboratory each sample of plankton was strained through a No. 16 mesh net which separated the plankton into a zooplanktonic segment with some scattered algae and an algal segment with some rotifers and nauplii. Half of each sample of zooplankton was saved for studies of population cycles of individual species and the other half was filtered onto oven-dried filter paper and dried at 60° C. for 24 hours. The weight of the filter paper with the plankton minus the weight of the filter paper was doubled and used as the dry weight of the zooplankton. The samples of phytoplankton were treated in like manner except that all of each sample was weighed following counts of individual species. In order to calculate standing crop, one revolution of the Clarke-Bumpus sampler was assumed to equal 4 liters of water.

PHYSICAL AND CHEMICAL CHARACTERISTICS

Leavenworth County State Lake was the more transparent of the two lakes (Fig. 9), except during autumnal overturn. The marked turbidity of Leavenworth County State Lake in October and November probably resulted from the circulation of materials that collected in the thermocline and that formed in the hypolimnion during summer stagnation. During the summer, the water in the thermocline was silty where fine materials had settled following summer storms. The influence of summer storms on transparency is illustrated by the change in Secchi disc readings between June 21 and June 25, 1958. On June 21, the Secchi disc reading was 2.9 M. Heavy rains occurred during this period and by June 25, the Secchi disc reading was 0.9 M. Fair weather followed and the lake cleared so that by July 5, the Secchi disc reading was 4.8 M. Rain and planktonic growth subsequent to this time resulted in Secchi disc values of 1.0-1.8 M. during the remainder of summer stagnation.

Nemaha County State Lake was persistently turbid with maximum transparency of 1.0 M. during a calm period in early May. This broad, shallow lake was usually windswept and wave action was marked. Strong currents frequently made operation of the Clarke-Bumpus sampler difficult. The turbulence resulting from such currents stirred up the sediments that caused the turbidity.

Maximal temperatures occurred in each lake in August (Tables 1, 2). In both lakes the temperature decreased between the two periods of sampling in June as a result of the rains mentioned above.

There is little evidence of thermal stratification in Nemaha County State Lake (Table 2, Fig. 3). Only on June 19 was there a marked departure from an isothermal condition and the difference between one and three meters was only 2.3 degrees C. However, even slight differences in temperature permitted some chemical stratification during periods of calm. But, because such periods of calm were of short duration, Nemaha County State Lake is considered an unstratified or third-class lake (Hutchinson, 1957).

Leavenworth County State Lake was isothermal in March (Fig. 4). The surface waters warmed rapidly during April. The thermocline was evident first in early May. During May and June the thermocline developed and was stabilized by early July. The thermocline was lowered about two meters during the heavy rains of late June. The lake level rose as a result of the increased inflow. Therefore, the level of the lake was lowered by opening the drainage valve at the bottom of the spillway. The effect of draining water from the lake is readily apparent by comparing the temperature values for June 21 and June 25 (Table 1). Although the epilimnion was cooled by means of the inflowing water, the hypolimnion was warmed as the colder water drained from the lake. Water that was at 10 M. on June 21 was at 12 M. on June 25. The lake was also a meter deeper, a condition that persisted through July. Rains in August again raised the water level, but there was less effect on the temperature curve.

Both lakes began cooling in the latter half of August. The thermocline in Leavenworth County State Lake gradually deepened and the overturn began in November (Fig. 4). Leavenworth County State Lake is a dimictic temperate lake of the second order (Whipple, 1898) or a second-class lake (Hutchinson, 1957).

In natural waters, carbonate, mainly HCO_3, normally exceeds sulfate and the latter exceeds chloride. This condition prevailed in both lakes except after storms in July and August when sulfate was brought into the lakes with the silt from the drainage basin and became the most abundant anion (Tables 3, 5).

Chloride is generally low in lakes not draining saline sediments. In 474 lakes of northeastern Wisconsin, the range of concentration was 0.1-4.5 mg./l. (Juday, Birge, and Meloche, 1938.) In the two Kansas lakes the concentrations were generally higher (Tables 3, 5) and were usually higher in Nemaha County State Lake than in Leavenworth County State Lake. The concentration of chloride tended to rise following rains. Such a relationship is particularly evident in Nemaha County State Lake in July and August and in Leavenworth County State Lake at seven meters on July 18. There is little indication of vertical stratification of chloride other than a slight increase in the thermocline during summer stratification. Such a stratification appears to be related to the accumulation of fine silt in the same region. There is no obvious seasonal variation that is consistent in both lakes. A marked decrease of chloride occurred in Nemaha County State Lake in September and October. A decrease of chloride also followed the periods of marked increase associated with summer storms. Probably the variations in content of chloride are more closely related to meteorological conditions than to intrinsic limnological factors.

The concentrations of sulfate were generally higher in both lakes than typical values for a series of lakes selected by Hutchinson (1957, p. 765). Sulfate was more concentrated in Nemaha County State Lake than in Leavenworth County State Lake most of the year. The major exception occurred in November when Leavenworth County State Lake was circulating. Sulfate was associated in both lakes with the silt brought into the lakes following severe rains. This relationship is evidenced by the high concentration (344 mg./l.) of sulfate at seven meters in Leavenworth County State Lake on July 18, 1958, and by the high values (372-520 mg./l.) in Nemaha County State Lake in July and August, 1958 (Tables 3, 5).

Evidence for vertical stratification of sulfate in Leavenworth County State Lake is inconclusive. There was some increase in sulfate in the hypolimnion in late July and early August. Vertical stratification was obscured by the effect of rain water bringing in large amounts of sulfate that temporarily accumulated in the thermocline. A slight decrease in sulfate coincided with an absence of oxygen in the hypolimnion on August 28 (Tables 1, 3). Mortimer (1941, 1942) demonstrated that sulfate decreased if anaerobic conditions persisted for sufficient time. However, similar decreases of sulfate with depth occurred when oxygen was abundant and the dynamics of vertical distribution must remain unknown.

Phosphate is usually in low concentrations in lakes of temperate regions. Over much of the year phosphate was not detected in either lake. However, both lakes had unusually high concentrations in late March and April, 1958, and in July and August, 1958. These high values coincided with drainage from agricultural lands during the heavy rains mentioned previously. There can be little doubt that the phosphate markedly influenced the phytoplankton blooms of the two lakes (Fig. 8), but the direct relationship is impossible to demonstrate because of the varied responses to phosphate by different species of algae and because of the lag effect between the introduction of phosphate and the growth of algal populations. In addition, such factors as available nitrogen and temperature interact with phosphate in producing algal populations. However, in this connection, it is interesting to note that algal populations were much lower in Nemaha County State Lake in the spring of 1959 when phosphate was undetectable than in the spring of 1958 when marked concentrations of phosphate were present.

The concentration of ammonia varied from 0-1.3 mg./1. in Nemaha County State Lake and from 0-1.92 mg./1. in Leavenworth County State Lake. In both lakes the maxima were in the summer. In Leavenworth County State Lake the highest concentrations of ammonia were found in the hypolimnion during summer stagnation. Similarly, the highest concentration of ammonia in Nemaha County State Lake was at 3 M. during a period of relative calm in June. On the same date, there was a temperature difference of 1.4° C. between one and three meters. Examination of Tables 2 and 5 reveals that other substances were also more concentrated at three meters. The content of ammonia of these lakes is higher than that typically found, even if only trophogenic zones are considered (Hutchinson, 1957:853).

Nitrite was present in every sample from Nemaha County State Lake (Table 5) and in all but four samples from Leavenworth County State Lake (Table 4). In the latter lake, nitrite was absent at one meter on July 18 and in the upper 10 meters on August 28. The concentrations varied from 0.01-1.38 mg./1. in Nemaha County State Lake and from 0-0.33 mg./1. in Leavenworth County State Lake. Maximal values occurred in both lakes during the summer.

Nitrate was present in every sample from both lakes. The concentration ranged from 0.1-4.3 mg./1. in Leavenworth County State Lake and from 1.4-12.0 mg./1. in Nemaha County State Lake. Although there was considerable fluctuation of nitrate in both lakes, maximal concentrations were in early spring in Leavenworth County State Lake and in early spring, early summer and autumn in Nemaha County State Lake. The highest single determination in Nemaha County State Lake occurred at three meters on June 27 when ammonia was also at its highest. Vertical distribution of nitrate was marked only in Leavenworth County State Lake during summer stagnation. In general, there was an accumulation of nitrate despite the decrease of oxygen.

The three forms of nitrogen are dynamically related in the metabolism of lakes. Nitrates occur as intermediates in oxidation or reduction processes. Both nitrate and ammonia are utilized by algae and bacteria. Generally, nitrate declines in concentration in the summer in both the trophogenic zone and the hypolimnion; ammonia tends to increase in the hypolimnion. Only on September 12 at 12 meters did the concentration of ammonia exceed that of nitrate in Leavenworth County State Lake. Nitrate always exceeded ammonia in Nemaha County State Lake. Nitrite never exceeded nitrate, but exceeded ammonia in about one-third of the determinations from Leavenworth County State Lake and in about one-half the determinations from Nemaha County State Lake. From the data it is difficult to determine whether ammonia was being converted to nitrate or whether the reverse reaction predominated. Presumably, in the hypolimnion, nitrate was converted to ammonia (Table 4, July). The problem is further complicated by the influence of rain water and the lowering of the lake by draining water from the hypolimnion.

The pH of both lakes occurred in the usual range for open lakes. In Leavenworth County State Lake, pH varied from 7.1-8.6 (Table 4); the higher values were more common in the spring. The range in Nemaha County State Lake was from 7.0-8.5 (Table 5); the higher values also occurred in the spring. Both lakes evidenced a slight decrease in pH in the deeper waters.

Throughout most of the year, the concentrations of free carbon dioxide of both lakes were higher than concentrations at equilibrium with the atmosphere (Tables 1, 2). The highest seasonal concentrations in Nemaha County State Lake occurred from August through November with peak levels in September. However, the concentrations of carbon dioxide in May, 1959, were the highest of any measurement. Thus one assumes that the levels of carbon dioxide in this unstratified lake are not related to the seasonal progression of events but to other ecological events. Carbon dioxide is formed during respiration and utilized during photosyntesis. Thus the concentration of carbon dioxide is related, in part, to the amount and kind of biological activity. High carbon dioxide occurred on September 2 (Table 2) when the standing crop of phytoplankton was low (Fig. 9, Table 6). During the remainder of September and through October 17, the standing crop of phytoplankton increased and the concentration of carbon dioxide decreased. However, the absolute level remained high as the standing crop of zooplankton increased. No doubt bacterial activity was high as the organic content of the water increased. During the latter part of October and November the level of carbon dioxide rose as the standing crop of phytoplankton decreased. Standing crop is not a satisfactory index of the relationship of the level of carbon dioxide to biological activity as standing crop does not measure the activity of the biomass. However, in the example chosen, the increase and subsequent decrease of the standing crop of phytoplankton are probably general indications of activity. In Leavenworth County State Lake a seasonal progression is evident (Table 1). Concentrations remained relatively low in the epilimnion and usually were lower than the concentrations in Nemaha County State Lake. However, the concentration increased in the hypolimnion during summer stagnation. With the onset of circulation in November the concentration rose as carbon dioxide from the hypolimnion became distributed throughout the water-mass. Bacterial activity was likely high throughout the water-mass as large amounts of organic material became available from the dying plants and animals and the standing crop of net plankton fell. The concentration of carbon dioxide decreased as circulation continued and the excess above equilibrium diffused into the atmosphere.

The situation of September 27 demonstrates the difficulty of correlating the concentration of carbon dioxide with biological activity based on standing crop. The concentration of carbon dioxide was relatively low as was the standing crop of phytoplankton (Table 6). But productivity must have been high as evidenced by the high concentrations of oxygen (Table 1), especially at five meters, and by the great increase in standing crop that developed by October 8.

The vertical distribution of carbon dioxide in Nemaha County State Lake showed no seasonal pattern (Table 2). When temporary stagnation occurred, the accumulation of carbon dioxide in the deeper water was considerable (Fig. 3, August 13). The vertical distribution of carbon dioxide was the inverse of the oxygen distribution except in April, when both decreased between the first and third meters.

A seasonal pattern of vertical distribution was evident in Leavenworth County State Lake (Fig. 5). The curve of vertical distribution was essentially orthograde in the spring. During summer stagnation, carbon dioxide accumulated in the hypolimnion, reaching maximal concentrations in August. As the autumnal overturn progressed, vertical stratification gradually disappeared. The vertical distribution on November 7, when the lake was essentially isothermal, was erratic, but was the inverse of the vertical distribution of oxygen. The curve of the distribution of carbon dioxide parallels closely the vertical distribution of zooplankton on that date (Fig. 8). Thus it seems likely that the respiration of the zooplankton contributed significantly to the concentration of carbon dioxide at various depths.

Because only methyl orange alkalinity was present in each lake, alkalinity resulted from the bicarbonate ion. Both lakes had vernal maxima and summer minima (Tables 3, 5). Bicarbonate was higher in Nemaha County State Lake than in Leavenworth County State Lake except in late July and early August. Bicarbonate increased in the hypolimnion of Leavenworth County State Lake during summer stagnation.

The water of Leavenworth County State Lake was nearly saturated throughout with oxygen at the time of vernal circulation (Tables 1, 6), but that of Nemaha County State Lake was not. However, analyses were not made in February or early March in either lake when oxygen-saturation would be expected. Both lakes were supersaturated, at least in part, from May through July. Neither lake was saturated during autumnal circulation, although Nemaha County State Lake was nearly so in November, 1958.

Saturation in Nemaha County State Lake ranged from 50.0-153.8% (Table 6). In general, there was little evidence of vertical distribution (Tables 2, 6; Fig. 3). Thus the distribution of oxygen was orthograde (Hutchinson, 1957:603).

Saturation of oxygen in Leavenworth County State Lake ranged from 0-171.1% (Tables 1, 6). Marked vertical distribution developed during the summer (Fig. 6). In March, the oxygen curve was orthograde. By May 20, there was a decrease in oxygen in the hypolimnion and the curve was less orthograde. The curve continued to change during the course of summer stagnation until a clinograde curve was established. As the thermocline was pushed deeper during the break-up of summer stagnation, the oxygen curve paralleled the temperature curve. The clinograde curve was replaced by an orthograde curve by November.

It is well-established that the depletion of oxygen from the hypolimnion results from oxidative processes occurring at the mud surface and on organic detritus in the water. The depletion of oxygen is typically paralleled by an increase of various ions. Leavenworth

County State Lake seems typical in this respect (Fig. 7). When the oxygen curve was clinograde, the curves of ammonia, carbon dioxide, nitrite, phosphate and alkalinity were reverse clinograde.

VERTICAL DISTRIBUTION OF PLANKTON

In stratified lakes there is typically an upward movement of zooplankton during summer stagnation as a result of the depletion of oxygen in the hypolimnion. The phytoplankton is limited to the region of light penetration, usually the epilimnion but also frequently including the thermocline.

There was a marked decrease in phytoplankton below 7 meters in July, August and September in Leavenworth County State Lake (Table 7, Fig. 8). Although the phytoplankton was distributed throughout the epilimnion, there was some concentration at 3 meters during most of this period. Concentrations also occurred at 6 meters on August 28 and at 7 meters on October 8; both of these were just above the thermocline and coincided with concentrations of zooplankton. From the latter part of October through the following March, the phytoplankton was fairly evenly distributed through the 9 meters. As the lake circulated during this period, the algae were probably distributed by the currents.

There is no obvious seasonal pattern to the vertical distribution of zooplankton. There is some correlation with light penetration. The population was concentrated at greater depths on June 21 than on June 25, when the Secchi disc reading was much lower (Figs. 8, 9). There was a general movement upwards during July that coincides with a reduction of light penetration. However, there were other days when the light penetration was low, but the concentration of zooplankton was fairly deep; *e. g.*, April 8. There was a marked reduction of zooplankton below 6 meters during July, August, and September when oxygen declined through the thermocline and hypolimnion (Table 1, Fig. 6). During autumnal overturn, the zooplankton was distributed throughout the 9 meters, with some tendency for concentration near the surface. The concentration near the surface was greater on March 28, 1959, when the Secchi disc reading was low than on March 22, 1958, when the Secchi disc reading was about twice (Figs. 8, 9). There are many instances when the patterns of vertical distribution of phytoplankton and zooplankton were similar (Fig. 8). Presumably some of these instances may have resulted when zooplankton concentrated in areas of food. Many factors determine the vertical distribution of zooplankters. In Leavenworth County State Lake, these factors interact with various species of zooplankton in a complex way (Tash and Armitage, 1960).

