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TULANE STUDIES IN ZOOLOGY

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(Complete in 3 parts

A NEW *EULIMNADIA* FROM THE RICE FIELDS OF ARKANSAS WITH A KEY TO THE AMERICAN SPECIES OF THE GENUS

(CONCHOSTRACA, LIMNADIIDAE)

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A NEW *EULIMNADIA* FROM THE RICE FIELDS OF ARKANSAS WITH A KEY TO THE AMERICAN SPECIES OF THE GENUS (CONCHOSTRACA, LIMNADIIDAE)

N. T. MATTOX

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Los Angeles, California.[1]

During the course of studying mosquito larvae in the rice fields near Stuttgart, Arkansas, Dr. F. E. Whitehead, Professor of Entomology at the University of Arkansas, encountered numerous specimens of a conchostracan phyllopod which were forwarded to the writer for determination. This, a new species, represents the second of the genus *Eulimnadia* to be collected in these rice fields by Dr. Whitehead. The other species, *E. alineata* Mattox, was collected near Stuttgart in August 1948 and again in June 1949. This presents an interesting ecological situation with two so different species occurring in the same region and in the same ecological niche. The present species is radically different from *alineata.* The name *Eulimnadia oryzae* is here proposed for this new species. The specific name refers to *Oryza,* the generic name of the rice plant.

EULIMNADIA **ORYZAE**, *sp. nov.*

Male.—With the characters of the genus (Packard, 1883, and Daday, 1926). The bivalved shell is practically colorless, transparent, and elongate-oval (fig. 1). The dorsal margin is only slightly rounded with the highest elevation at the umbo approximately one-third the length from the anterior margin. The ventral margin is regularly rounded, the posterior end is more elongate than the anterior. The length of the adult shell averages 6.8 mm with an average height of 4.2 mm. The variations in the type lot are 7.5 by 4.5 mm to 6.3 by 3.8 mm. The lines of growth vary in number from 10 to 12, and are usually crowded.

The head possesses the typical pyriform frontal organ which is located near the base of the eye protuberance (fig. 6). The front is moderately concave, the greatest concavity just above the ocellus; the rostrum is not greatly extended. The head is held in a position such as to place the eye protuberance directly forward; the head gives the impression of being quite small, much smaller than that of the female. The scape of the second antennae is very elongate, one half the length of the scape extends beyond the tip of the rostrum. The flagella of the second antennae are variously spined (not figured) and have nine segments each, the two flagella are of approximately the same length. The first antennae extend to the third segment of the second antennae flagella. The first antennae possess 12 to 15 dorsal sensory papillae.

The body bears 18 pairs of swimming appendages; the first and second are modified into the typical gnathopods. The two segments of the digitiform sixth endite of the first gnathopod are unequal, the

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[1] Allan Hancock Foundation Contribution No. 136.

distal segment is approximately three times the length of the basal segment (fig 4). The distal segment of the more elongate sixth endite of the second gnathopod is approximately twice the length of the basal segment (fig. 5). There is a very conspicuous notch at the base of the "thumb" of the fourth endite on both the first and second gnathopod. The posterior 9 or 10 body segments bear mid-dorsal spines.

The telson is elongate, rhomboid in outline, the ventral margin only slightly more than one half the entire length of the dorsal spined margin (fig. 3). The dorsal ridges of the telson bear from 14 to 20 spines; 15 is the average number. The terminal telson claws (cercopods) are elongate and tapered, extending posteriorly and are longer than the dorsal margin of the telson. The dorsal forked filament arises between the third and fourth pair of telson spines.

Female.—The female shell (fig. 2) is similar to the male but much more ovate in outline. The dorsal margin is much more convex than in the male with the greatest height approximately one-third the distance from the anterior end. There is a slight concavity on the posterior portion of the dorsal margin. The average size of the adult female shell is 8.0 mm in length by 5.4 mm in height. The number of lines of growth averages 11, with a variation of 9 to 12 in the adult (egg bearing) females.

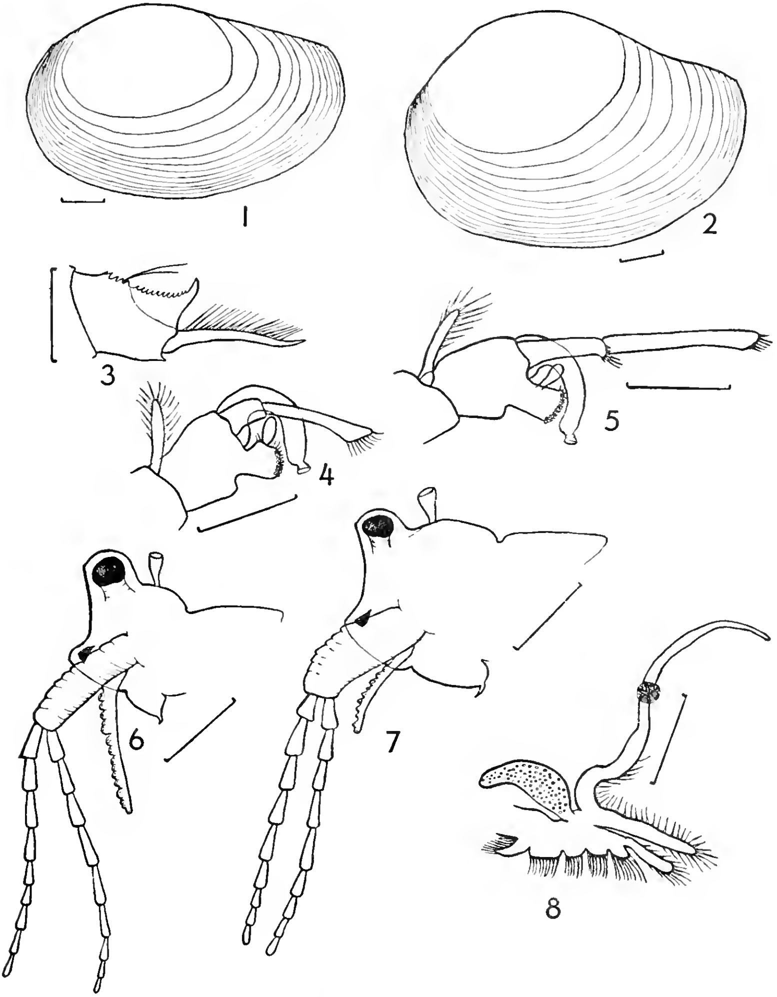
The front of the head is evenly and shallowly concave with a less pronounced rostrum than the male (fig. 7). In general outline the head of the female is much larger and more quadrate than the male. The second antennae are similar to those of the male. The first antennae are much shorter than in the male extending only to the first segment of the second antennal flagella. The occipital notch, as in the male, is very conspicuous.

The 18 pairs of swimming legs are unspecialized except for the elongated ovigerous epipodites of the ninth and tenth pairs. This epipodite is 2.5 times longer than the exopodite on the tenth pair (fig. 8). The dorsal body spines and the telson are similar to those of the male.

Type locality.—Rice fields at Stuttgart, Arkansas County, Arkansas.

Types.—Holotype, male, U.S.N.M. No. 96032; paratypes, both sexes, U.S.N.M. No. 96033; and in writer's collection.

Remarks.—Eulimnadia oryzae seems to be closely related to the eastern species *E. ventricosa* Mattox (1953), which is known from Virginia, Maryland, and Georgia. The shell of male *oryzae* is more elongate in outline and more attenuated posteriorly. The shell of females is not as full or elevated as in *ventricosa;* the length-height ratio of 1.5:1 as against 1.3:1 for *ventricosa.* The concavity on the posterior slope of *oryzae* is more pronounced than in *ventricosa.* The absence of color in the shell is distinctive for *oryzae.* The scape of the second antennae is longer in *oryzae;* the first antennae are proportionately shorter; the front is less concave; the telson is more elongate, and the cercopods longer in *oryzae* than in *ventricosa.* The basal segment of the sixth endite on the



Figures 1-8. *Eulimnadia oryzae,* sp. nov. **1.** Shell of male; **2.** Shell of female; **3.** Telson; **4.** First gnathopod of male; **5.** Second gnathopod of male; **6.** Profile of head of male; **7.** Head of female; **8.** Tenth swimming leg of female with egg on ovigerous epipodite. Scale lines for figures 4 and 5 equal 0.5 mm; all others are 1.0 mm.

first gnathopod of *oryzae* is proportionately shorter; the terminal segment of the sixth endite of the second gnathopod is proportionately longer than in *ventricosa.* The epipodite of the tenth leg of the female in *oryzae* is 2.5 longer than the exopodite, in *ventricosa* this proportion is less than 2.0. The number of growth lines on the shell and the number of telson spines are similar in *oryzae* and *ventricosa,* characters which separate these species from other North American forms. *E. alineata,* which has been taken from the rice fields in this same region, is smaller in size and is distinctive in lacking growth lines on the shell.

This species is based on one collection containing seven male and 33 female individuals taken on June 30, 1953 by Prof. F. E. Whitehead. Dr. Whitehead has indicated that these animals were so abundant that he believed there were actually thousands of them in a single cubic foot. The ecological notes, provided by Dr. Whitehead, in regard to the occurrence of these animals are worthy of note.

The rice fields typically are plowed in early spring and drilled to rice in April or May. Three to five weeks later, or when the rice is four to eight inches tall, the fields are flooded. After three to four weeks the fields are drained for the control of the rice water weevil. When the soil has become dry they are again flooded and kept under water until a week or ten days before harvest. The phyllopods occur in both the first and second flooding, but it is two or three weeks following the second flooding that they are most frequently extremely numerous. This is another indication of the rapid rate of development found in this group. *E. diversa* Mattox (1937) was shown to mature in 14 days.

Another interesting observation made by Dr. Whitehead indicates an unexpected resistance of these animals to insecticides. During field experiments a number of chlorinated hydrocarbon insecticides gave almost complete control of the mosquito larvae and produced a high mortality among other aquatic invertebrates present. However, without definite quantitative data it was observed that even at the higher strengths of insecticides there was an extremely low mortality among the phyllopods. These observations suggest some unknown physiological resistance possessed by *Eulimnadia* and possibly by other members of the order. To the best of the writer's knowledge the Conchostraca have not been extensively studied so far as physiological properties are concerned.

THE NORTH AMERICAN SPECIES OF *EULIMNADIA*

The genus *Eulimnadia* was proposed by Packard (1874) in order to separate this genus from *Limnadia* Brongniart 1820, the other member of the family Limnadiidae. This family is comprised of conchostracan phyllopods, those with a bivalve shell, possessing a pyriform, pediculated frontal organ on the mid dorsal surface of the head. The 18 pairs of trunk appendages, the conspicuous ventral spine on the telson at the base of the cercopods, and the second antennae flagella with 9 segments are the distinctive characters of the *Eulimnadia*. These characters were established by Daday in his monograph of the conchostracans in 1926.

The various *Eulimnadia,* as well as most of the conchostracans, usually appear in temporary pools during the warm months of the year. Some collections have been made in very small pools of rain water that appeared and dried up within two weeks. Many of the species of this genus are known only from their type localities indicating a very restricted range. Other species seem to be more widely dispersed. Members of this genus do not attain large size; all are less than 10 mm in shell length; most average 5 or 6 mm.

The morphological characters most used in separating the species are: the lines of growth on the shell; the size and shape of the shell; the telson spination; the form of the head; the male gnathopods, and the relative lengths of the antennae. The following is a key to the known species of the genus *Eulimnadia* found in North America. This key is intended only for sexually mature individuals. Maturity is judged on the basis of the presence of gravid females carrying egg masses on the modified epipodites of the ninth and tenth legs.

KEY TO THE GENUS *EULIMNADIA* OF NORTH AMERICA

1. Shell with lines of growth 2

Shell with no lines of growth; 4.2 by 2.6 mm average; 9 to 12 telson spines; forked filament of telson between spines 3 and 4. ....*Eulimnadia alineata* Mattox 1953

Known only from rice fields at Stuttgart, Arkansas.

2. Shell with one to four lines of growth; elongate, not strongly convex dorsally 3

Shell of females with 5 to 12 growth lines; usually ovate and convex dorsally 7

3. Telson with 9 or 10 dorsal spines 4

Telson with 12 to 16 dorsal spines 5

4. Shell 5 to 6 mm long by 3 to 4 mm wide; one to four growth lines; rostrum rounded; forked filament arises between telson spines 3 and 4. ....*Eulimnadia antillarum* (Baird 1852)

Has been taken in Louisiana and Mexico.

Shell 4.3 by 2.5 mm average; one to four growth lines; rostrum pointed; first antennae extend to fifth segment of second antennae in male; forked filament arises between telson spines 2 and 3. ....*Eulimnadia francesae* Mattox 1953

From pools on Bear Island, Potomac River, Montgomery Co., Maryland.

5\. Shell normally with two growth lines; shell of males averages 4.2 by 2.5 mm; front of head slightly convex; first antennae of male extend to fourth segment of second antennae; forked filament of telson between spines 3 and 4. .... *Eulimnadia diversa* Mattox 1937

Has been found only at Urbana, Illinois.

Shell with three or four lines of growth; 6 to 7.5 mm in length 6

6\. Telson with 12 dorsal spines; forked filament arising between telson spines 1 and 2; rostrum not pointed and inflected; shell size average 6.2 by 3.8 mm; first antennae of male do not extend beyond scape of the second antennae. .... *Eulimnadia agassizii* Packard 1874

Known only from Penikese Island, Massachusetts.

Telson with 16 dorsal spines, forked filament arising between spines 6 and 7; rostrum strongly pointed and inflected; males shell size average 7.3 by 4.3 mm; first antennae of male extend to fourth segment of second antennae. .... *Eulimnadia inflecta* Mattox 1939

Found at Prophetsown, Illinois, and Athens, Ohio.

7\. Female with five lines of growth; mature size less than 8 mm in length 8

Lines of growth 7 to 12; mature size more than 8 mm 9

8\. Shell size averages 5 by 3 mm; 7 to 9 telson spines; male first antennae slightly longer than those of female; rostrum of male extended and sharply pointed. .... *Eulimnadia antlei* Mackin 1940

Taken at three localities in Oklahoma.

Shell size averages 7 by 4 mm; telson with 16 to 20 spines; male first antennae extend to third segment of second antennae, in female shorter; rostrum rounded. .... *Eulimnadia texana* Packard 1871

Widely distributed in Texas, Kansas, Nebraska, and Oklahoma.

9\. Male first antennae extend beyond scape of second antennae; forked filament of telson arises between spines 3 and 4. 10

Male first antennae extend only to end of scape of second antennae; forked filament of telson arising between spines 5 and 6; 14 pairs of telson spines; average of 10 growth lines; shell size averages 8.5 by 6 mm .... *Eulimnadia stoningtonensis* Berry 1926

Has been found only at Stonington, Connecticut.

10. Male first antennae extend to second segment of second antennae; 14 to 20 pairs of telson spines; average size of shell 8.1 by 5.5 mm; females have an average of seven growth lines; rostrum of male not attenuated anteriorly. .... *Eulimnadia thompsoni* Mattox 1939

Found in pools on an island in the Illinois River at Ottawa, Illinois.

Male first antennae extend to third segment of second antennae; 10 to 12 growth lines. 11

11. The male rostrum is attenuated to a sharp point, slightly inflected, front concave; shell very ventricose; shell length-height ratio 1.3:1; telson cercopod length same as dorsal margin of telson; 14 to 16 dorsal telson spines; second antennal scape extends to tip of rostrum. .... *Eulimnadia ventricosa* Mattox 1953

Taken at several localities in Maryland, Virginia, and Georgia.

The male rostrum pointed but not greatly inflected; front slightly concave near rostral base; the occipital notch is conspicuous; growth lines crowded; shell length-height ratio 1.5:1; telson cercopods longer than dorsal telson margin; 14 to 20 dorsal telson spines; telson elongate; second antennal scape extends one-half length beyond rostrum. .... *Eulimnadia oryzae* sp. nov.

From ricefields at Stuttgart, Arkansas.

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STUDIES IN THE ECOLOGY OF THE NARROW-MOUTHED TOAD, *MICROHYLA CAROLINENSIS CAROLINENSIS*

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STUDIES IN THE ECOLOGY OF THE NARROW-MOUTHED TOAD, *MICROHYLA CAROLINENSIS CAROLINENSIS*[1]

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Orange, Massachusetts

Microhyla has received little attention from students of the Amphibia. The most extensive material is that of Wright (1932), Bragg (1943, 1950a, 1950b), and Freiburg (1951). This study contributes to our knowledge of the subspecies *Microhyla carolinensis carolinensis* and to our general understanding of anuran behavior.

The nomenclatural history has been outlined by Hecht and Matalas (1946) who concluded that *M. olivacea* and *M. mazatlanensis* should be considered as subspecies of *M. carolinensis*. Their view is followed in this paper but further evaluation of the systematics of these populations is required.

METHODS

The detailed procedures for both the field and laboratory researches are presented in pertinent sections of this report; only the general approach and sources of material are considered here.

Field studies during an eighteen-month period gave the author an opportunity to become thoroughly familiar with the species. Knowledge gained from seven weeks of observation in Louisiana and Florida was especially valuable.

Population samples were taken at several places near New Orleans, and from pine forests near Angie, Washington Parish, Louisiana. The New Orleans area material came from four localities: levees along the Bonnet Carré Spillway (St. Charles Parish, La.); levees along the Mississippi River near the Huey P. Long Bridge (Jefferson Parish, La.); abandoned fields at Camp Plauche (near Harahan, Jefferson Parish, La.); and, cypress swamps in Tulane University's Sarpy Wildlife Refuge (near Norco, St. Charles Parish, La.).

From the examination of 579 individuals (fresh and preserved) data were gathered for study of population composition, reproductive cycles, growth, and food habits. Snout-vent length measurements were made with a vernier caliper. Secondary sex characters were noted. The abdominal cavity was opened and the gonads were examined. Stomach contents of 203 individuals were analyzed.

Breeding behavior was observed in the field and laboratory. Ma-

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[1] From a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science of the Graduate School of Tulane University.

[2] The work was done under the direction of Dr. Fred R. Cagle, to whom the author wishes to express his gratitude for the inspiration and criticism that made the study possible. Dr. Harley N. Gould, of Newcomb College (now emeritus), also gave generous aid in interpretation of the cytological material.

cerated fresh pituitary glands were injected intraperitoneally to stimulate breeding activity in the laboratory.

ENVIRONMENT

Environmental Factors

Field observations suggest that there are two environmental factors which limit, more than any others, the distribution of this species in Louisiana. These two factors, moisture and cover, are closely related. The importance of moisture to these frogs and their extreme susceptibility to drying were demonstrated in trapping studies at Camp Plauche.

Traps used in these studies were constructed from 1/16″ mesh wire screening. The area was an abandoned and partially overgrown dump, providing abundant cover in the form of piles of tar paper, plaster, tin cans, and scattered boards and timbers. There was a sparse to dense covering of low grasses with an upper stratum of dense weeds including such forms as ragweed (*Ambrosia* spp.) and goldenrod (*Solidago* spp.). In the immediate area of the traps there was a stand of low willow (*Salix nigra*) which shaded some of them. Despite the shade it was necessary to check these traps within two hours after sunrise in order to prevent death of almost all individuals from desiccation. Even on cloudy days death resulted within four or five hours if the animals were not removed from their exposed position.

Desiccation makes these frogs vulnerable to predators, especially small ants (*Iridomyrmex humilis*).

Another apparent effect of moisture was the variation in the effectiveness of hand collecting methods at various periods during the year in the Camp Plauche area. In the moist spring months *Microhyla* was abundant under surface cover such as logs, old cardboard, and other debris. As the weather became drier, specimens became more and more difficult to discover in this manner. All cover had been carefully replaced and no animals had been removed from the area. By August and Stepember several hours of intensive search failed to reveal a single specimen. Possibly there had been a migration of the population from the immediate area to contiguous places, but thorough search failed to reveal individuals. Sporadic trapping during this period produced few frogs. This indicates that at least a few individuals remained and sought out retreats at some depth in the earth. By the following spring the accessible population had returned to its original level.

Many other factors influence the distribution of the frogs. Substrate in the habitat may range from permanently or temporarily flooded swamp or marsh to dry sandy pinelands. The amount of litter, duff, and humus differs greatly. That the substrate does affect population density was indicated by studies of pineland populations. Anderson, Liner and Etheridge (1952) found that the size of *Microhyla* populations in a Louisiana pineland area fluctuated with the depth of the organic layers of the soil.

In all habitats there seems to be a distinction between simple overhead cover, as characterized by boards, paper, tin cans, logs, or stones, and more complicated covers, where various crevices, crannies, or burrows are used. In cypress swamps near New Orleans *Microhyla* is often found buried in rotten logs and stumps, usually in relatively loose, soft wood. One individual was taken in a dead stump eight feet above the ground. Stumps have also provided the greatest concentrations thus far discovered. On March 15, 1950, a low hollow stump with an inside diameter averaging thirty inches produced twenty-six juveniles in a stratum six inches thick. Crevices between leaf bases of palmetto plants (*Sabal minor*) are used by *Microhyla* in swamps and in open thickets at the edge of the marshes. These log and palmetto covers often may be completely isolated by water of considerable depth during part of the year. Piles of hay or straw, and other decaying vegetation, such as the muskrat houses in marshes, are also favored cover types. All of these covers have at least two common factors, moisture and a loose structure which permits easy penetration.

Under certain conditions a short semi-burrow is constructed by the frog. Typically these are found where there is relatively loose overhead cover and the soil is granular. Under these circumstances a pear-shaped depression is hollowed out so that only the top of the animal's head is visible. This behavior was commonly shown by individuals on open levees.

Location of suitable breeding sites is also a factor that can exercise a limiting effect upon any anuran species. The wide adaptability of the present species, as shown in detail in a following section on breeding behavior, makes it unlikely that this factor can be of major importance anywhere in Louisiana.

Habitats

The foregoing remarks upon certain of the ecological requirements provide a groundwork for discussion of the ecological distribution of the species in Louisiana. Plant associations provide the best key to this distribution. The habitats favored by *Microhyla* may be divided into forest communities and non-forest or field and marsh communities.

Microhyla occurs in four major forest types: cypress-gum swamp, bottomland hardwood, live-oak ridges, and pine-oak uplands. The bottomland hardwoods and live-oak ridges have received little study.

A cypress-gum swamp in the Sarpy Wildlife Refuge has been studied intensively. The area is covered with a second growth cypress-gum forest interspersed with pure stands of cypress (*Taxodium distichum*) and of cut grass (*Zizaniopsis miliacea*) marsh. There are numerous "borrow pits" along the roads, and several sloughs and bayous partially covered by duckweed (*Lemna* spp.), water hyacinth (*Eichhornia crassipes*) and water fern (*Azolla caroliniana*). The water level fluctuates over a three foot interval. During a fourteen-month period the forest floor was uncovered for only about four months in late spring and summer. When the water is at a depth of only six or eight inches, there are numerous stumps, logs and hummocks exposed. The most productive collecting sites are floating or partly sunken logs, stumps, and the bases of palmetto plants.

The pine-oak community is essentially a dry environment in the areas studied. Longleaf pine (*Pinus palustris*) and post oak (*Quercus stellata*) are major forest trees. Along small streams and in moist depressions there are cypress-gum associations. Frequent burning removes much of the litter and the soil often has no considerable organic layer. Despite this, there appear to be large amphibian and reptile populations.

The non-forest habitats differ markedly from the forest types. They are abandoned fields, grassy levees, short grass areas (such as pastures, lawns, and golf courses), and marshes. Pure palmetto stands seem best considered as an intermediate type as they most often occur along the boundary zone between forest and marsh.

In abandoned fields and grassy levees the cover is about the same although the vegetation is different. The levees are typically covered with low dense grass, but may be grazed and thus belong in the short grass group. Abandoned fields are characterized by a mixture of grasses, weeds, and shrubs.

In urban areas, such as lawns and golf courses, the evaluation of the cover is difficult. There are always hedgerows or gardens where some cover exists, but thorough examination of such areas is difficult and no definite conclusion as to cover preference can be made.

Marshland communities are somewhat analagous to the cypress swamps in respect to water relationships, but have very different cover facilities. Such ridges as may be present may support live-oak (*Quercus virginiana*) or willow. Dr. Cagle tells me that where muskrats are present the frogs have been found in number in the lodges. Any hummock of organic material above the surface will often have one or more individuals buried in it.

BEHAVIOR

Diel Activity Cycle

Captive animals in outdoor terraria were observed at hourly or half-hourly intervals through the late afternoon and evening. The frogs burrowed in rotten wood during the day and moved to the surface at early dusk. Most individuals watched from concealment until it became almost fully dark and then began to move about in the open. Activity was typically much reduced by 10 to 11 P.M. Usually only one or two individuals out of six to ten in the terrarium were visible after midnight, whereas all were visible at dusk.

Field observations in Audubon Park, New Orleans, substantiated this pattern. Individuals were found moving about on the short grass of the golf course on many occasions at night. The peak of abundance was usually reached at the time full darkness began.

Movement

Locomotion on land is usually described as a scramble or crawl. This describes the escape behavior when disturbed. Locomotion of undisturbed animals may be described as a walk. Individuals have been observed in terraria and in the field to walk slowly and rather deliberately with the body well off the ground. When disturbed in the open where there is no cover readily available they will hop, covering distances up to twelve inches. They do not land well when hopping and usually fall at an angle so that they roll and have to regain their balance before starting the next hop, often in a different direction. Such erratic movement could have escape value.

In the water they are buoyant and swim well. Pope's statement (1919) that they do not dive is incorrect. Calling males and pairs in amplexus usually dive immediately when disturbed and individuals of both sexes floating in flood waters in the Bonnet Carré Spillway dived readily to escape capture.

Trapping yielded data on movement. The traps used at Camp Plauche were constructed of fine wire screen stapled to wooden frames. The frame consisted of one-inch strips nailed together to form a square, ten inches on a side. Between two square frames a single heavy piece of board, one or two inches wide and eighteen inches long was nailed. Screening was then attached to this frame to form a rectangular cage. The sides and one end were closed and a funnel of the same screening was set into the open end. This funnel projected inward for about eight inches and had an opening about four inches in diameter at the inner end. Drift fences eight to ten inches in height were constructed of asphalt siding stapled to stakes at intervals of about two feet. The angle of the fences leading into the mouth of the trap was about forty-five degrees. Before the fence was put down, the ground was scraped bare and, if possible, a shallow trench three inches wide was dug. The lower edge of the fence was bent and laid flat to the ground in the trench to form an apron on the inner side of the V, earth and debris were scraped over it and packed down to discourage animals from burrowing beneath the fence. Since it was hoped to study breeding movements, as well as normal activity, with these traps, they were placed around a small temporary pond. Five traps were used at the start of the study. All traps faced outward and were connected with an unbroken line of fence so that the pond was entirely fenced off. The line of the traps and the fence formed a clover-leaf around the pond with the traps at the angles between the leaflets.

Towards the end of the trapping period, which lasted from April 19 to May 22, two outgoing traps were added. They did not operate efficiently since there was no apron on the pond side of the fence and escape beneath it was probably not difficult.

All individuals found alive in the traps were tattooed with a number on the under surface of the thigh, sexed, measured, and released on the inner side of the fence. Since one of the returns had a faded and illegible number, it was feared that the markings were not holding and that many of the supposedly new individuals caught in the traps might be recaptures. For this reason six frogs were tattooed and kept in rotten wood in a moist terrarium for a period of two months and their markings were periodically examined. Although there was considerable fading, all but one of the numbers were clearly legible. The one illegible mark had faded, but there was no possibility of overlooking the fact that the individual had been marked. Therefore it is assumed that all unmarked individuals taken in the traps were being caught for the first time.

Trapping results show that considerable movement must have occurred (fig. 1). The first ten days of trap operations preceded the opening of the breeding season. In this period the average nightly catch was 2.7 individuals (1.0 males, 0.7 females, 0.7 juveniles). After the start of the breeding season there were twenty-three days of trap operation with an average nightly catch of 3.1 individuals (2.0 males, 0.45 females, and 0.5 juveniles). Nine trapped specimens were found dead and dried. These were included in the average nightly catch but could not be sexed or aged and thus cause a slight discrepancy between the two sets of figures. There were only five recoveries of marked individuals. All of these were less than six days after release and most were taken by lifting logs or other cover inside the fence. One was taken six days after its release inside the fence in an outgoing trap.

It appears that a large population was present and that there was considerable individual movement, both before and during the breeding season. An increase in total movement during the breeding season seems to be indicated by the trapping data. This increase occurs entirely among the males, and there is an apparent decrease in movement among females and juveniles.

The relative difference in movement of the sexes is strikingly demonstrated by examining the three large population samples which were based on movement and comparing them with samples taken by hand collecting. The sex ratios of all three samples are strongly in favor of males. Of 69 adults trapped at Camp Plauche, 52 were males and 17 were females (fig. 1). A sample taken from a pipeline ditch (Anderson, Liner, and Etheridge, 1952) during the breeding season consists of 147 males and 80 females. A February sample from an aggregation caused by rising flood waters has less disparity between the sexes (94 males and 55 females). The sex ratio was close to 1:1 in samples taken by hand collecting. Of 57 individuals taken in March, 29 were males and 28 females. Twenty-two of these came from the cypress swamps of the Sarpy Wildlife Refuge and 35 from the levee near the Huey P. Long Bridge. The swamp sample was made up entirely of immature individuals and consisted of 11 males and 11 females. The levee sample had 18 males (7 adults and 11 juveniles) and 17 females (13 adults and 4 juveniles).

These contrasting data in regard to sex ratios present a problem

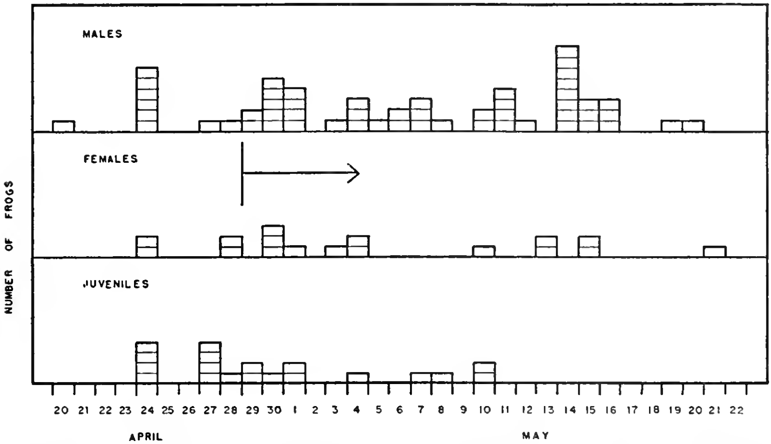

Figure 1. Summary of trapping data at Camp Plauche. Breeding activity (indicated by arrow) continued from April 29th throughout the study period. Each rectangle indicates one individual. Rainfall occurred on January 23-24, 27-30, and May 13-15.

in judgment. Either the movement is equal and the population truly predominantely male or else the sexes are about equal in numbers and the males are much more active. The case for greater activity on the part of the males seems the better one.

It is apparent this movement is related to the amount of moisture and the intensity of breeding drives. Temperature obviously also controls the activity. Samples taken in cold weather show a much greater percentage of empty stomachs than do those taken in warmer weather, indicating that periods of cold (50°F, or less) may prevent feeding over considerable intervals. In the New Orleans area field observations show that inactivity due to cold is sporadic and that the animals are generally active throughout the year.

Food Habits

Dickerson (1906) stated that *Microhyla* are generally eaters of ants.

Stomachs of 203 specimens were examined. These represent a year-round sampling from all habitats, though cypress-gum, short-grass and pineland habitats are best represented. Most food items are relatively undamaged in the stomach and can be identified readily. Food organisms were identified to order or family. A count was made of the individuals of each form present (Table 1). When the organisms were broken, heads were counted as whole individuals. Food items were sorted into piles and the percent of the total volume estimated for each form (Table 2). Stomachs are described as "full," "partly full," and "almost empty" (Tables 2, 3). Despite their smaller number the 40 "full" stomachs are probably the most representative indication of food habits. Organisms preyed upon by *Microhyla* range from 0.4 to 6.3 mm in length, averaging about 3 mm.

TABLE 1.
NUMBER OF INDIVIDUALS OF FOOD ORGANISMS IN FULL STOMACHS

Food Organisms	Mean	Maximum
Mollusca (snails)	1.5	2
Crustacea (Isopoda)	—	1
Arachnida (spiders)	2.0	4
Arachnida (mites)	1.2	2
Collembola	13.3	21
Isoptera	30.6	78
Coleoptera		
Carabidae	1.5	2
Curculionidae	1.6	4
Elateridae	1.2	2
Erotylidae	—	2
Scydmaenidae	2.0	2
Staphylinidae	2.9	8
Unidentified	1.4	3
Total Coleoptera	3.5	9
Lepidoptera	—	1
Hymenoptera		
Formicidae	65.6	248
Unidentified	1.0	1
Unidentified insects	2.5	7

Ants, termites, and small beetles are the principal items. Some of the beetles (scydmaenids, clavigerids, and staphylinids) are commonly associated with ants. Many of the organisms taken are secretive, suggesting that the frogs may feed while under cover as well as during the period of surface activity.

Food remains leave the stomach by late afternoon. When the material enters the large intestine, it is formed into fecal pellets 3 to 5 mm long and 2 to 4 mm in diameter.

Predation

No instance of natural predation has been observed in the field. Wright (1932) reported that *Microhyla* had been eaten by a garter snake (*Thamnophis sirtalis*). Anderson (1942) reported an instance of predation by the copperhead. Blair's (1936) report of *Microhyla* dwelling in tarantula burrows indicates that they may live unscathed in close association with formidable predators.

The secretion of *Microhyla carolinensis* has been thought to give it some protection from predators. If a bit of the mucous secretion touches one's eye, a violent burning sensation may persist for more than an hour. This secretion was also found to be irritating to the mucous membranes of the mouth and throat.

The functions of this skin secretion in protection of the animal from attack by ants was observed in the field on April 5, 1951. The following is an excerpt from field notes of that date.

> "Two individuals were found under a post which was swarming with small brown ants. When a frog was placed in the aroused colony numerous ants immediately

> attacked it. The frog sat very quietly and much material was secreted by the skin glands. The ants rapidly became entangled in this thick layer and their attention was diverted into attempts to escape rather than continued attack upon the frog. After a short while the frog ducked under a few lumps of dirt. When uncovered it was found free of ants. The frog was replaced among the ants and the procedure repeated. The next time the frog sought cover it could be seen that the mucous and the entangled ants were brushed off when the animal passed any object. (Captain Joseph Jones, U.S.A.F. identified the ants as *Iridomyrmex pruinosus.*)."

Field notes also show that this secretion may be toxic to other amphibians.

> "Thirty plus *Microhyla* in small bottle with four *Hyla cinerea* and one *H. squirella.* Upon reaching the laboratory *H. cinerea* and the *H. squirella* appeared dead. When washed in several rinses of water one of the *H. cinerea* recovered somewhat. It was placed in an aquarium and by noon the next day was stronger and had moved a little, but it weakened rapidly when handled. The tongue was partly extruded through the side of the

TABLE 2.
AVERAGE PERCENT BY VOLUME OF STOMACH CONTENTS

Food Organisms	Full Stomachs (Percent)	Partly Full Stomachs (Percent)
Mollusca (snails)	15.5	54.0
Crustacea (Isopoda)	22.5	—
Chilopoda	22.5	—
Arachnida (spiders)	9.3	9.1
Arachnida (mites)	1.3	6.3
Collembola	15.0	14.0
Isoptera	67.8	73.9
Hemiptera	3.7	11.4
Dermaptera	8.0	9.0
Coleoptera		
Carabidae	1.5	—
Clavigeridae	1.0	—
Curculionidae	15.5	19.8
Elateridae	10.0	18.2
Erotylidae	—	20.2
Scydmaenidae	3.5	5.0
Unidentified	7.5	17.0
Total Coleoptera	15.8	21.6
Lepidoptera	10.0	30.0
Hymenoptera		
Formicidae	69.0	58.2
Unidentified	5.5	—
Unidentified insects	17.6	19.2
Plant fragments	9.7	18.1
Sand	97.6	80.8
Unidentified material	41.7	38.2

> mouth and the mouth contained much slime and some blood. The next day the animal was found dead. Several of the *Microhyla* showed ill effects, but recovered shortly."

Some predation under abnormal conditions was found. *Microhyla* in the traps, handicapped by dehydration, were attacked and killed by small ants. Numerous ants would usually first be trapped in the frog's secretion and killed. On one occasion the headless body of a frog was found in a trap. It had apparently been killed and partially eaten by some small mammal.

Voice

In addition to the breeding call, which will be discussed in detail later, two other sounds are produced. Both are apparently protest notes. The first and most common one is a faint clicking produced when the individual is handled. The second, a chirp or squawk

TABLE 3.
FREQUENCIES OF OCCURRENCE OF FOOD ORGANISMS

Food Organisms	All Stomachs (203)	Full Stomachs (40)	Partly Full Stomachs (50)	Almost Empty * Stomachs (65)
Mollusca (snails)	4	2	2	—
Crustacea (Isopoda)	3	2	—	1
Chilopoda	2	2	—	—
Arachnida (spiders)	16	8	4	2
Arachnida (mites)	27	4	13	10
Collembola	7	3	3	1
Isoptera	12	6	3	1
Hemiptera	14	7	5	2
Dermaptera	2	1	1	—
Coleoptera				
Carabidae	2	2	—	—
Clavigeridae	1	1	—	—
Curculionidae	12	6	6	—
Elateridae	8	5	2	1
Erotylidae	1	—	1	—
Scydmaenidae	5	4	1	—
Staphylinidae	18	12	5	1
Unidentified	35	16	11	8
Total Coleoptera	58	23	20	10
Lepidoptera	2	1	1	—
Hymenoptera				
Formicidae	114	29	43	36
Unidentified	4	2	1	1
Unidentified insects	19	7	4	8
Shed skin	10	—	—	—
Plant fragments	36	9	13	10
Sand	26	5	9	8
Unidentified	25	6	13	6

* Other stomachs: Empty—32, Not noted—10.

sometimes given when the frog is roughly handled, apparently also replaces the clicking noise when the animal is in water. These sounds are made by both sexes.

REPRODUCTION

Gonadal Cycle

The reproductive behavior of most North American anurans has been assumed to be strongly cyclic. This conception is based on the sharply delineated breeding seasons of many frogs and toads inhabiting the northeastern portions of the continent. Bragg (1950a) on the basis of his field observations in Oklahoma, has strongly challenged the application of this view to several species. The question of cyclic versus non-cyclic patterns indicates a need for study of the gonadal cycles of many forms. The study of Glass and Rugh (1944) of the normal cycle of spermatogenesis of *Rana pipiens* in Vermont and the study of Fischer and Richards (1950) on the ovarian cycle of *Acris crepitans* in Oklahoma are the best sources of comparative information.

Sections of 44 testes and 31 ovaries were studied. Some ovaries and testes for cytological preparations were taken from fresh specimens and fixed in Bouin's, while others were taken from specimens which had been fixed in formaldehyde, washed in a deformalizing solution and placed in 50 percent alcohol, according to standard museum practice. There did not seem to be any great difference in the results obtained by these two methods. The gonads were embedded in paraffin and sectioned at eight microns. Mayer's haematoxylin or Galigher's haematoxylin was used, the latter usually proving more satisfactory.

Male Reproductive Cycle.—The appearance of the seminiferous tubules of the anuran testis has certain dissimilarities from that of the mammalian testis. The various stages of spermatogenesis are not evenly dispersed around the wall of the tubule, but are found in clusters which project out into the lumen and are distinct from other clusters. Rugh (1951) has suggested that each of these larger clusters may come from a single spermatogonium. There is no zonation inward from the tubule wall, but a linear arrangement of clusters along the wall. Sertoli nuclei are scattered close to the wall and do not occur in clusters. Spermatogonia occur singly or in small clusters.

The first step in interpretation of testes slides is identification of the several stages of spermatogenesis. Rugh (1951) describes the stages in some detail as found in *Rana pipiens*. His descriptions of spermatozoa, spermatids and secondary spermatocytes are readily applicable to the present species, but difficulty was encountered in identifying primary spermatocytes on the basis of his illustrations and descriptions. Rugh stated that nuclei of primary spermatocytes are irregularly spherical, very large, and never numerous. These characters readily fit nuclei which appear to belong to sertoli cells, but leave unidentified another type which is a major component of the seminiferous tubule wall. Because of this difficulty it is believed that a description of the stages as interpreted in this study is necessary.

Spermatozoa are easily identified. The heads are small, darkly stained, and bullet-like in shape. They may occur in clusters in the sertoli cells or scattered in the lumen of the tubules. All cells which have elongated nuclei are classed as spermatozoa.

Spermatids are small in size and usually consist of dense, darkly stained, circular nuclei, each surrounded by a ring of clear cytoplasm. These cells occur in clusters which extend into the lumen from the tubule wall and each cluster contains a large number of individual cells (mean 41.9). They usually differ from the secondary spermatocytes only in size and in the larger number of cells in a cluster.

Secondary spermatocytes occur in clusters containing a small number (mean 20.9) of cells larger than those found in spermatid clusters. Each cell consists of a medium-sized, dense, darkly stained nucleus with an outer ring of clear cytoplasm.

Primary spermatocytes occur in clusters which contain still fewer individuals (mean 13.5) and do not project very far into the lumen. The nuclei are large and granular, but are not dense or darkly staining.

Spermatogonia are much like the primary spermatocytes in appearance, but are smaller and often occur singly rather than in clusters. Since the change to primary spermatocytes is gradual, no exact criterion for separation is possible.

Sertoli cells have very large, pale granular nuclei. These may be irregular or regular and rounded in outline. They always occur singly, close to the wall of the tubule, and are never found in clusters. There are only a few (two to eight) visible in each tubule. They are often associated with clumps of spermatozoa which are obviously in sertoli cells.

Breeding activity of *Microhyla* in Louisiana occurs from the latter part of April until the middle of September. Testes of mature frogs taken throughout the year show all the maturation stages of spermatogenesis, but the relative numbers and the relative amount of space allocated to each stage varies greatly (fig. 2).

Testes of mature individuals taken in October are characterized by the presence of small numbers of spermatozoa scattered about in the lumen of the tubules. A few spermatozoa also are in sertoli cells, but nowhere do they occur in dense masses. Primary spermatocytes are the major component of the tubule wall.

Some November individuals show a condition similar to that found in October. In others spermatozoa have begun to increase in number, appearing in concentrations in sertoli cells. There is a marked decrease in the number of primary spermatocytes. These trends continue and by January the massed spermatozoa in the sertoli cells are so numerous as to cause a reduction in the size of the lumen. The primary spermatocytes have lost their place as the major component of the tubule wall and are found only in small scattered clusters.

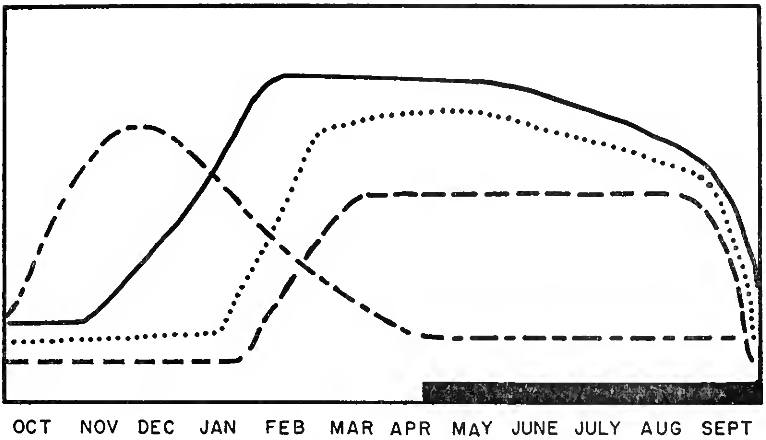

Figure 2. Spermatogenesis in *Microhyla c. carolinensis.* Solid line = spermatozoa; dashed line = spermatids; long dash-short dash line = primary spermatocytes; dotted line = secondary spermatocytes; wide solid black line at base of figure = breeding season.

In February the massing of the spermatozoa in sertoli cells reaches its peak. Massed spermatozoa nearly fill the lumen of the tubule and often extend outward to the tubule wall. Primary and secondary spermatocytes and spermatids occur in small clusters. The accumulation of the spermatozoa in the sertoli cells seems to be a slow, gradual process in the months after the close of the breeding season. During this period large numbers of secondary spermatocytes and spermatids do not occur.

The massed condition of the spermatozoa persists through the early part of the breeding season. With the initiation of breeding, however, there is a gradual thinning out of the spermatozoa in the sertoli cells and some appearance of massing in the lumen of the tubule.

For two months preceding the breeding season and during the first two months of the latter period a peak in general activity is reached. This is marked by the massing of the spermatozoa and by a great increase in the numbers of secondary spermatocytes and spermatids (fig. 2). This increase begins in March and the number of secondary spermatocytes and spermatids remains high through May and June.

In June there is a slow reduction in the number of secondary spermatocytes and spermatids, paralleled by a thinning out of the spermatozoa. There appears to be a very slight increase in the number of primary spermatocytes at this time. These trends continue through July and August.

In summary, the male gonadal cycle may be divided into two major phases. The first is the slow build up of spermatozoa following the cessation of breeding activity. This phase culminates in February with the massed spermatozoa filling the tubules. The second phase is initiated in March with the appearance of numerous secondary spermatocytes and spermatids. During the early part of the breeding season there is a height of spermatogenic activity characterized by the draining of mature spermatozoa from the supplies in the sertoli cells and a partial replacement of these from the developing secondary spermatocytes and spermatids. With the end of the breeding season the supply of the latter stages is no longer maintained and the spermatozoa are thus drained to a very low level, preparatory to the start of the first phase once again.

Secondary Sexual Characters and the Male Cycle.—Sexual dimorphism in *Microhyla* occurs in size, coloration, presence of vocal sacs, and presence of dermal modifications in the male. The size relationship will be discussed at another point in this paper, but the modification of skin pigmentation and structure show some cyclic fluctuations and will be considered here.

The black throat does not show marked cyclic changes and is characteristic of more than 85 percent of the males 22 mm or more in snout-vent length throughout the year. The throat of the male is usually abruptly darker than the abdomen and pectoral region. Some difficulty may be encountered in applying this character to strongly pigmented individuals. There is a slight intensification of this dark throat color during the breeding period.

Two secondary sex characteristics may be observed only in the breeding season. One, the presence of chin tubercles, was first described by Mittleman (1950). Tubercles may occur in a single or double row along the ventral surface of the lower jaw and may range from one to 28 in number. They are conical and project approximately 0.07 mm, as measured with an ocular micrometer scale. In the June sample of 129 males displaying a black throat, 114 showed tubercles. The second characteristic is the wrinkling or roughness of the skin of the whole throat area of the male. Wrinkling may be caused by the development of the vocal sac. There may also be small rough patches and occasionally transverse bands of tiny tubercles. There is great variation in these throat characteristics.

Female Reproductive Cycle.—The present study utilizes data derived from the study of gonad sections and the measurement of gross features of the female gonads. Examination of the gross changes in the ovary proved especially informative. This organ consists of a double-walled sack, normally divided into three to five lobes. The oogonia and the developing oocytes lie between the inner and outer walls of the sack. As the oocytes grow they bulge into the lumen of the ovary and are closely covered by the very thin inner membrane which forms most of the follicular wall. During their growth the oocytes pass through three distinct stages. Analysis of the occurrence of these stages furnishes a basis for determining the reproductive cycle.

The first of the oocyte stages is characterized by a clear, transparent cytoplasm having a whitish, granular-appearing nucleus. These cells have a diameter of from 0.08 to 0.45 mm, falling between 0.11

and 0.34 mm in most cases. These are present in all ovaries throughout the year. This clear stage is the only one present in all frogs less than 19 mm in length and in some up to a length of 22 mm.

Oocytes belonging to the second and succeeding stage of development become opaque and milky-white. They range in size from 0.23 to 0.77 mm and are found throughout the year in ovaries of most frogs over 20 mm in snout-vent length.

Oocytes belonging to the third and final stage are pigmented. These range in diameter from 0.69 to 1.49 mm. The smaller ones are pigmented throughout and are a dark brown color. The larger ones show a fully developed differentiation of the animal and vegetal poles, the former being a very dark brown, the latter white. The pigmented oocytes are present in individuals of more than 23 mm in length from January until breeding takes place. They are absent in all ovaries from late September until January.

In addition to developing oocytes, the walls and lumen of the ovary may contain degenerating pigmented oocytes. Some of these may be quite large and retain their shape while others are indicated only by small amorphous concentrations of dark pigment in the ovarian wall. These are believed to be oocytes which failed to ovulate or were caught in the ovarian tissues after ovulation. Presence of these oocytes suggests previous breeding, though they do not occur in all females which have had previous breeding seasons.

The ovaries of 142 frogs were examined. The ovarian wall was broken and the fragments studied under a dissecting microscope. The presence of various stages of oocyte development was noted and a sample of each class measured with an ocular micrometer. Since a random sample of each of the various stages could not be taken, ten or more oocytes of each class were measured representing the extremes and the apparent general trend. As the ovaries enlarge with the growth of the pigmented oocytes, many of the cells become angular. It is necessary therefore to search for oocytes which are still nearly spherical in making measurements.

The various oocyte types as outlined above also show certain cytological differences. The nuclei of the small oocytes, belonging to the clear variety, are regular in outline and have a few dark-staining, rounded nucleoli near the edge. The cytoplasm of these small oocytes may sometimes show large, radially oriented vacuoles. These vacuoles are reduced in size with the growth of the oocytes and eventually disappear entirely. They may contain small, dark-staining bodies and it seems possible that these have some relation to the yolk nuclei reported in *Bufo* by King (1908) and in *Acris* by Fisher and Richards (1950). The nuclei of the white oocytes show the greatest cyclic change. There is increasing irregularity of the nuclear margin, an increase in the number of nucleoli and a movement of the latter toward the center of the nucleus as the breeding season approaches. These trends are continued as the oocytes become pigmented and a highly irregular germinal vesicle, or nucleus, results. This has a dense scattering of small nucleoli at its center. The pigment in these maturing oocytes is laid down mostly around the outer rim of the cytoplasm.

The oviduct of the female and the fat bodies in both sexes display variation in correlation with that in the gonads. The oviduct is a white tube, wavy in its anterior part and much convoluted in the posterior glandular portion. It fluctuates greatly in size, being relatively slim throughout the post-breeding period in the fall and winter and enlarging greatly as the breeding season approaches. The fat bodies exhibit a reversed cycle. This occurs to some extent in both sexes but is clearly marked only in the female. The fat bodies are enlarged during the fall and winter and are reduced in size and finally almost disappear with the maximum development of the ovaries at the beginning of the breeding season. It is possible that they store materials used in the developing oocytes.

The results of the oocyte measurements give a clear picture of the female reproductive cycle. Females which have recently deposited their eggs have, with the exception of a few pigmented eggs that were not ovulated, only clear and white oocytes in the ovary. The ovary appears as a white, angular structure, molded about the postero-dorsal surface of the digestive tract and the posterior end of the body cavity. In section the ovaries also show oocytes of two classes. The larger ones have a palely staining cytoplasm which seems to indicate some yolk accumulation. The margins of the nuclei are irregular. The nucleoli are near the edge of the nucleus in some cells, or scattered inward to the centers in others. The smaller oocytes have a less variable, more darkly stained nucleus. The nuclear margins are regular or slightly scalloped and the nucleoli are near the surface. The smallest oocytes often have numerous large vacuoles arranged radially around the outer edge of the cytoplasm. The most noticeable features of these sections is the presence of collapsed follicular sacs.

There were no mature individuals available from the months of September and October, but the November and December samples furnish information which makes an evaluation of the period possible. Apparently there is little growth in oocyte size during the months of early fall and winter. The most notable feature is the disappearance of the collapsed follicles. There is considerable variation in the size of the oocytes. The larger ones have irregularly margined nuclei, and the nucleoli are scattered throughout the nucleus. Some small oocytes show vacuolated cytoplasm and others do not.

In January the first pigmented oocytes appear. From this time on they increase rapidly in number. Growth of pigmented oocytes follows a smooth curve with the exception of the March sample which was taken in 1951 (the other samples were taken in 1949-50). The apparent explanation for this discrepancy is that the 1949-50 winter and spring were exceptionally mild, while the 1950-51 winter was cold. If this effect is actually due to climatic conditions, it indicates considerable plasticity in the female reproductive cycle. This tardy development was apparently compensated for rapidly, for the breeding season began two weeks earlier in 1951 than it did in 1950.

During the period of development of pigmented oocytes there appears to be a decrease in the size of the white oocytes. This may be explained on the assumption that the larger white oocytes are becoming pigmented, and fall in another class, leaving only smaller cells behind and thus reducing the average size.

As a result of the great growth of the pigmented follicles the ovaries increase rapidly in size, almost surrounding the digestive tract. The white and clear oocytes are crowded into the corners between the maturing pigmented oocytes. All classes of oocytes are now angular in shape due to pressure from others nearby. With this ovarian enlargement there occurs the great enlargement of the oviducts, especially the glandular portions.

Discussion.—The gonadal cycle of male *Microhyla* contrasts sharply with that found for *Rana pipiens* in Vermont by Glass and Rugh (1944). The differences are understandable when the breeding seasons and activity periods of the two animals are considered. *Rana pipiens* is, in Vermont, a form with a restricted period of activity and a long hibernation; physiological processes are at their height during the warm months of the year and are slow during the long periods of hibernation. In the spring there is a short, definite, breeding period, preceding the seasonal optimum of environmental conditions, which gives the tadpoles a favorable period for growth and transformation and gives the adult a chance to prepare for the coming year. In *Microhyla* in southern Louisiana there is no period of hibernation, and there is no need for a rapid build up of reserves or an early preparation for the coming breeding season of the next year. There is also no problem of time for larval development.

Another interesting problem arising in relation to reproductive cycles is the matter of the timing of individual activity during an extended breeding season. Why one female deposits her eggs in April and another does so in September is not known. There seemed to be little variation in the degree of preparation for breeding among the females of the June sample. If the time of individual breeding is fixed by inheritance, interesting evolutionary implications arise, such as reproductive isolation resulting in fragmentation of sympatric populations.

The female reproductive cycle described here agrees with that given by Fisher and Richards (1950) for *Acris* in some respects, and differs considerably in others. Fisher and Richards do not emphasize the external morphology of the oocytes and thus comparison is difficult. They report a range of stages found in each ovary and this is interpreted as an indication of differential rates of development. In *Microhyla* it seems apparent that this variation cannot be attributed to differential rates but rather indicates that the ovary contains, at any given time, oocytes destined for use in at least two and possibly three breeding seasons. This situation apparently differs sharply from the ovarian cycle of *Rana pipiens,* for Rugh (1951) reports that after ovulation "the ovary has been freed of mature eggs and contains only oogonia with no pigment and little if any yolk." Although oogonia may be found in most sections of *Microhyla* ovaries, they are never common, while white and clear oocytes are always abundant. The pattern of nuclear change with oocyte growth seems to be identical with that reported by Fisher and Richards (1950) and Rugh (1951). However, Fisher and Richards (1950) seem to imply that such a phenomenon as the movement of the nucleoli toward the center of the nucleus occurs in all oocytes in a given ovary at once. This is not true of *Microhyla* for the nuclear condition is correlated with the gross morphology and small, clear-type oocytes always have few nucleoli and these are always near the nuclear border.

Reproductive Behavior

Field observations of the reproductive behavior of *Microhyla* are difficult because of the shyness of calling males and the dense vegetation in most breeding sites. However, techniques for field study of certain aspects have been worked out, and with practice it becomes easier to discover the males in their calling positions. Two sets of field observations, one at Century, Florida on July 15, 1950 and the other at New Orleans on July 28, 1950 provided much valuable material.

In addition to field observations, specimens injected with whole pituitary gland after the method standardized by Rugh (1935) were studied in the laboratory. Glands used were from ranid frogs of three species. Average doses in terms of glands from mature individuals of these donor species are as follows: *Rana pipiens,* two; *Rana clamitans,* one-half; *Rana catesbeiana,* one-third. Injections were made with a 1.5 ml syringe and #22 needle. Care was taken not to inject more than 0.05 ml of water into any individual. Individuals were placed in a large container with shallow water and some material upon which they could climb about. When amplexus began they were transferred to small aquaria for observation.

Information on other questions of reproductive behavior was obtained by examination of ovaries and oviducts.

It has been demonstrated above that a definite gonadal cycle exists. This cycle is considered as the primary factor in control of reproductive behavior. It may be assumed to be under hormonal control but has shown variations apparently attributable to climatic conditions.

Environmental Factors.—Weather conditions have been shown to influence the degree of general activity as well as breeding activity. Most authors are agreed that rain stimulates breeding behavior. Thus Wright (1932) states: "This subterranean species normally breeds and mates at night. Heavy, warm rains of one to four inches may precipitate mating in daylight and rarely one captures a croaking male at mid-day." Barbour (1941) reported a large chorus developing after a cloudburst. Bragg (1950a) on the other hand, stated that breeding of *M. c. carolinensis* in Oklahoma is not much influenced by rainfall. In this respect it should be noted that most authors, in describing time of breeding of this and other frogs, do not distinguish between occurrence of calling individuals and actual mating. There is no evidence that the two are necessarily synchronous. The notes of the writer show that choruses, like movement, are often initiated by rain. The first breeding of the 1950 season did not take place until after two days of rain. Until that time there had been no calling or other breeding activity. On the second night just after the rain had ceased large choruses were found at several localities and pairs were found in amplexus. Shorter rains as little as four days previously had had no effect and it seems obvious that this prolonged and very heavy rainfall was needed to initiate breeding.

Light, with its apparent inhibiting effect upon movement, also influences the breeding behavior. Daylight choruses are common at the height of the breeding season even in very dry weather, but no evidence of diurnal amplexus or egg deposition has been noticed.

Great adaptability is shown in regard to breeding sites. Males have been found calling, and tadpoles seen, in wheel ruts, ditches, small permanent ponds and margins of cypress lakes. These can be classified as being deep water or shallow water sites. Deep water sites are those with water one to six feet deep. Breeding activity takes place in such areas only when a dense mat of floating vegetation such as water hyacinth (*Eichhornia crassipes*) or alligator weed (*Alternanthera philoxeroides*) is present. Shallow water sites are less than one foot in depth and some have a maximum depth of only one or two inches. These sites may be temporary or permanent waters. Wright (1932) recorded a great mortality of eggs due to drying of temporary sites in the Okefinokee swamp.

Vegetation in shallow water may be dense or non-existent, but calling males have been seen using sticks, lumps of earth, crevices in the earth or in logs, loose bark, sparse short grasses and large clumps of tall grasses, alligator weed and water hyacinth as cover. This reaction is apparently based upon two factors: the shyness of the animal which keeps it partially under cover, and the need of some sort of support for maintenance of proper calling position.

The bottom of breeding ponds ranges from mud to decomposing organic matter to hard clay.

Observations made near New Orleans on July 28, 1950 suggest that there may be some sort of location sense in regard to traditional breeding sites. A location in Jefferson Parish was used heavily all through the spring. It consisted of a weedy pond, about 2.5 feet in maximum depth and 60 feet in diameter, with a wide belt of alligator weed around the shore. *Acris* called from the short and sparse weed nearer the center of the pond and *Microhyla* from the dense, tall weed along the edge. At some time between June 1st and July 20th an abandoned field stretching behind this pond was cleared with a bulldozer and the pond filled in. On July 28 after a rainy day *Microhyla* were found calling from puddles and crannies between lumps of earth. There was no living vegetation but cover was furnished in some pools by root stubs or bits of floating board. There was no apparent difference between any two parts of the field of approximately five acres. Despite this apparent complete similarity of possible breeding places over the whole area, the large chorus was found only in the immediate area of the former pond.

As there is a daily cycle of normal activity, there is also a cycle of breeding activity. It has been stated that during periods of intense breeding activity many individuals may remain in the breeding area and call throughout the day. In these and in all other cases there is a movement of individuals to the breeding sites at dusk. Observations at a small artificial pool in Audubon Park, New Orleans, show that the peak of this movement is just at full darkness. The males precede the females in moving to the breeding sites, the peak of male movement preceding that of the females by ten to twenty minutes.

Voice.—The call is usually described as a sheep-like bleat. Burt (1932) noted that in Louisiana and Mississippi he heard two calls, one "goat-like" and the other a "soft murmur." The writer has never been able to hear anything resembling this latter call either in field or laboratory. Some variations in the normal call take place when amplexus begins. The normal call has a duration of about 1.4 seconds at 25°C (water temperature).

The calling posture is constant as reported by various authors (Wright 1932, Barbour 1941). The body is usually in a vertical or near vertical position, immersed in water up to the axilla and supported against some object by the forelimbs.

While calling, the male does not move about, but retains his position without change for long periods of time. Of six individuals marked by placing tagged sticks near them at 8:45 P.M. (Century, Florida July 16, 1950), all retained positions at 9:00 P.M., four retained position at 9:30 P.M. and at 10:00 P.M. Since eggs were found in the regions occupied by the two that left their positions, it is likely that they had mated successfully. Again, near New Orleans on July

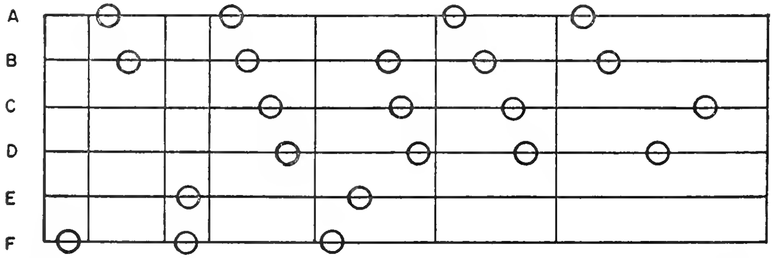

Figure 3. Calling patterns, July 28, 1950. Each letter and corresponding line represents a single individual. Vertical lines indicate pauses between series of calls.

TABLE 4.
CALLING PATTERNS IN A SMALL CHORUS

38 series of calls (total studied)	
34 —	2 or more individuals
20 —	3 or more individuals
14 —	4 or more individuals
5 —	5 or more individuals
3 —	6 individuals

Calling frequencies

Individuals	A	B	C	D	E	F
Total Calls	29	25	16	23	11	10
Started series	9	3	0	8	3	6
Called alone	0	0	0	0	3	1

Frequency of calling sequences

Combinations of two individuals	Combinations of three individuals	Combinations of four individuals
(30 possible comb.)	(240 possible comb.)	(420 possible comb.)
AB — 20	ABC — 9	ABCD — 3
AD — 4	ABD — 2	ABDC — 1
BC — 15	ADB — 2	ABDF — 1
BD — 2	ADE — 1	BDFE — 1
CD — 4	BCD — 4	BCDE — 1
DA — 9	BDC — 1	CDEG — 1
DB — 3	BDF — 1	DABC — 4
DC — 1	DAB — 6	DABD — 1
DE — 2	DFE — 1	EABC — 1
DF — 2	CDE — 1	EDAD — 1
ED — 1	EAB — 1	FDAB — 1
FA — 6	EDA — 1	FEDA — 1
FD — 1	FAB — 2	FADE — 1
FE — 3	FAD — 1	FABC — 2
	FDA — 1	
	FED — 1	

28th six individuals under observation maintained their positions with very little change for two and one-half hours. One remained in position and called for three hours before beginning to move about.

The calling of a group around a small pool was studied in both the Florida and New Orleans areas. A predominant pattern was perceived in the Florida chorus. A technique applied at a New Orleans site permitted the observer to record and analyze this pattern. A number of parallel lines were drawn, each representing an individual and designated by a letter. Each time an individual called a dot was placed on the line representing that individual. Since the calls of the individuals in a small aggregation are in bursts with intervals of silence between, each series is written as one would write a bar of music. Figure 3 gives an example of calling records obtained in this way and Table 4 presents the analysis of the data obtained for 38 series of calls around one pool. There were six males calling around this pool which was about three feet in diameter.

They could all be observed easily during this period.

When the data are summarized relationships between calling individuals are shown. Of the 38 series of calls, 34 have two or more individuals represented (Table 4). With 6 individuals calling there were 30 possible combinations of two. Of these possible sequences 15 occurred a total of 75 times. On the basis of equal chance and calling activity for each individual it would be expected that each of 30 combinations would have occurred slightly less than three times as an average. Actually one sequence (AB) occurred 20 times, another (BC) occurred 15 times, and a third (DA) occurred nine times. If those series which had three individuals calling are considered there are 120 possibilities, but only 16 occurred a total of 35 times. The chances that any sequence should occur more than once is thus small, yet the pattern ABC occurred nine times, the pattern DAB occurred six times, and the pattern BCD occurred four times. Considering series of four individuals there are 240 possible combinations; 14 series occurred a total of 20 times, and DABC occurred four times, ABCD three times, and FABC twice. There is thus a definite pattern, revolving around four individuals: A, B, C, and D. Examining the status of the remaining two individuals, E and F, it is seen in Table 4 that they are the only ones which called alone, that is, without being part of a series. It is further noted that they called less than the other individuals, but usually either called alone or began the series. Turning back to the original four it is seen that A and B called the most, but that B was not aggressive, rarely initiating a series of calls, while A and D were both aggressive in this sense. In contrast, C never started a series. Carrying these relationships further it is found that B followed A in 20 of the 25 series in which it took part, and that C followed B in 15 out of 16 series in which it took part.

