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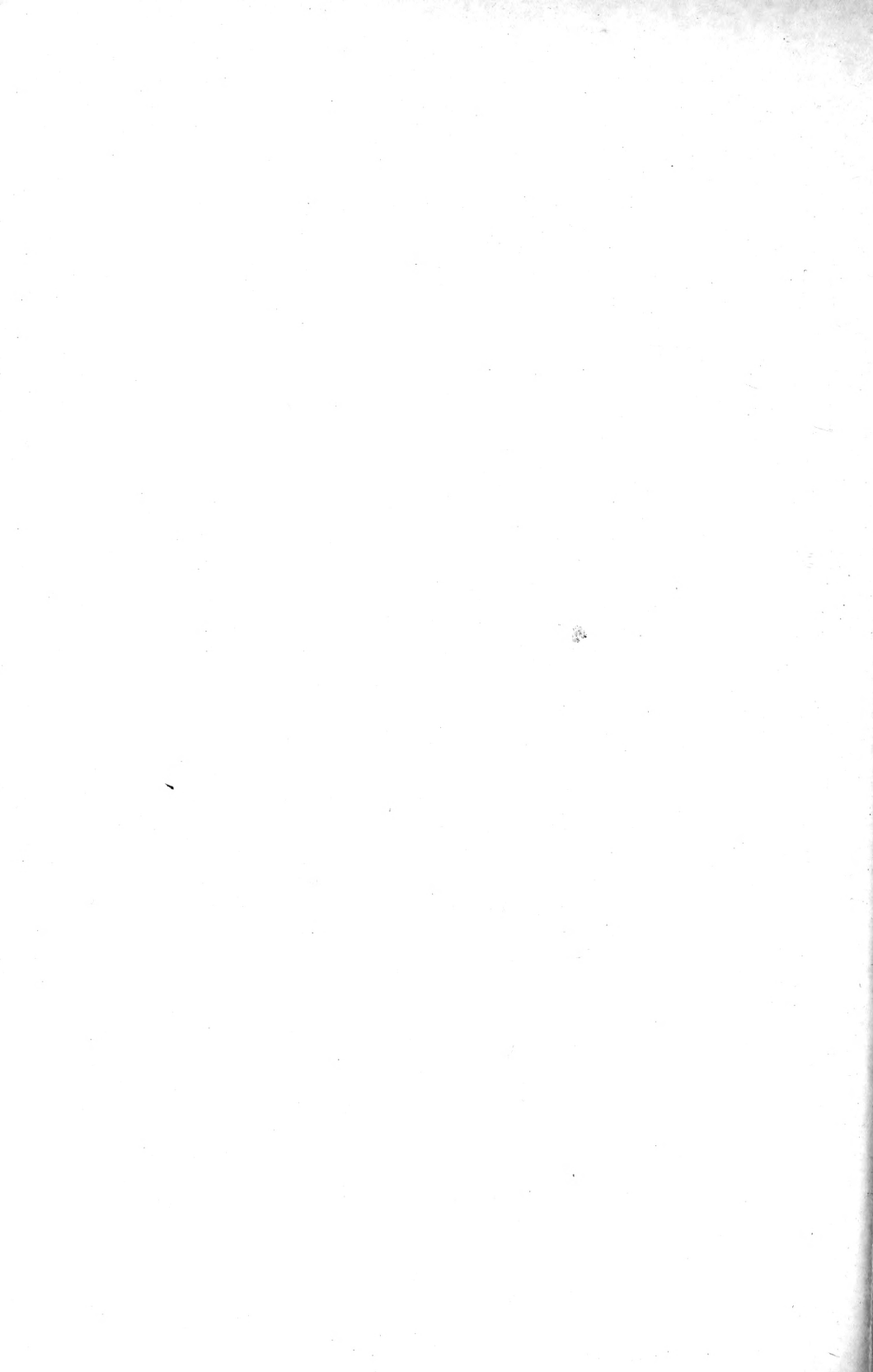
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AN EXPERIMENTAL STUDY OF THE REPRODUCTIVE
HABITS AND LIFE HISTORY OF THE CICHLID FISH,
AEQUIDENS LATIFRONS (Steindachner)

By C. M. BREDER, JR.
New York Aquarium

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New York Aquarium

INTRODUCTION

Although the reproductive habits of a large number of cichlid fishes have been described in various publications, the bulk of them have appeared in journals devoted to home aquaria and for most part are uncritical and concerned entirely with fish cultural interests. These fishes, with their highly specialized reproductive behavior, nevertheless recommend themselves strongly to the experimentalist. The present contribution is an attempt to analyze the more evident and basic of the elements involved in the breeding habits and life history of one member of the family Cichlidae, namely, *Aequidens latifrons* (Steindachner). Although this species is well known to aquarists and is mentioned in practically every list of small fishes, the writer has been unable to find a single paper devoted to a critical study of the behavior of this fish. Most briefly describe the aquarium habits of *A. coeruleopunctata* or *latifrons* and are essentially in agreement with the present studies in the general aspects. Engmann (1907) gives the most elaborate early discussion. The others, largely short notes, are not of sufficient bearing on the present study to warrant inclusion in the bibliography. Most recently, Schoenebeck (1933) considers the entire family, at considerable length, from the aquarists' viewpoint. Coates (1932) discusses in general terms the behavior of the parents of the fishes used for the present series of experiments.

As is well known, the cichlids either attach their eggs to some solid support and guard them, or carry them about in the mouth. The first and most common method is certainly the most

primitive. The egg-carrying habits of such genera as *Haplochromis* and *Tilapia* can only be considered a specialized development, as will be subsequently shown. Aside from this difference there is no outstanding change from one species to another in each group, so far as known, all following a general pattern with minor variations. The species considered herewith may serve as a typical representative of the more primitive group.

The fishes on which these studies were made are the aquarium-bred offspring of some specimens collected in 1931 by Mr. A. Eisinger at Barranquilla, Colombia. These fishes were brought to the New York Aquarium while still very small and as they grew up in aquaria their behavior appeared to be entirely normal, especially as compared with field observations made in 1924 on the questionably distinct *Aequidens coeruleopunctatus* (Kner and Steindachner) in Panama. Such details that could be seen under field conditions agree closely with those studied subsequently in the laboratory. Throughout the laboratory studies, helpful assistance was rendered by C. W. Coates of the Aquarium staff. The photographs were all made by S. C. Dunton, also of the Aquarium, excepting Figs. 5, 6A and 8A which are the author's.

The following sections discussing the details of behavior are presented, so far as possible, in chronological order, beginning with the young fish just after they have escaped the parental influence. Part of this is naturally of the simple observational procedure but is reinforced wherever possible by definite experimental work, which is so stated and explained at its place of occurrence, together with such discussional remarks that may pertain.

HABITS OF THE YOUNG FISH

When the young fish attain a sufficient size, the juvenile schooling reaction disappears and is replaced by some centrifugal influence causing the individuals to scatter. They then no longer seek one another's company and all comers appear to be unwelcome. At this time fighting appears but usually proceeds little beyond a chase and a single nip. Concomitantly with this change in behavior, or a little prior to it, the adult pattern and

coloration begin to appear, so there is reason to suppose that these changes in behavior are basically dependent on the developing gonads, or at least on changes in the endocrine complex foreshadowing sexual maturity.

As the parent fish in a state of nature may be seen in attendance on fishes at least 30 mm. long, and maturity is reached under such circumstances at a length of about 70 mm., it follows that the time between the schooling habit period and the full development of the adult behavior is not long and would be, presumably, an abrupt rather than a gradual one.¹ This is fully borne out by aquarium observations. In fact in the relatively close confines of an aquarium, it is sometimes difficult to decide when the juvenile school has broken up and courtship has begun. Maturity not infrequently occurs at smaller sizes in aquaria so that some individuals of one brood may actually be breeding while less precocious ones still show the last remnants of the juvenile schooling habit. A typical adult pair is illustrated in Fig. 4, and the young, at about the time they escape the parental solicitude but before they begin to take on adult coloration, in aquarium-reared material, are shown in Fig. 11B.

HABITS OF THE ADULT FISH

The behavior of the non-breeding but fully mature fish is very definite and all of its characteristics have been foreshadowed in the later stages of the family school. With the complete disappearance of the latter the fishes tend to become solitary and will fight, sometimes disastrously, with all of their own kind including both sexes, and not infrequently with other species, especially if they somewhat resemble themselves. Crowding emphasizes the fighting reaction to such an extent that the quarrels may almost be considered a direct function of the size of the aquarium up to a certain point beyond which the crowding seems to inhibit fighting on the basis of confusion. This fact is readily understood when considered in the light of the known behavior of a considerable variety of fishes. It is naturally evident chiefly in fishes that display a non-schooling reaction. Many such fishes

¹ Based on field observation of *Aequidens coeruleopunctatus*. See Breder (1927).

under feral conditions establish a kind of property right about some retreat or area, and join battle with any intruder that may so much as swim near the site. This behavior is especially notable about coral reefs where such a variety as *Xyrichtys*, *Abudefduf*, *Pomacentrus*¹ and *Gnathypops* may serve as illustrations, although such behavior may be found in other localities, both fresh and salt. In some species it appears only as a part of the reproductive behavior and then relates only to the nest area (e.g. *Lepomis*, *Boleosoma*, *Cyclopterus* and *Ameiurus*). The behavior in general terms appears to be analogous to the well known breeding and feeding areas of birds, especially as fighting does not normally occur in "neutral" territory. Even if two fish go for the same piece of food, the loser simply retreats. In the present species this phenomenon becomes more and more prominent with the development of the gonads.

It so happens that the regions in which *Aequidens* lives are subjected to rather protracted dry seasons. It is consequently not uncommon, at times, for the fishes to become concentrated in pools in the stream beds to an annoying degree (See Breder, 1927). Of course sometimes the pools do completely dry, with the result that fishes such as *Aequidens* expire along with others not able to respire atmospheric oxygen, move overland, or find protection by some such specialized means. Up to a certain point of concentration it is clearly valuable to the survivors to have their numbers reduced, which function *Aequidens* performs with much vigor. However, it is also evident that if the evaporation proceeds at a pace with which the killing off cannot keep up, the amount and number of dead fishes would only serve to hasten the death of all by their polluting effect. It might be thought that conditions as above are unlikely, and that the killing of excess fishes could always far outstrip desiccation. Such is not the case because the fights staged by *Aequidens* are not rapid affairs but usually take several days, even in an aquarium, to come to a fatal climax. Then, too, evaporation in the neo-tropical regions is not infrequently rapid, both from the surface and by soaking into the thirsty soil.

¹ These three forms have also been observed in the New York Aquarium where they will fight excessively if present beyond some critical concentration. See Breder and Coates (1933) for details regarding *Pomacentrus*.

Breder and Coates (1932) showed that in *Lebistes* the eating of newly born young is a direct coefficient of crowding. This fish, which may be thought of, relatively, as producing a continual stream of offspring, living in a large school can well cope with the population problem in this manner. *Aequidens*, on the other hand, producing comparatively occasional broods and not in schools, and protecting the young fish by means of an elaborate behavior, cannot control population by simple, direct infanticide but has recourse to adult destruction as previously outlined. Stating it another way these two reproductively different species differ in their solution of the population problem in accordance with their methods of procreation; *Lebistes* under crowding, simply eating the young as fast as they are born, and *Aequidens* fighting to kill off too near neighbors and then resting as a group, when such would be fatal, awaiting their doom or release according to the fortunes of weather.

The physiological cause of this reverse in the attitude of *Aequidens* towards their companions has become clear as a result of analyzing the conditions under which they do and do not fight. Below a temperature of 22° C. fighting becomes less frequent, and at 20° C. stops altogether. Between a range of pH 6.0 to 7.3 there seems to be no clear relationship to that measure except so far as the amount of free carbon dioxide modifies it. When the concentration of CO₂ is less than about 0.90 mM fighting generally occurs. When above that it generally ceases and at 2.00 mM it stops altogether, but suffocation does not commence to evidence itself before over 3.00 mM is reached. While the exactness of the measure cannot be pressed too far because of the difficulty of determining the actual "end point" of such a reaction as "fighting," it may be noted that at a temperature of 26° fighting stopped at 0.42 mM CO₂, whereas at a temperature of 21.5° it continued at a concentration of 0.82 mM CO₂. Typical readings are given in Table I. Since low temperatures are not involved in dry season pools, it follows that the CO₂ concentration determines the interesting change of attitude under crowding that may have a distinct survival value in a state of nature.