No particular pattern of vertical distribution would be expected in the shallow, wind-swept, unstratified Nemaha County State Lake. However, there are differences in the concentration of zooplankton at various depths (Fig. 8). From May through early July, zooplankton was more concentrated at 1 meter. During August and September, zooplankton was evenly distributed throughout. But during October and November, there was a marked concentration at 3 meters. There is no apparent correlation with light penetration (Figs. 8, 9). There was close agreement between the distribution of phytoplankton and zooplankton on eight of the 21 sampling trips and some agreement on other dates (Table 8). However, such agreement does not necessarily indicate that the zooplankton chose areas rich in phytoplankton. Indeed, such agreement in distribution is to be expected where the action of water-currents is a major ecological factor.

ANNUAL CYCLE OF STANDING CROP OF PLANKTON

The annual cycle of standing crop of total plankton of lakes of the second order typically has two maxima, a vernal maximum in April or May or into early June and an autumnal maximum in late September or early October (Welch, 1952). The vernal maximum Commonly exceeds the autumnal. The summer minimum generally occurs in August. Net plankton may not show such an annual cycle as the vernal maximum may be slight, but the autumnal maximum is usually well developed. Both Leavenworth County State Lake and Nemaha County State Lake had cycles similar to that expected for net plankton (Fig. 9, Tables 7, 8).

Phytoplankton evidenced a slight peak in Leavenworth County State Lake in April, a slightly higher peak in June, followed by a series of peaks in late July, early September and early October with minima in late August and late September. Subsequent to the maximum of early October there was a gradual decline in standing crop to a minimum in December. The standing crop of zooplankton had essentially the same cycle except that the midsummer peak came in early August instead of late July.

In Nemaha County State Lake, there was a slight peak of phytoplankton in early April followed by a steady decline to a minimum in May. This minimum was followed by a maximum in late June, a late July and August minimum and a maximum in September and October. Another minimum occurred in December. The maxima and minima of zooplankton agreed well with those of the phytoplankton except that there was a zooplanktonic minimum in October that coincided with the largest standing crop of phytoplankton measured in either lake. A doubling of the zooplankton occurred in the subsequent 10 days as the standing crop of phytoplankton decreased by about 40%. Also, the slight peak of zooplankton came later in April than the peak of phytoplankton. In both lakes, then, the major peak was autumnal. Only in Nemaha County State Lake did a vernal maximum occur and only in Leavenworth County State Lake did a summer maximum occur. The annual cycle of net plankton in a Colorado reservoir had autumnal and vernal peaks; the former was the major peak (Reed and Olive, 1956).

The standing crop of phytoplankton exceeded the standing crop of zooplankton in 11 of the 23 sampling periods in Leavenworth County State Lake (Table 7) and in 3 of the 21 sampling periods in Nemaha County State Lake (Table 8). One cannot readily interpret the significance of the phenomenon of the standing crop of consumers exceeding the standing crop of producers. Because there was no measurement of production, there is no way to assess the dynamics of energy flow in the ecosystem. A higher standing crop of zooplankton could be associated with a high rate of phytoplankton production and consumption by zooplankton. For example, such a condition probably existed in Leavenworth County State Lake in late July and August when the standing crop of zooplankton reached a maximum while the standing crop of phytoplankton decreased. When the standing crop and production of phytoplankton are low, the standing crop of zooplankton decreases. Such a situation could explain the decline in the standing crop of both phytoplankton and zooplankton in late April and early May in Leavenworth County State Lake. When phytoplankton production exceeds zooplankton production, the standing crop of the former is higher, although both might increase or the phytoplankton might increase while the zooplankton decreased. The first possibility is observed in Leavenworth County State Lake in September and the second possibility in Nemaha County State Lake in October. There are various combinations of rates of production of phytoplankton and zooplankton that could account for the observed curves and speculation could be almost endless. One should emphasize that the species of algae and animals composing the plankton will also markedly influence the changes in standing crop. In conclusion, the dynamics of production seem sufficient to account for the variations of standing crop of phytoplankton and zooplankton described in Fig. 9.

A correlation of standing crop of plankton with some physical or chemical factor is desirable, but usually impossible. Phosphate seems to be one of the chief limiting factors in eutrophic lakes. It is almost impossible to correlate phosphate with standing crop because of the ability of algae to accumulate phosphate which then effects algal growth at some later time. Although there is no evident correlation between chemical nutrients and the annual cycle of net plankton, there is a general correlation between nutrient level and the annual production of plankton.

Annual Production of Plankton

The production of plankton can be estimated by multiplying the average standing crop by the rate of turnover for plankton. The average standing crop, dry weight, of net plankton for Leavenworth County State Lake was 55.4 kg./hectare, of which 28.2 kg. was phytoplankton and 27.2 kg., zooplankton. The average standing crop, dry weight, of net plankton for Nemaha County State Lake was 48.8 kg./hectare, of which 25.7 kg. was phytoplankton and 23.1 kg., zooplankton. These values are probably a little high because samples were not collected during January and February when the standing crop is low. If a rate of turnover for plankton of once in two weeks is assumed (Juday, 1940), then 26 times the average standing crop gives the annual production. For Leavenworth County State Lake, the annual production, dry weight, of net plankton per hectare was 1440 kg., of which 734 kg. was phytoplankton and 706 kg. was zooplankton. For Nemaha County State Lake, the annual production, dry weight, of net plankton per hectare was 1268 kg., of which 668 kg. was phytoplankton and 600 kg. was zooplankton.

Reed and Olive (1956) report an annual production, dry weight, of 182 kg./hectare (data converted from lbs./acre) of net plankton in a Colorado reservoir with a widely fluctuating water level. The authors considered the Colorado reservoir to be mesotrophic.

Juday, working in Wisconsin, measured total plankton, so that his data are not directly comparable with the data for net plankton. However, the data for zooplankton are comparable and should serve as a means of evaluating the productivities. For Lake Mendota, Juday (1940) calculated an annual zooplankton production (dry weight) of 390 kg./hectare. Thus both Kansas lakes appear to be more productive of zooplankton than the eutrophic Lake Mendota.

Juday (1942) reported on the summer standing crop of four Wisconsin lakes, two rich in nutrients and two poor in nutrients. The average standing crop of zooplankton (wet weight) for July and August varied from 41-74 kg./hectare in the oligotrophic lakes and 120-177 kg./hectare in the eutrophic lakes. The average standing crop of zooplankton (dry weight) for July and August was 31.6 kg./hectare in Leavenworth County State Lake and 19.9 kg./hectare in Nemaha County State Lake. If these values for dry weight are converted to wet weight by multiplying by 10 (Birge, 1922), then the standing crop was 316 kg./hectare and 199 kg./hectare, respectively. Thus, the Kansas lakes had higher standing crops and seem by this comparison to have higher productivities.

The total annual production of net plankton for each lake can be calculated by multiplying the production per hectare times the area of the lake. About 110,800 kg. dry weight of net plankton was the total production for Leavenworth County State Lake and about 182,592 kg., dry weight, for Nemaha County State Lake.

DISCUSSION

Nemaha County State Lake had a higher standing crop per unit volume on 12 of 16 collecting trips during 1958 and Leavenworth County State Lake had a higher standing crop per unit area on 11 trips (Tables 7, 8). Nemaha County State Lake had an annual average standing crop, dry weight, of 1626 mg./M.^{3} and Leavenworth County State Lake had an annual standing crop, dry weight, of 657 mg./M.^{3}. Thus Nemaha County State Lake had a greater productivity per unit volume and Leavenworth County State Lake had a great productivity per unit area. Comparison of biomasses of many lakes have led to the consideration of unit volume as the better index of productivity (Ruttner, 1953:146). However, Rawson (1953) considers standing crop per unit area to be of more value because of the inverse relation of standing crop of net plankton to mean depth. Rawson believed samples collected in water much deeper or shallower than the mean depth of the lake might be misleading. These objections are not pertinent here where samples were collected throughout the trophogenic zone.

Differences between lakes in standing crop of plankton may be related to chemical nutrients, light, temperature or some other factor. In Pymatuning Reservoir, the differences in standing crop of Cladocera were related to pH, bicarbonate and carbonate, these serving as an index to food (Borecky, 1956). As previously pointed out, Nemaha County State Lake generally had higher concentrations of bicarbonate and phosphate. Presumably the higher amounts of these substances resulted in a higher rate of photosynthesis and the larger standing crops/vol. The turbulence of the shallower lake constantly mixed nutrients and organisms so that all the algae equally shared available light and nutrients. In the deeper lake, the lower level of nutrients per unit volume was compensated for by the greater depth of the trophogenic zone with the result that the standing crop was greater per unit area.

The chief differences between the lakes, then, seems to be in the richer supply of nutrients in Nemaha County State Lake resulting in a greater productivity per unit volume and in the morphometry of Leavenworth County State Lake with its deeper trophogenic zone resulting in a greater productivity per unit area.

SUMMARY

A limnological survey was made of Leavenworth County State Lake and Nemaha County State Lake, Kansas, between November 7, 1957, and May 29, 1958.

Nemaha County State Lake is a third-class lake and Leavenworth County State Lake is a second-class lake.

Chloride, bicarbonate and sulfate were higher than the average for temperate lakes not draining sediments particularly high in one of these ions. There was enrichment of phosphate and sulfate in both lakes following summer storms.

The lakes were frequently supersaturated with oxygen in the trophogenic zones. Concentrations of carbon dioxide were higher than those of atmospheric equilibrium during most of the period of study.

Chemical and planktonic changes in the hypolimnion of Leavenworth County State Lake were typical for a second-class lake.

The average standing crop, dry weight, of net plankton was 55.4 kg./hectare and 657 mg./M.^{3} for Leavenworth County State Lake and 48.8 kg./hectare and 1626 mg./M.^{3} for Nemaha County State Lake. On the basis of standing crop, both lakes are highly eutrophic.

The chief differences between the lakes seems to be in the richer nutrient level of Nemaha County State Lake and the deeper trophogenic zone of Leavenworth County State Lake.

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Fig. 1.—Nemaha County State Lake. Looking east across the lake from the dam. Note the cultivated fields and the lack of wooded areas. Collections were made in a northerly direction from the point of land at the right center of the picture.

Fig. 2.—Leavenworth County State Lake. Looking east across the lake into the south arm of the lake. Collections were made between the dam and the point of land dividing the arms of the lake at the upper left. Note the wooded shoreline.

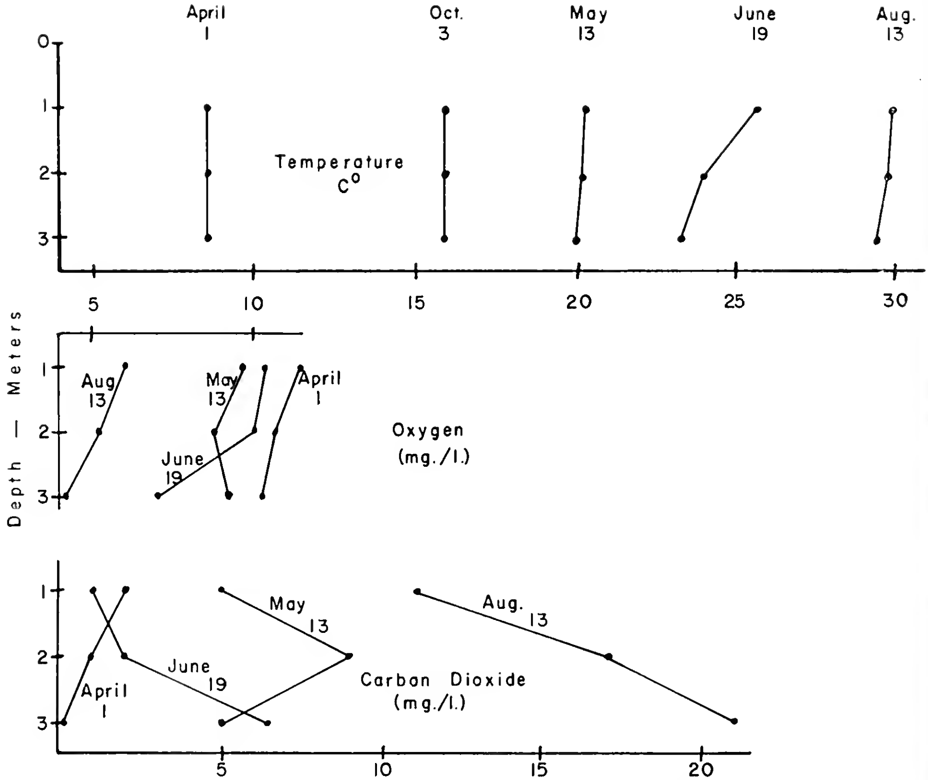

FIG. 3.—Vertical distribution of temperature, oxygen and carbon dioxide in Nemaha County State Lake.

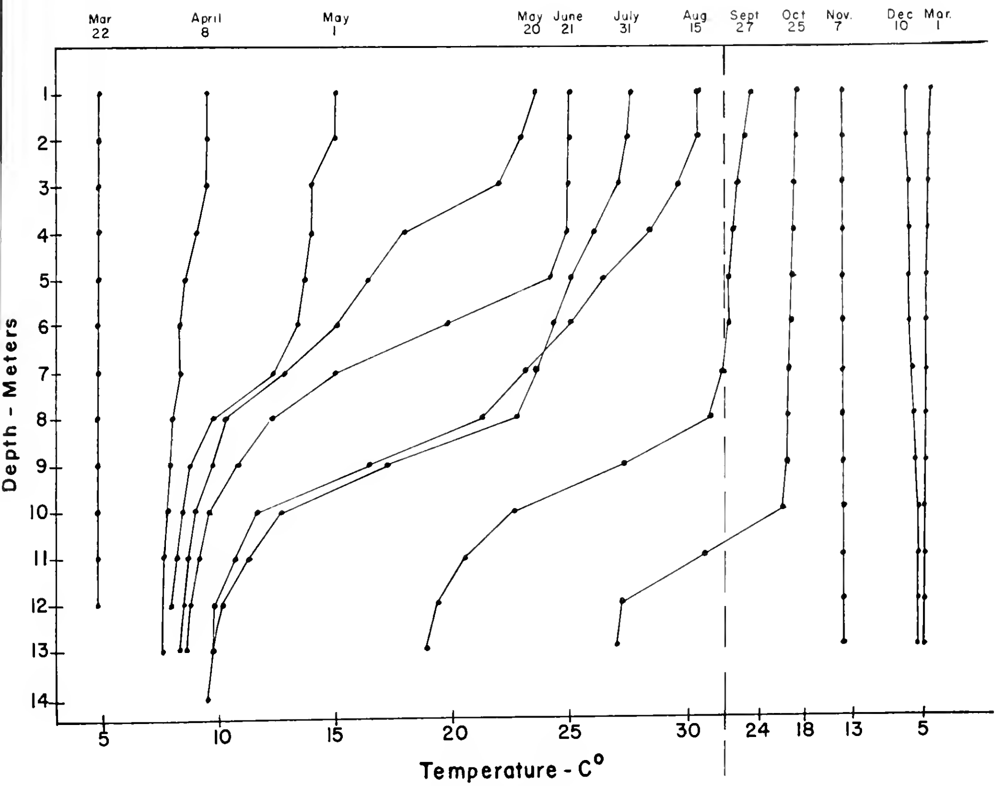

FIG. 4.—Seasonal changes in the vertical distribution of temperature in Leavenworth County State Lake.