The significance of these relations is not understood. A, apparently the dominant member of the group, remained in position and kept calling the longest, but did not succeed in attracting a female. Two other members of the group (exactly which ones could not be determined at the time) did go into amplexus some time after calling observations were made.

There seems to be no restriction upon calling densities. Calling individuals may be as close as one inch apart (three or four individuals at times) or as far as fifteen or twenty feet.

In the Jefferson Parish area studies on calling pattern there were numerous small complexes similar to the one studied. An attempt was made to apply the same method to groups as was applied to individuals and thus determine if there were relations between them also. The results did not indicate any significant patterns.

Sex Recognition.—The phenomena of sex recognition are obscure. On several occasions it has been possible to detect a faint vibration when males were handled, similar to that found in *Bufo,* but a function in sex recognition is not indicated by observations of mating behavior.

There are very few errors in recognition and only in one instance (in the laboratory) has a male been found clasping or attempting to clasp another male. Both individuals in this one case had received heavy doses of pituitary gland. The males have never been observed to clasp inanimate objects as male *Bufo* do.

Initiation of amplexus has been observed in water in laboratory aquaria. The female floats in a position characteristic of the species, with hind legs widely spread. The male, appearing to move about at random, will, when behind her, swim into clasping position and work up her back until the normal amplexus can be achieved. This procedure is not believed to illustrate the normal courtship behavior.

The following excerpt is from field notes taken at the Jefferson Parish area, July 28th, 1950. These notes were taken at the small pool described above where the studies on calling pattern had just been made. The observer sat about two feet from the pool. To his left was individual *A* in calling position behind a floating board. Directly across the pool (about 20 inches wide at this point) was individual *B*. Directly in front of the observer on the near bank were three individuals called in the notes the "trio". They were about one inch apart in a triangular formation. They were partly hidden by some sticks and other debris and behind them were at least one, possibly two other frogs which were hidden completely. The notes read:

> "During 9:00 to 9:30 interval the moon becomes brighter as the sky clears. The inter-group intervals seem to get longer and the intra-group calling density may be less. Individual seen moving across middle of pool, perhaps middle one of trio which has gone—it dives to avoid light and a small individual simultaneously appears on land near third of trio—it moves past in front of and almost touching the latter, which calls with increased frequency. An individual appears again in the middle of the pool briefly and the new individual near the trio vanishes.
>
> "Three grunts seem to come from near B's position and an individual seen scrambling up the bank from that area—B does not react. Another individual seen about one inch from B. Two more grunts heard, but position not definite, one has a croaklike quality—location established for these sounds—a pair in amplexus on board near A.
>
> "Nine minutes later a large individual comes down bank near the trio. The latter (two and possibly three are still present) begin to call rapidly. "A" speeds up calling in response. All three of trio members in original position, the newcomer moves between them and disappears. Three minutes later a pair in amplexus appears in that area."

These notes illustrate the difficulty of observation. They also illustrate several points. One is that calling males respond to the approach of another individual, presumably a female, by increasing the calling rate, but do not move from position to attempt amplexus, although the individual may pass very close. There appears to be two possibilities :(1) the wandering, non-calling individuals are females, and some action on the part of the female other than appearance or nearness and movement must serve as a release mechanism for amplexus; (2) these individuals are actually males and their sex is recognized by other males without amplexus or other contact. Observations indicate that most of the wandering individuals in a chorus are females.

The grunts and croaks noted at the approximate time of occurrence of amplexus have also been observed in the laboratory when terraria were set up in such a way that the males could call normally and the females move to them.

Noble and Aronson (1942) found that female *Rana pipiens* were not receptive to amplexus until ovulation had taken place. In *Microhyla* ovulation may sometimes begin either just before or after amplexus has started. Dissection of a female taken in amplexus and preserved forty-five minutes later revealed that ovulation had just begun. Approximately twenty percent of the eggs had reached the oviduct. Examination of thirteen other females taken in amplexus showed ovulation still in process in six individuals and complete in seven. Two unmated females found moving about in the same chorus had nearly completed ovulation. Observations in both field and laboratory indicate that egg deposition took place in from one and one-half to two hours after amplexus began. Thus ovulation is rapid and the females become receptive to males at or before its commencement. This pattern of rapid ovulation and early receptiveness might be of value to the species in arid climates, permitting the animals to take advantage of sudden rains for breeding purposes.

Amplexus is semi-pectoral or axillary depending on size relationships. It may be inguinal in cases where the female is not receptive, or in cases where a male grasps a male. In amplexus, as observed in pituitary injected individuals in the laboratory, the male rests on top of the female, clasping her strongly in a semi-pectoral embrace. The arms of the male pass just behind those of the female. The thumbs dig into the pectoral area just posterior and ventral to the insertion of the female's forearms. The palms are turned out and forward. There is considerable size disparity and the snout of the male just reaches the line between the female's eyes. The back of the male is just above the water surface, the thighs are flexed, with the shanks pointing dorso-laterally and the feet laterally and anteriorly. The body of the female is at an angle of about forty-five degrees to the surface of the water. Her thighs are partially extended, the shanks point postero-laterally, the feet laterally and slightly anterior.

Egg Deposition.—At the beginning of amplexus the male and female cooperate in swimming movements. As the time for egg deposition nears, the male ceases swimming actions and cocks his hind legs tightly in against his body.

Egg deposition can be anticipated by noting certain features of the behavior of the clasping pair. About twenty minutes before the time of deposition the female becomes restless and moves about. The interval between initiation of this behavior and egg deposition was the same in the field on July 28 as in the laboratory. In the field the female traveled about one foot overland to a deeper pool and back again carrying the male on her back. At about this time there is a change in the swimming movements of the female. She now swims with very short, jerky, simultaneous movements of the hind limbs.

At the start of egg deposition the female may raise the hind limbs and rear part of the body to the surface of the water and bring the extended hind limbs forward until they are at right angles to the midline on the same plane as the water surface. This produces a swaybacked position. The feet are then moved in short forward strokes, moving the animal backward one to two inches. The strokes then shorten further and the legs move ventrally. (This preparatory stage was omitted in those individuals seen in the field, but was exhibited by two of three pairs in the laboratory.) The female then extends the legs tensely in a ventro-lateral position with the toes bent downward, bringing the cloaca upward above the water surface. As she does this the male slides forward so that his cloacal opening is about one-eight inch anterior to that of the female. He brings his feet together so that they curve around her buttocks on either side of the cloaca with the ankle joint at about the cloaca level. In this position the eggs appear to boil from the cloaca of the female. About thirty eggs are laid in each such ejaculation.

No information has been obtained on the duration of the clasp after egg deposition is complete. In the laboratory the clasping position apparently may be retained indefinitely if the pair are kept in the water. If they have an opportunity to leave the water, it may be broken relatively soon and exit from the water may possibly stimulate the male to release his grip.

Discussion.—Bragg (1950b) has asserted that two major breeding patterns are discernible in North American anurans. These he designated as mesic and xeric. The mesic pattern, as he has defined it, is basically cyclic, little influenced by rainfall, and with physiological control vested in hormonal and other internal factors. In comparison, he defined the xeric pattern as non-cyclic, with the breeding independent of internal control to a great extent and initiated by rainfall. He recognized also, a third, or intermediate pattern. *Microhyla c. carolinensis* was considered by him to be a mesic form and *Microhyla c. olivacea* a xeric form. His basis for this separation was the belief that the breeding of *M. c. carolinensis* was more restricted as to season and was little influenced by rainfall. Unfortunately he had not had full opportunity to observe this form and make comparison. The cyclic gonadal pattern of *carolinensis* is certainly influenced to some degree by rainfall, particularly as to initiation of the breeding season. There is some breeding activity independent of rainfall but this activity is much reduced. The gonadal cycle appears to be adaptable to either a mesic or xeric behavior pattern and an existing pattern might be merely an effect of the local climate.

One factor in the breeding behavior which Bragg postulated for forms showing xeric behavior patterns is supported by material gathered here. This is the possibility that ovulation may not actually begin until after amplexus has started and the fact that it is quite rapid.

The social aspects of the reproductive behavior are so little studied that there can be little evaluation of them at this time. The significance to be given to the difference and similarities between the actions of egg deposition in *Microhyla* and in *Rana pipiens* as described by Noble and Aronson (1942) is also uncertain.

Reproductive Potential

The sample taken from the ditch at Angie in June was used for study of the reproductive potential of the species. In utilizing these data it is assumed that the sample is representative of the breeding females of the whole population as regards to both composition and the condition of unspent females. This means that it is also assumed that while males exhibit more movement than females, mature females of all size groups, in the equivalent physiological condition, move equally. (Although the breeding season had been underway for some time, no spent females were found in the sample.)

A total ovarian count was made upon each of 66 females with mature oocytes. The compliment of eggs per female ranged from 152 to 1,089. The mean number of eggs was 510 and the total was 33,657. An analyses by year classes shows that the three-year-olds bear the burden of the reproduction (Table 5).

The fact that so few two-year old individuals are recorded is difficult to explain. In view of the indications noted below that some of these may not breed until their third year, it seems possible also that many may not breed until late in the season. Periodic samples at the breeding ponds should prove useful in answering this question.

GROWTH AND DEVELOPMENT

The development of the embryo and the tadpole is not reported in this paper, although they have received some study. Deckert (1914) and Ryder (1891) have published short notes. Wright (1932) reported considerable material, and Orton (1946) discussed the growth and color pattern of the tadpole.

Both embryonic development and growth of the tadpole through metamorphosis are rapid, as would be expected in a species that often breeds in temporary rain pools.

Snout-vent measurements were made on 633 frogs. Preserved, freshly killed, and live individuals were used. The percentage of error in measurement of each type was calculated. This percentage was small in all methods (preserved, 1.2; freshly-killed 3.8; alive, 2.1). Measurements of a test series of individuals measured in all three conditions were used to determine if corrective factors were necessary for fresh and live material. The corrective factor of 0.989 indicated

TABLE 5.
REPRODUCTIVE POTENTIAL: ANALYSIS BY YEAR CLASSES

Age (yrs.)	Size (mm)	No. of Specimens	Mean No. of Eggs	Total Eggs	Percent of Total Production
2	23.0 — 24.4	6	377.8	2,267	6.7
3	24.5 — 26.9	44	466.3	20,516	60.9
4	27.0 — —	16	680.8	10,894	32.4

for fresh material as contrasted with preserved material is small enough so that in this study it may be ignored. It was found necessary to apply a corrective factor of 0.914 to measurements of live individuals.

The samples were found to be affected by the collecting situations studied. One was forced movement, caused by rising flood waters in the Bonnet Carré Spillway. The second was a combination of general feeding and breeding movement bringing the animals into traps at the Camp Plauche area and the third was apparently primarily breeding movement which caused the frogs to become trapped in a pipeline ditch near Angie, Louisiana.

Snout-vent frequencies were plotted for each month (fig. 4). A class interval of 0.7 mm seemed best suited for both large and small samples.

Study of these frequency distributions show that no sample is fully representative of the population. Year classes can be delineated only approximately and an accurate growth rate cannot be calculated. Only a rough outline of growth can be given.

Individuals transform at about 10.0 mm from May until October. Since some may thus have four months start on others of the same year class in their growth, the difficulties of delimiting the year classes are not surprising. The effect of this seems to be diminished somewhat in older individuals. A tentative separation into year groups for the months of May and June shows a progressively smaller range per group as size increases. It appears that most individuals are 13.0 to 19.0 mm in their first spring following transformation, 21.0 to 24.0 mm the second spring, 24.5 to 26.9 mm the third spring, and from 27 to 35 mm in succeeding years. This arrangement is substantiated by attainment of sexual maturity in the 21 to 24 mm size class. These estimates are found to coincide roughly with Wright's (1932) estimates of the early growth of the species in the Okefinokee. He found the transformation size to range from 8.5 to 12.0 mm with a mean of 10.8 mm. He then gave the year classes for the following spring as 15.0 to 20.0 mm for the first year group. However, he thinks they are 20 to 25 or 27 mm in the second spring and 27 to 36 mm in the third. The break at 26 to 27 mm in the curves given here is slight, but it occurs often enough to be significant. When the June samples are plotted with an 0.5 mm interval this break is greatly emphasized. Wright's classification would indicate that growth of maximum sized individuals is 8 mm from transformation until the first spring, 7 mm in the second year, and 9 mm in the third. This maintenance of an extremely rapid growth seems improbable in the light of the general understanding of the growth of reptiles and amphibians.

The size groups are demonstrated best if we combine the samples from October through February. Four classes indicate a maximum life span of five or more years (fig. 4).

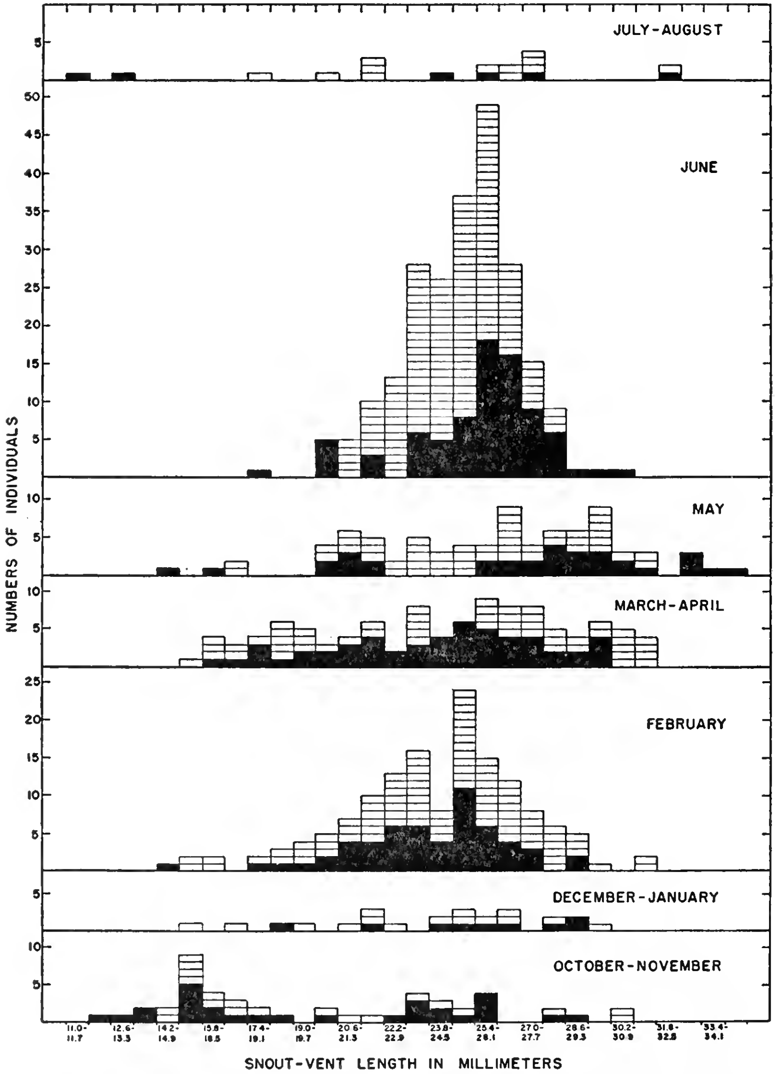

Figure 4. Size frequencies in population samples, sexes combined. Open rectangles = males; solid rectangles = females.

Individuals attaining sexual maturity by their second spring range in size from 21 to 24 mm. Several criteria are used to indicate the attainment of maturity. The criteria used for males are (1) the appearance of secondary sex characters, (2) the presence of mature spermatozoa, as indicated by smears of testes of both fresh and preserved individuals, and (3) the development of the gonads as indicated by the study of histological sections. The secondary sex characters of the female are largely negative and the examination of the ovary is the only criterion.

A distinction must be made between the determination of the smallest sexually mature size class at the breeding season and the actual time at which the individuals take up the adult gonadal cycle. A discussion of the relative importance of the two dates is academic, for both are important.

Analysis of the June sample shows that the secondary sex characters first develop in males of 21.0 to 22.9 mm snout-vent length. The blackening of the throat seems to occur first and the tubercles to appear at a slightly larger size (from 21.5 to 23.9 mm). Mature spermatozoa were found in smears of testes of individuals 21.0 mm or larger, but were sometimes absent in individuals of 23.0 to 23.4 mm.

Smears of testes taken throughout the year show that mature and active spermatozoa often are present before there is any external indication of sex. Spermatozoa have been found in smears of testes of individuals as small as 18.4 mm. In histological sections a very few spermatozoa were found in the testes of an individual measuring only 15.5 mm in snout-vent length. This individual was taken in October, showing that spermatozoa may be present during the year in which the individual transformed, a full year and a half before the first breeding activity is expected. Further study of sections of testes of immature individuals allows an estimation of the time at which the condition of the gonad approximates and begins to follow the seasonal cycle of adult individuals. The immature testis is characterized by very small tubules, each containing only a few cells. The arrangement of the cells in the tubules is very loose. They are not in clumps as found in mature testes. These characteristics are retained through the first winter and then are gradually lost so that by the middle or end of the second summer the mature condition is approximated and the annual cycle begins.

Study of June females demonstrates that pigmented eggs first occur at 23.0 mm but are lacking in some individuals up to 24.5 mm. In all monthly samples, comparison of the minimum size in which white oocytes are found and the maximum size in which only clear ones are found shows a considerable overlap. These facts indicate that some females may not deposit eggs until their third year.

There are insufficient specimens in the critical early fall period to allow an estimation of the time at which the young females develop the adult cyclic pattern.

Sexual dimorphism in size has been remarked upon by Wright

TABLE 6.
SEXUAL DIMORPHISM IN SIZE

	Males		Females	
Size Groups (mm)	No.	Percent of Total males	No.	Percent of Total females
22.2 — 23.7	62	16.6	27	10.4
23.8 — 25.3	75	20.1	44	16.9
25.4 — 26.9	85	22.8	64	24.6
27.0 — 28.5	38	10.2	32	12.3
28.6 — 30.1	19	5.1	19	7.3
30.2 — 31.7	15	4.0	4	1.5
31.8 — —	1	.3	6	2.3

(1932). This is manifest in the larger maximum size of females and by the relative percentages of male and female individuals in the larger size groups. The maximum size for males is 32.2 mm and the maximum for females 34.3 mm. A relatively larger percentage of females in the samples fall in the larger size groups (Table 6). This dimorphism is slight.

Shedding was observed in six females used in breeding experiments. Shed skins are found occasionally in the stomachs and may be identified by the outlines of toes or fingers (Table 3).

POPULATIONS

Some information about populations can be derived from the larger samples. The trapping data from Camp Plauche also gives a little information about the density and composition of a population.

In the discussion of movement, reference was made to the sex ratios found in various population samples. The relatively large percentage of males was considered to be due, in part at least, to greater movement by that sex. In support of this it was pointed out that samples collected by hand showed a less unbalanced relation.

The sex ratios are more nearly even in the smaller size classes. This could be attributed to an actual difference in the ratios in juvenile and adult populations or explained on the assumption that the relatively greater movement of the males does not express itself fully in immature individuals. It is impossible to tell whether either one, or both, of these factors contribute to the observed result.

The continuous catch of unmarked individuals at Camp Plauche indicates a large population, but since most recoveries were not made in the traps it is not possible to attempt a population estimate.

Interesting variations in size composition are seen in the different samples (fig. 4). A large percentage of immature individuals occurred only in the October-November and March-April samples. Both of these were hand collected samples. The proportion of immature individuals is considerably higher in the October-November sample than in any other. This is to be expected at the end of the breeding season but an additional significance is also suggested. This sample was collected in the cypress swamps of the Sarpy Wildlife Refuge and corroborates field observations which indicate a vastly different size composition in these swamp populations as compared with those from the abandoned fields and levees. Further comparative samples of both breeding and non-breeding populations must be taken before this situation can be interpreted. Some observations in the field suggest an ecological segregation of different size groups in the swamps.

The most abnormal of the samples from the point of view of composition is the June sample. This is found to be almost entirely composed of mature individuals and indicates a great difference in the movement of adult and juvenile individuals during the breeding season, rather than a true picture of the population.

CONCLUSIONS

1. *Microhyla carolinensis carolinensis* is highly adaptable in regard to habitat requirement. Moisture seems to be the most critical habitat requirement.

2. There is considerable nocturnal movement by all individuals. The males wander more than the females and juveniles.

3. A wide range of small organisms is taken as food. The major food items are ants, beetles, and termites.

4. There is little evidence of predation.

5. The reproductive behavior is cyclic. The gonadal cycle is, however, very different from that of *Rana pipiens* in the northeast. This difference seems to be correlated with seasonal activity as controlled by temperature.

6. Very little modification of the gonadal cycle, if any, would be required to permit breeding activity along the pattern which Bragg (1950a) designated as non-cyclic. The determining factor is probably environmental.

7. The breeding behavior is complex and is in need of further study. The phenomena of sex recognition found in other North American anurans were not observed in this subspecies.

8. The calling patterns of small groups indicate some sort of complex social relationship between calling individuals.

9. Population composition varies with the habitat. Further studies in the population dynamics of this subspecies are needed.

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A NEW SPECIES OF *DIAPTOMUS* FROM LOUISIANA AND TEXAS WITH NOTES ON THE SUBGENUS *LEPTODIAPTOMUS*

(COPEPODA, CALANOIDA)

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TULANE UNIVERSITY
NEW ORLEANS

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A NEW SPECIES OF *DIAPTOMUS* FROM LOUISIANA AND TEXAS WITH NOTES ON THE SUBGENUS *LEPTODIAPTOMUS*

(COPEPODA, CALANOIDA)

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The new species of *Diaptomus* for which the diagnosis is given herein has been known to me for some time from slides of dissected appendages in the S. F. Light accession in the United States National Museum. These appendages were from copepods collected in southeastern Texas by Dr. Edward S. Deevey. Since no more material was available it was impossible to characterize the species adequately, although it was apparent that it was related to the *signicauda* group of the subgenus *Leptodiaptomus.* A collection recently made in Louisiana by Dr. Walter G. Moore of Loyola University contained specimens agreeing with this form in the structure of the appendages, and verifying its position in the *signicauda* group by the presence in the female of a distal process on the right side of the genital segment.

The species is named for Dr. Moore whose interest in the freshwater invertebrates of Louisiana has previously revealed two other new species of *Diaptomus* (M. S. Wilson and Moore 1953a, b) and added much valuable material to study collections.

DIAPTOMUS (LEPTODIAPTOMUS) MOOREI, *sp. nov.*

Specimens Examined.—Type lot: twenty-one ♀♀ (two ovigerous), five ♂♂, shallow, muddy roadside pond, Louisiana highway 20, 12 miles south of Natchitoches, Natchitoches Parish, Louisiana, April 10, 1953, W. G. Moore. Associated with *D. pallidus* Herrick. Holotype ♀, United States National Museum catalog number 96023; allotype ♂, number 96024.

One ♀, non-ovigerous; ditch pond, U. S. highway 71, south of Lebeau, St. Landry Parish, Louisiana, April 5, 1951, W. G. Moore. Associated with *D. virginiensis* Marsh, *D. louisianensis* M. S. Wilson and Moore and *Osphranticum labronectum* S. A. Forbes.

Slide from Light collection, United States National Museum, ♂ leg 5 and right antennule; ♀ leg 5. Pond in swampy area ("Gum Swamp"), Walker County, Texas, May 11, 1940, E. S. Deevey. Associated with *D. clavipes* Schacht and *Osphranticum labronectum.*

Diagnosis.—With these characters of the subgenus *Leptodiaptomus:* one seta on segments 11 and 13-19 of female and left male antennules. Right antennule male, segment 14 without spinous process. Maxilliped slender, setae of distal portion not clawlike; four setae on distal lobe of basal segment. Leg 2 with Schmeil's organ on endopod segment 2 of both sexes. Leg 5 of female with third segment of exopod not developed and two setae on endopod. Leg 5 of male:

both processes of left exopod 2 short and digitiform, with rounded ends, the inner placed medially; pads of left exopod 2 both medial and well defined, without deep constriction between them; lateral spine of right exopod 2 not inserted on the same plane as that of the segment, strongly directed backwards; left basipod 2 with pronounced crosswise grooving of medial inner margin; claw of right leg at least as long as exopod.

Length, ♀ 1.27-1.32 mm; ♂ 1.15 mm. Greatest width of metasome in both sexes in segments 2 and 3. Segment 5 of female (lateral view) not swollen dorsally. Metasomal wings (fig. 1) only a little asymmetrical, not expanded laterally, inner part rounded but not enlarged into prominent lobes, distal outer corner produced posteriorly; sensilla minute. Urosome female (figs. 1, 2) two-segmented; genital segment with small cuticular lobe at distal outer portion of right side; proximal part with prominent lateral protrusions, that of left side larger and more rounded than that of right; anal segment and caudal rami subequal in length; caudal rami ciliate on inner margin. Urosome male (fig. 4) with segments 3 and 4 a little asymmetrical; segments 2, 3 and 4 with groups of spinules on dorsal, posterior surfaces. Spermatophore elongate; when attached, reaching beyond caudal rami of female (fig. 2). Ovisacs containing 16 and 17 small eggs respectively.

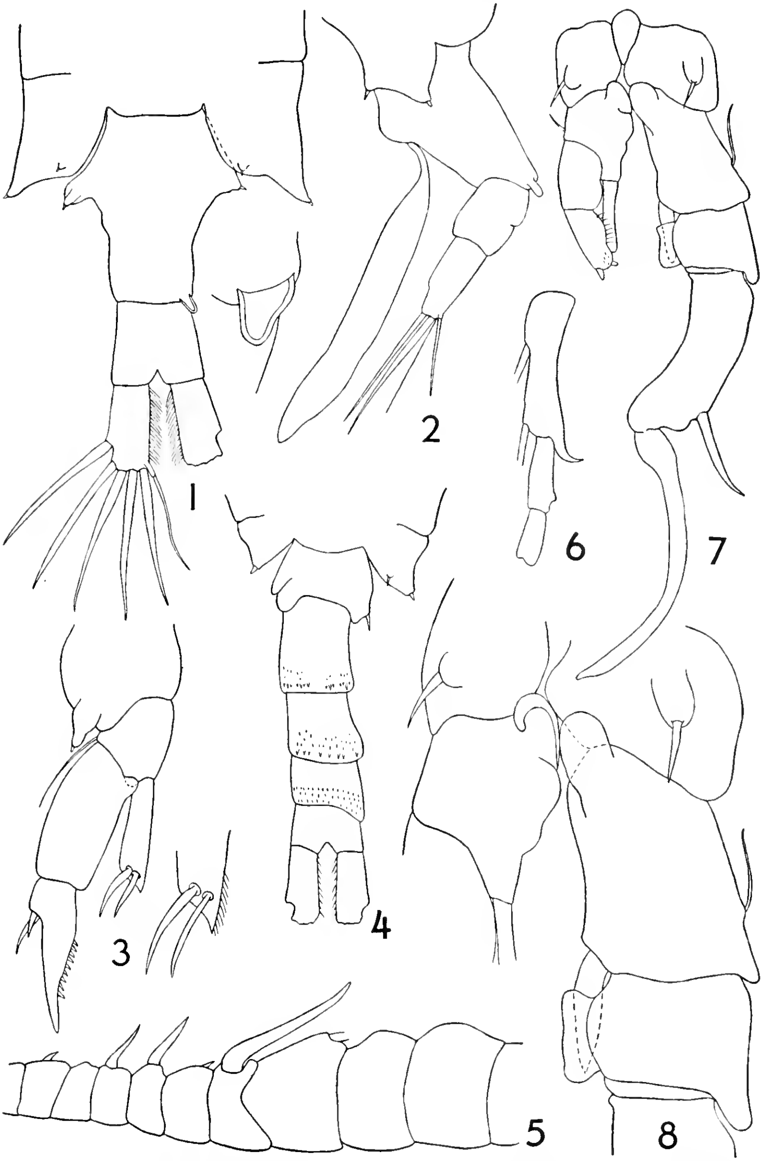
Antennules of female reaching beyond end of caudal rami. Right antennule of male (fig. 5) with spine of segment 8 not enlarged, that on 13 longer than that on 11 and reaching a little beyond segment 14. Proportions of spines to the segmental width and to one another:

Segment	10	11	13
Segment width	12	12	16
Spine length	10	12	29

Process of segment 23 (fig. 6) not reaching to middle of segment 24, the apex strongly outcurved.

Leg 5, female (fig. 3). Basal sensillum minute, on enlarged papilliform protrusion. Length of exopod segments 1 and 2 subequal; exopod with two lateral unequal setae. Endopod nearly as long as inner margin of exopod 1, the inner prolongation sharply pointed, the subequal setae a little less than half the length of the endopod (9:19).

Leg 5, male (figs. 7, 8). Left leg reaching to end of right exopod 1. Basal sensilla of both legs elongate and slender, on enlarged papilliform protrusions. Second basipod segments of both right and left legs with prominent inner protrusions of proximal portion. That of right basipod an upwardly projecting membranous process; the left an upward projection with sclerotized margin, the area of the usual inner groove posterior to this projection swollen marginally. Right exopod segment 1 with large hyaline lamella, subrectangular in shape, attached to midportion of segment and projecting mesiad.



Figures 1-8. *Diaptomus moorei, sp. nov.* Female: **1.** metasomal wings and urosome with detail distal process of genital segment, dorsal view; **2.** same, lateral view, specimen with attached spermatophore; **3.** leg 5, with detail endopod setae. Male: **4.** metasomal wings and urosome, dorsal view; **5.** right antennule, spines of segments 8-16; **6.** same, apical segments; **7.** leg 5, posterior view; **8.** same, detail basipods and right exopod 1.

Lateral spine of right exopod 2 strongly directed posteriorly, distally placed at a point about 89 percent of total length of segment; its length greater than the width of the segment. Claw a little longer than exopod, evenly curved, hardly tapered beyond the slightly swollen proximal portion so that its width is not greatly reduced throughout; tip blunt. Left exopod segments subequal to one another; processes of segment 2 subequal, the distal a little less than one-fourth length of segment. Right endopod not enlarged, a little shorter than first exopod segment; the left reaching just beyond the middle of second exopod segment.

NOTES ON THE SUBGENUS *Leptodiaptomus*

The subgenus *Leptodiaptomus* is the largest in number of species and the most widely spread group of diaptomids in North America. It is also represented in eastern Asia by *angustilobus* Sars (1898), and by *tyrrelli* Poppe which was reported from Kamchatka by Smirnov (1931). Since other leptodiaptomids occur in Alaska and northern Canada (*pribilofensis, nudus, sicilis, ashlandi*) it is possible that further investigation in the little known area of northern Asia may reveal their presence there.

A new key to the North American calanoid species has been prepared for the forthcoming revised edition of Ward and Whipple's *Fresh-Water Biology.* This includes synonyms, summary of distribution, and new illustrations of both sexes of all the known species of *Leptodiaptomus.* It is hoped that this will considerably clarify the confusion that has existed in the literature on this group. In this present paper, therefore, only the taxonomy of *moorei* will be discussed.

Some points, however, should be made on the nomenclature of the subgenus. As pointed out elsewhere (M. S. Wilson, 1951), *Psychrodiaptomus* Kiefer (1938) proposed for *angustilobus,* is a synonym of *Leptodiaptomus* Light (1938). In addition, the name *Eutrichodiaptomus* Light (1939) should also be placed in its synonymy. This subgenus was proposed for *ashlandi,* but I fail to find in comparative study of all the species of the group, any structural differences of subgeneric value separating it from the other species of *Leptodiaptomus.*

Also, there is in my mind a question as to whether the subgenus *Pelorodiaptomus* Light (1939) proposed for *trybomi,* should be maintained. This species has never been found since the original collection and accurate knowledge of much of its detail is still lacking. The only specimens available in North America are in the Schacht slide collection in the Illinois State Natural History Survey. These are from the type lot and consist of two females and one male. These slides have been studied and new drawings of the female prepared for the key in Ward and Whipple. The male fifth leg was so mounted that the relationship of pertinent parts could not be entirely clarified to my satisfaction. However, none of the characters observed in this study indicates any sharp departure from basic leptodiaptomid structure. One of the most striking differences, but one not of subgeneric value, is the exceptional length of the sensilla (sensory spines) of the basal segments in the fifth legs of both sexes. Oddly, this distinctive character in the female has never been noted in literature. In this, as well as all other characters, *trybomi* appears to present an extreme or bizarre development of the structures found in leptodiaptomid species. The problem cannot be fully clarified without additional unmounted specimens, and until such time as they are available for study, the status of *Pelorodiaptomus* is uncertain. Examination of the type material shows, however, that the species is distinct, not synonymous with *judayi* nor "a chimaera based upon poorly preserved material" as suggested by Kincaid (1953).

Comparative studies of leptodiaptomid species reveal within the subgenus some natural groups which are held together by combinations of several minor structural distinctions. *Diaptomus moorei* is referable to one of these groups which includes *signicauda* Lilljeborg, *novamexicanus* Herrick and *nudus* Marsh. The characters indicating the close relationship of these species are:

(1) Presence in the female of a distal process on the right side of the genital segment, which is also characterized by rather prominent lateral protrusions of the area bearing the sensilla.

(2) Endopod of the female fifth leg not swollen or rounded distally, but instead produced into a sharply pointed projection beyond the insertion of the setae.

(3) The process of the twenty-third segment of the male right antennule very short (not reaching beyond middle of segment 24) and strongly outcurved at the tip.

(4) Spine of segment 13 of male right antennule longer than that of segment 11. Segments 15 and 16 without cuticular spinous processes, except for a minute process usually present on segment 15 of *signicauda.*

(5) Claw of right fifth leg of male not tapered, but rather evenly broadened throughout its length, with slightly constricted, rounded or blunt end.

(6) Second basipod segment of male right leg with the inner proximal portion bulging upward, or with hyaline membranous extension.

In this group, the females of *signicauda* and *moorei* resemble one another closely. The metasomal wings are well developed in all, but those of *novamexicanus* and *nudus* are individually quite distinctive with prominent inner lobes on the left side and pronounced asymmetry; those of *signicauda* and *moorei* are very similar to one another, lacking well developed inner lobes and being only slightly asymmetrical. *D. signicauda* and *nudus* may show, in lateral view, a more or less pronounced gibbosity of the fifth metasomal segment not noted in *moorei,* but this is a variable character and its absence would not necessarily serve to distinguish *moorei* from *signicauda.* The process of the genital segment is very short in all the specimens of *moorei,* thus differing from the much more developed process observed in *signicauda,* but the possible extent of variation is not known. Considerable care should be taken therefore in separating females of these two species.

Two other leptodiaptomids, *judayi* and *spinicornis,* have on the genital segment a distal process similar in structure to that of this group. The immediate relationship of these two species does not appear to be with the *signicauda* group since the males differ in several characters.

The males of the *signicauda* group are distinct from one another in several characters. The great length of the spine of segment 13 of the right antennule as shown for *moorei* (fig. 5) is also found in *nudus;* it is shorter in the other two species, though always longer than that on segment 11. *D. novamexicanus* is strikingly individual in the structure of the process of the twenty-third segment of the male right antennule. *D. nudus* has an individual character in the presence of small cuticular lobes on the ventral inner side of the caudal rami of the male. There is a striking difference in the species of the group in the position of the lateral spine of the second exopod segment of the right fifth leg, that of *moorei* being most distally placed. The approximate comparative position of this spine in the four species is shown by the following percentage figures which indicate the point of placement of the spine from the base of the segment, in relation to the total length of the segment:

nudus	43%
novamexicanus	65%
signicauda	77%
moorei	89%

The fifth leg of the male of *Diaptomus moorei* differs from the other species in the position of this spine; in the enlarged inner protrusion of the left second basipod segment; and in the subrectangular shape and medial position of the lamellar process of the right first exopod segment. In identification of leptodiaptomids, care should be taken not to confuse this species with *siciloides* or *connexus,* two species closely related to one another, which also have a somewhat squarish or rectangular lamella on the right first exopod segment, and a similar process on the twenty-third segment of the right antennule. These species can be separated from *moorei* by the position of the lamella; that of *siciloides* and *connexus* is placed in the distal half of the segment, that of *moorei* is centrally placed. These species are further separable from *moorei* in both sexes by most of the characters which distinguish the *signicauda* group.

The differentiation of the *signicauda* group and of leptodiaptomid species which might be confused with them is shown by the following keys.

FEMALES

(Species of *Diaptomus* (*Leptodiaptomus*) having distal process on right side of genital segment)

1.	Genital segment rounded but without distinct protrusions.	*spinicornis* Light
	Genital segment with distinct lateral protrusions.	2
2.	Left metasomal wing with prominent inner lobe extending posteriorly beyond the outer portion of the wing.	3
	Left metasomal wing without such prominent inner lobe.	4
3.	Left wing conspicuously larger than the right.	*novamexicanus* Herrick
	Left wing not much larger than the right.	*nudus* Marsh
4.	Right wing, outer portion not posteriorly produced.	*judayi* Marsh
	Right wing, outer portion posteriorly produced.	5
5.	Genital segment, process reaching to near middle of anal segment or beyond.	*signicauda* Lilljeborg
	Process not reaching to middle of last segment.	*moorei* sp. nov.

MALES

(Species in which the process of segment 23 of right antennule does not reach beyond middle of segment 24, and has outcurved or hooklike tip)

1.	Right antennule, spine of segment 11 subequal to or longer than that of segment 13.	2
	Right antennule, spine of segment 11 shorter than that of segment 13.	3
2.	Right antennule, spine of segment 8 usually not enlarged (about same length as that on segment 12); metasome in dorsal view with greatest width at about the middle.	*siciloides* Lilljeborg
	Spine of segment 8 enlarged (at least twice the length of that on segment 12); metasome in dorsal view with greatest width in cephalic segment.	*connexus* Light
3.	Right antennule, segment 23, base of process starting at middle of segment.	*novamexicanus* Herrick
	This process entirely apical.	4
4.	Leg 5, right exopod 2, lateral spine above middle of segment.	*nudus* Marsh

This spine below middle of segment. 5

5. Leg 5, right exopod 1 with rounded, distally directed hyaline process on inner margin. .... *signicauda* Lilljeborg

This segment with subrectangular, medially directed process. .... *moorei* sp. nov.

Certain synonymy among these species should be noted here. No types of *D. novamexicanus* are in existence, but it appears impossible in the study of specimens from over a wide geographical range to recognize more than one species in which the process of the male right antennule is so peculiarly modified. The names *washingtonensis* Marsh (1907) and *garciai* Osorio Tafall (1942) are therefore apparently synonyms of *novamexicanus* as has already been suggested by Kincaid (1953).

Some other synonyms in *Diaptomus* (*Leptodiaptomus*) proposed by Kincaid are not tenable. As pointed out above, *judayi* is not a synonym of *trybomi.* Likewise, *connexus* is not identical with *siciloides,* though it is not yet clear what the type of taxonomic relationship between the two species is. The fifth leg of the males are indeed very similar as pointed out by Kincaid, but the body form of both sexes (see Key above) and the metasomal wings and the urosome of the females are distinct in the two forms. The differences in the females are as great as any that commonly exist between other allied species of leptodiaptomids. These characters were not variable in any of the several collections of both forms that have been examined (including the type lot of *connexus*) so that the exact relationship of the two may not be determinable on the basis of anatomical studies alone. Attention should be given not only to their variations, but to their distribution, associations and ecology, particularly in the geographical areas in which they co-occur. Much of significance applicable to the taxonomy of the genus may be learned from study of cases such as these, so it is important that their differences not be ignored or obscured as they would be if accepted as synonymous without critical appraisal. Therefore, I have retained the two names and separated them as species in the key in the forthcoming revised edition of Ward and Whipple's *Fresh-Water Biology,* in which figures illustrating the differences are included (M. S. Wilson, In Press).

Diaptomus siciloides has a very broad distribution over the North American continent, having been reported from most areas except the extreme north and the east coast. In Louisiana, it is the species listed by Moore (1950) as *Diaptomus* sp. from Lake Providence. *Diaptomus connexus* was originally described from Kern County, California by Light (1938) and additional collections in the Light accession in the National Museum indicate that it has a much wider distribution in the southwestern portion of the continent. It has been identified by Dr. Light from other California localities, from Nevada, Colorado, New Mexico and Lower California. Both species have been found in lakes, reservoirs and ponds. A Mexican form named *cuauhtemoci* by Osorio Tafall (1941) is also involved in the synonymy of one of these species. It may be referable to one or the other, but examination of whole topotypic specimens would be necessary to determine the exact identity.

Of the species of the *signicauda* group, *signicauda* and *novamexicanus* are known to be very common in the western part of the continent, and particularly so in the Rocky and Cascade mountains and the Sierra Nevadas. *D. signicauda* has been reported from Iowa (Stromsten, 1920) which is outside its apparent normal geographic range. *D. novamexicanus* is perhaps more widely distributed than *signicauda,* being common at sea level in California, and extending into Mexico. The record of this species from the Yucatan Peninsula by C. B. Wilson (1936) would appear to include another species since the figures given for the fifth legs of both sexes are neither *novamexicanus* nor referable to the subgenus *Leptodiaptomus.* The process of the male right antennule is similar to that of *novamexicanus* and may have been drawn from that species.

These two species have not yet been reported or collected from the far northern areas of the continent, but *nudus,* which also occurs in the Rocky Mountains of both the United States and Canada, may have an Arctic-alpine distribution pattern. It was found recently in a collection made for me from a tundra pond at Bethel, on the western Bering coast of Alaska.

The occurrence of the new species *moorei* in Louisiana and Texas, suggests that it should be looked for in the Mississippi Valley, other southern states of the Gulf of Mexico area and in Mexico and Central America.

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THREE NEW SPECIES AND NEW RECORDS OF SOUTHERN MILLIPEDS

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NEW ORLEANS

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THREE NEW SPECIES AND NEW RECORDS OF SOUTHERN MILLIPEDS

NELL B. CAUSEY,
Fayetteville, Arkansas

Unless stated otherwise, the specimens mentioned in this paper were collected by the author with the assistance of Dr. David Causey and are now in the author's collection; holotypes will be deposited in the American Museum of Natural History.

Order NEMATOPHORA
Suborder LYSIOPETALIDA

Three genera of lysiopetaloid millipeds are represented in the fauna of the Gulf States. The best known is *Abacion* Rafinesque (1820) of which several species occur in the states bound by a line from central Texas to North Dakota on the west and the Atlantic coast on the east. Three species of *Delophon* Chamberlin (1943) are known from North Carolina, Georgia, and Mississippi, but *Texophon* Chamberlin (1946) is known only from the generotype from Laguna Madre, Cameron Co., Texas. In species of *Delophon* and *Texophon* the body length is 25 mm or less, making them subject to easy confusion with larval specimens of the larger and ubiquitous species of *Abacion*.

The following key to these genera and to the three species of *Delophon* is based mainly on the gonopods of adult males.

1. Terminal branches of telopodite very short. .... *Texophon*
Terminal branches of telopodite long, conspicuous. 2
2. Terminal branches of telopodite variously curved, directed laterad. Coxite of gonopodal segment never sheath-like. .... *Abacion*
Terminal branches of telopodite almost straight, retrorse. Coxite on gonopodal segment forms a long, partial sheath around the shaft of the telopodite. .... (*Delophon*) 3
3. Terminal region of telopodite divided into two sharply pointed branches. About 34 ocelli in 7 or 8 transverse series. .... *Delophon serrulatum*, sp. nov.
Terminal region of telopodite divided into three sharply pointed branches. Ocelli in 8 or 9 transverse series. 4
4. About 58 ocelli in each eye. .... *Delophon georgianum* Chamberlin (1943).
About 43 or 45 ocelli in each eye. .... *Delophon carolinum* Hoffman (1950).

Family DORYPETALIDAE
Genus *Delophon*

Delophon Chamberlin, 1943, Bull. Univ. Utah, Biol. Ser., 8(2):13.

DELOPHON SERRULATUM, sp. nov.

Diagnosis.—Distinguished from the other two species of the genus by the reduced number of ocelli and by the presence of two rather than three acute terminal branches on the telopodite of the male gonopods.

Type locality.—Mississippi: Baldwin County, 9 miles west of Loxley at the junction of U. S. Highway No. 90 and Mississippi State Route No. 89; Jan. 5, 1954; 1 male.

Male holotype.—Body slender, cylindric, about 26.5 mm long, 1.2 mm wide; 48 segments, the last three legless. Medium brown above; legs and venter light brown. Eyes triangular, about 34 ocelli in seven or eight transverse series. Segments 2 and 3 of antennae subequal and slightly longer than segment 4, which is longer than 5. Forehead moderately rounded. Segment 6 conspicuously larger than segments 1 through 5 and slightly larger than 7 and the following segments. Collum with about 20 longitudinal crests, all ending on the caudal margin and of uniform height but not of uniform length. On the anterior segments both the primary and the secondary crests extend the full length of the metazonite and are subequal in height; on the middle segments the secondary crests diminish in both height and length, and on the posterior segments they fade out. The transition from ten to fourteen dorsal crests between the repugnatorial pores takes place on segment 12. Pore crests fusiform and scarcely more prominent than the adjacent primary crests. Last tergite short, without crests, but with six tuberculate setae near the hind margin and two long, projecting papillate hairs. Setae at end of primary crests not more than one-fourth the length of the crests. Legs 2, 3, and 4 each with a velutinous pad on the ventral surface of the distal half of the last article.

In situ the two gonopods are parallel and contiguous as far distad as the terminal branches, which are bent sharply in a retrorse direction. The long, ventro-caudally arched shaft of the telopodite is partially enclosed by the coxal sheath, or coxite, which extends as far ventrad as the terminal branches. The two terminal branches (figs. 1, 2, *bl, bm*) are almost straight and sharply pointed; the lateral branch is broader and slightly longer than the medial branch. The seminal canal branch (fig. 1, *bc*) is short, blunt, and arises from the medial branch. The coxal sheath is minutely rugose, and its apical region, which is less expanded along the mesial margin than in *georgianum,* is thin and irregularly serrulate (fig. 3, *cs*).

Ecology.—The collection site is a hilly, thin, mixed woodland. Myriapods were scarce; other than this specimen, a few lithoboid centipeds and larvae of *Abacion* sp. and *Cleidogona* sp. were found.

Suborder CHORDEUMIDA

Family CLEIDOGONIDAE

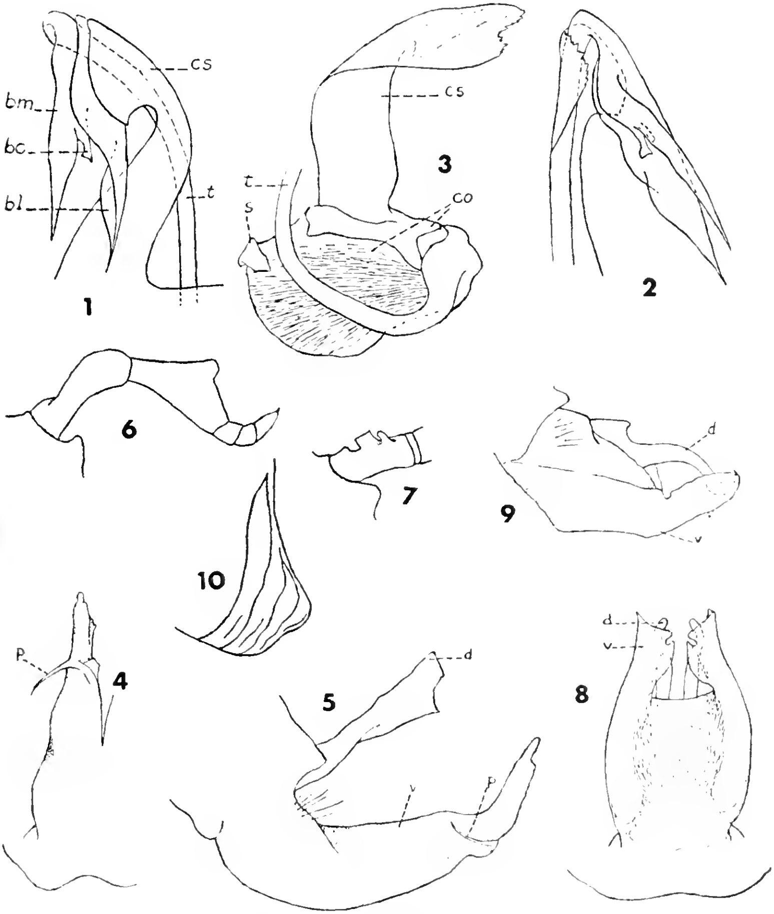
Genus *Cleidogona*

Cleidogona Cook and Collins 1896, Ann. New York Acad. Sci., 9(1-3): 41-42.

Cleidogona aspera Causey

Cleidogona aspera Causey, 1951, Jour. Washington Acad. Sci., 41(2):78, figs. 1-4.

New record.—Louisiana: Lincoln Par., Ruston; Oct., 1951; W. J. Harman; 3 males, 5 females.



Figures 1-10. *Delophon serrulatum*, sp. nov.: **1**. distal region of telopodite of left gonopod, lateral view; **2**. same, caudal view; **3**. basal region of left gonopod, mesial view. *Cleidogona sublettei*, sp. nov.: **4**. ventral branch of left gonopod, ventral view; **5**. left gonopod, lateral view. *Cleidogona arkansana*, sp. nov.: **6**. ninth leg; **7**. base of eleventh leg; **8**. gonopods, ventral view; **9**. left gonopod, lateral view. *Orthoporus ornatus* (Girard): **10**. ventral margin of collum, right side, female. Abbreviations: *bc* = seminal canal branch, *bl* = lateral branch, *bm* = mesial branch, *co* = coxa, *cs* = coxal sheath, *d* = dorsal branch, *p* = lateral process, *s* = cut middle surface of sternum, *t* = shaft of telopodite, *v* = ventral branch.

CLEIDOGONA **SUBLETTEI**, sp. nov.

Diagnosis.—The male gonopods of this species closely resemble those of *C. mississippiana* Chamberlin (1942). The two species are best separated by the absence in *C. sublettei* of a subterminal spine from the dorsal surface of the ventral branch.

Type locality.—Louisiana: Natchitoches Parish, Grand Ecore; Nov. 13, 1953; James E. Sublette, 3 males.

Male holotype.—Length about 20 mm. Brown above and laterad, with the usual areolated buff maculae; venter cream; tarsi brown, remainder of legs cream. Antennae and vertex of head brown; ocelli black, forming a triangular patch, in series of 1, 7, 6, 5, 4, 3, 2.

The second articles of the ninth leg are as in *mississippiana,* but the coxae differ in that the excavation is broader, as in *C. laminata* Cook and Collins (1895) and *C. aspera* Causey (1951), and the distal surface is granular. The coxae of the tenth and eleventh legs have each the usual short, cylindrical process through which the coxal gland opens; the eleventh coxae have each a small, flattened, capitate process on the caudal surface. The sternal process at the base of the twelfth legs is as in *C. unita* Causey (1951).

The ventral branches of the gonopods are attenuated, subparallel, relatively simple, and slightly arched, so the apices rest on the base of the eleventh legs; the laterally directed subterminal process (figs. 4, 5, *v, p*) is a spine rather than a lamella, as it is in *mississippiana.* The dorsal branch is straight, with the apical region broad and flattened (fig. 5, *v*).

CLEIDOGONA **ARKANSANA**, sp. nov.

Diagnosis.—The male gonopods of this species are nearest those of *C. fustis* Cook and Collins (1895). The two species are easily separated by the apex of the ventral branch, which in *fustis* is deeply bifid and abruptly twisted, and in *arkansana* is shallowly bifid and not twisted.

Type locality.—Arkansas: Dallas Co., four miles east of Princeton at a picnic site on Arkansas State Route No. 8; Jan. 7, 1954; one male, one female.

Male holotype.—Length about 15 mm. Light brown above and laterad, the usual areolated maculae scarcely visible. Antennae and vertex of head brown; ocelli black, forming a triangular patch, in series of 1, 7, 6, 5, 4 (3), 3, 2.

The seventh legs have each a mammillate process as large as the processes of the tenth legs on the caudal surface of the coxae. The ninth legs (fig. 6) have the first articles relatively simple, but the second articles are produced ventrad in an unusual way. The coxae of the tenth and eleventh legs have each the usual short, cylindrical process through which the coxal gland opens; the eleventh coxae (fig. 7) have each an additional, smaller, cylindrical process on the caudal surface. The sternal process at the bases of the twelfth legs is as in *C. unita* Causey (1951).

The ventral branches of the gonopods (fig. 8, *v*) are slightly bowed laterad, bringing the apices almost together; most of the space between these branches is filled by a thin lamella. The apex of the dorsal branch is truncated, shallowly bifid, and slightly curved laterad about the apex of the ventral branches. The arched dorsal branch (fig. 9) is abruptly bent at the apex.

Female allotype.—Somatic characters agree with those of the male.

Order POLYDESMIDA
Family EURYMERODESMIDAE
Genus *Eurymerodesmus*

Eurymerodesmus Brolemann 1900, Proc. Biol. Soc. Wash., 33:97-98.

Eurymerodesmus varius (McNeill)

Polydesmus varius McNeill, 1887, Proc. U. S. Natl. Mus., 10-323-324, pl. 11, figs. 1, 2 (female, Escambia Co., Fla.).

Eurymerodesmus minimus Loomis, 1943, Jour. Washington Acad. Sci., 33(10):320, fig. 2 (male, Marianna, Jackson Co., Fla.).

New records.—Florida: Escambia Co., Pensacola and Cantonment; Jan. 5, 1954; under live oaks, adults and larvae of both sexes. *Alabama:* Mobile Co., Spring Hill; March, 1954; one female; C. E. Valentine.

The specimens of *E. varius* in my collection correspond so closely to Loomis' excellent description of his *E. minimus* that there can be little doubt that the latter must be regarded as a synonym of *E. varius.*

Family XYSTODESMIDAE
Genus *Apheloria*

Apheloria Chamberlin 1921, Canad. Ent., 53:232.

Apheloria reducta Chamberlin

Apheloria reducta Chamberlin, 1939, Bull. Univ. Utah, Biol. Ser., 5(3):11, pl. 4, fig. 35 (male, Imboden, Lawrence Co., Ark.).

New record.—Oklahoma: McCurtain Co.; July 20, 1954; one male, width 10.8 mm, length about 41 mm; W. J. Harman.

This species has heretofore been known only from northern and western Arkansas and southern Missouri.

Order SPIROSTREPTIDA
Family SPIROSTREPTIDAE
Genus *Orthoporus*

Orthoporus Attems 1914, Zoologica, 25(5/6):132.

Orthoporus ornatus (Girard)

Julus ornatus Girard, 1853. In Marcy, Report on Red River Exped., p. 274 ("collected on the 27th of June").

Spirobolus ornatus, Wood, 1865, Trans. Amer. Philos. Soc., 13:208-209; Bollman, 1887, Ann. New York Acad. Sci., 4:43.

New record.—Texas: Randall Co., Palo Duro Canyon State Park; July, 1953; 1 female; H. H. Iltis.

Girard's references to the longer antennae, the shape of the eyes, and the upper lip indicate that his *Julus ornatus* is an orthoporid, not a spirobolid, but there is little of specific value in his description. His collection date fixes the type locality as either within or very near the present Palo Duro Canyon State Park, Randall County, Texas. A resident of that area reported to me in 1953 that "these big thousand-leggers have been migrating across our road in great numbers all summer."

Female topotype.—Width 11 mm, length about 185 mm, 70 segments. Most segments with three annuli, of which the most anterior is tan and visible only on the dorsal surface of many segments, the middle is widest and almost black, and the caudal is narrow and dark red. Legs almost black. The blue color observed by Girard and not observed in this specimen is usually associated with a recently molted condition. Eyes composed of seven transverse series of from fourteen to three ocelli. Both corners of collum (fig. 10) rounded, the anterior slightly produced, and the ventral margin slightly concave between the corners. Collum with four impressed lines branching from the marginal sulcus to the caudal margin; the upper limit of the marginal sulcus is the height of the caudal row of ocelli. Body surface finely and evenly punctuate. Segmental sutures light, only slightly indented toward the pores, which are located about one-fourth the distance from the segmental sutures to the caudal margin of the segments. Caudal one-third of last tergite abruptly depressed and more coarsely punctuate than the remainder of the surface; apex of tergite slightly obtuse and well exceeded by the thin margins of the anal valves.

The large size and the shape of the lateral margins of the collum should serve to distinguish females of *O. ornatus* from other orthoporids in adjacent areas of Texas and Oklahoma.

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NOTROPIS BAILEYI, A NEW CYPRINID FISH FROM THE PASCAGOULA AND MOBILE BAY DRAINAGES OF MISSISSIPPI AND ALABAMA

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NOTROPIS BAILEYI, A NEW CYPRINID FISH FROM THE PASCAGOULA AND MOBILE BAY DRAINAGES OF MISSISSIPPI AND ALABAMA

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Intensive ichthyological field studies in southeastern United States in recent years have revealed several new forms of *Notropis,* the largest genus of North American Cyprinidae. One is described below and also included are studies of other closely related forms, especially *Notropis lutipinnis* (Jordan and Brayton) and *Notropis chrosomus* (Jordan), which are little known. The habits and ecology of these small fishes are suggested as interesting and worthwhile studies for regional ichthyologists.

Material of the new species has been collected by the authors and others listed below to whom we give hearty thanks for personal assistance in the field or for the loan of specimens. They are Bancroft Cooper, Ralph L. Chermock, Charles F. Cole, Robert H. Gibbs, Herbert D. Gibson, Charles D. Hancock, P. S. Handwerk, L. James Kezer, H. T. Rainwater, C. Richard Robins, Merlin G. Suttkus and William S. Woolcott. Vladimir Walters has made available tooth and anal ray counts for *Notropis lutipinnis.* Helen J. Illick has kindly supplied counts for the cephalic lateral line pores from an unpublished study of these structures in North American Cyprinidae. We are grateful to Reeve M. Bailey, Ernest A. Lachner, and Carl L. Hubbs for a critical review of the manuscript and other favors. This form is named for Dr. Reeve M. Bailey, Curator of Fishes, Museum of Zoology, University of Michigan, who has contributed much to the knowledge of North American freshwater fishes and who has been ever helpful in our studies. Counts and measurements were taken as described by Hubbs and Lagler (1947: 8-15).

NOTROPIS BAILEYI, sp. nov.

Figs. 1 and 2, Map 1

The type material consists of 222 specimens from 21 to 63 mm in standard length taken at seven localities in the Alabama River System. Other material examined consists of 338 specimens, 19-55 mm from 19 localities in the Tombigbee and Pascagoula drainages. Below in parentheses are indicated the number of specimens and the range of standard length in millimeters, *e.g.* (4, 35-56). In addition to stand-

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[1] Aid for field studies and collections of fishes now at Cornell was obtained through awards from the Cornell University Faculty Research Grants Committee.

ard compass directions, with the following "of" deleted, these abbreviations are used: Co. = County, Cr. = Creek, mi. = mile or miles, R. = River, trib. = tributary (of), ANSP = The Academy of Natural Sciences of Philadelphia, CU = Cornell University, TU = Tulane University, UMMZ = University of Michigan, Museum of Zoology and USNM = United States National Museum.

Material.—Holotype, CU 28224, an adult female 59.6 mm in standard length, taken in the Alabama River system in a trib. Sawacklahatchee Cr., 1.7 mi. W. Society Hill on U. S. Route 80, Macon Co., Alabama, on June 12, 1949, by Royal D. Suttkus, Charles F. Cole and Robert H. Gibbs. Designated as paratypes (CU 16020) are 66 specimens from 29 to 63 mm in standard length which bear the same data as the holotype.

Other paratypes from the Alabama River system of Alabama are as follows: TU 3195 (4, 33-56), Pine Barren Cr., 2.5 mi. S. Forest Home, Butler Co., June 2, 1951; TU 2637 (30, 30-43), trib. Alabama R., 17.3 mi. S.S.W. Camden, Monroe Co., June 3, 1951; TU 3430 (75, 29-48), Pursley Cr., trib. Alabama R., 3.4 mi. S.W. Camden, Wilcox Co., June 3, 1951; TU 2965 (4, 21-46), Gravel Cr., trib. Pursley Cr., 6.3 mi. S.W. Camden, Wilcox Co., June 3, 1951; TU 3066 (41, 31-52), trib. Pursley Cr., 1.8 mi. E. Camden, Wilcox Co., June 3, 1951; USNM 163568 (1, 31), 5 mi. W. Attalla, Etowah Co., September 13, 1947; UMMZ 105526 (2, 59-61), branch 4 mi. W. Auburn, Wire Road, [Lee Co.], June 1938; UMMZ 105554 (73, 33-53), creek, 4 mi. W. Auburn, Wire Road, [Lee Co.], March 9, 1939; UMMZ 124018 (1, 27), Big Swamp, 5 mi. S.E. Tuskegee, [Macon Co.], September 13, 1937; UMMZ 124024 (1, 61), Long Branch, 1 mi. W. Marvyn (Columbus Road), [Lee Co.], September 20, 1937; UMMZ 124094 (41, 18-48), Loblockee Cr., N. Auburn, [Lee Co.], September 19, 1938; UMMZ 124117 (45, 27-55), Olin Cr., (= Odom Cr., S. Auburn), [Lee Co.], September 26, 1938; UMMZ 146517 (5, 42-47), Beaver Cr., 5 mi. W. Autaugaville, Autauga Co., June 13, 1942; UMMZ 146533 (16, 34-55), trib. Beaver Cr., 5 mi. W. Autaugaville, Autauga Co., March 20, 1942; UMMZ 146544 (97, 30-56), Beaver Cr., 5 mi. W. Autaugaville, Autauga Co., December 20, 1942.

Additional specimens examined are as follows: Black Warrior drainage, Alabama, CU 13991 (2, 36-37), Black Warrior R., 10.1 mi. N.E. Eutaw, Greene Co., March 31, 1948; CU 21165 (2, 26-30), 3.5 mi. N.W. Black Warrior R. bridge at Demopolis, Greene Co., March 10, 1951; CU 21166 (26, 19-46), Woods Cr. on Romulus Rd., Tuscaloosa Co., March 10, 1951; CU 13999 (6, 28-45), trib. Hurricane Cr., 1.6 mi. W. Vance, Tuscaloosa Co., March 31, 1948; CU 13785 (38, 19-51), trib. Black Warrior R. at Cottondale, Tuscaloosa Co., March 31, 1948; CU 19264 (20, 24-45), Hurricane Cr., 6 mi. E. Tuscaloosa, Tuscaloosa Co., October 21, 1950; CU 19259 (60, 28-54), Cottondale Cr. near Hurricane Cr., Tuscaloosa Co., May 19, 1950; UMMZ 166361 (60, 21-45), creek, 5 mi. N. Tuscaloosa, detour US Hwy. 45, [Tuscaloosa Co.], May 4, 1952.

Tombigbee drainage, Alabama, CU 15544 (5, 32-45), trib. Alamuchee Cr., 2.2 mi. N.E. York, Sumter Co., March 31, 1948; CU 25705 (38, 29-41), Williams Cr., just N. Hamilton, Marion Co., August 17, 1953; UMMZ 113914 (42, 27-42), headwater of Luxapallila Cr., ¼ mi. S.E. Winfield, Fayette Co., June 4, 1932; UMMZ 135892 (2, 38-42), Vaughn Cr., 4 mi. N.E. Mount Sterling, Choctaw Co., September 4, 1942; UMMZ 141152 (1, 46), lake at Winfield (Winfield is on Luxapallila Cr.), [Marion Co.], 1943(?); UMMZ 166383 (275, 25-59), Luxapallila Cr., 2 mi. W. Winfield, US Hwy. 43, [Marion Co.], May 4, 1952.

Tombigbee drainage, Mississippi, UMMZ 113872 (3, 42-52), Ponta Cr., trib. Sucarnoochee Cr., 12 mi. S. Electric Mills, US Hwy. 45, Lauderdale Co., June 3, 1932.

Pascagoula drainage system, Mississippi, Covington Co.: CU 16261 (15, 27-50), trib. Okatoma Cr., 1.7 mi. E. Collins, June 14, 1949; CU 12578 (43, 22-55), trib. Bowie Cr., 10.9 mi. W. Collins, August 7, 1948; Clarke Co.: UMMZ 157782 (11, 23-57), small creek from US Hwy. 11 to mouth in Chickasawhay R., 1 mi. N. Enterprise, August 17, 1939; Wayne Co.: (all distances from Waynesboro Post Office, abbreviated W.P.O.) TU 8052 (2, 29-31), Patton Cr., 2 mi. W.P.O., Feb. 1954; TU 8031 (15, 26-47), Meadow Cr., 2.5 mi. W.P.O., Feb. 1954; TU 8047 (9, 21-44), Tatum Cr., 3 mi. W.P.O., March 17, 1954; TU 8073 (4, 32-48), 3.5 mi. W.P.O., Feb. 24, 1954; TU 8038 (15, 25-46), Limestone Cr., 4 mi. W.P.O., March 18, 1954; TU 8056 (25, 34-47), 3.5 mi. W.P.O., Feb. 18, 1954; TU 8063 (8, 31-48), Limestone Cr., 4 mi. W.P.O., March 24, 1954; TU 8066 (5, 34-50), Taylor Cr., 1.5 mi. W.P.O., March 9, 1954.