In addition to taking some locality for their own, usually a corner of an aquarium, *Aequidens* goes to some trouble in modi-

fyng it to suit. A hole is generally excavated in the sand, or if that is covered with a sufficiently thick layer of detritus the latter only is removed. This has generally been considered only as part of the breeding behavior, in aquarium literature, and although the matter of hole digging does appear again in that connection, the following evidence demonstrates that the excavation of holes is primarily associated with the establishment of a retreat and is not an integral part of the reproductive habits.

Four compartments were arranged, as indicated in Fig. 1, to provide for four male fishes. A detailed consideration of this illustration and its explanatory legend shows distinctly that these fishes usually dig excavations in the most protected parts of the aquarium. After fifteen days of being left alone, with only nominal disturbance, all four fish excavated holes along the back and two along the front as well (Fig. 1-1). On smoothing out the sand, two dug where they had before, and one in a new place, although one had the choice of a ready-made hole (Fig. 1-2). Again on smoothing the sand and protecting the sides all around, each fish accepted the "artificial" retreat, although only one was in the original place (Fig. 1-3). On removing the cover one, fish A, went back to its original location (Fig. 1-4). A female was next placed with the male B. No further nest building occurred there but C, which could see these two fish, dug a hole farthest from them diagonal to their nest. Females also dig holes. This one, removed to a circular jar, dug in the center. A dark card and a light one were placed on either side of the tank. Then a hole was dug nearest the dark card. An introduced male induced no further excavation. This experiment was used as a check on numerous observations and establishes that *Aequidens* of both sexes digs retreats adjacent to dark surfaces and that these lack association with reproductive activity, since some of the fishes were not in breeding condition. Further, there is a strong tendency to return to the same spot for building a retreat if a conditioning has once been established and if there is none, such as in the case of a fish newly placed in an aquarium, there is a general acceptance of existing retreats even if they are not in what might be considered the most acceptable position. Dissatisfaction with an aquarium appears to stimulate continual

digging as a response to much disturbance, such as too great activity in sight of the fishes, especially if the aquarium is very small. In one such case, in a small exhibition tank of the New York Aquarium, the fish in question moved all of the sand from one back corner so that he could scarcely be seen. Further work would eventually cut the excavation through to the front glass. When this happened he would begin all over at the opposite end and repeat. This went on as a daily performance until the fish was moved to more commodious quarters.

MATING

The details of sex recognition may not be altogether evident but would seem to be peculiarly simple. As the reproductive urge begins to make itself felt the males, at least, become more active and make forays farther and farther from their retreat, accompanied by an ever brightening of the coloration. Sexual dimorphism is not great in this species. Aside from somewhat longer anal and dorsal filaments and slightly more brilliant colors, there is little to distinguish the sexes. Even to this there are exceptions, so that not infrequently a fish taken to be of one sex, by comparison with its tank mates, sometimes turns out to actually be the other. Unless there is some chemical differentiation that we cannot readily determine, it is doubtful if sex is really distinguished by ordinary sensory perception. It would seem that the reaction between any two fishes is identical, subsequent behavior leading to fighting ordinarily, or to reproduction if both specimens are properly sexed and physiologically ready for spawning. When two fishes approach they normally line up for fighting purposes. This may be head-on with mouths open, or side by side, head to tail, when a peculiar rocking motion on the part of one or both is indulged in. Such activity usually results in torn fins of the smaller of the two. This is true of two males, or a male and a non-breeding female. Two females have not been seen to maul one another in this manner.

All or part of the above also takes place even when spawning is subsequent so that the female or sometimes the male, or both, may spawn with the fins torn. It seems that when a female is

ready to spawn she does not retreat as far, or at least is not completely routed. As spawning becomes more imminent the side to side position is assumed with increasing frequency and less actual fighting takes place. Finally there comes a time when the female in such a position gives a peculiar quiver to her dorsal and anal fins, which is not easily described in detail. This seems to be a signal of impending spawning and fighting rarely occurs after it. An item for which no explanation is offered is that after spawning has once occurred the pair seldom fight again, but generally live in peace spawning repeatedly thereafter. The fish never leave one another for any great distance, and much time is spent apparently searching for a place to deposit the eggs. This is usually a rock that is cleaned by fanning away any detritus that may be present, and picking off any larger object with the mouth. In an aquarium, in lieu of a suitable rock, the glass walls may be used although an opaque surface is preferred. Experimentally, a glass painted black on the reverse side will be selected in preference to a transparent piece. If there is only a thin layer of sand a spot may be cleared free of this cover but holes are not dug for this purpose. A considerable variety of surfaces were presented at one time or another which resulted in the conclusion that a large variety of factors enter into the choice of a site. A dark rock will be selected in preference to a light one, but any rock will be picked in preference to any glass. This may have to do with the texture of the surface. A rectangular cement "box" with a partition near one end was constructed to give a variety of surfaces. The first spawning was on top, as shown in Figs. 7A, 9A and B and 10A. The second spawning was on the side as shown in Fig. 7B. It is to be noted, however, that the vertical surface was selected only after the block had been moved so that there was more swimming room between it and the glass side. There was no disposition at any time to spawn under the shelter of the construction. At one end there was a shallow shelter and at the other a deep one. The fishes, sometimes, when not breeding hid just within the entrance, but never went out of sight. The site of the egg deposition may or may not be near one of the earlier made holes, but in an average small aquarium there is little opportunity to recede very far from it.

The actual deposition of spawn may be studied at close range as the fishes are usually so intent on the process they are not readily disturbed. Apparently, spawning is usually or probably always done in daylight. *Aequidens* is quite inactive at night, both in the natural state and in aquaria. Since it was already known that under the conditions in the experimental aquaria spawning occurred about every twenty-five days, it was a simple matter to plan long in advance for the anticipated egg laying. The aquarium was arranged in such a fashion as to cause reproduction to take place in a readily visible location. As the choice of egg laying sites was already well understood, the tank arrangement became a simple matter and the only requirement was to be on hand at the prognosticated time. The details of one spawning studied intently, which included the use of a hand lens, may be considered as typical.

Spawning commenced at about 10.00 a.m. and was not completed until about 12.30. The eggs were laid on a rounded cement disc especially made for such a purpose. Just prior to depositing the first eggs the female engaged herself in a final "cleaning" of the spawning site by continually biting at the rock. At the same time a more or less violent quivering is observable. The male takes no part in this final procedure, merely swimming about leisurely close to the rock. At this time the ovipositor of the female and the inseminating tube of the male are both extended to their full limit. The former is decidedly blunt and larger in diameter than the latter which is pointed. See Fig. 2-A and B. Both point slightly backward. According to C. W. Coates (personal communication) those of *Cichlasoma nigrofasciata* Günther, point slightly forward as do those of the pomacentrid, *Pomacentrus leucoris*, Breder and Coates (1933). The female proceeds to drag the ovipositor gently over the rock surface with the tips of the long ventral fins trailing out on either side. The eggs come singly and may be seen passing down the translucent tube. The fish comes to rest generally when the egg is about half extruded. Due to the fact that the tube is bent backward because of being dragged over the rock the eggs are held free of it until the female slows her motion a little, or rises slightly so that the egg comes in contact with the rock surface.

Here it adheres and the female passes on to repeat the process. Usually the tube crumples slightly and were it not for its flaccid condition would appear to be used to press the egg in place. This is certainly not the case as any significant pressure would be mechanically impossible by such a feeble structure. As the female pulls away from the egg a slight quivering of the body may be noted. A diagram of the action of the egg laying is given in Fig. 2—C, D and E. The above description gives the simplest of the behavior in egg laying. About half of the time the ventral fins assist in expressing the egg. It would seem that the passage is not always entirely easy. Under such conditions the fins are brought together, slightly pinching the tube between them and are then pressed downwards, resulting in stripping the tube of the egg. This action of the fins is naturally very gentle and weak, due to the poor leverage, but is apparently adequate. In addition to the mechanical side of the performance, there may of course be some nervous stimulation that is not so obvious.

The male is in no way attentive to the female proper but proceeds to drag his inseminating tube over the rocks and eggs in a similar manner to that of the female, stopping and quivering every so often. Apparently at such times the sperm is ejected, but in such small quantities that nothing could be seen that for certainty could be designated a cloud of sperm. The male does not usually follow the female about but moves over the eggs, rather independent of her, trailing his fertilizing tube over the eggs generally where she has been recently depositing spawn. Although he is as likely as not to be at right angles to her on encountering new eggs, he is apt to line up where she was while the fluid is emitted, as evidenced by the characteristic tremor. By this time the female has usually moved on and is headed in some other direction. It would seem that the presence of the new egg stimulates the male to emission. Possibly the greater adhesive quality of the newest egg or eggs has a stimulating effect that is lost as soon as they water harden. In any event he goes over the entire patch so often that it is unlikely that any would be missed, even on a most haphazard fertilization. The actual spawning is illustrated in Figs. 5 and 6A. The latter shows the

fish in as close an approach as they ever make to each other. The male is on the left following the female.

The first eggs are laid in rather rapid order and may be along straight or slightly curved lines to the number of five or six. This explains the presence of such groups that may be seen in each photograph of the eggs in this paper (especially Fig. 8). Beldt (1923), one of the relatively recent writers in small aquaria journals, states that about twenty eggs are laid in a row and that the male fertilizes them as soon as a row is laid. The writer observed no rows as long as that, nor that the male paid any particular attention to rows, as such. With longer rows, however, such behavior might become apparent. After several such groups have been laid the female passes over and over the cluster, placing an egg wherever there is room, which explains the presence of those not in lines. The spacing of the eggs is likewise evident, the minimum being accounted for by the thickness of the walls of the ovipositor. After a fair number of eggs have been laid, the remainder seem to be under less pressure and the actions are more deliberate. At such times the female may be seen trying to fit the ovipositor with its contained egg between two previously laid. Near the end of spawning the eggs come with much less frequency, but also the available spaces between previously laid eggs become fewer, resulting in longer and longer periods of "feeling" for a vacancy. Frequently, at such times, the female apparently unable to retain the egg any longer, rushes to the edge of the cluster and makes deposition well beyond the main group. This clearly accounts for the scattering or thinning of the eggs toward the edge of a group of spawn. This feature is likewise indicated in each of the photographs. Thus it becomes evident that the characteristic pattern of the egg cluster of *Aequidens* is explainable on a purely mechanical basis in which the scattered lines of eggs, the irregularly placed ones and the thinning toward the edge of the group are all functions of (1) the speed with which the eggs are delivered, and (2) the tendency to lay the eggs as closely together as the size of the ovipositor will allow.

On the completion of spawning, the male moves off to stand guard and the female fans the eggs. The genital tubes shrink

to a small size within a half hour and the characteristic defense behavior against intrusion takes place. The male in Figure 10A of another pair, still plainly shows his shrinking genital tube. Spawning may take place at a temperature of about 26° C. but one pair in running tap water spawned at 21° C. Beldt (1923) found them breeding at 70° F. and that they could withstand temperatures as low as 56° F. Breder (1927) found the Panama fish breeding between 76° and 86° F. The color of the eggs in all cases was a deep amber but Beldt (1923) describes the color as red. If this is not an error, there is more variation in this regard than would be supposed from the writer's experience. All other mention of egg color in the aquarium literature agrees with the author's observation. The number of eggs deposited at one spawning as indicated in Table II ranges up to 485 at least. Beldt (1923) gives a range of from 200 to 350 and the time of laying as forty-five minutes which is considerably shorter than the observation described herewith which, however, is in accord with the fewer eggs. As indicated in Table II the eggs, under our conditions, hatch in two or three days. Beldt (1923) gives four days.

PARENTAL CARE

The most striking features in the reproduction of *Aequidens* are involved in the details of parental care. The parent fishes cooperate to a remarkable degree in this feature of behavior. As soon as the eggs are deposited, which event may occupy several hours, both parents occupy themselves by circulating the water over them, as noted by Beldt (1923). This may be done by the pectoral fins, or by waving the caudal as well as the long lobe of the anal fin. Usually only one fish at a time thus works over the eggs. The other cruises about nearby as though scouting for possible enemies. If the eggs are more spread out than is generally the case both parents, at times, may work over the eggs simultaneously. Such behavior is shown in Fig. 9A. After a period varying from one to fifteen minutes, the guarding parent will approach the incubating parent and then they will change places. This changing of the guard is illustrated in Figure 6B which shows the female coming to relieve the male. The guard-

ing parent alone takes "time out" to feed. The taking of food is almost always followed by a quicker than usual return to the eggs, a reaction tending to insure that both get food? Coates (1932) describing the behavior of the parents of these fishes, in a tank containing various species, states it as follows. "At feeding time the male would dash into the milling swarm of fishes congregated about the falling food, snatch a few mouthfuls—always keeping a wary eye on the manoeuvring of the other fishes, ready to drive away any that appeared unduly interested in his nest—and then swim over to the nest to relieve the female of her nursery duties. Immediately upon his arrival, but not an instant before, she would hurry over to the feeding place and, while snapping up some food, ably perform the policing duties of her consort. After a few mouthfuls she would return to the nest, and the male would come back for more food. This interchange of duties would occur as many as three times before the hunger of either was appeased." Scores of observations show that the male spends more time fanning the eggs than the female.