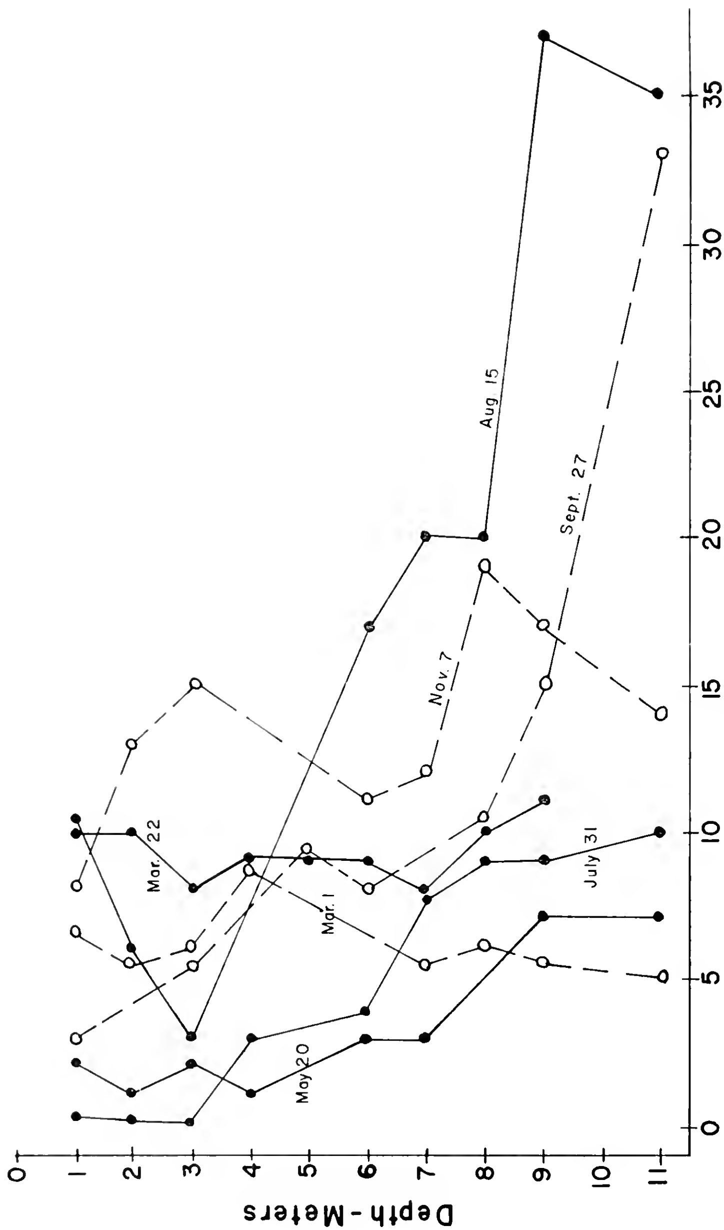

FIG. 5.—Seasonal changes in the vertical distribution of carbon dioxide in Leavenworth County State Lake. —— onset of summer stagnation, - - - onset of autumnal overturn and circulation.

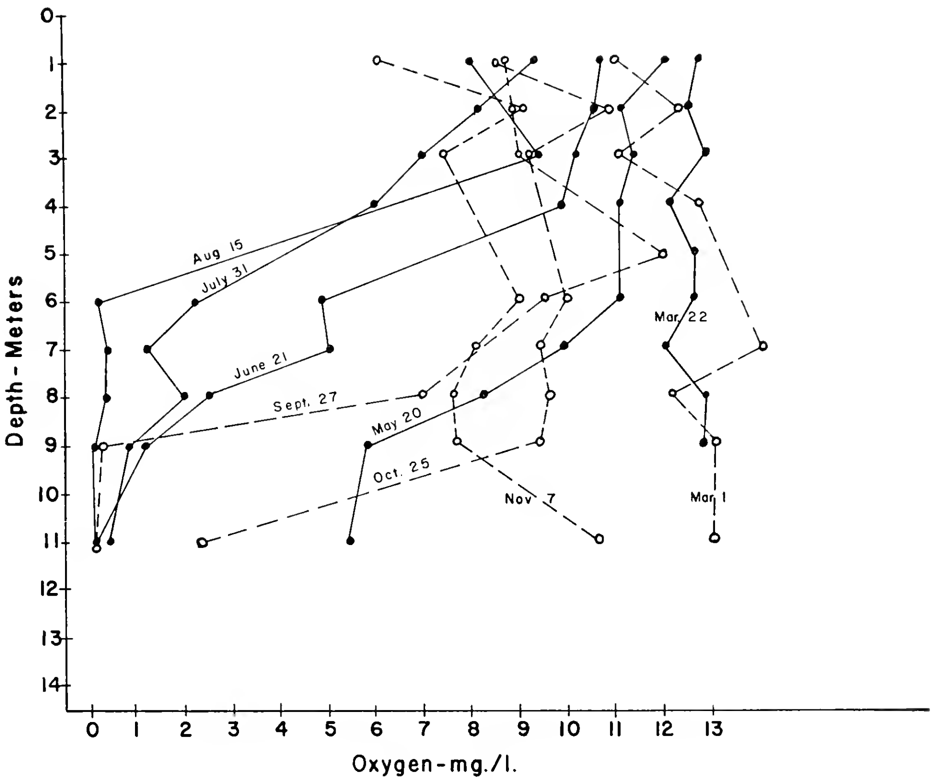

Fig. 6.—Seasonal changes in the vertical distribution of oxygen in Leavenworth County State Lake. —— onset of summer stagnation, - - - onset of autumnal overturn and circulation.

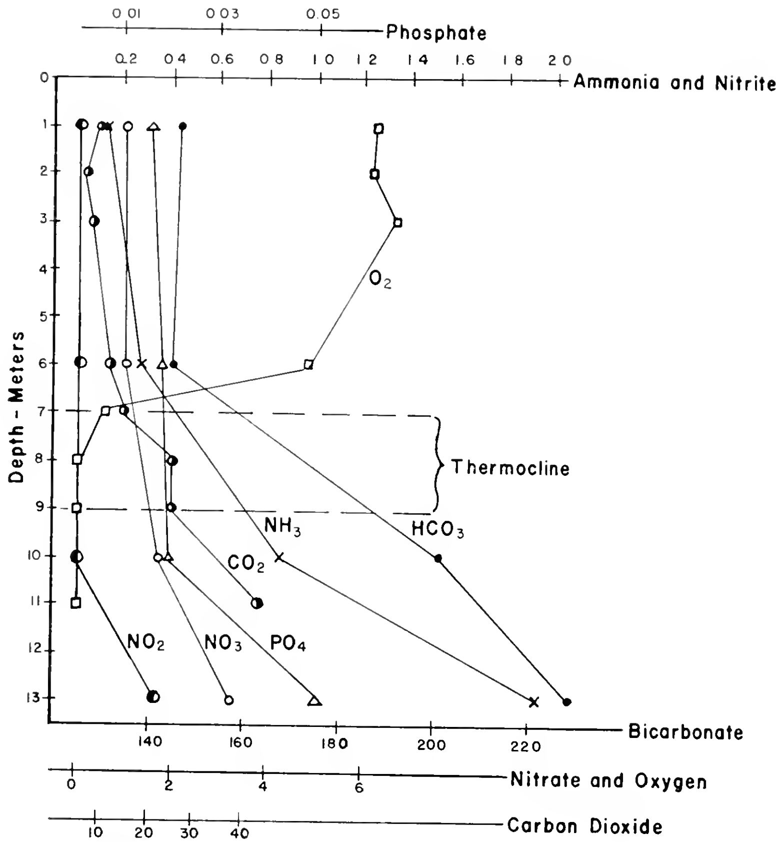

FIG. 7.—Vertical distribution of selected ions in Leavenworth County State Lake on August 28, 1959. All values in mg./l.

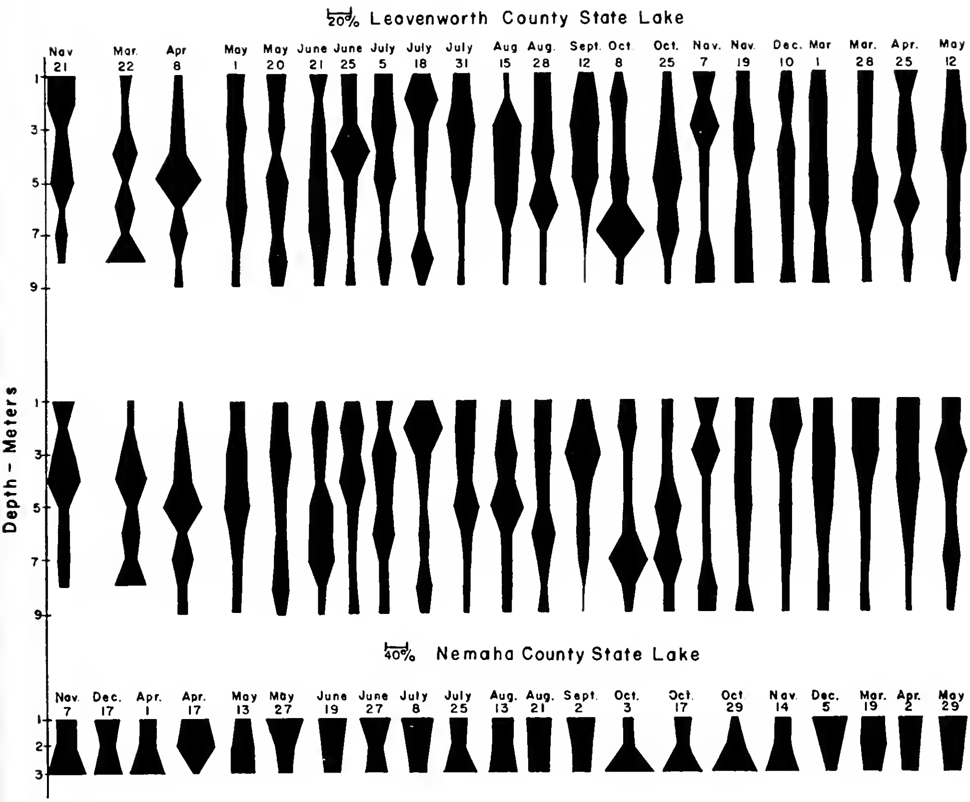

FIG. 8.—Vertical distribution of phytoplankton and zooplankton in Leavenworth County State Lake and of zooplankton in Nemaha County State Lake.

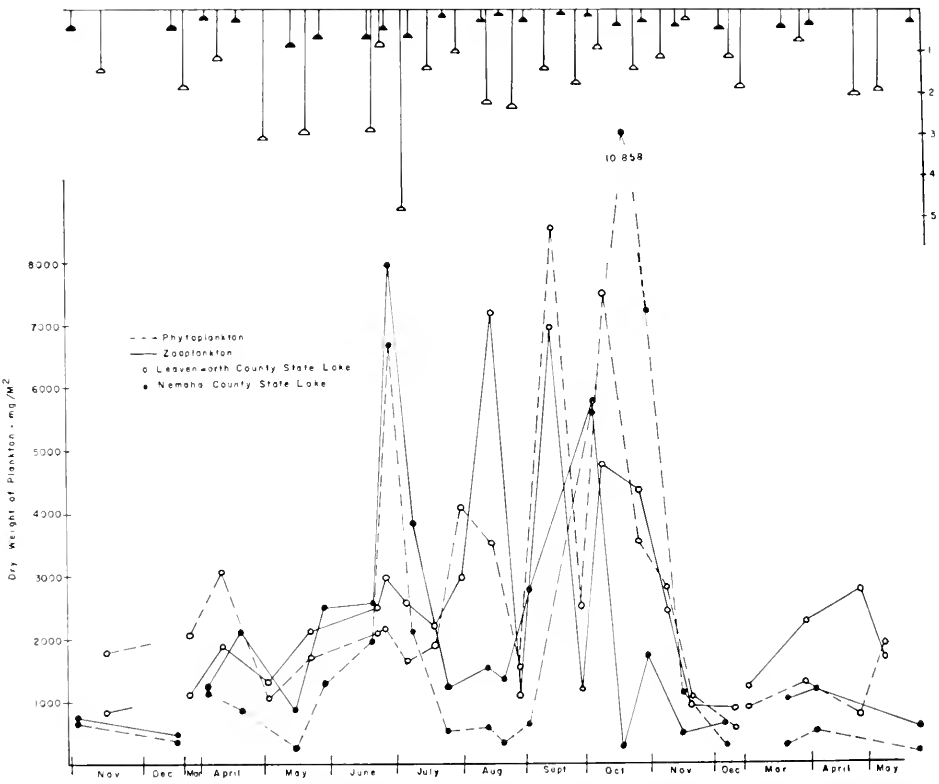

FIG. 9.—Annual cycle of standing crop of net plankton in Leavenworth County State Lake and Nemaha County State Lake. Secchi disc depths are indicated across the top of the figure.

Table 1.—The annual cycle and vertical distribution of temperature (C°), oxygen (mg./1) and carbon dioxide (mg./l.) in Leavenworth County State Lake.

Depth M	Nov.	Mar.	Apr.	May		June		July			Aug.		Sept.		Oct.		Nov.		Dec.	March		Apr.	May
	21	22	8	1	20	21	25	5	18	31	15	28	12	27	8	25	7	19	10	1	28	25	12
Temperature																							
1.....	7.7	4.4	9.2	15.2	23.4	25.2	23.2	26.2	......	27.7	30.4	26.3	25.6	23.6	19.4	17.6	12.8	11.4	4.5	5.7	9.1	15.0	21.3
2.....	7.7	4.4	9.2	15.1	23.0	25.2	23.2	26.1	......	27.6	30.4	26.1	25.4	23.4	19.4	17.4	12.8	11.3	4.5	5.6	9.0	15.2	21.0
3.....	7.7	4.4	9.2	14.3	22.1	25.1	23.2	26.1	......	26.7	29.8	25.9	25.2	23.3	19.3	17.4	12.8	11.3	4.6	5.4	9.0	15.2	20.7
4.....	7.7	4.4	8.9	14.3	18.2	25.1	23.1	26.1	......	26.0	28.4	25.9	25.2	23.2	19.3	17.4	12.8	11.3	4.6	5.3	8.9	15.1	19.0
5.....	7.7	4.4	8.7	13.9	16.4	24.2	23.1	25.2	......	25.3	26.2	25.6	25.0	22.9	19.1	17.4	12.8	11.2	4.6	5.1	8.9	15.1	18.9
6.....	7.7	4.4	8.2	13.5	15.2	19.8	21.7	22.9	......	24.5	24.8	24.8	24.9	22.9	19.0	17.4	12.8	11.2	4.6	5.1	8.7	15.1	18.7
7.....	7.7	4.4	8.2	12.1	12.5	15.0	14.1	18.9	......	23.7	22.9	23.7	24.3	22.8	18.9	17.4	12.8	11.2	4.6	5.1	8.6	14.9	16.3
8.....	7.7	4.4	8.1	9.5	11.1	12.3	12.8	15.0	......	22.9	21.3	21.1	20.8	22.1	18.8	17.4	12.8	11.2	4.6	5.0	8.4	12.8	13.4
9.....	7.7	4.4	8.0	9.0	9.7	10.9	11.7	11.7	......	17.6	16.3	15.6	16.2	18.1	18.6	17.4	12.8	11.2	4.6	5.0	8.4	12.0	12.3
10.....	......	......	7.9	8.3	9.2	9.7	10.6	10.6	......	13.0	11.7	12.7	12.8	13.8	16.9	17.3	12.8	11.0	4.7	5.0	8.4	11.7	11.8
11.....	......	......	7.8	8.2	8.7	9.3	9.9	9.8	......	11.2	10.5	10.6	11.0	11.7	12.2	13.9	12.8	11.0	4.7	5.0	8.4	11.6	11.4
12.....	......	......	7.8	8.1	8.3	8.9	9.7	9.4	......	10.3	9.9	10.0	10.0	10.3	11.2	11.1	12.8	10.9	4.7	5.0	8.4	11.6	11.3
13.....	......	......	7.8	......	7.8	8.8	9.0	9.2	......	9.9	9.9	9.8	9.9	10.0	10.3	10.2	12.8	10.9	4.7	5.0	8.4	11.6	11.2
14.....	......	......	......	......	......	......	8.9	8.9	......	9.7	......	9.7	......	......	......	......	......	......	......	......	8.4	......	......
Oxygen																							
1.....	9.6	12.7	10.7	10.1	12.1	10.6	9.6	13.6	12.6	9.4	8.0	6.4	6.4	8.6	7.4	8.6	6.0	8.0	9.6	11	7.4	8.6	8
2.....	9.7	12.5	10.6	10.2	10.6	10.6	9.0	14.0	13.0	7.6	8.8	6.2	6.6	......	9.2	10.8	9.0	7.2	10.2	12.4	7.8	......	......
3.....	9.6	12.9	10.6	10.9	11.4	10.2	9.0	14.8	11.0	7.0	9.4	6.6	7.8	9.0	8.8	9.0	7.4	6.8	10	11	7.7	8	8.2
4.....	9.5	12.2	9.8	9.7	11.2	9.9	9.8	14.4	12.0	6.0	......	......	......	......	......	......	......	......	10.2	13.1	7.5	9	8
5.....	10	12.6	10.4	......	......	......	10	13.0	......	......	......	......	......	12.0	8.4	......	......	7.2	......	......	......	......	......
6.....	9.1	12.6	10.4	......	11.2	4.8	......	......	8.4	2.2	0.2	4.8	......	9.0	8.2	10	9.0	8.2	9.6	......	7.6	12	7.2
7.....	9.5	12.1	10.5	10.5	9.9	5.0	4.4	5.8	5.8	1.2	0.4	0.6	6.8	......	7.8	9.4	8.2	8.2	9.4	14	6.8	12	5.2
8.....	7.7	12.9	10.7	10	8.3	2.5	3.4	1.2	5.4	2.0	0.4	0	0.2	7.0	8.2	9.6	7.6	7.6	10	12.1	......	11.6	5.2
9.....	6.9	12.8	10.8	8.9	5.9	1.2	1.4	0.6	1.0	0.8	0.2	0	0	0.2	6.2	9.4	7.6	8.0	9.2	13	6.6	10	5
11.....	......	......	......	7.2	5.5	0.2	1.0	0.2	0.1	0.4	0.2	0	0	0.2	5.2	2.4	10.6	8.4	10.8	13	4.2	8	1.6
Carbon Dioxide																							
1.....	20	......	1	6	2	0	4	6	4	0	10	10	16	3	8	4	8	12	8	6	2	16	14
2.....	22	10	1	5	1	0	4	3	2	0	6	6	9	......	8	4	13	12	8	5	2	......	......
3.....	25	8	3	5	2	......	4	3	2	0	3	7	12	5	8	4	14	11	8	6	3	12	14
4.....	22	9	2	4	1	0	2	3	2	3	......	......	......	......	......	......	......	......	10	9	4	8	14
5.....	25	9	3	......	......	......	2	6	......	......	......	......	......	9	9	......	......	10	......	......	......	......	......
6.....	19	9	4	......	3	1	......	......	4	4	17	11	......	8	9	3	11	12	9	......	6	9	12
7.....	20	8	4	5	3	1	6	9	4	8	20	15	18	......	9	......	12	14	10	5	8	12	21
8.....	20	10	4	4	5	1	7	13	6	9	20	28	26	10	12	5	19	14	9	6	......	11	24
9.....	21	11	3	7	7	1	10	12	6	9	37	26	30	15	16	5	17	11	9	5	6	11	24
11.....	......	......	......	4	7	1	10	15	6	10	35	43	35	33	23	8	14	10	9	5	6	13	36