Diagnosis.—A species of *Notropis* with 2, 4—4, 2 teeth and 7 anal rays. Other fin rays: dorsal 8; pectoral 14, occasionally 15; pelvic 8. Scales: predorsal rows 15, rarely 16; above lateral line to dorsal origin 5 or 6; below lateral line to anal origin 4 or 3; in lateral line 36, sometimes 37; around body before dorsal 23 to 30, usually 24 to 28; around caudal peduncle 12, sometimes 13. Body moderately deep and compressed. Dorsal origin directly above pelvic origin. Mouth inclined, moderately large; upper jaw much longer than eye length. Lateral line complete. Anterior lateral line scales not elevated. Middorsal streak dark, continuous and encircles dorsal fin base. Moderate to strong dark lateral band on body. Prominent dark basicaudal spot. Size small, to 60 mm standard length. Apparently allied to but sharply differentiated from *Notropis chrosomus* and *Notropis lutipinnis,* both of which have 8 anal rays.

Description.—Besides the pertinent characters given above, counts and measurements are given in Tables 1-3 and include comparisons with *Notropis chrosomus* and *Notropis lutipinnis.* Measurements of the holotype are detailed in Table 1 and its fin ray and scale counts in Table 3 are the usual counts unless indicated otherwise by an asterisk. Additional characters are illustrated in Figures 1-4. Other

TABLE 1.

MEASUREMENTS OF *Notropis* IN THOUSANDTHS OF STANDARD LENGTH. FOR EACH CHARACTER IS GIVEN THE RANGE OF VARIATION AND BELOW (IN PARENTHESES) THE MEAN.

Species	*baileyi*		*lutipinnis*	*chrosomus*
Stream system	Alabama		Chattahoochee	Alabama
Catalog number, CU	28224	16020	28226	17743
No. and sex of specimens measured	Holotype ♀	Paratype* 5 ♀, 4 ♂	2 ♀, 8 ♂	5 ♀, 5 ♂
Standard length	60.3	42.5-62.9	43.5-54.5	42.0-62.9
Dorsal origin to snout tip	506	492-518 (510)	518-544 (533)	496-531 (518)
Dorsal origin to caudal base	532	514-535 (525)	474-531 (508)	500-533 (517)
Dorsal origin to occiput	318	304-323 (315)	314-346 (330)	312-343 (332)
Pelvic insertion to snout tip	520	491-520 (504)	460-506 (490)	480-518 (497)
Anal origin to caudal base	331	328-350 (338)	262-370 (344)	312-355 (335)
Body depth	255	228-261 (247)	220-252 (237)	217-252 (233)
Body width	159	140-162 (152)	137-167 (151)	151-183 (169)
Dorsal origin to lateral line	149	146-165 (158)	148-167 (156)	133-157 (146)
Pelvic insertion to lateral line	119	107-135 (115)	088-119 (106)	097-128 (114)
Caudal peduncle length	210	210-236 (225)	190-239 (220)	218-253 (234)
Caudal peduncle depth	106	097-116 (104)	097-107 (101)	087-102 (096)
Head length	253	244-258 (251)	267-288 (275)	218-238 (228)
Head depth	168	156-172 (168)	166-178 (173)	156-171 (174)
Head width	143	127-145 (136)	120-144 (136)	122-141 (131)
Interorbital, least fleshy	084	084-088 (085)	082-094 (089)	080-088 (083)
Snout length	074	074-083 (080)	085-093 (088)	068-078 (074)
Eye length	074	066-074 (070)	063-074 (067)	057-068 (062)
Upper jaw length	086	083-090 (086)	090-105 (100)	065-080 (073)
Suborbital, least width	032	030-036 (032)	028-034 (031)	028-033 (030)
Dorsal fin, depressed length	214	210-239 (219)	218-247 (231)	183-231 (204)
Anal fin, depressed length	194	177-194 (185)	218-232 (225)	179-200 (187)
Caudal fin length from mid-base to tip of longest ray	243	243-294 (269)	239-275 (257)	231-271 (249)
Pectoral fin length	173	173-209 (186)	201-223 (214)	176-217 (196)
Pelvic fin length	153	151-172 (160)	152-178 (168)	147-176 (161)

* The mean includes the measurement of the holotype.

descriptive features follow: The fusiform body is rather deep and somewhat compressed. Among the black banded species of *Notropis* with 2, 4—4, 2 teeth it most closely resembles *lutipinnis* but differs from it in many characters including the anal ray count (8 in *lutipinnis*). The mouth is terminal; the snout is slightly blunt. The head is subtriangular. The dorsum rises rather uniformly from the region of the nostrils and levels off only slightly before the dorsal fin origin. Posteriorly it descends gradually and ascends again just before the procurrent caudal rays. The ventral outline anteriorly is only slightly less elevated than the dorsal. It curves abruptly upward beginning at the pelvic base and levels off midway on the caudal peduncle, which is rather stout. The lateral line is complete; anteriorly it begins only slightly below the upper margin of opercular opening and descends gradually to level off about one-third of the distance to the dorsal origin. It continues horizontally, slightly below the ventral edge of the dark lateral band, to a point below the posterior dorsal fin base. Here it rises gradually and continuously reaching the upper edge of the dark lateral band at about the narrowest part of the caudal peduncle only to descend again near the caudal base. In *lutipinnis* the course of the lateral line is similar to that of *baileyi* except that it does not dip as far ventrally on the anterior half nor reach as far dorsally on the posterior half of the lateral band. In *chrosomus* the lateral line is included within the lateral band for its entire length, but in its anterior half is closer to the ventral border of the band, while the reverse is true on the posterior half of the body.

In the following description of the lateral line canal and pores on the head, the number of specimens counted is given in parentheses. In counting pores the anteriormost is number one. In N. *baileyi,* the supratemporal canal is always incomplete, with two pores on each side (7) or with 3 on the left and 2 on the right (1). N. *chrosomus* is essentially the same: incomplete, with 2 pores on each side (6) or with 2 on the left and 3 on the right (1). N. *lutipinnis* differs from both in having the supratemporal usually complete with only 3 pores (4); one had an incomplete canal with 2 pores on each side.

The supraorbital canal is complete in the three species under consideration. N. *baileyi* usually has a pore count of 8 (6) or 9 (2); a line projected vertically from the posterior margin of the eye falls between pores six and seven when the count is 8 and between seven and eight when the count is 9. N. *lutipinnis* is similar with 8 (3) or 9 (2); a line from the posterior margin of the eye falls on or very close to the next to last pore. N. *chrosomus* differs in the small sample counted in having 8 (2), 9 (4), or 10 (1). A vertical from the posterior margin of the eye falls between pores six and seven when the count is 8, between pores seven and eight when count is 9, and between eight and nine when 10.

The infraorbital canal is complete in *baileyi* and *lutipinnis.* In *baileyi* the count is 15 (4), 14 (3), or 13 (1). A vertical projected from the anterior margin of the eye falls between pores five and six

TABLE 2.
ANAL RAY COUNTS IN THREE SPECIES OF *Notropis*

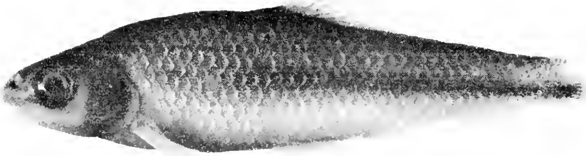
Species and drainage	6	7	8	9	Number	Mean
baileyi						
Alabama R.	1	65	1	—	67	7.00
Black Warrior R.	—	137	18	—	155	7.12
Tombigbee R.	—	41	2	—	43	7.05
Pascagoula R.	—	58	—	—	58	7.00
Totals	1	301	21	—	323	7.06
lutipinnis						
Savannah, Altamaha and Chattahooche rivers	—	1	166	7	174	8.03
chrosomus						
Alabama R.	—	4	75	12	91	8.09

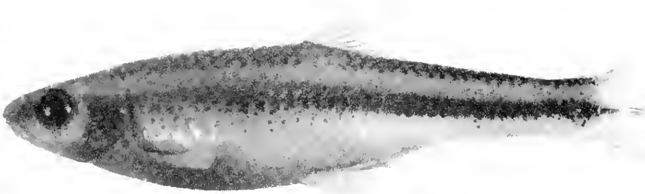
and four and five respectively. In *lutipinnis,* the count is lower, 14 (4) or 13 (1); a line from the anterior margin of the eye falls between pores five and six. The infraorbital in *chrosomus* is complete in four out of five specimens studied and shows the greatest variation in pore count with 13 (3), 14 (1), 15 (1), or 16 (1). One specimen with a pore count of 16 is incomplete with a break between pores twelve and thirteen in the temporal region. A line projected from the anterior margin of the eye falls between pores four and five.

The preoperculomandibular canal is complete in the three species. In *baileyi,* the pore count is usually 10 (4), but occasionally 9 (2) or 11 (2). In *lutipinnis* the count is 9 (3), 8 (1), or 10 (1). In *chrosomus* the number is 10 (4), 11 (1), or 12 (2). In *chrosomus* all pores, but especially those of the preoperculomandibular series are much larger than in either *baileyi* or *lutipinnis.* Also *lutipinnis* usually differs from *chrosomus* in having the preoperculomandibular pores more widely separated and has a particularly wide space between pores four and five.

Dorsal fin straight on posterior border; when depressed the anterior rays exceed the posterior rays. Anal fin slightly falcate; when depressed the posterior rays exceed the anterior rays.

The pharyngeal arch is fairly strong. The teeth in the main row are pointed and hooked at the tip. The serrulate grinding surface is well developed especially on the middle two teeth. The teeth in





Figures 1-4. **1.** (top) *Notropis baileyi*, paratype, adult female, 56 mm in standard length, from the type locality, a trib. Sawacklahatchee Cr., 1.7 mi. W. Society Hill, Tallapoosa River drainage, Macon Co., Alabama; **2.** (second) *Notropis baileyi*, adult male, 48 mm from a trib. Black Warrior River at east limits of Cottondale, Tuscaloosa Co., Alabama; **3.** (third) *Notropis lutipinnis*, a mature female, 58 mm from Bushy Creek, 9 mi. S. Wrens, Savannah River drainage, Jefferson Co., Georgia; **4.** (bottom) *Notropis chrosomus*, a mature female, 58 mm from a trib. Oostanaula River, 6.3 mi. S.W. Calhoun, Coosa River drainage, Gordon Co., Georgia. (Photographs by Douglass M. Payne)

the lesser row are about half as high as those in main row which are pointed and hooked slightly; the grinding surface is moderately developed. The gill rakers on the anterior gill arch number 4 to 6. They are short subtriangular in shape and only the two near the center of the arch are pointed. The nape is scaled. The breast is scaleless forward of a transverse line between the posterior margin of the pelvic bases.

As has been noted repeatedly for other species of *Notropis* slight but consistent color or pattern differences are present. Most of these are included in Table 3. Typically, *baileyi* is a black banded species. The band is prominent, is intensified posteriorly and if at all is only weakly marked by more intense spots above and below each lateral line pore. It continues on the head behind the eye but is less intense immediately before the eye and fades considerably on the anterior part of the snout. A sharp light stripe borders the dark band above. A prominent and diagnostic feature, except in some specimens from the Black Warrior system, is the series of dark ovals located on the first full scale row below the dark lateral band (fig. 1). A prominent quadrate basicaudal blotch is continuous with and somewhat darker than the band immediately in front. The blotch continues on to the 4 to 6 median caudal rays a distance about equal to the length of the spot on the caudal peduncle. The dark edging on the midcaudal rays continues to the fork but is weaker posteriorly. The prominent middorsal dark streak is continuous, although not intensified, around the base of the dorsal fin and although present behind the dorsal base is only about two-thirds as wide. It narrows somewhat about half way between the occiput and dorsal origin. The midventral dark band on the caudal peduncle is limited to the area at the base and immediately behind the depressed anal fin. The top of the head is dark. A light preorbital bar extends forward to include the area about the nostrils. A wedge-shaped dark blotch lies above the nostrils. A diamond-shaped dark bar crosses the head just anterior to the hind margin of the eyes. The heart-shaped mark on the rear of the head is more or less completely divided by a transverse light line and is outlined on its posterior lateral margin by another light bar. A dark subtriangular blotch overlays the temporal region anterior to a dark transverse occipital bar which continues laterally and downward behind the opercle to the pectoral fin base. The lips have scattered melanophores. The chin is peppered and has a lighter area near the center. The upper oral breathing valve bears a few melanophores.

The fins are generally light. The first pectoral ray is darkish and the second ray bears a few melanophores. The caudal fin rays, especially those in the center, are finely margined with black. The dorsal rays are margined with black and there are scattered melanophores on the membranes near the base of the fin. The anal and pelvic fins are white.

The dark lines which margin the scale pockets although not pro-

TABLE 3.
COMPARISON OF THREE SPECIES OF *Notropis*

Character	*baileyi*	*lutipinnis*	*chrosomus*
Mouth, side view	Oblique, rising anteriorly to middle or one-third of pupil. Slightly notched in center	Oblique, rising to middle of pupil. Front half or one-third somewhat curved downward	Evenly curved downward anteriorly, barely reaching lower level of pupil
Posterior tip of upper jaw in relation to a perpendicular from the anterior edge of eye	Reaches	Extends behind	Barely reaches
Middorsal stripe continuous about base of D. fin	Yes	No	No
Midventral peritoneum	Dusky with large scattered melanophores	Light	Light
Heart-shaped mark on back of head	Divided by a transverse light line	Not divided	Divided faintly into three sections
Lower border of dark lateral band on opercle	Limited to upper opercle	Limited to upper opercle	Extends far down on opercle
Oblique dark bar behind opercle	Well developed	Weak	Well developed
Dark color laterad and posterior to the anus	Present	Absent	Absent
Body about base of anal fin	Dark	Light with few small deep seated melanophores	Light with few melanophores at base of rays
Basicaudal spot	Present, subquadrate, continuous with and somewhat darker than the lateral band on body	Absent, although midcaudal rays are somewhat darkened to caudal fork	Small spot, central caudal rays dark

Dark lateral band on anterior half of body	Intense; weakly marked above and below lateral line pores	Strong; lacks intensifications above and below lateral line pores	Weak, with scattered melanophores; spots present above and below lateral line pores
Origin of dorsal fin in relation to anterior pelvic insertion	Directly over	Well behind	Slightly behind
Body depth in relation to head length	Slightly greater	Much less	Greater
Head length into standard length	Intermediate; about 4 times	Long; considerably less than 4	Short; considerably more than 4
Snout length as percentage of standard length	Intermediate; 7.4 - 8.3%	Long; 8.5 - 9.3%	Short; 6.8 - 7.8%
Upper jaw length as percentage of standard length	Intermediate; 8.3 - 9.0%	Long; 9.0 - 10.5%	Short; 6.5 - 8.0%
Fin rays			
Anal (typically)	7	8	8
Pectoral	14, often 15	15, occasionally 16	14 or 15
Pelvic	8	8, rarely 9	8, occasionally 9
Scales			
Predorsal rows	15, rarely 16	16 to 21, usually 17-18	16, occasionally 17
Dorsal origin to lateral line	5, often 6	6 to 8, usually 6-7	5, occasionally 6
Anal origin to lateral line	4, often 3 *	4, often 5	3, often 4
In lateral line	36, occasionally 37 *	37-39, usually 38	36-38, usually 37-38
Around body before dorsal fin	23-30, usually 24-28	26-31, usually 27-30	22-24, usually 22-23
Around caudal peduncle	12, occasionally 13	14-17, usually 14-16	12

* Count of holotype.

nounced cross the light stripe which lies above and parallels the dark lateral band of the midside. The scale centers are somewhat lighter than their borders. The breast and belly are white; occasionally the dark of the peritoneum shows through.

In the field males from Black Warrior system taken on March 31 were observed to have a wide whitish or lead colored line along the side. C. Richard Robins notes that specimens taken on August 12 had a metallic lateral band and that the caudal fin and the pectoral fin base were orange. At breeding time it is brightly colored with shades of red through yellow. Detailed color notes on specimens contained in UMMZ 105554, 146533 and 166383 were furnished by Reeve M. Bailey. Specimens in UMMZ 105554 had a deep-lying light orange area above the steel blue-black lateral band which graded to yellow over the back. The orange and the black were separated superficially by a leaden-white line. The lateral band was also bordered on its lower side by a silver white streak which petered out toward the caudal but was broadened on the trunk and anteriorly graded into the silvery side of the face. The mid-dorsal stripe and scale borders above were deep moss-green. There was considerable orange-red on the lower sides posteriorly. Bright red colored the axil of the pectoral fin but not about the pelvics. A red line bordered the dorsal margin of the lateral band on the side of the head; was interrupted by the eye but reappeared as a watery rose stripe around the snout. There was a wash of rose color on the fins which was strongest on the areas immediately above and below the basicaudal spot. Specimens in UMMZ 146533 were essentially the same in color as above, however the sides anteriorly were bright red which shaded into orange posteriorly. The dorso-lateral white line was broadened anteriorly and obscured the lateral band. The red on the sides faded dorsally but was strong on the breast, about the base of the pelvics, and down to and posterior to the anal fin. The pectoral axil was deep red as were the markings behind the eye and on the snout. The body and fins of the males in UMMZ 166383 were bright yellow instead of washed with red. The females lacked the bright yellow on the body and fins. The sex products were easily expressed from the breeding individuals.

Nuptial tubercles are well developed in both sexes. In the male the top and sides of the head bear fine or moderate sized scattered tubercles with rather coarse ones prominently interspersed. Both types of tubercles are present on the opercle but only fine ones appear on the cheek. Fine tubercles cover the underside of the head. Large pointed ones occur on the lower jaw. Scattered fine tubercles with a few interspersed large pointed ones are found on the snout. *N. lutipinnis* differs in having only fine or moderately developed tubercles on these parts. *N. chrosomus* has large coarse tubercles scattered over the top of the head and snout, with a well developed row on edge of the latter; scattered large tubercles and numerous small ones on the opercles, cheek and preorbital area; and moderate tubercles scattered on the dentary and underside of head. *N. baileyi* has small tubercles on the edge of the scales and has 2 to 3 larger ones in vertical row near the scale base. On the ventral scales there are fewer tubercles posteriorly. In *lutipinnis* the scales are densely tuberculate, with large ones on the margin. Tubercles are common posteriorly and on the underside of the body. In *chrosomus* there is a prominent row on the posterior margin of each scale. Those on the second scale row below the lateral line are not as well developed. Those on upper and lower pectoral rays are in one or two rows. In *lutipinnis* a row of sharp tubercles line the rays on the upper side of the pectoral fin. *N. chrosomus* is like *lutipinnis* but lacks tubercles on the first ray. The pelvic and anal fins of *baileyi* and *lutipinnis* have a row on the upper side of the rays and on either side of the dorsal rays while these are absent in *chrosomus.* Tubercles are abundant along the caudal rays of *lutipinnis* but are absent in *baileyi* and *chrosomus.*

Sexual dimorphism.—In males of *baileyi,* the pelvic fins are longer and nearly always reach to the origin of the anal fin, and in the exceptions always extend posterior to the urogenital elevation. In females the shorter pelvic fins barely, if at all, extend beyond the distal end of urogenital elevation. In males the pectoral fins are broader than in females. However they are not as broad proportionally as in males of *lutipinnis.* In females the pectoral fins are narrower and have more acute distal tips. In females the nuptial tubercles are less developed than in males although some tubercles on the head are nearly as large. There are none or only a few small tubercles on the dorsal and lateral scales. Transverse rows of fine tubercles line the belly scales. The head is finely tuberculate, with a scattering of large tubercles.

In males of *lutipinnis* the pelvic fin nearly always reaches the origin of the anal fin and commonly extends well beyond, whereas in the female the pelvic fin may reach the posterior edge of the urogenital elevation, but seldom if ever to the origin of the anal fin. In *lutipinnis* the pectoral fin in the male has a rounded distal tip and is much broader than in the female. Nuptial tubercles are less developed in the female; some are found on the margins of dorsal and lateral scales; none or only a few occur on the lower sides and belly, and fine tubercles are scattered on the head. Some may be seen on parts of all fins.

The sexual dimorphism is similar in *chrosomus.* The pelvic fins are longer in the male and extend posteriorly beyond the urinogenital elevation and often nearly to the origin of the anal fin, whereas in the female the pelvics do not reach the former point. The pectoral fin of the male is longer and more pointed. In females some large tubercles are scattered over the head and anterior body, but are lacking on the fins. Both sexes are brightly colored with red and orange at spawning time. This is one of the most attractive species of *Notropis.*

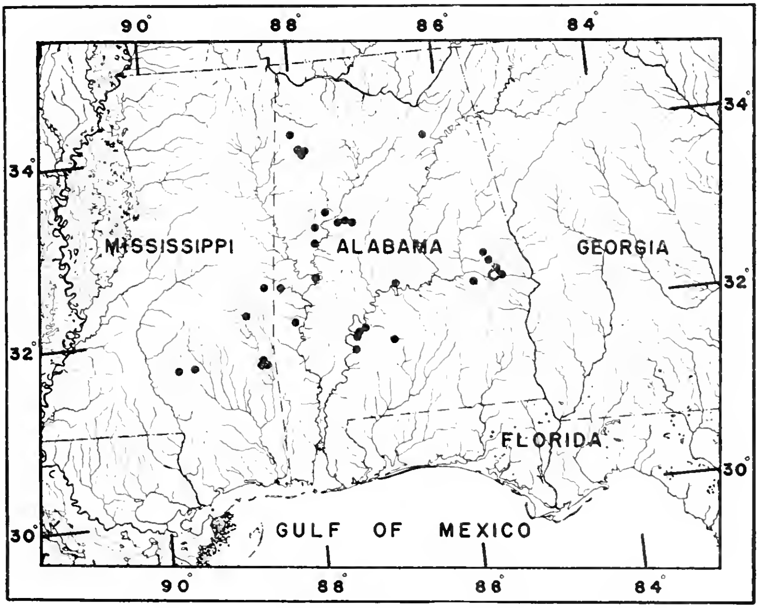
Infraspecific variation.—The dark ovals typically found immediately below the dark lateral band are missing in adult specimens taken in the Black Warrior River system (fig. 2). They also show a higher average number of circumferential scales (26 to 30, usually 26 to 28) while those from the Pascagoula and Alabama River systems range from 23 to 27, usually 24 to 26. Black Warrior specimens also have larger and coarser nuptial tubercles.

Relationships.—Among the species of *Notropis* with 2, 4—4, 2 teeth and a dark lateral band, *baileyi* is similar to and probably related to *lutipinnis* which is not found in the same drainage. It is also related to *chrosomus* which is found in the upper reaches of the Alabama River system and which was taken in the same collection with *baileyi. N. baileyi* differs trenchantly from both in the anal ray count, which is 8 in *lutipinnis* and *chrosomus,* and in many details of pattern, proportions, fin ray and scale counts given for the three species in comparative form in Tables 1 and 3.

On re-examination the types of *N. norrisi* Fowler (1945: 235, figs. 114 and 116), which were said in the original description to resemble *lutipinnis,* prove to be *Hybopsis harperi* (Fowler) the types of which were also studied. The teeth are 4—4 and the anal rays 8 in the type, ANSP 70705, and in 5 paratypes, ANSP 70706-10. Ernest A. Lachner has pointed out that the types of *norrisi* which are listed as being collected from near Fitzgerald, Georgia, are more likely to have been taken from the Suwannee River system than from the "basin of the Altamaha River". This seems certainly to be true if taken in or near Fitzgerald where the drainage system is to the south via the Alapaha River system. A re-examination of the types of *N. williami* Fowler (1945: 236, figs. 117, 118, 119) shows this to be *N. petersoni* Fowler (types also examined), as was surmised by Hubbs and Raney (1951: 9). The teeth of *williami* on re-examination are 2, 4—4, 2 in the "type", ANSP 70702, not 1, 4—4, 1 as given in the original description. Fin ray counts on the three types of *williami* are anal 7, dorsal 8, pectorals 13 and pelvics 8 (7 on one side of one specimen). Scale counts on the type and largest paratype follow: predorsal rows 16, 15; scales around body before dorsal fin 23, 22; scales around caudal peduncle 12 and lateral line scales 35.

N. baileyi may be separated from *petersoni, xaenocephalus, roseus* and an undescribed species from the Mobile Bay drainage, all of which have a dark lateral band, 7 anal rays and 2, 4—4, 2 teeth by the following characters: 1. middorsal stripe dark and continuous, encircling the dorsal fin base and extending as far as the procurrent caudal rays, rather than being poorly developed or absent posteriorly, not encircling the dorsal base; 2. mouth large, with the upper jaw much longer than the eye, rather than of equal length or smaller; 3. dark lateral band immediately behind the eye continuous and of the same intensity and width as the band on the opercle, rather than being broken immediately behind eye and represented by scattered melanophores; 4. dark lateral band on body fairly uniform in density throughout, with the lower margin entire, rather than being of varying density, especially on the anterior half, and with small spots associated with the lateral line pores. As determined from an examination of the types, *baileyi* is not the "wide mouth" variety of *"Notropis xaenocephalus"* of Jordan (1877: 335).

Distribution and ecology.—Upper Coastal Plain and nearby Piedmont from the Leaf and Chickasawhay rivers of the Pascagoula drainage of Mississippi eastward through the Mobile Bay drainage of Alabama where it has been taken in the Tombigbee, Black Warrior, and Alabama rivers; in the Alabama basin it extends eastward as far as the Tallapoosa River (Map 1). A single specimen from the upper Piedmont, 5 mi. W. of Attalla in the Coosa River system indicates the possibility of scattered populations throughout the Piedmont.



Map 1. Distribution of *Notropis baileyi.* (Circle indicates type locality)

All of our material comes from small wooded streams which were seldom more than 15 feet and often only 5 to 10 feet wide with a moderate flow. Bottom was almost always sand and gravel. The water was white where noted and vegetation was usually absent.

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A RECONSIDERATION OF THE RACER, *COLUBER CONSTRICTOR*, IN EASTERN UNITED STATES

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A RECONSIDERATION OF THE RACER, *COLUBER CONSTRICTOR,* IN EASTERN UNITED STATES

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A quarter of a century has passed since the publication of Ortenburger's (1928) monograph on the whipsnakes and racers. During the intervening years such factors as effect generic, specific and racial validity, distributional problems and the evaluation of diagnostic characters in these snakes have been quite generally discussed in many short papers. Yet, the taxonomic status and relationships of the various subspecies are still incompletely known. This seems especially true of those forms which inhabit the coastal areas of southern United States. Descriptions have been based on characters present in a few specimens at hand, with little knowledge of the extent of variation, either individual or geographic.

This study is primarily concerned with the morphological variations existing in the eastern forms. Notes and comments are presented on more western populations when they contribute to a better understanding of the variations which are found in the East.

In order to understand individual and geographic variation of southeastern forms practically all of the available material from the area was studied. Thus a total of 1,560 specimens from both institutional and private collections was examined. Since Florida was to be a focal point in the study of variation, many more specimens were examined from this state than any other (1,008). Of the remaining 552, 491 were from east of the Great Plains, and over two-thirds of these from the southeastern states.

Efforts were made to examine as many living specimens as possible, and 377 became available for study. The results were especially worthwhile for without live animals knowledge of certain colors (which fade rapidly in preservatives) would not have been available.

Throughout the course of this paper the following abbreviations are used when reference is made to specimens or to collections: AMNH = American Museum of Natural History, New York, New York; ANSP = Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania; CHM = Charleston Museum, Charleston, South Carolina; CM = Carnegie Museum, Pittsburgh, Pennsylvania; CNHM = Chicago Natural History Museum, Chicago, Illinois; UF = Department of Biology, University of Florida, Gainesville, Florida; JWC = John W. Crenshaw Collection, Gainesville, Florida; MCZ = Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts; RA-WTN = Ross Allen-Wilfred T. Neill Collection, Silver Springs, Florida; ST = Sam Telford Collection, Winter Haven, Flor-

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[1] A thesis presented to the Graduate Council of the University of Florida in partial fulfillment of the requirements for the Degree of Master of Science.

ida; T = University of Texas, Austin, Texas; TU = Tulane University, New Orleans, Louisiana; UMMZ = University of Michigan Museum of Zoology, Ann Arbor, Michigan; WA = Walter Auffenberg Collection, Gainesville, Florida.

TAXONOMY

There are two major groups included within the genus *Coluber,* the whipsnakes and racers. As now recognized there are eight subspecies of the racer, *Coluber constrictor.*[2] Together they are distributed throughout the United States, from coast to coast, and from the Gulf of Mexico and Guatemala northward into southern Canada. Although widely distributed, there are probably no true desert forms. However, some populations occur in mountainous areas, between, or even surrounded by truly arid conditions. They do not seem to occur on the tops of high mountains.[3] The range of *Coluber constrictor mormon* extends from the Pacific Coast to, and including most of, the Rocky Mountains; *Coluber c. flaviventris* is found in the Great Plains, from the eastern slopes of the Rocky Mountains to the forested provinces of eastern North America; *Coluber c. stejnegerianus* occurs from Guatemala northward to Nueces County, Texas, along the Gulf Coast; while *Coluber c. paludicolus* is found in the Everglades of southern Florida and on Cape Canaveral, Brevard County, Florida. These four subspecies are light in color. They may vary from green through brown to bluish-gray. The belly is always light. Another form, *Coluber c. anthicus,* of western Louisiana and eastern Texas, is spotted with yellow, buff, or bluish, on a blue, black, or tan ground color. The remaining three races are slaty-black above and below. The light-colored chin contrasts with the dark belly or throat. These are distributed throughout eastern North America. *Coluber c. priapus* is found in the Coastal Plain from North Carolina southward throughout most of Florida, westward to the Mississippi River, and thence northward to southern Illinois and Indiana along the Mississippi and Ohio River Valleys. *Coluber c. constrictor* is found from the eastern edge of the Mississippi Valley to the Atlantic Coast in the northeast, and to the Fall Line in the southeast. In the northeastern parts of its range it is found as far northward as Halifax, Canada. *Coluber c. helvigularis* subsp. nov. is found in the area of the Chipola and Appalachicola River Valleys of western Florida (fig. 1).

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[2] Etheridge (1952) has shown that the supposedly diagnostic characters of *Coluber ortenburgeri* fall within the variation of *Coluber c. stejnegerianus,* and that the former should be regarded "at most" a subspecies of *constrictor.* In view of the lack of any diagnostic character which would serve to separate the two forms I see no reason for retaining *ortenburgeri* as a nominal subspecies. The name should be referred to the synonymy of *Coluber c. stejnegerianus. Coluber c. haasti* of Bell (1952) is not regarded as a valid form for reasons to be given later in this paper.

[3] Brimley (1942) stated that *C. c. constrictor* is not found above 4,000 feet in North Carolina. Linsdale (1940) stated that *C. c. mormon* is found between 4,000 and 6,000 feet elevation in Nevada.

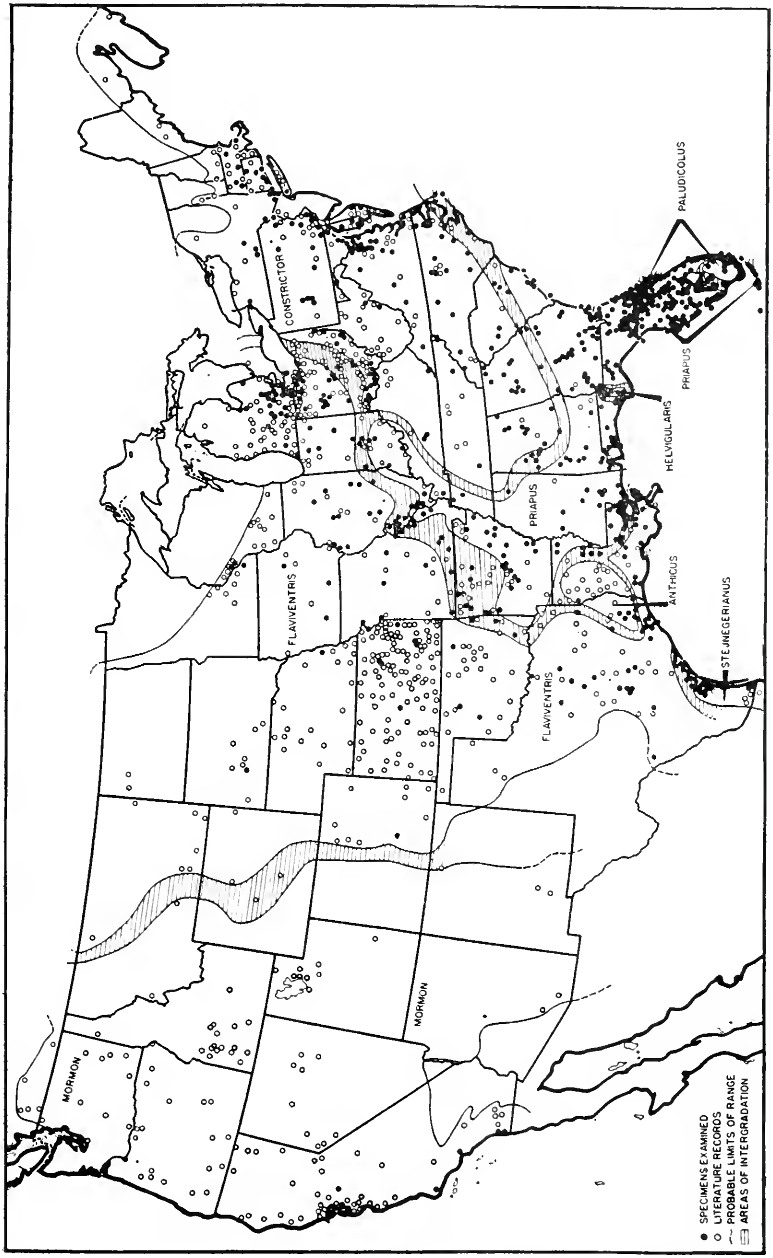

Figure 1. Distribution of the subspecies of *Coluber constrictor*.

All of these races are known to intergrade with one another at the mutual borders of their ranges with the exception of *C. c. mormon* and *C. c. flaviventris.* Intermediate populations between these two forms probably occur, although as yet none have been reported. Intergradation (if it does exist) is to be expected in Montana, where a record for *C. c. mormon* brings this racer's range within 130 miles of that of *C. c. flaviventris* (Stuart, 1930:44). Intermediate populations will probably also be found to occur throughout, or near, the Front Ranges of the Rocky Mountains.

Besides these eight recognized races there are several populations of varying sizes which, judging from their morphological characters, may be incipient subspecies. Areas in which these populations occur are listed here, although they will be discussed later in the paper. (1) The Outer, or Lower Florida Keys: speckled individuals reminiscent of intergrade specimens between *C. c. priapus* and *C. c. anthicus* are available from certain of these islands. However, they coexist with typical, uniformly black specimens and probably represent nothing more than mutant individuals. (2) The Mississippi Delta and the associated mainland: *C. c. flaviventris* from this area seems to be rather distinct from populations throughout the remainder of the range of this subspecies. These differences mainly concern coloration and scutellation. (3) Eastern Steppe Province: populations of *C. c. flaviventris* from the states of Ohio, Michigan, Indiana and Illinois differ from populations of the same subspecies from the Great Plains. The name *Coluber c. foxi* Baird and Girard, has recently been revived for this population (Schmidt, 1953:187). However, from the specimens which I have examined I am forced to conclude at the present time that a gradual cline exists between the Great Plains and Eastern Steppe populations. Further work should be conducted in these areas, especially Missouri and Iowa, to determine the nature and extent of the area of intergradation and degree of homogeneity of characters in the regions pertinent to an understanding of the situation. Until this is done it may be more advantageous to retain *C. c. foxi* in the synonomy of *flaviventris.* This interpretation has been followed throughout the present paper. (4) St. Johns River Valley, Florida: specimens of *C. c. priapus* from Seminole County to Lake Okeechobee along the lowlands of the St. Johns River are intermediate between *C. c. priapus* and *C. c. paludicolus.* This population is homogeneous and can be separated from either *priapus* or *paludicolus* on the basis of the amount of white on the ventral surface. However, they cannot be distinguished from intergrades between *priapus* and *paludicolus* from other areas where ranges of the two subspecies meet. Preliminary investigation suggests that the St. Johns River lowlands receive considerable gene-flow from Everglades populations in other species of snakes as well, *e.g. Liodytes alleni, Thamnophis sauritus, Lampropeltis getulus, L. doliata,* and *Diadophis punctatus.* The two areas are separated by a very low stream divide, and the ecological characters of both provinces are quite similar.

The condition seems somewhat comparable to that between the *flaviventris—foxi—constrictor* complex, and in this paper the lower St. Johns River specimens are considered as representing an intergrade population. However, further study may show that they deserve nominal status. At the present time no real advantage would be gained by recognizing these specimens as a separate race, for the implication would be that they had attained an evolutionary level equal to that of the other accepted subspecies in North America. In view of our present knowledge this hypothesis seems untenable.

KEY TO ADULT SPECIMENS

1. Dorsal surface and most of ventral surface slaty black. 2

   Dorsal surface lighter, being greenish, olive, brownish, bluish, or spotted. Ventral surface light, being whitish, yellow or light slaty blue. 4

2. Enlarged basal hemipenial spines up to 2½ times the length of the adjacent proximal spines; in large adults there is usually very little white on the chin and throat. The supralabials are usually almost completely black in large adults. The iris is always brown or dark amber, never bright red or orange. .... *Coluber constrictor constrictor*

   Enlarged basal hemipenial spines at least 3 times the length of the adjacent proximal spines, and are usually 4 times the length of these spines; in large adults from peninsular Florida there is usually a considerable amount of white on the chin and throat; the supralabials are usually half white and half black in specimens from peninsular Florida, darker on the Florida Keys and throughout the remainder of the range. The iris is usually brown, but may be amber, red, or even orange in specimens from central peninsular Florida. 3

3. Chin light tan or brown, or mottled with light tan or brown; never all white or blotched with black. Supralabials and infralabials always with a light tan or brownish suffusion. Iris in adults always brown, never bright red or orange. .... *Coluber constrictor helvigularis*

   Chin white, or mottled with black, never light brown or tan. Supralabials and infralabials white, black, or with both colors present, never distinctly light tan or brown except near the area of intergradation with *paludicolus*, or in isolated populations in western peninsular Florida. Iris brown, red, amber, or orange. .... *Coluber constrictor priapus*

4\. Dorsal surface spotted with white, yellow, buff or dark blue. .... *Coluber constrictor anthicus*

Dorsal surface not spotted, unicolor. 5

5\. Usually 7 supralabials, average adults over three feet. 6

Usually 8 supralabials, average adults under three feet. 7

6\. Subcaudals less than 99; ventral color usually some shade of yellow, but may be grayish, bluish-white or yellowish-white; iris usually brown, but may be reddish in specimens from southeastern Louisiana; practically never any darker clouding on the belly; 1st supralabial rarely in contact with the loreal. .... *Coluber constrictor flaviventris*

Subcaudals more than 99; ventral color whitish, never distinctly yellow; iris always reddish, amber or orange, rarely brown; usually with light brownish-gray or powder blue cloudy markings on the belly; 1st supralabial commonly in contact with the loreal. .... *Coluber constrictor paludicolus*

7\. Infralabials usually eight; dorsal color greenish. .... *Coluber constrictor stejnegerianus*

Infralabials usually nine; dorsal color usually olive. .... *Coluber constrictor mormon.*

For the most part this study has concerned itself with the variations existing in the four eastern races of *Coluber constrictor: constrictor, priapus, paludicolus,* and *helvigularis* (new subspecies). Variation in the portion of the range of the race *flaviventris* which is found east of the Mississippi river is discussed in somewhat less detail. An abbreviated synonymy and description of the four subspecies mentioned above follow:

Coluber constrictor constrictor Linnaeus

Northern Black Racer

Coluber constrictor (part) Linnaeus, 1758: 385 ("Habitat in America septentrionale").

Bascanion constrictor Baird and Girard, 1853: 93.

Bascanion foxii (part) Baird and Girard, 1853: 96.

Coryphodon constrictor (part) Dumeril, Bibron and Dumeril, 1854: 183.

Masticophis flagelliformis testaceous (part) Jan, 1863: 65.

Coryphodon constrictor vertustus (part) Jan, 1867: fig. 3.

Bascanion flaviventris (part) Dumeril and Bocourt, 1870: 697.

Bascanion constrictor flaviventris (part) Yarrow and Henshaw, 1879, App. L. of App. N. N.

Zamenis constrictor (part) Boulenger, 1893: 387.

Zamenis constrictor flaviventris (part) Ditmars, 1907: 285.

Zamenis constrictor constrictor (part) Ellis and Henderson, 1913: 103.

Coluber constrictor constrictor (part) Stejneger and Barbour, 1917: 79.
Coluber constrictor flaviventris (part) Ortenburger, 1928: 175.

Diagnosis.—A subspecies of *Coluber constrictor* in which the ventral and dorsal coloration of the adults is slaty black; the enlarged hemipenial spine is less than three times the length of the adjacent proximal spine and the eyes are always brown or dark amber.

Holotype.—None assigned, but the type locality is probably in the vicinity of Philadelphia (Dunn and Wood, 1939).

Description.—Dorsal surface in adults uniform slaty black, fading to dark olive gray where it integrades with *flaviventris.* Scales with a satiny luster. Top and sides of head slaty black like the remainder of the body and tail. In full grown specimens the supralabials practically all black, but in some adults, or in smaller specimens, black above and white below. Ventral coloration dark slaty black to dark gray. Chin usually white and in large specimens more or less spotted with black, sometimes practically all black. Iris usually dark brown or dark amber.

Juvenile specimens possess a distinct pattern until after the first year. Ground color slaty gray or brownish-gray. There are 48 to 71 saddle-shaped blotches of dark gray, dark brown or reddish-brown, edged with darker gray or black, arranged in a single series down the back, and extending down the sides to the second or third scale rows.

On the side of the body, alternating with the dorsal saddles, are faint darker spots one to two scales long and wide. They may occur singly or in pairs, one spot being above the other. Small black punctations may occur over the same area.

On the anterior half to two-thirds of the belly there are many small semicircular or crescent-like gray, black, or brownish spots, usually two on each scute, which are usually found on the lateral edges of the ventral plates.

Supralabials cream or white, with a dark brown or black edge on the posterior margin of each plate. Infralabials white or cream, and unspotted.

Specimens in the transitional stage of color suffusion are usually very dark gray dorsally, with faint indications of dorsal spots anteriorly. Top and sides of the head usually black. The snout may be lighter, depending on stage of transition. Supralabials usually black above and white below.

The ventral coloration of the juveniles is frequently retained though the color of the dorsal surface may be typical of mature specimens. At one stage of the transition, when the ventral coloration begins to turn darker, the underside of the tail and the anterior third of the belly remain light, while the middle portion of the belly slowly turns darker. The darker coloration moves in from the lateral portions of the ventral plates, and in some specimens there remains a light area, appearing somewhat as a stripe extending down the center of the belly. Specimens which are further along in the transition usually have uniform, slaty black bellies. Blotches or spots of black or very dark gray are frequently found on the throat. The dark ventral spots of the juveniles may be retained for a long time, as has been shown by Pope (1944: 172), who mentioned seeing traces of juvenile belly markings on a specimen of *flaviventris* that was 42 inches in length.

Dorsal scale rows normally 17-17-15. Reduction takes place by loss of the third or fourth lateral scale row. Occasionally an additional vertebral reduction by loss of the seventh or eighth scale row. Ventrals from 161-193 (mean 178.2±1.2), males 177.3±1.9, and females 178.8±1.3; subcaudals from 72-101 (mean 96.2±1.5), males 99.8±1.9, females 93.2±1.7; supralabials usually 7, from 8-11; preoculars normally 2, occasionally 1 or 3; postoculars 2, frequently 3; temporals 2-2-2, but quite variable. Anterior chin shields shorter than the posterior pair; loreal present, usually longer than high, and occasionally divided; body elongate, with a long and slender tail.

Large specimens are about five feet long. Ortenburger (1928: 196) mentioned a large specimen 1660 mm in total length as the largest that he had measured. Babbitt (1932: 27) reported a specimen 1854 mm long and has told me that he measured a specimen from Simsbury, Conn., which was 1905 mm in length. Roddy (1923: 32) recorded one from Pennsylvania "over six feet". Another large specimen which was 1886 mm in total length was reported by Atkinson (1901: 146).

The hemipenial characters are as follows: organ slightly bilobed, with a single sulcus; spines number 89-130, in 6-9 rows, covering about one-third of the length of the organ; the tip is smooth with a raised margin formed by the edges of the distal calyces, these edges being made up of several minute, flat, blunt, spine-like processes; three large spines are set around the basal portion of the organ. These large spines are usually from 2-2½ times longer than their predecessors in the same row. The base of the organ is smooth, but occasionally may be covered with very small spinules.

Maxillary teeth 14-16; dentary teeth 17-22; palatine teeth 13-15; and pterygoid teeth 20-26.

Range.—By and large *C. c. constrictor* is an eastern humid forest form. It ranges from Halifax, Canada, south through eastern Maine to northern North Carolina. Further inland it is found north of the Fall Line, throughout the Piedmont and Appalachian Mountain and Plateau provinces. It occurs as far westward as the Mississippi Valley in the states of Mississippi, Tennessee and Kentucky. The range has been shown to be correlated with the unglaciated regions of Ohio, occurring only in the eastern and south-central parts of that state (Conant, 1938: 50).

Remarks.—Occasional light-bellied adults are found in various parts of the range. They resemble intergrades between *flaviventris* and *constrictor* from Ohio in that they are black dorsally and have light gray or yellowish-gray ventral surfaces. Eckel and Paulmier (1902:

371) reported such an individual from New York which was "yellow" ventrally.

Coluber constrictor priapus Dunn and Wood
Southern Black Racer

Coluber constrictor Holbrook, 1843: 55.
Bascanion constrictor (part) Baird and Girard, 1853: 93.
Coryphodon constrictor Gunther, 1858: 108.
Zamenis constrictor (part) Boulenger, 1893: 387.
Coluber constrictor constrictor (part) Stejneger and Barbour, 1917: 79.
Coluber constrictor priapus Dunn and Wood, 1939: 4.
Coluber constrictor haasti Bell, 1952: 21.

Diagnosis.—A subspecies of *Coluber constrictor* in which the dorsal and ventral coloration is mostly slaty black; the enlarged basal hemipenial spine is three or more times the length of its predecessor in the same row. The iris is usually brown or dark amber, but may be red in both juveniles and adults from Florida.

Holotype.—ANSP 16111, collected by George B. Wood. The type locality is West Palm Beach, Palm Beach County, Florida.

Description.—For the most part very similar to *Coluber c. constrictor.* Dorsal surface of adults uniform black with a satiny luster. Top and sides of head black. Snout brownish in many half grown specimens or even adults. Supralabials usually quite dark, practically always showing slight traces of white on lower portions of at least the anterior plates. Large adults from Florida frequently have these scales colored black above and white below. Ventral coloration dark slaty gray to slaty black. In some specimens from the northern parts of its range, as well as those from the Florida Keys, there is no white on the throat, while in others from peninsular Florida the white may extend a considerable distance on the throat and anterior parts of the belly. In some specimens from central Florida this white color may extend for nearly two-thirds the entire length of the venter. Chin usually white, but may be spotted with black or very dark gray, and is frequently so suffused by black that only a few traces of white are discernible. Iris usually brown, but sometimes dark amber. In Florida the iris may be reddish, or even orange.

The coloration of juvenile specimens is very similar to that of *constrictor,* except that in central Florida the dorsal saddles may be brownish-red, and the posterior ventral plates may show a distinct reddish or even a pinkish tinge. There are 47-73 saddles along the back. Small lateral spots alternate with the larger dorsal blotches. Ventral spots one-fourth to one-eighth as wide as ventrals. These markings usually brownish or even black in color, but may be reddish or orange in specimens from Florida. The transitional coloration is seemingly identical with that of *constrictor.*

Dorsal scale rows 17-17-15. Reduction occurs laterally on the third or fourth scale rows. Occasional specimens are examined that also have a vertebral reduction by a loss of the seventh or eighth scale rows. Ventrals 154-199 (mean 178.0±0.58), males 177.2±0.87, females 179.1±0.84; subcaudals 70-119 (mean 99.8±0.62), males 101.1±0.61, females 96.3±0.98. Supralabials usually 7, but vary from 6-9; infralabials 6-12, usually 8; preoculars 2, rarely 3; postoculars 2, occasionally 3; temporals 2-2-2, but quite variable. Anterior chin shields shorter than posterior pair; loreal present, longer than high, rarely divided and in specimens from Florida frequently in contact with the first supralabial, rarely so in specimens from other parts of its range.

At least the Florida specimens of this race seem smaller than most examples of *constrictor* that I have examined. Whether or not this is true of populations in the more western or northern parts of the range I cannot say with any degree of certainty. Of the southeastern specimens that I have examined, the largest was a male 1320 mm in total length. Ditmars (1936: 94) has mentioned that individuals from the southeastern states are not as large as those from more northern states. This seems to be true, for the average length of 171 Florida specimens with a uniform coloration is 920 mm while from New York 34 similarly-colored specimens average 1041 mm.

Hemipenial spines as in *constrictor,* except that the enlarged basal spines are much longer, practically always three times the length of the adjacent proximal spines of the same row. They vary from one to 5½ times the length of these adjacent spines. Smaller spines from 72-132, disposed in 6-10 rows, covering about one-third of the organ.

Maxillary teeth 14-17; dentary teeth 16-20; palatine teeth 13-16; and pterygoid teeth 20-30.

Range.—The range of *C. c. priapus* includes the southeastern Coastal Plain from northeastern North Carolina, including all of Florida except the Everglades, and associated regions, Cape Canaveral, Brevard County, and the Chipola and Appalachicola River Valleys in northwestern Florida. The populations on the Lower Florida Keys are typical of this race. It also occurs along the Gulf Coastal Plain to the Mississippi River, thence up its valley, including the northwestern part of Louisiana and a large portion of Arkansas, except the Boston Mountains and adjacent areas, and northward to the vicinity of St. Louis, Missouri. In the Ohio River Valley it is found in southern Illinois and Indiana. It occurs in the states of Kentucky and Tennessee where they border the valley of the Mississippi River.

Remarks.—Black-colored specimens from outside of the range as just described have been reported. A specimen "slaty black above" has been reported from Eddyville, Iowa by Guthrie (1926: 177). Anderson (1942: 211) mentioned two specimens taken near Independence, Missouri that were black dorsally and blue-gray ventrally. These would seem to be intergrades, although the author noted that other specimens from the area were colored like typical *flaviventris.* Burt and Hoyle (1934: 34) reported a "blue-black" specimen taken in Rogers County, Oklahoma, well within the range of *flaviventris.* Branson (1904: 412) stated that although present in Kansas, black-colored racers are rare in that area. Strecker (1908: 73) stated that a black *Coluber constrictor* was taken in the Bosque Hills, north of Waco, McLennon County, Texas, and in 1915 (p. 35) reported that they were taken "as far south as Bosque and McLennon Counties". Strecker and Williams (1927: 21) reported that a half-grown specimen from San Marcos, Texas was typical of the race *constrictor,* being black in color. They added that similar specimens are found in the hill districts of Travis County and other sections nearby. This does not seem to have been mentioned in the literature since 1927, and students familiar with this area do not seem acquainted with this color variety.

The distribution of this race in the western portions of its range is not well known. All of the specimens I have examined from states west of the Mississippi River have a hemipenial spine characteristic of the race *priapus.* The nearest typical specimen of *C. c. constrictor* comes from east of the Mississippi River. On this basis I have assumed that all reliable records of black-colored snakes from west of the river refer to individuals genetically more similar to specimens of *priapus* than to *constrictor.*

It will be noted that the range of this form combined with the range of *C. c. constrictor* is not the same as that indicated by Ortenburger (1928: 183 ff.), who included Arkansas within the range of *flaviventris.* A number of the specimens examined from Arkansas are black on both dorsal and ventral surfaces. For example, AMNH 64730 from Big Buffalo River, near Pruitt, Ark., is black above and below, with a white chin. The supralabials are black above and white below. AMNH 64731 from Little Rock, Pulaski County, is black above and the anterior portion of the ventral surface is white and heavily mottled with black. The supralabials are black above and white below. I have included these and similar specimens in the race *priapus.* Only one specimen is referable to *flaviventris* among those which I have seen from Arkansas (CM 25025, from McGehee, Desha County). This individual is grayish above and very light-colored below. The supralabials are dark gray above and yellow below.

The literature includes references to black-colored snakes from Arkansas, usually identified as *constrictor* by the authors. Thus Taylor restricted the range of *flaviventris* in Arkansas to the northwestern portion of the state and listed both Washington and Benton Counties. On the other hand, Burt (1935: 312) reported *flaviventris* from Boone, Carrol, Cleveland, Madison, Crawford, Pope, Saline and Washington Counties, indicating a much more extensive range. Such references might be indicative of interdigitation between the races. Dellinger and Black (1932: 21) referred to this situation in stating the following:

> "Most students believe that there is a great deal of

> intergradation between the two subspecies of *constrictor* found in Arkansas, and that the ranges of both forms overlap to a considerable extent. For the most part *flaviventris* is found in the hills and *constrictor* [*priapus*] in the lowlands . . . but the separation is far from distinct . . . [and] we believe the disposition of these forms as made by Ortenburger is preferable."

It is unfortunate that none of these authors described or mentioned intergrades from these areas. Intermediate specimens do exist, such as those from the lower tier of counties in the southwestern corner or Missouri. In USNM 99600 from Berryville, Carrol County, Arkansas, the dorsal surface and supralabials are black. Ventrally it is very light colored, indicating some genetic affinities with *flaviventris*, and is best described as an intergrade. CM 25018 from 3.7 mi. west of Wynne, Cross County, CM 25083, 2 miles west of Fayetteville, Washington County and CM 25004 from Berryville, Carrol County (all in Arkansas) are similar, being black dorsally and bluish-gray ventrally. Until further study is conducted in this area (preferably of an ecological nature) the best disposition of specimens from Arkansas is to call all racers that are black both dorsally and ventrally, and which possess white chins, *priapus*. All specimens that are black or bluish-black dorsally and light gray or bluish-white ventrally should be called intergrades, and all individuals bluish, brownish, or gray dorsally and white, gray, or yellowish below, *flaviventris*.

Although Brown (1950) cited no records of black-colored racers from Texas, *priapus* probably occurs there. Its range would seem to embrace only the northeastern corner of the state. Strecker (1908: 73) mentioned specimens of *constrictor* (probably *priapus*) from northeastern Texas. I have heard of three other specimens from this area that are very dark, but which, unfortunately, I could not examine. Whether or not black racers are found in eastern Oklahoma is unknown. Ortenburger (1926, 1927, 1928 and 1930a and b) and Smith and Leonard (1934) did not mention *C. c. constrictor* in the state. Blair and Hubbell (1938) indicated that the Mississippi Biotic Province extends into the southeastern corner of Oklahoma. This is the warmest and most humid part of the state, and the plant associations are typical of those of the Coastal Plain. A common snake of the Coastal Plain, *Farancia abacura*, has recently been recorded from this region (Burger, 1948: 133). A *Coluber constrictor* (T 14003), from 3 miles northeast of Procter, Oklahoma, is black dorsally and bluish-white ventrally. Unfortunately, the specimen is rather small and exact identification is difficult. However, its coloration is reminiscent of young intergrade specimens between black and light colored races in other portions of North America. Another specimen (T 6513) from 1 mile south of Nashola, Oklahoma, resembles an intergrade specimen in color, although it seems closer to *priapus* than to *flaviventris*, being black dorsally and bluish-black ventrally. The supralabials are practically all black. Burt and Burt (1929: 10) recorded a specimen of *flaviventris* from Wister, Le

Flore County, Oklahoma in the extreme southeastern part of the state that somewhat confuses the issue. If populations of black-colored racers occur in both northeastern Texas and southeastern Oklahoma these will undoubtedly be found to represent the subspecies *priapus.*

As mentioned above, Ortenburger placed southern Illinois within the range of *flaviventris.* This is difficult to understand in view of his color descriptions of this race and of *constrictor.* One of the specimens, the color of which was described as typical of *flaviventris* is from Hillsboro, Illinois. It was "blackish mouse gray" on the dorsal surface and lateral tenth of the ventral plates. Below it was "light olive gray" on the median half of the belly. In describing the typical coloration of *constrictor* a specimen was chosen from Marion County, Florida. The dorsal surface was "blackish mouse gray", covering the lateral fifth of the ventral plates. The middle portion of each scute was "Hathi gray", and the anterior edges "light olive gray". Obviously these two specimens were very similar. At most the Illinois specimen was an intergrade. That southern Illinois contains other areas with black-colored racers is indicated by numerous references in the literature. Lueth (1941: 29) and Cagle (1941) mentioned *C. c. constrictor* from extreme southern Illinois. In 1942 Cagle (p. 187) stated that most specimens from Union and Jackson Counties were intergrades between *flaviventris* and *constrictor.* Blanchard (1924: 536) reported two specimens of *C. c. constrictor* from Johnson County, Illinois. Ditmars (1936: 59) mentioned *constrictor* from Swallow Rock, Jackson County, Illinois. USNM 94362 from the same locality is intermediate in that the belly is fairly light. On the other hand, the supralabials and dorsal surface are both black. This specimen, though similar to *flaviventris* in its belly color, is closer to *priapus* (*constrictor* of earlier workers). Of four adults from Olney, Illinois (USNM 13833, 14150a, b and c) three are intermediate. One is a good example of the race *priapus.* This specimen is black dorsally and ventrally. The chin is white and this color extends posteriorly to the eighth ventral plate. The supralabials in all are black above and white below.

Mittleman (1947: 481) has already called attention to the black-colored racers of southern Indiana. Of five specimens from wheatland, three are referable to *priapus.* Two are intergrades. A specimen from New Albany is typical of the race *priapus.*

Coluber c. priapus also extends into extreme southeastern Missouri. It probably occurs in a narrow band along the Mississippi River. I have examined intermediates from St. Louis, Montgomery, Oregon, Ozark, Jackson, Jefferson and Cape Girardeau Counties, Missouri.

Coluber constrictor haasti, recently described by Bell (1952: 21), is referred to the synonymy of *Coluber c. priapus,* because the characters given as diagnostic are not confined to the Florida Keys and they are frequently, and in some cases characteristically observed in other localities.

Coluber constrictor paludicolus Auffenberg and Babbitt
Everglades Racer

Coluber constrictor constrictor Conant, 1930: 60.
Coluber constrictor priapus Allen and Slatten, 1945: 26.
Coluber constrictor paludicolus Auffenberg and Babbitt, 1953: 44.

Diagnosis.—A light-colored racer, bluish-gray, greenish-gray, or occasionally brownish-gray dorsally. Ventrally whitish or light powder blue, with or without darker cloudy markings. Gulars frequently tinted with brown and the iris is usually red, sometimes orange or bright yellow. It differs from *flaviventris* in a higher number of subcaudals, a higher mean number of ventrals, the high frequency of contact between the 1st supralabial and the loreal and in the juveniles which have a smaller number of dorsal blotches.

Holotype.—USNM 131900, collected March 23, 1950, by Lewis Hall Babbitt, three miles west of Kendall, Dade County, Florida.

Description.—Dorsal coloration usually bluish-gray, but varies from greenish-gray to greenish-brown. A few are decidedly tan. Ventrally yellowish-white to white, frequently bluish-white. Ventral markings of adults, when present, may be in the form of cloudy blotches ranging from powder blue to grayish-brown or light tan, and in some specimens placed along the edges of the ventral plates so that there is formed a distinct light median line. Posterior gulars and lateral scales of the anterior part of neck usually tinged with light brown. Small black punctations may be scattered on the ventral surface. Top and sides of head usually olive. Snout frequently tan. Supralabials bluish-gray above, usually with a band or area of tan or grayish-brown below this. The bottom third of each plate is white, or in some cases yellowish. Chin white, but may be yellowish. Iris usually red, frequently orange, amber or even bright yellow, rarely brownish-red in adults.

Juveniles with 42 to 65 reddish-brown dorsal saddles, frequently decidedly reddish, or even pink. The smaller alternating lateral spots are reddish. Ground color grayish brown. A distinct pinkish or reddish hue is present posteriorly. Ventral surface pinkish-white anteriorly and decidedly pinkish posteriorly. Ventral spots usually small, scattered and reddish to reddish-brown in color. Many specimens have no ventral markings at all.

Dorsal scale rows usually 17-17-15, the reduction at the lateral third or fourth scale rows. Occasional specimens have an additional vertebral reduction of the seventh or eighth scale rows. Head plates normal in number. The 1st supralabial frequently in contact with the loreal, which is rarely divided. Ventrals 177-190, mean 184.0 ± 0.36, males 183.7 ± 0.56, females 187.0 ± 1.07. Subcaudals 99-117, mean 107.2 ± 0.45, males 107.8 ± 0.81, females 106.9 ± 1.01. Total length divided by the tail length varies from 3.2 to 3.8.

The largest specimen of this race examined is 1689 mm, while the mean length of 22 uni-colored specimens is 1119.2 mm. Hemipenial characters and dentition the same as in *priapus*.

Range.—This subspecies is found in two isolated populations which do not seem to be recognizably differentiated. One of these is on Cape Canaveral, Brevard County, Florida. Intergrades between this population and those of *priapus* on the adjacent mainland occur on Merritts Island (fig. 2). The other, and more widely distributed population, is found in the Everglades and adjacent areas of southern Florida, from Cape Sable throughout the southern tip of the penin-

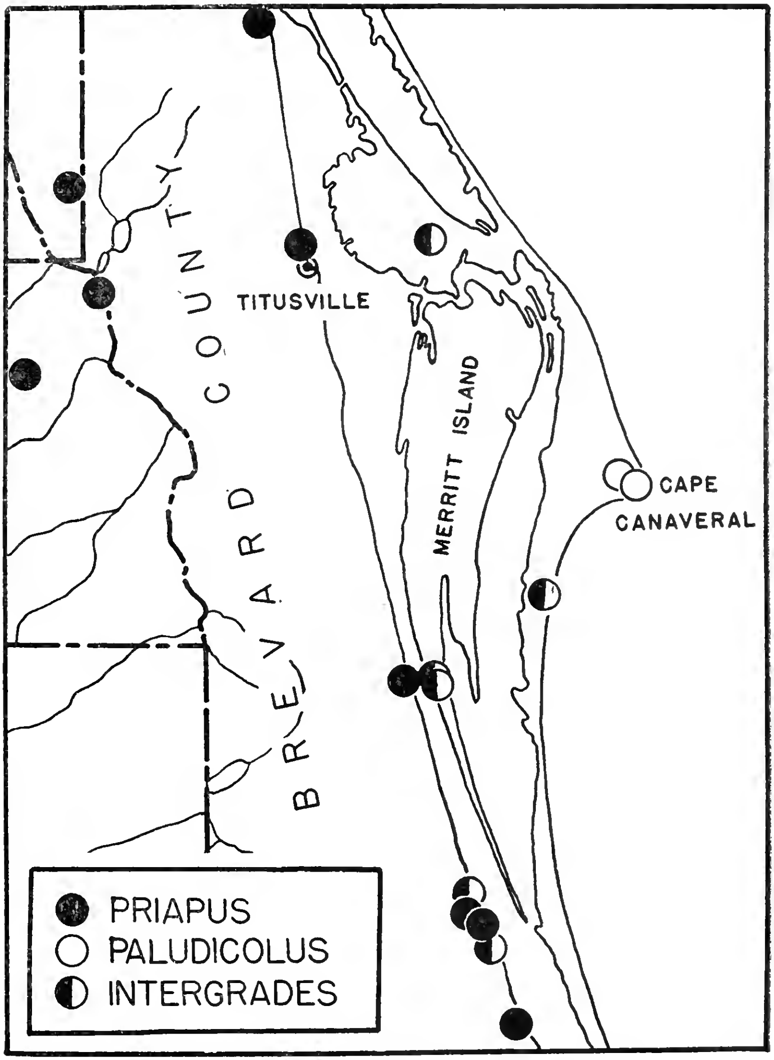

Figure 2. Distribution of *Coluber c. paludicolus* on Cape Canaveral, Brevard County, Florida.

sula, westward to the Big Cypress Swamp in Collier County, northward to the southeastern portion of the Okaloacoochee Slough in Hendry County, eastward to central Palm Beach County, and southward throughout most of Broward County with the exception of the eastern portion along the Atlantic Coast. It intergrades with *Coluber c. priapus* on both Upper and Lower Matecumbe Keys, Monroe County, and possibly on Key Largo. Intergrades are also found

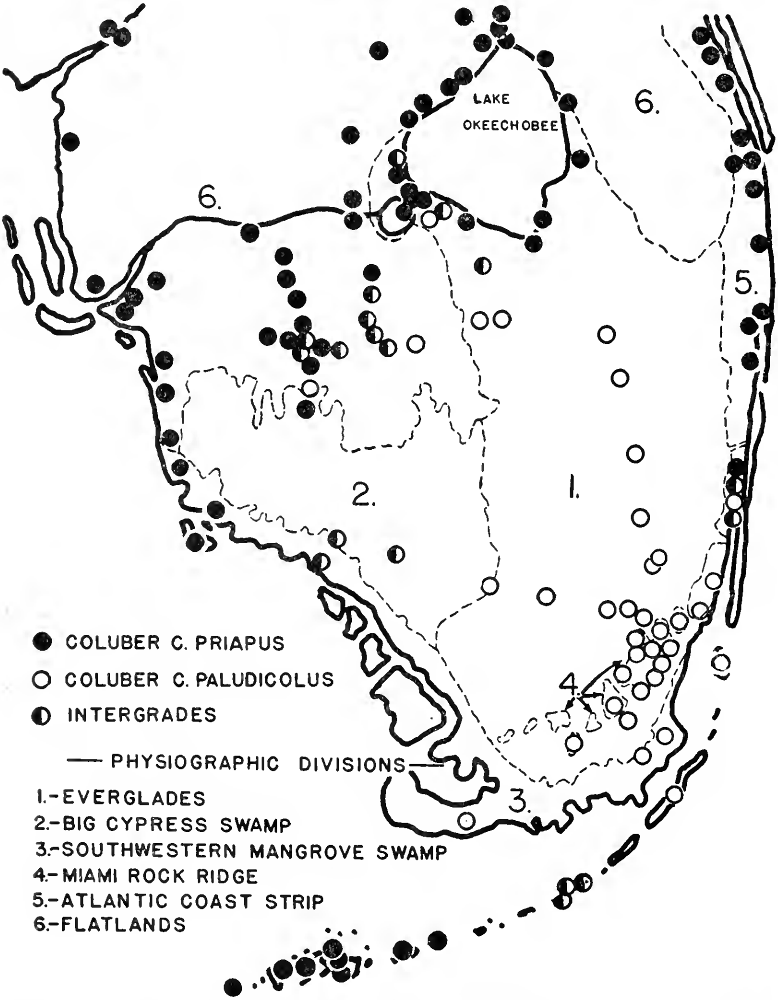

Figure 3. Distribution of *Coluber c. paludicolus* and *Coluber c. priapus* in southern Florida. For the most part, *paludicolus* is confined to the Everglades, the southern portion of the Southwestern Mangrove Swamp and the Miami Rock Ridge. It is also known from Biscayne Key in Miami Bay and Key Largo.

around the periphery of the range as stated above, except, of course, where it borders the sea (fig. 3). Intermediate specimens between *priapus* and *paludicolus* appear practically identical with those between *priapus* and *flaviventris*, or between *constrictor* and *flaviventris.* They are black dorsally and light slaty-black, gray, or light bluish-white ventrally. The supralabials are black above and light gray to white below.