It has been generally assumed that the above described behavior has to do with an adequate aeration of the eggs. That this has nothing to do with such activity, on the part of these fishes at least, is established by the fact that they will hatch just as well when removed from the parental influence. This is directly contradictory to Beldt (1923) who states, "Were you to remove the parents as soon as the eggs are laid they would decay." Figure 8D shows the newly hatched eggs of Figs. 6B and 8B, which had been taken from their parents. Although in an aquarium this behavior is thus patently unnecessary to the hatching of the eggs, in a state of nature it undoubtedly is of genuine significance on two counts at least. Small, exploring, bottom life destructive to fish eggs, such as crustacea and worms, may be certainly kept off by such means, while the guarding parent fends off larger attacks, such as other fishes. Both these effects have been observed in aquaria in which such organisms have been placed or kept. Coates (1932) writes as follows concerning defense of the nest: "At no time was the nest unguarded, and likewise at no time were the other inhabitants of the tank free

to go where they pleased. They were all herded into the end of the tank farthest from the nest; unmolested if they did not wander, but unceremoniously hustled back if they did." Chute (1933) states "... it is a common sight at the Aquarium to see, in a tank holding ten or fifteen *Acaras*, two pairs of fishes fanning eggs and a third pair guarding a flock of young fry, while they take turns herding the unoccupied adults into one corner of the tank." Possibly even more important is the prevention of suffocation of the eggs by the silting processes of most natural streams. In the Panama waters inhabited by *Aequidens coeruleopunctatus* such silting is general and fills all small depressions. On the other hand, the nandid, *Monocirrhus polyacanthus* Heckel, which hangs its eggs on the underside of a leaf, Coates (1933), where they are automatically protected from silt, shows not nearly as much current producing activity, acting more as a standing guard. While its vibratory fin tips produce a fair current, this movement is normal in the resting fish, just as it is to *Umbra*, Breder (1925).

At times when *Aequidens* are not caring for eggs or young they flee from any object intruded into the aquarium. When eggs are present the fish are very aggressive and will attack fingers or net, at times holding on with their minute teeth and shaking bulldog fashion. A small rock quietly introduced shares the same fate. One fish was observed to "work" on such an object for nearly an hour. Removal of the eggs causes the fish to lurk in the vicinity for some days. Both parents attacking an intruding hand is shown in Fig. 9B. The male, to the left, is half turned in his effort to tear out a piece of flesh.

The question as to what stimulus causes this response naturally arises, for non-breeding individuals will attack and eat either eggs or young of another pair. This seems to be one of the chief problems of a pair in tank containing other fishes, either additional *Aequidens* or different species. The greater aggressiveness of the parents seems to "bluff" even specimens much larger and there is usually a short chase only. At no time has such a raider been seen to offer fight. Aside from physiological changes incident to spawning, what may account for the observed behavior? Are the fish attracted to the eggs or to the site at which

they spawned? In order to determine this the following experiment was undertaken. Two identical cement blocks were prepared and placed in an aquarium with a pair of fish about ready to spawn. Realizing the preference of these fish for a rock, rather than the glass walls of an aquarium, it was anticipated that they would spawn on one of them. This occurred in due course of time. This was a second spawning on such a block similar to that shown in Figs. 5 and 6A. The following day a dark glass was dropped into the aquarium and the two fishes herded behind it. Then the two cement blocks, one holding the eggs and the other not, were quickly reversed as to position, as shown in Fig. 3A. It was expected that the fish would either tend the eggs in this new position, or stay at the old site. When the opaque partition was removed neither happened. For some time the parent fish took no apparent notice of either block but cruised about the tank as do fish that have been recently netted. In about an hour they were seen picking the eggs off the rock. These were then stowed in the bottom of an old excavation farthest from the front glass. Here they were incubated after the fashion of centrarchids. It is thus evident that the place of oviposition does not determine the parental behavior. Further than this it demonstrates that these fish are sufficiently responsive to environmental modifications to resent such changes by decamping with their family to a new site. So far as the writer knows, this has no parallel in vertebrates lower than mammals (*e.g.* the domestic cat) and has none in the egg-laying vertebrates. It is stated in the popular aquarium literature that various related cichlids may lay their eggs either attached to a solid support or in a sand depression. On a basis of the above it would seem likely that the cases of laying eggs in the sand may only be cases of such change of locality due to disturbance, and described from fragmentary observation.

On toward the time of hatching, the guarding parent becomes more and more industrious in digging new holes. While the difference is slight it would seem that the female is the more active in this regard. This may be simply because the male does the bulk of the egg fanning. The sand digging operation is well illustrated by Fig. 10B. The force with which the sand is ejected may be noted by the distance of the particles from the

fish as they fall down the glass wall. Shortly after the eggs have hatched they are removed by the parents to one of these newly made depressions, usually one larva at a time, as was also noted by Beldt (1923). They are gently picked off from the shells to which they hang by their adhesive organs. Eggs that are dead are likewise picked off but whether or not they are segregated could not be determined. The young fish are usually placed in one depression but may occupy two or even three. It would seem that the "team-work" of the parents is not perfect at this point, one favoring one hole and the other another. From now on until the yolk sac is absorbed and the young fish rise from the sand in a cloud, the parents' efforts are mostly those of guarding. Occasionally they will take up a mouthful of young fish and blow them back in the nest which seems to serve to prevent their packing into a suffocating mass, or, more likely, has to do with the problem of silting in a state of nature as already alluded to. The young without parents suffer no inconvenience in an aquarium but scatter out widely. The method of handling is entirely by sucking in on the respiratory current and ejecting by the special method fishes use in blowing out water, as described by Breder (1925a and b).

After the fish have risen, about three days later,¹ the parents' activities are of three distinct parts. There are always stragglers lagging behind the school of young fish, or precocious ones darting ahead or to one side. These are picked up and blown back into the mass with considerable violence. A male gathering up venturesome offspring to return them to the nest, is shown in Fig. 11A. Guarding the young becomes more difficult but is carried on with equal energy. Hole digging seems to be of a specialized kind. It is persisted in but the holes are small and shallow. As soon as a small hole is dug, accompanied by a flurry of fine debris, the young swarm into it and apparently feed on the small particles brought up. As the young grow the relationship with their parents becomes progressively more loose. At about twenty-five days from the egg laying, the parents are generally ready to spawn again, at which time they usually lose all interest in their earlier young, and may eat them if not

¹ See Table II. Beldt (1923) also gives this figure.

too well fed. The few that do escape merge with the next brood when the latter rise from the sand but are readily distinguished by their much larger size. If the eggs are removed, as previously described, and the young returned to the parents when able to swim, they are devoured as any food object. The parental instinct is thus destroyed by absence from the eggs. On the other hand, young from another brood are not distinguished by the parents from their own, even if of a considerably different size. In fact one pair attempted to herd two young *Lebistes reticulatus* together with their offspring. The efforts of the *Lebistes* were those of violent escape, quite different than those of the young *Aequidens*.

REACTIONS OF THE YOUNG

The preceding description of the attitude of the parents toward the young presents a very inadequate picture of the family life of *Aequidens*, since it is an integration of such factors with those of the young fish themselves. The tropisms of the young fish give valuable clues to the complicated reproductive activities of the species since they are not overlaid by the various conditionings that help to becloud the elements involved in the parents' behavior.

The newly swimming larval *Aequidens* are negatively heliotropic in a rather weak fashion. In a simple aquarium without fittings they will regularly gravitate to the darkest end. They will not, however, go into a completely darkened portion but may possibly be better described as seeking some optimum of light intensity. This is apparently similar to the behavior of young toads as described by Riley (1913). Young reared in the presence of the "breeding block" shown in Figs. 7, 9 and 10 never entered its shelter although they sometimes stayed within its shadow, nor did the parents try to urge them to it but dug new holes for them as shown in Fig. 10B. The visual stimuli appear to be by far the most predominant ones. Cutting across the negative heliotropism, and sometimes directly opposed to it, is a positive response to moving objects. This is not interfered with, either by size, color, degree or kind of motion, through a

wide range. It is this that certainly keeps the school of young fish together, and in company with their parents. The limiting factors of reaction are purely mechanical, such as distance of moving objects in relation to size, intensity of light, amplitude and speed of motion.

In the experiments used to define these responses, flat cards of the sizes shown in Figure 3B were employed. These were suspended from a pivot so that they could be swung to and fro at a distance by means of a cord passed over a series of pulleys. Figure 12 shows the position of a school before and after moving a dark oval card. In this case the moving target was suspended in a beaker within the aquarium, but it worked just as well entirely free and outside of the tank. Figure 12A shows the fishes in a school at the dark end of the aquarium, taking no heed of the target about the size of their parents, and Figure 12B shows them clustered about it a few moments after it had been slightly oscillated, contrary to the negative heliotropism. At a distance of 30 cm. object number 1, in Figure 3B, caused an appropriate reaction, as did a black and a white card 3" x 5" at a slightly greater distance. Items 2 and 3 of the same figure would induce a reaction at a closer distance only, and item 4, which was merely the bare wire that supported the cards, would work not farther away than 5 cm. A further complicating reaction is that any sudden change to either a brighter or duller light intensity causes the fish to drop to the bottom. Tapping on the glass, as when in Figure 12 the target is oscillated too far, had no apparent effect; but a violent agitation, such as a very heavy jar to the table, would cause them to drop to the bottom.

These reactions together with those of the parents may account for the entire behavior ordinarily observed which sometimes appears to be very complicated. In a wild state the value of these reactions is quite apparent. The negative heliotropism to strong light tends to keep the fish on the bottom, as all the bright light under such conditions comes from above, while the positive heliotropism to weak light keeps the young fish out of dark holes that may hide lurking predators. The positive reaction to moving objects of any size keeps the schools together and in company of the parents. The dropping to the bottom on a sud-

den change in light intensity keeps the fish where they are best able to be protected by the parents when a larger fish passes overhead, or an overhanging plant is brushed aside by some stream-side animal. A slight mechanical jar would not likely occur in their native waters, but to a violent action, such as the planting of a hoof in the water, they are negative. One of the characteristic acts of the parent fish with young at this stage, when danger threatens, is to immediately swim over the school of young fish and snap the ventrals out fanwise. This may be repeated several times before he dashes to attack the intruder. The young fish consequently drop to the bottom. It is little wonder that such behavior has led the uncritical to write in an extreme anthropomorphic vein about cichlids, vesting them with all manner of human attributes.

As the fishes grow larger and sturdier these reactions become gradually less and less pronounced. At one point, when the young are about six days old, the small school takes on characteristic "streaming" movements. Not infrequently these form a figure eight as indicated in Figure 3C. The young in this aquarium passed through this double loop in an average time of 12 seconds, showing them to have a speed of about 5 feet per minute. This is naturally before the time they scatter out and its function, if any, is not clear. It is imperative that the young leave the parents before another spawning, however, which may be as soon as twenty-five days. If this does not take place the old fish try to guard the young indefinitely and very likely accounts for some fish seen in Panama with exceedingly large young. After they once leave the parents, the cycle is completed, with the young going on to maturity. Certain other items of behavior, not readily discussed with the foregoing, have been relegated to the following section. Some are explainable at this time and others are not, but in some ways they form the most interesting items in this study.