TABLE 2.—The annual cycle and vertical distribution of temperature (C°), oxygen (mg./1) and carbon dioxide (mg./1.) in Nemaha County State Lake.

Depth M	Nov. 7	Dec. 17	April 1	April 17	May 13	May 27	June 19	June 27	July 8	July 25	Aug. 13	Aug. 21	Sept. 2	Sept. 20	Oct. 3	Oct. 17	Oct. 29	Nov. 14	Dec. 5	Mar. 19	Apr. 2	May 29
OXYGEN																						
1...........	9.4	12.9	11.2	10 5	9.7	9.1	10.4	13.8	10	10.4	6	6.6	5.8	6.4	8	9.6	10	10.6	11.6	8.4	9	5
2...........	9.7	12.5	10.7	10.5	8.9	8.7	10.1	11	9.6	10	5.1	6.2	6.1	6	6	11	12	12	10	8	10	6
3...........	9.5	12.2	10.4	10.5	9.2	9.3	7.0	13	8	5.6	4	6	6.8	6.6	6	11	11.4	12.6	9.4	7.2	9	7
CARBON DIOXIDE																						
1...........	2	6.5	2	0	5	4	1	6.5	0	10	11	12	25	18	13	12	16	21	11	5	8	24
2...........	3.8	6.7	1	0	9	3	2	5	1	16	17	9	19	18	12	8	14	24	10	4	7	22
3...........	5.2	6.3	0	0	5	4	6.5	10	1.5	8	21	9	10	20	15	8	15	29	12	5	7	22
TEMPERATURE																						
1...........	7.9	2.2	8.6	14.3	20.4	23.3	25.6	22.2	25.9	29.0	30.0	26.8	25.0	20.0	16.2	19.2	12.2	11.3	2.7	8.0	12.0	23.8
2...........	7.9	2.3	8.6	14.1	20.3	22.4	24.1	21.4	26.0	......	30.0	26.8	24.9	20.0	16.2	19.0	12.2	11.3	2.7	8.0	12.0	23.7
3...........	7.8	2.8	8.6	13.7	20.0	21.8	23.3	20.8	25.9	......	29.6	26.8	24.7	20.0	16.2	18.6	12.2	11.3	2.7	8.0	12.1	23.4

TABLE 3.—Annual cycle and vertical distribution of alkalinity, phosphate, sulfate and chloride in Leavenworth County State Lake. All concentrations in mg./1.

Depth M	Nov. 21	Mar. 22	Apr. 8	May 1	May 20	June 21	June 25	July 5	July 18	July 31	Aug. 15	Aug. 28	Sept. 12	Sept. 27	Oct. 8	Oct. 25	Nov. 7	Nov. 19	Dec. 10	March 1	March 28	Apr. 25	May 12
BICARBONATE																							
1	158	176	183	183	174	147	131	146	154	147	152	147	143	151	152	152	164	136	157	167	175	183	185
4	156	158	178	183	179	135	135	140	159	141									158	167	173		
5																		140				183	183
6											147	145				156	156						
7	175	150	176	183	187	172	135	146	137	139			146	146	146				152	167	170	183	
9	153	146	178								217			162	152		158	146				183	178
10												201	206			158			152				
11				180	186	190	175	183	225	190	179				158		170	143		169	165		181
12													218	195		236							
13												229											
PHOSPHATE																							
1	0	.2	.27	0	0	0	0	.13	.08	.07	.05	.015	0	0	0	0	0	0	0	0	0	0	0
4	.005	.07	.43	0	0	0	0	.05	.07	.08									0	0	0		
5																		0				0	0
6											.06	.02				0	0						
7	0	.07	.295	0	0	0	0	.03	.06	.08			0	0	0				0	0	0	0	
9	0	.08	.295								.055			0	0		0	0				0	0
10												.017	0			0			0				
11				0	0	0	0	.03	.06	.075	.06				0		0	0		0	0		0
12													0	0		0							
13												.05											
SULFATE																							
1	148	32	8	12	20	32	44	20	24	12	32	16	16	16	60	52	78	16	20	16	20	20	12
4	130	28	12	16	20	36	28	28	24	12									20	16	24		
5																		16				24	14
6											52	16				54	76						
7	52	24	12	16	12	36	32	28	344	20			16	20	56				24	17	22	26	
9	40	28	12								16			16	60		68	15				28	12
10												12	12			52			28				
11				16	12	24	32	32	36	30	40				60		72	12		16	24		12
12													12	16		80							
13												12											

Table 3.—Annual cycle and vertical distribution of alkalinity, phosphate, sulfate and chloride in Leavenworth County State Lake. All concentrations in mg./1.—Concluded.

Depth M	Nov. 21	Mar. 22	Apr. 8	May		June		July			Aug.		Sept.		Oct.		Nov.		Dec. 10	March		Apr. 25	May 12
				1	20	21	25	5	18	31	15	28	12	27	8	25	7	19		1	28		
Chloride																							
1.....	4	6	5	6	5	8	7	6	7	4	7	6	6	7	7	5	10	8	8	8	6	10	7
4.....	4	5	5	7	6	8	7	6	6	5	......	......	......	......	......	......	......	......	8	8	7	......	......
5.....	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	......	9	......	......	......	10	6
6.....	......	......	......	......	......	......	......	......	......	......	7	8	......	......	......	7	10	......	......	......	......	......	......
7.....	5	5	4	6	6	6	7	7	10	5	......	......	7	7	6	......	......	......	8	9	7	10	......
9.....	4	5	6	......	......	......	......	......	......	......	6	......	......	8	9	......	9	8	......	......	......	11	6
10.....	......	......	......	......	......	......	......	......	......	......	......	8	6	......	......	6	......	......	9	......	......	......	......
11.....	......	......	......	6	6	5	6	7	7	5	8	......	......	......	8	......	10	8	......	8	8	......	8
12.....	......	......	......	......	......	......	......	......	......	......	......	......	6	8	......	9	......	......	......	......	......	......	......
13.....	......	......	......	......	......	......	......	......	......	......	......	7	......	......	......	......	......	......	......	......	......	......	......

Table 4.—The annual cycle and vertical distribution of pH and of nitrate, nitrite and ammonia as mg./l. in Leavenworth County State Lake.

Depth M	Nov. 21	Mar. 22	Apr. 8	May		June		July			Aug.		Sept.		Oct.		Nov.		Dec. 10	March		Apr. 25	May 12
				1	20	21	25	5	18	31	15	28	12	27	8	25	7	19		1	28		
											Nitrate												
1	1.1	3.7	1.5	2.8	1.7	1.5	1.2	1.7	.75	.3	1	.9	1	.8	1.6	1.1	.8	1	2.7	1.2	2.1	1.9	1.3
4	1.2	3.6	1.6	4.2	1.2	1.2	1.6	1.6	.1	1.2										1.2	2.1		
5																		1.5	2.7			1.9	1.2
6											1	1				1	.85						
7	1	3.8	1.4	4.3	1	2.3	2.6	2.2	.55	2.5			1.2	.8	1.4				2.7	1.1	2.1	1.6	
9	1	3.3	1.5								1.1			.8	.8		.9	1.5				1.7	1.2
10												1.6	1.3			1			3.1				
11				4.2	.9	2.6	2.5	3.2	1.6	1.1	1.5				1		.75	1.5		1.3	2		1.3
12													1.2	.8		1							
13												3.2											
											Nitrite												
1	.029	.026	.02	.024	.039	.034	.037	.088	0	.198	.06	0	.016	.03	.034	.042	.032	.039	.035	.013	.03	.049	.032
4	.033	.026	.026	.034	.039	.034	.026	.061	.019	.264									.035	.013	.035		
5																		.039				.049	.032
6											.05	0				.042	.029						
7	.029	.026	.026	.04	.039	.075	.033	.1	.026	.33			.039	.013	.038				.035	.016	.036	.051	
9	.029	.024	.022								.06			.013	.046		.033	.041				.052	.033
10												0	.025			.039			.036				
11				.026	.049	.059	.049	.18	.065	.16	.06				.079		.035	.038		.016	.039		.042
12													.027	.013		.024							
13												.032											
											Ammonia												
1	.134	.17	0	0	.048	.145			0	.048	.25	.024	0	0	0	.256	.269	0	.073	0	.244	.276	.73
4	.195	.122	0	0	.026	.125	.265	.61	0	.17									.073	0	.243		
5																		0				.254	.696
6											.30	.265				.264	.265						
7	.183	.097	.015	.024	.048	.125	.097	.549	.012	.305			.097	0	0				.073	0	.206	.266	
9	.195	.122	.024								.405			.292	0		.275	0				.28	.7
10												.854	1.22			.268			0				
11				.024	.44	.565	.048	.549	.012	.488	.39				.219		.28	0		.024	.195		.67
12													1.71	.353		1.22							
13												1.92											

Table 4.—The annual cycle and vertical distribution of pH and of nitrate, nitrite and ammonia as mg./1. in Leavenworth County State Lake.—Concluded.

Depth M	Nov. 21	Mar. 22	Apr. 8	May		June		July			Aug.		Sept.		Oct.		Nov.		Dec. 10	March		Apr. 25	May 12
				1	20	21	25	5	18	31	15	28	12	27	8	25	7	19		1	28		
pH																							
1	8.1	8.2	8.4	8.4	8.4	8.3	8.2	7.6	8	8.4	8.3	7.9	8	8.1	8.4	7.8	7.8	7.3	7.6	8	8.1	8.4	8.6
4	8.1	8	8.3	8.3	8.4	8.2	8	8	8	8									8	8.1	8.1		
5																		7.3				8.3	8.4
6											7.2	7.9				7.6	7.8						
7	8	8.2	8.3	8.2	8.4	8	7.2	7.2	7	7.3			7.5	7.5	7.8				8.1	8.2	8.3	8.2	
9	7.8	8.3	8.3								7.3			7.4	7.8		7.8	7.4				8.2	8.5
10												7.4	7.5			8			7.2				
11				8	8.2	7.8	7.6	7.1	7.2	7.3	7.2				7.2		7.8	7.2		8.2	8.3		8.4
12													7.2	7.2		7.2							
13												7.4											

TABLE 5.—The annual and vertical distribution of pH and other ions (mg./l.) in Nemaha County State Lake.

Depth M	Nov. 7	Dec. 17	April 1	April 17	May 13	May 27	June 19	June 27	July 8	July 25	Aug. 13	Aug. 21	Sept. 2	Sept. 20	Oct. 3	Oct. 17	Oct. 29	Nov. 14	Dec. 5	Mar. 19	Apr. 2	May 29
BICARBONATE																						
1...........	246	170	241	244	245	268	257	208	200	120	122	156	165	158	189	178	230	251	256	269	268	226
2...........	251	173	250	256	239	268	257	209	197	122	118	158	170	161	183	180	230	245	258	273	265	217
3...........	246	178	245	261	240	268	296	221	200	112	122	158	165	158	189	178	226	244	253	280	265	219
PHOSPHATE																						
1...........	0	0	.37	.33	0	0	0	0	.05	.04	0	.09	0	0	0	0	0	0	0	0	0	0
2...........	0	0	.30	.28	0	0	0	0	.14	.05	0	.35	0	0	0	0	0	0	0	0	0	0
3...........	0	0	.27	.39	0	0	0	0	.09	.05	0	.11	0	0	0	0	0	0	0	0	0	0
SULFATE																						
1...........	24	36	48	40	20	24	40	64	60	480	372	41	16	24	24	20	56	28	38	36	32	24
2...........	36	48	52	40	32	28	28	60	60	440	428	40	12	22	24	20	54	30	40	36	32	24
3...........	24	52	48	32	28	32	60	60	80	520	460	36	12	24	21	20	51	28	12	36	32	25
CHLORIDE																						
1...........	7	7	10	7	8	7	7	9	10	21	9	5	3	.8	1	5	2	10	4	7	6	10
2...........	6	7	12	8	6	7	7	9	10	14	17	5	2	1	1	6	3	9	4	8	7	9
3...........	5	7	11	9	5	6	8	10	10	13	8	6	3	.8	1	6	2	9	1	7	7	11
NITRATE																						
1...........	3.7	6.8	3	6.4	3.8	1.6	4.5	4.1	2.2	2	3.1	4.2	3.6	2	6	4.2	3.3	2.4	3.8	3.6	5.5	4.2
2...........	2.6	6.8	2.7	5.8	3.5	1.8	4	6.6	2	1.9	3.1	5.2	1.2	1.8	5.3	4	3.3	2.6	4.2	3.8	5	4.2
3...........	2.4	7.0	2.4	6.2	2.9	1.4	6.2	12	1.5	2.4	3.9	6.6	3	1.6	5.5	4.2	3.1	2.6	1	3.8	5.2	4.3
NITRITE																						
1...........	.32	.07	.07	.28	.09	.09	.2	.2	.13	.35	1.38	.01	.09	.31	.23	.05	.08	.04	.07	.08	.08	.24
2...........	.32	.07	.07	.3	.08	.09	.21	.24	.13	.12	1.18	.05	.09	.31	.31	.05	.07	.03	.07	.08	.07	.24
3...........	.34	.07	.07	.28	.08	.08	.21	.28	.13	.46	1.38	.01	.09	.29	.29	.05	.08	.03	.07	.07	.07	.21
AMMONIA																						
1...........	.42	.44	0	0	0	.04	.17	.19	.04	.34	.24	.72	.02	0	0	.07	.21	.01	.27	.21	.3	.18
2...........	.92	.96	0	0	0	0	.12	.73	.24	.46	.12	.61	.17	0	0	.09	.20	.02	.29	.21	.3	.5
3...........	.44	0	0	0	0	0	.14	1.3	.24	.46	.12	.85	0	0	0	.08	.20	.02	.3	.22	.3	.46
pH																						
1...........	7.8	8.3	8.4	8.4	8.4	8.5	8.4	8.4	8	7	8.1	8.1	7.4	7.2	8	8.5	8	8.2	8.4	8.2	8.4	8.4
2...........	7.8	8.3	8.4	8.4	8.5	8.5	8.4	8.4	8.2	7	8	7.9	7.4	7.2	8	8.5	7.8	8.2	8.4	8.2	8.4	8.1
3...........	7.9	8.3	8.4	8.4	8.4	8.1	8.2	8.2	8.2	7	7.8	7.9	7.4	7.2	7.4	8.5	7.8	8.2	8.4	8.2	8.4	8.4

TABLE 6.—Percent saturation of oxygen at various depths for selected dates in 1958-1859.