Remarks.—Besides the two populations mentioned above, I have examined three other specimens from peninsular Florida which are colored like examples of this race. One is from "Key West, Monroe County" (USNM 14417), while the other is from "Long Pine Key, Monroe County" (MCZ 31797). These two specimens, though outside the range of *paludicolus,* probably have the correct locality data. Influence from this race could be expected over the relatively short distance to the mainland. However, USNM 83294, labeled "Gainesville", Alachua County, Florida, undoubtedly has incorrect locality data. Of close to 200 racers which I have examined from Alachua County, none approached the coloration of *paludicolus.*

Coluber constrictor **helvigularis,** subsp. nov.

Brown-chinned Racer

Diagnosis.—A subspecies of *Coluber constrictor* recognized by the large amount of very light brown or light tan on the supralabials, infralabials, and especially the chin and throat of adults. Although adult specimens of *paludicolus* normally have tan supralabials and posterior gulars, these two races are immediately distinguishable on the basis of their dorsal and ventral coloration. In *helvigularis* these surfaces are slaty-black, while in *paludicolus* they are much lighter.

Holotype.—CM 21462, collected April 9, 1942, by Coleman J. Goin, 8 miles west of Wewahitchka, Gulf County, Florida.

Description of holotype.—An adult female in which the top and sides of the head as well as the dorsal surface is dark slaty-black. Supralabials black above and light brown on the lower half of each plate. Infralabials and throat entirely light brown. Chin very light brown, with a few white blotches, each covering only a few scales. There are traces of a slightly darker shade of brown on the belly as well as on the underside of the tail wherever the slaty-black color, which covers most of the belly and tail, is not evident.

Supralabials 7-7, infralabials 8-8; no contact between the loreal and the first supralabial; postoculars 2-2; preoculars 2-2; temporals 2-2-2 on one side and 2-1-2-2 on the other; gulars 4. Scale rows 17-17-15. Ventrals 173, anal divided, subcaudals 102.

Paratypes.—Two specimens are designated as paratypes: UF 1496-7, Scott's Ferry, Calhoun County, Florida.

Variation.—Top and sides of the head and the dorsal surface of the body of adults black. Ventrally, however, there may be varying traces of very light brown intermingled with the more prevalent black color. Chin light brown, but with a few white blotches. Throat either very light brown or white, the latter strongly contrasted with the brown chin. Supralabials always light tan or light brown on the lower half of each scale and black above. Snout either black or with varying traces of very light brown. Infralabials also tan or light brown.

Supralabials 7-7; infralabials 8-8; loreal in contact with first supralabial in three specimens; preoculars 2-2; postoculars 2-2; gulars ranging from 3-5, mean 4.0; temporals normally 2-2-2, but in some specimens 2-1-2-2 or 2-1-2. Dorsal scale rows 17-17-15, with the lateral reduction occurring by loss of the third or fourth scale row, from the 99th-126th ventral. Ventrals 169-174, mean 171.6±2.32. Subcaudals 88-102, mean 97.3±1.76. In two of the specimens the last ventral before the anal plate is divided. The hemipenial spines seem identical with those of *priapus,* including the enlarged proximal spines.

Range.—The flood plains and adjacent pine flatwoods along the Chipola and Appalachicola Rivers of northwest Florida. Specimens are available from Gulf and Calhoun Counties (fig. 4).

Remarks.—A specimen in the Ross Allen-Wilfred T. Neill collection (no. 435) which bears the data Iron City, Seminole County, Georgia, is typical of this race. The chin is heavily mottled with light brown. Both the infra- and supralabials are suffused with this color. No other specimens are available from the immediate locality. However, seven specimens are available from the area near the junction of the Flint and Chattahoochee Rivers (UF 3728-34). Five of them are from Florida and two from Georgia. Only two of these specimens have the faintest indication of brown on the chin. Those of the remaining specimens are pure white. In the collection of John W. Crenshaw there are 18 adult specimens from Baker County, Georgia. This locality is about 35 miles northeast of Iron City, Seminole County. None show any tendency toward a brownish-tinted chin. The only other specimen which is available from this section of Georgia is one from Fort Benning, Chattahooche County (USNM 80948), which is on the Fall Line. It is an intergrade between *priapus* and *constrictor* and has no brown on either the chin or labials. In southeastern Alabama I have seen a specimen from Enterprise, Coffee County (WA 2501). This locality is about 40 miles west of the Apalachicola River. The specimen shows no tendencies towards the coloration of *helvigularis.*

Intermediate specimens have been examined from Florida and extreme southwestern Georgia. CM 21464 from 12.2 miles west of Wewahitchka, Gulf County, has a light brownish tinted chin, with considerable amount of white present. This specimen, though intermediate, is closer to *helvigularis.* DBUF 2644 from Blue Springs, Jackson County, is practically identical to *priapus* except that the posterior gulars are light brownish. The supralabials also have considerable brown on them. The same is true of two other specimens from near Panama City, Bay County (USNM 81174). These last three specimens are certainly closest to *priapus,* although the presence

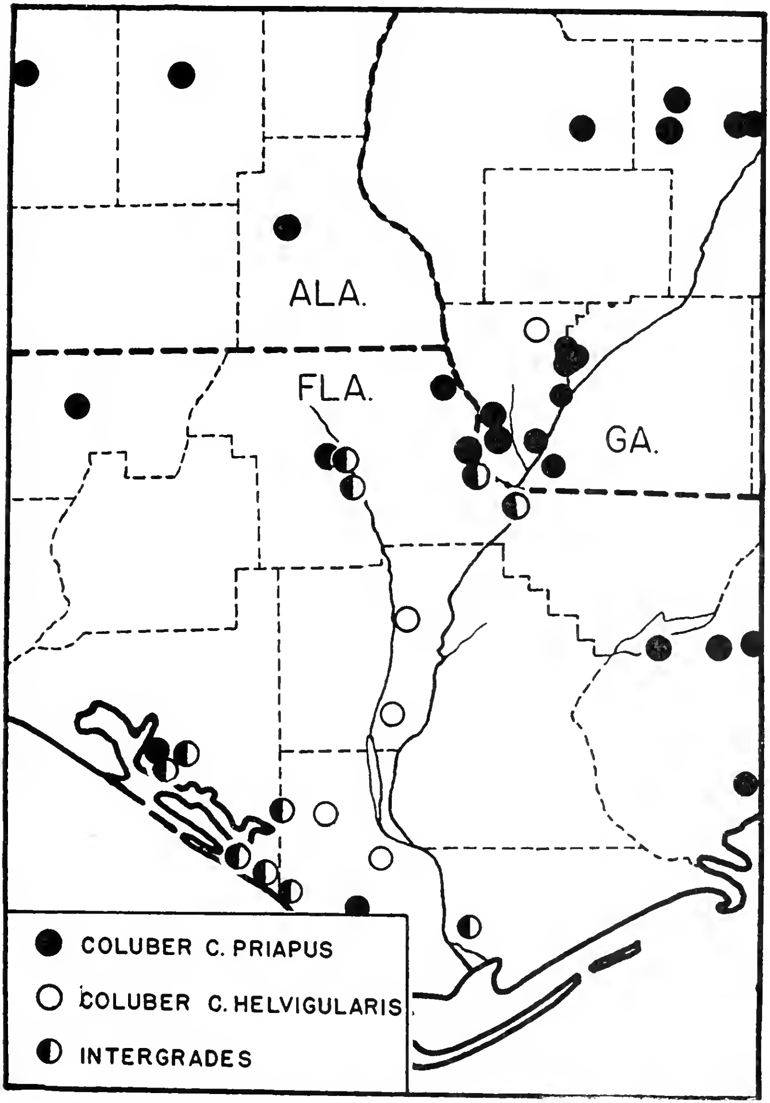

Figure 4. Distribution of *Coluber c. priapus* and *Coluber c. helvigularis*, subsp. nov.

of a considerable amount of light tan coloration shows a notable genetic influence from *helvigularis* populations farther eastward. All of these localities are about 25 miles west of the Appalachicola River. Two other specimens (WA 4001 and 4002) from 5-7 miles east of Tyndall Air Base, Bay County, Florida, are intergrades but closer to *helvigularis.* A specimen which I have seen (no longer available) from extreme western Leon County, near Bloxham, was typical of the race *priapus.* UF 3731, from Sealy Springs, Seminole County, Georgia, has *very* faint indications of light brown on the chin. The same is true of UF 3729 from Chattahoochee, Gadson County, Florida.

INDIVIDUAL AND GEOGRAPHIC VARIATION

CORRELATED VARIATION

Under this heading are discussed the variations in color and scutellation which are correlated with geographic locality, sex, environment, or ontogeny.

The term cline has been used to express a condition in which the values of a variable character form a slope or gradient over a geographic area. With increasing knowledge of variation systematists have come to recognize different types of clines. Although closely related, two obvious types come to attention. These are the *eco-* and *geoclines.* In the first, a character gradient is present which conforms with an ecological gradient over the same area. In the second, the character gradient simply seems correlated with distances or areas. In most cases it is obviously difficult to divorce the ecocline from the geocline.

Other than these two distinctions, character gradients may have varying slopes when the values of the character being examined are plotted against distance. Two general types of gradients seem to be recognizable by this type of analysis. One of these is the *external cline.* In this type the continuous sloping character-gradient is interrupted and may be thought of as resembling a stair case, with the separate subspecies corresponding with the treads, flat or very gently sloping, and being united by steep slopes—the zones of intergradation. The mean values for different characters of the various subspecies will often form a gradient. This condition may also be called an intergroup cline (see Huxley, 1943: 211). The other type is called an *internal cline,* which does not show any steepening of the character gradient, or cline, in certain areas, but rather a continuously sloping character-gradient with no obvious interruptions (Huxley, *loc. cit.*).

A rather special type of cline, generally termed an *ontocline,* is also shown in *Coluber constrictor.* It is an ontogenetic change that varies as a character-gradient in degree or intensity with distance.

External Clines

Length of the hemipenial spines.—The characters associated with the hemipenes of male snakes have long been used in taxonomic studies of serpents. In general they have been used as characters of generic, or specific consequence. However, Dunn and Wood (1939: 1 ff) have shown that proportional measurements of the proximal spines may also serve as one of racial significance.

In *Coluber constrictor* the basal portion of the hemipenes is spinous. These spines are disposed in definite rows, with a gradual proximal increase in the size of the spines. At the basal end of certain of these rows there is also a very much enlarged spine. Dunn and Wood (*ibid.*) have suggested a standardization of terms for the proportional measurements of the enlarged basal spines and the smaller preceding ones in the same rows. A basal spine that shows only a slight enlargement over the preceding one is called "not significantly enlarged". If it is two times the length of the adjacent proximal spine it is "significantly enlarged". It is called a "basal hook" if it is four times the length of the next smaller spine in the same row (fig. 5).

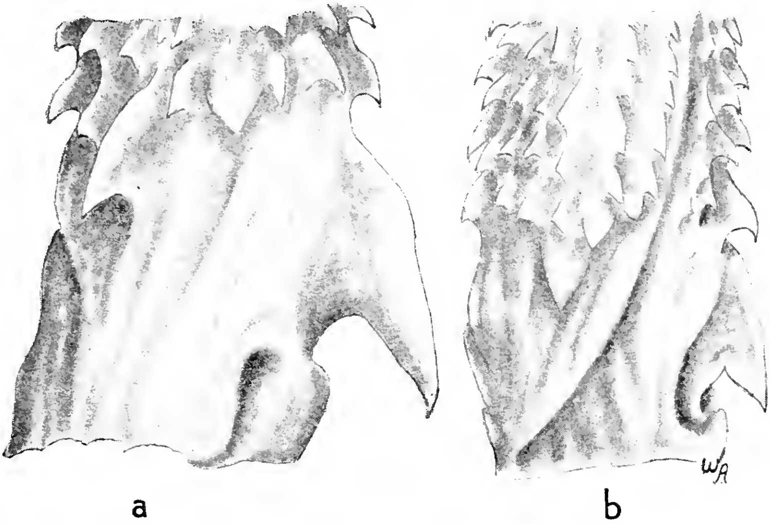

Figure 5. Variation of the enlarged basal spines on the hemipenis of *Coluber constrictor*. **a.** Basal portion of the hemipenis of a typical specimen of *C. c. priapus* (WA 3009, Alachua County, Florida). **b.** Basal portion of the hemipenis of a typical specimen of *C. c. constrictor* (WA 3670, Atlanta, DeKalb County, Georgia).

Following an examination of several male black racers from eastern North America, Dunn and Wood (*ibid.*) found that all of the Florida specimens were provided with a "basal hook", while others from New York, New Jersey, Pennsylvania and Virginia had basal spines which were, at most, "significantly enlarged". In view of this geographic variation, they proposed the name *Coluber c. priapus* as a new subspecies, which was then known only from Florida. In the present study an examination of many specimens from the eastern half of North America has shown that this race is not restricted to Florida, but has a distribution which is very similar to that of many other Coastal Plain reptiles and amphibians.

The basal spines of this species may vary in two ways: (1) the length of the spines (as shown by Dunn and Wood), and (2) the number of basal spines which may be termed hooks. The values of the former may be constant over large areas of North America, with zones of intergradation between. However, the mean lengths in these same areas vary geographically as a gradient. In view of these two characteristics I have included this type of variation under "external clines". The latter situation (2) has already been referred to by Dunn and Wood (*ibid.*), who stated that some Florida specimens have one hook, some have two, and others even have three. This will be discussed under "internal clines".

Although the eastern limits of the range of *flaviventris* has been shown to lie westward of that indicated by Ortenburger (1928: 183 ff), specimens on the eastern side of the Mississippi River have always been referred to the race *constrictor.* In view of this it is unusual that Dunn and Wood (*ibid.*), in writing of a male from Samburg, Tennessee (ANSP 4489) that had one basal "hook", did not question the restricted Floridian range of *priapus*. Mittleman (1947: 479) has indicated that specimens of *Coluber c. constrictor* from near the area of intergradation with *C. c. flaviventris* possess the large basal hooks upon which *priapus* has been described. He raised the question that if basal hooks occur among some specimens of middle-western *constrictor,* the entire question of the correlation of these structures with geographic dispersion should be re-examined.

All of the races of *constrictor,* with the exception of *constrictor constrictor,* appear to have basal spines which may be termed "hooks". In the black-colored racers there is at least one hook present in specimens from southern Illinois and Indiana, western Kentucky and Tennessee, extreme eastern Missouri, Arkansas, northeastern Louisiana as well as the Florida Parishes, all of Mississippi except the northeastern corner, and all of Alabama, Georgia and South Carolina below the Fall Line, throughout Florida, and in coastal North Carolina north to the Cape Hatteras region. This, with the exception of the ranges of *paludicolus* and *helvigularis,* is the distribution of *priapus.*

Practically all of the specimens that I have examined from the Coastal Plain have a basal hook. However, the ratios varied from one to five and a half. In view of such individual variation mean ratios were calculated for various regions of the eastern United States to obtain an estimate of broader geographic variation. These ratios are given in Table 1. It is apparent that these data fall into two groups which correspond to the ranges of the two races, *priapus* and *constrictor*.

Along the Fall Line specimens are frequently taken in which the spines are two and three quarters, three or three and a quarter times the length of the smaller spines. I have called these specimens intergrades. In eastern Ohio, where color intermediates occur between *constrictor* and *flaviventris,* the hemipenial spines do not seem to be intermediate, but resemble those of *constrictor.*

The overall ratios of specimens for the southern portion of the range (using individual ratios for calculation) was 3.7±0.67. The corresponding value for northern specimens was 2.2±0.57. Hence the two groups of specimens bear a difference in the mean values that is statistically significant ($t = 5.73$).

TABLE 1.
GEOGRAPHIC VARIATION IN MEAN RATIOS OF THE LENGTH OF THE PROXIMAL HEMIPENIAL SPINES

Area	Mean Ratio	No. of Specimens
Florida	3.9	305
Southern Georgia (below Fall Line)	3.8	31
Coastal South Carolina	3.3	12
Coastal North Carolina (excluding N.E. part)	3.3	7
Southern Alabama	4.0	26
Southern Mississippi	3.6	8
Eastern Louisiana	3.6	21
Arkansas (excluding N.W. part)	3.8	23
Western Ky., Tenn. & southern Ill. & Ind.	4.0	11
New York	2.1	26
Pennsylvania	2.2	12
Virginia	2.3	15
Eastern Ohio	1.7	18
Northern Georgia	2.1	20
Western North Carolina	2.2	11

Specimens from coastal North and South Carolina frequently have basal spines which are about three times the length of the adjacent proximal spine. There is no sharp break between the specimens with small proximal spines which are only significantly enlarged, and those with true basal hooks. The region of intergradation in the coastal areas of these two states is wide and exhibits a more gentle gradient than is found in the intergradation area along the Fall Line of Georgia and Alabama.

Color.—It is obvious that the distinguishing character of *priapus* is restricted in its value, not only in view of the fact that it is sex-limited, but also in that it is accurately reliable in only rather large, dead or preserved specimens. Coloration is one of the predominant diagnostic characters used to distinguish the various races of *Coluber constrictor.* It has been referred to time and again in relation to southeastern populations of this species. Ortenburger (1928: 213) was one of the first workers to mention the presence of a distinguishable coloration in specimens from the southeast: "In the southeast the throat and chin are almost always immaculate blue-white, while to the north of Georgia the chin and throat are white, but more or less spotted with dark gray."

Ditmars (1936: 94; 1939: 191) mentioned this peculiarity and gave some indication of a race confined to the southern portion of the United States: "With specimens from South Carolina, Georgia and Florida the white may cover the entire upper labials, thus indicating a fairly well defined southern race."

The exact range of variation in this coloration has never been examined.

A complication in the description of color in this species is that an ontogenetic color and pattern change occurs when the snake is about one year old. The blotched pattern of the juvenile becomes the uniform coloration of the adult through continuous and successive stages of suffusion by a darker color. Color notes taken on specimens from one area are not comparable to notes taken on specimens from other areas, unless the specimens are of the same size or age. Unfortunately the size at darkening is not the same in every individual, as has been shown by Kelly (1936: 43). In some cases the size at color transition is somewhat correlated with geographic locality. Another difficulty is that in preservatives not only does the entire specimen become more or less darkened, but certain colors, such as those of the iris and tongue, fade rapidly.

Adult dorsal color.—This is one of the most important criteria used in distinguishing the races of *Coluber constrictor*. Based on their dorsal coloration these subspecies fall into three main groups. They include (1) the light, usually greenish, brownish or bluish group, which is composed of the races *C. c. mormon, stejnegerianus, flaviventris* and *paludicolus*. For the most part they inhabit rather open situations, under relatively little forest canopy. They are primarily found in grasslands, and one subspecies, in marshes. Another group (2) is formed of only one race, *anthicus*. It is spotted and occurs in the pine forests of eastern Texas and western Louisiana (fig. 16). The last group (3) is black and is composed of three subspecies, *constrictor, priapus* and *helvigularis*. These are primarily associated with the forested portions of eastern United States (fig. 16). It might be added that *flaviventris* inhabits a great variety of habitats and is also the most variable as regards coloration. Specimens are lightest in the Great Plains and darkest in the northeastern portions of its range where it has invaded the forests of the glaciated regions of North America. This post-glacial eastern extension of typical steppe fauna has been frequently discussed (Schmidt, 1938; Ruthven, 1908; and Grobman, 1941).

The light-colored subspecies show perfect intergradation with darker forms at their mutual borders, and for this reason adult color is included under "external clines".

The dorsal color of the races *priapus, helvigularis* and *constrictor* is nearly always slaty black. Ortenburger (1928: 212-213), stated that ". . . specimens from southern Florida, and to a certain degree those of New England are more intensely black than those from any other part of the entire range". Undoubtedly he was writing of specimens from the Florida Keys, for southern peninsular Florida is inhabited by a very light race, *paludicolus*. This is exemplified, not only by the lighter coloration of the dorsal surface, chin, supralabials and belly of adult specimens from this area, but by the lighter-colored juveniles as well. This is opposed to the darkly-colored juveniles and adults of northern parts of the state. The light color of this Everglades population has been mentioned by Conant (1930: 60), Carr (1940: 81) and Allen and Slatten (1945: 25). Specimens from the Keys are black dorsally, but not appreciably darker than specimens from Alabama, Mississippi, southern Georgia, or even northern Florida.

The dorsal coloration of *paludicolus* is a bluish-gray, but in some specimens is greenish-brown to greenish-gray. I have been told that specimens from Cape Sable are tan. The only individual that I have examined from this area is greenish-gray. Intergrades between this race and *priapus* occur in Collier, Hendry, Palm Beach, Broward and Monroe Counties (fig. 3).

There is a southward extension of the range of *priapus* down both the east and west coasts of the peninsula. On the east its range seems correlated with an area known as the Atlantic Coast Strip which is mostly composed of deep sands and is higher than the Everglades. Forests of pine cover most of the area, while in the dunes along the sea the vegetation is decidedly scrubby. The race *priapus* also occurs in the Pine Flatlands of the lower west coast. This area is gently rolling, with many small ponds and sloughs. Open pine forests with grasses and thickets of saw palmetto predominate the landscape. The Florida Keys are for the most part covered with scrubby bushes and trees. On the other hand, the Everglades is a shallow, praire-like basin, that, before the digging of drainage canals, was about 80 percent marshland. Trees occur only along the edges of natural sloughs or in "islands" on slightly higher ground. The conditions of these two major habitats simulate those between the forests and prairies of our middle west. The resemblance of the two prairie situations, even though one is wet and the other is dry, and the similarity of the color of the forms inhabiting both suggests that approximately equivalent natural selective factors have acted on both of these populations.

A series of seven specimens in the AMNH (6981-7) and a head (USNM 44518) from, respectively, Canaveral Light and Canaveral, Brevard County, Florida, are colored exactly like specimens of *paludicolus* from the Everglades. The color in all is greenish-gray to greenish-brown. Three of them (AMNH 6983, 6985 and 6987) have the light brownish-colored posterior gulars frequently observed in *paludicolus*. Three adult intergrades between the Cape population and *priapus* have been examined. USNM 11989, from Georgiana, Brevard County, has a coloration which resembles that of the specimens from Cape Canaveral. WA 3719, from seven miles east of Titusville, Brevard County, is intermediate. In life it was black on the anterior portion of the dorsal surface, and brownish-black posteriorly. Ventrally it was light bluish-black, and, as frequently happens in intergrade specimens from the Big Cypress Swamp of Collier County, there was a light powder blue line mid-ventrally. The gulars and middle third of the supralabials were brownish. Six specimens from Eau Gallie, Brevard County are typical of the race *priapus*, except for one, AMNH 6919. This specimen is very dark above, but quite light ventrally. The gulars are tinted with light brown.

This is also considered an intermediate specimen (fig. 2).

There are two separate populations of *paludicolus* which do not seem to differ in any color characters. The scale counts of these two populations are also practically identical. An offshore bar extends southward from Cape Canaveral for a considerable distance. One intergrade specimen has been examined from this bar.

The dorsal color clines which are found in the area of intergradation between *priapus* and *paludicolus* are exactly the same as those between *flaviventris* and *constrictor* in Ohio, or between *flaviventris* and *priapus.*

Specimens from intermediate areas are black dorsally and light ventrally. The ventral color seems to change over a greater geographical distance than does the dorsal color. For example, in southern Florida the change in ventral color from slaty black to the light color of *paludicolus* takes place over approximately 55 miles, while the change in dorsal color takes place over 30 miles at most. As would be expected, the width of the intermediate zone is dependent on the distance over which grasslands, or essentially prairie conditions, change into a forested condition. As a result, the slope of the cline is directly proportional to the proportion of prairie and forest constituents over a given area. This is exemplified by the rather short distance in which the dorsal color and topography change along the edges of the Big Cypress Swamp and the Everglades, as compared to the more gradual change in the dorsal color and topography in central Ohio.

I have seen eight specimens from Upper and Lower Matecumbe Keys, Monroe County, Florida, some 20 miles south of the mainland, which are very unusual in that many of the dorsal scales have lighter centers, so that they appear speckled. USNM 85303, from Key West, Monroe County, Florida, also has dorsal scales which have slightly lighter centers, but in addition, certain scales are distinctly tinted, though faintly, with greenish, brown, or blue. The ground color of all of these specimens is slaty black. They are reminiscent of intergrades between *anthicus* and *priapus* which I have examined from Louisiana and Arkansas, except that the speckling is not as evident. Certain specimens of *paludicolus*, which I have seen have scales whose centers are slightly darker than their edges.

Adult ventral color.—A resume of the general coloration of the ventral surface as found in the various races would serve no real purpose, since the belly color is seemingly correlated with the dorsal coloration. That is, subspecies dark on the dorsal surface are also darkly colored ventrally. It is only in the zones of intergradation between light and dark-colored forms that one finds snakes that are very dark above and light below. The contrast between the two surfaces is considerable. Such specimens have been described in earlier parts of the paper.

Recently Schmidt (1953: 187) revived the name *Coluber c. foxi* (Baird and Girard) for those populations of *Coluber constrictor* inhabiting the Eastern Steppe Province of Ohio, Indiana, Illinois and Michigan. Following an examination of many specimens from Ohio and Michigan it is obvious that the adult ventral color of this population and that of the Great Plains is quite different. Ortenburger made reference to this difference (1928: 191), "The typical yellow coloration is found in Kansas; the blue-gray, in the northern part of the range". However, he failed to recognize two subspecies on this basis alone. Specimens from the states of Iowa, Illinois, and Missouri seem to indicate that the change in ventral coloration is gradual and covers a great distance; that is, it seems to exhibit an internal, rather than an external cline. Such a wide band of intergradation is incongruent with the widths of zones of intergradation between other subspecies of *Coluber constrictor* in eastern United States.

The darker ventral surface of *foxi* is interpreted in the present paper as an indication of past or present genetic influence from dark bellied forms, such as *constrictor* or *priapus.* Specimens of *flaviventris* from southern Louisiana, near the range of *priapus,* are very similar to *foxi* in the coloration of their ventral surface. This certainly indicates an approach to *priapus* in this area. It has been previously shown that the ventral coloration changes over a greater area than does the dorsal coloration in areas of intergradation between light and dark-colored forms.

Until a critical study is made of the nature and degree of intergradation between the yellow and grayish-bellied forms, and the degree of homogeneity in the two proposed nominal populations, the best disposition seems to be to regard them as slightly differing populations of the same subspecies.

Occasional specimens are taken throughout the range of *constrictor* and *priapus* that are black above and very light gray or bluish-white below. These individuals appear like intergrades between *priapus* and *paludicolus* or *flaviventris* and *constrictor.* Eckel and Paulmier (1902: 371) seem to have had such a specimen in mind when they referred to specimens from New York which were "greenish-yellow" ventrally, though black dorsally. This coloration seems most common along the Atlantic Coast, yet still unusual in these areas. Only 4.3% of the specimens from South Carolina are so colored, 1.9% in eastern Georgia, 3.2% in northern Florida and 8.2% in central Florida.

Adult chin color.—The chin color of adult racers has been mentioned by a number of earlier workers as a possible diagnostic character of a southeastern race. One of the difficulties in describing the coloration of racers lies in the fact that there is an ontogenetic change in coloration. All juvenile racers have a white chin, usually without markings of any kind. In the races *flaviventris, mormon, stejnegerianus, anthicus,* and *paludicolus* there is no appreciable color change to adulthood, except possibly with an introduction of a yellowish tint. However, in the black-colored racers of the eastern parts of North America specimens have chins mottled with black, or brown, as in the case of *helvigularis.* This mottled appearance is brought about by growth and fusion of black blotches on the chin where before there were none. In this manner some specimens attain practically solid black chins.

Not all specimens from one locality exhibit the same degree of darkening on the chin. In twenty individuals from Key West, Monroe County, Florida, practically every gradation between an immaculate white chin and one which is almost entirely black is represented. The specimen with the least white on the chin that I have examined from the Florida Keys is CMNH 33816, in which only the mental scale is white. The darkest racer that I have examined is WA 2506 from 5 miles north of Florence, South Carolina. There is no pure white on any part of this snake. The anterior portion of the chin exhibits a few smoky-gray vermiculations.

Although Ortenburger (1928: 213) and Ditmars (1936: 94; 1939: 191) indicated that specimens from the southeast have less white on the chin than specimens from more northern states, an evaluation of individuals over 1000 mm in total length has indicated that the number of specimens in the southeast with black-colored chins is quite large. However, specimens from central Florida have a con-

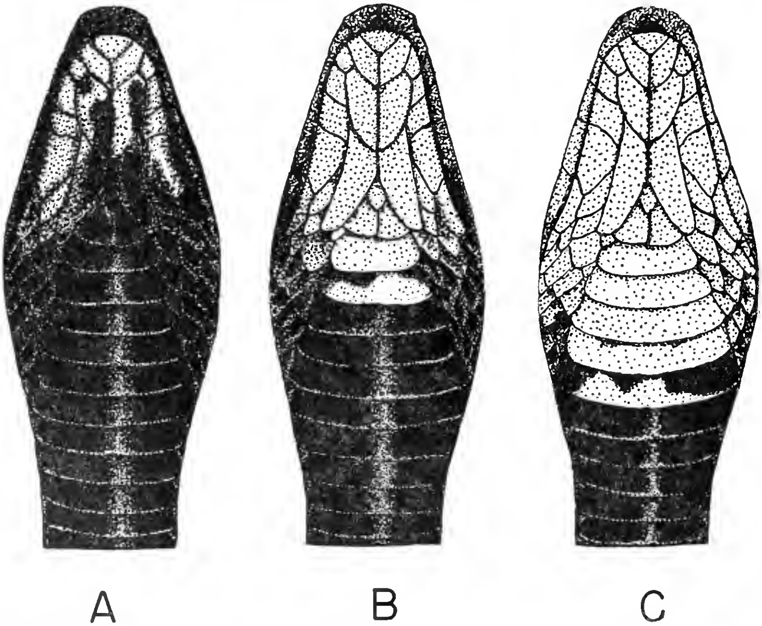

Figure 6. The amount of white on the chin of three typical specimens of *Coluber constrictor* from eastern United States. **A.** Typical adult from New York State. **B.** Typical adult from South Carolina. **C.** Typical adult from northern Florida. Any of these variations may be found in any area of eastern North America, and the amount of white on adult specimens is best measured by the mean number of white ventrals (*cf* fig. 7).

siderable amount of white on the chin and throat. This variation is best measured by tabulating the number of ventrals on which white occurs. When this is done for states along the Atlantic Coast the distribution is typical of that of an external cline. There are two areas in which the values, though distinct, are fairly constant, with a steepened gradient in the zone of intergradation between. Figure 6 shows three typical specimens from the Atlantic coastal states, while figure 7 shows the results of an analysis of the amount of white on the chin and throat of specimens over 36 inches long from various localities in eastern United States. Although a southeastern race cannot be described on this basis alone, there is an indication of a differentiated population occurring in the lowlands of the lower portion of the St. Johns River in Florida. However, these specimens are probably intergrades between *priapus* and *paludicolus,* even though considerable homogeneity seems indicated (*cf* page 92).

Adult gular and supralabial color.—The lateral gulars of large specimens of *C. c. constrictor* and *C. c. priapus,* except those from central and south-central Florida, are usually spotted with black. Occasional specimens have completely black gulars. In central Florida specimens usually have much white on the chin and throat, and in these the gulars are also white. In the region of the flood plains of the Chipola and Appalachicola Rivers of western Florida the entire chin and throat may be suffused with very light brown or tan. These specimens have been designated as a new subspecies, *C. c. helvigularis.* Brownish-tinted posterior gulars are also quite common in specimens of *C. c. paludicolus.* Intergrades between the latter and *priapus* frequently exhibit this coloration. Specimens from the west coast of Florida rarely have brownish-tinted gulars. This color never seems to be found in other specimens of *priapus.* Both *paludicolus* and *helvigularis* have light brown or tan on the supralabials. In both, though especially in the latter, the ventral surface is frequently clouded with light brown or tan.

Specimens with unusually-colored gulars or chins are occasionally found, such as a specimen from DeLand, Volusia County, Florida (WA 3610) in which these parts were light orange in life. In specimens of *flaviventris, mormon, stejnegerianus,* or *anthicus* the gular scales are yellow, white, or yellowish-white.

The supralabials of full grown specimens of *constrictor* are usually black with only traces of white on the lower parts of the first few plates. This is also true of large examples of *priapus* from its entire range, except individuals from central peninsular Florida. Specimens from this area usually have supralabials which are black above and white below. Half grown specimens of *constrictor* and *priapus* have these scales similarly colored. Individuals are frequently taken in south-central Florida from Lake Okeechobee south to the Big Cypress Swamp of Collier County that have supralabials which are black above, and immediately below this there is a narrow band of very light tan or light brown. The bottom third is white. In this regard

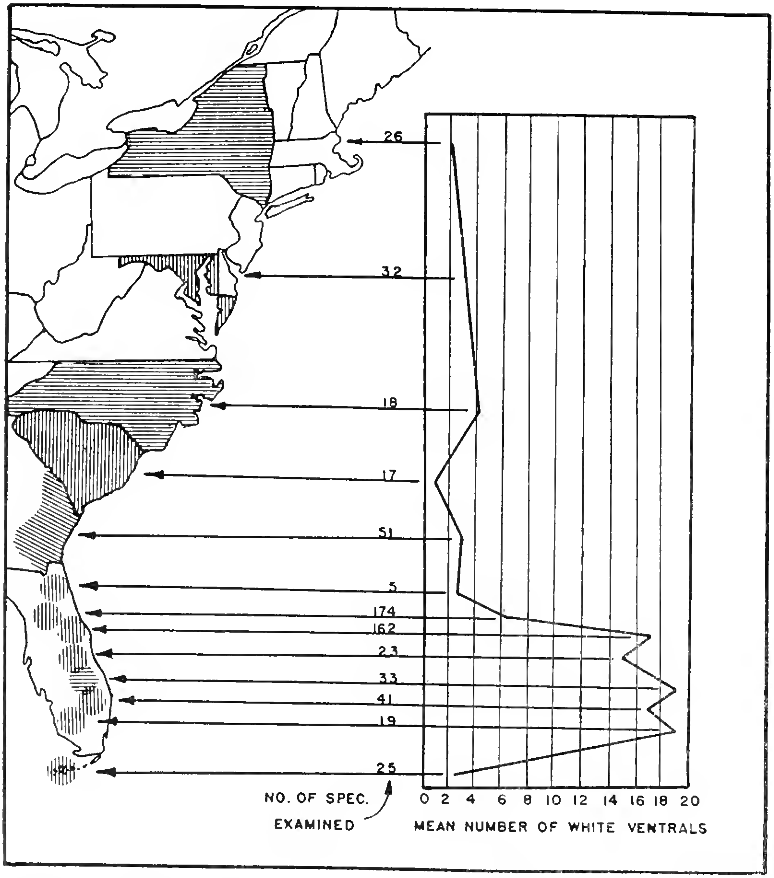

Figure 7. The mean number of white ventrals on the throats of specimens of *Coluber constrictor* from the Atlantic Coast area. The distribution of mean values in this figure is a fairly good example of an external cline in which the slope of the character-gradient is rather level over two large areas, but with a rapid increase in slope over a narrow portion of the range—the zones of character intergradation. These zones occur in northern Florida and on the Upper Keys. Although this figure would indicate the presence of another nominal population in central Florida, the character, and its distribution in this region, points to a narrow zone of frequent gene flow between two nominal populations inhabiting two rather similar ecological situations, and separated by an obviously inefficient barrier (see page 92).

these specimens show a genetic influence from populations of *paludicolus* from farther south. In this race the upper portion of each plate is dark gray or bluish-gray rather than black. Individuals with light tan or brown on the supralabials are frequently taken in the vicinity of Sarasota, Manatee County, in west-central Florida (fig. 16). The posterior gulars of specimens from this area are tan. Individuals that possess a very small amount of light brown or tan on the supralabials are also taken in the Gulf Hammock region of western peninsular Florida. Full grown adults from northwestern Florida, except those from within, or near the range of *helvigularis,* nearly always have black supralabials. Large specimens from this area which have these plates half black and half white are much less common than in specimens from peninsular Florida.

Along the zones of intergradation with light-colored racers of middle North America the supralabials become dark blue or black above and white below, gradually fading into the lighter colors characteristic of the western subspecies. The supralabials of specimens of *anthicus* from the eastern parts of its range are black above and white below. In the western parts of its range the supralabials are dark gray or bluish above and whitish below. In the middle portions of the range of *anthicus* the supralabials are usually either all light tan, or tan above and whitish below. The color of the supralabials in *flaviventris* may range from dark bluish-gray to light brown above. Below they may vary from white to bright yellow. The latter coloration is especially prevalent in the Great Plains portion of its range, while the former is most frequently found in the northeastern parts of its range.

Temporal coloration.—There are certain other colors frequently found on the heads of racers which may vary geographically. One of the most obvious of these is the coloration of the temporal scales. In most subspecies of *Coluber constrictor* these scales are slightly darker than the supralabials, parietals, or lateral scales of the neck, all of which surround the temporals. However, many specimens from Michigan, Indiana, Ohio, Illinois, and especially southeastern Louisiana have very darkly-colored temporals which, in many cases, gives an impression of a vague, short, postocular stripe. This color is usually a dark grayish-blue. Whether or not populations possessing dark-colored temporals form steep gradients where they intergrade with populations having lighter-colored temporals is unknown. However, the fact that this characteristic seems to be found in rather definite areas may indicate that the zone of intergradation is narrow.

Internal Clines

Number of hemipenial spines.—It has been previously shown that on mapping the proportionate lengths of the basal hemipenial spines in specimens of *Coluber constrictor* an external cline is indicated; *i. e.,* a definite and relatively narrow area of intergradation exists between populations having basal hemipenial hooks and those that do not. However, the *number* of hooks also seems to vary geographically, but as a steady cline or gradient, with no obvious areas of intergradation (steepening of the cline). Huxley (1943: 220) also called this a continuous cline.

The maximum number of hooks found in any specimen is three. This number occurs occasionally in all subspecies that normally possess at least one hook. Most of the specimens of *C. c. mormon* that were examined by Dunn and Wood (1939: 1-4) had three hooks present. In an examination of twelve specimens from California eight possessed three hooks, three had two and only one had one hook. In 15 specimens of *C. c. stejnegerianus* from Nueces County, Texas, nine had three hooks, four had two and two had only a single hook. In three specimens of *C. c. anthicus* none had three hooks, one had two, and two had a single hook. Although *C. c. flaviventris* frequently has three hooks, this number seems much more common in the southern portions of its range than in the northern parts. In fact, a large number of specimens from Michigan do not have any basal hooks at all, but have basal spines which are from three to three and three-fourths times the length of the adjacent proximal spines in the same rows. Of 211 adult black racers from Florida (*C. c. priapus*) 72.0% have one hook, 14.6% have two hooks, 11.1% have three hooks and 2.3% have no hooks. The evidence, though admittedly scanty from extreme western United States, seems to indicate that a large geocline is present in the number of basal hemipenial hooks as found on *Coluber constrictor.* Three hooks are most frequently found in populations from the western states, one hook being normal in eastern populations. Of 32 adult male specimens from the states of Missouri and Arkansas, 34.3% have three hooks, 40.9% have two hooks, 21.7% have one hook and 3.1% have no hooks, indicating an intermediate condition between the two extremes, both numerically and geographically.

Color of the young.—The transformation of the color and pattern of the juvenile racers to that of the adult follows certain well defined trends. On the dorsal surface the suffusion of the body blotches takes place from the posterior to the anterior regions. Even on some newly hatched specimens it is quite difficult to count the total number of these markings due to a certain amount of darkening on the posterior portions of the body while the snake was still in the egg. In most newly hatched specimens the total number of these dorsal markings can be counted easily.

The mean number of dorsal blotches in young racers varies geographically, as has been shown by Ortenburger (1928: 180, 213, and 216). Populations of this species which inhabit the western portions of North America have a higher mean number of body blotches than do populations from more eastern localities. Furthermore, this geographic variation is a gradual cline, except possibly in central Ohio (Conant, 1938: 54). This character gradient is best described as a geocline, and more specifically—an internal cline.

The subspecies, *C. c. stejnegerianus,* is thought to be closest to the ancestral stock, and this form possesses the highest number of dorsal blotches. However, the total number is seldom countable due to the fact that they are rather indistinct posteriorly. They range from 42-53 on the anterior third of the body and are not saddle-shaped as in the eastern forms, but crossbands (Auffenberg, 1949: 55). *C. c.*

flaviventris has 43-80 blotches. Specimens of this race from southeastern Louisiana have fewer dorsal saddles than do those from more northern parts of the range. In 23 newly hatched specimens from Jefferson Parish, Louisiana (WA 3673-96), the number varies from 43-63 (mean, 55). This is considerably lower than in a series of 18 specimens of *flaviventris* from Oakland County, Michigan (WA 3026-44), in which they range from 68-76 (mean, 71.3). In Florida, from which a large number of young are available, a definite trend is indicated, whereby specimens from southern Florida seem to have fewer blotches than do those from northern Florida. Of 56 newly hatched specimens from northern Florida the total number of blotches varies from 43-73, mean 52. In 32 specimens from central Florida the number of blotches ranges from 45-76, mean 49.7. In 10 specimens from extreme southern Florida in which the total number of dorsal blotches could be counted, they vary from 40-57, mean 45.8.

Conant (1942: 195) has also shown that geographic variation exists in the coloration of newly hatched racers. He mentioned that specimens of *priapus* from five miles south of Brighton, Glades County, Florida, had body blotches which were "rich chestnut brown", while in a series from Philadelphia, Pennsylvania these markings were "dark brown". The specimens from Florida were also more reddish in other parts of the body and these colors were suggested as additional means of distinguishing juvenile specimens of *priapus* and *constrictor.*

An examination of the material has shown that not all specimens of *priapus,* or even all specimens of *priapus* from Florida, have such brilliant colors. Ditmars (1939: 192) mentioned dark brown blotches on a specimen from Marion County, Florida. Although he recognized a difference concerning the color of the chin and supralabials of adult specimens from the southeast as compared with those of the northeast, still, in describing the typical young of black racers he used a specimen from Florida. In a series of 18 specimens from Columbia County, Florida, the dorsal blotches are a very dark reddish-brown and, when placed next to a series of hatchlings from Scioto County, Ohio, no appreciable difference can be discerned. However, in eleven specimens from Alachua County, which is directly south of Columbia County, the blotches are decidedly more reddish. Another juvenile described by Ditmars (*ibid,* p. 192) from Connecticut has dorsal blotches which are "grayish-brown", being lighter than the markings of the Columbia County, Florida specimens. A hatchling from Pensacola, Escambia County, Florida, has pinkish-gray blotches, while one from Tampa, Hillsborough County, Florida, has dorsal blotches which are very dark brown.

On the whole, most juvenile specimens from northern Florida northward, including the remainder of the range of *priapus* and all of that of *constrictor,* have markings which are usually some shade of dark brown, frequently dark reddish-brown. Conant's specimens from Glades County, which is quite far southward in the state, shows a portion of the cline exhibited by this coloration in peninsular Florida. In the Everglades of southern Florida practically all of the juveniles have light chestnut, or even reddish or pinkish blotches. Such light colors are never found in specimens from northern Florida, but are frequently found in individuals from south-central Florida. These colors are not diagnostic of the race as a whole, but the character exists as a geocline throughout peninsular Florida.

Specimens of *flaviventris* from southeastern Louisiana, which seem to have fewer dorsal blotches than do specimens of the same race from farther north, also have dorsal blotches which are decidedly more reddish than do specimens from farther north.

Conant (*op. cit.*) also mentioned the general reddish cast to the entire body as of possible significance in the identification of juvenile specimens of *priapus*. This characteristic, as with the lighter dorsal markings, is most prevalent in the Everglades race, *paludicolus*. Throughout the major portion of the range of *priapus* (excluding south-central Florida) most juveniles have a gray, or grayish-brown ground color as do specimens of *constrictor*. Of special significance is the fact that specimens of *flaviventris* from southeastern Louisiana show the reddish suffusion of the general body colors which is characteristic of juvenile *paludicolus*. Specimens of *flaviventris* from more northern parts of the range do not show this coloration, but are similar to *constrictor*.

The ventral color of juveniles from south-central Florida is also different from that of specimens in the Philadelphia area (Conant, *ibid*). This difference involves both the ground color and the small ventral spots. Conant's specimens from Glades County, Florida had "spots on the belly orange brown; ground color of belly (posteriorly) bright pinkish orange". Specimens from the Philadelphia area had ventral spots which were "very dark brown or black", and the ground color of the belly was "bluish-gray". Ditmars (1939: 192), regarding a juvenile from Marion County, Florida, wrote of "brick-red" ventral spots. In 18 juveniles from Columbia County, Florida, the posterior ground color of the belly is not pinkish and the ventral spots are dark reddish-brown. In USNM 17655 from Tampa, Hillsborough County, Florida, the ventral spots are reddish-brown. In USNM 4736 from Micanopy, Alachua County, Florida, these spots are brown, while in eleven others from Alachua County (WA 3647-56, and 3680) the ventral markings are light reddish-brown. In WA 3657 from 4 miles north of Kissimmee, Osceola County, Florida, the ventral spots are dark pinkish-orange. These few examples indicate that the color of the ventral spots is probably clinal in the state of Florida. Juvenile specimens from northern areas of the peninsula usually have reddish-brown ventral spots with no reddish suffusion posteriorly, while those from southern Florida have reddish ventral spots with a similar color suffusion posteriorly. Thus, for the same reason that the color of the dorsal blotches cannot be used as a diagnostic character of the race *priapus*, neither can the coloration of the ventral spots be so used; namely, the character is an internal cline in Florida (fig. 16). The ventral spots of both *flaviventris* from southeastern Louisiana and *paludicolus* are decidedly reddish or orange. The general ground color of the belly is slightly pinkish in specimens from both localities. The ventral color of juvenile *flaviventris* from the northern parts of its range resembles that of juvenile *constrictor.*

Throughout the entire range of *constrictor,* and most of that of *priapus* (except south-central Florida), the ventral markings are rather large. They are about one-fourth to one-sixth as wide as the width of the ventral plates themselves. In *priapus* from south-central Florida, as well as in *paludicolus,* these markings are much smaller. They are practically never larger than one-eighth the width of the ventral plates and are frequently absent entirely. This reduction in the size of the ventral spots in specimens from southern Florida is again paralleled in *flaviventris* from southeastern Louisiana. The small number of live specimens which I have examined from this area have fewer and smaller ventral markings than do specimens from Michigan and adjacent states.

Scutellation.—Certain scales of the head and body of racers have been shown to vary geographically (Ortenburger, 1928: 174 ff). This is especially true of the number of ventral and subcaudal scales, both of which form continuous clines.

Ventral scales.—It was first pointed out by Ortenburger (*ibid.*) that the mean number of ventral scales in *Coluber constrictor* varies geographically as a continuous gradient. The highest means are found in Florida and the extreme northeastern portions of the United States, while the lowest mean count is found in southern Texas. This last area is inhabited by the subspecies *stejnegerianus.* During the early part of the century only a few specimens of this race were available and it was thought to represent nothing more than a variant of *C. c. flaviventris.* During the past few years many specimens have become available and studies of this form by Mulaik and Mulaik (1942: 13-15) indicated that the form deserves subspecific designation. Later studies (Auffenberg, 1948: 53 ff), based on a much larger number of specimens than were available to Ortenburger, showed that the mean number of ventral scales of this race is lower than that of any other subspecies in North America.

It is significant that of the specimens from Florida, those from the southern parts of the peninsular have a higher mean number of ventral scales than do those from the more northern portions of the peninsula. This portion of the state is believed to have been populated from more northern localities. This, in part, constitutes the basis of Ortenburger's hypothesis which states that low ventral scale counts in *Coluber constrictor* are ancestral to higher ones. On the whole the present study has corroborated this hypothesis, though certain complications have become evident with additional material.

In Trapido's study of the genus *Storeria* (1944), as well as in

Ortenburger's monograph of the whipsnakes and racers, the cline in the number of ventral scales is more rapid and exaggerated in Florida than in any other portion of the ranges of the genera involved in these studies. This is also true of the subcaudal scale counts.

According to Ortenburger the mean number of ventral plates in specimens from the northern parts of Florida is 177.4. For the southern portions, this average is stated as 181.6. Figure 8 shows the results of mapping the mean number of ventral scales in 872 specimens from the state of Florida. Means are shown for various localities, but only if at least five specimens are available from that area. A number of other specimens (136) were examined, but not included due to the unreliability of the counts of only a few specimens scattered over rather large areas. Also drawn on the map are the physiographic provinces of the state as outlined by Cooke (1939:

Figure 8. Mean number of ventral scales for various localities in Florida, based on data from localities from which at least five specimens were available. The data presented on the map represent scale counts of 872 specimens.

14). Because the specimens from the extreme southern parts of the peninsula are so noticeably different from those on the Keys, the mean number of ventral scales was tabulated separately for these two areas. By separating these counts the mean number of ventral plates for the populations of the Lower Keys is 176.7±.49, while in a large sample of specimens from Alachua County, in northern Florida, the mean is 178.3±0.38. On the other hand, specimens from Dade County, at the southern extremity of the peninsula, have a mean of 184.0±.36. It is obvious that the number of ventral plates of the specimens from the Keys is much closer to those from Alachua County in northern Florida than to the geographically closer locality of Dade County.

The difference between the means for northern and southern Florida, as found by Ortenburger, is 4.2 scales. By separating the Keys populations from those of the southern mainland I find a difference between the populations of northern and southern peninsular Florida of 6.7 scales ($P = > .001$). Specimens from Cape Canaveral, Brevard County, which are identical in color with the Everglades race, *paludicolus,* also have a higher number of ventrals than do populations of typical *priapus* from the mainland (fig. 8). From the Cape the mean is 184.6±0.39, while for the adjacent mainland population of *priapus* it is 182.0±0.52. However, the difference between the means of the two populations is not significant. It should be pointed out, however, that the samples from both of these areas are rather small.

Series of specimens from a number of localities over the state of Florida suggest that the cline in the number of mean ventral scales is not simply north-south in the peninsula. In figure 8 there is shown a Central Highlands District. This area may be termed the backbone of the state, and is composed of significantly older formations than are the surrounding Coastal Areas (Cooke, 1939, 1945; MacNeill, 1951, *et al*). Large portions of it are the site of the Floridian Archipelago, formed during former high sea levels and which may be important in the distribution of the fauna of the extreme southeastern states. Within each one of these districts there seems to be a slight suggestion of a north-south trend in the number of ventral scales. Specimens from the northern portions of each district have lower counts (though not statistically significant) than do those from the southern parts of the district. The mean for the entire northeastern part of the Coastal Lowlands is 180.1±0.42, while for Dade County, in extreme southern peninsular Florida, it is 184.0±0.36. In the Central Highlands the mean in the entire northern portion is 178.2±0.32, while in the extreme southern tip of this district it is 179.6±0.65. Specimens from the western panhandle of the state have the lowest mean number of ventral scales of any area in Florida. This region includes the northwestern Coastal Lowlands, the Western Highlands, Mariana Lowlands and the Tallahassee Hills. The mean for this entire region is 174.1±0.72.

Reference has been made to specimens from Sarasota County, on the west coast of Florida which approach intergrade coloration (*paludicolus* X *priapus*). It seems significant that this region also has a higher mean number of ventral scales than the surrounding counties, and that this count approaches that of the race *paludicolus*. In the region of Lake and Sumpter Counties in central Florida, the number of ventrals (181.3) is higher than in populations to the north or south of them. This general region also seems to be the one in which it is believed a seaway extended from the east to the west coasts of Florida during a large portion of the early Pleistocene. Whether or not there is any direct correlation is unknown at present. Specimens from the geologically recent portions of Florida, comprising the Pamlico Terrace of the extreme eastern coastal strip and much of southern peninsular Florida, have the highest mean number of ventrals of any area in the state. The mean number of ventral scales for all of the western "panhandle" is 174.1±0.72; for the Central Highlands, 178.1±0.35; and for the peninsular Coastal Lowlands, 181.8±0.38. There is a difference of 4.0 scales ($P = >.001$) between the means for the western districts and the Central Highlands; and 3.7 scales difference ($P = >.001$) between the means for the Central Highlands and the peninsular Coastal Lowlands. In the specimens from Sumpter and Lake Counties in the middle portion of the Central Highlands, the mean is 181.3, while to the north the mean for Marion and Alachua Counties is 177.5. The difference between the two areas is 3.5 scales, but is not statistically significant. The mean for Orange, Polk and northwestern Osceola Counties (south of Lake and Sumpter Counties) is 176.8, the difference between them being 4.2 scales. Again, the difference is not significant, but only suggestive. The difference between the means of specimens from the Everglades and the Keys is quite great, being 7.3 ($P = >.001$). This difference, though actually gradual, takes place over approximately 150 miles. Although the difference between the mean number of ventral scales within the State of Florida is quite small, it seems significant that the differences among the mean number of ventrals of a sample of *stejnegerianus* from extreme southern Texas, and another sample of *flaviventris* from Nebraska is 10 scales ($P = >.001$). This involves a distance of approximately 1,500 miles.

An isophene is drawn for the various mean numbers of ventral scales in Florida in figure 9. This is based entirely on figure 8. Figure 10 shows the results of drawing an isophene of the mean number of ventral scales throughout the United States. Due to the proportionately lesser number of specimens used in this evaluation as compared with that of Florida, this representation is more generalized than that for Florida. However, it is evident that there are two areas with very high mean ventral scales: (1) the New York, Pennsylvania, Maryland and eastern Ohio region; and (2) the eastern and southern coastal regions of peninsular Florida. The area with the lowest mean count is in southern Texas. The pattern is one of more

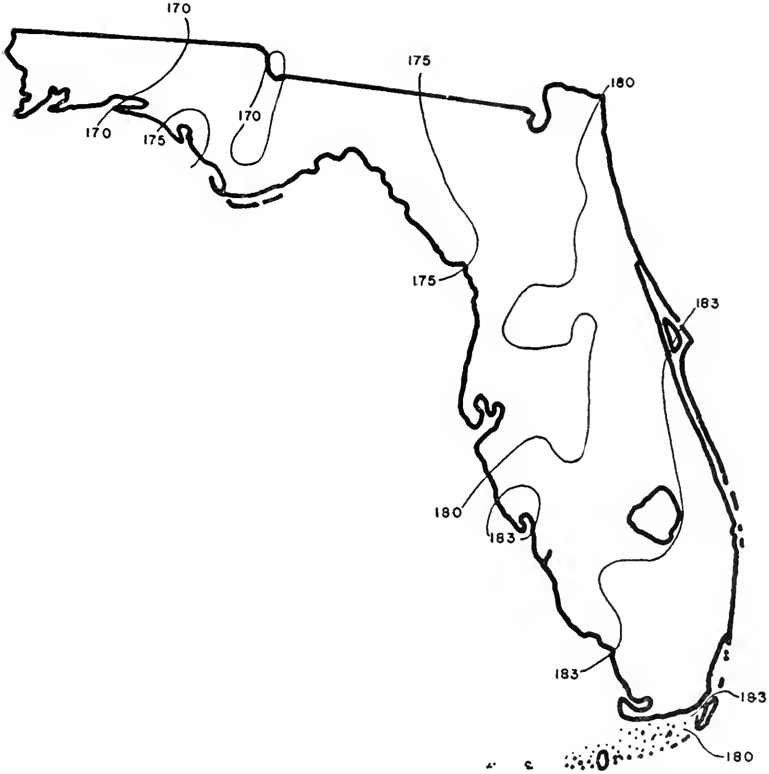

Figure 9. An isophene based on the mean number of ventral scales of specimens from Florida, based on data obtained from figure 8.

or less concentric circles away from this area having a low mean number of ventral scales. It will also be noted that the counts are lower along the northern parts of the entire range of the species. This is especially evident in the New England States, where the counts drop from a mean of 180.1 in New York state to practically 170 in Maine. This has been thought to be due to the effects of minimum vital conditions found in this northern region (Ortenburger, 1928: 231), and not an integral part of the inherent tendencies along the paths of dispersal.

Subcaudal scales.—The geographic variation of the subcaudal scales is very similar to those of the ventral scales. Analysis of the available data by Ortenburger (*op. cit.*) indicated that a geocline exists in the mean number of subcaudals. The present study has substantiated these data, at least for the eastern United States.

Figure 11 is an isophene drawn from the available material of eastern United States. Unfortunately, a large number of specimens have broken tails, so that even large series from one locality have many specimens that cannot be utilized for an analysis of this character. As a result, the isophene based on subcaudals is necessarily more generalized than that for the ventral plates.

Similarities between the two isophenes (figs. 10, 11) are apparent. This is especially true in Florida. The western portion of the state has the lowest mean number of subcaudals of any area in the state (97.5±1.02). The southern portion of the peninsula has a higher mean number of caudals (107.9±0.82) than does the northern part of the peninsula (103.2±0.93). On the Keys the mean number is 102.5±1.31, being more similar to the mean of the population from northern peninsular Florida. It is also significant that the isophene representing a mean number of 105 caudals is very similar to that representing a mean of 180 ventrals in figure 9. In New York State, where specimens also have a high number of ventral plates, the number of subcaudals is also relatively high, but not significantly higher than those from many other portions of the eastern United States.

Reduction of scale rows.—Ortenburger (1928: 205) discussed the mean point of reduction of the dorsal scale rows, especially in terms of geographic variation. He showed that the point of scale row reduction is "farther posteriorly in specimens from the Northeast and from the Southeast than from the southwestern part of the range". This is to be expected if the point of decrease is correlated with the total number of ventral scales in this species. The mean number of ventral scales at which this reduction occurs in specimens from Alachua, Marion and Columbia Counties, Florida, is 108.4±1.32; for specimens from Volusia and Seminole Counties, Florida; it is 109.0±1.02; for the Keys, 107.5±1.72; and from Collier and

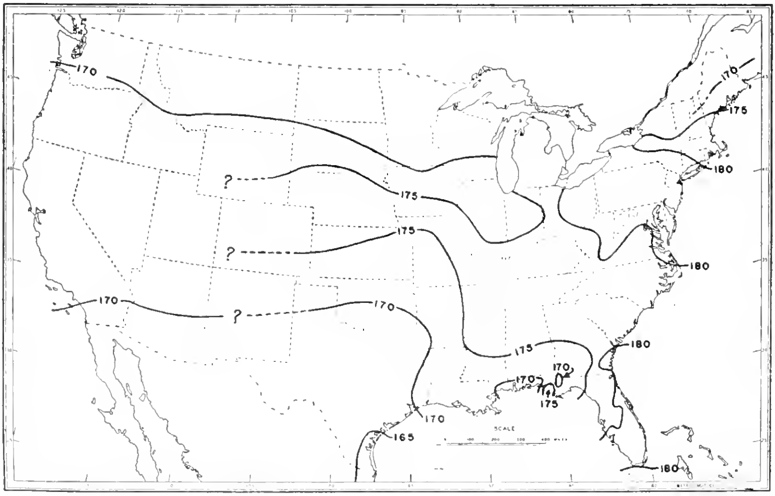

Figure 10. An isophene based on the mean number of ventral scales of specimens of *Coluber constrictor* from the United States.

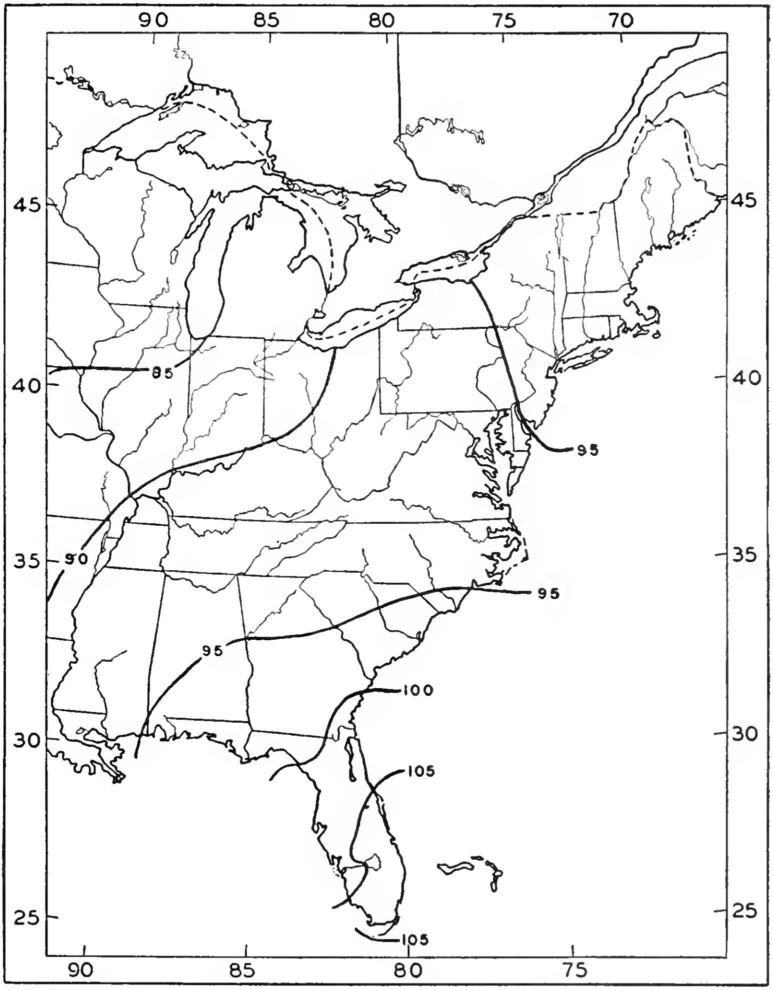

Figure 11. An isophene based on the mean number of subcaudal scales in specimens of *Coluber constrictor* from eastern United States.