EXCEPTIONAL ITEMS OF BEHAVIOR

In the case where eggs were deposited on the black partition of aquarium "B" of Fig. 1 and shown in Fig. 8C, a most

remarkable performance took place in aquarium "A" which still contained the solitary male originally placed there for the hole-digging experiments. This fish took up a position on its side of the perfectly opaque partition and proceeded to fan and otherwise father the area exactly opposite, the spot covered by the eggs. Fig. 13A shows the two fish on either side of the glass in characteristic poses.¹ It was first thought that the possible chemical emanations from the eggs, passing through the slight crack between the partition and the aquarium side, attracted this male fish. That this was not the case became evident later as this fish carried on his incubating efforts for the entire time, stopping only when the parents had removed the young to one of their sand pits. The exactitude with which this fish covered the area corresponding to that occupied by the eggs, can still not be adequately explained at this writing. As vision and chemical sense could not well account for this effect, sound and mechanical jar were considered; especially the latter as the fishes on either side of the partition actually attempted to fight through this opaque wall through which they could not possibly see their opponent. In various places they would bump their noses against the glass exactly opposite to each other. These fighting regions were generally somewhere near the eggs, but sometimes as much as half way across the tank. Observation of such behavior lead to an experiment based on a modification of the targets earlier described in studying the tropisms of the young. The oscillating member was set up, as shown in Figure 13B. A piece of rubber tubing was placed on the moving end at an angle so that it could be made to tap the partition on the egg-bearing side with any degree of firmness. Light taps such as the fish might give caused no response, and stronger ones merely induced the fleeing reaction which was only temporary because of the strong attraction to the place opposite the eggs. Further observation revealed the real cause of the "fighting through the wall" which proved to be as simple as it was mystifying.

The crack between the glass side of the tank and the black

¹ It will be noted that the excavations in the sand in this and the following three pictures do not tally exactly with those of Fig. 1-5. This is because these photographs were taken much later when still other holes had been dug. Close inspection will, however, show the original excavations of the earlier period.

partition was not more than one-eighth of an inch wide. Due to the large angle of vision of these fishes they could actually see each other through it. This was checked by placing smaller strips of black glass against the aquarium walls but sufficiently distant from the partition not to interfere with a free interchange of water so as not to inhibit any chemical effusions. Under such conditions all fighting stopped only to reappear again when the baffles were removed. This completely explained the fighting at the edge of the partition but not that remote from its edge. Long and continued observation explained this also as it was noted that all "fights" started at the crack. In their struggles to get through at each other, each fish struck the aquarium wall and then moved back from it (or knocked itself back). Then they would be facing just about opposite each other and if first noticed in such a position were decidedly puzzling. It may well be also, that the tapping on the glass of the opposite fish influenced them to continue even if mechanical imitation could not initiate such behavior.

Before attempting to explain the attitude of the lone fish, toward the eggs, the events following hatching may be mentioned. At the time the young began to rise and swim around, some young fish of another pair were introduced to both aquarium "A" and "B." Those in "B" were absorbed in the "family" school and the male in "A" immediately took characteristic parental care of his charges. This is entirely unlike the behavior of non-breeding adults which see the little fish only as food objects. This is even true when some are returned to parents whose nest has been robbed as has already been pointed out. Further than this, as the young fish grew and became more adventuresome, the male in "A" managed to rob the true parents. He would lie in wait near the crack and as a young fish came close literally suck it through the crack. Fig. 14A shows the two aquaria with the young fish up and active. The fish in "A" has just begun to gather the school together. Fig. 14B shows a later condition where he had actually rounded up the bulk of them on his side of the wall. From then on much of the time was spent with the fishes on either side of the fence taking the young fish back and forth (Fig. 14C). Sometimes most were on one side and some-

times on the other. This was kept up until the fish were removed to make way for other experiments.

An attempted explanation of the unusual behavior of this solitary male is offered for whatever it may be worth. Since these fish normally eat the young of others unless they are tending a brood of their own, and since the male in question showed all the reactions of a fish that had just spawned, it is supposed that while the pair in "B" were spawning on the glass partition, the male in "A" became stimulated to discharge its gonads, directing attention to the crack through which the female could be intermittently seen. In fact it is not impossible that some of the eggs may have been fertilized by the extraneous male. Of course if the partition had not been there, one male or the other would have been vanquished and probably killed.

In a large aquarium containing a stable population, not unlike that described for *Lebistes* by Breder and Coates (1932), it was not uncommon for as many as three pairs to be caring for young at the same time.¹ Apparently these broods would never get mixed up. Observation showed that they closely approached, but would veer off from each other just as they would be about to merge. Since the schools were always composed of slightly different sized fishes, they could be distinguished. That the size difference had no bearing on it is shown by the merging of the remnants of an earlier school with a later as previously described. Incidentally, the schools in this larger tank were always more compact due to the greater attention given by the parents presumably because of the aggression of non-breeding fish. Eventually, most of the young would nevertheless disappear that way, just enough growing up to replace deaths from other causes.

DISCUSSION

The study of the reproductive habits of *Aequidens latifrons* makes clear the fact that these fishes excavate holes for both the purpose of modifying their environment to suit their convenience, and also at the time of breeding as receptacles for their young. It has also been shown that to a very remarkable degree

¹ Chute (1933) made similar observations in the much larger exhibition tanks of the Shedd Aquarium in Chicago.

these fishes will modify their behavior to suit a given set of circumstances, as for example the case where a pair removed their eggs from a rock, following disturbance, and incubated them in a sand hole not unlike the method of the centrarchids. Given such a tendency to transport both eggs and young under appropriate stimuli, it is not difficult to imagine how oral incubation may have arisen. Continual annoyance in a state of nature by other creatures may have induced continued transportation until finally no resting place at all was selected, Breder (1933).

Checking from the other end, that is, from species that carry their eggs regularly, there are other evidences to support this view. While these experiments were in progress a pair of *Tilapia heudeloti* Dumeril, were also studied. While the full details of their reproductive habits will not be gone into at this time, the following remarks are distinctly pertinent. Prior to spawning, a large but shallow hole was dug, approximately in the center of the tank, and all loose detritus brushed back. The eggs were deposited in the hole and immediately gathered up by the male. As there is an obvious necessity for depositing eggs in a place from which they may be recovered, the retention of hole digging and cleaning as a habit is clearly of survival value. Another species, *Haplochromis strigigena* Pfeffer, that carries its eggs about, may or may not prepare an excavation for the eggs, as is well known. Whether or not a nest is made seems to depend on the aquarium. If large, and with a quantity of detritus on the bottom, a nest is likely; whereas in a scrupulously clean, small tank, one is unlikely. Here, again, seems to be a well-marked disposition to fit the behavior to the condition. In this species the females normally take care of the eggs, but as Breder (1918) has shown, the male may sometimes take on the role. As one fish normally takes care of the eggs, the tendency for either or alternate sexes to take the role would seem to be relict of a time when both were interested in protecting the young. The fact that the brooding type normally alternate their attention to the eggs, further suggests a reason why both fish do not each take some. Actually, this does occur in the oral incubating *Betta pugnax* Cantor, which derives its habits from a different basic type. A further consideration of the significance of these differences will

be discussed in a later communication. Apparently, the origin of oral incubation in the Siluridæ, on the other hand, had its inception in a habit closely similar to that of the Cichlidae. As pointed out by Breder (1932), incubating *Ameiurus* frequently take their eggs in their mouth and churn them about. This, which has a special significance, will be discussed in full in a detailed consideration of their reproductive habits.

SUMMARY

1. *Aequidens latifrons* may lay eggs as frequently as every twenty-five days at a temperature of about 25° C.
2. The eggs are fanned for the full period of incubation and the young protected until the parents are ready to reproduce again.
3. The adhesive eggs are attached to a solid support, preferably an opaque one, such as a rock, up to the number of about 485 at least.
4. If the fish are sufficiently disturbed the eggs may be removed, carried to some hollow in the sand, and incubated there. This behavior suggests the inception of the buccal incubation of other genera of cichlids. Further disturbance will sometimes result in the young or eggs being eaten.
5. Holes are regularly excavated in the substrate and act as lurking places, and, at times of reproduction, as sites to place the newly hatched fish before they are able to swim, or for the eggs if the original site is disturbed.
6. The young are negatively heliotropic, move toward any moving object of sufficient size to be detected, and descend to the bottom on any sudden change in light intensity to either greater or lesser brilliance and to violent mechanical jars. These reactions, coupled with those of the parents, account for most of the apparent, complicated, family relationships.

7. Sex recognition is accomplished by the differential behavior of a female ready to spawn as compared with that of males or non-spawning females which fight on approach.
8. Well established areas of proprietorship are patrolled by *Aequidens*, usually about some natural retreat or sand hole. Neutral areas exist where fighting does not ensue.
9. Artificial holes are sometimes accepted, chiefly in strange aquaria where there has been no conditioning to previous places. Under the latter conditions a hole may be re-dug repeatedly in one spot after having been destroyed.
10. Hole digging may be intensified by continued annoyance and confinement in too small a container.
11. Fighting is somewhat a coefficient of crowding up to a certain point of concentration beyond which it falls off, due apparently to the establishment of an unnatural condition or one simulating the excessive crowding witnessed in the dry season of the native streams. The value of this reversal of habit is evident when it is considered that the resulting dead tissue from excessive deaths by fighting would reduce the chances of survival of the remainder by pollution. The increase in CO₂ concentration acts to inhibit fighting as here noted, but long before the suffocation threshold is reached.

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¹ Since this study went to press, Dr. G. S. Myers presented a paper at the Seventeenth Annual Meeting of the American Society of Ichthyologists and Herpetologists entitled, "A Possible Method of Evolution of Oral Brooding Habits in Cichlid Fishes." The views expressed therein are in essential agreement with the present concerning the origin of oral incubation, and with the abstract of Breder (1933). It is noteworthy that these two workers independently find their conclusions in such full accord.

TABLE I

Fighting Reactions of *Aequidens* under Varying Conditions

Attitude	mM Free CO ₂	mM Combined CO ₂	pH	° C.	Date
F	0.25	2.24	7.3	26	June 13
N	0.42	2.96	7.3	26	13
F	0.29	1.69	6.8	23	14
N	2.01	1.88	6.1	26	14
N ¹	3.15	1.69	6.0	26	14
F	0.82	1.96	6.6	21.5	15
N	...	...	7.0	20	16
F ²	...	...	7.0	21	19
N	...	...	7.0	20	20
F	...	...	7.0	22	24
N	...	...	7.0	22	25
F	...	...	7.0	22	27
F	0.37	0.27	6.8	22.5	July 11

F=Fight. N=No fight.

CO₂ readings made with a Van Slyke apparatus; pH readings made with a LaMotte comparator, both by T. H. Howley.

¹ Fish suffocating.

² Fighting slight.

TABLE II

Reproduction Data on *Aequidens latifrons*

Spawn No.	Pair of Fish	Spawned	Hatched	Arose from Nest	Days since Spawning	No. of eggs	Temp. ° C.	Eggs placed on	See Fig. No.
1	A	May 5	May 6	May 11	..	485	25.5	white rock	6B, 8B, D
2	B	May 5	May 8	May 11	..	358	25.5	black glass	8C, 13, 14
3	B	May 30	.....	June 5	25	...	...	round block	3A, 5, 6A
4	B	June 24	June 27	.....	25	486	26.	round block	2, 8A
5	C ¹	June 28	.....	.....	..	...	21.	slate bottom	.....
6	D ²	July 15	.....	.....	..	...	23.5	round block	.....
7	B	July 17	July 19	.....	23	300±	23.5	top of square	7A, 9, 10
8	E ³	July 31	Aug. 2	.....				side of square	7B

¹ In running tap water.

² Same male but different female from pair "C."

³ Female from pair "B"; male from pair "D."