Depth M	March 22	May 1	May 20	June 21	July 5	July 31	Aug. 15	Sept. 27	Nov. 7	Dec. 10	March 28
LEAVENWORTH COUNTY STATE LAKE											
1	99	100.9	139.4	125.9	158.6	115.3	102.8	99.0	55.7	71.0	63.1
2	95	102.8	120.1	125.9	162.5	92.3	112.5	....	83.6	78.8	66.3
3	100	105.7	127.8	120.1	171.1	83.6	119.2	103.8	69.2	75.9	65.3
4	93.2	93.3	117.3	118.2	170.1	71.1	....	....	....	78.8	61.1
5	97	....	....	....	151.9	....	....	138.4			
6	97		110.5	50.9	....	25.4	2.7	103.8	83.6	71.0	61.1
7	92.3	97.1	92.3	49.0	61.5	12.9	4.3	....	75.9	71.1	55.7
8	100	86.5	74.0	23.0	11.0	22.1	3.3	79.8	71.1	75.9	
9	99.5	75.9	50.9	10.5	4.8	7.2	1.5	1.2	71.1	70.1	55.7
11	....	60.6	47.1	0.96	1.2	2.8	1.2	1.2	100.9	83.6	35.0

NEMAHA COUNTY STATE LAKE

Depth M	April 1	May 13	May 27	June 19	June 27	July 8	Aug. 13	Oct. 3	Nov. 11	March 19
1	95	105.7	104.9	124.0	153.8	119.2	75.9	80.7	97.1	70.1
2	90.5	99.0	99.0	117.3	112.5	114.1	63.4	60.5	107.6	66.3
3	88.4	100.0	101.8	79.8	145.1	95.1	50.0	60.5	111.1	60.5

TABLE 7.—The standing crop of plankton from Leavenworth County State Lake. The dry-weight of plankton is expressed per unit volume (mg./M³) and per unit surface area (mg./M²). The average mg./M³ is derived by adding all the values at each meter sampled on a given date and dividing by the number of samples collected on that date.

Depth M	Nov. 21	Mar. 22	Apr. 8	May		June		July			Aug.		Sept.		Oct.		Nov.		Dec. 10	March		Apr. 25	May 12
				1	20	21	25	5	18	31	15	28	12	27	8	25	7	19		1	28		
PHYTOPLANKTON—mg./M³																							
1	367	193	217	124	246	240	254	212	218	449	109	185	918	269	416	250	430	144	51	80	143	134	188
2	403	97	265	115	168	141	236	222	469	570	191	189	1463	....	855	318	227	100	72	108	161	64	241
3	153	202	263	163	180	200	219	296	235	788	742	185	1733	....	680	375	580	143	63	104	142	97	320
4	250	389	306	100	107	218	585	207	199	635	711	249	1492	394	738	545	196	143	85	98	137	110	321
5	303	102	1160	138	277	294	261	275	131	600	595	157	1655	214	768	717	230	85	73	121	201	63	195
6	81	295	193	158	220	327	193	126	123	381	580	351	694	835	666	438	234	88	68	126	210	139	191
7	153	204	417	104	151	330	135	94	115	236	204	77	433	82	2585	540	177	122	60	71	108	45	173
8	84	590	94	76	208	198	125	165	322	206	194	79	36	85	423	261	316	118	53	83	73	66	203
9	......	......	160	78	144	123	148	93	110	205	173	89	89	61	352	177	372	142	73	92	88	30	66
Average mg./M³	224	230	342	117	189	230	240	188	214	452	389	173	946	277	831	402	307	117	67	98	140	83	211
mg./M²	1794	2072	3075	1056	1701	2071	2156	1690	1922	4070	3499	1561	8513	1940	7183	3624	2762	1055	601	883	1263	748	1898
ZOOPLANKTON—mg./M³																							
1	144	45	64	155	207	167	304	315	285	450	357	146	600	120	529	376	416	132	160	158	155	164	290
2	49	67	120	137	262	331	542	214	645	440	479	146	1113	......	700	339	203	123	215	182	415	163	226
3	137	131	189	195	332	253	380	445	264	395	1233	114	2100	......	298	298	518	117	100	206	441	424	433
4	188	260	273	204	289	168	611	337	185	324	1057	111	1050	321	350	431	146	114	76	177	260	465	197
5	59	88	581	227	194	117	296	285	101	644	1760	122	650	131	330	845	153	114	81	148	168	316	143
6	68	136	409	163	178	423	219	411	172	262	759	211	725	106	493	453	146	84	76	132	168	268	141
7	74	105	295	86	223	482	187	171	147	126	539	107	575	66	1310	833	163	71	68	79	144	167	203
8	50	255	122	66	282	161	177	141	225	197	491	45	84	113	514	380	333	75	60	99	117	77	143
9	......	......	142	64	143	143	260	129	170	95	469	55	78	44	252	357	331	107	49	111	158	68	102
Average mg./M³	96	135	211	144	234	279	331	272	244	326	794	121	775	129	530	179	267	104	98	141	262	301	209
mg./M²	769	1087	1895	1297	2107	2515	2976	2148	2194	2930	7144	1087	6975	901	4776	1312	2409	937	885	1292	2359	2712	1878
TOTAL NET PLANKTON																							
Average mg./M³	320	365	553	261	423	509	571	460	458	778	1183	294	1721	406	1361	981	574	221	165	242	402	381	420
mg./M²	2563	3159	4970	2353	3808	4586	5132	4138	4116	7000	10643	2648	10234	2811	12259	7933	5171	1992	1486	2175	3622	3460	3776

Table 8.—The standing crop of plankton from Nemaha County State Lake. The dry-weight of plankton is expressed per unit volume (mg./M^3) and per unit surface area (mg. M^2).

Depth M	Nov. 7	Dec. 17	April 1	April 17	May 13	May 27	June 19	June 27	July 8	July 25	Aug. 13	Aug. 21	Sept. 2	Oct. 3	Oct. 17	Oct. 29	Nov. 11	Dec. 5	Mar. 19	Apr. 2	May 29
Phytoplankton—mg./M^3																					
1	93	57	168	282	88	724	941	2456	706	97	149	118	150	2042	6823	1316	145	111	15	39	67
2	113	52	368	423	116	335	641	1071	661	80	227	139	179	1314	3014	3029	472	......	196	93	51
3	523	298	637	166	95	261	372	3108	742	362	222	124	26	2271	1021	2522	460	45	59	383	73
Average mg./M^3	243	136	391	290	100	440	651	2212	703	180	199	127	218	1876	3619	2299	359	52	100	172	61
mg./M^2	729	407	1173	871	299	1320	1954	6635	2109	539	598	381	655	5627	10858	6897	1077	156	300	515	191
Zooplankton—mg./M^3																					
1	152	164	273	847	201	1335	1102	3525	1781	372	491	463	1112	704	63	92	110	336	330	552	213
2	165	101	348	1155	321	744	863	1686	1178	290	468	143	861	1031	45	479	122	214	372	356	201
3	439	193	660	149	403	435	573	2750	842	636	619	414	716	4012	154	1111	206	98	308	328	151
Average mg./M^3	252	153	427	717	308	838	846	2654	1267	433	526	440	916	1926	87	561	146	216	337	412	198
mg./M^2	756	458	1281	2151	925	2514	2538	7961	3801	1298	1578	1320	2749	5777	262	1682	438	648	1010	1236	595
Total Net Plankton																					
Average mg./M^3	495	289	818	1007	408	1278	1497	4866	1970	613	725	567	1131	3802	3706	2860	505	268	437	581	262
mg./M^2	1485	865	2454	3022	1224	3834	4192	14596	5910	1837	2176	1701	3404	11401	11120	8579	1515	801	1310	1751	786

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The Physicochemical Responses of Cellular Components to pH. I. Some Effects of pH on the Solubility of Cellular Components from Several Rat Organs [1]

BY

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INTRODUCTION

Anderson (1) has shown that *in vitro* solubility of isolated hyaloplasm is a function of pH. He has assumed that some work on solubility can be validly applied to the study of the intact cell.

This paper will help to establish that the solubilities of several cellular components are a function of pH. The corresponding cellular components from different organs, moreover, exhibit general similarities with respect to solubility but also appreciable differences. Further, the results of the work reported herein give indications that pH plays an important role in maintaining the integrity of intracellular components.

MATERIALS AND METHODS

Organs were obtained from adult, anesthetized, heparinized rats which were perfused with warm (35° to 40° C.), 0.9% unbuffered saline. The carotid artery of the anesthetized rat was severed. As soon as the animal died, the pleural cavity was opened and the descending aorta freed from mesentaries to facilitate cannulation of the vessel. A hemostat was applied to the posterior vena cava which was then severed anterior to the hemostat. Perfusion of the body was continued until the effluent saline of the posterior vena cava was colorless and the liver was blanched.

In a first series of experiments, the organs (heart, liver, kidney, and spleen) were removed from the animals and put into cold, un-

1. This work was supported, in part, by research grants from the Kansas Heart Association and The Office of Naval Research, NR 104-497, Nonr 2724 (00).

buffered saline and stored at 0° to 3° C. for three weeks. Before fractionating the organs, all major blood vessels, connective tissue, and accessory structures were removed. In the heart preparation only the myocardium was used. The organs were fractionated following a modification of the methods of DeDuve (2) and Klein and Johnson (3) as shown in the flow chart in Figure 1. In this series buffered 0.25 *M* sucrose was used as the medium.

As a preliminary check on the usefulness of fractionation procedures, vital and supravital stains were used to verify the gross integrity of the fractions. Bismarch Brown was used to identify nuclei (4); Janus Green to identify mitochondria (5); and Neutral Red to identify cytoplasmic particles (6). The distribution and intensity of stained material was noted. None of the stained fractions was used in the subsequent work on solubility of the fractions derived from the organs.

The fractions obtained using the procedure outlined in Figure 1 were dialyzed immediately against large volumes of 0.9% unbuffered saline for 18 hours at 0° to 3° C. with one change at 12 hours. Because the fractions containing soluble protein and nuclei necessarily contained a large amount of sucrose, they were dialyzed against approximately 12 volumes of saline as compared with the 4 volumes of saline used for the fractions containing mitochondria and microsomes. After dialysis, the nuclei and soluble proteins were concentrated, while still in the dialysis bag, by means of fan-circulated air at room temperatures.

Estimates were made of protein concentration in each of the fractions to facilitate appropriate sampling dilutions for nitrogen determinations. The protein nitrogens were determined colorimetrically employing Nesslers reagent, as suggested by Lanni and co-workers (7). The fractions were diluted so that they contained 60 to 90 μgm of protein nitrogen/ml.

To make possible a more realistic estimate of effects of pH alone on the fractions, care was taken to select buffers which contained no metabolites of the enzyme systems known to be in the fractions derived from the organs. The three buffer systems used and their theoretical pH ranges at 20° C. were (1) acetic acid, sodium acetate—3.78 to 5.95; (2) potassium acid phosphate, sodium hypophosphate—6.43 to 7.64; (3) potassium chloride-boric acid, sodium hydroxide—8.00 to 10.00. All buffer concentrations were 0.2 M.

Aliquants of each diluted fraction were introduced into equal volumes of the buffer solutions ranging from pH 3.59 to 8.08 and shaken vigorously. The tubes were then allowed to equilibrate for

40 hours at 0° to 3° C. The supernatant in each tube was drawn off and its pH measured to the nearest 0.01 pH unit by means of a Beckman Model G pH meter. The protein nitrogen remaining in the supernatants was used as the means of revealing the solubility of the fractions at the various pH values.

Some supernatants were turbid while others were clear. Still others contained a clear layer of supernatant above a turbid layer. The supernatants were drawn up without regard to the turbidity or clearness of the supernatants. Therefore, the protein nitrogen measured in the first series was not all from soluble protein.

In a second series of experiments, organs were obtained from rats as in the first series. In two respects the processing of the cleaned organs was different from that employed in the first series. The organs were fractionated on the same day they were obtained from the animals instead of three weeks later and 0.25 *M* unbuffered sucrose solution was used. All other physicochemical conditions of the fractionation were the same. Samples of each diluted fraction were adjusted through the same range of pH values, as in the first series. The tubes were allowed to equilibrate in the refrigerator for 40 hours. These tubes were then centrifuged at 3500 rpm for 15 minutes in the International Refrigerated Centrifuge at 2° to 3° C. The clear supernatants were decanted into precooled, clean tubes, tested for pH value, and then for concentration of protein nitrogen in the supernatants.

In both series of experiments, the pH was determined at the temperature at which the fractions had equilibrated.

EXPERIMENTAL RESULTS

The results were graphed both as pH *vs* μgm of protein nitrogen in solution and as pH *vs* relative solubility. Since some precipitate formed at every pH, in the latter method of graphing the 100% solubility was arbitrarily designated as the highest experimentally determined from the supernatants, not as the amount of protein nitrogen introduced into the buffer systems. The general patterns obtained in either kind of graph were the same in that each component exhibited a minimum solubility between pH 4 and 5 and maximum solubility at the extremes of pH 3.59 and 8.08. All data presented, therefore, are in terms of pH *vs* relative solubility.

The results of the first series of experiments are shown in Figure 2. The curve for the heart mitochondria is distinctly different from the other three mitochondrial curves. The curve for spleen mitochondria does not exhibit a bimodality. The heart soluble protein fraction reacts differently from the other fractions in that the curve has two distinct minima.

Figure 2 also contains a comparison of the solubilities of all the fractions derived from rat liver. Each fraction exhibits its own distinctive curve. The microsomal and mitochondrial fractions had somewhat similar curves. The curves for the nuclei and soluble protein fractions also exhibit similarities. All of the fractions have at least a slight bimodality in their solubility curves; of these, that of the mitochondria is the most striking. Note also that the solubilities of the particulate fractions were much lower than were those of the soluble proteins fractions.

The results of the second series of experiments are shown in Figure 3. In Figure 3a, the solubilities of the heart nuclei and the liver are quite similar. In Figure 3b, there is a marked difference in the shape of the curves representing heart and liver microsomes. Here, the heart curve is like the soluble proteins fractions. Figure 3c shows that the curves for the soluble proteins of heart and liver are similar except for the shift to the left of the low solubility point on the abscissa.

Figure 3d shows the loss of the bimodality from the curves of liver fraction such as was obtained in the first series. Figure 3e shows that the over-all responses of the heart fractions are similar to those of the liver fractions, except for the already-mentioned difference in the microsomes (Fig. 3b).

Figure 4 is a graphical comparison of some of the results obtained in the first and second series of experiments. The general differences between the first and second series are 1) a smoother curve was obtained in the second series of experiments, and 2) a shift toward lower pH values occurred in the low solubility points of the microsome and soluble protein fractions of the second series.