Dade Counties in extreme southern Florida it is 115.7±1.01. As in the distribution of the number of ventral and subcaudal scales, the populations from the Keys are more similar to those from northern peninsular Florida than to those from the geographically closer locality of extreme southern mainland Florida. Populations from localities between the northern part of the peninsula and the Everglades of southern Florida have the scale reduction occurring between the 108th and 115th ventral plates and exhibit a geocline in that the scale reduction is found farther back on the body as populations are encountered which have progressively higher ventral scales. When the mean number of ventral scales of any population is divided by the mean ventral scale at which the scale reduction occurs, the resultant ratio varies from 1.6 to 1.8.

Osteology.—During the latter part of this study some skulls of *Coluber constrictor* were examined. Certain variations became evident, but because of the small number of prepared crania most of these cannot be discussed at present with any degree of certainty. However, one character-gradient dealing with the bones of the skull is rather obvious. This is the shape of the premaxillary.

Premaxillary shape.—Bogert (1947: 11) has mentioned the use of this bone as a possible indicator of phylogenetic relationships among various genera and species of snakes. In *Coluber constrictor* the premaxillary is roughly "skate-shaped", having two "wings" extended out in a horizontal plane, perpendicular to the axis. At the posterior inner edge of these flat, lateral "wings", are two posterior projections of the processes.

An examination of 32 specimens for this character has disclosed that a geocline seems to exist from *mormon* and *stejnegerianus* through *flaviventris* to *priapus.* This cline is concerned with the shape and plane of the axis of the two posterior processes mentioned above. In *flaviventris, mormon* and *stejnegerianus* these processes are rather short, being shortest in the last two subspecies. In all of these races they lie in a nearly horizontal plane, but decidedly less so in *flaviventris.* In *constrictor* they are in a horizontal plane, but longer than in *flaviventris.* They are longest of all in southeastern specimens of *priapus* and *paludicolus,* and are, furthermore, twisted in these two races so that the outer edges of the two posterior processes have been rolled upwards, causing them to lie in a vertical, rather than a more or less horizontal plane. The shape and nature of the axis of these processes varies both geographically and individually.

The shape of the lateral "wings" of the premaxillary may also vary individually and geographically. In the western races the tips of these processes usually form less acute angles than do the tips on specimens from the east, and especially the southeast. In some of these specimens this tip may be formed into a sharp, slightly recurved hook.

In the description of a fossil Pleistocene snake, *Coluber acuminatus,* Cope (1899: 197) described the shape of the premaxillary as "subconic", and "narrower and more protuberant than in *Z. constrictor* . . . with which I have compared it". The degree of protuberance of the anterior tip of this bone is variable, individually, geographically and ontogenetically. Adult specimens from the southeastern states have a much more protuberant profile than specimens from the western states. Juvenile specimens from the southeastern states have a less protuberant profile than do the adults from these areas and are similar to adult specimens of more western races.[4]

Dentition.—That the number of teeth in this species varies geographically has already been shown by Ortenburger (*op. cit.*). Moreover, the number of teeth increases from the western races to those of the eastern parts of North America. Figure 12 shows the range of variation in the number of dentary, palatine, pterygoid and maxillary teeth in the races of *Coluber constrictor.*

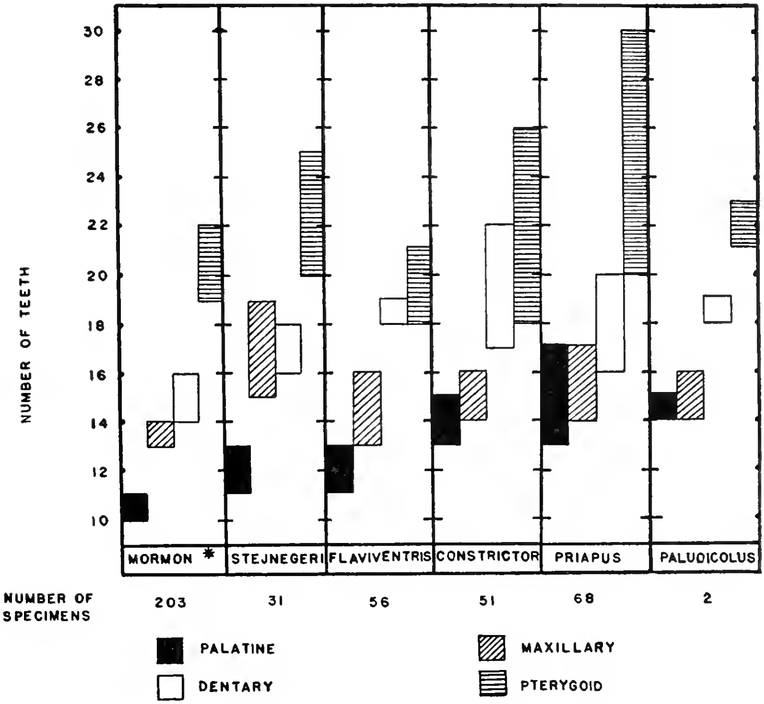

Figure 12. Range of variation in the number of teeth in some of the subspecies of *Coluber constrictor.* The relationship of the number of palatine and dentary teeth is especially interesting. In *priapus* the numbers overlap slightly, while in the other races the numbers of these teeth are discrete. There is an apparent increase in the number of palatine teeth from the western to the eastern races. There is also a general increase in the numbers of other teeth. The decrease in number of dentary teeth from *constrictor* to *priapus* and *paludicolus* is interesting in view of a general increase from *mormon* to *constrictor* (* data from Ortenburger, 1928: 174).

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[4] A paper by the author (in print) compares the variation in the skeletal elements of *Coluber constrictor* with *Coluber acuminatus,* and shows that *acuminatus* should be referred to the synonymy of *Coluber constrictor.*

Ontoclines[5]

Color of the iris.—The color of the iris in specimens of *Coluber constrictor* is important. Conant (1942: 195) has suggested that the red eyes observed in both adult and juvenile racers from Florida may be characteristic of the race *priapus,* and may be of value in distinguishing both sexes of this subspecies from *constrictor.* The latter usually have brown-colored eyes. The range of variation, either individual or geographic, was practically unknown, although Perkins (1949: 10) suggested that the degree of consistency in this character needed more confirmation, especially in adults.

In all living examples of *constrictor, flaviventris* and *priapus,* in the more northern and western portions of its range, the iris is usually brown. Sometimes it may be dark amber, tan or reddish-brown, but never distinctly reddish or orange. Specimens with a red, or orange iris occur in Florida. However, analysis of this character is complicated by the simultaneous existence of a geocline and an ontogenetic change in the color of the iris in specimens from peninsular Florida.

Of the living adults that I have examined from the extreme northern portions of Florida, none possesses red eyes. However, of eleven newly hatched specimens from Columbia County, which is situated in the northern part of the peninsula, four possessed red eyes, while those of the remainder were brown. Both parents of these hatchlings (WA 3345-6) had brown-colored eyes. The female parent of nine red-eyed hatchlings from Alachua County, which borders Columbia County on the south, was also brown-eyed. Seven other newly hatched specimens from Columbia County and six others from Alachua County had brown eyes. In eight young from Kissimmee, Osceola County, in central Florida, seven had red eyes and those of the remaining snake were brown. Moreover, there were many adults from Osceola County that had red eyes, while in Alachua County there were only a few. Of 38 living specimens of *paludicolus* from southern Florida, practically all of the juveniles *and* adults had red eyes. Those that were not red were yellow, or rarely reddish-brown. In the case of specimens from northern Florida, the number of young with bright red eyes (25.3%), and the fact that only a very few red-eyed adults were taken (5.2%) seem to indicate that this character is, at least in part, ontogenetic. That is, most red-eyed juveniles simply change to brown-eyed adults. This is somewhat substantiated by the brown-eyed parents of red-eyed juveniles. In living specimens from the Kissimmee area, not only are red eyes more frequent in newly hatched specimens than in those from northern Florida (69.8%), but many retain this color into maturity (58.2%). In extreme southern Florida, practically all of the juveniles possess red eyes (78.4%). None seem to change this color, for a large number

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[5] An ontocline may be either a geo- or ecocline, and at the same time an external or internal cline. It is a condition in which an ontogenetic change varies geographically as a character-gradient.

of the adults examined were also red-eyed (75.3%). The relationship of the color of the eyes in juveniles and the geographic locality of various populations is shown in figure 13.

That the eyes of juvenile snakes from northern peninsular Florida change color is strongly substantiated by living specimens of all ages in which all gradations from red to brown have been observed. In specimens with red eyes the first indication of change is in the lower half of the iris, next to the pupil (fig. 14). Here there is formed a reddish-brown crescent that gradually gets larger. In specimens of about 30-40 inches there is frequently noted a red crescent on the upper portion of the iris, while the remainder is brown. This crescent in the iris of adult specimens is probably an indication of its previously red-colored iris as a juvenile.

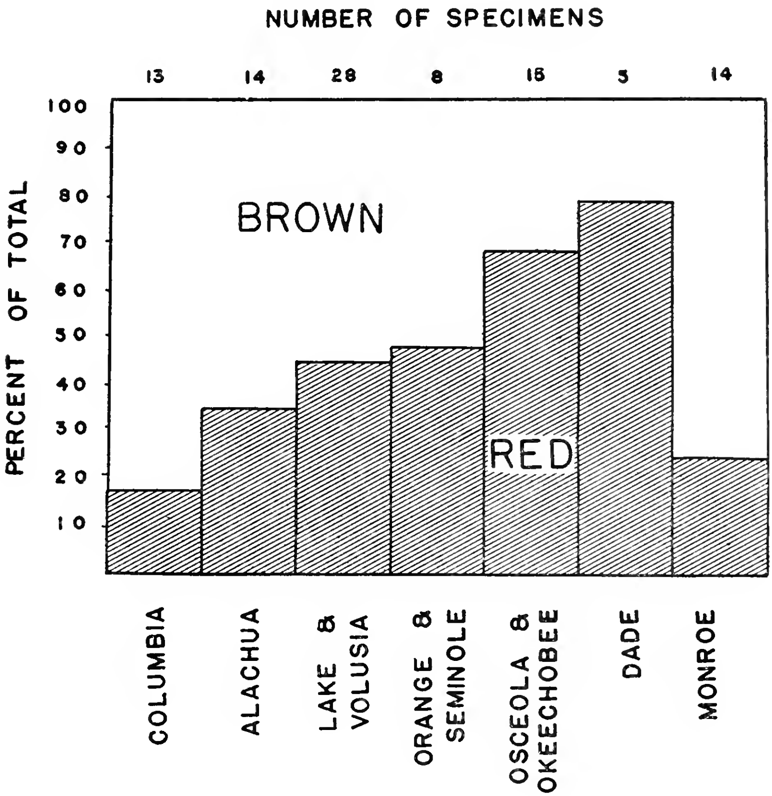

Figure 13. Geographic variation in the coloration of the iris in juvenile specimens of *Coluber constrictor* from Florida. Note the gradual increase in the number of red-eyed specimens from Columbia County to Dade County, Florida, and the similarity between the specimens from the Outer, or Lower Keys and northern peninsular Florida.

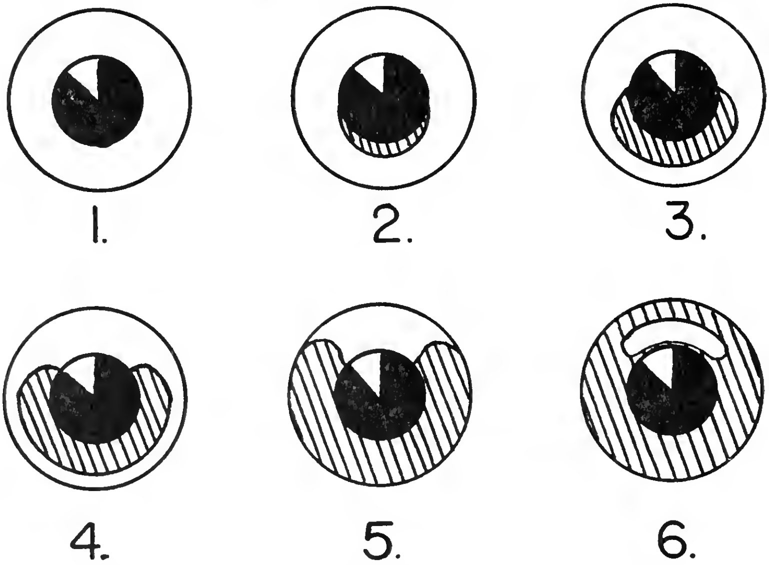

Figure 14. Ontogenetic changes in the coloration of the iris of specimens of *Coluber constrictor.* Shaded areas represent regions of the iris which are dark brown in life. Clear areas represent regions which are bright red or yellow in life. The eyes, numbered 1-6, show the change of red-eyed hatchlings through successive stages in which the brown color increases, to the practically all brown eye of the adult. Faint traces of red are usually found above the pupil in even very large adults (6).

Another interesting parallel between the race *paludicolus* and specimens of *flaviventris* from southeastern Louisiana is that the iris of juveniles from both areas is usually reddish. All the live juvenile specimens of *flaviventris* which I have seen from Michigan and Ohio have brown eyes (fig. 16).

Dimorphism

Geographically variable dimorphism.—A character not mentioned by any earlier workers, and of frequent occurrence in the southeastern part of North America, is the contact of the first supralabial and the loreal. This is made possible by an elongation of the upper posterior corner of the first supralabial making contact with the lower, anterior corner of the loreal. It may be present on one side, but not on the other.

The presence of a contact between these two scales is found mainly in specimens from the southern states, and then only in a fair degree of regularity. However, it seems to be generally absent in specimens from the northern portions of the ranges of *C. c. flaviventris* (except in Michigan, and Ohio, where it occurs in 12.2 percent) and *C. c. constrictor.* It is absent in the few specimens of *flaviventris* that I have examined from the central parts of its range, as well as in all specimens of the race *mormon*. It occurs in at least 10% of all specimens of *priapus* except those from extreme eastern North Carolina (fig. 16). I have found this contact in 6.6% of the specimens of *constrictor* from north of the Fall Line in Georgia, and in 7.1% of the specimens from Tennessee. It does not seem to occur in any other portions of the range of this form.

In the southern portions of the states of Mississippi, Alabama, Georgia and South Carolina, this contact occurs in at least 15% of the specimens, while in northern peninsular Florida it occurs in 10-35% of the specimens. In the central part of the peninsula it occurs in 25-45%, while in the southern counties it is found in 40-50% of the individuals.

Although a cline is indicated by the frequency with which this contact is found, this cline is not steady and gradual. Various inconsistencies occur throughout the peninsula, such as, for example, the counts obtained from specimens from northern Florida. Of one hundred and seventy-eight specimens from Alachua County 45.9% have a contact between these two scales. However, in specimens from adjacent counties it occurs in only 20-30% of all of the individuals examined. In Volusia County, from which 134 specimens are available, it occurs in only 10%, while in the surrounding counties it occurs in closer to 30% of the individuals examined (102). In Pinellas County it is found in 50% of the specimens, while in adjacent counties it occurs in 26.9-34.3%.

The means for the degree of frequency in which such contact occurs for northern, central and southern Florida are, respectively, 28.2%, 33.8% and 44.2%. Thus, there is a tendency for more specimens to have a loreal-first supralabial contact in southern Florida than in the northern parts of the state. Furthermore, such contact seems confined to the southern half of the United States, and is more frequent below the Fall Line (fig. 16). It also seems significant that the population from the Florida Keys have this contact in a degree of frequency (27.3%) which is more similar to that of northern Florida (28.2%) than to that of southern Florida (44.2%).

Sexual dimorphism.—Aside from rather obvious sexual dimorphism such as that concerning the reproductive organs, certain other characters are evidently related to the sex of the individuals. However, most of these differences are not obvious, and are based on mean values of significantly large samples.

Scutellation.—The only scale character which I have found exhibiting statistically significant sexual divergence is the number of caudals, but only on the basis of local populations. A comparison of the mean number of caudals for males and females of large samples from restricted localities indicates that differences in the means are significant ($P = > 0.001$). On the other hand, when the means for all of the males and females are analyzed, the observed differences are not significant ($P = < 0.03$).

Other scale characters, such as the point of reduction of dorsal scale rows and the total number of ventrals, have been mentioned by Ortenburger (1928: 185) as showing sexual dimorphism, expressed by mean values. However, on statistical analysis such differences as might exist in these characters could be due to effects of random sampling ($P = <0.03$).

A valuable statistic, the coefficient of divergence, has been given for a few species of snakes. A comparison of the coefficients of divergence that have been determined for the ventrals and caudals of two species by Klauber (1940: 208), two races by Grobman (1941: 21) and one by Dowling (1950: 21), as well as those of the eastern races of *Coluber constrictor,* are shown in Table 2. As in other species for which such coefficients are available, *Coluber constrictor* exhibits more divergence in the mean number of caudals than in the number of ventrals. In fact, sexual differences in the mean number of ventrals do not approach statistically significant levels, even for large samples from restricted localities ($P = 0.8\text{-}0.3$).

TABLE 2.
COEFFICIENTS OF SEXUAL DIVERGENCE

Form	Number of Specimens	Ventrals	Caudals
Lampropeltis g. californiae	271	.009	.073
Opheodrys v. vernalis	391	.006	.147
Opheodrys v. blanchardi	56	.072	.163
Phyllorhynchus d. perkinsi	225	.073	.256
Seminatrix p. pygaea	203	?	.228
Coluber c. constrictor	278	.008	.068
Coluber c. priapus	1008	.010	.049
Coluber c. flaviventris	102	.012	.071
Coluber c. paludicolus	58	.017	.008

Although the coefficients of divergence of the mean number of ventral scales of the eastern races of *Coluber constrictor* seem to form a group, the same is not true of the caudal scales. The coefficient of sexual divergence in the mean number of caudals in *Coluber c. paludicolus* is quite different from those of the other subspecies, and the low value of this statistic may be of some diagnostic importance.

Size and proportion.—Very few specimens were measured during the course of this study, partly because of the difficulty encountered in obtaining accurate measurements of preserved specimens. However, measurements of 103 living specimens seem to indicate that females attain a larger size than do males of the same subspecies. The mean length of 51 male specimens of *Coluber c. priapus* is 943 mm, while the mean for 26 females of the same race is 955 mm. The largest specimen of this race that I have examined is a male, 1473 mm in total length. Of 13 male specimens of *paludicolus,* the mean is 951 mm, while for eight females it is 1043 mm. The largest specimen is a female, 1689 mm in total length. The mean length of 13 male specimens of *constrictor* is 949 mm, while for 12 females it is 999 mm. The largest example of this race which I have measured is a female, 1588 mm in total length.

Ortenburger (1928: 186) has shown that there is considerable sexual dimorphism in proportionate tail length; "the male has a much longer tail than the female; the averages are 0.254 and 0.233 respectively". He has also shown that there is a positive correlation between the number of caudals and the proportionate tail length within each sex.

Environmentally Produced Characters

For the most part practically all of the characters used in the description of variations of snakes, either individual or geographic, are assumed to be genetic in origin. However, Fox (1948) has shown that the number of scales on various parts of at least certain species of snakes may be influenced by environmental conditions.

Character-gradients, or geoclines, are frequently found to have as their basis of expression, environmental factors which exist in a similar gradient. This has been shown both experimentally and in field studies for a number of species of fishes (Tåning, 1952; Hubbs, 1922a, 1922b, 1940; Jordan, 1893; Schultz, 1926). In all of these studies temperature was of utmost importance in the expression of meristic characters. It is entirely within the realm of possibility that the number of caudal and ventral scales in *Coluber constrictor,* as well as other clinal characters, are environmentally influenced during development of the embryo within the egg, either by temperature alone, or in combination with other ecological factors. Aside from these possibilities of environmental influence on the embryo of young racers, it was found that such factors may affect the appearance of racers *after* they are hatched. This change is concerned with the color of the ventral surface.

Coloration of the ventral surface.—Cope (1900: 793) mentioned black punctations on the ventral surface of a racer from Galveston, Texas (USNM 10481). This coloration is a common phenomenon in many individuals from southern United States, even being evident on the black bellies of many specimens of *priapus.* These marks are rarely encountered in specimens of *flaviventris* or *constrictor* from the northern parts of their ranges. I have never noticed such marks on newly hatched or juvenile specimens. They are present on adult specimens of *flaviventris* from east central Texas, and are very evident on adult *anthicus.* The latter frequently has such marks on the first few rows of dorsal scales as well as on the ventral surface. They are also common in many adult specimens of *priapus* from southern Mississippi, Alabama, Georgia, South Carolina and Florida. Many specimens of *paludicolus* also have them (fig. 16).

Close examination of these minute black punctations shows that a very large number of them contain a small mite (*Ophioptes* sp., near *tropicalis* Ewing), which is buried beneath the noncellular outer layer of the skin. Presumably they are not discarded when the skin is cast. In preservation the mite is pale buff to white, and the black punctations are composed of very minute black specks or streaks.

The taxonomic implications of this phenomenon are intriguing. The distribution of specimens with black punctations on the venter may indicate the Coastal Plain range of the mite. Of more significance is the fact that this distribution may reflect a physiologically variable character in which the racers from southern United States may be more susceptable as host animals to the parasitic mite, and that the mite is actually found over a much greater range.

The influence of the environment on cold-blooded vertebrates, and especially reptiles, is very little known. Of particular importance to the taxonomist interested in these groups is its effect on meristic characters. Jordan (1893) found a general correlation between water temperature and the number of vertebrae in marine fishes, while Schultz (1926) showed the existence of a similar phenomenon in the fresh water fish *Notemegonus crysoleucas.* Both of these studies were based on field data and indicated that most species of fishes tend to have a higher number of vertebrae or fin rays with decreasing temperatures. Hubbs (1922a and b, 1940) and Tåning (1952) worked with specimens in which the temperature during the developmental period was controlled. The results of these experiments tended to substantiate theories based on field data. It was also found that decreasing oxygen pressure and rapid changes in temperature during the sensitive period of embryonic development produced a difference in the mean number of vertebrae (Tåning, 1952). Field observations concerning the effect of salinity on meristic characters have been rather inconclusive.

In reptiles the only studies of this nature have been on one ovoviviparous species of snake, *Thamnophis e. atratus* (Fox, 1948). The subject is of vast importance in the study of herpetology in view of our present practice of utilizing the mean number of scales in the description of nominal populations. As in fishes, racial studies involving geographical variation are more difficult than previously supposed because of the possibility of dependence of some meristic characters on environmental factors. The subject affords many opportunities for worthwhile contributions to our knowledge of variation.

UNCORRELATED VARIATION

In this section are discussed all of the external morphological variations which do not seem correlated with age, sex, environment or geographic locality.

Scutellation

Dorsal scales.—For the most part, practically all of the specimens of *Coluber constrictor* have a dorsal scale formula of 17-17-15 rows. However, occasionally specimens are examined that have a vertebral reduction in addition to the normal lateral type. Ortenburger (1928: 204-205) stated that this type of reduction occurred only rarely in *Coluber constrictor,* being found in only 4 out of over 400 examined. However, of 86 specimens of *priapus* that I have examined for this character, I find that it occurs on the body in 5.6%. A vertebral reduction occurs over the anal plate in 34.3%, and on the base of the tail just behind the anal plate, in 60.1%. A typical dorsal scale formula of a specimen possessing a vertebral reduction on the body is given in the manner suggested by Dowling (1951: 131-133). The specimen is from Columbia County, Florida.

$$21\ \frac{3\quad 4(2)}{3\quad 4(3)}\ 19\ \frac{3\quad 4(8)}{3\quad 4(9)}\ 17\ \frac{3\quad 4(100)}{3\quad 4(102)}\ 15\ \frac{7}{8(146)}\ 14\ \frac{7}{7(148)}\ 13(178)$$

The high incidence of a vertebral reduction in *Coluber* and the fact that the race *ruthveni* of *Masticophis taeniatus* is more or less characterized by having no vertebral reduction (58% of the specimens have a scale formula of 15-13 *fide* Ortenburger, 1928: 87) lends support to the proposition that perhaps the two genera should be united, and not given generic distinction as indicated by Inger and Clark (1943: 492). No subspecies of *Coluber constrictor* is characterized by having a vertebral reduction, although the condition seems to occur sparingly throughout the range of the species.

Scales between the chin shields.—The presence or absence of small scales between the posterior chin shields of specimens is also of taxonomic importance (Inger and Clark, *ibid.*). A small proportion of the specimens (24.5%) examined do not have these scales present between the chin shields. When present, they vary from 1-8.

Supralabials.—The number of supralabials in this species may vary from 3-12. Both extremes are rather rare and are produced by a considerable amount of fusion or splitting of the scales. They usually range from 6-8. In the eastern races they are usually 7 (mean 7.2). Occasionally 8 supralabials (7.1%) are found in specimens from eastern United States. Although this number is characteristic of two races (*stejnegerianus* and *mormon*) from the western parts of North America, it is not found in any definite area in eastern United States in a higher frequency than in any other, and the number seems uncorrelated with locality in this area. The mean number for *flaviventris* is 7.11±0.11, for *priapus* it is 7.10±0.09, for *paludicolus* 7.05±0.27, and for *helvigularis* 7.01±0.34. The possibility of sexual dimorphism is discussed under infralabials.

Infralabials.—The number of infralabials in the races of *Coluber constrictor* from the eastern portion of North America varies from 6-12, usually 8-9, mean 8.36±0.31. The occurrence of a number of infralabials other than 8 or 9 does not seem correlated with any geographic region. The mean number for *flaviventris* is 8.75±0.57, for *constrictor* 8.31±0.82, for *priapus* 8.32±0.48, for *paludicolus* 8.41±0.78 and for *helvigularis* 8.51±0.92. The suggested geographic variation is not statistically significant ($P = 0.03$).

Ortenburger (1928: 186 *ff*) mentioned the possibility of a slight sexual dimorphism in the number of supralabials and infralabials, at least in the race *flaviventris*. However, statistical analysis shows that the observed results could have been obtained from random sampling ($P = 0.3$). Table 3 shows the mean number of infralabials and supralabials for a sample of *flaviventris* from Michigan, Ohio and Indiana, and a sample of *priapus* from northern Florida. The mean numbers of these scales in males and females are not significantly different and the coefficients of divergences are low, as would be expected ($P = 0.8$-0.3).

TABLE 3.
NUMBER OF SUPRALABIALS AND INFRALABIALS

Subspecies	Sex	Number of Specimens	Supralabials Mean	Supralabials C. D.	Infralabials Mean	Infralabials C. D.
Coluber c.	♀	59	7.12	.005	8.66	.017
flaviventris	♂	53	7.08		8.51	
Coluber c.	♀	154	7.12	.005	8.36	.014
priapus	♂	231	7.08		8.28	

Postoculars.—The number of postoculars varies from 2-4 (mean 3.01±0.08). The occurrence of either 2 or 4 postocular scales does not seem correlated with any geographic area, as it occurs rarely throughout the entire range of the species. The small differences among the mean number of these scales for specimens from various parts of the United States do not reach statistical significance.

Preoculars.—The preoculars are usually 2, rarely 1, mean 1.97± 0.06. The occurrence of 1 preocular is not correlated with any geographic area of North America.

Loreal scale.—The loreal scale is usually single (97.01%) but may be divided into two or three smaller scales. The shape is usually square to slightly higher than long. The posterior edge may be straight or slightly convex. Variations as might exist seem individual rather than geographic.

Temporals.—The number of temporals is quite variable. They are usually disposed in three pairs, one behind the other, indicated by the formula 2-2-2 (80.5%). Four pairs are also common (16.9%), shown by 2-2-2-2, or in two pairs (1.3%), indicated by 2-2, or even five pairs (1.3%), 2-2-2-2-2. Frequently an additional scale may be present in any vertical row, in which case the formula is expressed as 2-2-3, 2-3-2, or 3-2-2. Three scales may occur in more than one row, as 3-3-2, 3-3-3, or 2-3-3. Occasionally the pair of scales in each vertical row may be reduced to form a condition expressed as 1-2-2, 2-1-1, etc. Frequently an additional scale is present between two pairs of scales, so that the formula is expressed as 2-2-1-2, 3-1-2-2, etc. Practically all combinations of numbers from 1-5, either in pairs or not, are found. There is no apparent correlation with geography. The lowest number of temporals which I have counted is expressed as 2-2, the highest as 3-3-2-2 and 2-3-3-2, both totaling ten scales in all.

Color

In general, the coloration of individuals, both juveniles and adults, is correlated with geographic locality and has been discussed previously. However, certain facets concerning the coloration of the eastern races, such as the manner in which the juvenile pattern changes to that of the adult, seem uncorrelated with geographic locality. This is also true of aberrant colors of both young and adult specimens.

Ontogenetic color and pattern changes.—It has been mentioned that the transformation of color and markings of juvenile specimens, which are blotched, to the adults, which are uniform in color, follows rather basic patterns. On the dorsal surface the markings are first obliterated posteriorly. This suffusion slowly moves anteriorly. On many newly hatched specimens, such posterior suffusion is already present, so that accurate counts of the total number of blotches is difficult. Numerous authors have reported that these markings disappear completely during the second or third year. The total length at which this suffusion is complete is about 500 mm. WA 3423 from Astor Park, Lake County, Florida, which is 458 mm in total length, has a dorsal surface spotted with faint dark brown blotches. In WA 3204 from the same locality and 519 mm in total length, there is no indication of any dorsal markings. A specimen from Winter Haven, Polk County, Florida (SRT 250), which is 623 mm, does not have any visible dorsal markings. In USNM 4423 from Georgetown, South Carolina, which is 526 mm in length, the ventral spots are quite evident while the dorsal spots are completely suffused by black. Practically all of the specimens which I have examined that are under 480 mm in total length, had visible dorsal spots, while most of those over 600 mm showed no indication of such markings. McCauley (1945: 74) stated that in Maryland the largest specimen that he has examined that had noticeable dorsal blotches was 584 mm. The smallest one that was completely transformed was 640 mm.

In the subspecies with a dark, slate-colored belly (*priapus, constrictor* and *helvigularis*) there is frequently observed a light stripe extending down the middle of the ventral surface. Loennberg (1894) described such a specimen from Arcadia, DeSoto County, Florida, in which there is a median stripe of small white, cloudy spots. This is a consequence of the method by which the ventral suffusion takes place. A specimen 521 mm in total length, from 4 miles north of Kissimmee, Osceola County, Florida, was kept alive for a long period and notes were taken on color changes that occurred over a period of nine months. Ventrally this specimen was bluish-gray with pinkish-orange ventral spots (Sept. 14, 1951). By November 16 there was a noticeable area of dark grayish-blue on the lateral edges of the ventral plates in the mid-body region. This left a lighter stripe of the original ground color down the center of the belly. Anteriorly, and on the underside of the tail, the specimen was still light-colored. By April, 1952, it was 617 mm in total length. The darker pigment which was slowly suffusing the midbody outer surfaces of the ventral plates was slaty-black and the light mid-ventral stripe became very evident.

This observed change is also borne out by many living and preserved specimens. In most adult individuals the belly is slaty-black with only the chin and first few ventral plates being white. The underside of the tail is also frequently white. This coloration seems typical of most large specimens from peninsular Florida. Large individuals from New York, New Jersey and other northeastern states usually have much more black on the chin, throat and underside of the tail. In many specimens from such widely separated states as New York and Florida, the anterior portion of the underside of the body and throat may be white, blotched with black. A similar condition is also frequently noted on the underside of the tail. McCauley (1945: 74) reported a specimen from Allegheny County, Maryland,

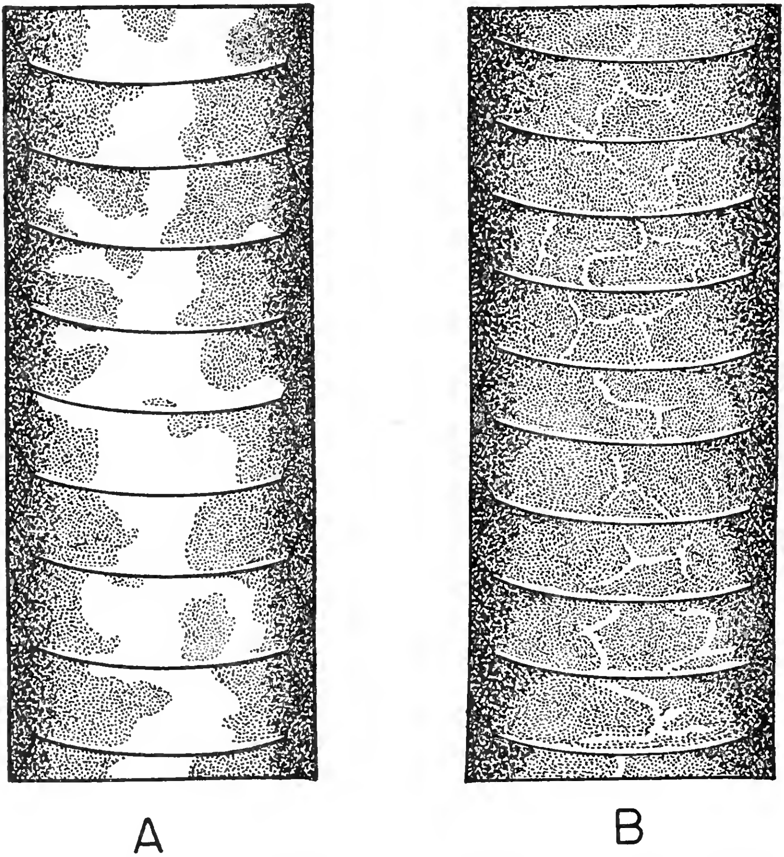

Figure 15. Ontogenetic color and pattern changes in subadult specimens of *Coluber constrictor* from eastern United States. Black blotches on the anterior portion of the belly of young subadults (A) slowly get larger. This causes light, faint reticulations to be formed in older specimens (B). The final stage is complete fusion of the blotches, causing a uniform coloration.

1130 mm in length, which was mottled with black about 100 mm down the belly. UMNZ 57059 from Enterprise, Volusia County, Florida, has very large blotches on the anterior portion of the ventral surface. The same is true of AMNH 6719, labeled "Arkansas". WA 3561 from Astor Park, Lake County, Florida, is similar. None of these specimens are full-grown, but are about 760 mm in total length. They all come from areas in which full-grown specimens have a black throat and belly. This would seem to indicate that while the mid-body ventral suffusion takes place over a large area on the lateral surfaces of the ventral plates, in the region of the throat this suffusion takes place by a gradual growth, and finally, a coalescence of slaty-black blotches. In many specimens from Florida that are between 760-1020 mm in total length, the anterior portion of the belly and throat is mostly black, but with faint reticulations of bluish-white. These specimens represent the next to the last stage in the ventral ontogenetic color change, in which the black blotches are practically completely fused (fig. 15).

In the races that have a light-colored ventral surface (i. e., *flaviventris, anthicus, mormon, stejnegerianus,* and *paludicolus*) the ventral markings of the juvenile may be retained for a long time. This is especially true near the anterior end. Pope (1944: 172) mentioned a male *flaviventris* 1067 mm long which possessed traces of the juvenile spots. I have seen two specimens from Michigan that were 914 and 1001 mm long on which traces of ventral markings were quite noticeable anteriorly. Occasionally specimens of *paludicolus* also retain this juvenile ventral coloration anteriorly, though always faint as in the other subspecies.

Abberrant head color.—Occasional individuals are examined that have the supralabials, infralabials and sometimes the chin, variously colored, usually some shade of yellow, or even orange in some cases. Although occurring rarely, they are found throughout the range of the species, at least in the eastern portions of North America.

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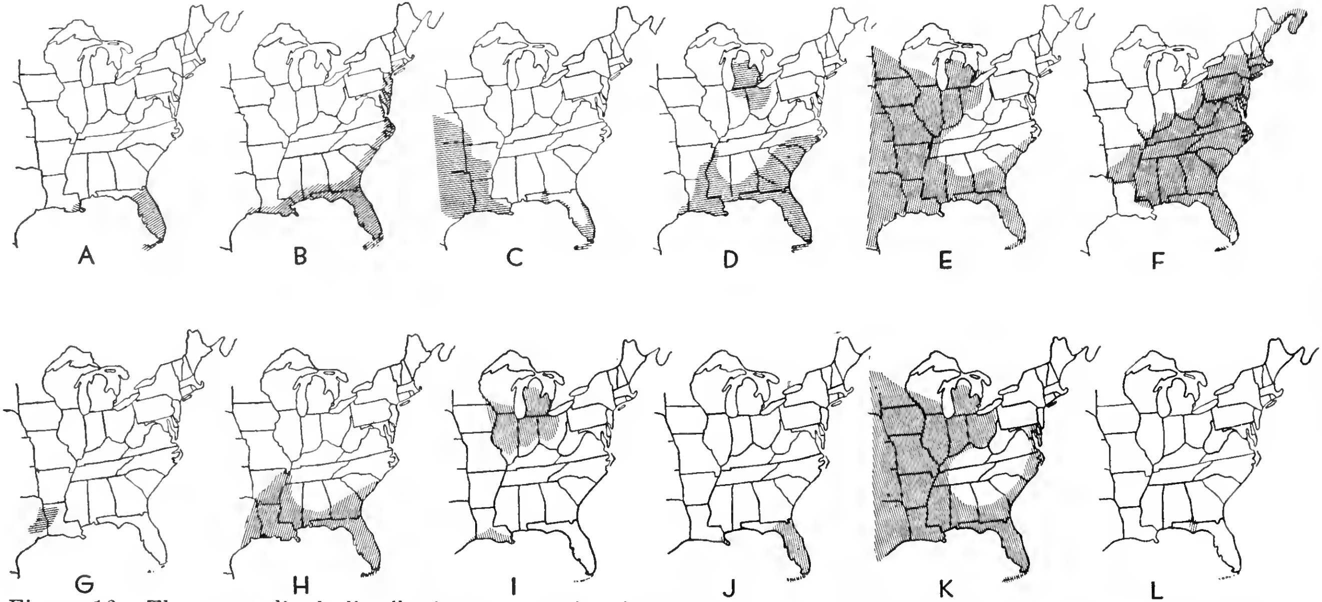

Figure 16. The generalized distribution of certain characters in *Coluber constrictor* of eastern United States: **A.** regions in which red-eyed juveniles may be found; **B.** areas in which red ventral spots may be found on juveniles; **C.** regions in which adult specimens may have brown on the supralabials; **D.** areas in which at least 10% of the specimens may have the loreal in contact with the first supralabial; **E.** regions in which hemipenial hooks are usually found; **F.** regions in which black-colored adults are found; **G.** regions in which speckled adults are found; **H.** areas in which adults may have black punctations on the ventral surface, caused by a burrowing mite (*Ophioptes* sp.); **I.** regions in which dark "postocular stripes" may be found; **J.** regions in which the ventral spots may be very much reduced, or absent entirely; **K.** areas in which full grown specimens usually have white chins; **L.** regions in which full grown specimens have brown or tan chins.

on this group which he made available to me. I wish to thank Messrs. E. Ross Allen and Wilfred T. Neill, Silver Springs, Florida, who have made every attempt to obtain specimens from critical areas in the Southeast. I also wish to thank Dr. James A. Oliver, now at the New York Zoological Park, and Mr. John W. Crenshaw, University of Florida, for valuable criticisms.

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SUMMARY

As now recognized, the genus *Coluber* includes four species. These are:

Coluber oaxaca (Jan) 1863: 63. A species known from a very few specimens. It has been recorded from the Mexican states of Oaxaca and Colima.

Coluber spinalis (Peters) 1866: 91. An Asiatic form of northern China and Mongolia.

Coluber acuminatus (Cope) 1899: 197. A fossil species which is reported from the Pleistocene of Montgomery County, Pennsylvania. Examination of the skulls of a few specimens of *Coluber constrictor* seems to indicate that there is reason to doubt the validity of the fossil species.

Coluber constrictor Linneaus 1758: 216. This is a polytypic species dispersed throughout most of North America. It is found as far north as Halifax, Canada, and as far south as the Florida Keys on the east coast. On the Pacific coast it occurs from British Columbia to extreme southern California. In middle North America it is found from North Dakota to southern Texas, and in the eastern Gulf Coastal Plain of Mexico to the state of Vera Cruz, thence to Guatemala.

Included in the species *Coluber constrictor* are eight races. These are:

Coluber c. mormon Baird and Girard 1852: 351. No intergradation is known between this race and its closest relative geographically (*flaviventris*), and is included as a subspecies because of its extreme similarity to other members of the group. Although *mormon* and *flaviventris* have been found within 130 miles of one another (Stuart, 1930: 44), large series will have to become available from suspected areas of intergradation before intermediate populations can be demonstrated. Undoubtedly such series will show that intergradation exists, at least in Montana, and probably along the Front Ranges of the Rocky Mountains in other states farther south.

It is distributed from southern British Columbia to extreme southern California and from the Pacific Coast to the Rocky Mountains. It seems absent from the Sonoran Physiographic Province of southeastern California and western Arizona.

Coluber c. stejnegerianus (Cope) 1895: 797. A subspecies of extreme southern Texas and Mexico, being found from Nueces County south in the Gulf Coastal Plain to Vera Cruz. *Coluber c. ortenburgeri* Stuart is referred to the synonymy list of this form, as there seems to be no reliable character with which to separate the two races, thus extending the range of *stejnegerianus* to Guatemala.

Coluber c. flaviventris Say 1823: 185. A subspecies of the Great Plains and Interior Lowlands as well as restricted portions of the Gulf Coastal Plain in eastern Texas and southern Louisiana. Its northern limits of distribution are from Montana to North Dakota, southern Minnesota and Lower Michigan. It extends westward as far as the Front Ranges of the Rocky Mountains and the Edwards Plateau in southern Texas. In the northern parts of its range its distribution has been shown to be correlated with the prairie provinces in both Ohio and Minnesota by Conant (1938: 50) and Breckenridge (1944: 116). Further collecting will probably show that this is true of the remainder of the northern parts of its range.

Specimens of this race, although so far reported only from Ontario in Canada (Mills, 1948: 10), will probably be found in the southern portions of Saskatchewan and Alberta. Intergradation between this race and *constrictor* is to be sought along the northern shore of Lake Erie in southern Ontario.

Coluber c. constrictor Linnaeus 1758: 216. This is a subspecies of the eastern forests. It does not seem to range above 4,000 feet elevation in the Appalachian Mountains. It is found from Halifax, Canada, south to the Fall Line; west to the Mississippi Lowlands and the unglaciated portions of Ohio. It seems absent from the non-coastal areas of Maine, the greater part of New Hampshire and Vermont and the Adirondack

Mountains. The distributional patterns of this race and *flaviventris* are nearly congruent with those of many other groups of snakes (Schmidt, 1938; Ruthven, 1908; Grobman, 1941; *et. al.*).

Coluber c. priapus Dunn and Wood 1939: 4. A lowland form of southern United States being found in the Atlantic and Gulf Coastal Plain from North Carolina to Lake Pontchartrain, Louisiana, and north in the Mississippi Lowlands to extreme southwestern Ohio. Considerable interdigitation seems to exist in Arkansas between this race and *flaviventris.* It is a syngeograph of many southeastern snakes, including *Farancia abacura, Agkistrodon piscivorus, Crotalus h. atricaudatus,* etc., as well as many frogs, such as *Rana grylio, Hyla cinerea,* etc.

Coluber c. anthicus (Cope) 1862: 238. A subspecies found in western Louisiana and eastern Texas.

Coluber c. helvigularis subsp. nov. This is a form inhabiting an area along the Appalachicola and Chipola Rivers in western Florida. *Lampropeltis g. goini* seems to have a somewhat equivalent range.

Coluber c. paludicolus Auffenberg and Babbitt 1953: 44. A race mainly confined to the Everglades of southern Florida. An outlying population occurs on Cape Canaveral, Brevard County, Florida. Geographical equivalents are found in such forms as *Seminatrix p. cyclas, Liodytes a. lineapiatus* and *Pseudobranchus s. belli.*

Three new subspecies have been proposed since Ortenburger's monograph, and even since the 5th Edition of the Checklist (Stejneger and Barbour, 1943). All of these are from Florida and are: *C. c. paludicolus* Auffenberg and Babbitt (1953), *C. c. helvigularis* subsp. nov. and *C. c. haasti* Bell (1952). The last named race does not seem worthy of subspecific designation. Of the five characters stated as being diagnostic of *haasti,* one is always found in typical specimens of *priapus* (black belly); one is occasionally found in both *priapus* and *haasti* (brown snouts); another is found in all specimens of *priapus* except the central and south-central Florida peninsular populations (black supralabials); and I consider the comparative luster and size extremely difficult to measure (there being considerable overlap), and of too small an average difference, if they exist at all, to warrant the erection of a new subspecies based on these characters alone. It also seems highly significant that of all of the characters which have been examined, the populations from the Middle and Lower Keys seem to have closer affinities to those from the northern parts of the peninsula than to those from any other portion of the southeast. In fact, the two populations seem practically identical, and I find it impossible to tell them apart on the basis of any character, or group of characters, which I have studied so far.

Three names have been revived from the synonymy of *C. c. flaviventris* since Ortenburger's monograph. These are *C. c. anthicus, C. c. foxi* and *C. c. stejnegerianus.* Two races (*anthicus* and *stejnegerianus*) seem worthy of this distinction. *Coluber c. foxi,* considered a synonym of *C. c. flaviventris* in this paper, may deserve subspecific designation if it is shown that the area of intergradation between the two populations exhibits an external, rather than an internal cline as suggested in this paper.

The variations found in the eastern races have been examined critically. Some of these were found to be correlated with either locality, sex, environment, or age.

Of the correlated variations, those concerned with geographic variation are most obvious. When plotted, they appear to be internal, external and ontogenetic clines or character gradients. Some of these have been summarized in figure 16 for easier reference and to show the varying limits of distribution from one character to the next.

External Clines:

Length of the hemipenial spines.—An examination of this character has indicated that the range of *C. c. priapus,* heretofore thought to be restricted to peninsular Florida, includes the Atlantic and Gulf Coastal Plains and the Mississippi Lowlands. *Coluber c. constrictor* is the only subspecies which does not possess an enlarged basal hemipenial spine which may be termed a hook.

Coloration.—The color of the temporals, gulars, supralabials, chin, and ventral and dorsal surfaces are examples of this type of cline. On the basis of the dorsal and ventral coloration the ranges of *C. c. constrictor* and *C. c. flaviventris* have been changed from those given by Ortenburger (1928). The eastern edge of the range of *flaviventris* has been placed farther westward in Arkansas and northeastern Louisiana. The southern edge of the range of this form in the states of Illinois and Indiana has been placed a little farther northward.

Internal Clines:

Number of hemipenial spines.—The number of spines on the hemipenis of male specimens, which may be termed hooks, is variable and seems to form a continuous gradient. A lower number of hooks are found in the eastern forms than in those from western United States. Although specimens of *Coluber c. flaviventris* normally have at least one hook, many specimens from the northern portions of the range of this form have basal spines which are not large enough to be termed hooks. Specimens which are intermediate in coloration between the races *flaviventris* and *constrictor* from central Ohio do not seem to be intermediate in this spinal character.

Coloration of the young.—Many colors suspected of being characteristic of populations from the Southeast have been shown to be character-gradients. These include the color of the dorsal and ventral surfaces and the number and size of the dorsal and ventral markings. The mean number of dorsal spots is highest in the West,

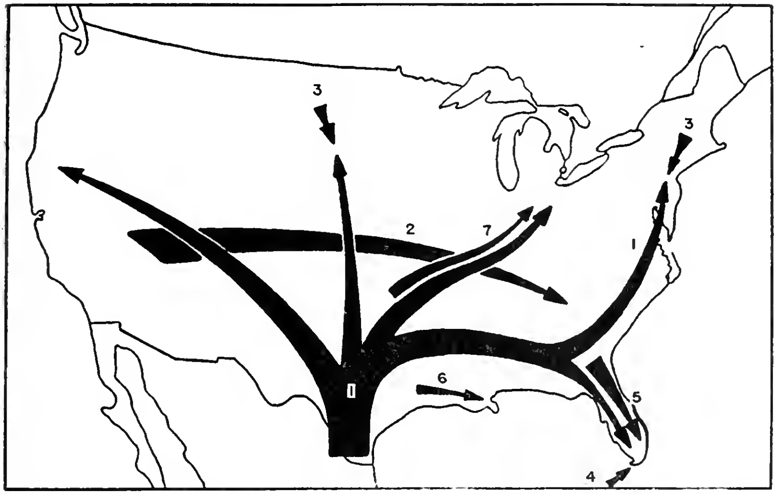

Figure 17. Generalized directions for the major internal geoclines which are evident in the morphological variations of *Coluber constrictor*. **1.** A primary focal point, represented by the race *C. c. stejnegerianus*, is the basis for many clines running in northerly directions, such as the internal clines represented by the number of ventral and caudal scales, the point of reduction of the dorsal scale rows, and adult size. Most of these characters increase in value or degree as one moves away from southern Texas. **2.** A very broad and generalized cline from western to the eastern portions of North America, which seems to terminate in southeastern United States. The characters involved in this cline are the general increase in the number of some of the teeth, the number of hemipenial spines, and the changing shape of the premaxillary bone. **3.** An obvious reversed cline is found in the extreme northern portions of the range of this species, at least in central and eastern United States. This internal cline deals with the number of ventrals and caudals, and the point of reduction of dorsal scale rows. This is a reversal of cline number 1. **4.** Another reversed cline is found from the Lower to the Upper Keys of Florida. It is represented by the increase of ventrals, caudals, point of reduction of the dorsal scale rows, larger size (?), and the gradual change from brown to reddish eyes in the adults, as well as an increase of red colors in the juveniles on both dorsal and ventral surfaces. **5.** A cline from the continental portions of the southern Coastal Plain into peninsular Florida, terminating in the extreme southern tip of the mainland. It is represented by the increase in the frequency of a loreal-first supralabial contact, increase in the number of ventrals and caudals, more posterior reduction of the dorsal scales, a gradual change from brownish to red eyes, larger size, and decrease of number of dorsal and ventral spots in the juveniles, as well as a change of color in these markings. **6.** A cline from *flaviventris* from the Great Plains and Coastal Prairies of Texas along the Coastal Prairies of Louisiana into the delta region. It is represented by an increase in the reddish colors on the ventral surface of juveniles, the decrease of ventral markings in number and size, and the increase of darkly colored temporals in adults. **7.** An internal cline from the populations of *flaviventris* of the Great Plains northeastward into the Steppe Peninsula, represented by the increase of the number and size of juvenile belly markings, and the increase of the frequency of darkly-colored temporals.

where the spots are smallest, and lowest in the East, where they are largest. The number and size of the ventral markings are largest and most numerous in the northern latitudes, and smallest and least numerous in the southern latitudes.

Scutellation.—The mean number of both ventral and caudal scales for various localities have been shown to be internal clines. The lowest mean numbers of ventral and caudal scales are found in the western races, while the highest are found in peninsular Florida and the greater part of the glaciated regions of North America. The highest mean number of ventrals and caudals is found in the south Florida race, *paludicolus.* The lowest number occurs in the southeastern Texas and Mexican Gulf Coast race, *stejnegerianus.* The mean number of ventral and caudal scales of populations from Florida show fair correlation with the physiographic divisions of the state; the geologically "older" portions of the state having significantly lower mean counts than do those from the geologically "newer", and lower coastal areas. The northern portions of these peninsular physiographic areas tend to have lower mean counts than do the southern portions, though the differences are not statistically significant. However, significant differences occur between specimens from northern, southern and the Keys areas of Florida. The coastal areas of Georgia and South Carolina have higher mean counts than do populations from the Piedmont and Appalachian Mountain Provinces of these two states.

A high percentage of the specimens from southern United States possess a contact between the loreal and first supralabial. However, these percentages vary with locality and the character is a good example of geographically variable dimorphism. This contact occurs infrequently in specimens from Michigan, Ohio and Illinois, but in at least 10% of the specimens from south of the Fall Line. It occurs in about 60% of the specimens from southern Florida.

The point of reduction of the dorsal scale formula has been found to vary geographically and represents an internal cline. It varies in direct proportion to the total number of mean ventral scales, and is contained in that number from 1.6-1.8 times, regardless of locality.

Osteology.—The shape of the premaxillary bone has been found to vary geographically as an internal cline. In the western subspecies the two posterior processes are shorter and in a horizontal plane, whereas in the eastern races, and especially in *priapus* and *paludicolus,* they are in a vertical plane, and longer.

Dentition.—The number of teeth also varies geographically, and in general the means are lower in the western races than in the eastern forms.

Dimorphism:

Scutellation.—The contact of the first supralabial and loreal has already been mentioned as a dimorphic character, but it also varies geographically as an internal cline.

Sexual dimorphism.—Dimorphism of this nature is indicated in the number of caudals, though not statistically significant. Very slight differences in the mean numbers of ventrals and supralabials, mentioned by Ortenburger as being sexually dimorphic characters, are shown to be non-significant. Associated with the number of caudals is the relative length of the tail, and as in the caudals, the differences in length are probably not statistically significant.

Environmentally produced characters.—Small black punctations on the ventral and lower lateral surfaces of adults have been shown to be caused by a small burrowing mite (*Ophioptes* sp., near *tropicalis* Ewing). Although seemingly restricted to the Mississippi Lowlands and the Coastal Plain, the character does not have obvious taxonomic significance.

Variations in the following characters have been found to be uncorrelated with environment, age, sex or locality: dorsal scales, number of scales between the chin shields, number of supralabials, infralabials, postoculars, preoculars, loreals and temporal scales. Variations in the ontogenetic color change from a blotched pattern of the juvenile to the uniform coloration of the adult do not seem correlated with locality.

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NOTROPIS HYPSILEPIS, A NEW CYPRINID FISH FROM THE APALACHICOLA RIVER SYSTEM OF GEORGIA AND ALABAMA

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NOTROPIS HYPSILEPIS, A NEW CYPRINID FISH FROM THE APALACHICOLA RIVER SYSTEM OF GEORGIA AND ALABAMA

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The small species of *Notropis* described below appears to be endemic to the Apalachicola River system. It has been overlooked, or confused with *Notropis xaenocephalus* (Jordan), which is native in the upper Alabama River system of Alabama and Georgia. Little is known of its life history or habitat and judging from the few times it has been taken it seems to be scarce, or, possibly, it prefers a habitat not normally investigated.

The material is deposited in the Cornell University fish collection and was collected by the authors with the aid of R. H. Backus, J. Willard Colston, R. W. Crawford, J. S. Dendy, J. N. Layne, C. R. Robins, and R. L. Wigley. Counts and a description of the lateral line head pores were kindly made available by Helen J. Illick. Counts and measurements were taken using the methods described by Hubbs and Lagler (1947: 8-15).

NOTROPIS **HYPSILEPIS**, sp. nov.

Figs. 1 and 2, Map 1

The 50 available specimens, all designated as types, range from 19 to 51 mm in standard length and are from eight localities. In the enumeration of the material below the number of specimens and range of standard length of the series measured in millimeters are given in parentheses, *e. g.* (6, 41-51). In addition to standard abbreviations for compass directions, with the following "of" deleted, the following are used: Co. = County, Cr. = Creek, Hwy. = Highway, mi. = mile or miles, junct. = junction, R. = River, trib. = tributary (of), CU = Cornell University fish collection, UMMZ = University of Michigan, Museum of Zoology.

Material.—Holotype, CU 17442, an adult male, 51 mm from trib. Soque R., 0.4 mi. W. Soque R. and 1.5 mi. W. Clarksville on Ga. Hwy. 115, Chattahoochee R. system, Habersham Co., Georgia, on April 1, 1950, by Edward C. Raney, Royal D. Suttkus, Richard H. Backus and C. Richard Robins. Designated as paratypes are CU 28237 (6, 41-51) which were taken with the holotype.

Other paratypes from the Apalachicola River system are listed

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[1] A grant from the Cornell University Faculty Research Grants Committee made possible the ichthyological explorations which discovered this species.

below. Chattahoochee River system of Georgia: CU 18102 (8, 34-50), Grant Cr., trib. Soque R. near junct. with Chattahoochee R., near Cornelia, Habersham Co., June, 1949; CU 19625 (9, 45-51), Chestatee R. at mouth of Yahoola Cr., 2.1 mi. S.E. Dahlonega, Lumpkin Co., March 26, 1951; CU 17138 (19, 34-51), Vickery Cr. at junct. with Chattahoochee R. at Roswell, Fulton Co., March 30, 1950; CU 17279 (3, 19-27), Hodchodkee Cr., 1.4 mi. S. Lumpkin, Stewart Co., March 28, 1950; UMMZ 157957 (1, 48), Cane Cr., 1¼ mi. W.S.W. Dahlonega, Lumpkin Co., August 25, 1939. Chattahoochee River system of Alabama: UMMZ 142910 (2, 41-43), Halawakee Cr., 10 mi. N.E. Opelika, Lee Co., October 17, 1938. Flint River system: CU 21138 (1, 40), trib. Lazier Cr., 2.9 mi. W. Talbotton, Talbot Co., March 26, 1952. Also examined was a single adult specimen, not designated as a paratype, taken from Little Uchee Cr., trib. Chattahoochee R., at US Hwy. 80, Russel Co., Alabama, October 10, 1953, by Jack S. Dendy. This specimen is now in the collection of the Alabama Polytechnic Institute.

Diagnosis—A small, pale-colored species of *Notropis* with 2, 4—4, 2 teeth and 7 anal rays. Other fin rays: dorsal 8, rarely 7; caudal 19; pectoral 13-16, usually 14; pelvic 8, or occasionally 9. Anterior lateral line scales elevated; exposed portion of third scale 4 times as high as wide. Scales: predorsal rows usually 15, rarely 16 or 17; above lateral line to dorsal origin 5, rarely 6; below lateral line to anal origin 3 or 4; in lateral line 35 or 36; around body before dorsal fin 21 to 26, usually 22 or 23; around caudal peduncle 12. Snout blunt, mouth inferior. Body subterete. Lateral line on body complete. Middorsal dark stripe little developed before and scarcely if at all behind the dorsal fin. Lateral band on body weak. Diagnostic dark patches on body at base of the first 4 or 5 dorsal and anal rays. Area about the anus light. Small wedge-shaped basicaudal spot separated from the lateral band on body by a light area. Oblique dark scapular bar lacking. Size small, to 51 mm.

Description.—Proportional measurements for the holotype and 11 paratypes are given in Table 1. In the following enumeration of fin, teeth, and scale counts, the count for the holotype is in bold face. The frequency is shown in parentheses. Dorsal rays, **8** (44), 7 (3); anal rays **7** (47); caudal rays, **19** (20); pectoral rays, 13 (3), **14** (12), 15 (6), 16 (1); pelvic rays, 8 (71), 9 (15), holotype **9—8.** In upstream samples the pelvic count averages high: the two samples (CU 17442, 18102) from tributaries of the Soque R. have 8 (18), 9 (12). Teeth **2, 4—4, 2** (9), 1, 4—4, 2 (1). Predorsal scale rows, 15 (8), **16** (2), 17 (1); scales from dorsal origin to lateral line, 5 (10), **6** (1); scales from anal origin to lateral line, 3 (5), **4** (6); lateral line scales, 35 (10), **36** (9); scales around body before dorsal fin, 21 (1), 22 (7), 23 (5), 24 (3), **25** (2), 26 (1), with 10 to **12,** usually 11, above the lateral line and 9 to 12, usually 9 or 10, **11** in holotype below the lateral line; caudal peduncle scale rows, **12** (11), the formula being **5—2—5.**

TABLE 1.

PROPORTIONAL MEASUREMENTS OF ELEVEN ADULT *Notropis hypsilepis* IN THOUSANDTHS OF THE STANDARD LENGTH. SEVEN MALES AND FOUR FEMALES WERE MEASURED.

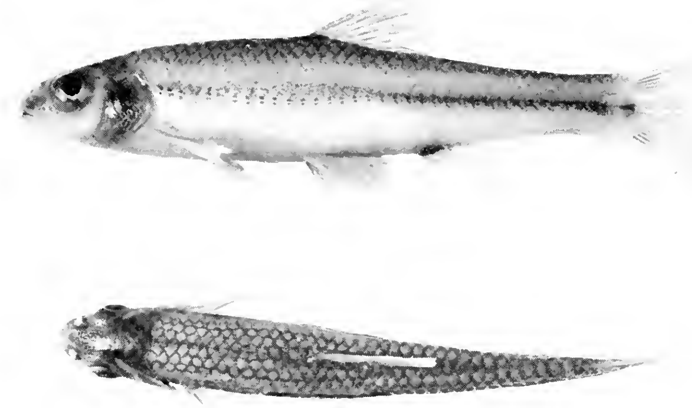
Measurement	Holotype CU 17442	Paratypes CU 28237 and 18102			
	Male	Males		Females	
		Range	Avg.*	Range	Avg.
Standard length, mm	51.2	41.2-51.2	47.0	37.1-48.2	43.9
Dorsal origin to snout tip	502	491-510	501	495-525	505
Dorsal origin to caudal base	529	514-546	530	527-545	538
Dorsal origin to occiput	307	287-316	301	269-321	296
Pelvic insertion to snout tip	488	488-499	494	480-484	482
Anal origin to caudal base	344	336-365	348	338-347	341
Body, greatest depth	193	177-210	198	184-244	212
greatest width	127	119-137	126	116-135	129
Dorsal origin to lateral line	127	112-134	126	121-139	133
Pelvic insertion to lateral line	092	082-102	092	084-112	100
Caudal peduncle, length	226	226-248	240	226-252	239
least depth	094	090-105	097	085-097	091
Head, length	244	239-259	247	242-258	250
depth	161	152-161	157	154-156	155
width	131	123-136	129	119-130	124
Interorbital, least fleshy width	088	085-095	090	085-090	087
Snout length	080	080-087	084	079-084	082
Eye length	065	065-075	070	069-074	071
Upper jaw length	073	072-078	075	067-075	071
Suborbital, least width	041	032-041	036	031-136	034
Dorsal fin, depressed length	227	226-246	235	225-231	228
Anal fin, depressed length	184	174-193	185	169-179	174
Caudal fin, length	270	270-304	285	271-288	276
Pectoral fin length	191	191-213	202	188-194	190
Pelvic fin length	164	162-181	171	155-174	166

* Holotype included.

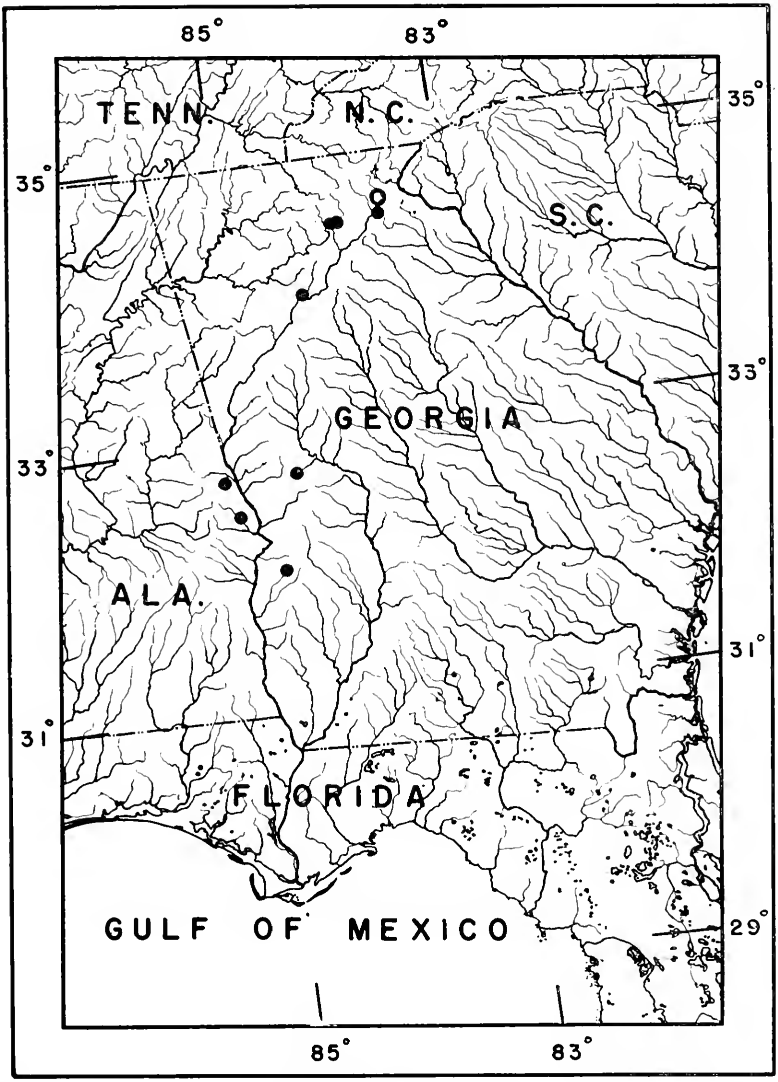
The body shape and other characters are illustrated in Figures 1 and 2. The body is subterete. The subtriangular head terminates in a blunt snout, which extends slightly beyond the upper lip and far in front of the lower lip. The contour of the dorsum posterior to the occiput is straight and rises gradually to the dorsal origin; it dips at the dorsal fin base and then extends in an almost straight line posteriorly to the procurrent caudal rays. Ventrally the body curves gently downward to a point two-thirds the distance between the pectoral fin base and the pelvic fin insertion; posteriorly the contour is almost a straight line to the anal origin and then curves in a gentle arc to the procurrent caudal rays. The least depth of the caudal peduncle is just anterior to the procurrent caudal rays. The upper jaw does not reach to below the anterior margin of the eye. The gape of the mouth is little inclined. The upper lip is curved about midway, its anterior half is almost horizontal and at its anterior tip it barely reaches the lower level of the eye. Viewed from below the gape is U-shaped. The eye is shorter than the snout and is rather high. The interorbital region is moderately convex. The center of the eye is slightly closer to the tip of snout than to the margin of opercle.