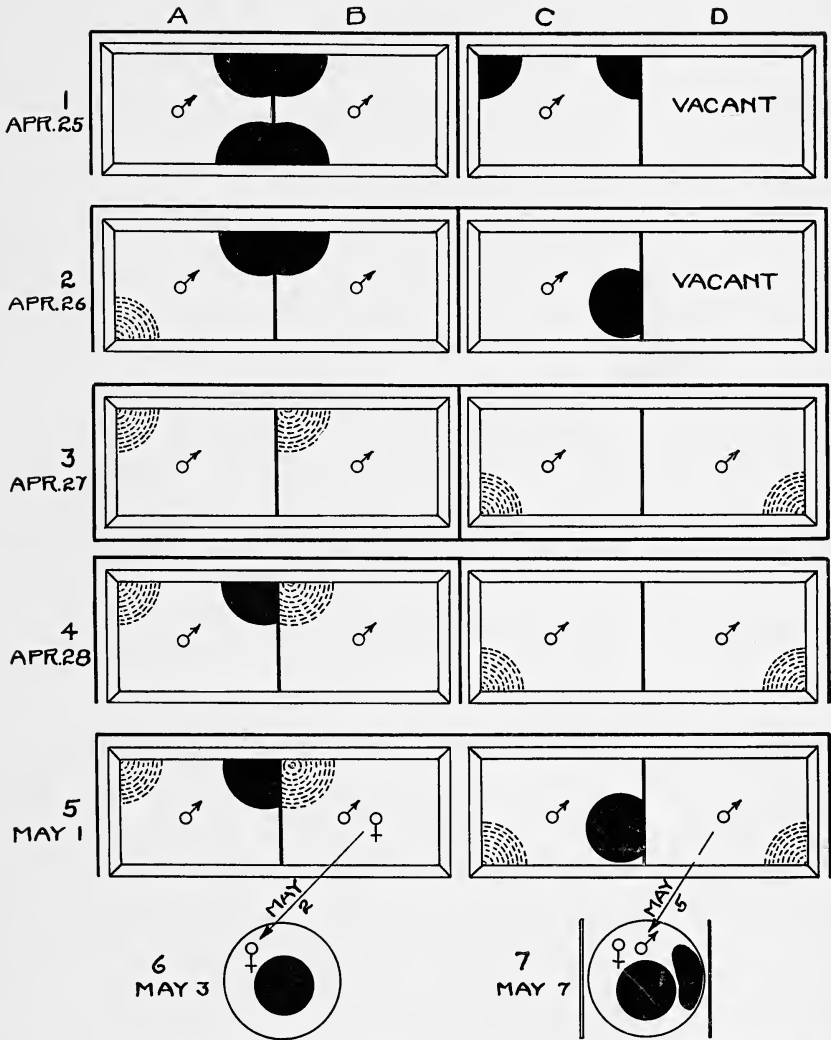


Fig. 1.—The excavating habits of *Aequidens*. A, B, C and D represent two aquaria, each bisected by a black glass partition. The outer black lines represent cardboard walls further restricting vision outside their aquaria. Black areas represent excavations made by the fishes. Dotted areas represent excavations made by hand in imitation of the retreats. Sex symbols indicate number and sex of specimens. See text for explanation. 1. Condition of aquaria after standing for fifteen days. 2. Condition of aquaria after smoothing of sand the day previous, and the construction of an artificial retreat in "A". 3. Condition of aquaria after smoothing the day previous, and the construction of an artificial retreat in each aquarium, coupled with a complete blinding of each aquarium. (Note especially the board walls.) 4. Condition of aquaria after the removal of the front wall. 5. Condition of aquaria three days after introduction of female in "B", and removal of partition between "B" and "C". 6. Place of nest made by female in a circular aquarium evenly illuminated. 7. Place of second nest in circular aquarium after the placing of a light and a black card on either side of the aquarium. See text for discussion.

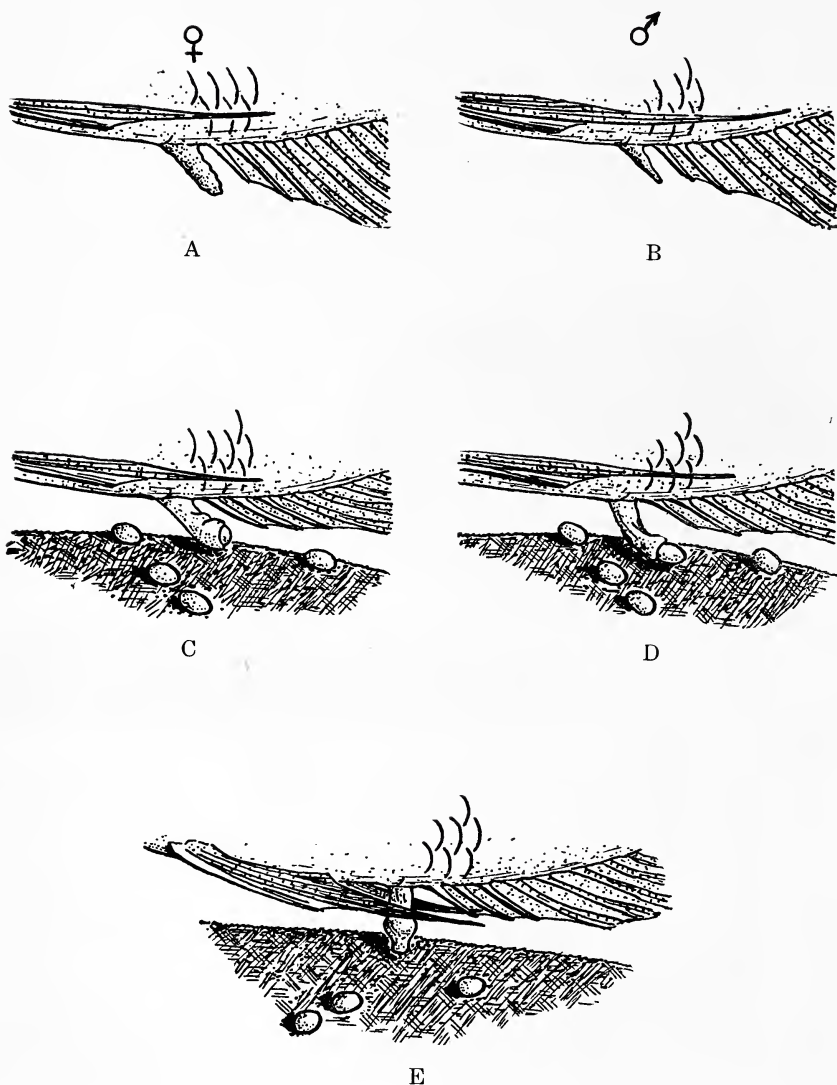
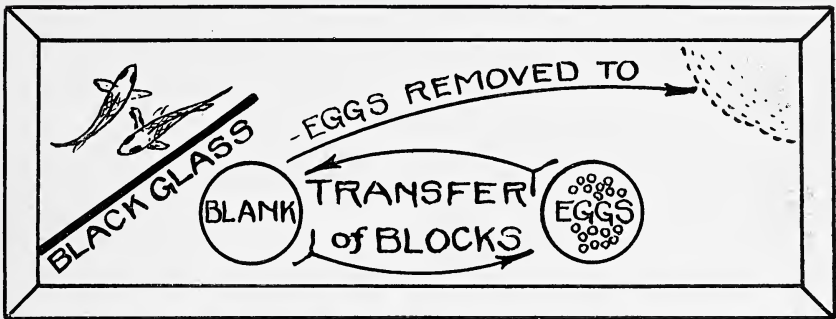
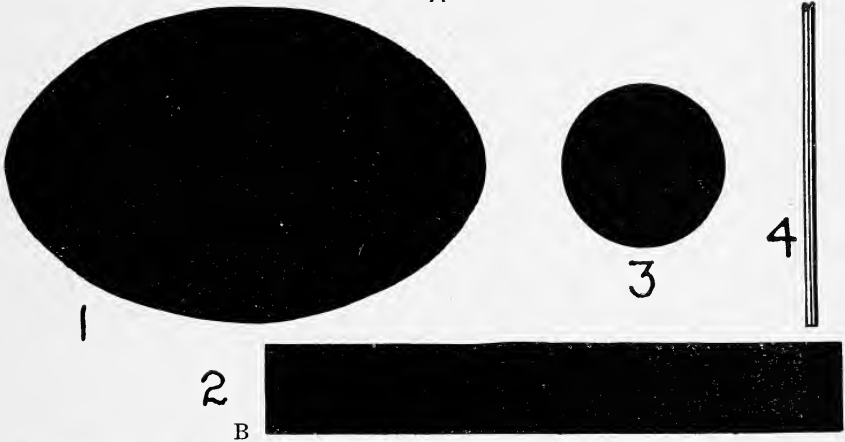


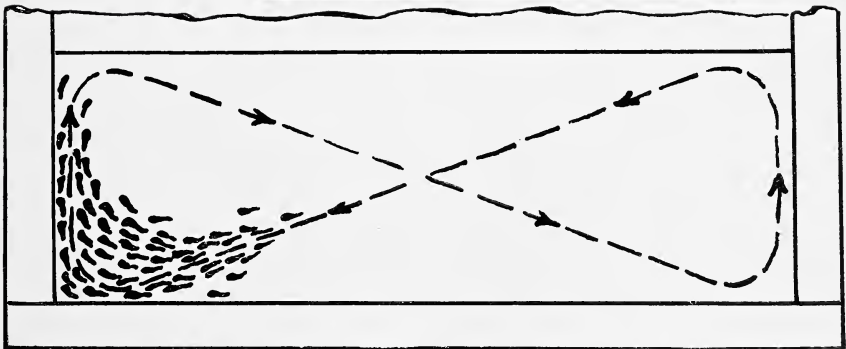
Fig. 2.—Egg laying of *Aequidens*. A. Female ovipositor. B. Male fertilizing organ. C. Female dragging ovipositor, with egg nearly extruded. D. The passage of the egg. E. The female assisting the passage of an egg by means of the ventral fins. See text for details. In all, the organs are slightly exaggerated in size.



A



B



C

Fig. 3.—A. Diagram of method employed in shifting the eggs laid on an especially made cement block in such a fashion that the parents could not see the action. See text for explanatory discussion. B. Diagram of objects used in the study of tropisms of juvenile *Aequidens*. Items 1, 2 and 3 are black card targets, and 4 is the pale grey wire used for their support. C. Diagram of streaming movements of young fish in a small aquarium.

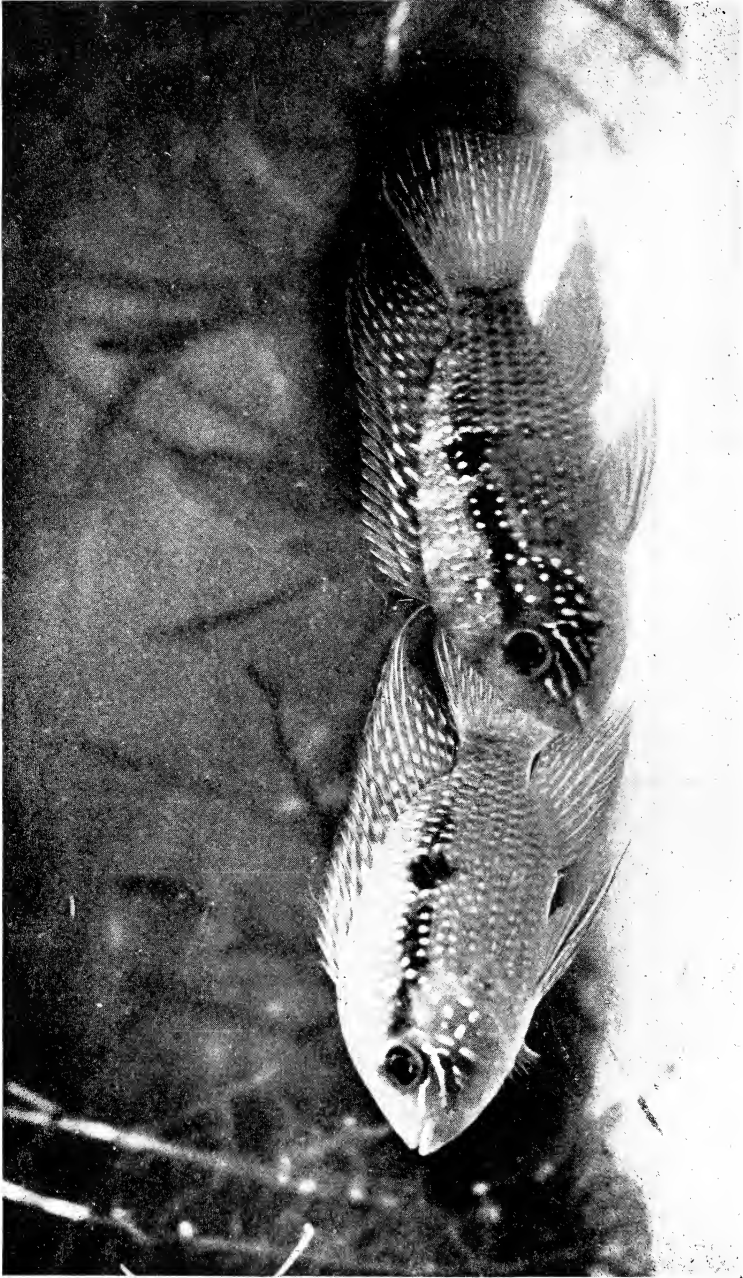
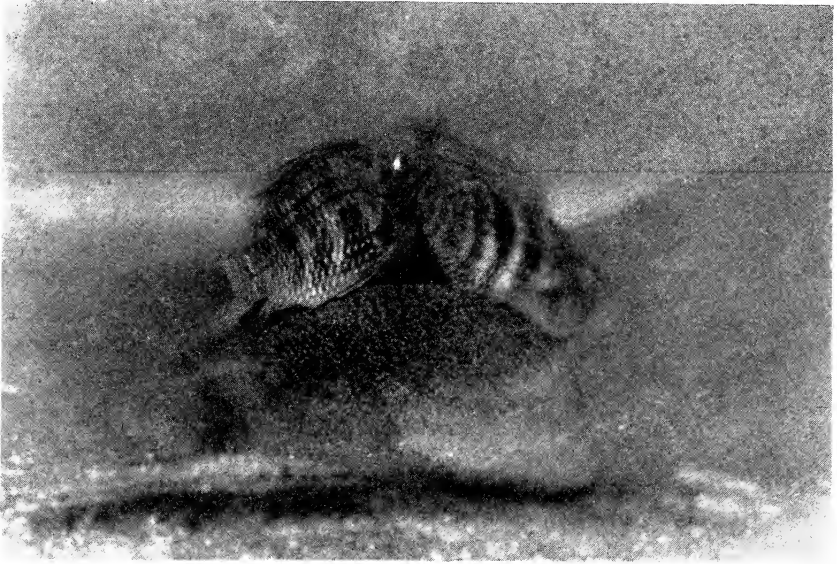