In summary, all cellular components exhibited the lowest relative solubility between pH 3.5 and 6.5. The particulate fractions exhibited lower relative solubilities (as low as 0.12) than did the soluble protein fractions (0.60). The position of minimal solubility four each fraction and component varied within the above pH range.

The solubility curves in the second series of experiments do not have the bimodality found in the first series. This can be traced to the elimination of suspended material in the supernatants by centrifugation. Generally, the amount of precipitate in the spun tube was inversely proportional to the relative solubility, although there was some precipitate in the control tubes.

DISCUSSION

We are not yet able to establish the reasons for the shift in pH values for the low solubility points in the second series of tests. There are, however, three major differences between the two series of experiments: 1) The equilibrated tubes were centrifuged in the second series before pH or protein nitrogen determinations were taken. 2) In the second series, the organs were fractionated the same day they were obtained from the animals, while in the first series, the organs were stored for three weeks. 3) In the second series, the fractionation was performed using unbuffered sucrose rather than buffered sucrose.

Difference 1 would influence markedly the protein concentration in the supernatants and therefore change the graphical representation of the physicochemical response of the fractions to pH change. Differences 2 and 3 would influence the character of the fractions, which were assumed to be basically the same, as opposed to the graphical representation of the reaction.

Difference 2 would cause a greater amount of free protein to be present in the soluble proteins fraction of the first series due to autolysis of the organelles and metabolism within the whole cell. Difference 3 would lead to the yield of a slightly different fraction because of fluctuations in pH that occurred during the second series fractionation. For example, at all times the pH was below 6.8. Our studies show that the solubility of the proteins of the mitochondrial fraction decreases with increasing acidity. Because we used a method of fractionation dependent in part upon the sedimentation of the cellular components, we can assume, because of pH difference, that the mitochondria of the second series did not contain the same complement of proteins as the first series.

When all the above possibilities for variation are considered, it is remarkable and encouraging that consistent results were obtained at all. The statement by Anderson that the soluble proteins fraction of the liver has a sharp drop in solubility near pH 5 has been substantiated to the point that this fraction does show a precipitous drop in solubility in the acid range, but not at pH 5.25, nor so sharply as he stated.

We have found, in addition, that the other cellular fractions respond to pH in manners similar to, but with appreciable differences from the response of the soluble proteins fraction. Corresponding fractions from different organs, in general, show similar responses to pH when obtained and examined under identical conditions. There are only two exceptions to this statement: 1) The heart mitochondria of the first series yielded a solubility curve which was almost the inverse of the solubility curves of the mitochondria of liver, kidney and spleen. 2) In the second series, the heart nuclei solubility curve exhibited an inverse relationship to the solubility curve of the liver nuclei.

In the first series of solubility tests some of the supernatants were turbid at various pH values. The failure of a fraction to settle completely or to completely dissolve is unquestionably a useful characteristic in analyzing its response to changes in pH. The bimodality and trimodality of the curve obtained in the first series of experiments (Fig. 2) are the consequence of the tissual proteins remaining suspended. It is possible that the tendencies for the fractions to be soluble at some pH values, to form fine particles and remain dispersed at other pH values, and to form aggregates and settle at still other pH values, illustrate one of the mechanisms involved in the formation of organelles within living cells.

Proteins are impressionable. They change minutely from moment to moment in response to immediate conditions. A protein system at pH 6 is not exactly the same as that system at pH 4. The changes that occur may or may not be reversible; they may or may not effect the solubility. Solubility of protein systems is not an accurate description, then, for this study. Rather, as implied before in this discussion, a better description is the physicochemical response of protein systems at different pH values. That is, we are observing the results of the responses that occur in a system when its surroundings are changed from pH 6.85 (the pH of the unbuffered homogenates of the organs) to 3.5, from pH 6.85 to 4.5, *etc.* What we are measuring are those proteins that remain soluble at the different pH values; these proteins are assumed to be relatively unchanged from their native condition. The insoluble proteins in the systems are, therefore, assumed to be different from that with which we started in the homogenate.

The degree and kinds of chemical differences among the protein systems at varying pH values are not known yet. Perhaps the protein molecules vary only in the relative number of free radicals such as hydroxyl groups. The chemical changes which occur in response to pH change in a protein are yet another field of study from the one now under discussion. At this time we can state only that we are almost certain that some chemical changes do occur which we do not completely understand.

Of primary importance is the fact that in none of the particulate systems is the relative solubility lowest near the biologically neutral pH of 6.85 (7). It seems only reasonable that the particular cellular components exist within the cell, not as mere aggregations of protein, but rather as functional physical entities. Indeed, that we can isolate these cellular components by the methods used in this study is evidence that the components are physical entities at least for some of the time. It is then striking that the cellular components isolated at pH 7.12 by differential centrifugation can, after a while, be found to be soluble at this same pH. Keeping in mind the difference in tissue storage time between the first and second series, it seems evident that cellular components maintain their integrity as physical entities as long as the cell is not damaged. Upon homogenizing the tissue and breaking the cells, the physical integrity of the particulate components is no longer ensured.

Cellular components soon lose their ability to resist pH changes after being removed from the whole cell. In working with fractions, speed of manipulation is very important. It is doubtful that, even with speed, biochemical work can be done with cell fractions that is directly applicable to the actual conditions within the living cell.

It has been known for several years that there are localized regions of different hydrogen ion concentration in the living cell (7). From the solubility curves obtained in this study it is reasonable to assume that organelles in cells are present or absent, in part, as a consequence of localized changes in the pH normally occurring in intracellular metabolism. It is conceivable, then, that pH plays an important role in the maintenance of the integrity of intracellular structures.

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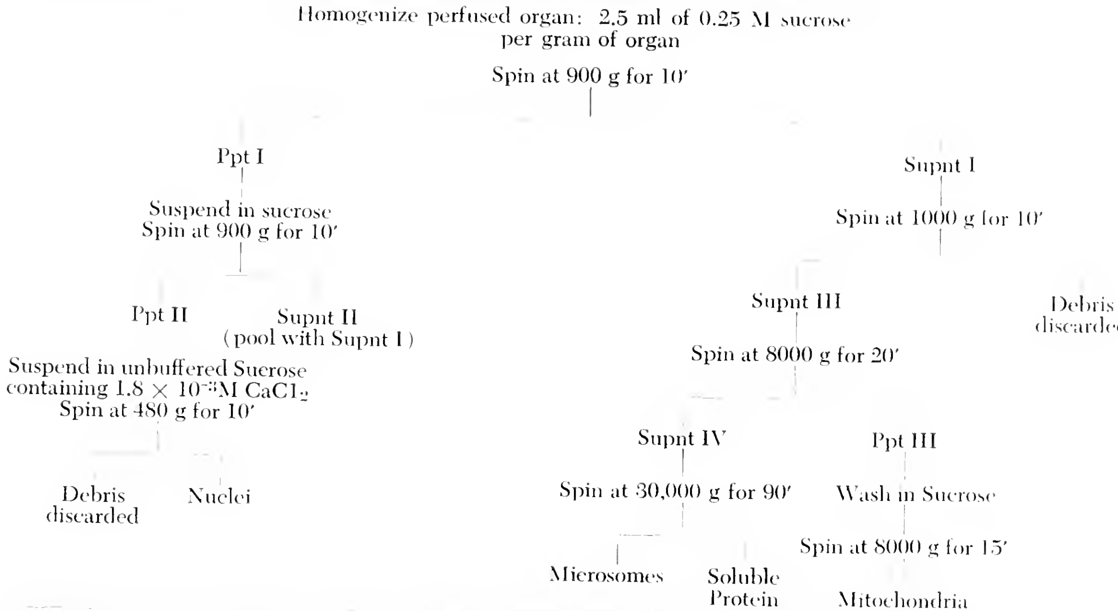
FIGURE 1



Scheme of manipulation for the fractionation of vertebrate organs, modified from DeDuve (1954) and Klein and Johnson (1954). The solutions of sucrose used were buffered to pH 7.12 with M/150 Na_2HPO_4 and M 150 KH_2 PO_4, except that the sucrose solution containing 1.81×10^{-3}M $CaCl_2$ was not buffered.

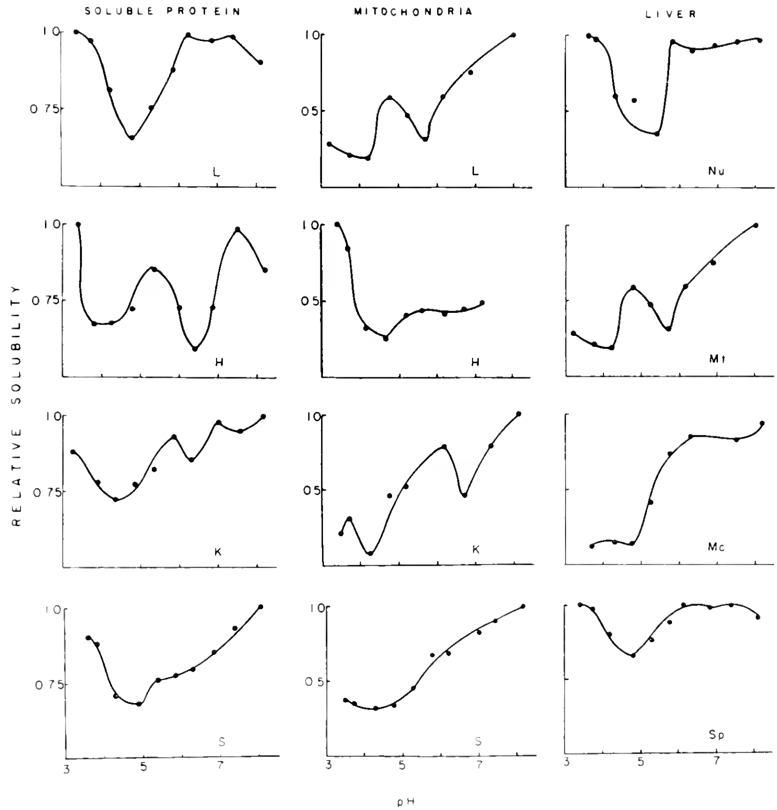


Fig. 2.—Results of first series of experiments: Relative Solubility of Cell Components from rat heart, kidney, spleen and liver as affected by pH. L, liver; H, heart; K, kidney; S, spleen; Nu, nuclei; Mt, mitochondria; Mc, microsomes; Sp, soluble protein.

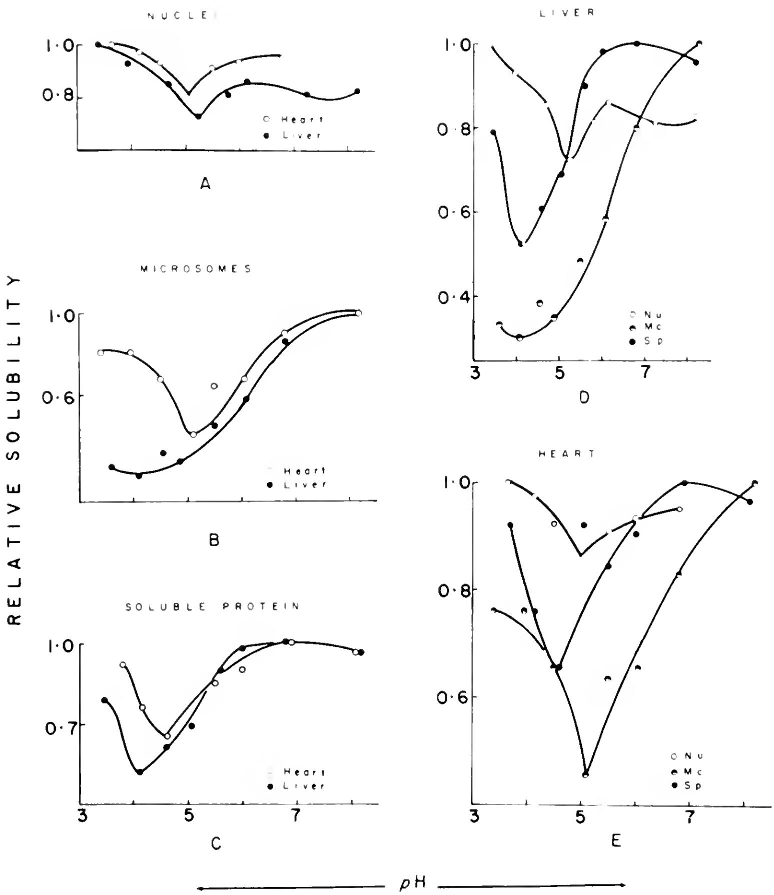


FIG. 3.—Results of second series of experiments: Relative Solubility of Components from rat heart and liver as affected by pH. Nu, nuclei; Mc, microsomes; Sp, soluble protein.

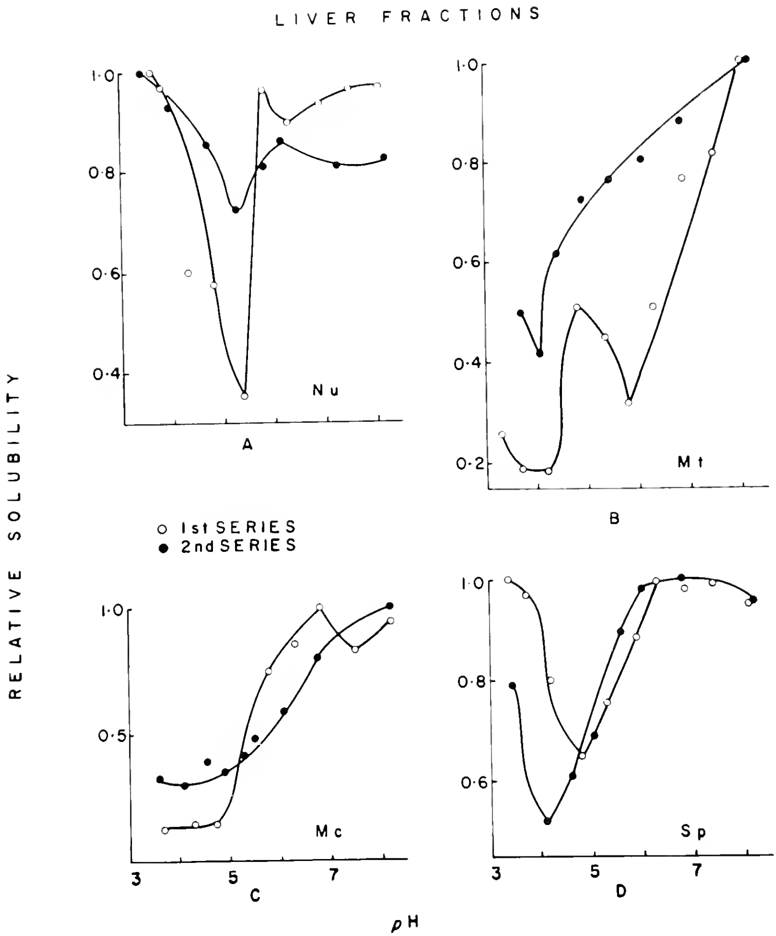


Fig. 4.—Comparison of the results of the first and second series of experiments for rat liver fractions. Nu, nuclei; Mt, mitochondria; Mc, microsomes; Sp, soluble protein.

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The Physicochemical Responses of Cellular Components to pH. II. Soluble Proteins and Microsomes from the Livers of Rats [1]

BY

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INTRODUCTION

Ergastoplasm is characteristically represented in electronmicrographs as a double-walled membrane on which are situated particles of RNP (1). Prevailing opinions (2) imply that the specific functions of cells such as the secretion of hormones or enzymes are accomplished by this membranous structure. Consequently, understanding the nature of the intracellular forces that induce these and other membranes to form is of importance in learning how cells do their work.

Gay (3) and Prescott (10) have stated that RNA is liberated from the nucleus into the cytoplasm. Anderson (4) has indicated that membranes can be induced to form *in vitro* from RNA-containing soluble proteins fractions by lowering the pH of the system to the vicinity of 5. The "pH 5 enzymes" of Goldstein and Holley (9) are analogous to the pH 5 protein of Anderson. These enzymes were reported to be inhibited in their substrate interaction by the presence of soluble RNA.