The lateral line is complete. Anteriorly its path is marked by small aggregations of melanophores above and below each pore. Posteriorly it curves gently downward to a point opposite the pelvic fin insertion and then curves upward to a point opposite the posterior end of the dorsal fin base. The remaining part is straight and lies within the upper part of the relatively narrow dark lateral band. In the following description of the cephalic lateral line pores, the number of specimens is given in parentheses. In making the pore counts on a canal the anteriormost is designated number one. Five specimens (CU 17138) were studied. The supratemporal canal is incomplete and may be broken irregularly. In three specimens, the count is 2 on the left and 1 on the right; in two, there are 2 on the left, 2 isolated in or near the center and 1 on the right. The supraorbital canal is complete in four of the five specimens studied, with pore counts of 8 (2), 9 (1), 10 (1); in one specimen it is incomplete, with a break between pores four and five. The supraorbital may end opposite a vertical line projected from the posterior margin of the eye but usually this line falls on the penultimate pore. The infraorbital canal is complete in three out of the five studied, with pore counts of 14 (1), 15 (1), 17 (1). In two specimens, with counts of 17 and 16 respectively, the canal is incomplete and irregularly broken; in one the break comes between pores four and five; in the other, in the temporal region, between pores fourteen and fifteen. A vertical from the anterior margin of the eye falls between pores four and five in four specimens and on pore seven in one. The preoperculomandibular canal is incomplete in four, with a count of 13, and complete in one, with a count of 12. When this canal is incomplete, it is broken between pores five and six. In respect to the high count of this canal, *hypsilepis* stands extreme among species with 2, 4—4, 2 teeth and 7 or 8 anal rays.

The extended dorsal and anal fins are almost straight on the distal border; when depressed the tip of the anterior rays of the dorsal exceed the tip of the posterior ray while the reverse is true of the anal fin. The dorsal fin is relatively high. The distance from the midcaudal base to the midfork is less than half the distance from the caudal base to the tip of the longest lobe. The posterior margin of the pectoral and pelvic fins is gently rounded. The origin of the dorsal fin is directly over or slightly posterior to the insertion of the pelvic fin.



Figures 1-2. *Notropis hypsilepis*, sp. nov. **1.** (top) Side view of holotype, an adult male, 51 mm in standard length, from trib. Soque River, 0.4 mi. W. Soque River and 1.5 mi. W. Clarksville, Chattahoochee River system, Habersham Co., Georgia. **2.** (bottom) Top view of a paratype, an adult male, 51 mm in standard length, from the same series as the holotype. (Photographs by Douglass M. Payne.)



Map 1. Distribution of *Notropis hypsilepis*. (Circle designates the type locality)

The pharyngeal arch which bears the teeth is shaped like a fish hook and the extreme tip of the short arm is curved abruptly outward. The upper two-fifths of the arch is widened prominently. The teeth in the main row are three to four times higher than wide and the hooked tips partly overhang the well developed grinding surface, which has serrulate edges. The small teeth of the lesser row are similarly shaped and have a well developed grinding surface, but the hook is not as pronounced. There are only three developed, bluntish gill rakers on the first arch. One lies near the angle and the other two on the upper half of the lower arch. The nape and breast are scaled.

In separating the light-colored *hypsilepis* from the other species of *Notropis* in the southeastern United States, many details of pigmentation are diagnostic. The other forms with 2, 4—4, 2 teeth and 7 anal rays, are usually darkish, with a prominent dark lateral band running the length of the body. In *hypsilepis* the lateral band is weakly developed throughout. Anteriorly it consists of a scattering of melanophores which lie above the lateral line and in addition there is a small group of melanophores immediately above and below each lateral line pore. Posteriorly the lateral band is darker, narrower, and more continuous close to the lateral line. On the rear half of the caudal peduncle the melanophores are arranged in oblique lines, some of which form chevrons. The dark lateral band is paralleled above by a prominent clear band which is wider. The lower side is white. On the snout and opercle the lateral band is weak. The adjacent areas behind the eye and the fleshy margin of the opercle lack or have very few chromatophores. The dark appearance of the opercle of the holotype (fig. 1) is due to the darkness of the underlying gills which changed upon preservation.

The white area from the eye to and including the nostrils contrasts with the internarial region which bears scattered melanophores. On the top of the head between the eyes are two subquadrate blotches, separated by a clear area. The heart-shaped mark on the rear of the head is divided into three parts, each with a lighter center. The temporal region has scattered melanophores. There is no oblique dark bar posterior to the opercular slit. The anterior quarter of the upper lip and the groove above bear scattered melanophores; the lower lip is white, as is the lower half of the head and the inside of the mouth.

Each of the dorsal scales, except those on the midline, has a light center and the posterior third bears small scattered chromatophores. The middorsal streak anterior to the dorsal fin origin consists of a thin line of one to three rows of melanophores and it lacks an expanded concentration immediately before the dorsal fin. Diagnostic are the dark marks on the body that extend along the base of the first 4 to 5 developed rays of the dorsal and anal fins. Posterior to the dorsal fin base the middorsal streak is absent or consists of a weak line just behind the dorsal base. The basicaudal dark spot is a wedge with its apex pointing forward; about half is on the caudal rays. It is separated from the dark lateral band on the caudal peduncle, which is also expanded posteriorly, by a clear space which sometimes has a few scattered melanophores. Just above the diffuse dark area on the posterior caudal peduncle is a faint band of melanophores, which extends to the base of the caudal rays. The area immediately before and behind the anus is white. On the lower edge of the caudal peduncle two or three rows of melanophores form a weak band that normally reaches to the procurrent caudal rays. The peritoneum is silvery, with large scattered melanophores which become more common dorsolaterally. The fins are white and transparent; the dorsal and caudal have the ray margins faintly outlined by a row of melanophores and the first two pectoral rays are similarly marked. No bright colors were noted in the field.

Nuptial tubercles are well developed on the male. Small scattered tubercles are present on the opercle and elsewhere on the head. Anteriorly they are coarse and irregularly arranged on the snout, below the eye, and on the dentary. Fine tubercles cover the lips, isthmus, and branchiostegals. The scales from the occiput to the dorsal fin have small tubercles, mostly in an irregular row on the posterior border. A vertical row of tubercles is present on the front third of each lateral line scale on the anterior half of the body. These are absent on the scales in the row above the lateral line and none were noted on the scales below the lateral line row, except for a few scattered, coarse tubercles on two or three transverse scale rows immediately behind the opercle. The small tubercles on scales and head were red in specimens taken on March 26 (CU 19625). Tubercles are absent on fins, except on the upper side of the first 8 pectoral rays, where they are arranged in several rows; the maximum development is on rays 3 to 6. The female has small tubercles and many developed "sensory" pits on the head but no tubercles on body or fins. Other than in the degree of development of nuptial tubercles, sexual dimorphism is not marked but the pelvic fins are slightly longer and the pectoral fins somewhat broader in the male. Judged from the large ovarian eggs and the high development of tubercles, spawning occurs sometime in June rather than in March or April.

Relationships.—Among the species of *Notropis* with 2, 4—4, 2 teeth *hypsilepis* seems to be most closely related to *roseus, xaenocephalus* and an undescribed species from the Mobile Bay drainage. It differs from *chalybaeus, chrosomus* and *lutipinnis,* which have 8 anal rays, in numerous characters but especially in body shape, the type of mouth, the shape of caudal spot, the development of the middorsal stripe, the nature of the dark lateral band on body and head, and the elevated anterior lateral line scales. A description of many of these characters was given for the above-mentioned species by Suttkus and Raney (1955: 73-84).

Besides the elevated anterior lateral line scales, the poorly developed dark lateral band, the light colored body, inferior mouth and blunt snout *hypsilepis* differs from *baileyi, petersoni, xaenocephalus* and *roseus,* which have a black lateral stripe, 2, 4—4, 2 teeth and 7 anal rays, in numerous details of pigmentation. The following characters are helpful in separating *hypsilepis* from the forms listed immediately above.

(1) Body light-colored, with contrasting dark patch on body at the anterior base of the first 4 or 5 dorsal and anal fin rays, rather than being darker, with the dark blotch extending along entire base.

(2) Melanophores lacking rather than present immediately behind or beside anus.

(3) Dark lateral band on body very weak and mostly developed posteriorly, rather than being well developed for its entire length.

(4) Basicaudal dark spot separated from the posterior extension of the lateral band and forming a small wedge no wider than 3 caudal rays at its posterior end, rather than being well developed and continuous with the dark lateral band, or only slightly separated (*N. petersoni*), and quadrate, or, if wedge-shaped, as wide as 5 or 6 caudal rays.

(5) Lacks oblique scapular bar, rather than being strong to weak.

(6) Upper lip white on its posterior two-thirds and lower lips white, rather than each being dusky to black in whole or in part.

(7) Heart-shaped mark on top of head divided into three sections, rather than two.

(8) Peritoneum silvery with, no or few scattered melanophores midventrally, rather than being somewhat dusky and blotched ventrally.

Superficially and in the elevation of the anterior lateral line scales *hypsilepis* resembles *volucellus* but the similarity is attributable to convergence. These species differ trenchantly in tooth and anal ray counts (4—4 and 8 in *volucellus*), as well as many details of proportions and coloration.

Distribution and ecology.—Notropis hypsilepis is apparently endemic to the Apalachicola River drainage. Eight stations are known from the Chattahoochee River system and one collection is available from the upper Flint River system. It apparently prefers "Piedmont" type streams with sand bottom. Although it has been collected three times in small creeks from 10 to 20 feet wide, it has been taken in greatest abundance in or near the mouths of streams at a point where they enter large rivers. In color and body shape it seems to be adapted for life on or near the bottom.

The name *hypsilepis,* derived from *hypsi,* high, and *lepis,* scale, refers to the elevated anterior lateral line scales.

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SUTTKUS, ROYAL D. and EDWARD C. RANEY. 1955. *Notropis baileyi,* a new cyprinid fish from the Pascagoula and Mobile Bay drainages of Mississippi and Alabama. *Tulane Stud. Zool.*, 2(5): 69-86, 4 figs., 1 map.

CORRIGENDUM

Material housed in the University of Michigan, Museum of Zoology should be acknowledged in the second paragraph of paper.

ADDENDUM

A very fine series of 42 specimens of *Notropis hypsilepis* was examined by the senior author while the paper was in press. These specimens are hereby designated as paratypes.

Pigmentation, counts and measurements of these additional specimens agree favorably (with one exception) with those given in the diagnosis, description and elsewhere in the paper. The one exception noticed was an anal-ray count of 8 rather than 7.

This additional series bears the following data: UMMZ 136086 (42, 34-48), trib. Chattahoochee R., just below Hwy. 43, just E. Dahlonega, Georgia, collected by C. L. and L. C. Hubbs, May 15, 1937.

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THE FISHES OF TWO GULF COASTAL MARSH AREAS OF FLORIDA

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THE FISHES OF TWO GULF COASTAL MARSH AREAS OF FLORIDA

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The low shores of the currently exposed peninsula of Florida slowly emerge from a much larger land mass, the almost flat Floridan Plateau, barely covered by the waters of the Gulf of Mexico on the west and the Atlantic on the east. This plateau is considered one of the earth's most stable areas and is believed to be of great age, having changed only slightly during its many millions of years of existence. At times it has been exposed almost entirely and at others it has been almost submerged. Throughout the Pleistocene the records of these fluctuations in water levels have been preserved with sufficient clarity for geologists to show at least seven old shorelines during that period. The intermittent rises and falls of the water levels, although not great, made conspicuous changes in the amount of land exposed, reducing it at times to only a few small islands and increasing it at others to an area at least double that of the present. In addition to these events, there appears to have been a long-time but gentle tilting of the plateau toward the west, which has gradually and almost imperceptibly drowned a large segment of the Gulf coast of the state and at the same time elevated, with equal gentleness, a major fraction of the Atlantic coast. (*cf.* Campbell 1940; Cook 1945).

Thus, where the shallow seas which cover the submerged portions of the Floridan Plateau meet the almost flat shoreline of the peninsula, a wide intertidal zone results along much of the coast. This zone, between land and sea, is particularly conspicuous in estaurine localities where it often extends many miles inland, at the southern tip of the state where it is covered primarily by mangrove swamps, and along the Gulf side of the northern half of the peninsula where extensive coastal marshes have developed. If we can judge the past by the present, it is not difficult to conclude that intertidal marshes have been long-term features of the Florida coast; and certainly since the Pleistocene they have been much as we see them today, an ecologically distinct habitat fraught with the inhospitalities of unstable water levels, fluctuating temperatures, and rapidly varying salinities.

Although this intertidal (or "coastal" or "salt" or "brackish") marsh reaches its maximum extent on the Gulf coast of the upper peninsula of Florida, it is found in greater or lesser degree all along the more than twelve hundred mile shore of the state, and everywhere it harbors a fauna of fishes conspicuous for its variety of species and its abundance of individual representatives. Questions concerning these fishes are: What is the composition of the brackish marsh fauna? Was it

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[1] Contribution from the Department of Biology, University of Florida.

derived from fresh waters or the sea? Or, perhaps, is it unique in itself? What are some of the more conspicuous ecological factors of the marshes that mold its fish fauna?

Apparently no intensive ecological or faunistic study has been made of brackish marsh fishes, although there are several studies of the fishes of bays and other inshore waters. In addition, the problem of the relations of fish distribution to water salinities has received no detailed attention in Florida. As Gunter (1938, 1942, 1945) has pointed out, this relationship is known imperfectly for most species of fish which are neither wholly marine nor strictly fresh water inhabitants. Yet the members of this euryhaline group include some of the most important commercial fishes of the world, and in Florida much of the income from fisheries is derived from species which make extensive use of the brackish waters of the state.

The present study was designed to gather data about the fishes of the brackish water marshes as well as of those species which cross that zone by moving back and forth between marine and fresh waters. The principal objectives of the undertaking were to determine which fishes were present and to what extent they inhabited the brackish marshes. A secondary aim was to investigate the influence of salinity on the distribution of marsh fishes. Incidental to the work, some information was obtained relative to the life histories of the species encountered. Certain of these findings are included in the present paper and others have been presented previously by the writer (Kilby, 1949).

Two marshes were selected for the field work. One, at Bayport, receives fresh water from river discharge; the other, at Cedar Key, has a negligible dilution of its water from stream flow. The areas proved to be quite different in both their physical and faunistic features.

Monthly collections of fishes made during 1948 were augmented by many preliminary collections during the preceding six months. Collecting was done in and adjacent to the coastal or salt marshes bordering the Gulf of Mexico. In addition, a number of exploratory collections were made in the shallower waters of the Gulf, the bays, and the fresh waters close to the mainland margins of the salt marshes.

Although no detailed faunal study of intertidal marsh fishes has been attempted in North America, several workers have been concerned with the effects of salinity on fish distribution and the fish populations of bays and other open waters near the shores of the sea. Foremost are Gunter, who studied the temperature and salinity effects and the fish faunas of Texas bay waters; Longley, whose findings of a twenty-five year study of the fishes of the Dry Tortugas were completed and edited by Hildebrand; Hildebrand and Schroeder, who compiled a pioneering work on the fishes of Chesapeake Bay; and, more recently, Reid, who worked on the eulittoral zone fishes of Cedar Key. Without the findings of these and other workers, this study would never have gained much of its substance and, without the challenge presented by Homer Smith's (1943) stimulating lectures on the kidney, it is doubtful that it would have been undertaken.

METHODS

An attempt was made to collect random samples of the fish populations. This goal was difficult to maintain and when bias was recognized appropriate note was taken. D-type dip nets, tea strainers, and poison were employed but by far the most frequently used collecting devices were seines of ten and twenty-five foot lengths having a depth of four feet, mesh of a quarter inch, and a four-foot bag located in the center. Whenever possible, the seine hauls were planned so that the body of water being worked was covered by the net from shore to shore and from top to bottom. Seining was continued until it was believed that practically all species of fish present were represented in the collection. The details of these collecting procedures, and those of the methods which follow are available in a manuscript in the University of Florida Library (Kilby, 1950); consequently they are given here with considerable abbreviation.

The fishes were preserved in ten percent formalin and each collection was tagged by a field number identical with that on a field catalog card bearing entries descriptive of the station at the time of the collecting.

McBee Keysort Cards were used for the field catalog, and as the fishes of each collection were identified and examined in the laboratory many of the resulting data were recorded on the card for the proper collection. Subsequent coded punching of the cards permitted rapid recovery of the data.

Unless otherwise stated, all measurements are in millimeters. Lengths are standard lengths and were made with the aid of a fish measuring board.

Salinities were calculated in the laboratory from water temperature and density data collected in the field at the time each collection was made. The equipment and the method varied within permissible limits from the technique employed by the U. S. Coast and Geodetic Survey as described by Schureman (1941: 81-85).

The calculation of interspecific association coefficients, as improved and explained by Cole (1949), was used to answer the following questions: "Are these two species of fish occurring together more (or less) often than is to be expected by chance?" "To what extent do the two species appear to be associated either positively (occurring together), or negatively (occurring separately)?" "How reliable (in terms of its standard error) is the obtained coefficient?"

Calculation of the coefficient produces two figures: the coefficient itself (C) and its standard error (S E). For the species pair *Fundulus c. confluentus* and *Cyprinodon v. variegatus* at Bayport, for example, $C \pm S\ E = 0.81 \pm 0.13$. This means that the two species were found together frequently, and the best measure of the association is 81 percent. (If two species were always together, $C = +1.00$; if their association was random, $C = 0.00$; and if they were never together, $C = -1.00$). The standard error gives an estimate of the reliability of the coefficient in the usual statistical sense and consequently it decreases in magnitude as the number of collections increases.

Other statistical techniques and terms used in the treatment of data are based on those recommended by Simpson and Roe (1939). All errors shown are standard errors.

With the exception of a few specimens deposited elsewhere, all of the fishes taken during this study are available in the University of Florida Collections maintained jointly by the Florida State Museum and the University's Department of Biology.

THE CEDAR KEY AREA

The extreme diversity of the coastal physiography at Cedar Key can be appreciated fully only by an aerial view. Complexity of the land and water features of the intertidal zone, which ranges up to three miles in width, is a result of the irregularities in the shore line of the mainland, the presence of numerous islands and oyster bars in the tidal area, the fringing beaches of the Gulf, and the tortuous passageways which facilitate the tidal ebbs and flows. To the eye of a person on the ground the extensiveness of the open water in the intertidal zone is minimized by the presence of emergent vegetation which covers, and also fringes, the shallows around the islands and, to a lesser extent, many of the larger or higher oyster bars. The dominant emergent hydrophyte of the tidal area is oyster grass, *Spartina alterniflora* Linnaeus, but occasional strips and patches of black rush, *Juncus Roemerianus* Scheele, are conspicuous, especially near the mainland and in the vicinities of the larger islands. On top of the oyster bars and skirting the shallows adjacent to the islands, black mangrove, *Avicennia nitida* Linnaeus, frequently forms dense thickets; these, as much as the sweeps of grass, contribute to the impression that the tidal area is much more heavily vegetated than it is shown to be by an aerial observation.

Elevations in the area, although not great, have a marked influence on the vegetation. The mainland near the coast, for instance, is a mere three to five feet above normal high tide level and, from the evidence of the change in tide levels, the gradient across the tidal area is approximately one foot per mile. Thus, an oyster bar which is only twelve inches above the surrounding mud flats may support a dense growth of *Spartina,* or even *Avicennia,* and the slightly more elevated islands and the mainland produce pine woods.

At times of extreme high tide the entire tidal area is submerged and takes the appearance of a vast sheet of water being occasionally interrupted by the more prominent islands. Conversely, at extreme low tide, all waters are withdrawn except for those in pools and channels. At such times one would not hesitate to walk through the marshes from the mainland to the town of Cedar Key at the edge of the Gulf and could do so without getting in water over knee deep. Such a trip, however, would impress upon the venturer that mud is one of the most conspicuous features of the entire area. Mud overlays all of the surfaces of the marshes, except for the outlying strips of beach where white, wave-worked sand may be encountered. The mud is a soft, black, highly organic ooze of considerable depth into which a walker may sink as much as three feet, but usually it is sufficiently compacted to permit fairly easy progress on foot.

In planning the collecting at Cedar Key it was considered logical to follow a transect across the marshes in an attempt to encounter as many different fish habitats as possible, and to work all such stations on an intensive basis for at least a consecutive twelve-month period. It was soon evident, however, that the number of stations had to be limited, although a good means of access to the marshes exists by a road which could be considered a transect line. As a result eleven stations were picked for periodic examination along the road. Five of these were pools situated inside the marshes near the mainland; two were similarly constituted pools near the Gulf margin of the marshes; three were bayous or creeks penetrating the marshes near the mainland; and three were shallows along the shores of the larger bays and of the Gulf. The characteristics of these stations, which are designated by the terms Inner Pools, Outer Pools, Water-courses, and Open Waters, respectively, are outlined in Table 1. The major features of these four categories of habitats are summarized in order to emphasize some of the more pertinent factors of each of them.

Inner Pools

For the purposes of this study a pool is defined as a small, shallow body of water usually devoid of emergent vegetation, which either may retain water during periods of low tide, or become entirely drained at such times. The inner pools at Cedar Key were all surrounded by expanses of oyster grass, *Spartina alterniflora.* They consisted of slight depressions in the surface of the surrounding mud which, in addition to supporting the emergent vegetation, were flooded regularly at high tide. Thus, at extreme low tide some of the pools were drained completely while others, further removed from channels or open waters, might retain up to three and one-half feet of water. At high tide, the influx of water not only raised the levels of the pools, but overflowed into the adjacent marshes in all directions. At such times, fishes could and did leave most of the pools and either fed or took refuge in the surrounding marshes. This flooding also permitted the fishes free access to all parts of the marshes, and therefore facilitated their movements from area to area. The receding waters of the ebb tide forced the fishes to concentrate in the pools, water-courses, and margins of open waters. At such times of concentration they could be netted with facility and consequently nearly all the pool collecting was done at low tide.

The salinity of the pool waters varied through a greater range (1.2 to 35.6 ppt) than that for any other of the groups of habitats, and

TABLE 1.

Descriptions of Collecting Stations in the Cedar Key Area

Station No. & Name	Location	Maximum Diameters	Min. & Max. Depths	Bottom Slope	Bottom Composition	Submerged Aquatics	Tide Influence	No. of Colls.	Salinity in PPT.		Temperature in °C.		No. of Spec.	No. of Species	Most Abundant Species (% of total catch at station shown for each species)
									Range	Mean	Range	Mean			
							INNER POOLS								
1 Roadside Pool	Close to mainland	40′x60′	3.3′-3.5′	Gently shelving	Sand and mud	None	Occasional	13	5.4-35.6	17.6	12.0-33.0	24.5	3465	11	*M. latipinna* 48.9, *C. variegatus* 31.5, *A. xenica* 6.6, *F similis* 5.4, *Gambusia* 4.3.
2 Upper Pool	Close to mainland	18′x35′	1.5′-2.0′	Precipitous	Black organic mud	None	Regular	8	18.6-26.1	21.8	22.0-32.0	29.4	6255	11	*M. latipinna* 61.1, *A. xenica* 14.0, *Gambusia* 12.2, *C. variegatus* 8.8, *F. c. confluentus* 2.8.
3 Middle Pool	Close to mainland	25′x40′	1.8′-2.0′	Precipitous	Black organic mud	None	Regular	8	2.5-23.9	18.6	15.5-32.5	26.8	3177	16	*M. latipinna* 43.9, *A. xenica* 26.3, *C. variegatus* 11.8, *F. c. confluentus* 9.5, *Gambusia* 3.9, *M. cephalus* 1.3, *F. similis* 1.3.
4 Lower Pool	Close to mainland	15′x50′	0.0′-2.0′	Precipitous	Black organic mud	None	Regular	7	1.2-25.2	18.7	15.5-34.0	26.3	1594	13	*A. xenica* 46.1, *M. latipinna* 24.4, *C. variegatus* 15.7, *F. c. confluentus* 7.0.
5 Culvert Pool	Close to mainland	8′x10′	1.5′-2.5′	Sharply sloping	Sand	None	Regular	15	14.5-27.4	20.9	12.5-37.5	25.3	2155	14	*M. latipinna* 33.3, *C. variegatus* 20.8, *F. g. grandis* 18.7, *A. xenica* 12.7, *F. similis* 9.0.
							OUTER POOLS								
6 Airport Pool	Gulf edge of marsh	20′x60′	0.2′-2.5′	Gently shelving	Black organic mud	None	Regular	15	19.1-30.2	24.1	17.0-35.5	26.8	5876	28	*M. latipinna* 22.3, *M cephalus* 21.7, *A. xenica* 16.6, *C. variegatus* 15.5, *F. grandis* 10.9, *F. similis* 4.7.
7 Borrow Pool	Gulf edge of marsh	45′x400′	4.5′-5.0′	Gently shelving	Mud and sand	None	High tide only	16	15.4-27.8	23.2	16.0-36.0	27.2	6126	29	*M. beryllina* 21.2, M. *latipinna* 21.0, *A. xenica* 13.0, *L. xanthurus* 10.8, *C. variegatus* 9.6, *F. similis* 7.2.

							WATER COURSES							
8 Bayous	Mainland edge of marsh	20′x—	0.1′-4.5′	Flat; sides often steep	Sand and mud	None	Regular	8	0.8-17.5	8.9	12.0-27.0	19.2	976	15 *C. variegatus* 34.9, *F. grandis* 17.7, *F. similis* 14.3, *A. xenica* 13.1, *M. latipinna* 5.6, *E. argenteus* 3.9.
							OPEN WATERS							
9 Airport Bay	Gulf margin shallows	500′x500′	0.0′-4.5′	Gently shelving	Mud and oyster bars	None	Regular	5	25.9-37.6	30.5	19.0-31.0	24.3	474	30 *E. argenteus* 16.2, *A. xenica* 10.8, *A. m. diaphana* 10.1, *S. ocellatus* 10.1, *F. similis* 7.4, *F. carpio* 6.3, *F. grandis* 5.5.
10 Causeway Bay	Bay margin shallows	Indefinite	0.0′-4.0′	Gently shelving	Mud and oyster bars	None	Regular	6	16.3-26.5	20.1	22.0-26.0	25.9	636	16 *C. variegatus* 21.9, *M. cephalus* 17.8, *F. similis* 16.4, *A. m. diaphana* 12.4, *L. xanthurus* 9.9, *M. berryllina* 4.0, *A. xenica* 4.1.
11 Gulf Beach	Beach shallows of Gulf	Indefinite	0.0′-4.5′	Gently shelving	Hard sand and sandy mud	None	Regular	16	20.0-31.1	25.9	17.0-31.0	25.8	2507	40 *A. m. diaphana* 40.8, *M. beryllina* 16.0, *F. similis* 9.2, *E. gula* 8.1, *M. cephalus* 6.2, *M. vagrans* 4.4.

the same is true for temperature, which showed a range of 12 to 37.5°C. This observed variation is not unexpected when it is considered that the tide waters are spread over the muds of the marshes in a thin sheet, usually to a depth of only a few inches, and that under these conditions the effects of precipitation, evaporation, radiation, and dilution by seepage waters are quickly discernible.

In these areas the characteristic combination of species is *Mollienesia latipinna, Cyprinodon v. variegatus* and *Adinia xenica* (Table 1).

Outer Pools

The outer pools at Cedar Key are substantially like those nearer the mainland except that they are closer to the high salinity waters of the Gulf and their areas of surrounding marsh are less extensive. These factors probably account for the higher mean salinity encountered, its smaller range (15.4 to 30.2 ppt), and possibly the more moderate temperature range (16° to 36°C) in comparison with the inner pools.

Species were more numerous, but not necessarily more abundant in individuals, in the outer pools than in any other habitat except the Gulf shore waters. The variety is due to the presence of the marsh species plus additions from the nearby Gulf.

In addition to *Mollienesia latipinna, Adinia xenica,* and *Cyprinodon v. variegatus,* which were also found abundantly in the inner pools, appreciable numbers of *Fundulus similis* always were present in the outer pools.

Water-courses

The bayous, creeks, tide guts, and channels were grouped together under this title, and all collections from such habitats were considered together after a separate study showed that the similarities between stations warranted such a procedure.

At Cedar Key the water-courses studied were in the mainland edge of the marsh and proved particularly difficult as collecting stations. Seining during high tide was unproductive and at low tide was not much better. Apparently no species is well adapted to the swift waters and the rapidly changing levels of the bayous.

Salinities in the water-courses near the mainland are low to medium (0.8 to 17.5 ppt). This condition is due almost entirely to dilution by underground seepage water from the mainland, and this fresh water is supplied in sufficient quantities to offset the rise in salinity of the marsh waters due to evaporation. At dead low tide the bayou water does not taste salty and can be seen seeping into the channel from the sands along the banks.

The species which are characteristic of the water-courses include *Fundulus g. grandis* and *Fundulus similis* when taken with *Cyprinodon v. variegatus, Adinia xenica,* and *Mollienesia latipinna.* Also characteristic, however, is the size of the specimens found. The pool fishes usually are of all sizes, with an emphasis in numbers on the smaller individuals, whereas the fishes of the water-courses are almost always adults or at least half-grown individuals.

Open Waters

This category was assigned to include those stations where the collecting was accomplished in the shallows along the margins of the bays and the Gulf. These habitats were examined principally in order to determine, in part, the availability of species for populating the marshes. Collecting was done by seining the shallows both parallel and perpendicular to the shore, and the exploring was kept within two hundred feet of the land.

Salinities of these open waters showed a short range varying from 16.3 to 31.1 ppt for all locations. The range, however, was much less for individual stations. Temperatures were neither quite so low nor quite so high as at other stations, and it is likely that if the data had been collected further from shore, the range of both salinity and temperature would have been lessened.

Fundulus similis and *Menidia beryllina* were present in most of the catches, but other species were caught with less regularity.

* * *

The pools, water-courses, and inshore waters at Cedar Key are under the influence of the nearby offshore waters from both a physical and a faunistic standpoint. The offshore region presents a variety of fish habitats and the fish fauna is rich in both species and numbers of individuals. One of the more obvious causes for the abundance of fish found in the offshore region lies in the luxuriant and extensive bottom vegetation. Such is not the case in the intertidal zone where submerged aquatic plants are so poorly represented that they could not be of real importance in either the food or the cover relationships of the marsh fishes.

The causes for this paucity of submerged vegetation may rest partly in salinity. Although the salinity range is extensive at Cedar Key (0.8 to 37.6 ppt), the mean salinity is high (21.1 ppt) (fig. 1). Such a high mean salinity appears to prevent the development of the dense stands of aquatic spermatophytes so often found in the fresh and the mildly brackish waters of Florida.

Water temperature data are shown in figure 2. The range was from 12°C to 37.5°C; the mean was 25.9°C. The Bayport temperatures appear to be less variable than those for Cedar Key (fig. 2). The Coefficient of Variation for temperatures taken at Cedar Key is 25.4% and the equivalent for Bayport is 17.4%. These coefficients support the above statement that the Bayport temperatures are less variable than those at Cedar Key. (The difference between the coefficients contains its error 4.2 times. This indicates that the difference is real insofar as these data give a true picture of the situation.)

THE BAYPORT AREA

The Bayport area has much in common with that at Cedar Key, but an aerial view emphasizes the differences. From a physiographic viewpoint the Bayport tidal area appears much less diverse than the one at Cedar Key; although the mainland has an irregular outline, the tidal area is dotted with islands, and the Gulf margin of the land is tortuous. The most obvious simplifying factor is the absence of expanses of open water within the tidal zone. At Bayport the mud flats are vegetated principally with dense stands of black rush, *Juncus Roemerianus,* which is intermixed with small patches of oyster grass, *Spartina alterniflora.* Thus the oyster bars are eliminated, as well as the mud-bottomed embayments of open water which are so con-

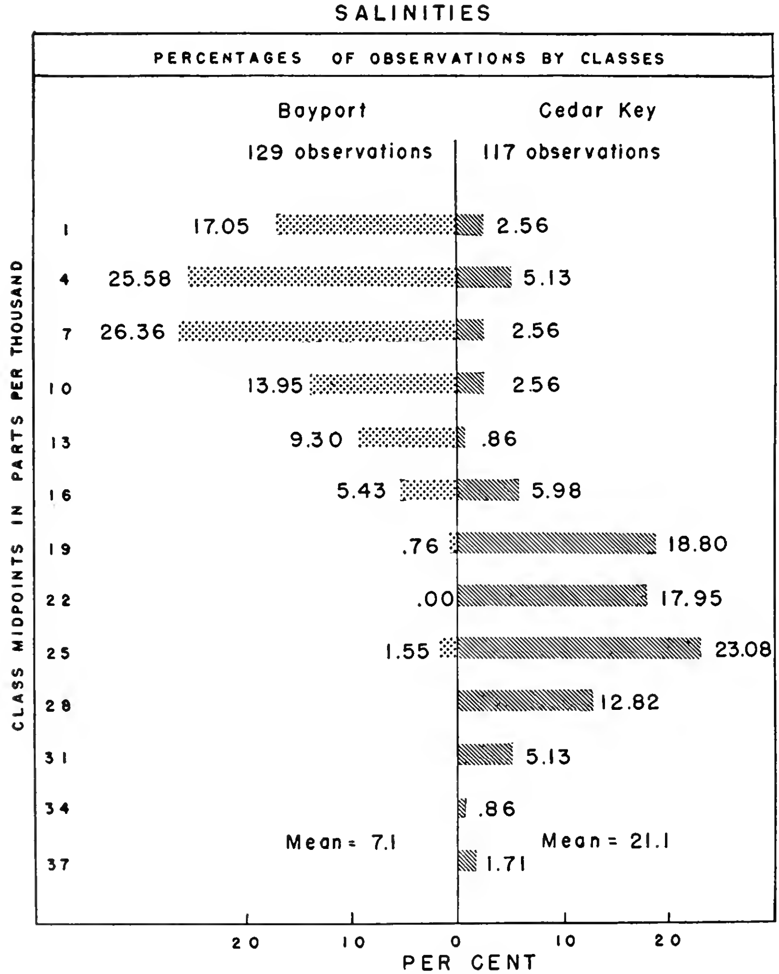

Figure 1. Salinities. Salinities, in parts per thousand, are shown by percentages of total observations for Bayport and Cedar Key respectively.

spicuous at Cedar Key.

Another major difference lies in the width of the two intertidal areas. At Bayport the zone is about one-third that at Cedar Key and this circumstance is reflected in the distribution of the fishes. At Cedar Key a fish must cross the mud-bottomed, oyster-bar-dotted embayment to move from areas near the Gulf to areas near the mainland, whereas at Bayport ready access by a much shorter route up the bayous is available for the crossing.

A third difference of importance is the influx of fresh waters into the Bayport area in sufficient quantities to affect materially the salinity, and quite possibly the temperature, of the water. The two

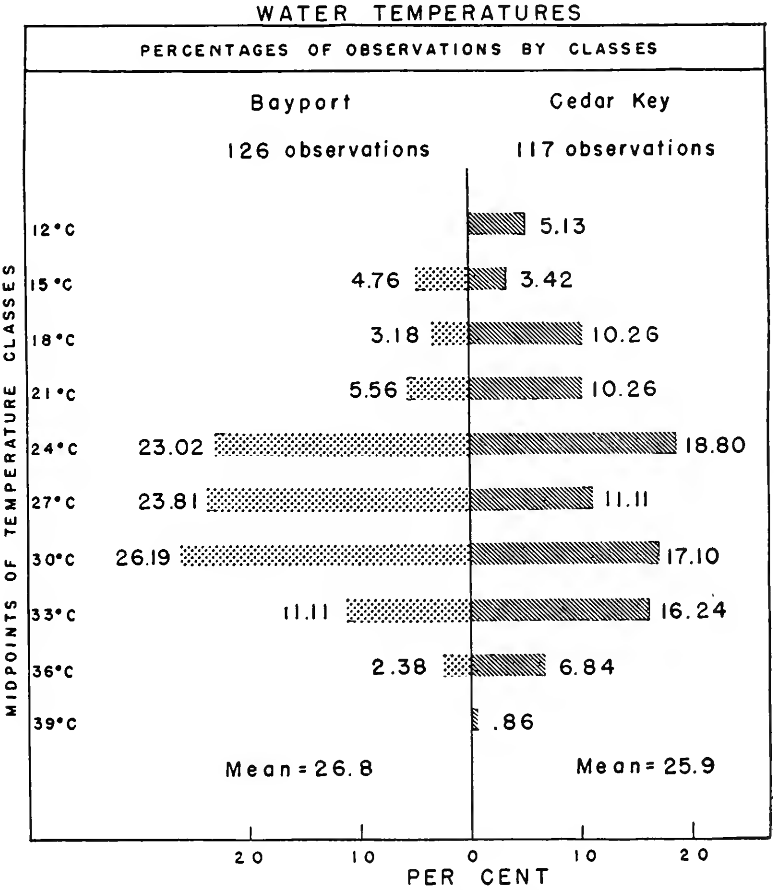

Figure 2. Water Temperatures. Temperatures, in degrees Centigrade, are shown by percentages of observations for Bayport and Cedar Key respectively.

major streams emptying into the Bayport marshes are the Mud and the Weekiwatchee rivers. Both are of spring origin and receive some contribution from runoff along their courses. The water of the two streams is faintly brackish due to the mild salinities of some of their springs. This almost-fresh water of the rivers tends to reduce salinities in the marshes and also, because of the relatively constant temperatures of the springs, to partially stabilize the temperature of the diluted marsh waters. Figure 2 presents the temperature data. As has been discussed previously, the temperatures at Bayport appear to be less variable (Coefficient of Variation = 17.4%) than those at Cedar Key (C.V. = 25.4%).

Despite these major differences, which have an effect on the fish populations, the transect method of selecting collecting stations was again employed, and the habitats worked were grouped into the same categories as described for Cedar Key. These groups are discussed in the following paragraphs, and the major features of the individual stations are summarized in Table 2.

Inner Pools

Four salt marsh pools and a group of mainland fresh water pools were selected. The inner marsh pools were near the mainland, and the fresh water ones were directly connected to brackish water by their drainages, but were elevated sufficiently to escape salt water influx except during maximum storm tides. Ordinary high tides rarely reached the inner pools of the marshes but, as a rule, the biweekly spring tides were sufficiently high for the purpose.

The fresh water pools differed most conspicuously from those of the marshes by being vegetated with cattail (*Typha*), pondweed (*Nais*), widgeon grass (*Ruppia*), spike rush (*Eleocharis*), and arrow head (*Sagittaria*). Together this vegetation gave a wholly fresh water aspect to the habitats. Salinity in these pools, however, reached 7.5 ppt on one occasion, but usually it was much closer to zero. The marsh pools maintained salinity means of 10.4 ppt or less, although the salinity range was from 0.0 ppt to 24.7 ppt.

The temperatures recorded showed a range of 14.5°C to 32°C.

At Cedar Key none of the inner pools was vegetated, but at Bayport some of the inner marsh pools contained submerged aquatics and these plants were present during all months.

The inner Bayport pools contained *Mollienesia latipinna*, *Cyprinodon v. variegatus*, *Gambusia affinis holbrooki*, *Lucania parva*, and *Fundulus confluentus* as constant and conspicuous elements of the fauna. *Adinia xenica*, which was also conspicuous in the inner pools at Cedar Key, was found only rarely at Bayport.

Outer Pools

The three outer pools were close to the bay area at Bayport and were, as at Cedar Key, very similar to the inner pools.

All of the outer pools were vegetated with *Ruppia* or a combination of *Ruppia* and *Chara*. The vegetation, however, was sparse, and tended to be in patches. Water levels consistently rose and fell almost the full extent of the total change for the area in all of the outer pools.

Salinities showed a maximum variation at a given station of about 11 ppt, and the range for all stations taken together was 3.3 to 17.1 ppt. The mean salinities for the outer pools were 8.3, 9.1, and 10.4 ppt, which are high for the Bayport area (Table 2). Temperatures of from 14.5°C to 33°C were recorded.

The fishes which were both prominent and consistently present in the outer pool collections were *Menidia beryllina, Eucinostomus argenteus* and *Lucania parva.*

Water-courses

In keeping with the practice at Cedar Key, the channels, bayous, creeks, and tide guts were grouped into this category. Unlike the Cedar Key habitats, however, these were heavily vegetated over much of their bottoms with dense growths composed principally of *Ruppia,* which formed mats from the bottom to the surface. Open water areas existed, however, and where no vegetation grew the bottom was of sand, rock, or shells. Elsewhere, an organic mud was present and this overlaid the calcareous rock substratum for various depths up to several feet.

The water-courses facilitated the movement of tidal water and some of them assisted in the discharge of the influx from the Mud and Weekiwatchee Rivers. Currents were never more than about four miles per hour and were usually barely perceptible except in the main channels during the latter half of the ebb.

Salinities in the water-courses ranged from 1.1 ppt to 11.8 ppt and their means were between 4 and 7 ppt. Temperatures varied from 15°C to 35°C.

The water-courses contained more species of fish than any of the other groups of habitats at Bayport. This was due to the presence of both fresh water and Gulf species, which were added to the normal marsh complement.

Prominent in the list from the standpoint of both numbers and regular appearance were *Lucania parva, Menidia beryllina, Eucinostomus argenteus, Mollienesia latipinna, Gambusia affinis holbrooki* and *Fundulus g. grandis.*

Open Waters

The shallows adjacent to the Gulf beach were assigned to this category. The floor of the Gulf at Bayport slopes very gently, an estimated eight inches in the first quarter to half mile. The bottom inshore is vegetated to the normal low tide mark, and between low and high tide levels a dense stand of black rush, *Juncus Roemerianus,* is present. During low tides, seining near shore in the shallows proved to be productive and it was here that collecting was done.

Salinities ranged from 2.0 ppt to 16.2 ppt but averaged only 8.4 ppt, which indicated the diluting effects of the river discharges in

TABLE 2.

SUMMARY DESCRIPTIONS OF BAYPORT COLLECTING STATIONS.

Station No. & Name	Location	Maximum Diameters	Min. & Max. Depths	Bottom Slope	Bottom Composition	Submerged Aquatics	Tide Influence	No. of Colls.	Salinity in PPT.		Temperature in °C.		No. of Spec.	No. of Species	Most Abundant Species (% of total catch at station shown for each species)
									Range	Mean	Range	Mean			
							INNER POOLS								
1 East Pool	Close to mainland	12′x35′	1.0′-1.5′	Flat; undercut banks	Soft, black organic mud	None	Only highest tides	8	2.2-16.6	10.4	25.0-32.0	28.1	2952	14	*M. latipinna* 62.8, *J. floridae* 12.4, *C. variegatus* 6.2, *G. a. holbrooki* 5.9, *F. c. confluentus* 4.7, *L. parva* 3.9.
2 West Pool	Close to mainland	35′x60′	1.0′-1.5′	Gently shelving	Soft, calcareous ooze	A few sprigs of Ruppia	Only highest tides	10	1.1-24.7	8.6	21.0-31.0	27.6	2654	15	*M. latipinna* 46.6, *C. variegatus* 11.3, *J. Floridae* 9.8, *M. beryllina* 9.0, *L. parva* 7.9, *G. a. holbrooki* 6.4, *F. c. confluentus* 4.9.
3 Sandhill Pool	Close to mainland	15′x1000′	2.5′-2.7′	Gently shelving	Soft, calcareous mud and sand	Dense beds of Chara	Only highest tides	10	0.0-11.2	6.9	14.5-32.0	25.7	1772	19	*M. latipinna* 50.8, *G. a. holbrooki* 19.2, *L. parva* 11.8, *H. formosa* 5.8, *F. c. confluentus* 5.3, *C. variegatus* 4.1.
4 Gate Pool	Close to mainland	75′x150′	4.5′-4.5′	Precipitous	Soft, black mud	Scattered strands Ruppia	Only storm tides	4	0.1-5.2	2.8	16.0-29.0	21.0	345	9	*G. a. holbrooki* 58.0, *M. beryllina* 14.8, *C. variegatus* 13.3, *M. latipinna* 9.6, *F. c. confluentus* 1.7, *L. parva* 1.4.
5 Fresh Pools	Mainland near marsh	Several sizes	Various	Various	Soft, black mud	Ruppia, Nais, Typha	Only storm tides	9	0.0-7.5	2.4	25.0-31.0	27.1	694	16	*G. a. holbrooki* 32.0, *H. formosa* 13.7, *L. parva* 10.5, *N. c. bosci* 10.2, *L. m. purpurescens* 5.5, *C. goodei* 4.3.
							OUTER POOLS								
6 Bimini Pool	Bay margin of marsh	35′x400′	0.2′-2.5′	Gently shelving	Calcareous rock, shell and mud	Patches of Ruppia & Chara	Regular	10	3.3-13.3	8.3	14.5-36.0	25.3	1895	21	*M. beryllina* 21.1, *G. a. holbrooki* 19.1, *L. parva* 19.3, *E. argenteus* 10.5, *M. latipinna* 10.4, *C. variegatus* 9.0.

7 Palm Pools	Bay margin of marsh	Several small pools	0.1′-2.5′	Gently shelving	Black organic mud	Wisps of Ruppia & Chara	Regular	10	6.2-16.7	9.1	21.0-30.5	26.9	2113	19	*C. variegatus* 18.0, *E. argenteus* 15.4, *L. parva* 12.7. *A. xenica* 10.4, *M. beryllina* 9.0, *F. grandis* 8.8, *F. confluentus* 7.9.
8 New Bridge Pool	Bay margin of marsh	25′x35′	0.5′-2.5′	Gently shelving	Sand with some mud	Thin stand of Ruppia	Regular	13	6.2-17.1	10.4	14.5-33.0	25.0	1894	22	*E. argenteus* 33.5, *L. parva* 27.0, *M. beryllina* 13.6, *C. variegatus* 10.2, *M. cephalus* 3.2, *L. rhomboides* 2.2.
							WATER COURSES								
9 Brunner	Gulf edge of marsh	Indefinite	0.5′-3.5′	Flat: banks steep	Sand, mud, shells, rock	Dense mats of Ruppia	Regular	11	1.1-11.8	6.8	25.0-33.0	30.3	1962	26	*L. parva* 42.3, *M. beryllina* 20.0, *E. argenteus* 9.7, *G. a. holbrooki* 6.1, *M. latipinna* 5.6, *A. xenica* 5.0, *F. grandis* 3.3.
10 Garrison	Gulf edge of marsh	30′x100′	0.5′-3.5′	Shelving; banks steep	Black organic mud	Heavy stand of Ruppia	Regular	16	1.8-7.5	4.1	15.0-35.0	27.7	1718	21	*L. parva* 44.8, *M. latipinna* 16.7, *G. a. holbrooki* 10.1, *E. argenteus* 9.8, *M. beryllina* 5.8, *F. grandis* 5.1.
							OPEN WATERS								
11 Battery	Beach shallows of Gulf	Indefinite	0.0′-4.0′	Gently shelving	Soft sand & sandy-mud	Patches & clumps-Ruppia	Regular	18	2.0-16.2	8.4	14.0-33.5	26.5	2421	23	*L. parva* 28.5, *E. argenteus* 24.7, *F. carpio* 19.7, *M. beryllina* 9.1, *F. similis* 3.8, *M. gulosus* 3.6, *E. gula* 3.1.

the area. Temperatures in the shallows varied widely from 14°C to 33.5°C.

The fishes most prominent in the collections were *Lucania parva, Eucinostomus argenteus, Floridichthys c. carpio, Menidia beryllina, Fundulus similis, Microgobius gulosus* and *Eucinostomus gula.*

The marshes of the Bayport area, like those at Cedar Key, are bordered on the seaward side by the inshore shallows of the Gulf. These shallows are much less diverse in habitats than those at Cedar Key and support a fish fauna which is limited, if not in variety of forms, then certainly in numbers of individuals. Toward the mainland, on the other hand, the marshes come in contact with the mouths of spring-fed streams, other marshes where the water is almost fresh, coastal swamp waters, and the margins of mesophytic hammocks, pine woods, and palm thickets.

Thus at Bayport the mainland waters and their fish faunas would be expected to have a marked influence on the waters and fishes of the intertidal zone. One of these influences is well illustrated by a consideration of salinity. As previously mentioned, the Bayport marshes receive a considerable amount of almost fresh water from mainland streams. Salinities varied from 0.0 ppt to 24.7 ppt and showed a mean of 7.1 ppt. The salinities in the marshes at Bayport and at Cedar Key (Mean = 21.1 ppt) were conspicuously dissimilar in distribution (fig. 1).

The more conspicuous similarities and differences between the habitats of the two areas and the physiographic features underlying those factors may be restated in tabular form as follows:

Cedar Key	*Bayport*
1. The marsh area is about three miles in width	1. The marsh area is only about a mile wide
2. Influx of fresh water is negligible, consequently: Salinity relatively high; Range: 0.8–37.6 ppt Mean: 20.5 ppt	2. Influx of fresh water from two moderately small rivers conspicuously reduces salinities, consequently: Salinity relatively low; Range: 0.0–26.1 ppt Mean: 7.1 ppt
3. Water temperatures somewhat variable Range: 11.5–37.5°C Mean: 25.9°C Coefficient of Variation = 25.4	3. Water temperatures less variable than those for Cedar Key Range: 16–35°C Mean: 26.7°C Coefficient of Variation = 17.4
4. The dominant emergent of the marshes is *Spartina alterniflora*	4. The marsh dominant is *Juncus Roemerianus*
5. Submerged hydrophytes absent from marsh pools and water-courses	5. Submerged hydrophytes abundant in water-courses and present in varying amounts in pools
6. Offshore Gulf shallows have diverse bottoms, both vegetated and clean	6. Offshore Gulf shallows are mostly smooth bottomed; only sparse patches of vegetation in limited areas

7. Eulittoral waters densely populated with fishes	7. Eulittoral waters much less densely populated

All of the fishes taken from the marshes and their immediately adjacent waters are presented in the following annotated list of species. When the data seem to warrant it, conclusions relative to the influence of some of the ecological factors on the occurrence, abundance, and distribution of certain of the fishes are advanced. Particular attention has been directed to the influence of salinity on the fishes.

ANNOTATED LIST OF SPECIES

DASYATIDAE: Stingrays

1. *Dasyatis sabina* (Le Sueur), Southern Stingray.

One immature specimen with a total length of 239 mm was taken in July from the channel near the public dock at Bayport. The salinity was 2.5 ppt and the water temperature 25°C.

LEPISOSTEIDAE: Gars

2. *Lepisosteus platyrhyncus* DeKay, Florida Spotted Gar.

Gars were not encountered at Cedar Key, but at Bayport they were numerous and reached sizes of about four feet in total length. Occasional individuals fed in the open waters of the Gulf at least a mile offshore, and even these few cause the bay fishermen considerable annoyance, especially during the summer. Field observations indicated that the gars were most numerous in the Weekiwatchee River, especially near its mouth, but only rarely do they enter the strictly marsh waters.

Three gars were seen in the marshes which, when collected, proved to be *L. platyrhyncus*. Two were taken in July at a salinity of 1.1 ppt and the other in November at a salinity of 2.8 ppt. All came from dense mats of *Ruppia* near the channels. The November individual was 169 mm in length; the July specimens measured 445 mm and 495 mm.

ELOPIDAE: Tenpounders

3. *Elops saurus* Linnaeus, Ladyfish (Tenpounder).

Ladyfish occur only in the open bay at Bayport. At Cedar Key, on the other hand, twelve collections included 19 specimens ranging in size from 31 to 153 mm, with the smallest taken in May and the largest in June. These young fish were taken only during the period April-July inclusive, and only from marsh pools. Salinities at the times the fish were taken ranged from 9.0 ppt to 35.6 ppt (avg = 23.3 ppt).

In the open bay at Cedar Key ladyfish are abundant, at least seasonally, and in order to maintain the observed numbers of adults the young would necessarily have to be much more numerous than is here indicated. Thus the Cedar Key marshes probably contain only strays of the young concentrated elsewhere.

Although the number of specimens collected was small, and consequently may not represent a reliable sample of the population, from the data available growth appears to be rapid. This trend is shown by the following data.

Month of Collection	Mean Length in mm	No. of Specimens
April	50	1
May	55	12
June	96	5
July	101	1

CLUPEIDAE: Herrings

4. *Harengula pensacolae* Goode and Bean, Pilchard.

Four specimens were taken from the shallow waters of the Gulf beach at Cedar Key during April (salinity 20.8 ppt) and October (salinity 30.2 ppt). The October individuals measured 34 and 62 mm, respectively, and those of April were 115 mm and 125 mm. In both instances the tide was low but rising, the water had a milky or whitish color, the temperature of the water was the same (25°C), and *Anchoa m. diaphana* was by far the most dominant fish in the collections, constituting 81.8% of the April catch and 91.8% of the October catch.

ENGRAULIDAE: Anchovies

5. *Anchoa mitchilli diaphana* Hildebrand, Southern Bay Anchovy.

Seventeen of the Cedar Key collections included 1160 specimens of this anchovy. None was caught at Bayport. With the exception of one fish, all were taken from either the shallow waters along the shores of the Gulf or the larger bays (1152 specimens), or from marsh pools very close to the beach (7 specimens) (Table 3), and nearly all of Reid's (1954) specimens came from along the beaches. Most were collected in October (962) but some were found in February (1), April (109), June (16), July (29), August (1), November (1), and December (41) (Table 4).

Sizes of 16 to 19 mm were present in June, July, and October; specimens less than 25 mm were caught in those months, and also in December. The two largest fish were 67 mm each. The presence of the small fish in June and October indicates at least two breeding seasons, or possibly a very extended one. Emphasis on the October season is indicated by the preponderance of specimens caught at that time, and by their small sizes. Gunter (1945: 34) found strong indications of an extended breeding season, "probably extending from spring to fall," and Hildebrand and Cable (1930: 288-9) found the same season in North Carolina.

Salinities of the waters where catches included the anchovies ranged from 6.2 ppt (1 specimen) to 37.6 ppt (41 specimens), and showed a mean of 25.2 ppt. Six of the collections contained more specimens of anchovies than of any other species. These showed a salinity range of 20.8 ppt to 37.6 ppt (mean = 28.2 ppt). The Cedar Key area anchovies are more abundant in the areas of high salinities, and the salinity index of 31.03 (Table 6) is the second highest for any species. Gunter (1945: 34) took more than eleven thousand specimens along the Texas coast; his data do not indicate that the fish show a marked preference for any particular salinity. He caught specimens in large numbers at salinities of less than 5 ppt, and in those waters his average catch per haul was slightly greater than in saltier places. His work, however, was done in open waters. Thus, on the basis of present findings and those of Gunter and of Reid, it is clear that *Anchoa m. diaphana* is a fish of the open bays, particularly their shallower parts, and that the degree of salinity is not an important factor in their local distribution, provided the water is at least mildly brackish (2.3 ppt or more).

SYNODONTIDAE: Lizard Fishes

6. *Synodus foetens* (Linnaeus), Lizard Fish.

Only five specimens were taken during the study and these were from the shallow waters along the Gulf beach at Cedar Key. A 57 mm specimen was taken in August (salinity 24.4 ppt), and the other four, ranging from 44 mm to 74 mm, were taken in November (salinity 31.2 ppt). Obviously the fish is not a marsh inhabitant.

CYPRINIDAE: Carps

7. *Notemigonus crysoleucas bosci* (Valenciennes), Southeastern Golden Shiner.

Seventy-four specimens were taken at Bayport in four collections obtained from mainland waters. Salinities varied from freshwater, in a tributary of the Weekiwatchee River, to 5.6 ppt in a pool near the marshes subject to an influx of salt water at times of abnormally high, storm tides. In this latter habitat, where both the aquatic plants and the fish population indicated a fresh water condition, 35 specimens were taken in February at a salinity of 0.8 ppt, and 36 specimens were caught in June when the salinity was 5.6 ppt. Many others, particularly adults, were observed in the Weekiwatchee River and in the spring at its head. Thus *Notemigonus crysoleucas bosci* had ready access to the coastal marshes and penetrated to their edges, but was never found where waters were more than weakly saline, although the fish is able to tolerate salinities up to at least 5.6 ppt. It appears that the fish is confined to fresh water, but in areas very near the coast it is found occasionally in slightly brackish situations.

8. *Notropis petersoni* Fowler, Coastal Shiner.

Only 37 specimens were caught and these were found in two collections. Thirty-six were taken in the mainland edge of the marshes at the mouth of the Weekiwatchee River when the salinity was 1.4 ppt. The other specimen was caught upstream at a salinity of 2.5 ppt.

Since no individuals were taken in the marshes proper, and the fish was found only at low salinities in mainland waters, it is shown that this fresh water fish occasionally is found in weakly saline waters near the coast.

AMEIURIDAE: Catfishes

9. *Ameiurus natalis erebennus* Jordan, Southeastern Yellow Bullhead.

Ten specimens were taken in four Bayport collections but none was found at Cedar Key. Five came from the Weekiwatchee River (two collections) and the other five were caught from a pool deep within the marshes where salinities were 2.5 ppt and 15.0 ppt on the two occasions involved. These pool individuals were young, ranging in size from 53 mm to 73 mm, and were taken in February and April. The fish from the Weekiwatchee were less than 26 mm in length and were taken in July. Adults were caught by hook and line fishermen as far bayward as the Channel at Bayport and were not difficult to obtain when fished for at night in other water-courses of the vicinity. (Except for several exploratory night collections and a number of night observations at Bayport, all of the field work of this study was done during daylight hours.)

The species is a well known freshwater form which, at least at Bayport, is not uncommon in slightly saline waters and which occasionally tolerates salinities up to at least 15.0 ppt.

HEMIRHAMPHIDAE: Halfbeaks

10. *Hyporhamphus unifasciatus* (Ranzani), Ballyhoo.

Halfbeaks were caught at both Cedar Key (3 collections, 22 specimens) and Bayport (3 collections, 3 specimens). All collections were from open waters near the shores of bays or of the Gulf. Many schools of halfbeaks, presumably of this species, were observed in the shallow, open waters of the Gulf, and on several occasions much time was spent in unsuccessful attempts to catch representatives. Undoubtedly these fish are among those forms most successful at avoiding nets. They take flight at the slightest disturbance, and the term "flight" is used advisedly since they almost can leave the water, sometimes skittering fifty feet or more over the surface with only their tails submerged.

The Cedar Key specimens were taken in May, June, and July at salinities of 21.3 ppt, 24.4 ppt, and 27.2 ppt, respectively. Sizes were distributed fairly evenly between 60 mm and 95 mm. Of the three Bayport individuals two were caught in April (180 mm, salinity 7.5 ppt; and 184 mm, salinity 16.2 ppt) and one in November (186 mm, salinity not taken).

Its total absence from the marshes and its presence in the bays nearby excludes this species from consideration with the marsh fauna.

BELONIDAE: Needlefishes

11. *Strongylura notata* (Poey), Needlefish.

Seven Cedar Key collections included 14 specimens. Two were taken in June (salinities 24.7 ppt and 26.1 ppt), two in July (salinity 27.2 ppt), and ten in October (salinities 30.2, 27.3, 26.1, 27.7 ppt). Six came from tide pools adjacent to the Gulf and eight were taken from shallow water along the Gulf beach. None was collected deep within the marshes. Sizes ranged from 90 mm to 230 mm and showed no observable pattern by months.

S. notata was present in twelve Bayport collections and was represented by 40 specimens taken in March, April, June, July, and November. Sizes varied from 50 mm (April and July) to 260 mm (March and April). All were taken from either the shallow waters of the Gulf or from pools and ditches having open water connections with them. Salinities ranged from 0.8 ppt to 17.1 ppt (mean = 9.3 ppt). Temperatures varied from 25°C to 32°C.

This species and *Strongylura timucu* appear to be associated in the collections; this observation is discussed under the latter species.

12. *Strongylura timucu* (Walbaum), Needlefish, Timucu.

Nine Cedar Key collections included 40 individuals of *S. timucu*. These were taken in April, May, June, July, September, and October at salinities ranging from 4.5 ppt to 30.2 ppt (mean = 22.9 ppt). Temperatures ranged from 20°C (October) to 32.5°C (September). Four were taken near the mainland margin of the marshes. One of these was from a marsh pool and the other three were from a bayou. All others came from shallow waters along the Gulf shore except for two individuals caught in a pool close to the open Gulf. Sizes ranged from 80 mm to 190 mm. The small number of individuals and their distribution through the months by sizes gave little clue to the growth rates or to the breeding season.

Eighteen Bayport collections included 53 specimens caught in January, February, March, April, May, June, July, October, and November at salinities from 3.3 ppt to 17.1 ppt (mean = 10.0 ppt). Temperatures varied between 21.5°C and 33°C. All specimens were obtained from either Gulf shore waters or the pools and bayous directly connected to the Gulf by open water passageways. Sizes ranged from 35 mm to 440 mm but gave no conclusive information on growth rate. The 35 mm specimen was taken in June and was the only individual sufficiently small to indicate a breeding date close to that of the time of capture.

S. notata is rather weakly associated with *S. timucu* at both Cedar Key (C = 0.38 ± 0.10) and Bayport (C = 0.52 ± 0.11) (*cf.* p. 177).

Needlefishes were seen in the Weekiwatchee River on many occasions and they ascend that stream to its headwaters. It was thought that both species here discussed were represented, but since specimens were not collected the identifications are uncertain.

ANGUILLIDAE: Eels

13. *Anguilla bostoniensis* (Le Sueur), Common Eel.

A single 292 mm individual was taken at Bayport in November by net from the mouth of a large bayou. The fishermen at Bayport occasionally catch a specimen from the brackish waters of the marshes where I have observed them at night on several occasions.

MYRIDAE: Worm Eels

14. *Myrophis punctatus* Lutken, Worm Eel.

A single specimen 165 mm in length was captured among the damp shells of an oyster bar exposed during an extremely low tide at Cedar Key in August, 1948. That they are more abundant than here indicated has been established by later collecting with rotenone in shell bottomed pools near the mouths of bayous.

CYPRINODONTIDAE: Killifishes

15. *Fundulus chrysotus* Holbrook, Golden Topminnow.

Nine Bayport collections included 29 specimens, but only two of these were taken in marsh waters. The others were collected in mainland swamps, streams, and springs. The presence of the two specimens in the brackish marshes is attributed to accidental straying from fresh waters nearby, but since the salinities were 15.0 ppt and 24.7 ppt at the times *F. chrysotus* was taken, it is obvious that the species can tolerate a rather high salinity, at least for short periods. The species is a resident of Salt Spring at Bayport where salinities usually are close to 1.8 ppt.

16. *Fundulus similis* (Baird and Girard), Longnose Killifish.

One thousand nine hundred fifty-four specimens were collected and of these 1750 came from 87 Cedar Key collections and 204 were from 34 Bayport collections. The species represented 5.23% of all specimens taken at Cedar Key and only 0.96% of those from Bayport.

The fish from Cedar Key ranged in size from 13 mm to 111 mm; larger specimens were observed but not caught. Bayport individuals were from 12 mm to 120 mm. Very young fish were present in the collections during all seasons at both areas. These occurred at Bayport about equally through the months, but they showed perceptible increases in January and in May at Cedar Key. These observations are in substantial agreement, but less marked, than those of Gunter (1945: 44).

Growth charts on the species were not particularly illuminating, but the one for Cedar Key suggested that the young of January probably reached a length of at least 45-55 mm by June, and that the young of May probably reached 40 mm by late July and 55 mm in late October. On this basis it might be assumed that specimens exceeding 60 mm are at least six months old. These conclusions are similar to those reached by Gunter (1945: 44).

The species is widely distributed throughout the marshes in spite of its greater abundance in the shallow shore waters and pools where salinities are constantly high (Table 3). Field observations repeatedly showed that the fish was more abundant in shore waters than elsewhere, but the catches did not reflect that abundance in its true perspective because of the skill of the larger specimens in avoiding capture. It is certain that the proportions of large fish are less in the collections than those in the populations.

The percentage of *Fundulus similis* was greatest in catches made during the summer and early fall (Tables 4, 5).

Table 8 indicates at Cedar Key a weak positive association (0.36± 0.17) between *F. similis* and *Menidia beryllina,* which are both "open water" species; a negative association (—0.34±0.10) with *Gambusia affinis holbrooki,* which is a "protected water" form; and a positive association (0.50±0.11) with *Fundulus g. grandis,* which is a widely distributed marsh form. Other correlations are not marked and emphasize the fact that *F. similis* is widely distributed in the marshes.