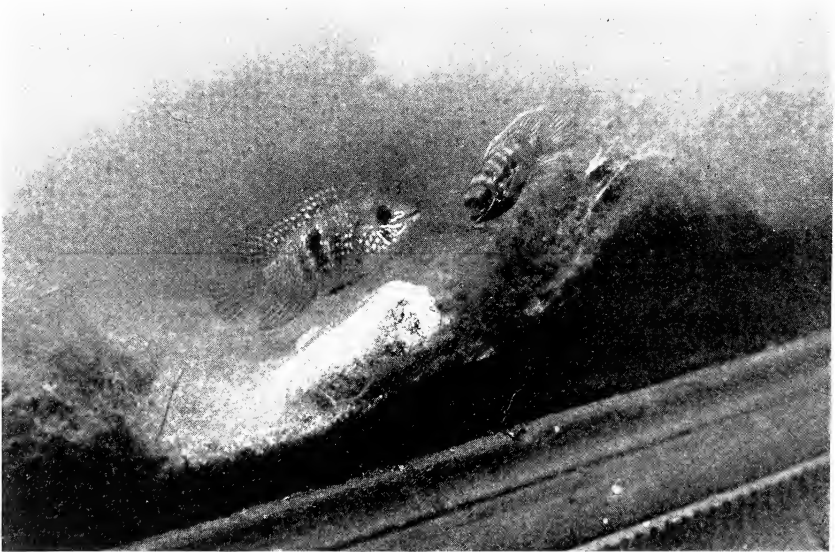
Fig. 4.—A typical pair of adult *Aequidens latifrons*, the parents of the fishes on which this study was based. Male, left; female, right.



Fig. 5.—Two typical postures of *Aequidens* in spawning. The male to the left in both cases.

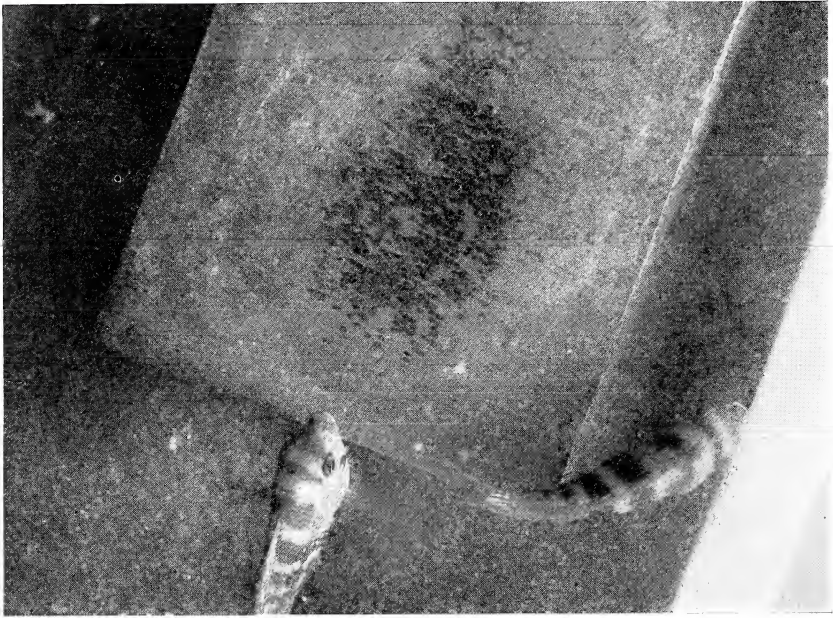


A

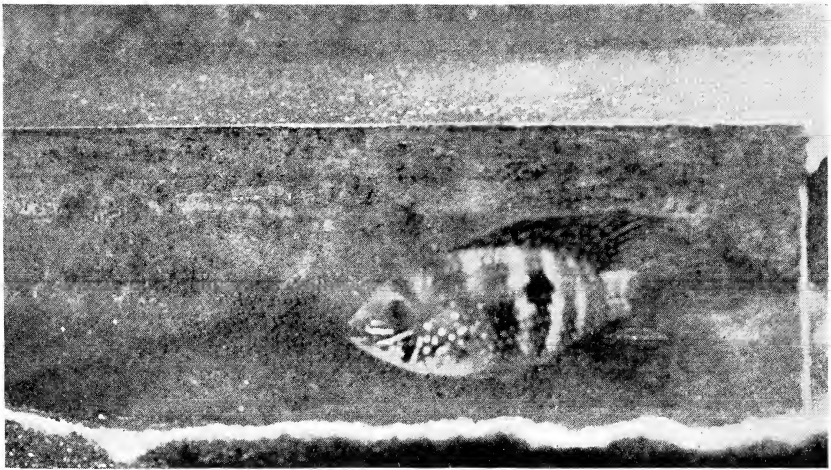


B

Fig. 6.—A. *Acquidens* near the end of a spawning. Male, right; female, left. B. Male *Acquidens* fanning water over eggs, with female approaching to relieve him. Note how the bottom has been cleared of detritus in the vicinity of the nest.



A



B

Fig. 7.—A. Eggs on the top of the cement block. B. Eggs on the side of the cement block.

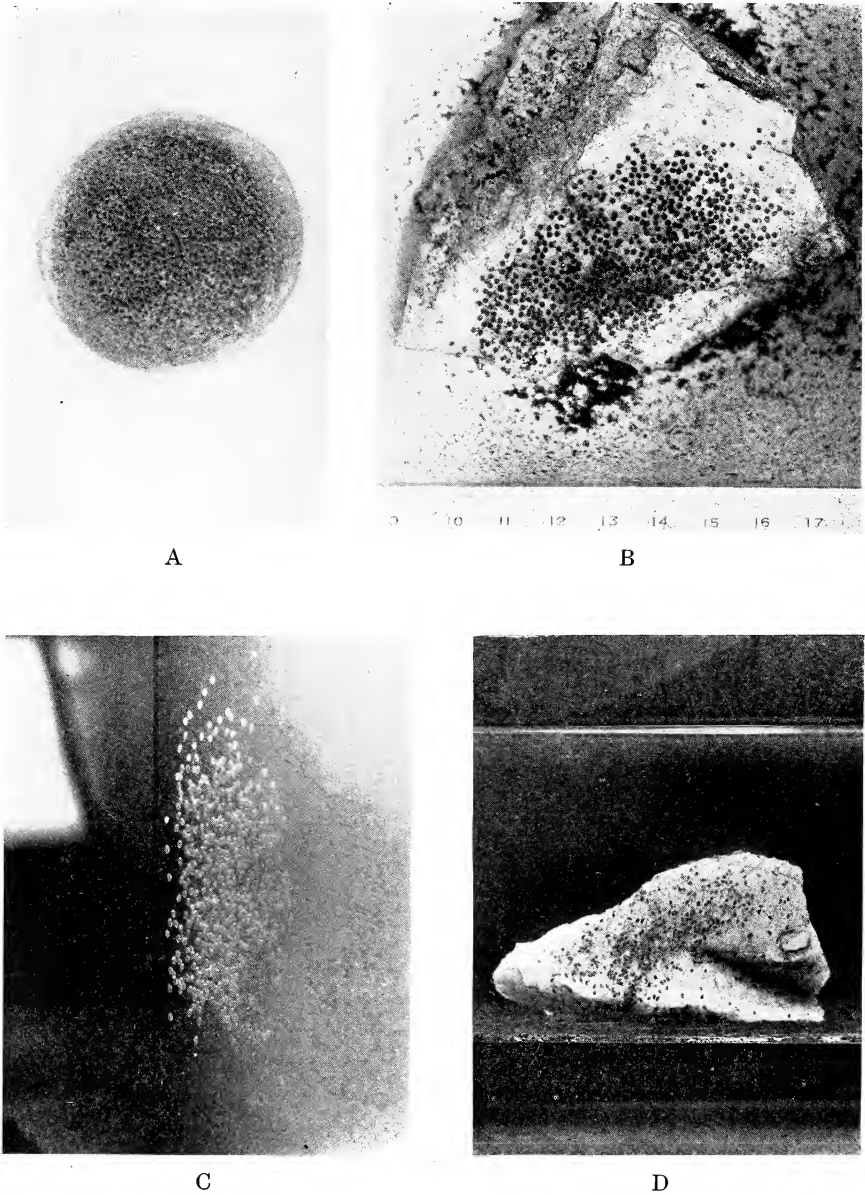
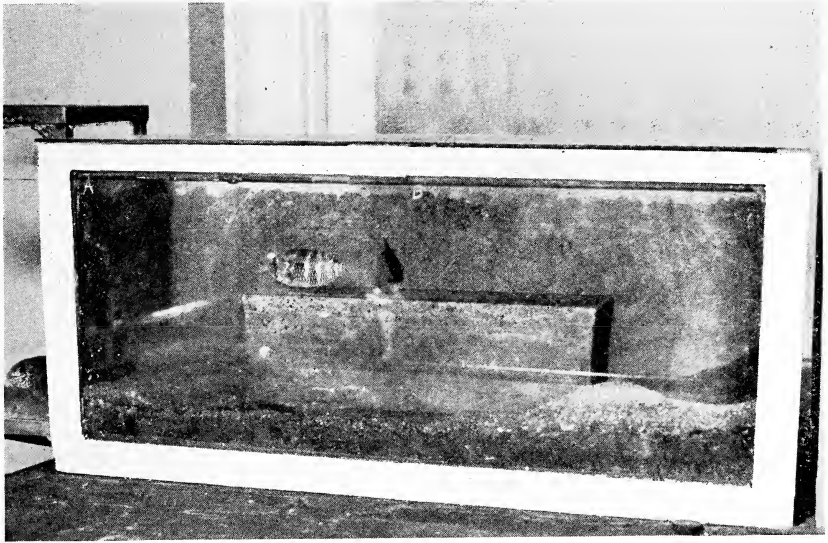
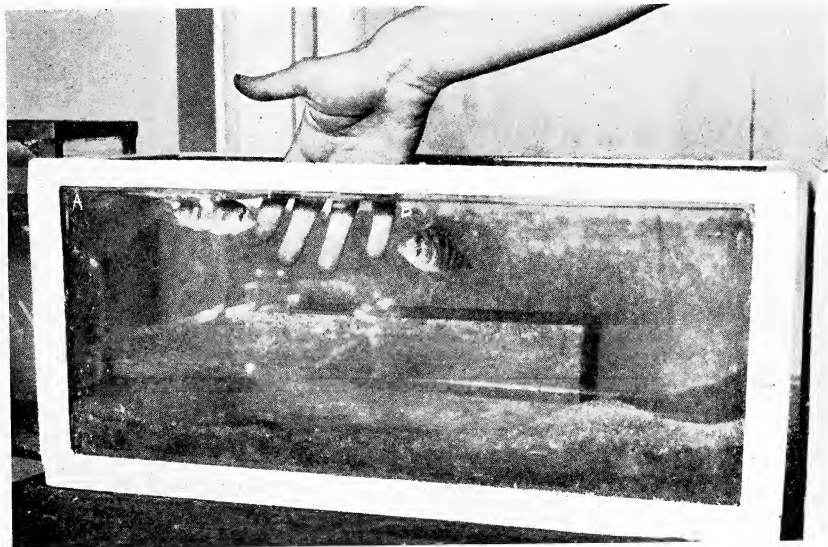


Fig. 8.—A. Eggs on a round cement block. B. Eggs on a white rock. C. Eggs on a black glass. D. The newly hatched young on the white rock shown in "B".