The work reported herein are further investigations of the effect of pH on *in vitro* responses by the soluble proteins fraction from rat liver. On the assumption that the microsomes derived by standard, high-speed, differential centrifugation are fragments of the ergastoplasm (1), the effects of pH on their solubility also were studied.

1. This work was supported, in part, by research grants from the Kansas Heart Association and the Office of Naval Research, NR 104-497, Nonr 2724 (00).

MATERIALS AND METHODS

In the first series of experiments on the effects of change in pH on rat liver soluble protein (Test I), the procedures of Anderson (5) were followed. All manipulations and tests were carried out in minimal time. The liver was obtained using the procedure previously described (6). Fractionations were carried out in a medium of M 150 phosphate-buffered, 0.25 M sucrose at pH 6.8. Only the soluble protein (ratlivsol) and microsomal (ratlivmic) fractions were saved. Both of these fractions were dialyzed against a large volume of unbuffered saline for 12 hours, with one change at 8 hours.

An aliquant of the dialyzed soluble proteins fraction was adjusted to pH 5 at room temperature with phosphate buffer, then centrifuged at 0° to 2° C. for 30 minutes at 8,000g. The fatty materials were removed by suction from the surface of the centrifuged supernatant. The clear supernatant was recentrifuged at 10,000g for ten minutes and was then considered to be free of "pH 5 protein."

A 0.1% solution of RNA (obtained as a powder from Nutritional Biochemicals Company), ratlivsol, ratlivmic and ratlivsol minus "pH 5 proteins" were subjected to the pH titration as previously described (6), using the Ward-Prideaux Universal buffer (7). The buffered solutions were centrifuged immediately for 30 minues at 2000g. The resultant supernatants were decanted into clean cool tubes, after which the pH and the protein nitrogen concentration in each solution were determined.

The procedures used in a second series of experiments (Test II) are shown in the flow chart of Figure 1. All sets of titrations were photographed after they had incubated at 0° to 3° C. for 72 hours. The tubes were then centrifuged for 30 minutes at 2000g. The pH values and protein concentrations of the supernatants were measured.

The discarded microsomal precipitate (line 4a, Figure 1) was weighed in a semi-moist state to give relative microsomal protein concentration in each of the two tubes. These reaction tubes were photographed before the microsomal protein was sedimented by centrifugation (line 4). The supernatants, L and K (line 4a), were allowed to stand 2 weeks at 0° to 3° C. before being adjusted to pH 5. The pH values were measured before and after each manipulation.

For simplicity in referring to the fractions obtained in lines 1 to 3 of Figure 1, the following nomenclature was adopted: Ratlivsol in sucrose, SRLSP; sucrose ratlivsol minus the pH 5 protein, SRLSP-SPRLSP; the pH 5 protein from sucrose ratlivsol, SPRLSP. Those fractions obtained in a saline medium were given the prefix N instead of S.

A paper-strip electrophoretic analysis was run on the three saline fractions at pH 8.6 using Veronal buffer. The paper strips were dyed with Beckman B-4 dye and analyzed on the Spinco Analytrol Model RA, slit width 1.5 mm., B-5 cam.

EXPERIMENTAL DATA

The results of Test I are shown in Figure 2. The 0.1% RNA solution and ratlivsol minus pH 5 protein (SRLSP-SPRLSP) exhibit almost straight-line flat solubility curves. Solubility of the RNA is lowest near the isoelectric point of RNP. Ratlivmic demonstrates only a slight loss of solubility at pH 4.6 and has the highest solubility at pH 9.9. The ratlivsol solubility curve is unlike that reported by Anderson (5) and us in prior studies (6). Although the low solubility point is at pH 5.4, the drop in solubility is not so sharp as we reported previously. In this ratlivsol sample the point of highest solubility is at pH 2.55.

Figure 3A shows the solubility curves of Test II in which saline-extracted fractions were obtained. Fraction NRLSP exhibits a sharp drop in solubility between pH 2.35 and 4.6 and a more gradual change in solubility between pH 5.0 and 7.2. The 58% drop in solubility is much more than the 20% drop reported by Anderson (5). The low solubility points extend over a wider range than that reported by Anderson. The NPRLSP fraction exhibits an even wider range of low solubility points than the NRLSP. The point of lowest solubility in NPRLSP is pH 5.35, the pH at which this fraction was removed after spinning NRLSP for 30 minutes at 0° C. Fraction NRLSP-NPRLSP exhibits a much smaller drop in solubility at pH 4.75 to 5.0 than does NRLSP.

The results of the electrophoretic analysis of the saline fractions are shown in Figure 4. Figure 4A shows that NRLSP has at least 3 major components. The per cents of total for components a, b, and c are 59.4, 18.9, and 21.7, respectively. Figure 4B shows that the e are at least 5 major components in fraction NRLSP-NPRLSP. The per cents of total for components d through h are 6.1, 15.3, 33.7, 19.4 and 25.5, respectively. Based on their relative mobilities, component a is similar to f, c is similar to h, and b is similar to g. Components c and h, and b and g have approximately the same relative concentrations. The total per cents of components d, e and f are approximately equal to component a. Therefore, component a seems to have changed partially to components d and e. Figure 4D shows that NPRLSP is a relatively pure species of protein as evidenced by the very slight amount of protein that had mobility toward the anode.

Figure 3B shows the solubility curves of the sucrose fractions SRLSP and SPRLSP. SRLSP exhibits a much steeper drop in solubility than NRLSP. The decrease in solubility is greater, however, for NRLSP than for SRLSP. Almost all the protein of fraction SPRLSP is precipitated at pH 5.1, the pH at which this fraction was removed after spinning SRLSP for 30 min. at 2000g and 0° C. The valley of the solubility curve of SPRLSP is deeper and more narrow than all other fractions.

Figure 5A is a photograph of the pH titration of NRLSP just before it was centrifuged (line 2, Figure 1). This is the visual representation of the solubility curve for NRLSP seen in Figure 3. A comparison of these two representations shows that they are indeed complementary. Note that although NRLSP is not at its highest point of solubility at pH 6.30, it is most highly dispersed at this pH. The sucrose ratlivsol did not exhibit this dispersion phenomenon at any of the pH values tested.

Figure 5B is a photograph of the pH titration of SPRLSP just before it was spun (line 2). Note that the dispersion phenomenon present in NRLSP is again present, although it did not appear in SRLSP. NPRLSP did not exhibit this phenomenon at any of the observed pH values. Due to technical difficulties, no solubility curve was obtained for SRLSP-SPRLSP. The pH and a photograph (Figure 5C) were, however, obtained. Note that there is very little difference among any of the precipitates at the different pH values. There is a somewhat greater amount of precipitate at pH 5.29, tube 4.

Figure 5D is a photograph of the ratkidmic (rat kidney microsome) and ratlivmic suspensions in ratlivsol minus pH 5 protein. After 72 hours at 0° to 5° C., the tube containing liver microsomes had a well-formed precipitate and a relatively clear supernatant. In contrast, in the tube containing kidney microsomes, the precipitate remained suspended. Both tubes were centrifuged at 30,000g to remove the microsomes. The pH of supernatants of both tubes was 6.15 before and after centrifugation (Figure 1) and were the same light amber color. There were no observed changes in pH of the mixtures during the two weeks the supernatants remained in the cold. When the pH was lowered again to 5, after the 2 weeks incubation, both supernatants became turbid and contained approximately the same amount of precipitate after spinning. Except for a small amount of material, the new pellets dissolved at pH 7.2.

DISCUSSION

The most striking result of Test I is that, when the pH 5 protein is removed from ratlivsol and the supernatant protein solution is tested immediately, no appreciable amount of precipitate forms in the pH range 2.1 to 10.0. This means that all pH-labile proteins are removed from ratlivsol at one pH. Thus, there seems to be only one protein in ratlivsol which is characteristically insoluble at its isoelectric point.

The flat solubility curve of RNA indicates that soluble RNA does not precipitate in the pH ranges tested and, hence, is not responsible for the solubility curves of the fractions. The solubility of ratlivsol is highest, moreover, at the pH at which RNA is least soluble.

The differences in the results of Tests I and II were the shape of the ratlivsol curves, and the reappearance of pH 5 protein in RLSP-PRLSP in Test II as opposed to the non-appearance of it in Test I. These divergencies are not contradictory and are due to the differences in reaction times in the two tests.

The reason for the wide range of low solubility points for RLSP in Test I, that had a reaction-time of 30 minutes, would seem to be that much of the pH-labile protein had not been completely converted to its insoluble state. Some of the protein that precipitated at the pH ranges 2 to 4 and 6 to 10 was similar to, but not like pH 5 protein. These similar proteins were mutating toward the insoluble state and they lost some of their ability to remain soluble in transit. In Test II the reaction time was 72 hours rather than 30 minutes and in this time, most of the mutating protein was stabilized as pH 5 protein.

The differences between the curves in Tests I and II for RLSP-PRLSP give weight to the reality of intermediate forms. In Test II the 72 hours were sufficient to allow the intermediate protein forms to attain a pH stabile state. There is, of course, the possibility, too, that there was sufficient time for more pH labile protein to be synthesized by soluble RNP in the brei.

Using fast tissue-processing procedures, Anderson (5) obtained 7 or 8 major electrophoretic components for ratlivsol. With slower processing, we obtained only 3. Soon after treatment the RLSP-PRLSP demonstrated 7 major electrophoretic components; 24 hours later it demonstrated only 5. In both cases the RLSP showed only 3 components.

After separating the soluble protein fraction from the mitochondria, the energy source of the cell, and eliminating the need for the products (if any) of the soluble protein by other intracellular structures, or other cells, or other tissues, we have obtained a closed energy system. No energy is supplied to the system nor extracted from it in the natural metabolic sense. Under these conditions, the entropy of the soluble proteins fraction will increase. Increase in entropy should lead to a mutation of the proteins in the system to yield the most stabile system possible. Our results indicate that incorporation of the free energy in the system by the several proteins leads to the establishment of three protein forms which are stabile. Much of the results of this work can be explained in terms of the delta phi mechanism. For example, the development of several protein forms in RLSP-PRLSP from the three protein forms of RLSP could be the result of adding more free energy (in the form of H^+) to the run-down RLSP. The delta phi mechanism could also be applied to the rather broad pH labile range observed for PRLSP. There were 72 hours for this system to lose energy and convert its protein to stable forms.

In the natural metabolic state the hyaloplasm proteins are saturated with free energy. There are many forms of the same protein doing different chores. When removed from the energy source, the reversible mutability of the proteins is destroyed. Adding energy to the unnatural test-tube state of the proteins will partially restore the capacity of reversible mutability.

The electrophoretic results give further weight to the reality of mutable protein. Our results indicate that pH 5 protein is derived from all the proteins present in the soluble protein fraction. We consider components d, e, and f to be derived from the a component because the relative amounts of components a, b, and c did not change after the pH 5 protein had been removed. Component a seems to be the most easily changed of the three original components. Two of the components d and e, derived from a, have an isoelectric point above pH 10. This is reasonable in that protein would probably not be conjugated or developed at or near its isoelectric point.

We realize that the existence of the ergastoplasmic membranes may be an artifact of fixation in the electron microscope and, further, that the pH 5 insoluble protein may have nothing in common with these membranes if they do, in fact, exist. But assuming that the membranes are real and consist, at least partly, of pH 5 protein, then the following facts from our work are of interest. The presence of RNP in the form of microsomes, either from the heterologous or homologous organ, does not inhibit or prevent the formation of pH 5 protein in the RLSP-PRLSP mixture. Goldstein and Holley (9) have shown that RNA can inhibit the enzymatic activity of "pH 5 enzyme" which is the same as our pH 5 protein. These two facts would seem to indicate that we have at least part of the mechanism of ergastoplasm formation. It seems logical that RNA would need a rather inert bed to lie on, chemically speaking. It seems equally logical that RNA would not inhibit the formation of this "bed" in the hyaloplasm.

Earlier interpretations of the development of precipitates in ratlivsol or soluble proteins fraction from any organ implied that the changes were degradative with respect to normal protein structures in cells. The precipitate was considered to be denatured protein resulting from the disorganized and unnatural autolytic action of the enzymes in the brei of the cells. We suggest that the control and reversible regulation of the enzymes is lost as a consequence of the disruption of cells, and that the entropy of the system increases. The precipitates, however, are normal mutagenic activities for cellular systems. The precipitates that formed in our tubes were partially sensitive to pH. Some of the precipitated protein would dissolve above or below pH 5. Microchanges in pH that would permit formation or removal of membranes (precipitates) within this hyaloplasm are reasonable assumptions of normal cellular activity.

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FIGURE 1.—Scheme of manipulations used to study the effect of pH and microsomes on the formation of ultramicroscopic membranes from the "soluble" constituents of the tissues in the livers of rats. The solutions of sucrose and saline used were buffered to pH 7.12 with M/150 Na_2HPO_4 and M/150 KH_2PO_4.

Key:

Ratlivsol—the fraction of rat liver that could not be sedimented in 0.25 M sucrose after spinning at 30,000 g, 0° to 3° C. for 90 minutes.

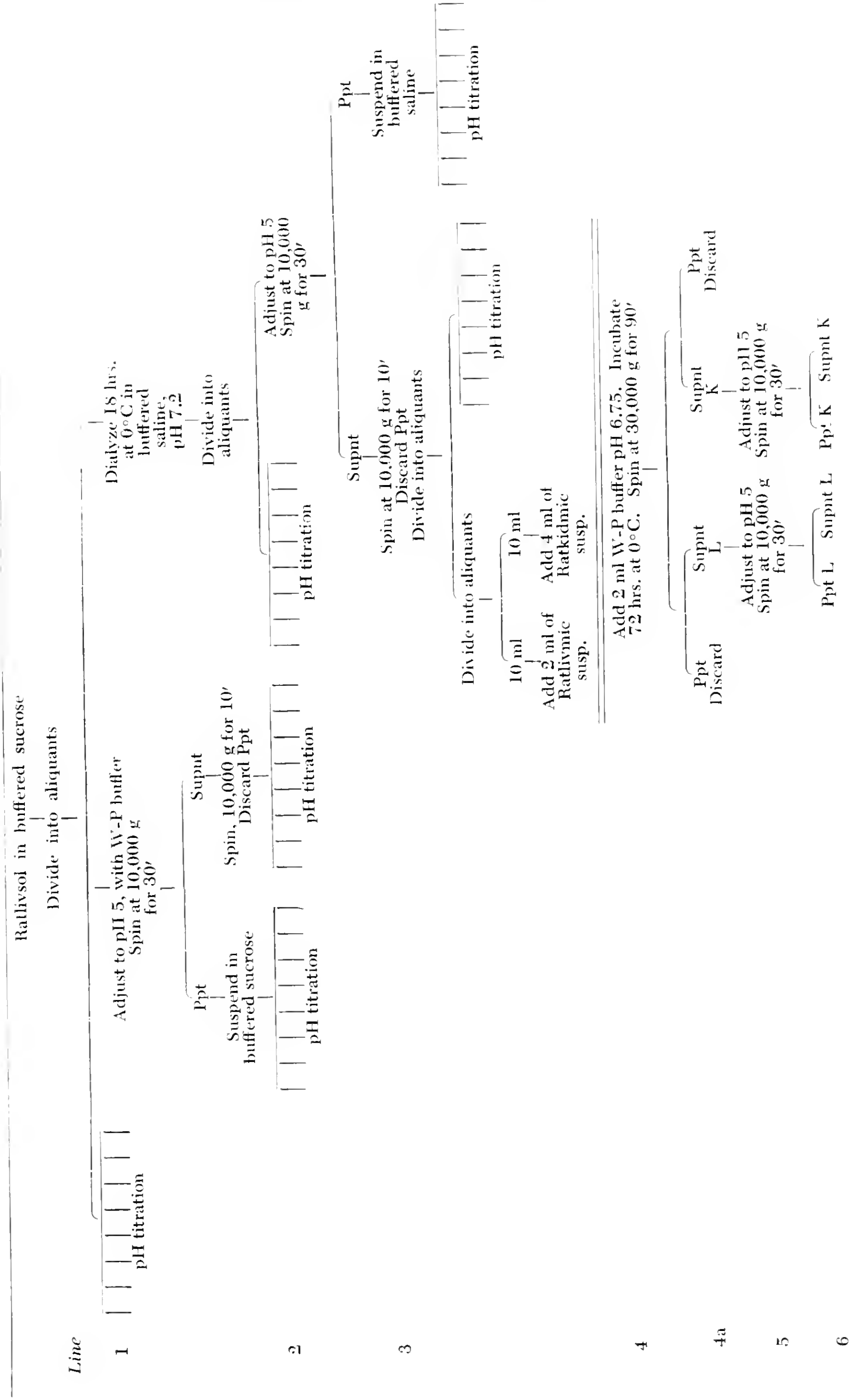
pH titration—the procedure of buffering aliquants of the various solutions or suspensions of liver material at pH values ranging from 2.35 to 8.25 using Ward-Prideaux universal buffer. The mixtures were incubated for 42 hours at 0° to 3° C. and each tube examined for the formation of or dissolution of precipitate, as was pertinent. After spinning at 3,000 rpm for 15′, a Nessler's nitrogen determination was made on the supernatant of each tube.