Bangham (1942: 297) lists *F. similis* from the fresh waters of Silver Springs, Florida, but this is almost certainly in error as has been noted by Hubbs and Allen (1943: 22).

17. *Fundulus grandis grandis* Baird and Girard, Gulf Killifish.

One thousand nine hundred seventy-nine specimens were obtained and of these 1476 were taken in 75 collections at Cedar Key, and 503 were from 56 collections made at Bayport.

The presence of fish of all size ranges (20 mm or less to 100 mm or more) at all seasons of the year indicates a continuous breeding season. This killifish exhibited increases in abundance during May, November, and December at Cedar Key (Table 4), and during January, June, and November at Bayport (Table 5). These are not striking increases and are mentioned for comparison with Gunter's (1945: 43) findings in Texas where "the fish was caught in greatest abundance in summer and again in midwinter."

At Cedar Key *F. g. grandis* was taken at salinities from 0.8 to 35.6 ppt, and at Bayport it was taken at salinities from 0.8 to 16.2 ppt. The fish was taken in all possible salinity classes at Cedar Key and showed a slight increase above expectancy for salinities centering around both 2.5 and 22.5 ppt (Table 6). Contrarily, the species was more abundant at low salinities for Bayport (Table 7). Gunter (1945: 126) showed that his Texas specimens were more abundant at salinities less than 15 ppt. Thus it becomes clear that this species can tolerate a wide range in salinity but reaches its population peaks at salinities between about 5 and 25 ppt. The contradictory findings of the present study are resolved, to a great extent, by a consideration of habitat preferences.

F. g. grandis occurs most abundantly in outer pools, water-courses, and, to a less extent, open waters at both Cedar Key and Bayport (Table 3). And, as noted previously, the salinities of those habitats average higher at Cedar Key than at Bayport. It appears, then, that *F. g. grandis* is more responsive to the type of habitat than to the salinity of its water, provided that the water is at least brackish and not above about 25 ppt.

At Cedar Key *F. g. grandis* exhibits a moderate positive association (C is 0.50±0.11) with *F. similis* and both of these species show a preference for the same habitats. A negative association is shown with *Gambusia affinis holbrooki* by both *F. similis* and *F. g. grandis* (C is —0.62±0.12). *Gambusia* is a fish of the inner pools and sheltered places, whereas both species of *Fundulus* under consideration prefer the outer pools and shore waters. At Bayport a positive association is indicated with *Cyprinodon v. variegatus* (0.50±0.12) and with *F. similis* (0.38±0.13), and a possible negative but weak association with *Gambusia* (—0.21±0.09).

18. *Fundulus confluentus confluentus* Goode and Bean, Eastern Marsh Killifish.

One thousand six hundred seventy-nine specimens were collected from the marshes and several hundred others were taken in the inland fresh waters of Levy County many miles from the coast. The Cedar Key specimens numbered 1,080 and were included in 75 collections. Forty-eight Bayport catches accounted for the remaining 599 individuals.

Sizes ranged from 11 mm to 69 mm, but fish of less than 25 mm were poorly represented in the collections. At Bayport, however, small fish were taken with some regularity, being absent (or nearly so) only in November and December. They were also absent for these months at Cedar Key and, in addition, were not present in the March, April, and May collections. The growth charts prepared for this species are not particularly informative except to suggest that the breeding season is prolonged, the mortality rate high, and that the majority of the fish live only a single season during which they attain a maximum size of a little over 55 mm. These interpretations are tentative, and further observation on the species in these respects is needed.

At Cedar Key *F. c. confluentus* was taken in greater abundance than expected on the basis of random distribution at salinities between 20 and 30 ppt, and less than expected both above and below those limits (Table 6). The comparable optimum salinities at Bayport were between 10 and 30 ppt.

The species occurred most abundantly in the inner pools at Cedar Key, but at Bayport it occurred abundantly in both the inner and the outer pools (Table 3). These occurrences explain, for the most part, the differences in salinity distribution, since the salinities of these habitats vary in the two areas. These are correlated with the habits of the species in freshwater where they are found most abundant in sheltered pools.

A positive interspecific association is indicated at Cedar Key (Table 8) between *F. c. confluentus* and *Mollienesia latipinna* (0.94±0.13), *Adinia xenica* (0.64±0.11), *Cyprinodon v. variegatus* (0.89±0.13), and *Gambusia affinis holbrooki* (0.81±0.21). Negative associations are with *Menidia beryllina* (—0.35±0.11), *Eucinostomus argenteus* (—0.39±0.13), *Anchoa m. diaphana* (—0.81±0.17), and *Floridichthys c. carpio* (—0.64±0.23).

At Bayport (Table 9) the positive associations are with *Mollienesia* *latipinna* (0.70±0.19), *Adinia xenica* (0.64±0.15), *Cyprinodon v. variegatus* (0.81±0.13), *Mugil cephalus* (0.83±0.18), *Jordanella floridae* (0.79±0.18), and *Gambusia affinis holbrooki* (0.52±0.14). Negative association is indicated possibly for *Eucinostomus argenteus* (—0.34±0.12). These associations emphasize the occurrence in the inner pools and the sparcity of numbers found in the water-courses and the shallows of the bays and Gulf.

19. *Adinia xenica* (Jordan and Gilbert), Diamond Killifish.

Five thousand three hundred and three specimens were collected; of these 4,939 were taken in 84 collections at Cedar Key, while 364 came from 22 Bayport catches.

Sizes ranged from 12 mm to 42 mm. Specimens of 15 mm or less were present in nearly all months (fig. 3). Thus the breeding season at Cedar Key seems to be continuous, except for possible breaks in the March-April period and again in December. The rate of growth appeared to be rapid. Considering the period June-September, it seems that certain of the size groups can be followed through the several months. For instance, the 19 mm group of June is possibly the 22 mm group of July, the 24 mm one of August, and the 25 mm one of September. This same trend of size increase is developed by following the maximum-size group for the same months, and is substantiated to a limited degree by the record of a 9 mm specimen of December which grew to 37 mm in twelve months in a large aquarium.

The monthly catches for Cedar Key (Table 4) indicate that the population reached a peak during the fall, maintained a high level during the winter, declined in February and March, and increased from that low through the spring and summer to the fall peak.

At Cedar Key considerably more specimens of *Adinia* were caught where salinities ranged from 20 to 24.9 ppt than from any other range of comparable size, and that the percentage (56.29%) at these salinities was greater than expected (36.68%) when assuming a random distribution (Table 6). The comparable Bayport figures (Table 7) indicate a greater abundance in salinities between 15 and 20 ppt than in any other class.

At Cedar Key this species is distributed by habitats almost the same as are all other species taken together (Table 3). There existed, however, a tendency to avoid open waters and to be more abundant in inner pools. Table 3 indicates a strong tendency at Bayport to avoid inner pools and open waters and to concentrate in the water-courses and particularly in the outer pools. These data suggest that the fish prefers medium salinities between 15 and 25 ppt, and that outer pools and water-courses are chosen for habitats. The fish occurs in much greater numbers at Cedar Key than at Bayport, possibly because the salinities in the former area more nearly meet its requirements.

At Cedar Key *Adinia xenica* showed a positive association (Table

8) with *Mollienesia latipinna* (0.72±0.11), *Cyprinodon v. variegatus* (0.70±0.11), *Gambusia a. holbrooki* (0.77±0.25), and *Fundulus c. confluentus* (0.64±0.11). Negative association was indicated between it and *Menidia beryllina* (—0.35±0.11) and *Anchoa m. diaphana* (—0.67±0.15). These associations add strength to the indications that this species avoids open waters and is most abundant in medium salinities. Positive Bayport associations are with *M. latipinna* (0.67±0.32), *C. variegatus* (0.89±0.23), *F. c. confluentus* (0.64±0.15), and possibly *Floridichthys c. carpio* (0.37±0.12). No negative associations are shown. This emphasizes the scattered nature

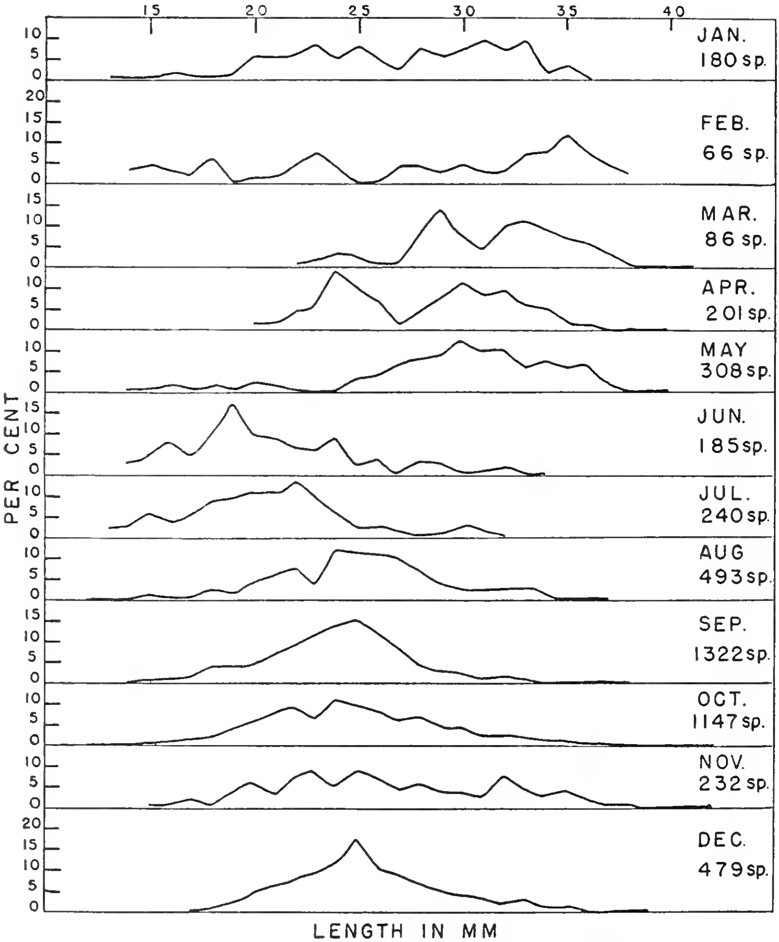

Figure 3. *Adinia xenica*, Cedar Key specimens. Monthly length-frequency curves.

of the population at Bayport where the species is not abundant and where it is probably finding difficulty in adapting itself to a habitat in which salinities are bordering on the unsuitable.

20. *Lucania parva* (Baird and Girard), Rainwater Killifish.

Four thousand two hundred and five specimens were obtained. Ninety-eight collections at Bayport included 4,192 of these and the other 13 specimens were taken in nine collections at Cedar Key.

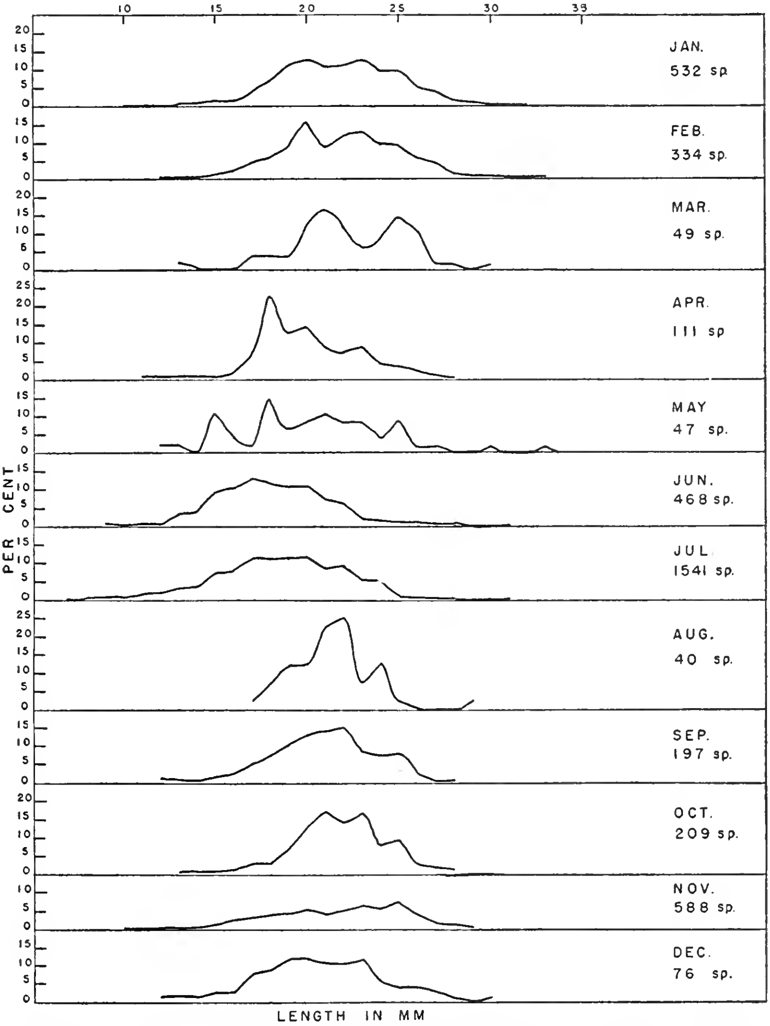

Figure 4. *Lucania parva*, Bayport specimens. Monthly length-frequency curves.

Reid (1954: 28) found only three individuals in the shallow offshore waters of the Gulf at Cedar Key.

Sizes ranged from 7 to 39 mm and young were present in all seasons. The size distribution by months at Bayport (fig. 4) indicates a more or less continuous breeding season but is not informative relative to growth rates. The use of time intervals shorter than a month for making collections in the study of this species might have given more growth rate information. The absence of any determinable trends in the growth of the population renders further speculation on the matter inadvisable.

Lucania parva was second only to *Mollienesia latipinna* in abundance at Bayport and it was found in more collections (98) than any other species (Table 5). Its relative abundance, however, fluctuated widely from month to month. Over the year it averaged 19.64% of all specimens taken, but in January it constituted nearly 55% of the total catch, and in May it made up only a little more than 2% of all the fish taken. It showed a decrease from the January peak through the months to June when it began an ascension lasting through August. Another peak was present in November and for December the population took its average position for the year.

Salinities at which the species was taken varied from 0.1 to 28.2 ppt; however, 81% of all specimens were taken from waters of 10 ppt or less (Table 7).

A positive association existed at Bayport between *Lucania parva* and *Cyprinodon v. variegatus* (0.52±0.13), *Menidia beryllina* (0.66±0.14), and *Eucinostomus argenteus* (0.49±0.16). No negative associations were evident (Table 9).

The positive association indicated with *C. v. variegatus* is due in part to the wide distribution of the latter in the Bayport marshes and, it is believed, in part to collecting errors. As is shown later, *C. v. variegatus* is most abundant in unvegetated waters, whereas *L. parva* appears to avoid such places. In seining at Bayport, however, it is difficult to avoid encompassing both situations in a given seine haul. The same error is present in the case of *Menidia beryllina,* and to a lesser extent in the association with *Eucinostomus argenteus.* All of these forms, however, occupied the water-courses and thus show an association which would not be in evidence if the seining could have been sufficiently selective.

21. *Chriopeops goodei* (Jordan), Redtail Killifish.

One hundred twenty-six specimens of *Chriopeops goodei* (*Lucania goodei* of several recent authors) were obtained from fifteen Bayport collections and none was taken at Cedar Key. The data on these fish are summarized:

Month	No. of Colls.	No. of Spec.	Size (mm)	Sal. (ppt)	Temp. (°C)
Feb.	1	1	27	0.8	25
June	3	27	12 – 29	1.4, 5.6, 10.3	27, 31, 25.5
July	8	87	9 – 30	0.0 – 7.5 Mean: 2.8	24.5 – 26 Mean: 25.6
Sept.	2	8	15 – 24	0.0 – 1.8	24, 24
Nov.	1	3	20 – 27	—	—

All but four of the specimens were taken from mainland waters where the salinities recorded were due to a mild or periodic influx of tide water or were derived from slightly saline springs. The four individuals which constituted exceptions were from the Gulf edge of the marsh and possibly were stragglers. The occasional tolerance, however, of salinities up to 10.3 ppt would definitely enable this species to penetrate into brackish waters and thus have an added chance for wider distribution by moving from one drainage system to another by way of the coastal marshes which connect their mouths.

22. *Cyprinodon variegatus variegatus* Lacépède, Southern Sheepshead Killifish.

A total of 6,191 specimens was collected. Of these 4,747 were in 91 collections from Cedar Key and 1,444 were found in 75 Bayport catches.

Sizes of individuals ranged from 8 mm to 63 mm. Young fish of 15 mm or less were present during all months except January, February and March, when fewer specimens were taken than for any other period of equal length (fig. 5). In a study conducted at Beaufort, N. C., Hildebrand (1917) found that *C. variegatus* had a long breeding season, both individually and collectively. For example, one of his females laid eggs over a period of about five consecutive months, and other females were found in spawning condition from mid-March to October. Thus in the warmer waters of the Gulf, it would not be surprising to find the species spawning on a year-round basis.

Little information on the rate of growth is obtainable from length-frequency curves (fig. 5).

Cyprinodon v. variegatus was taken from waters of salinities varying between 0.0 and 35.6 ppt. A preference was shown by the fish for salinities less than 20 ppt at both Bayport and Cedar Key (Tables 6, 7).

At Bayport the species exhibited a decided preference for outer pools and a lesser one for inner pools (Table 3). At Cedar Key the preference appeared to be for inner pools and water-courses (Table 3). These choices placed the fish in waters of the two areas where the submerged aquatics were either absent or not particularly abundant, and at the same time permitted it to avoid the shallows of the open bays and of the Gulf. This agrees with the findings of Reid (1954: 29) who found no individuals in the open Gulf at Cedar

Key except in the shallows very near the marsh borders of islands. Field observations were consistent with these conclusions in that this species was encountered with practical certainty where areas of unvegetated bottom were present in pools and water-courses. During extremely low tides the fish were found buried in the detritus and mud of the bottoms where they also went when disturbed.

At Cedar Key *C. v. variegatus* showed a positive association with *Fundulus c. confluentus* (0.89±0.13) and negative associations with *Menidia beryllina* (—0.56±0.15), *Eucinostomus argenteus* (—0.35±0.10), *Anchoa m. diaphana* (—0.77±0.13), and *Floridichthys c. carpio* (—0.61±0.17) (Table 8). These associations emphasize the preference exhibited by *C. v. variegatus* for marsh waters rather than for the shallows along the shores of the bays and Gulf.

At Bayport *C. v. variegatus* exhibits a positive association with all but three of the twelve species with which it is compared in Table 9,

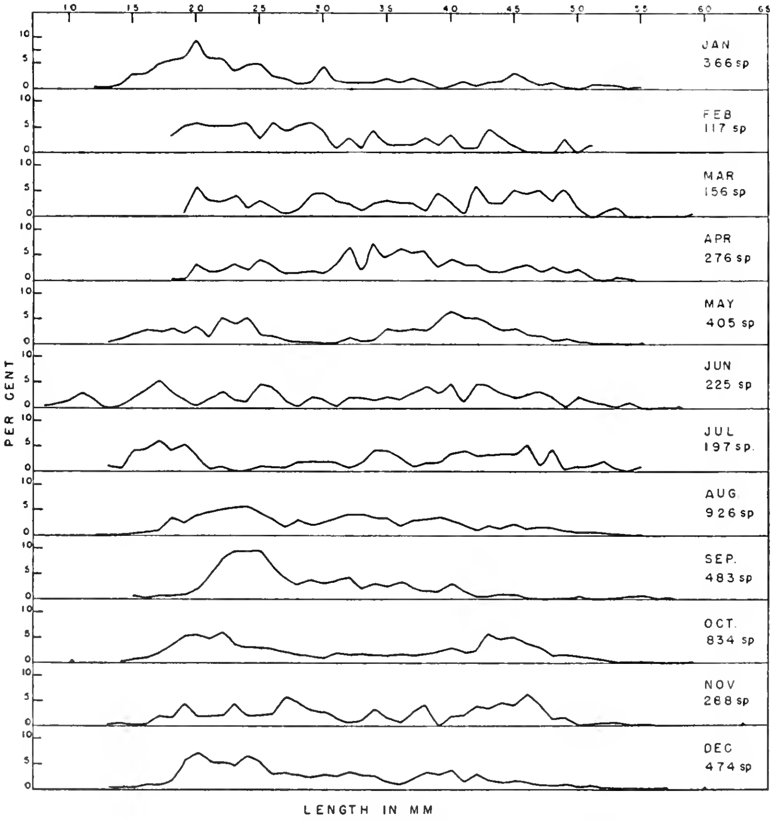

Figure 5. *Cyprinodon v. variegatus*, Cedar Key specimens. Monthly length-frequency curves.

and which constitute the bulk of the marsh fishes in that area. In short, at Bayport *C. v. variegatus* is distributed throughout the marshes to such an extent that it is to be found almost everywhere other fish occur, despite its evident habitat preferences.

23. *Floridichthys carpio carpio* (Günther), Florida Goldspotted Killifish.

Seven hundred eleven specimens were obtained. Thirty-six Bayport collections included 663 examples, and 48 were taken in ten collections from Cedar Key. Reid (1954: 29) found four individuals in trawl catches from open Gulf waters at Cedar Key and four others on shallow flats in the vicinity of islands.

Sizes ranged from 12 to 58 mm. With the exception of March, when very few (17) specimens were taken, and April and August when none was caught, young specimens of 15 mm or less appeared in all months. These young were particularly abundant from late May until mid-July at Bayport, and scattered in the remaining portion of the year. From February through July the fish were of two distinct sizes: less than 29 mm and greater than 30 mm. The young fish averaged approximately 19 mm, whereas the older group averaged about 50 mm. Except for a few stragglers, the older group disappeared during late July and the young group grew rapidly to average about 34 mm by late October. In November and December very few (35) specimens were taken at Bayport and only 39 specimens were caught at Cedar Key. These indicated that growth was slower during the colder months, but some individuals of the year reached 45 mm in December. Growth is rapid during the first several months and adulthood is reached in one year. Fish larger than sizes reached the first year are very rare. This may be the result of decreased growth rate or a failure to survive the breeding season for any appreciable time. While at Bayport the fish is most abundant during the summer, at Cedar Key only two specimens were caught between January and October.

At both Cedar Key and Bayport, *F. c. carpio* was found exclusively in two habitats (outer pools and open waters) and in both 70% of the specimens were taken from open waters (Table 3).

At Cedar Key no specimens were caught at salinities below 20.0 ppt or above 37.6 ppt; at Bayport all specimens came from salinities between 2.0 and 15.8 ppt. These data indicate that the fish is more severely restricted by habitat than by salinity, and that the combined favorable conditions, *i.e.* open waters plus moderate salinities, possibly are accountable for the greater density of population at Bayport than at Cedar Key.

As would be expected, *F. c. carpio* is shown (Table 9) at Bayport to have a positive association with species which have some preference for open waters, such as *Menidia beryllina* (0.47±0.15), *Fundulus similis* (0.47±0.09), *Eucinostomus argenteus* (0.74±0.13), and *Adinia xenica* (0.37±0.12), as well as with the ubiquitous *Cyprino-*

don variegatus (0.68±0.16). At Cedar Key, however, a negative association (—0.61±0.17) exists between *F. carpio* and *Cyprinodon variegatus,* which illustrates very nicely the fact that *Cyprinodon* and *Floridichthys* occupy different habitats when permitted to do so by the availability of their choices. *Cyprinodon* is a fish of the marshes, whereas *Floridichthys,* at least in the Bayport and Cedar Key areas, mostly occurs in the shallow shore waters of the Gulf which lie at the very edges of the marshes.

24. *Jordanella floridae* Goode and Bean, Flagfish.

Six hundred forty-four examples were taken in fifteen Bayport collections and none has been recorded for Cedar Key.

Sizes ranged from 12 mm to 39 mm and specimens less than 20 mm were taken during all seasons. Nearly 500 were caught in May and the numbers taken during the other months ranged from five to eighty-four. An inspection of the growth charts prepared for the species showed no recognizable growth rate trends.

This fish was found in waters where the salinity varied from 1.1 to 26.1 ppt, but since only 44 individuals were from salinities below 10 ppt and over 600 were from higher salinities, the data suggest that this species prefers saltier waters. This is not in agreement with the known distribution of the fish, however, for it is found in entirely freshwater situations at many points in Florida. The anomaly arises from the fact that those pools in the salt marshes where *J. floridae* was found normally have much lower salinities than happened to be present when the two collections, which contained the majority of the specimens under consideration, were made. Their presence in the waters of high salinity, however, demonstrates their tolerance of salt for at least limited periods, and this would allow the species to use the marshes as avenues in range extension. Since no specimens were taken at Cedar Key, it is assumed that the salinities of that area, which are higher than at Bayport, may act as a barrier.

All of the Bayport specimens were taken from marsh pools near the mainland and, insofar as I am aware, these records are the first to extend the ecological range of the species into brackish waters.

POECILIIDAE: Poeciliids

25. *Gambusia affinis holbrooki* Girard, Eastern Gambusia.

Eighty Bayport collections included 2026 specimens, and 29 collections from Cedar Key yielded 1,132 to make a total of 3,158, which is not a high number for *G. a. holbrooki* in Florida. In fresh waters, where it invades every possible type of habitat, I have taken over 4,000 specimens in a single short haul with a ten-foot net, and, judging from field observations, it is not unlikely that it is both the most abundant and the most frequently encountered fish in Florida fresh waters.

In the brackish marshes fish were caught which ranged from 7 mm to 47 mm. Gravid females were taken in all months of the year, as were young fish of 18 mm or less, and at any season it would have been possible to take a very small fish by using fine nets in the waters where vegetation or other cover was present.

At Cedar Key specimens were collected only from the inner pools near the mainland. Salinities in these pools are often high, sometimes quite low, and changes are rapid. At Bayport the fish was found everywhere except in open waters, but was most abundant in the inner pools and in the heavily vegetated waters. These places at Bayport normally have rather low salinities. It thus appears that the fish is most numerous in protected waters such as shallow pools and vegetated areas where the salinities are lowest, at least periodically, but it can tolerate salinities up to at least 26 ppt (Table 6).

Table 8 indicates that *G. a. holbrooki* is positively associated at Cedar Key with *Mollienesia latipinna* (1±0.31), *Adinia xenica* (0.77±0.25), and *Fundulus c. confluentus* (0.81±0.21), and at Bayport with *M. latipinna* (0.64±0.11) and *F. c. confluentus* (0.52±0.14), all of which occur in the same protected waters. Fishes not of the protected water group such as *Menidia beryllina* (—0.61±0.18) and *Fundulus similis* (—0.34±0.10) at Cedar Key, and *Eucinostomus argenteus* (—0.44±0.10) at Bayport show negative associations (Tables 8, 9).

26. *Mollienesia latipinna* LeSueur, Sailfin Molly.

Cedar Key Area.—Ten thousand eight hundred and forty-six specimens representing 32.43% of all the fish caught at Cedar Key were of this species which occurred in 93 of the 119 collections studied. On this basis, this species was more than twice as abundant and slightly more frequently encountered than the next most abundant species, *Adinia xenica*, which totaled 4,939 specimens in 84 collections.

Sizes ranged from 12 mm to 69 mm as shown by the length-frequency curves (fig. 6). Individuals less than 20 mm were encountered during all months of the year except March and April. Sizes of from 12 mm to 14 mm were obtained from mid-May to the last of September and indicate a prolonged breeding season during the warmer months of the year, at least.

In general, the size groups tend to segregate, and it was not unusual to find the entire sample of several hundred specimens from a shallow pool deep within the marshes restricted to fish of less than 35 mm in length. On the same day, a collection from a deeper pool might not contain a single specimen less than 37 mm, and yet a third collection would contain fish from 14 mm to 64 mm.

The calculation of growth rates from length-frequency curves is unreliable when it is impossible to follow the development of any one age group for consecutive months. Such a situation exists with *M. latipinna* because of the extended breeding season, the tendency to segregate into size groups, and possibly other reasons.

M. latipinna tolerates a wide salinity range and occurs in Florida in inland freshwater habitats, as well as along the coasts in protected areas of brackish water. At Cedar Key, specimens were collected in waters of salinities varying from 1.2 ppt to 37.6 ppt. Temperatures ranged from 11.5°C to 37°C. Open waters of the Gulf, bays, and bayous were avoided (Table 3). Nearly every collection made in the small marsh pools revealed the species, but it was absent in 14 of the 16 collections along the Gulf beaches and, except for one instance, all the other collections in which it was not found were from the shores of bays, from creeks or bayous, or from pools very close to the open Gulf beaches. Gunter (1945: 46) obtained only a single specimen during his work in Texas bays where the open waters, rather than the sheltered places, were studied, and Reid (1954: 29) took none in trawl catches in the Gulf at Cedar Key.

With a single exception, *M. latipinna* was dominant in the fish fauna of all pools located deep within the marshes and without direct connections with the bays or bayous. The number of individuals was as high as 61.1% of the total catch at one such pool, and as low as 43.9% in another. In pools having direct connections with larger

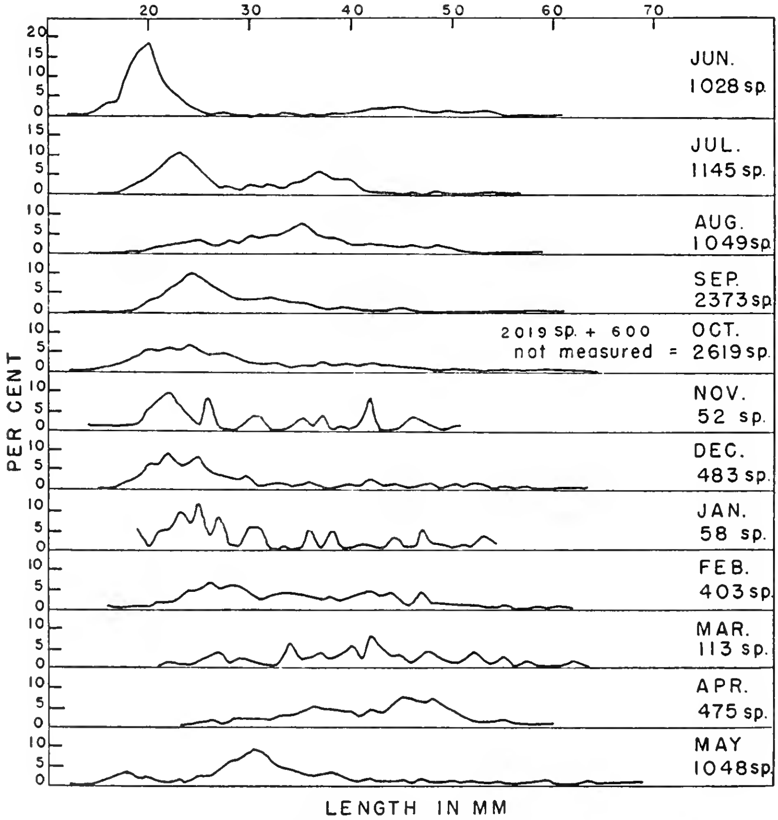

Figure 6. *Mollienesia latipinna,* Cedar Key specimens. Monthly length-frequency curves.

bodies of water, *M. latipinna* was the dominant species in numbers in two instances, but was exceeded by another species in one instance. In the bayous, along the bay shores, and at the open Gulf beach it totaled between 4% and 5.6% of the catches for the year, and from 4 to 5 species exceeded it in abundance at those stations.

At Cedar Key, *M. latipinna* appeared to be associated positively (Table 8) with *Adinia xenica* (0.72±0.11), *Cyprinodon v. variegatus* (0.60±0.03), *Gambusia affinis holbrooki* (1±0.31), and *Fundulus c. confluentus* (0.94±0.13). All of these species are conspicuous in the fauna of the sheltered waters. Negative associations existed between *M. latipinna* and *Menidia beryllina* (—0.59±0.15), and *Anchoa m. diaphana* (—0.40±0.12). Both of these species occur most abundantly in open water.

Bayport Area.—From the Bayport area 4,889 specimens of *M. latipinna* were collected and these accounted for 22.91% of all the fishes caught there. This species was taken from all the habitats studied and occurred in 95 of the 130 collections made. The next most abundant species was *Lucania parva* with 4,192 specimens (19.64%) in 98 of the 130 collections.

Sizes varied from 9 mm to 60 mm, and specimens less than 20 mm were found in all months except February, March, and December. Sizes of 14 mm or less were taken in June, July, September, October and November (fig. 7).

Segregation into size groups was apparent at times, but was not as pronounced as at Cedar Key. As was the case at Cedar Key, an inspection of the length-frequency curves gave no recognizable information on growth rates.

M. latipinna was taken at Bayport in salinities ranging from 0.0 ppt to 26.1 ppt but the distribution of the species in the marshes is not a matter of salinity, but rather one of habitat. In marsh pools isolated from water-courses, *i.e.,* the most sheltered places, 42 collections were made and *M. latipinna* was present in all but two of them. On the other hand, 42 collections were made in unsheltered places including the Gulf beach and the marsh water-courses and *M. latipinna* was absent from 19 of those collections. In 26 collections made in partially sheltered situations within the marshes *M. latipinna* was absent in five instances.

At Bayport *M. latipinna* appeared to be associated positively (Table 9) with sheltered water species including *Gambusia a. holbrooki* (0.64±0.11), and *Fundulus c. confluentus* (0.70±0.19). No negative associations were indicated.

Summary.—At both Cedar Key and Bayport *M. latipinna* was the most abundant species in the collections. In both areas it was found in all of the habitats studied, and showed greatest abundance in sheltered pools deep within the marshes. Frequently such pools at Bayport were vegetated, principally with *Chara* and *Ruppia,* whereas those at Cedar Key were not. Salinities appeared to have no determinable effect on distribution.

At Bayport a higher proportion of small fish and a lower percentage of large specimens were taken than at Cedar Key. The very small individuals were collected, almost invariably, from the heavily vegetated areas and, as has been mentioned, submerged vegetation was much more abundant at Bayport than at Cedar Key. It is assumed that many of the very small fish at Cedar Key were not collected because they were localized in the shallows in emergent vegetation where effective seining was not possible.

The smallest specimens and the greatest abundances of the small sizes were found during the warmer months of the year at both areas, which indicate an extended breeding season and eliminate the possibility of calculating growth rates by an examination of the collections. Size segregation was noticeable but not absolute. The smaller sizes were found in the shallowest and most sheltered pools, and

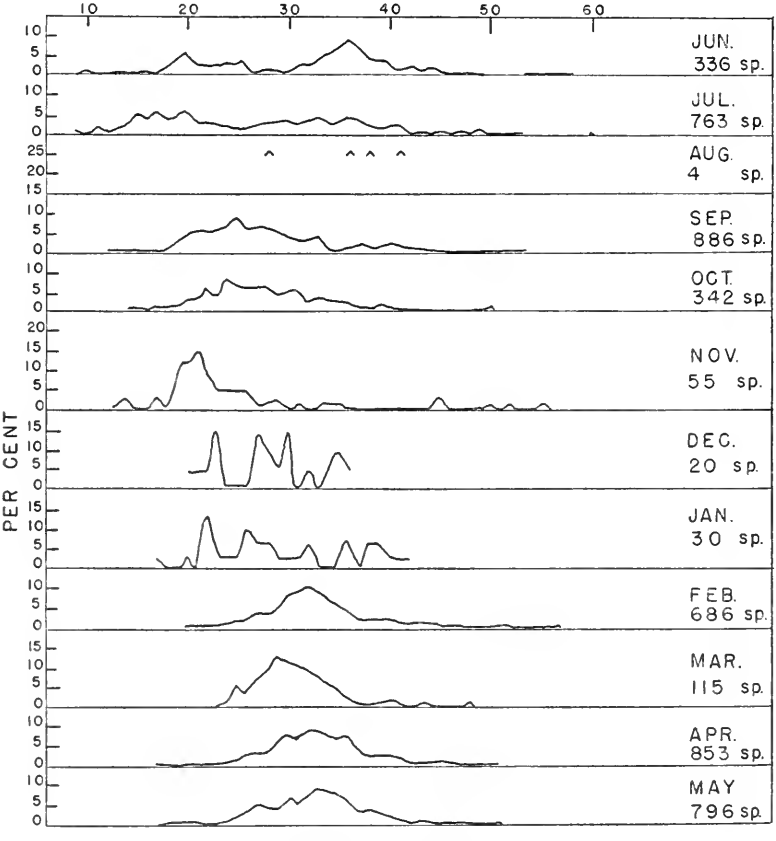

Figure 7. *Mollienesia latipinna,* Bayport specimens. Monthly length-frequency curves.

larger fish in the deeper and less sheltered places.

The total Cedar Key fish population was composed of a greater proportion (32.43%) of *M. latipinna* than the one at Bayport (22.91%). Two very obvious differences existed between the two areas: Cedar Key stations showed a higher mean salinity (20.9 ppt) than Bayport (7.1 ppt) and a paucity of the submerged aquatic plants which were fairly abundant in the Bayport habitats. Since the species occurs abundantly in fresh water, and was more abundant at Cedar Key than at Bayport, and since Cedar Key salinities were higher than the Bayport ones, salinity was not considered a major factor in the distribution or abundance of the species. On the other hand, *M. latipinna* was almost always the dominant species in numbers at those stations, both Bayport and Cedar Key, where the following conditions obtained: soft mud bottom, no submerged aquatics, sheltered pool not directly connected with a large body of water or marsh water-course. At Bayport it was frequently dominant in numbers, even when submerged aquatics were present, in the mud-bottomed, sheltered pools, but the degree of dominance was less conspicuous in these places than in the non-vegetated pools described.

27. *Heterandria formosa* (Agassiz), Least Killifish.

Four hundred seventy specimens were present in a total of 30 Bayport collections, but none was encountered at Cedar Key.

Sizes ranged from 5 mm to 23 mm. Most of the specimens (331) were taken in July, but this was due to their presence in a half dozen exploratory collections during which vegetated waters were searched intensively. Permanent, although small, populations lived in the marshes on a year-round basis. During months other than July, individuals appeared in the collections at a rate believed to reflect their relative position in the populations of these marshes much more accurately than did the large catches of July. Young fish of 15 mm or less were found at all seasons and gravid females were present during all months in which specimens were captured.

H. formosa was confined in the marshes to waters which were vegetated heavily with submerged aquatics. These places were, in order of the abundance of the vegetation, water courses, inner pools, and outer pools. The order of abundance for the fish is the same, with emphasis on numbers from the water courses (Table 3).

Although the species is a well known fresh water form in Florida and, from my observations, occurs most abundantly where the submerged vegetation is thickest, it is certain that the fish can also live in brackish marshes where it can maintain a population provided salinities are mild and cover is abundant. *H. formosa* was taken at salinities of 0.0 to 15.0 ppt, but most of the specimens were found where and when salinities were between 0.0 and 4.9 ppt (Table 7). On the basis of these data this fish may be characterized as a fresh water species which sometimes invades heavily vegetated coastal waters of low salinity.

MONACANTHIDAE: Filefishes

28. *Stephanolepis hispidus* (Linnaeus), Common Filefish.

A single 18 mm example was taken in July at Bayport from shallow, sand-bottomed, shore-waters of the Gulf (salinity 12.0 ppt, temperature 26.5°C). Exploratory collecting offshore in the bay at Cedar Key indicated that this fish was not uncommon in the areas where the bottom was vegetated.

TETRADONTIDAE: Swellfishes

29. *Spheroides nephelus* (Goode and Bean), Florida Swellfish.

Sixteen immature individuals were taken in seven collections at Cedar Key. The data on the Cedar Key collections is summarized as follows:

Month Taken	No. Colls.	No. Spec.	Sizes (mm)	Sal. (ppt)	Temp. (°C)
Apr.	1	5	10 – 25	21.2	24.5
May	1	2	16 – 17	—	—
Oct.	2	5	15 – 32	25.9 & 27.7	21.5 & 31
Nov.	2	3	20 – 25	21.2 & 31.1	22 & 25
Dec.	1	1	18	37.6	19

All were taken from mud flats or mud-bottomed marsh tide pools at the edge of the Gulf. They are frequently found on the offshore bottoms in the Gulf at both Cedar Key, where Reid (1954: 71) found it not uncommon, and at Bayport.

SPHYRAENIDAE: Barracudas

30. *Sphyraena barracuda* (Walbaum), Great Barracuda.

One immature specimen, 48 mm in length, provisionally assigned to this species, was taken in October from a pool near the Gulf edge of the marsh at Bayport. The salinity was 16.7 ppt, and the temperature 28.5°C.

MUGILIDAE: Mullets

During this study more than two thousand young mullet were collected and their identification was difficult, principally because of my inexperience with the fish. During one phase of the study I was convinced that all my material was one species, *Mugil cephalus* (Kilby 1949). Fortunately, Dr. Carl L. Hubbs read that paper, kindly directed my attention to the possibility of the presence of other species in the material, and furnished me with his notes on the characteristics of the several forms. Those notes, and examination of specimens at the Museum of Zoology, University of Michigan, enabled me to review the material and to identify three species in it. Dr. Hubbs then verified the identifications of representative samples of the three species, *M. cephalus, M. curema* and *M. trichodon.*

31. *Mugil cephalus* Linnaeus, Striped Mullet.

Two thousand one hundred thirty specimens were taken: 1,924 in 37 collections from Cedar Key; 203 in 19 Bayport catches.

Sizes ranged from 16 mm to 103 mm. This latter specimen is not shown on figure 8 which illustrates the size distribution of the fish by months. The growth of the young has been discussed previously (Kilby 1949: 19), and subtraction of the specimens of *M. curema* and *M. trichodon* from the specimens used does not change the conclusions reached on either the length of the breeding season or the rate of growth. In summary, the breeding season is long, extending from October through May at Cedar Key and from December through July at Bayport. The rate of growth, which agrees with that of Texas fish studied by Gunter (1945: 51-2), permits an October individual of approximately 18 mm to reach about 65 mm by mid-April, at which time the fish begins an exodus from the marshes

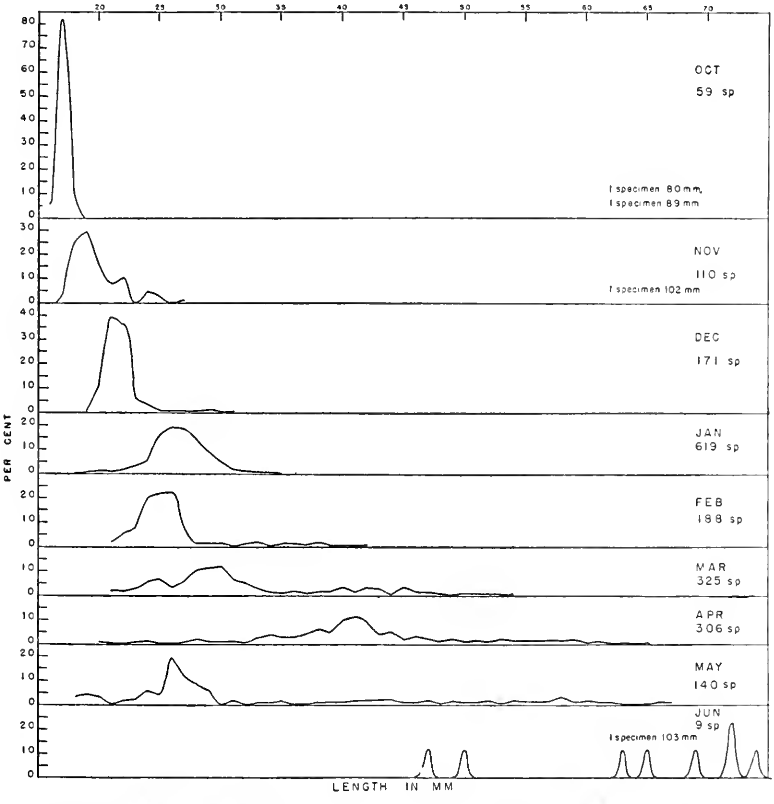

Figure 8. *Mugil cephalus*, Cedar Key specimens. Monthly length-frequency curves.

resulting at Cedar Key in a depletion of the marsh population by June. At Bayport the trends are not as sharply defined, and this is due, probably, to temperatures, which are more moderate than at Cedar Key.

At Cedar Key the young appeared in October collections and became more prominent in the fauna until January, when they constituted 39.13% of the specimens caught. Through April the young were conspicuous in the catches, but declined in May, and by the end of June disappeared entirely. At Bayport the young first appeared in November, reached a peak of 10.57% of the catches in December, and then continued irregularly in the collections through September. None was found in October, although a thorough search was conducted for them during that month.

Young *M. cephalus* were restricted almost entirely to the pools (outer and inner) at both Cedar Key and Bayport (Table 3). The open water specimens at Cedar Key were less than 20 mm in length, and it was believed that these would have entered the marshes at the next high tide, thus vacating the beach waters where they were taken.

Although *M. cephalus* was taken at salinities ranging from 2.5 ppt to 35.6 ppt at Cedar Key, most of the specimens there came from waters with salinities between 15 and 30 ppt (Table 6). The Bayport specimens were restricted largely to waters with salinities between 5 and 20 ppt. These differences are understandable when it is noted that the young fish are found most often in sheltered, mud-bottomed pools which are devoid of submerged aquatics. Both the inner and outer pools (low salinities) at Bayport, and the outer pools (high salinity) at Cedar Key, met those habitat requirements. Since during comparable collecting about ten times as many specimens were taken at Cedar Key as at Bayport, it may be that the combination of high salinity with other requirements accounts for the greater density of the former population. However, the adult population in the bay at Cedar Key is much denser than the one at Bayport, and that probably affects the number of young produced.

At Cedar Key *M. cephalus* exhibited no conspicuous association (Table 8) with any of the species with which it was tested, but at Bayport it appeared to be associated with *Jordanella floridae* (0.53±0.10), *F. c. confluentus* (0.83±0.16), and *Cyprinodon variegatus* (0.88±0.25). These associations reflect its occurrence in the pools of that area.

32. *Mugil curema* Cuvier and Valenciennes, White Mullet.

Fifty-three were taken in eight collections at Cedar Key and eight were caught in six Bayport collections. The data on these are summarized as follows:

Month	No. of Colls.	No. of Spec.	Size (mm)	Sal. (ppt)	Temp. (°C)
			Cedar Key		
Mar.	2	2	30, 30	19.1 – 15.4	19.5 – 23
Apr.	2	3	29 – 31	21.2 – 20.8	24.5 – 25
May	3	40	24 – 65	20.6 – 25.2	32 – 33
June	1	8	24 – 36	24.7	35.4
			Bayport		
May	1	1	53	24.7	24.5
June	2	2	35, 38	11.8 – 11.2	29.5 – 32
July	1	3	36 – 38	17.8	31
Aug.	1	1	65	4.1	27
Sept.	1	1	49	4.8	29

All of the Cedar Key specimens were collected in mud-bottomed, marsh pools which were very close to the open Gulf, thus accounting for the rather high salinities observed. On the other hand, all of the Bayport fish were taken from mud-bottomed, marsh pools which were near the mainland side of the marshes and (except for two specimens) at times when the salinities were relatively high for Bayport situations.

Their absence during the colder months is a reflection, perhaps, of the greater abundance of the species in more tropical waters, although it is recorded from Cape Cod on the Atlantic coast. Breeding is accomplished at Cedar Key, as is attested by the presence of specimens 24 mm in length. The season is lengthy, as fish of 30 mm or less were found from March to June. The greatest number (40) of these were caught in May.

33. *Mugil trichodon* Poey, Fan-tail Mullet.

Only 44 specimens of this interesting little mullet were caught. All came from three collections made at Cedar Key. The data recorded are summarized as follows:

Month	No. of Spec.	Sizes (mm)	Sal. (ppt)	Temp. (°C)
May	15	23 – 30	24.7	32.0
Jun.	4	47 – 58	24.7	34.5
Nov.	25	19 – 24	30.7	24.5

All were caught in mud-bottomed tide pools in the marshes adjacent to the open Gulf where the salinities were relatively high.

ATHERINIDAE: Silversides

34. *Membras vagrans vagrans* (Goode and Bean), Rough Silversides.

One hundred and ten specimens were taken in five collections at

Cedar Key. None was encountered at Bayport. The data are summarized as follows:

Month	No. of Spec.	Sizes (mm)	Sal. (ppt)	Temp. (°C)
Apr.	9	53 – 62	21.3	30
May	3	30 – 45	20.8	25
Jun.	31	26 – 43	24.4	31
Jul.	58	40 – 59	27.2	31
Oct.	9	40 – 52	30.2	25

Each collection was made in the shallow waters along the Gulf beach when the salinity was high; no specimens were encountered in the marshes.

35. *Menidia beryllina* (Cope), Glassminnow.

Three thousand seven hundred sixty-eight glassminnows were collected during this study. Sixty-nine of the Bayport collections included 1,913 individuals; the remaining 1,855 were in fifty-two of the catches at Cedar Key.

The fish were caught during all months of the year at both areas, and sizes ranged from 10 to 99 mm. The Bayport fish seldom reached 50 mm, whereas the ones from Cedar Key were about as well represented in sizes larger than 50 mm as they were in the smaller sizes. The largest fish at Cedar Key (99 mm) probably constitutes a size record. Very young fish were taken in all seasons at both localities.

An inspection of size charts prepared by months gave no definite clue to the growth rate, although field experience suggested a very rapid turnover in the population. Gunter (1945: 49) suggested a short life cycle for Texas representatives.

At Cedar Key the fish was most abundant during March and September, and at Bayport it remained a conspicuous element in the population during all seasons. The relatively large numbers taken in August were due, in part at least, to selective collecting, and thus are not to be judged as comparable to the figures for the other months.

Field experience showed that *M. beryllina* was most abundant in open waters at all sizes above about 35 mm. Below that size, particularly at Bayport, the fish was found frequently near, or more often in, the open water just above the dense mats of submerged aquatics. In a water-course or pool, however, where a central area of open water existed, even if this open water was limited to a surface stratum only a few inches in depth, *M. beryllina* could be observed in schools which kept out of the vegetation and very near the surface. Unfortunately it was not practicable to make the regular collections in a manner that would demonstrate this obvious occupancy of the open waters and, consequently, the data recorded in the vegetated areas at Bayport are misleading on this point. The almost total lack of aquatics at Cedar Key presented a different situation;

there *M. beryllina* was most abundant in the larger water bodies and tended to congregate in the centers of pools rather than in the shallows near shore. In all cases, however, the fish remained near the surface and, unless disturbed, assembled in the top twelve or eighteen inches of water.

Most of the specimens from Cedar Key were taken in the outer pools and the open waters along the Gulf shore (Table 3). At Bayport (Table 3) the species was most abundant in the outer pools and water courses, but occurred also in the open waters and the inner pools. Of these latter situations it preferred those with submerged aquatics, and few specimens were taken elsewhere.

The fish at Cedar Key were taken substantially from salinities between 15 and 30 ppt, but some were found where the salinity was as low as 2.5 ppt and others where the salinity reached 35.6 ppt (Table 6). More than half of the Bayport specimens (Table 7) were taken at salinities between 5 and 10 ppt, and almost all of the others came from within 5 ppt above or below those limits. Since this fish was about as abundant at Cedar Key as at Bayport, it appears that the degree of salinity is not important to this species, although at Cedar Key, where the salinity was higher than at Bayport, the fish grew to larger size. Gunter (1945: 44) found the fish at salinities of 0.0 ppt and on one occasion at 71.3 ppt, and in summary stated "this species was more or less equally distributed in all salinities."

At Cedar Key *M. beryllina* (Table 8) was associated positively with *E. argenteus* (0.45±0.15), *A. m. diaphana* (0.90±0.20) and *F. c. carpio* (0.82±0.27) which are all characterized as open water and/or outer pool species. Negative association at Cedar Key is shown with such protected water species as *M. latipinna* (—0.59±0.15), *A. xenica* (—0.48±0.13), *C. variegatus* (—0.56±0.15), *G. a. holbrooki* (—0.61±0.18) and *F. c. confluentus* (—0.35±0.11).

Because of the non-selective character of the seining operations at Bayport, as explained above, the associations at that area may not be characteristic.

CENTRARCHIDAE: Sunfishes

36. *Micropterus salmoides floridanus* (LeSueur), Florida Largemouth Bass.

Eighteen specimens were taken by seining at Bayport, and hundreds were observed in the channels where it is difficult to seine with sufficient rapidity to catch so wary a fish. Hook and line techniques give good results in the brackish waters if cut bait is used, and many of the local fishermen depend on the fish as a mainstay of their sport. The bass bite best during low, or nearly low, tides, and appear to favor a late afternoon feeding period. Stomachs examined contained blue crabs, needlefish, pinfish, snappers, mojarras, shrimp, *Gambusia* and catfish.

No bass were taken from the marsh pools, although the fish was common in the adjacent channels, and adults were observed on numerous occasions apparently feeding in the marshes at high tide. Thus, by avoiding the pools, the fish also avoided high salinities, and only one specimen was taken where the salinity reached 11.8 ppt.

Specimens as small as 16 mm were taken in the marshes in July but since only 18 small fish were taken, no definite conclusions could be reached relative to growth rates or the length of the breeding season in the marshes. Marjorie Carr (1942) has discussed the early development and growth of young bass from Florida waters.

37. *Lepomis punctatus punctatus* (Valenciennes), Eastern Spotted Sunfish.

One hundred sixty-six specimens were present in 28 Bayport collections, but none was found at Cedar Key.

Sizes ranged from 12 to 128 mm in the net catches, but larger specimens were taken by local sport fishermen. Very young fish were present in all seasons and nesting was observed during all months of the year, although field observation indicated that the height of the season was reached in mid-summer.

The adult fish were caught on hook and line as far out as the open bay, but, in general, the fish tended to occur abundantly only in the very mildly brackish waters near the mainland where the salt was usually less than 5 ppt. The salinity range was from 0.0 to 11.8 ppt.

The species was found at Bayport almost exclusively in inner pools and water-courses, and exhibited a decided preference for the latter (Table 3). It was absent almost invariably from all situations where the submerged aquatic vegetation was not abundant, and thus at Bayport would be restricted to the two stated habitats.

38. *Lepomis microlophus* (Günther), Redear Sunfish.

Thirty-eight specimens were obtained; these were found only in the Bayport area at salinities of 12.3 ppt or less. Five of the nine collections including this species were from the brackish channels and pools of the marshes. The other four collections were from mainland pools nearby, where occasional storm tides bring in salt water which raises the pool salinities to at least 5.6 ppt. On the Gulf side, the water yielding *L. microlophus* showed salinities up to 5.3 ppt, and in marsh pools up to 12.3 ppt, but nearly 90% of the individuals were caught where the salt was less than 5 ppt.

The smallest specimens taken were in June (12 mm) and in November (19 mm). A graph of the distribution in time by sizes, however, failed to indicate the growth rate. The breeding season is obviously a long one, since individuals 30 mm or less were taken from January through November.

Like *L. p. punctatus,* the species showed preference for the vegetated waters, particularly the inner pools, and occasionally it ventured into heavily vegetated water-courses (Table 3).

39. *Lepomis macrochirus purpurescens* Cope, Southeastern Bluegill.

Thirty-eight bluegills were taken from mainland fresh waters at

Bayport. However, one collection in June from a pool separated from the marshes by the width of a road yielded nineteen specimens at a salinity of 5.6 ppt. A month later the salinity of this pool was down to 1.2 ppt and *L. m. purpurescens* was still abundant. No specimens were encountered in the brackish marshes, although the species had ready access to those places in the Bayport area. Fish as small as 13 mm were taken in July and 16 mm specimens were found in June.

40. *Chaenobryttus coronarius* (Bartram), Warmouth.

Many specimens were collected from fresh water habitats near Bayport during the course of this study, but only three individuals were found in brackish waters. It was never taken at salinities above 1.8 ppt, but it is a resident of Salt Creek at Bayport where the salinity is usually around 1.5 ppt. Its ready access to the marshes, and its almost total absence there, is a strong indication that the fish is practically restricted to fresh water.

41. *Elassoma evergladei* Jordan, Everglades Pigmy Sunfish.

Specimens were locally abundant in the swamp waters of the mainland at Bayport and pathways were available for its emigration to the marshes nearby, but no individual was discovered in these marshes, nor in any nearby mainland waters showing the least hint of tide water influence. On this basis, the species appears to be entirely restricted to fresh water.

LUTJANIDAE: Snappers

42. *Lutjanus griseus* (Linnaeus), Gray Snapper.

Three snappers were caught in as many collections at Cedar Key, and seventeen specimens were taken in a total of eight catches at Bayport. It is much more abundant at Bayport (and possibly at Cedar Key) than the catches indicate. The bottoms of the channels at Bayport literally are covered with schools of individuals during the summer and winter months, and at low tide almost every nook and crevice in the rocks and shells contains at least one individual, even if the fish had to curl into a ball to squeeze itself into a niche. Occasional specimens would bite a baited hook, but nearly all individuals were incredibly successful at avoiding nets of any type. For instance, schools of snappers in less than five inches of water would repeatedly escape a cast net thrown over scores of them.

Longley, in Longley and Hildebrand (1941: 115-116), made interesting notes on this snapper at Tortugas, where it is "in many respects the dominant fish in the local fauna." Herald and Strickland (1949: 105) recorded it as "fairly common" in the fresh waters of Homosassa Springs, Florida.

The data for the fish caught in the present study are summarized as follows:

Month	No. of Colls.	No. of Spec.	Size (mm)	Sal. (ppt)	Temp. (°C)
			Cedar Key		
Sep.	1	1	55	24.6	31.5
Oct.	1	1	49	4.5	24.0
Nov.	1	1	57	5.5	23.0
			Bayport		
Apr.	2	2	118 – 122	7.5, 17.1	25, 26
Jun.	2	8	75 – 128	10.2, 11.8	25, 29.5
Jul.	1	1	113	7.7	33
Sep.	1	2	41 – 49	8.5	32
Nov.	2	4	41 – 115	— and 3.9	— and 22

The three Cedar Key specimens were taken from shallow bayous and marsh pools near the mainland edge of the brackish marshes. Three of the Bayport fish were from marsh pools, and the others were caught in channels of the marshes. Salinity does not appear to be a primary factor in their distribution at Bayport, as they ascend both the Weekiwatchee River and Salt Creek where salinities are usually less than 2.0 ppt.

GERRIDAE: Mojarras

43. *Eucinostomus gula* (Cuvier and Valenciennes), Common Mojarra.

A total of 312 specimens was obtained. Of these, 211 were in 9 Cedar Key collections, and 101 came from 14 catches at Bayport.

Sizes ranged from 13 to 77 mm in the marshes, but larger specimens were observed in the nets of fishermen operating offshore. At both Bayport and Cedar Key the first specimens appeared in June and by early December the species was no longer present. Gunter (1945: 65) also found it absent from his early year catches, which covered the deeper waters of the bay extending into the Gulf, as well as the shallows. Since only immature fish were taken, it appears almost certain that the adults spawn in the open Gulf and the young fish make some use of the marshes. No clue to growth rate was discernible in the charts showing monthly distribution by size.

At Cedar Key nearly all specimens were taken from the shallow waters along the Gulf beach, and at Bayport most (73%) came from the same category of habitat while, except for a few specimens, the remainder (26%) were in outer pools close by the Gulf (Table 3).

At Bayport (Table 7) nearly 90% of the specimens of *E. gula* were from waters of 5 to 15 ppt salt, whereas at Cedar Key (Table 6) over 96% were taken where the salinity was between 20 and 30 ppt. In both instances, however, the fish occupied the waters furtherest from the mainland regardless of salinity, type of bottom, or vegetation.

Concerning the habits of the fish during the early part of the calendar year, apparently little is known for the Gulf coast. A part of the lack may be due to the confusion of this species with *E. argenteus,* for several authors have mentioned experiencing that difficulty.

44. *Eucinostomus argenteus* Baird and Girard, Silver Mojarra.

Two thousand four hundred seventeen individuals were collected and most of these were from Bayport (2,141 specimens in 62 catches). The remainder (276 in 26 collections) were from Cedar Key.

Sizes ranged from 10 mm to 90 mm. At Bayport the species is a year round resident of the marshes where young fish of 16 mm or less were present during all months. At Cedar Key no specimens were found in catches for the January through April period, and very young fish were taken there only in May, October, December. Very few of the individuals were larger than 50 mm in either area, and consequently it appeared that only the young made any appreciable use of the marshes or the inshore waters of the Gulf. The young fish were most abundant at both Cedar Key and Bayport during the period May through October, but at Cedar Key a drop in numbers occurred in July, August and September.

E. argenteus, although found in all habitats, showed concentrations at Cedar Key in water courses and open waters, whereas at Bayport the concentrations were in the outer pools and the open waters (Table 3). The chart also points out the ecological difference between *E. gula* and *E. argenteus.* At both localities *E. gula* reaches the marsh area from the Gulf side but does not penetrate it to any appreciable extent, while *E. argenteus* not only reaches the marsh from the Gulf, but also conspicuously enters all its habitats except the inner pools, where it occurs rarely.

As indicated by Tables 6 and 7, salinity preferences of the two species are close, but at both Cedar Key and Bayport *E. argenteus* was found distributed throughout the possible salinities and *E. gula* was confined to a much narrower range. *E. argenteus* was recorded by Herald and Strickland (1948: 106) from the fresh waters of Homosassa Springs, Florida.

Table 8 indicates that *E. argenteus* is associated positively at Cedar Key with such open water forms as *M. beryllina* (0.45±0.15) and *A. m. diaphana* (0.62±0.12), and negatively with the protected water species represented by *Adinia xenica* (—0.35±0.11), *Cyprinodon variegatus* (—0.35±0.10), and *F. c. confluentus* (—0.39±0.13). At Bayport its positive association with *M. beryllina* (0.49±0.10) and *Floridichthys c. carpio* (0.74±0.13) indicates its preference for the open waters, whereas its additional preference for the watercourses is shown by the positive association with *Lucania parva* (0.49±0.16). Negative associations at Bayport with *Gambusia a. holbrooki* (—0.44±0.10), and *Jordanella floridae* (—0.72±0.26) are reflections of the tendency of *E. argenteus* to avoid the inner pools.

CARANGIDAE: Pompanos, Jacks.

45. *Chloroscombrus chrysurus* (Linnaeus), Bumper.

Six specimens were taken in a single collection from the shallows of the Gulf beach at Cedar Key during October. Sizes ranged from 42 to 46 mm; salinity, 30.2 ppt; temperature, 25°C. None was caught at Bayport.

46. *Oligoplites saurus* (Bloch and Schneider), Leather-jacket.

Seventy-three specimens were taken in a total of twelve Cedar Key collections, but none was caught at Bayport. A summary of the data is presented:

Month	No. of Colls.	No. of Spec.	Sizes (mm)	Sal. (ppt)	Temp. (°C)
Jun.	2	6	29 – 39	24.4, 24.7	31, 34.5
Jul.	2	23	30 – 79	26.7, 27.2	31, 33
Sep.	1	2	40, 46	28.1	30
Oct.	7	42	25 – 68	27.7 – 30.2	21.5 – 34.5

All the fish were taken from shallows along the Gulf beach or from similar shallows along the shores of the largest bays. No specimens were found inside the marshes, although their presence in the bays would probably permit them to wander into the larger channels of the marshes on occasions.

The sizes of the smallest specimens from Cedar Key indicated an extended breeding season of at least four months, but since the data did not give a clue to growth rates, the time of the season is not determinable.

47. *Trachinotus falcatus* (Linnaeus), Round Pompano.

Only a single specimen (43 mm) of this pompano was encountered. It came from shallows of the bay east of Cedar Key where the bottom was of soft mud liberally mixed with shells.

HAEMULIDAE: Grunts

48. *Orthopristis chrysopterus* (Linnaeus), Pigfish.

Two specimens were taken. One individual (173 mm) was caught in April (salinity 20.8 ppt, temperature 25°C) in the shallows along the Gulf beach at Cedar Key, and the other (143 mm) was taken in November from a marsh channel at Bayport (salinity and temperature not recorded).

SPARIDAE: Porgies

49. *Lagodon rhomboides* (Linnaeus), Pinfish.

Pinfish are very conspicuous in the offshore fauna of the Gulf at both Cedar Key and Bayport wherever the shallows are vegetated. At Cedar Key Reid (1954: 44) took over five thousand individuals from the open waters of the Gulf. Inshore they also show a preference for vegetated areas and at Bayport the channels contain both the plants and the pinfish. The catches at Bayport do not reflect the true abundance of this form because pinfish are adept at escaping capture.

Seven Cedar Key catches netted 116 specimens, and 41 of the Bayport collections totalled 190 individuals. Sizes ranged from 13 to 146 mm, but more than half of the fish were less than 50 mm in length.

The smallest fish were taken between late December and late February, and the growth charts prepared (but not included here) indicated that two size groups were present in January. The first was of small fish between 13 and 20 mm. The second group was less defined and included sizes from about 50 mm. By the end of the year the small group had reached sizes of between 45 and 80 mm and were approximately one year old. By July the larger group was represented by specimens of 100 mm or greater. The lack of large numbers of specimens does not permit precise analysis of these growth trends, but they are in substantial agreement with the Texas findings of Gunter (1945: 63) and the Cedar Key conclusions of Reid (*loc. cit.*).