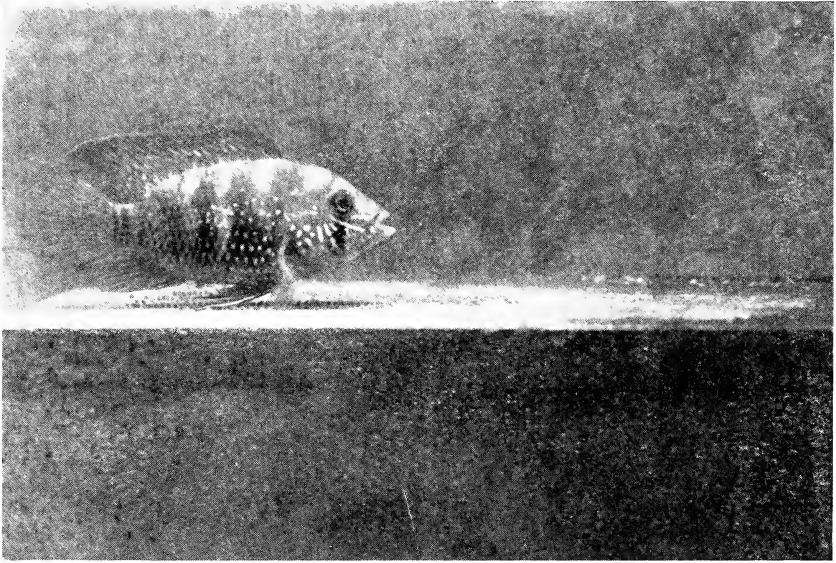


A

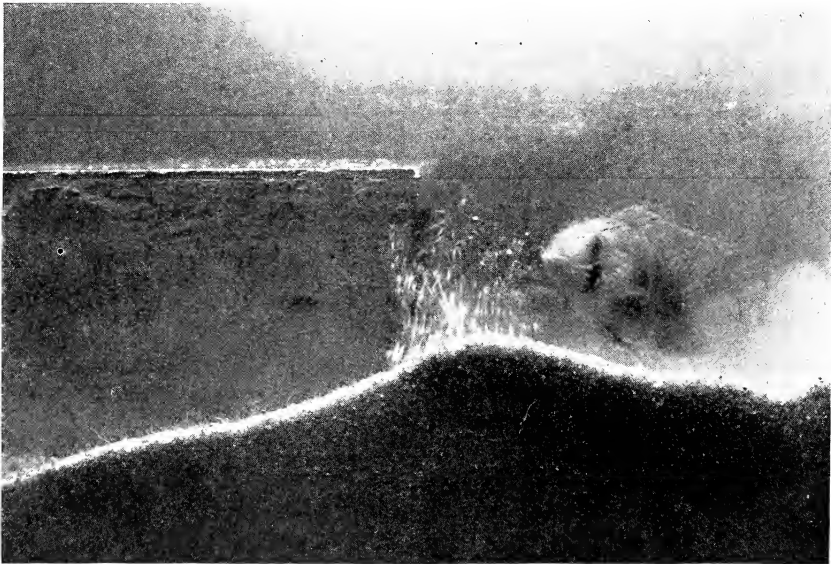


B

Fig. 9.—A. Both male and female incubating simultaneously. B. The same pair defending their eggs against an intruding hand.



A

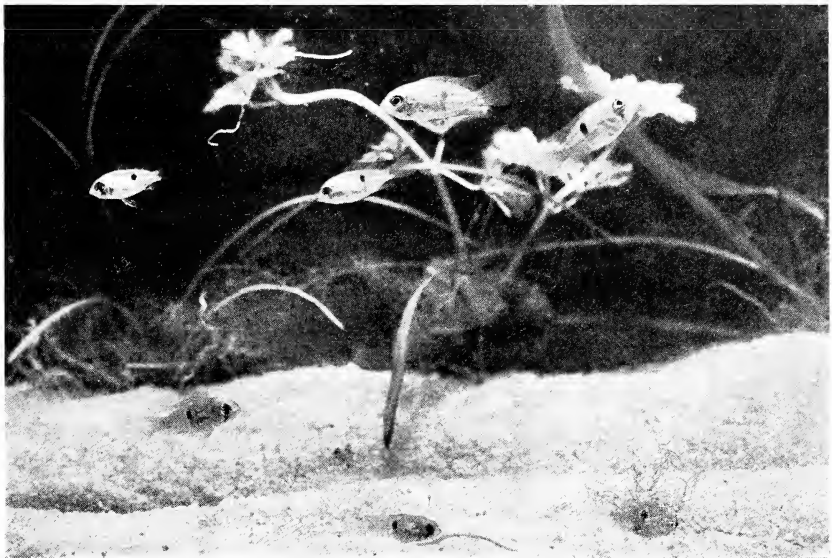


B

Fig. 10.—A. The male of Fig. 9 incubating and wiping the eggs with his ventral fins. B. The female of Fig. 9 excavating a hole for the reception of the young about to hatch. The sand grains ejected from the female's mouth have struck the glass wall and are falling.

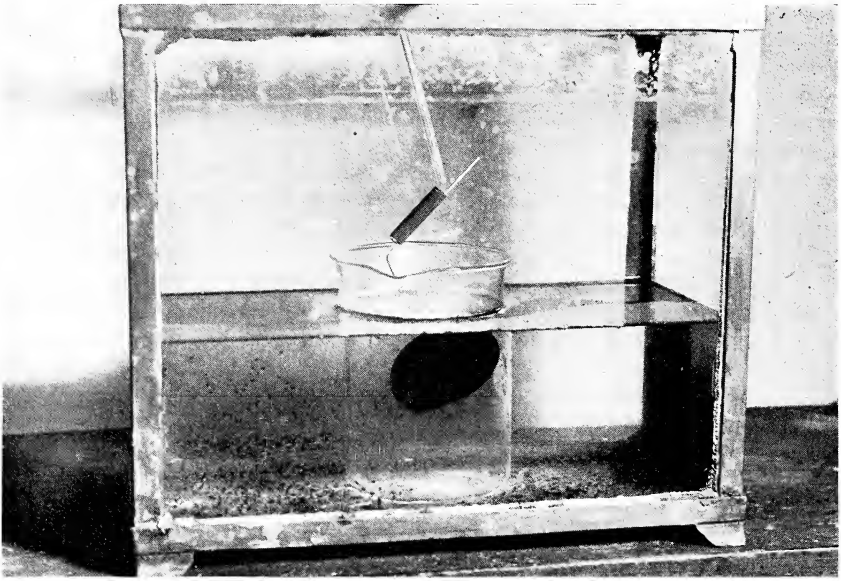


A

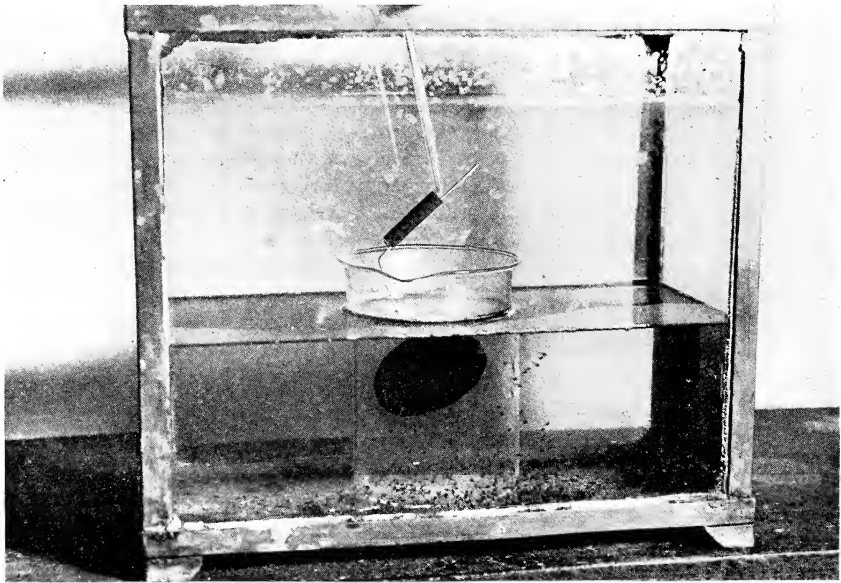


B

Fig. 11.—A. A male *Aequidens* gathering adventurous young, to return them to the brood shown in the background. B. Young *Aequidens* at the stage that they usually begin to escape from parental solicitude.

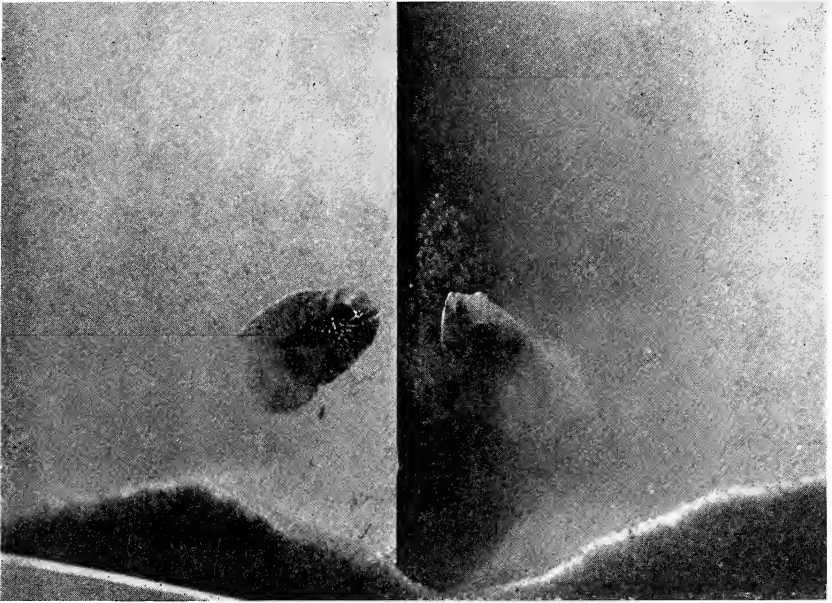


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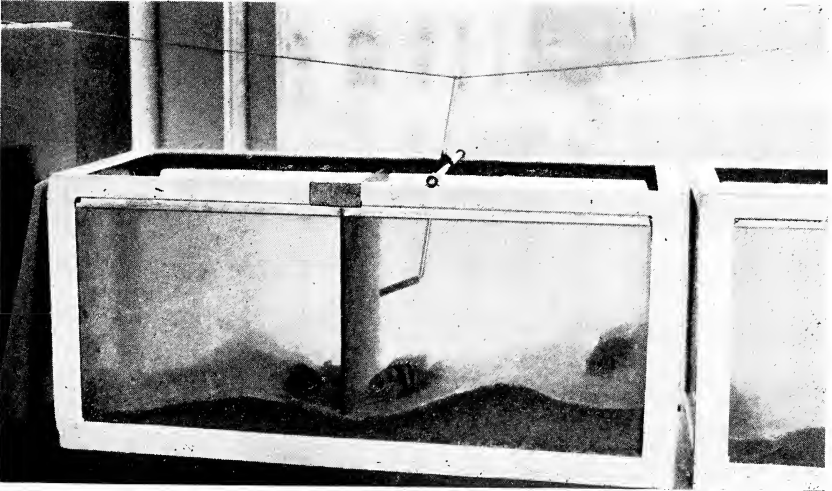


B

Fig. 12.—Reactions of juvenile *Aequidens* to a moving dark object in relation to their negative heliotropism. A. Young fish at end of tank farthest from light before oval target was moved. B. Young fish about beaker containing target after it had been oscillated a few times.