Ratlivmic—a suspension of microsomes from rat liver.

Ratkidmic—a suspension of microsomes from rat kidney.

W-P Buffer—Ward-Prideaux Universal Buffer.

FIGURE 1


Line
1
2
3
4
4a
5
6
Ratlivsol in buffered sucrose
Divide into aliquants
pH titration
Adjust to pH 5, with W-P buffer
Spin at 10,000 g
for 30′
Ppt
Suspend in buffered sucrose
pH titration
Supnt
Spin, 10,000 g for 10′
Discard Ppt
pH titration
Dialyze 18 hrs. at 0° C in buffered saline, pH 7.2
Divide into aliquants
pH titration
Adjust to pH 5
Spin at 10,000 g for 30′
Supnt
Spin at 10,000 g for 10′
Discard Ppt
Divide into aliquants
Divide into aliquants
10 ml
Add 2 ml of Ratlivmic susp.
10 ml
Add 4 ml of Ratkidmic susp.
pH titration
Ppt
Suspend in buffered saline
pH titration
Add 2 ml W-P buffer pH 6.75. Incubate 72 hrs. at 0° C. Spin at 30,000 g for 90′
Ppt
Discard
Supnt
L
Adjust to pH 5
Spin at 10,000 g
for 30′
Ppt L
Supnt L
Supnt
K
Ppt
Discard
Adjust to pH 5
Spin at 10,000 g
for 30′
Ppt K
Supnt K

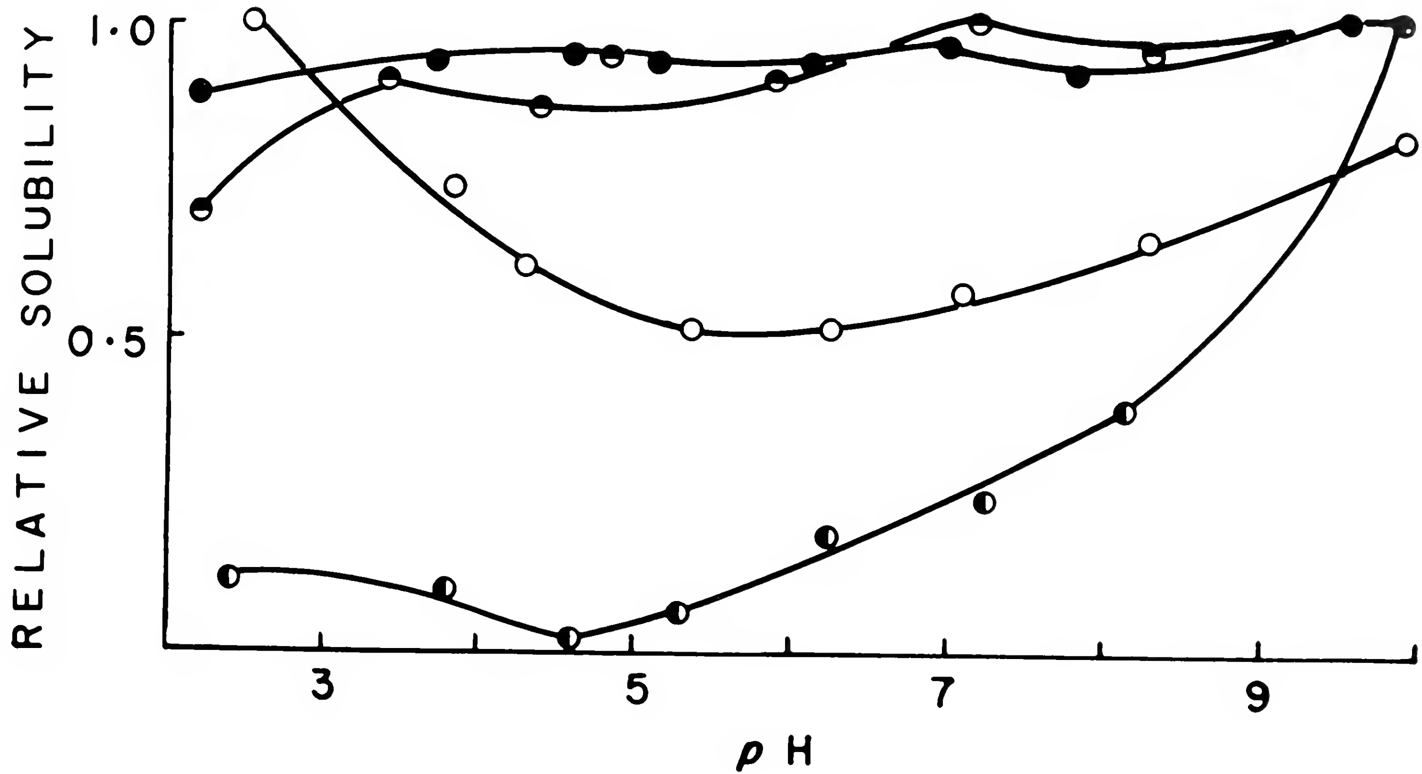


FIGURE 2.—Results of Test I: Relative solubility of a 0.1% RNA solution ◒; ratlivsol, ○; ratlivmic, ◐ and ratlivsol minus pH 5 precipitative protein, ●.

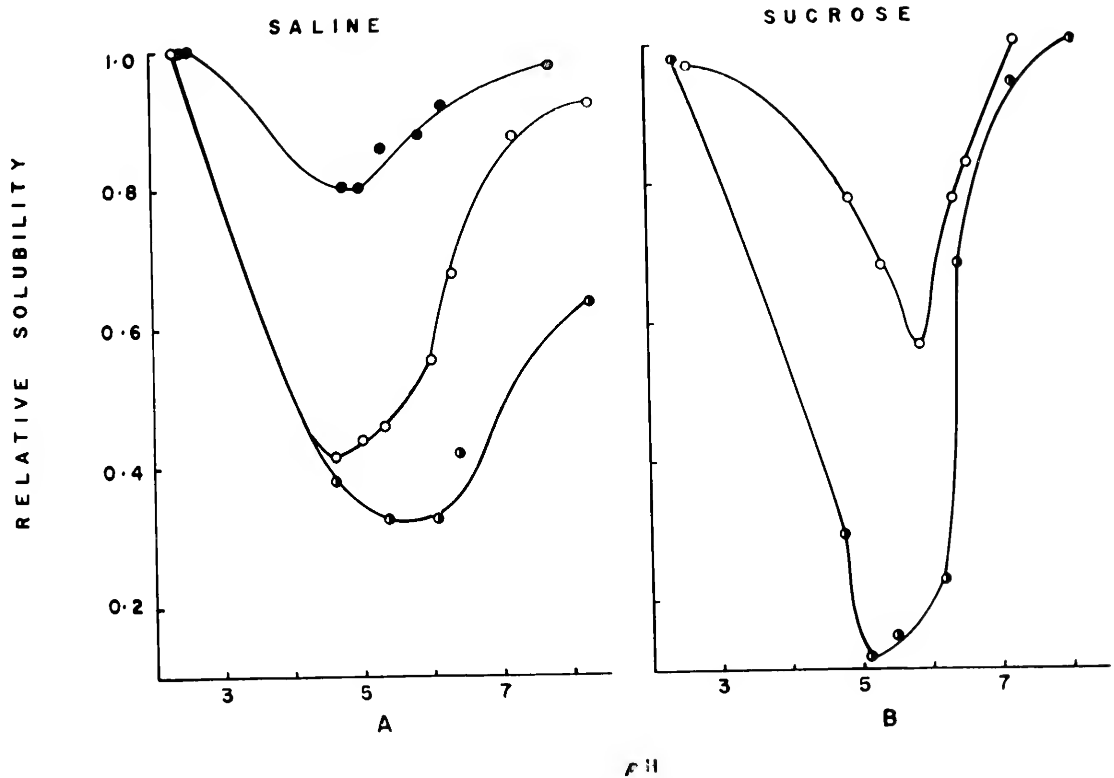


FIGURE 3.—Effect of pH on relative solubility of saline and sucrose extractions of ratlivsol and its two fractions. Ratlivsol, ◯; pH 5 precipitative protein from ratlivsol, ◑, and ratlivsol minus pH 5 precipitative protein, ●.

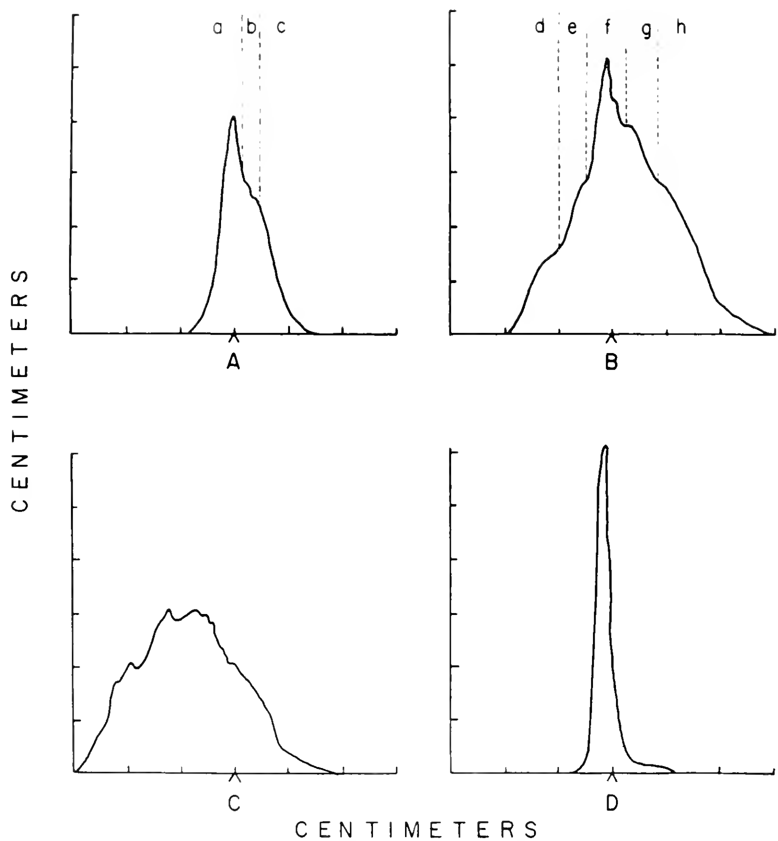


FIGURE 4.—Paper electrophoretic tests of tissual fractions from rat liver. The mark on the abscissa identified the point of origin of each run which was made at pH 8.6. A—saline-extracted rat liver soluble protein. C—saline-extracted rat liver soluble protein immediately after precipitation of its pH 5 insoluble protein. B—sample C 24 hours later. D—pH 5 insoluble protein from rat liver.

FIGURE 5

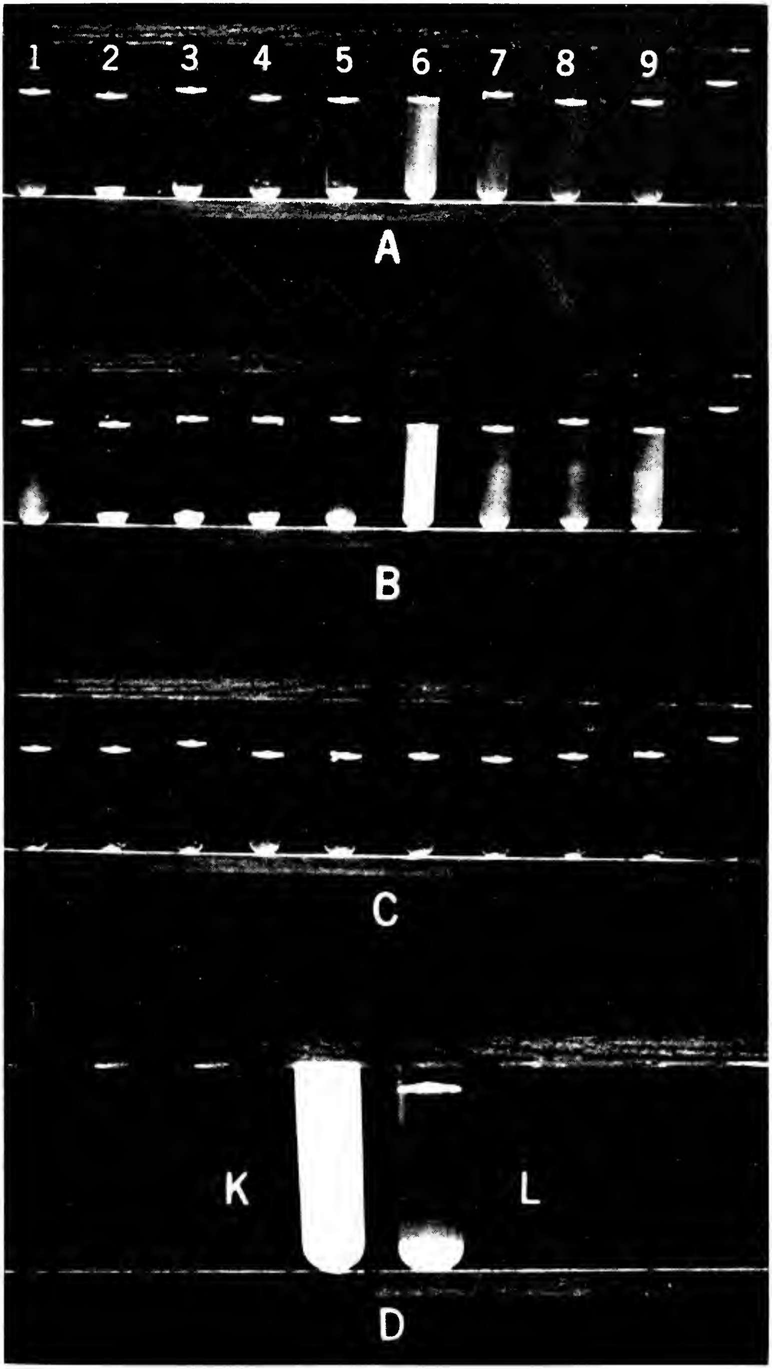
A. A pH titration of saline-extracted rat liver soluble protein. pH of tubes 1 to 8: 2.37, 4.62, 5.00, 5.33, 6.00, 6.32, 7.20, 8.28. Tube 9, saline control, pH 6.87; unnumbered tube, optical control.

B. A pH titration of sucrose-extracted pH 5 insoluble protein from rat liver. pH of tubes 1 to 8: 2.40, 4.75, 5.10, 5.48, 6.20, 6.46, 7.25, 8.10. Tube 9, saline control, pH 6.60; unnumbered tube, optical control.

C. A pH titration of suerose-extracted rat liver soluble protein minus its pH 5 insoluble protein. pH of tubes 1 to 8: 2.37, 4.70, 5.00, 5.29, 6.02, 6.37, 7.23, 8.05. Tube 9, saline control, pH 6.20; unnumbered tube, optical control.

D. Suspensions of microsomes from rat kidney (K) and from rat liver (L) in a solution of rat liver soluble protein minus its pH 5 insoluble protein after 72 hours at pH 6.15.

FIGURE 5



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