At Cedar Key 85% of the specimens were from outer pools and nearly all of the remainder (14%) were taken from the shallows along the shore of the Gulf and of the bays. At Bayport the fish seldom was taken from the inner pools but was found in all other habitats (Table 3). Preference there was for the heavily vegetated water-courses and this preference is reflected in the salinity figures.

At Bayport the species preferred low salinities and more than half of the specimens were taken from waters of 5 to 10 ppt salt (Table 7). The remainder were mostly from waters within 5 ppt above and below that range. Substantially those salinities are the ones of the water-courses. At Cedar Key the salinities at which *L. rhomboides* was found are higher (15 to 30 ppt), and correspond to the salinities of the outer waters there. Herald and Strickland (1949: 106) reported the species in the fresh waters of Homosassa Springs, Florida.

In summary, as also concluded by Gunter (1945: 63), the fish does not seek out a particular salinity, and the evidence of the present study indicates that aquatic vegetation is of greater importance than the degree of salinity in the choice of habitat.

50. *Archosargus probatocephalus* (Walbaum), Sheepshead.

Only one sheepshead, a specimen of 23 mm, was taken. It came from a July collection (salinity 2.2 ppt, temperature 33°C) made in the dense mats of *Ruppia maritima* in a marsh channel at Bayport. This and other channels at Bayport contained hundreds of larger sheepshead which were repeatedly observed at night by the aid of lights. Most of these fish were 120 mm to 250 mm in length, but fishermen occasionally take larger individuals.

At Bayport the sheepshead ascends the Weekiwatchee River for at least a mile, where it was observed in waters of 1.2 ppt salinity in July. Herald and Strickland (1948: 106) record the species as common in the fresh waters of Homosassa Springs, Florida.

SCIAENIDAE: Croakers and Drums

51. *Bairdiella chrysura* (Lacépède), Silver Perch, Yellow Tail.

Eight fish were caught at Cedar Key and three at Bayport. The data are listed:

Month	No. of Spec.	Size (mm)	Sal. (ppt)	Temp. (°C)
		Cedar Key		
Apr.	1	141	20.8	25.0
Jun.	4	66 – 76	26.1	34.5
Oct.	3	97 – 108	27.3	20.0
		Bayport		
Jul.	2	34 and 53	6.4	30
Jul.	1	47	5.6	31

The April specimen from Cedar Key was caught in the shallows along the Gulf beach and all others were taken in a nearby marsh pool. Both collections at Bayport were at dead low tide at the head of the Channel in dense mats of *Ruppia maritima.*

Hildebrand and Cable (1930: 411) found *B. chrysura* spawning from late April to mid-July at Beaufort, N. C.; Welsh and Breder (1924: 171) found the height of the North Carolina season to be in May; and Gunter (1945: 66) found fish in breeding condition in April, May, and June in Texas. The sizes of specimens taken at Bayport and Cedar Key indicate a spring and early summer breeding season. Welsh and Breder discussed the growth rates and stated that the first breeding occurs at twenty-four months after hatching.

52. *Cynoscion nebulosus* (Cuvier), Spotted Sea Trout.

Six specimens were caught at Cedar Key and three at Bayport. The data are as follows:

Month	No. of Spec.	Size (mm)	Sal. (ppt)	Temp. (°C)
		Cedar Key		
Jun.	1	35	24.7	34.5
Jul.	1	53	26.7	33
Oct.	3	30, 38, 45	25.9	31
Nov.	1	58	31.1	25
		Bayport		
Jul.	2	100, 109	12.3	26
Jul.	1	130	5.1	30

One of the Cedar Key specimens was from the beach-line waters of the Gulf, another came from a nearby mud flat, and the others were taken in the marsh tide pools near the Gulf.

Two of the Bayport fish were from the Gulf margin, and the other

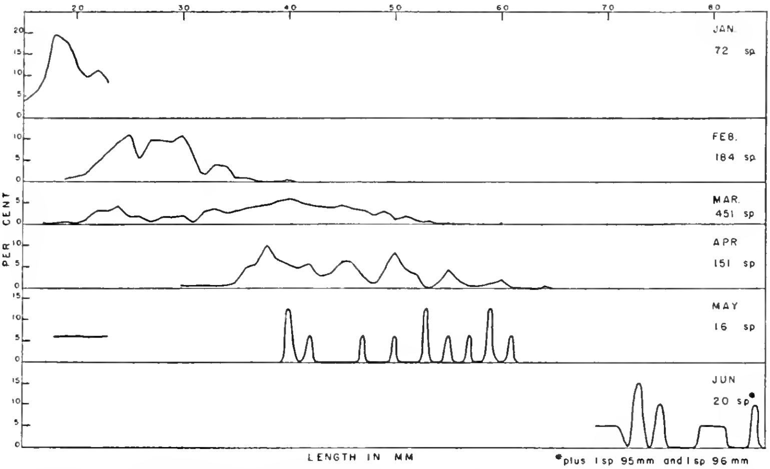

Figure 9. *Leiostomus xanthurus,* Cedar Key specimens. Monthly length-frequency curves.

from a marsh pool.

Reid (1954: 53-54) found this species not uncommon at Cedar Key and summarized Moody's (1950) study of the form in the Cedar Key area. Moody's findings were in substantial agreement with those of both Pearson (1929) and Gunter (1945: 76-78).

53. *Cynoscion arenarius* Ginsburg, Silver Sea Trout.

Four specimens were caught at Cedar Key and none at Bayport. Two (19 mm and 66 mm) were taken in June (salinity 24.4 ppt, temperature 31° C) from the Gulf beach, and two July specimens (56 mm and 70 mm) were from a mud-bottomed, tide pool near the Gulf beach (salinity 26.7 ppt, temperature 33°C).

54. *Leiostomus xanthurus* Lacépède, Spot.

Eight hundred eighty-nine spots were collected at Cedar Key. These were contained in twenty catches. Only 39 specimens were caught at Bayport and these were in five collections.

Sizes at Cedar Key (fig. 9) ranged from 15 to 96 mm. Specimens less than 20 mm were present during January, February, March and May; these small individuals indicate a breeding season lasting about the first three months of the year. Some spawning may occur for the next two months, but it is not pronounced. The length-frequency curves (fig. 9) indicate rather strongly that the January young reach sizes between about 70 and 85 mm in June, when they were taken for the last time during the year. Apparently the fish move out of the marshes in June when they have reached lengths of about 80 mm. These observations correspond with the conclusions of Reid (1954: 49-50) and of Gunter (1945: 70), who also summarized previously reported accounts. According to Gunter, spawning occurs offshore during the winter, and the young spread into the inshore shallows.

The spot showed a rather high incidence of occurrence at salinities between 15 and 20 ppt at Cedar Key (Table 6) and between 5 and 10 ppt at Bayport (Table 7). At both Cedar Key and Bayport, however, the fish was particularly partial to outer pools and was found rarely, or not at all, in the other habitats, with the exception of the water-courses (Table 3). Thus it appears that habitat, rather than salinity, is the deciding factor accounting for the young in the marshes. On the basis of these findings and those of Gunter(*op. cit.*), it is thought that the young which penetrated into the marshes at Cedar Key and Bayport were part of a much larger population which concentrated in the nearby shallows of the bays and of the Gulf.

55. *Pogonias cromis* (Linnaeus), Black Drum.

Nine specimens were taken in six May and June collections at Cedar Key. The seven May fish ranged from 17 to 43 mm, and the two June ones were 49 and 83 mm respectively. All specimens came from tide pools near the open Gulf. Salinities ranged from 20.6 to 26.1 ppt, and showed a mean of 24.3 ppt. Temperatures were all high (32°C to 34.5°C; mean 33.2°C).

56. *Sciaenops ocellata* (Linnaeus), Redfish.

One hundred forty specimens were taken at Cedar Key in a total of twenty-four collections. Only eleven redfish were caught at Bayport and these appeared in three November collections.

Sizes were from 12 to 146 mm, excluding specimens taken by hook and line. The smallest fish appeared in the fall catches (September and October at Cedar Key, and November at Bayport). The Cedar Key fish grew rapidly, by late November their sizes centering around 46 mm, and by the following March most of these passing 100 mm in length.

These conclusions are not at variance with the findings of Pearson (1929) and Gunter (1945) who concluded that their Texas specimens were a year old at about 300 mm.

At Cedar Key the young redfish were most abundant in open waters, outer pools, and water-courses, in that order (Table 3). At Bayport, the few fish caught came from open waters and water-courses.

More than half of the specimens taken at Cedar Key were from waters where the salinity ranged between 25 and 30 ppt, but the fish was also caught at salinities which went as low as 0.8 ppt and as high at 37.6 ppt (Table 6).

The adults are well known, marine littoral fish which feed both on the bottom and pelagically, and my field experience supports the findings of Gunter (1945) and Pearson (1929) in these respects. Night observations in the clear waters at Bayport showed that the adults were most abundant in the channels, and almost invariably they were seen on, or very near, the bottom where they appeared to be searching for food.

EPHIPPIDAE: Spadefishes

57. *Chaetodipterus faber* (Broussonet), Spadefish.

One 20 mm specimen was taken in October at Cedar Key from the inshore shallows of the bay. The salinity was 26.5 ppt and the temperature 26°C. The bottom was of mud and shell, soft and unvegetated.

TRIGLIDAE: Sea Robins

58. *Prionotus tribulus* (Cuvier), Bighead Sea Robin.

Seven of these sea robins were caught in a total of five Cedar Key collections, but none was taken at Bayport. The catches were made in February (1 specimen of 30 mm, salinity 27.2 ppt, temperature 24°C), October (2, 10 and 14 mm; 25.9 ppt; 31°C), October (2, 20 and 24 mm; 27.7 ppt; 21.5°C), November (1, 13 mm; 23.8 ppt; 17.3°C), and November (1, 13 mm; 21.2 ppt; 22°C). All of the catches were made where the Gulf meets the marsh, and at times of relatively low temperatures and high salinities.

BATRACHOIDIDAE: Toadfishes

59. *Opsanus beta* (Goode and Bean), Toadfish.

Nineteen specimens were taken in three Cedar Key collections and sixteen were included in nine Bayport catches. Sizes ranged from 19 to 175 mm at Bayport, and from 32 to 130 mm at Cedar Key. The species is a secretive form and hides in any cover available. It is abundant about oyster bars; 18 of the 19 Cedar Key specimens were caught in the Gulf shallows by hand at low tide from tiny basins of water under clumps of exposed oyster shells. The Bayport specimens were obtained by seining in dense mats of *Ruppia maritima.*

The smallest Bayport individuals were caught in two July collections, and by November this age group may have grown to approximately 65 mm in length.

At Bayport, salinities ranged from 1.8 to 7.9 ppt (mean, 5.5 ppt) and temperatures 23°C to 32°C (mean, 27.5°C). The Cedar Key salinities were 24.4, 27.7, and 37.6 ppt; the respective temperatures were 31°C, 21.5°C, and 19°C. These collections were in August, October, and December, while the Bayport ones were made in February, June, July, September and November.

The species is undoubtedly more abundant than is indicated for either area, but it is not a marsh form. It occasionally may be found on the Gulf edge of the marshes, and may even penetrate into them where cover in the form of shells or vegetation is available in the channels.

SYNGNATHIDAE: Pipefishes and Seahorses

60. *Syngnathus scovelli* (Everman and Kendall), Scovell's Pipefish.

Twenty specimens were taken: twelve from Cedar Key in two collections, and eight from Bayport in eight collections. Sizes ranged from 33 to 78 mm at Bayport and from 35 to 78 mm at Cedar Key. Specimens 35 mm or less were taken in November at Cedar Key and in June at Bayport.

The Cedar Key individuals were all taken in November, where the salinities were 31.1 and 23.8 ppt, and the respective temperatures 25°C and 17°C, from a shallow tide basin on the beach (11 specimens) or in the adjacent shallows of the open Gulf (1 specimen).

All of the Bayport individuals were taken in seine hauls over *Ruppia* covered bottoms in either the exposed Gulf beach situations, or in waters directly connected with those places. Salinities ranged from 4.8 to 11.8 ppt (mean = 7.6 ppt). Temperatures of 14.5°C to 33.5°C were recorded (mean = 29.2°C). Specimens were taken at Bayport in June (3), July (3), September (1), and November (1). No individuals were encountered in the interior of the marshes or in the fresh waters of the nearby streams, although the fish has been shown to be an abundant, year-round, continuously breeding, resident of the inshore Gulf waters at Cedar Key (Reid 1954: 24-25).

61. *Syngnathus floridae floridae* (Jordan and Gilbert), Florida Pipefish.

Twenty-one specimens were caught at Cedar Key. Nineteen of these came from a shallow tide basin on the open sand beach of the Gulf (salinity 31.1 ppt, temperature 25°C) during November, and the others were taken from the nearby shallow, shore-line waters of the open Gulf in November (salinity 23.8 ppt, temperature 17°C) and December (salinity and temperature not taken). Sizes ranged from 58 to 102 mm in November, and the December specimen was 74 mm in length. The species is met with frequently in the grassy areas of the open Gulf, as shown by Reid (1954: 26).

62. *Syngnathus louisianae* (Günther), Louisiana Pipefish.

Two specimens were taken from a very small tide basin on the open sand beach at Cedar Key in November. The salinity was 31.1 ppt, the temperature 25°C, and the sizes of the fish 89 mm and 164 mm. The species is not a common resident in the nearby shallows of the open Gulf where Reid (1954: 25) took only thirteen specimens during his intensive survey.

63. *Micrognathus crinigera* (Bean and Dresel), Least Pipefish.

One diminutive specimen of 42 mm was found during November in a tiny tide basin on the open sand beach of the Gulf at Cedar Key where the water was only about two inches deep. At the same time, thirty-two other pipefish, representing the previously mentioned three species, were taken, but subsequent collecting in the same basin failed to produce specimens of any of the forms. The pipefish were caught in water which had a salinity of 31.1 ppt and a temperature of 25°C. Reid (1954: 27) found them regularly, but not abundantly, in his collections in the offshore waters at Cedar Key.

64. *Hippocampus hudsonius punctulatus* Guichenot, Seahorse.

One specimen of 26 mm (salinity 31.1 ppt, temperature 25°C) was taken in November and another of approximately 100 mm (salinity and temperature not recorded) was caught in December. Both came from vegetated bottoms in the shallow waters along the Gulf margin at Cedar Key. No seahorses were taken at Bayport.

GOBIIDAE: Gobies

65. *Bathygobius soporator catulus* (Girard), Mapo.

Four Cedar Key collections included one specimen each and all were taken from shallow, shore-line waters of the Gulf, or from a nearby tide pool in the marsh. The data are: February (64 mm, salinity 26.1 ppt, temperature 25°C), November (30 mm, 23.8 ppt, 17°C), December (26 mm, 37.6 ppt, 19°C; 37 mm, 28.1 ppt, 23°C).

66. *Microgobius gulosus* (Girard), Large-mouthed Goby.

Two hundred fifty-six specimens of this fish were caught. The majority (235) were taken in fourteen collections at Cedar Key; twenty-one came from ten Bayport catches.

Sizes ranged from 12 to 62 mm. The smallest fish were taken at Bayport in late September and at Cedar Key during May. This indicates an extended breeding season, and the presence of individuals of 25 mm or less during all seasons of the year indicates either a continuous breeding season, or very slow growth of the young. Although the data do not prove the point, the growth charts prepared suggest a rather rapid development which produced 35 mm specimens in approximately one year; these reached maximum sizes within the next six to eight months.

The majority of the Cedar Key specimens were taken from outer pools and the few Bayport individuals were scattered throughout the possible habitats (Table 3). It was noted at Bayport, however, that the fish were taken almost exclusively where the bottom was muddy and the submerged aquatic vegetation was dense, and that at Cedar Key the species was most abundant in the deepest part of a mud-bottomed, outer pool.

At Bayport *M. gulosus* was never taken in water above salinity 10.5 ppt, and at Cedar Key it was never found below 15.4 ppt. This indicates that salinity is not of prime consideration, although the greater abundance of the species at Cedar Key may be a reflection of the higher salinities there. On the other hand, its occurrence in the St. Johns River as far south as Welaka, where the water is almost fresh, strengthens the idea of wide salinity tolerance (Everman and Kendall 1900: 91).

67. *Gobiosoma bosci* Lacépède, Naked Goby.

Four collections at Cedar Key yielded twenty-nine specimens. The collections were made in February (11 specimens; salinity 26.1 ppt; temperature 25°C), April (13, 20.8 ppt; 25°C), May (3, 24.7 ppt; 32°C), and July (2, 26.1 ppt; 32°C). None was caught at Bayport, and all of those from Cedar Key came from one marsh pool near the open Gulf. The smallest specimen (15 mm) was caught in February and the largest (46 mm) in May. The size distribution by months does not give information regarding growth trends.

68. *Gobionellus stigmaturus* Goode and Bean, Spot-tailed Goby.

Two specimens were obtained at Cedar Key. One was caught in October (salinity 22.9 ppt, temperature 27°C) and the other in November (salinity 21.2 ppt, temperature 22°C). Both were in Gulf shore waters with mud bottoms. None was found at Bayport and, since Reid (1954: 58) did not find the species at Cedar Key, the form appears to be rare in the areas studied.

69. *Gobiosoma robustum* Ginsburg, Robust Goby.

Five specimens were collected at Cedar Key in two December catches (salinity 37.6 ppt, temperature 19°C, and salinity 28.1 ppt, temperature 23°C). Two were taken at Bayport in one January catch (salinity 7.0 ppt, temperature 18°C). All specimens were from Gulf shore waters where the bottom was muddy. Sizes ranged from 16 mm to 28 mm in December, and from 18 mm to 21 mm in January.

Reid (1954: 59) found *G. robustum* abundant on the shallow flats at Cedar Key, but much less so in deeper waters. These data indicate that the species lives in the bays and approaches the shore only in the coldest months of the year.

BLENNIIDAE: Blennies

70. *Chasmodes saburrae* Jordan and Gilbert, Florida Blenny.

In July, 1947, at Bayport there was an extremely low tide which lasted most of the night of the sixth. While walking on the exposed bottom of the Gulf approximately half a mile from the normal shoreline, I found one 27 mm specimen of *C. saburrae* in a half-cup of water under a cluster of oyster shells. Many specimens of sizes ranging up to 103 mm have been taken from the open Gulf at Cedar Key by myself and by Reid (1954: 61-62), but at no time was the form found in the marshes.

BOTHIDAE: Left-eyed Flounders

71. *Etropus crossotus atlanticus* (Parr), Atlantic Fringed Flounder.

One 60 mm specimen was taken in August from the shallow water near the Gulf beach at Cedar Key where the salinity was 24.4 ppt and the temperature 31°C. Reid (1954: 64) regularly encountered it in small numbers at Cedar Key, particularly in channels and on deep flats of the open Gulf.

72. *Paralichthys albigutta* Jordan and Gilbert, Gulf Flounder.

A single, 65 mm specimen was caught at Cedar Key from a marsh pool near the open Gulf in April (salinity 20.8 ppt, temperature 25°C). Reid (1954: 65) found it not uncommon at Cedar Key where he took many small individuals from the grassy flats near shore and larger fish from the deeper waters worked by trawl.

ACHIRIDAE: Broad Soles

73. *Trinectes maculatus fasciatus* (Lacépède), Southern Hogchoker.

Five Cedar Key collections included nine specimens of *T. m. fasciatus* (*Achirus fasciatus* Lacépède of many authors) and none was taken at Bayport, although the form is locally abundant in Weekiwatchee Spring at the head of the Weekiwatchee River. It has also been recorded from a number of other fresh water situations in Florida reaching from tributaries of the Apalachicola River in Liberty County to Silver Springs in Marion County.

The Cedar Key specimens were taken in March (salinity 2.5 ppt, temperature 15.5°C), April (19.6 ppt, 29°C), and October (18.8, 19.4 and 21.8 ppt; 33.5°C, 34.5°C, and 28°C). Sizes of individuals ranged from 10 to 30 mm in October to 24 to 36 mm in March and April. All specimens were taken from shallows with mud bottoms, either in marsh pools or imediately adjacent to the marshes in the shore waters of the smaller bays. Reid (1954: 66) encountered the species irregularly in trawl catches at Cedar Key.

Gunter (1945: 87-88) found the fish an inhabitant of both Gulf and bay habitats, and he caught most of his specimens in bottom trawls where the salinity was above 10.0 ppt. The species inhabits fresh, brackish, and saline waters along the Gulf coast and thus may be said to be euryhaline.

74. *Achirus lineatus* (Linnaeus), Striped Sole.

Twelve Cedar Key collections included a total of 46 specimens of this sole and two were taken at Bayport in as many collections. The Cedar Key fish were from three areas; fourteen were caught from a small cove of the Gulf, 24 were in a marsh pool near the Gulf, and eight were found in marsh pools close to high ground of the mainland. All were taken from mud bottoms. Seventeen of the smallest specimens were taken in late October from waters no more than an inch deep in a Gulf cove where the mud was soft, deep, and mixed with oyster shells. Three of these fish were 11 mm, and twelve were less than 17 mm. Subsequent catches indicate a fairly regular growth through the months until the following September, when the smallest was 33 mm. Although the total number of specimens involved was small, no exceptions to this growth rate were observed. It is possible, then, that the breeding season is restricted to the early fall or late summer and that growth is slow: from 11 mm in October to approximately 33 mm a year later. Reid (1954: 67), who took thirty-three specimens at Cedar Key from a number of habitats, agrees with this assumption of a slow growth rate.

One specimen was taken when the salinity was 2.5 ppt. The others were all caught when it was from 19.6 to 30.2 ppt. Temperatures varied from 15°C to 31°C.

The two Bayport specimens were both taken from shallows at the edge of the open Gulf in September (salinity 5.4 ppt, temperature

30.5°C) and October (salinity 2.0 ppt, temperature 25°C), and were possibly year old fish of 28 mm and 33 mm respectively.

Gunter (1945: 88) caught 125 of these soles from the bays and Gulf. His data on temperature and salinity are in striking agreement with those presented here.

Considering both the findings of Gunter (*op. cit.*) and those of the present study, *A. lineatus* appears to be a slow-growing, bottom species inhabiting the bays where salinities are moderate, but occasionally wandering into bay and marsh areas of low salinity, and also into the more saline Gulf waters.

CYNOGLOSSIDAE: Tonguefishes

75. *Symphurus plagiusa* (Linnaeus), Tonguefish.

Two specimens, one in March (83 mm), one in December (30 mm), were taken at Cedar Key from waters of salinities 15.4 and 37.6 ppt respectively. Both came from muddy bottoms of waters near the open Gulf: one from a shallow cove, the other from a marsh pool. Water temperatures were relatively low, 23°C in March, and 19°C in December.

DISCUSSION

It will be recalled that compared with Bayport, the Cedar Key marshes were described as being much wider, more saline, less intimately interdigitating with freshwater habitats, almost lacking in submerged aquatics, and having more variable water temperatures.

There can be little doubt that these and other differences are reflected in the fish populations. Figure 10 shows the percentage of the total catch at Bayport represented by each of the most abundant fifteen species and the comparable percentages for fourteen species at Cedar Key. The figure makes it clear that, although there is considerable similarity in population composition by species, there is a marked difference in abundance of most of the species between the two areas. A consideration of the entire species list, however, showed other conspicuous differences. These are summarized as follows:

	Cedar Key	*Bayport*
Number of species collected	55	49
Number of species found in one area but not in the other	26	20
Number of species known to be permanent residents of fresh water but also found in brackish water	5	19
Number of marine species also found in brackish water	36	17

Twenty-nine species were found at both Cedar Key and Bayport. Only five of these were restricted to the brackish marshes and the immediately adjacent waters. These were: *Fundulus similis, Fundulus grandis grandis, Adinia xenica, Cyprinodon variegatus variegatus,*

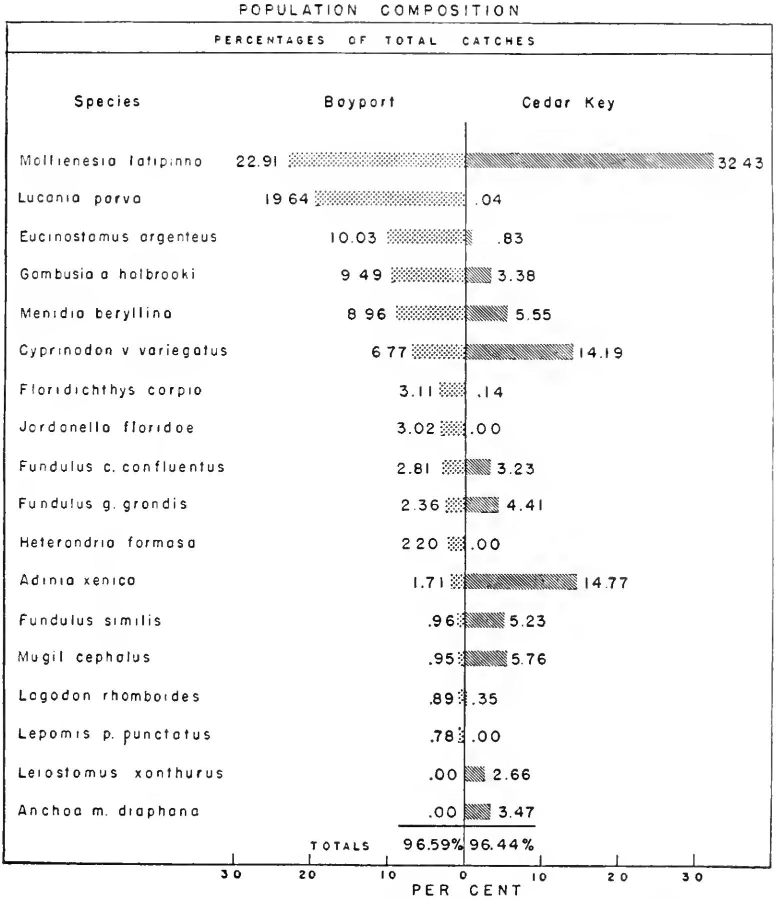

Figure 10. Population composition for Bayport and Cedar Key fishes. Percentage composition is shown for the most abundant species.

and *Floridichthys carpio carpio*.

These species are all members of the family *Cyprinodontidae* and their numbers constituted 38.75% of all fish taken at Cedar Key and 14.8% of the total at Bayport. If other cyprinodontid fishes which are adapted equally to brackish and to fresh waters were included, the list would show the addition of *Fundulus confluentus confluentus, Lucania parva, Gambusia affinis holbrooki,* and *Mollienesia latipinna.*

The equivalent percentages of the total catch would be raised to 77.84 at Cedar Key and to 69.74 for Bayport, and the fact that the two percentages are now subequal re-emphasizes that the primary ecological difference between the Cedar Key and Bayport habitats is one of salinity. A reflection of this same difference may be seen in the composition of the lists of the species which occurred at one of the two areas but not at the other. These species can be characterized briefly as marine (M), fresh water (F), catadromous (C), and fresh water and marine (FM). The lists are as follows:

Species found only at Bayport

Dasyatis sabina (M), *Lepisosteus platyrhyncus* (F), *Notemigonus chrysoleucas bosci* (F), *Notropis petersoni* (F), *Ameiurus natalis erebennus* (F), *Anguilla bostoniensis* (C), *Fundulus chrysotus* (F), *Chriopeops goodei* (F), *Jordanella floridae* (F), *Heterandria formosa* (F), *Stephanolepis hispidus* (M), *Sphyraena barracuda* (M), *Micropterus salmoides floridanus* (F), *Lepomis punctatus punctatus* (F), *Lepomis microlophus* (F), *Lepomis macrochirus purpurescens* (F), *Chaenobryttus coronarius* (F), *Elassoma evergladei* (F), *Archosargus probatocephalus* (M), and *Chasmodes saburrae* (M). Totals: Fresh water species, 14; Marine, 5; Catadromous, 1.

Species found only at Cedar Key

Elops saurus (M), *Harengula pensacolae* (M), *Anchoa mitchilli diaphana* (M), *Synodus foetens* (M), *Myrophis punctatus* (M), *Spheroides nephelus* (M), *Mugil trichodon* (M), *Membras vagrans vagrans* (M), *Chloroscombrus chrysurus* (M), *Oligoplites saurus* (M), *Trachinotus falcatus* (M), *Pogonias cromis* (M), *Chaetodipterus faber* (M), *Prionotus tribulus* (M), *Syngnathus floridae floridae* (M), *Syngnathus louisianae* (M), *Micrognathus crinigera* (M), *Hippocampus hudsonius punctulatus* (M), *Bathygobius soporator catulus* (M), *Gobiosoma bosci* (M), *Gobionellus stigmaturus* (M), *Etropus crossotus atlanticus* (M), *Paralichthys albigutta* (M), *Trinectes maculatus fasciatus* (FM), *Symphurus plagiusa* (M). Totals: Fresh water species, 1 (?); Marine, 25.

Thus it is evident that those species peculiar to Cedar Key include, at best, only one freshwater representative. On the other hand, more than two-thirds of those found only at Bayport live principally in fresh waters.

On the basis of these differences in population composition, there appears little doubt that salinity is an important factor in shaping the faunas of these two brackish marshes. Other possibly significant factors have been suggested previously. Among these the availability of species capable of adjusting to the total ecology of the marshes must be considered.

Both of the areas studied border directly on the shallow, eulittoral zone of the Gulf of Mexico and, although this zone has not been studied at Bayport as intensively as it has at Cedar Key, it is obvious to anyone familiar with both localities that the offshore fish faunas are similar, if only their qualitative make up be considered. Equally obvious, however, is the fact that the overall population density at Cedar Key far exceeds that at Bayport. It seems very likely that this greater population density would provide more opportunity for individual marine fish to invade the brackish marshes there than in the case of Bayport waters. Contrariwise, fresh waters at Bayport, occupied by a variety of fishes, intimately interdigitate with the brackish marshes, while at Cedar Key such fresh waters are limited and discontinuously distributed. Thus, to the factors of propinquity and accessibility alone may be attributed part of the faunal divergence (both quantitative and qualitative) of the two areas. Obviously, however, an accurate appraisal of the contribution of these influences, as compared to other ecological factors, would be difficult, if not impossible, to make.

Regardless of the relative importance of the factors of salinity and the availability of species, the fishes which occur in greatest abundance in the brackish marshes at both Cedar Key and Bayport are mostly species which belong to freshwater groups. Sixteen species contributed more than 96% of the total catch of individuals at Bayport (fig. 10). Of these, only three (*Eucinostomous argenteus, Mugil cephalus* and *Lagodon rhomboides*) can be considered euryhaline representatives of marine groups of fishes. The other thirteen, clearly belonging to freshwater families, contributed 87.72% of the total catches of individuals. In like manner, fourteen species account for more than 96% of the catches at Cedar Key. Of these, only five (*Eucinostomous argenteus, Mugil cephalus, Lagodon rhomboides, Leiostomus xanthurus* and *Anchoa m. diaphana*) are from marine families, while the remaining nine, all of freshwater groups, contributed 83.37% of the Cedar Key total. Expressing this another way, approximately 85% of the specimens caught during this study in the brackish marshes were of species belonging to freshwater, or to freshwater-brackish water, groups.

It is also of interest that within this list of five marine species, none is known to breed in the marshes. Contrarily, all of the nonmarine group of species not only breed in the brackish marshes but maintain permanent populations there. On the basis of these data rests the conclusion that the brackish waters of the intertidal marshes at Cedar Key and at Bayport are populated principally by species which have freshwater, rather than marine, affinities. Moreover, although many marine species invade the brackish marshes temporarily, it is the freshwater fishes which are contributing most conspicuously to the permanent occupancy of the marshes by their establishment of resident breeding populations.

In general, the above condition usually obtains in Florida waters, but there are several striking exceptions of typically marine groups with species which have established breeding populations in fresh waters. Also an imposing list of typically marine species temporarily go far inland in Florida fresh waters.

SUMMARY

A study was made of the fish faunas of two coastal marshes on the Gulf Coast of Florida to determine, primarily, the composition of

TABLE 3.

Distribution of Fishes by Habitats for Cedar Key and Bayport. Shown are the Total Number of Specimens by Species and the Percent of this Total Collected from the Several Habitats. For Comparison, the Habitat Distribution of the Total Catch is Shown.

Species	CEDAR KEY					BAYPORT				
	Total Number of Specimens	Habitats and Percentage of Specimens				Total Number of Specimens	Habitats and Percentage of Specimens			
		Inner Pools	Outer Pools	Water Courses	Open Waters		Inner Pools	Outer Pools	Water Courses	Open Waters
Total All Species	33,443	50.38	35.89	2.92	10.81	21,343	39.44	27.65	21.57	11.34
Dasyatis sabina	0	—	—	—	—	1	—	—	100.00	—
Lepisosteus platyrhyncus	0	—	—	—	—	3	—	—	100.00	—
Elops saurus	19	47.37	42.11	—	10.53	0	—	—	—	—
Harengula pensacolae	4	—	—	—	100.00	0	—	—	—	—
Anchoa m. diaphana	1,160	—	.78	.08	99.14	0	—	—	—	—
Synodus foetens	5	—	—	—	100.00	0	—	—	—	—
Notemigonus c. bosci	0	—	—	—	—	74	95.96	—	4.04	—
Notropis petersoni	0	—	—	—	—	37	—	—	100.00	—
Ameiurus n. erebennus	0	—	—	—	—	10	50.00	—	50.00	—
Hyporhampus unifasciatus	22	—	—	—	100.00	3	—	—	66.67	33.33
Strongylura notata	14	—	42.86	—	57.14	40	2.50	17.50	2.50	77.50
Strongylura timucu	40	2.50	5.00	7.50	85.00	53	—	18.87	32.08	49.06
Anguilla bostoniensis	0	—	—	—	—	1	—	—	100.00	—
Myrophis punctatus	1	—	—	—	100.00	0	—	—	—	—
Fundulus chrysotus	0	—	—	—	—	29	37.93	—	62.07	—
Fundulus similis	1,750	30.00	40.91	8.00	21.09	204	17.65	36.76	.49	45.10
Fundulus g. grandis	1,476	30.08	51.02	11.72	7.18	503	7.36	45.13	30.42	17.10
Fundulus c. confluentus	1,080	67.87	30.83	.18	1.11	599	61.77	33.22	5.01	—
Adinia xenica	4,939	59.71	35.92	2.59	1.78	364	1.37	71.43	26.92	.27
Lucania parva	13	30.77	69.23	—	—	4,192	14.58	27.31	41.65	16.46
Chriopeops goodei	0	—	—	—	—	126	29.37	—	70.63	—
Cyprinodon v. variegatus	4,747	57.49	31.47	7.18	3.86	1,444	41.62	51.45	3.81	3.12
Floridichthys c. carpio	48	—	20.83	—	79.17	663	—	28.05	—	71.95
Jordanella floridae	0	—	—	—	—	644	100.00	—	—	—
Gambusia a. holbrooki	1,132	100.00	—	—	—	2,026	54.64	22.21	23.15	—
Mollienesia latipinna	10,846	74.85	23.94	.51	.70	4,889	82.59	6.97	10.21	.23
Heterandria formosa	0	—	—	—	—	470	42.13	.85	57.02	—
Stephanolepis hispidus	0	—	—	—	—	1	—	—	—	100.00
Sphoeroides nephelus	16	—	37.50	—	62.50	0	—	—	—	—
Sphyraena barracuda	0	—	—	—	—	1	—	100.00	—	—
Mugil cephalus	1,927	5.09	79.87	.73	14.32	203	59.61	40.39	—	—

Mugi lcurema	53	—	100.00	—	—	8	87.50	12.50	—	—
Mugil trichodon	44	—	100.00	—	—	0	—	—	—	—
Membras v. vagrans	110	—	—	—	100.00	0	—	—	—	—
Menidia beryllina	1,855	2.86	71.37	1.35	24.42	1,913	17.41	45.27	25.77	11.55
Micropterus s. floridanus	0	—	—	—	—	18	72.22	—	27.78	—
Lepomis p. punctatus	0	—	—	—	—	166	36.14	.60	63.25	—
Lepomis microlophus	0	—	—	—	—	38	84.21	—	15.79	—
Lepomis m. purpurescens	0	—	—	—	—	38	100.00	—	—	—
Chaenobryttus coronarius	0	—	—	—	—	22	81.82	—	18.18	—
Elassoma evergladei	0	—	—	—	—	3	100.00	—	—	—
Lutjanus griseus	3	33.33	—	66.67	—	17	5.88	29.41	64.71	—
Eucinostomus gula	211	—	.47	—	99.53	101	—	25.74	.99	73.27
Eucinostomus argenteus	276	6.52	38.04	13.77	41.67	2,141	.51	54.18	17.33	27.98
Chloroscombrus chrysurus	6	—	—	—	100.00	0	—	—	—	—
Oligoplites saurus	73	—	4.11	—	95.89	0	—	—	—	—
Trachinotus falcatus	1	—	—	—	100.00	0	—	—	—	—
Orthopristis chrysopterus	1	—	—	—	100.00	1	—	—	100.00	—
Lagodon rhomboides	116	—	85.34	.86	13.79	190	1.05	34.21	45.26	19.47
Archosargus probatocephalus	0	—	—	—	—	1	—	—	100.00	—
Bairdiella chrysoura	8	—	87.50	—	12.50	3	—	—	100.00	—
Cynoscion nebulosus	6	—	33.33	—	66.67	3	—	33.33	—	66.67
Cynoscion nothus	4	—	50.00	—	50.00	0	—	—	—	—
Leiostomus xanthurus	889	1.57	86.84	2.70	8.89	39	—	76.92	23.08	—
Pogonias cromis	9	—	88.89	—	11.11	0	—	—	—	—
Sciaenops ocellatus	140	2.86	32.86	20.71	43.57	11	—	—	9.09	90.91
Chaetodipterus faber	1	—	—	—	100.00	0	—	—	—	—
Prionotus tribulus	7	—	14.29	—	85.71	0	—	—	—	—
Opsanus beta	19	—	—	—	100.00	16	—	50.00	43.75	6.25
Syngnathus scovelli	12	—	—	—	100.00	8	—	37.50	12.50	50.00
Syngnathus floridae	21	—	—	—	100.00	0	—	—	—	—
Syngnathus louisianae	2	—	—	—	100.00	0	—	—	—	—
Micrognathus crinigera	1	—	—	—	100.00	0	—	—	—	—
Hippocampus h. punctulatus	2	—	—	—	100.00	0	—	—	—	—
Bathygobius s. catulus	4	—	25.00	—	75.00	0	—	—	—	—
Microgobius gulosus	235	.43	95.32	—	4.26	21	28.57	28.57	9.52	33.33
Gobiosoma bosci	29	—	100.00	—	—	0	—	—	—	—
Gobiosoma robustum	5	—	—	—	100.00	2	—	—	—	100.00
Gobionellus stigmaturus	2	—	50.00	—	50.00	0	—	—	—	—
Chasmodes saburrae	0	—	—	—	—	1	—	—	—	100.00
Etropus c. atlanticus	1	—	—	—	100.00	0	—	—	—	—
Paralichthys albigutta	1	—	100.00	—	—	0	—	—	—	—
Trinectes m. fasciatus	9	88.89	11.11	—	—	0	—	—	—	—
Achirus lineatus	46	17.39	45.65	—	36.96	2	—	—	—	100.00
Symphurus plagiusa	2	—	50.00	—	50.00	0	—	—	—	—

TABLE 4.

Distribution of Monthly Catches of Cedar Key Fishes by Species.

Species	Percentages of Monthly Catches												No. of Spec.	% of Total Catch
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.		
Mollienesia latipinna	3.7	28.4	5.5	25.0	35.6	48.0	55.4	34.3	47.5	34.4	3.4	22.5	10,846	32.43
Adinia xenica	11.4	4.6	4.2	10.6	10.5	8.6	11.6	16.1	26.4	15.1	15.3	22.3	4,939	14.77
Cyprinodon v. variegatus	23.1	8.2	7.6	14.5	13.8	10.5	9.5	30.3	9.7	11.0	19.0	22.1	4.747	14.19
Mugil cephalus	39.1	13.2	15.8	16.1	4.8	.4	—	—	—	.8	7.3	8.0	1,927	5.76
Menidia beryllina	.8	7.3	27.6	5.9	3.0	5.5	4.0	.3	.6	6.3	11.1	4.1	1,855	5.55
Fundulus similis	5.4	3.0	6.3	2.6	3.3	6.3	7.2	10.0	2.0	4.4	15.2	4.3	1,750	5.23
Fundulus g. grandis	11.0	2.3	6.1	1.4	4.9	.8	1.6	2.3	3.9	3.7	15.7	6.4	1,476	4.41
Anchoa m. diaphana	—	.1	—	5.7	—	.8	1.4	.03	—	12.6	.1	1.9	1,160	3.47
Gambusia a. holbrooki	.4	9.2	.8	.8	9.1	5.7	1.5	.5	1.6	5.6	.2	.9	1,132	3.38
Fundulus c. confluentus	.4	2.0	.8	1.1	7.8	5.3	1.8	4.8	4.9	1.6	1.9	4.0	1,080	3.23
Leiostomus xanthurus	4.6	13.0	22.0	8.0	.5	.7	—	—	—	—	—	—	889	2.66
Eucinostomus argenteus	—	—	—	—	1.8	1.8	.8	.1	.3	1.6	1.0	.9	276	.83
Microgobius gulosus	.1	5.9	.6	4.7	1.0	.3	—	—	—	.1	—	.1	235	.70
Eucinostomus gula	—	—	—	—	—	.1	—	.9	3.0	.3	.3	.1	211	.63
Sciaenops ocellatus	—	.2	.3	.2	.1	—	—	—	.04	.8	3.5	.4	140	.42
Lagodon rhomboides	—	1.3	1.7	1.2	.4	1.3	—	—	—	—	—	—	116	.35
Membras v. vagrans	—	—	—	.5	.1	1.5	2.8	—	—	.1	—	—	110	.33
Oligoplites saurus	—	—	—	—	—	.3	1.1	—	.04	.6	—	—	73	.22
Mugil curema	—	—	.1	.2	1.4	.4	—	—	—	—	—	—	53	.16
Floridichthys c. carpio	—	.1	.1	—	—	—	—	—	—	.1	.9	1.2	48	.14
Achirus lineatus	—	.3	.2	.3	.1	—	—	.1	.04	.3	.4	.1	46	.14
Mugil trichodon	—	—	—	—	.5	2	—	—	—	—	1.7	—	44	.13
Strongylura timucu	—	—	—	.1	.03	1.0	.4	—	.02	.1	—	—	40	.12
Gobiosoma bosci	—	.8	—	.7	.1	—	.1	—	—	—	—	—	29	.09
Hyporhampus unifasciatus	—	—	—	—	.3	.1	.4	—	—	—	—	—	22	.07
Syngnathus floridae	—	—	—	—	—	—	—	—	—	—	1.3	.1	21	.06
Opsanus beta	—	—	—	—	—	—	—	.2	—	.2	—	.1	19	.06
Elops saurus	—	—	—	.1	.4	.2	.1	—	—	—	—	—	19	.06

Sphoeroides nephelus	—	—	—	.3	.1	—	—	—	—	.1	.2	.1	16	.05
Strongylura notata	—	—	—	—	—	.1	.1	—	—	.1	—	—	14	.04
Lucania parva	—	.1	.1	.1	.03	—	—	—	.02	.01	—	.2	13	.04
Syngnathus scovelli	—	—	—	—	—	—	—	—	—	—	.8	—	12	.04
Trinectes m. fasciatus	—	—	.1	.1	—	—	—	—	—	.1	—	—	9	.03
Pogonias cromis	—	—	—	—	.2	.1	—	—	—	—	—	—	9	.03
Bairdiella chrysoura	—	—	—	.1	—	.2	—	—	—	.04	—	—	8	.02
Prionotus tribulus	—	.1	—	—	—	—	—	—	—	.1	.1	—	7	.02
Chloroscombrus chrysurus	—	—	—	—	—	—	—	—	—	.1	—	—	6	.02
Cynoscion nebulosus	—	—	—	—	—	.1	.1	—	—	.04	.1	—	6	.02
Gobiosoma robustum	—	—	—	—	—	—	—	—	—	—	—	.2	5	.01
Synodus foetens	—	—	—	—	—	—	—	.03	—	—	.3	—	5	.01
Cynoscion nothus	—	—	—	—	—	.1	.1	—	—	—	—	—	4	.01
Harengula pensacolae	—	—	—	.1	—	—	—	—	—	.03	—	—	4	.01
Bathygobius s. catulus	—	.1	—	—	—	—	—	—	—	—	.1	.1	4	.01
Lutjanus griseus	—	—	—	—	—	—	—	—	.02	.01	—	.1	3	.01
Syngnathus louisianae	—	—	—	—	—	—	—	—	—	—	.1	—	2	.005
Hippocampus h. punctulatus	—	—	—	—	—	—	—	—	—	—	.1	.1	2	.005
Gibionellus stigmaturus	—	—	—	—	—	—	—	—	—	.01	.1	—	2	.005
Symphurus plagiusa	—	—	.1	—	—	—	—	—	—	—	—	.1	2	.005
Orthopristis chrysopterus	—	—	—	.1	—	—	—	—	—	—	—	—	1	.003
Myrophis punctatus	—	—	—	—	—	—	—	.03	—	—	—	—	1	.003
Trachinotus falcatus	—	—	—	—	—	—	—	—	—	.01	—	—	1	.003
Chaetodipterus faber	—	—	—	—	—	—	—	—	—	.01	—	—	1	.003
Micrognathus crinigera	—	—	—	—	—	—	—	—	—	—	.1	—	1	.003
Etropus c. atlanticus	—	—	—	—	—	—	—	.03	—	—	—	—	1	.003
Paralichthys albigutta	—	—	—	.1	—	—	—	—	—	—	—	—	1	.003
Total Specimens	1582	1421	2052	1899	2941	2144	2067	3058	5001	7613	1518	2147	33,443	

TABLE 5.
DISTRIBUTION OF MONTHLY CATCHES OF BAYPORT FISHES BY SPECIES.

Species	Percentages of Monthly Catches												No. of Spec.	% of Total Catch
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.		
Mollienesia latipinna	3.1	44.2	28.0	50.9	34.9	11.3	12.4	4.7	43.0	25.5	4.0	5.2	4,889	22.91
Lucania parva	55.0	21.5	11.9	6.6	2.1	15.8	25.0	46.5	9.6	15.6	40.8	19.6	4,192	19.64
Eucinostomus argenteus	1.1	1.4	—	1.9	12.1	23.2	11.4	2.3	7.7	14.3	3.5	2.3	2,141	10.03
Gambusia a. holbrooki	8.6	4.3	14.1	11.9	8.8	13.0	7.6	—	9.2	4.9	12.1	34.0	2,026	9.49
Menidia beryllina	.8	1.3	11.4	.7	8.4	8.7	15.0	30.2	5.8	4.2	12.6	17.5	1,913	8.96
Cyprinodon v. variegatus	10.9	9.4	7.5	2.8	6.1	6.8	5.3	1.2	8.3	11.5	6.9	5.4	1,444	6.77
Floridichthys c. carpio	—	.5	3.9	—	1.5	4.2	5.4	—	2.8	4.6	2.3	.5	663	3.11
Jordanella floridae	—	1.1	1.2	5.0	21.4	.8	.1	—	.6	.5	—	—	644	3.02
Fundulus c. confluentus	6.0	4.1	3.7	9.7	3.1	.7	.7	2.3	3.3	5.3	1.5	1.3	599	2.81
Fundulus g. grandis	4.3	1.7	1.0	.4	.2	3.5	3.5	1.2	1.3	1.1	3.7	.5	503	2.36
Heterandria formosa	2.1	.2	—	1.8	—	1.3	5.4	—	1.5	1.0	.1	—	470	2.20
Adinia xenica	3.0	.6	—	—	—	.2	1.7	—	1.7	9.5	3.5	1.6	364	1.71
Fundulus similis	—	.2	—	1.5	.1	1.6	.6	9.3	1.3	.6	3.0	1.0	204	.96
Mugil cephalus	1.6	.6	5.1	4.1	1.0	.2	.2	1.2	.2	—	.1	10.6	203	.95
Lagodon rhomboides	1.6	1.4	4.6	.4	.2	.8	1.4	—	—	—	1.0	.3	190	.89
Lepomis p. punctatus	.7	1.6	—	—	—	2.1	.5	—	.7	—	2.0	—	166	.78
Chriopeops goodei	—	.1	—	—	—	1.0	1.4	—	.4	—	.2	—	126	.59
Eucinostomus gula	—	—	—	—	—	.4	.8	—	1.1	1.0	.4	—	101	.47
Notemigonus c. bosci	—	2.3	—	—	—	1.2	.1	—	—	—	—	—	74	.35
Strongylura timucu	.1	.4	3.7	.4	.1	.3	.2	—	—	.1	.3	—	53	.25
Strongylura notata	—	—	2.0	1.1	—	.03	.2	—	—	—	.1	—	40	.19
Leiostomus xanthurus	.3	1.9	1.5	—	—	—	—	—	—	—	—	.3	39	.18
Lepomis microlophus	—	.8	—	.1	—	.5	.02	—	.05	—	.4	—	38	.18
Lepomis m. purpurescens	—	—	—	—	—	.6	.2	—	.2	—	—	—	38	.18
Notropis petersoni	—	—	—	—	—	1.2	.02	—	—	—	—	—	37	.17
Fundulus chrysotus	.1	—	—	.1	.1	—	.1	—	.8	.3	—	—	29	.14
Chaenobryttus coronarius	.1	.5	—	—	—	—	.2	—	.1	—	—	—	22	.10
Microgobius gulosus	.5	.1	.5	.3	.1	—	—	—	.3	—	—	—	21	.10

Micropterus s floridanus	—	—	—	—	—	.1	.2	—	.1	—	—	—	18	.08
Lutjanus griseus	—	—	—	.1	—	.3	.02	—	.1	—	.3	—	17	.08
Opsanus beta	—	.1	—	—	—	.03	.2	—	.1	—	.2	—	16	.07
Sciaenops ocellatus	—	—	—	—	—	—	—	—	—	—	.8	—	11	.05
Ameiurus n. erebennus	—	.1	—	.2	—	—	.1	—	—	—	—	—	10	.05
Mugil curema	—	—	—	—	.1	.1	.1	1.2	.1	—	—	—	8	.04
Syngnathus scovelli	—	—	—	—	—	.1	.1	—	.1	—	.1	—	8	.04
Bairdiella chrysoura	—	—	—	—	—	—	.1	—	—	—	—	—	3	.01
Hyporhampus unifasciatus	—	—	—	.1	—	—	—	—	—	—	.1	—	3	.01
Lepisosteus platyrhyncus	—	—	—	—	—	—	.03	—	—	—	.1	—	3	.01
Cynoscion nebulosus	—	—	—	—	—	—	.1	—	—	—	—	—	3	.01
Elassoma evergladei	—	—	—	—	—	—	.1	—	—	—	—	—	3	.01
Achirus lineatus	—	—	—	—	—	—	—	—	.1	.1	—	—	2	.009
Gobiosoma robustum	.2	—	—	—	—	—	—	—	—	—	—	—	2	.009
Anguilla bostoniensis	—	—	—	—	—	—	—	—	—	—	.1	—	1	.005
Archosargus probatocephalus	—	—	—	—	—	—	.02	—	—	—	—	—	1	.005
Chasmodes saburrae	—	—	—	—	—	—	.02	—	—	—	—	—	1	.005
Dasyatis sabina	—	—	—	—	—	—	.02	—	—	—	—	—	1	.005
Orthopristis chrysopterus	—	—	—	—	—	—	—	—	—	—	.1	—	1	.005
Sphyraena barracuda	—	—	—	—	—	—	—	—	—	.1	—	—	1	.005
Stephanolepis hispidus	—	—	—	—	—	—	.02	—	—	—	—	—	1	.005
Total Specimens	968	1551	411	1676	2280	2967	6175	86	2060	1340	1441	388	21,343	

TABLE 6.

DISTRIBUTION BY SALINITIES OF SELECTED CEDAR KEY FISHES.

Species	Number of Spec.	Percentages of Specimens by Salinity Classes										
		0-4.9	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9	Not Rec.	Minimum, Maximum Salin.	Salin. Index*
Anchoa m. diaphana	1,160	.00	.00	.00	.09	10.78	10.17	75.43	3.53	.00	17.5-37.6	31.03
Floridichthys c. carpio	48	.00	.00	.00	.00	29.16	16.67	2.08	50.00	2.08	20.0-37.6	31.17
Eucinostomus gula	211	.00	.00	.00	.00	14.69	81.52	2.37	1.42	.00	22.9-37.6	26.98
Microgobius gulosus	235	.00	.00	.00	5.53	49.79	40.85	.00	.00	3.83	15.4-27.7	24.29
Menidia beryllina	1,855	.05	1.24	.22	29.76	22.64	41.56	3.29	.05	1.19	3.5-37.6	23.17
Lucania parva	13	.00	.00	.00	15.38	61.54	23.08	.00	.00	.00	15.4-28.2	22.84
Fundulus c. confluentus	1,080	1.76	2.50	.09	11.67	55.19	27.22	.93	.09	.56	0.8-35.6	22.60
Eucinostomus argenteus	276	12.32	3.26	.00	1.09	36.96	36.96	5.78	3.62	.00	4.5-37.6	22.41
Mugil cephalus	1,927	1.14	1.40	1.09	20.45	56.14	14.95	4.46	.05	.31	2.5-35.6	22.09
Adinia xenica	4,939	2.83	1.50	1.48	14.23	56.29	21.52	1.13	.18	.83	0.8-37.6	22.01
Gambusia a. holbrooki	1,132	7.07	10.78	.00	5.65	32.16	44.35	.00	.00	.00	1.2-25.2	21.36
Mollienesia latipinna	10,846	2.99	9.29	.02	21.54	35.82	26.30	3.48	.42	.15	1.2-37.6	21.09
Sciaenops ocellatus	140	20.00	.00	.00	7.14	17.14	52.86	.00	2.14	.71	0.8-37.6	21.05
Lagodon rhomboides	116	.00	.00	.00	31.03	18.16	39.66	.00	.00	11.20	4.5-26.1	22.95
Fundulus similis	1,750	7.09	3.43	6.06	22.74	31.37	23.60	3.54	.57	1.60	0.8-37.6	20.37
Leiostomus xanthurus	889	.67	.00	2.02	56.47	16.87	22.27	.00	.00	1.69	1.2-26.1	20.36
Fundulus g. grandis	1,476	9.69	.61	4.61	17.27	46.07	18.97	.95	.54	1.29	0.8-35.6	20.19
Cyprinodon v. variegatus	4,747	9.25	7.69	1.50	32.74	23.17	22.44	2.72	.21	.29	0.8-35.6	19.17
Total All Species	33,443	4.09	5.18	1.09	20.82	36.68	25.68	5.35	.53	.60	0.8-37.5	21.60

* The salinity index is the mean of the salinities calculated on the basis of the salinity class midpoints and the percentages of fish in each salinity class.

TABLE 7.

DISTRIBUTION BY SALINITIES OF SELECTED BAYPORT FISHES

Species	Number of Spec.	Percentages of Specimens by Salinity Classes 0-4.9	5-9.9	10-14.9	15-19.9	20-24.9	25-29.9	30-34.9	35-39.9	Not Rec.	Minimum, Maximum Salin.	Salin. Index*
Jordanella floridae	644	6.52	.00	7.76	10.09	34.32	41.30	.00	.00	.00	0.0-26.1	21.93
Mugil cephalus	203	5.42	22.17	20.69	40.89	7.88	2.96	.00	.00	.00	1.1-26.1	14.08
Fundulus c. confluentus	599	21.04	25.54	22.37	19.53	6.68	4.84	.00	.00	.00	0.1-26.1	11.44
Mollienesia latipinna	4,889	35.41	16.20	15.73	16.61	10.55	5.34	.00	.00	.16	0.0-26.1	10.79
Adinia xenica	364	27.75	31.31	6.59	34.34	.00	.00	.00	.00	.00	1.1-16.5	9.83
Fundulus similis	204	16.18	50.00	16.18	17.65	.00	.00	.00	.00	.00	0.8-16.2	9.22
Eucinostomus gula	101	8.91	49.50	37.62	2.97	.00	.00	.00	.00	.99	2.0-16.5	9.20
Cyprinodon v. variegatus	1,444	27.00	32.48	26.80	11.15	2.08	.48	.00	.00	.00	0.0-26.1	8.96
Gambusia a. holbrooki	2,026	36.87	20.73	27.79	3.70	6.32	3.55	.00	.00	1.04	0.0-26.1	9.04
Microgobius gulosus	21	9.52	57.14	33.33	.00	.00	.00	.00	.00	.00	2.9-10.5	8.64
Eucinostomus argenteus	2,141	10.65	62.21	18.78	7.52	.28	.00	.00	.00	.56	1.1-24.7	8.66
Floridichthys c. carpio	663	11.46	63.05	22.32	3.17	.00	.00	.00	.00	.00	2.0-15.8	8.31
Sciaenops ocellatus	11	.00	100.00	.00	.00	.00	.00	.00	.00	.00	5.3- 5.3	7.45
Menidia beryllina	1,913	23.94	55.57	19.45	.58	.37	.00	.00	.00	.05	0.1-24.7	7.33
Lagodon rhomboides	190	17.89	55.26	17.89	2.63	.00	.00	.00	.00	6.32	1.4-15.8	7.73
Leiostomus xanthurus	39	23.08	58.97	17.95	.00	.00	.00	.00	.00	.00	2.9-11.8	7.19
Lucania parva	4,192	30.03	51.88	14.27	3.10	.14	.00	.00	.00	.57	0.1-24.7	6.99
Fundulus g. grandis	503	33.20	45.92	16.90	2.78	.00	.00	.00	.00	1.19	0.8-16.2	6.90
Heterandria formosa	470	68.09	12.34	15.32	.21	.00	.00	.00	.00	4.04	0.0-15.0	4.72
Total All Species	21,343	28.72	36.40	17.86	8.80	4.55	3.00	.00	.00	.67	0.0-26.1	9.08

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* The salinity index is the mean of the salinities calculated on the basis of the salinity class midpoints and the percentages of fish in each salinity class.

TABLE 8.
INTERSPECIFIC ASSOCIATION COEFFICIENTS OF SELECTED SPECIES FROM CEDAR KEY

Lucania parva	9*	*Lucania parva*												
Mollienesia latipinna	93	.49±.61	*Mollienesia latipinna*											
Gambusia a. holbrooki	29	-.09±.56	1±.31	*Gambusia a. holbrooki*										
Cyprinodon v. variegatus	91	1±.58	.60±.03	.85±.29	*Cyprinodon v. variegatus*									
Menidia beryllina	52	.61±.28	-.59±.15	-.61±.18	-.56±.15	*Menidia beryllina*								
Eucinostomus argenteus	26	.15±.17	-.11±.09	.53±.31	-.35±.10	.45±.15	*Eucinostomus argenteus*							
Fundulus g. grandis	75	.40±.42	.16±.13	-.62±.12	.32±.13	.17±.13	.06± 23	*Fundulus g. grandis*						
Fundulus c. confluentus	75	.40±.42	.94±.13	.81±.21	.89±.13	-.35±.11	-.39±.13	.02±.09	*Fundulus c. confluentus*					
Floridichthys c. carpio	10	.03±.10	-.36±.16	- 1±.53	-.61±.17	.82±.27	.10±.16	.46±.39	-.68±.23	*Floridichthys c. carpio*				
Fundulus similis	87	.59±.53	-.14±.28	-.34±.10	.17±.10	.36±.17	.43±.29	.50±.11	.01±.11	.26±.50	*Fundulus similis*			
Adinia xenica	84	.24±.49	.72±.11	.77±.25	.70±.11	-.48±.13	-.35±.11	.23±.11	.64±.11	-.29±.20	-.04±.23	*Adinia xenica*		
Mugil cephalus	37	.36±.22	.01±.26	-.22±.24	.31±.25	.18±.12	-.51±.26	.49±.18	.27±.18	.57±.20	.30±.23	.08±.21	*Mugil cephalus*	
Anchoa m. diaphana	17	-.22±.78	-.40±.12	- 1±.40	-.77±.13	.90±.20	.62±.12	-.16±.17	-.81±.17	.30±.12	-.12±.14	-.67±.15	-.43±.33	*Anchoa m. diaphana*

* The whole numbers following the species name indicate the number of collections in which the species was taken at Cedar Key.

TABLE 9.
INTERSPECIFIC ASSOCIATION COEFFICIENTS OF SELECTED SPECIES FROM BAYPORT.

Lucania parva	98*	*Lucania parva*												
Mollienesia latipinna	95	.08±.09	*Mollienesia latipinna*											
Gambusia a. holbrooki	80	.08±.12	.64±.11	*Gambusia a. holbrooki*										
Cyprinodon v. variegatus	75	.52±.13	.32±.12	.04±.09	*Cyprinodon v. variegatus*									
Menidia beryllina	69	.66±.14	.10±.13	-.17±.12	.32±.10	*Menidia beryllina*								
Eucinostomus argenteus	62	.49±.16	-.21±.13	-.44±.10	.13±.11	.49±.10	*Eucinostomus argenteus*							
Fundulus g. grandis	56	.43±.17	.22±.16	-.21±.09	.50±.12	.25±.11	.15±.10	*Fundulus g. grandis*						
Fundulus c. confluentus	48	.34±.20	.70±.19	.52±.14	.81±.13	.12±.12	-.34±.12	.36±.10	*Fundulus c. confluentus*					
Floridichthys c. carpio	36	.12±.24	-.05±.09	-.50±.36	.68±.16	.47±.15	.74±.13	.18±.12	.24±.19	*Floridichthys c. carpio*				
Fundulus similis	34	.07±.25	.14±.24	-.28±.12	.79±.17	.38±.16	.33±.14	.38±.13	.26±.11	.47±.09	*Fundulus similis*			
Adinia xenica	22	.82±.33	.67±.32	.42±.24	.89±.23	.33±.21	.14±.18	.21±.17	.64±.15	.37±.12	.33±.12	*Adinia xenica*		
Mugil cephalus	19	.37±.37	.62±.34	.46±.27	.88±.25	.56±.22	-.56±.22	.36±.18	.83±.16	-.43±.34	.15±.13	.05±.10	*Mugil cephalus*	
Jordanella floridae	15	-.11±.14	1±.39	.83±.30	.69±.28	.01±.26	-.72±.26	.07±.21	.79±.18	-1±.39	-.49±.41	-1±.54	.53±.10	*Jordanella floridae*

* The whole number following the species name indicates the number of collections in which the species was taken at Bayport.

those faunas and to discover, if possible, the more obvious ecological factors which were shaping them.

The two areas were different ecologically. The one at Bayport had less saline waters and more stable temperatures than the one at Cedar Key in addition to other differences which were described.

Seventy-five species were recorded during the study and species data are presented in an annotated list. This treatment is supplemented by tables, graphs, and other compilations designed to present certain of the data which could be summarized.

Five species, *Fundulus similis, Fundulus grandis grandis, Adinia xenica, Cyprinodon variegatus variegatus,* and *Floridichthys carpio carpio* were found only in the brackish waters of the marshes or immediately adjacent brackish waters. These are considered to be brackish zone fishes and are all members of the family Cyprinodontidae. They comprized 14.89% of the total catch at Bayport and 38.75% of that from Cedar Key. If four other cyprinodontids which reside in both brackish and fresh waters are added to the list, the respective percentages of the total catches are raised to 69.74 for Bayport and 77.84 for Cedar Key. Thus the cyprinodontids were the dominant family of fishes in the brackish waters studied.

The availability of species capable of adjusting to the total ecology of the brackish marshes was considered. At Cedar Key, where mainland fresh water is at a minimum, dense populations of eulittoral marine species were available to the marshes. At Bayport the marine fishes, although substantially equal to those at Cedar Key in species present, occurred in much fewer numbers of individuals, but the propinquity of fresh waters permitted easy access to the marshes for many freshwater fishes.

Despite the relative importance of the factors of salinity and the availability of species, it was noted that the fishes which occur in greatest abundance in the brackish marshes at both Cedar Key and Bayport belong to freshwater groups. In other words, approximately 85% of the specimens caught in the brackish marshes during this study are of species representing either freshwater or freshwater-brackish water groups of fishes. Furthermore, of the sixteen species at Bayport contributing 96% of the total catch only three represented marine species, and of the fourteen species at Cedar Key contributing 96% of the total catch only five were marine. None of these five marine species (*Eucinostomus argenteus, Mugil cephalus, Lagodon rhomboides, Leiostomous xanthurus* and *Anchoa mitchilli diaphana*) is known to breed in the brackish marshes, whereas all of the freshwater affinates in reference not only breed in the marshes but also maintain permanent populations there. Thus it is concluded that the intertidal marshes at Cedar Key and at Bayport are populated principally by fishes with freshwater, rather than marine affinities.

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