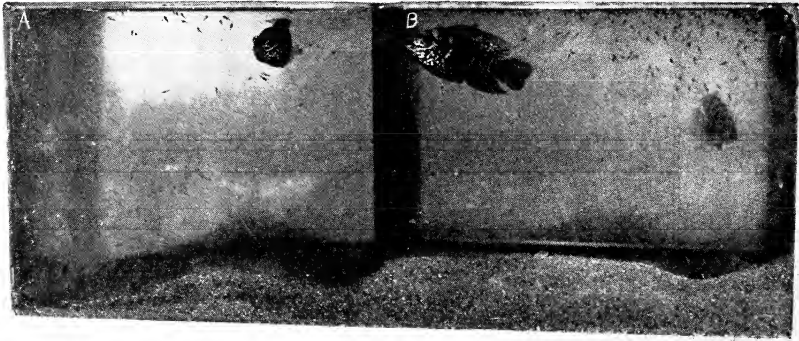


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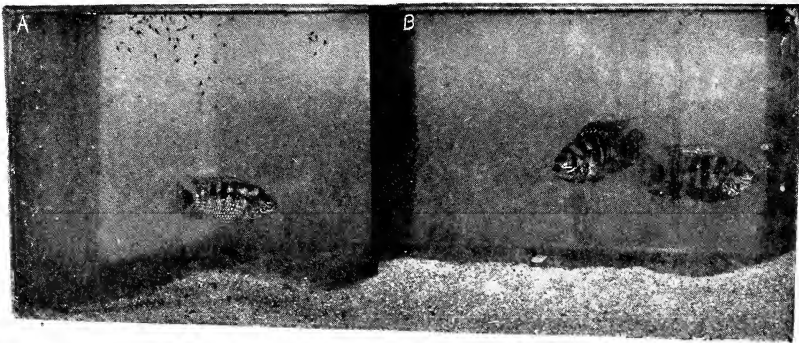


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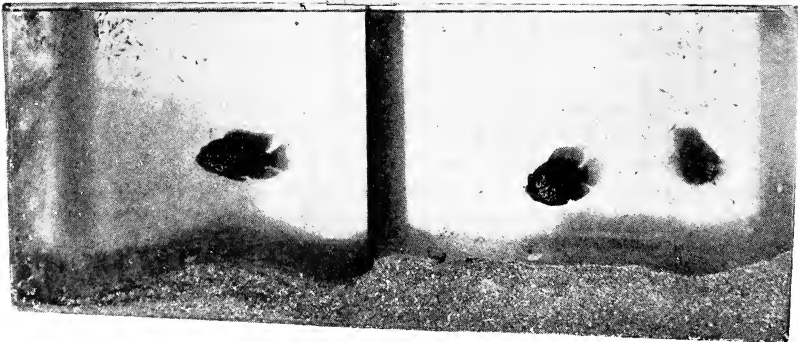
Fig. 13.—A. *Aequidens* fanning eggs on a black glass aquarium partition, and the peculiarly interested lone male on the other side of the partition. These eggs are the same as those shown in Figure 8C. B. Aquaria "A" and "B" of Figure 1 showing the tapping device.



A



B



C

Fig. 14.—A. A lone male *Acquidens* in the process of robbing the parents of their brood. (Center) At the start, with only a few obtained. B. and C. Later, when the lone male actually had more young than the parents.



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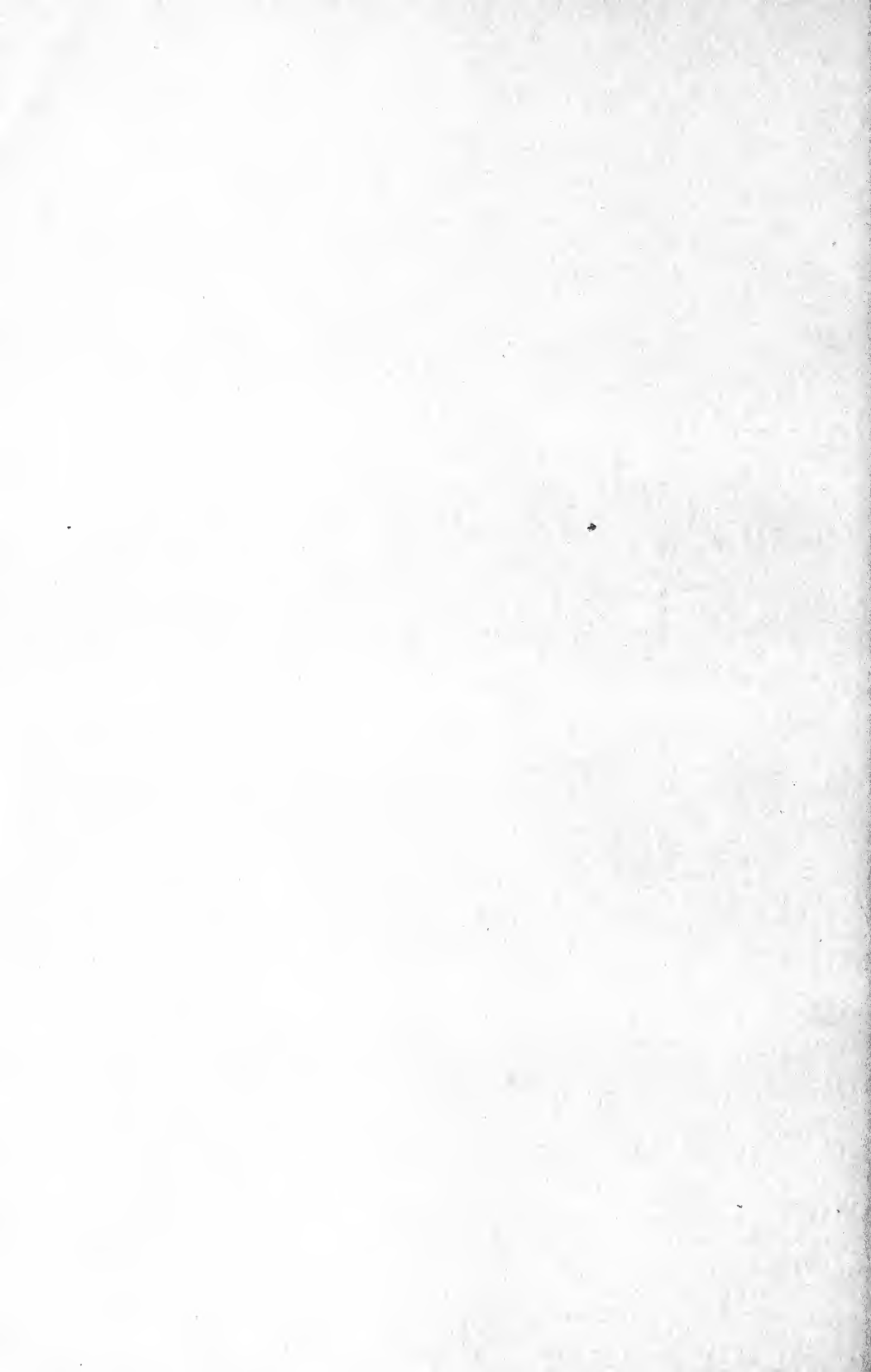
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BY CHARLES HASKINS TOWNSEND

Director New York Aquarium

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THE FUR SEAL OF THE GALAPAGOS ISLANDS

Arctocephalus galapagoensis Heller

BY CHARLES HASKINS TOWNSEND

Director New York Aquarium

According to the meager records at present available, it is about thirty-five years since organized sealing operations at the Galapagos Islands terminated. The supply of fur seals, originally abundant but declining for nearly a century, was exhausted.

The last of these records relates to the taking of 224 seals by the sealing schooner *Julia E. Whalen* of San Francisco, in charge of Captain W. P. Noyes. This vessel was accompanied by two naturalists, Edmund Heller and Robert E. Snodgrass, for the purpose of making collections for the zoological department of Stanford University. The voyage lasted ten months (1898-1899) during which every island of the group was visited. The catch was small as compared with those made by sealing vessels a decade or so earlier.

The fur seal of the Galapagos, long known to naturalists as *Arctocephalus philippi*, so named by Peters in 1866, was described by Heller in 1904 as *A. galapagoensis*.¹ It is probable that Peters had no specimens from these islands, and assumed that the Galapagos seal was not different from that inhabiting Juan Fernandez and Masafuero off the coast of Chili, where hundreds of thousands of fur seals were taken during the early part of the nineteenth century.

The capture of several living fur seals at the Galapagos in 1932 and 1933 by Captain G. Allan Hancock of Los Angeles, California, owner and master of the cruiser *Valero III*, has made available for study the only specimens of this seal that have been taken since 1906. At that time a single specimen was secured by R. H. Beck. During recent years the Galapagos fur seal has been regarded as

¹ Proc. Cal. Acad. Sci. 1904. 3d series. Vol. III. No. 7. pp. 245-48.

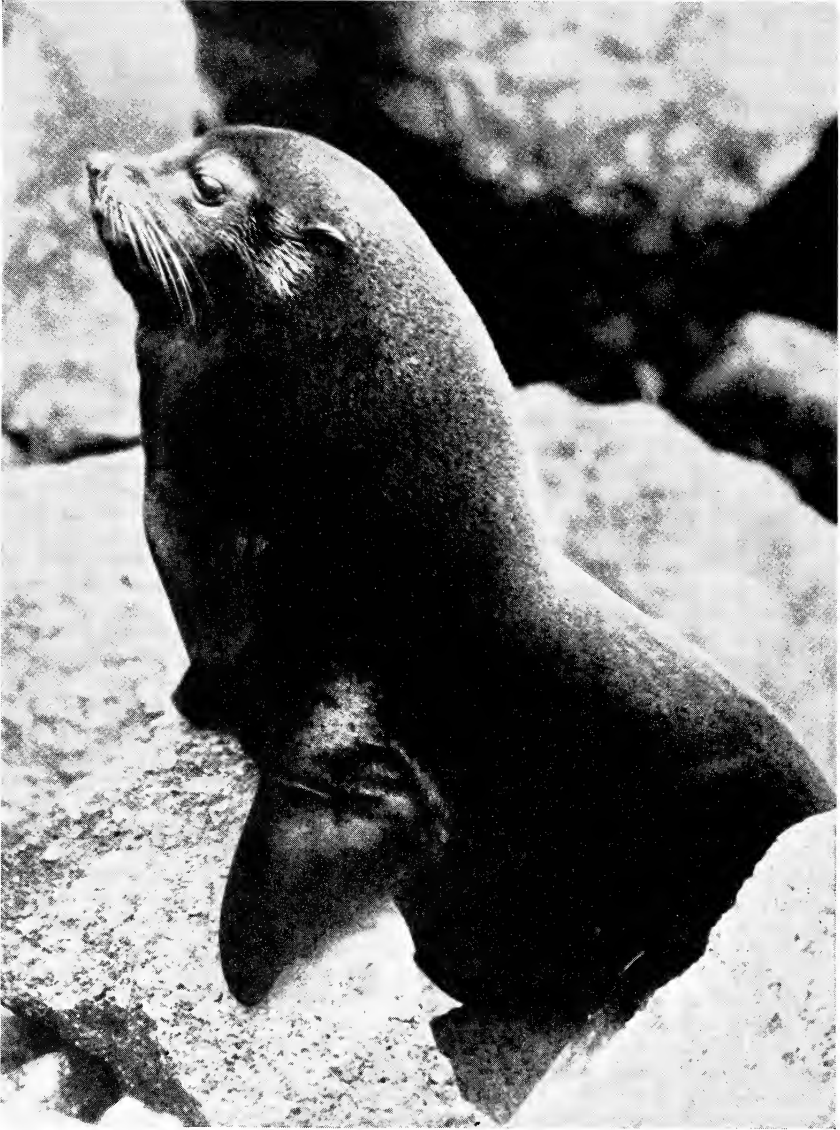


Fig. 15. Galapagos fur seal, *Arctocephalus galapagoensis* Heller. Adult male. Zoological Garden, San Diego, California.

probably extinct. Captain Hancock is to be felicitated on its re-discovery.

The living seals, six or eight in number, were presented by Captain Hancock to the Zoological Garden at San Diego, California, where the accompanying photographs were made. Three of these seals, that died some months later, were sent (in the flesh) to the writer by Dr. H. M. Wegeforth, President of the Zoological Society of San Diego, who accompanied Captain Hancock on his second voyage. The skins and skeletons are now in the American Museum of Natural History in New York. The skins will be mounted as a group showing adult male, adult female, and young.

The photographs reproduced herewith are of decided interest, being the only ones known of this rare seal. Their publication was the principal motive in the preparation of this paper. We at least know what the animal looks like. It can hardly be numerous anywhere in the archipelago. The writer, on the lookout for it during four voyages to the Galapagos, found no indication of its presence. The survivors must have hidden by day in caves protected by rocky shores where boat landings are hazardous. Those taken by Captain Hancock's party were hidden in a dark crevice in the rocks.

Photographs of the living seals were received from the San Diego Zoological Society some time before their frozen bodies arrived. Being well acquainted with the northern fur seal (*Callorhinus alascanus*) as observed personally on the Pribilof Islands, it seemed as though the ancestors of the Galapagos seal must have come from the north, rather than the south. The photographs were at once compared with some made on the Pribilofs. The resemblance was striking and the arrival of the Galapagos seals was awaited with great interest.

According to the photographs of the adult male, the head is short snouted and distinctly higher than in *Arctocephalus*, the body proportionately thicker and the fore limb broader. The skull, however, is comparable with that of *Arctocephalus* and not of *Callorhinus*. Among the skulls of the former that were examined, were those collected by the writer many years ago in the Straits of Magellan and on the beaches at the Galapagos. There was also available the skull of an adult male *Arctocephalus* of Guadalupe Island, Lower California.

It seems necessary, therefore, despite the resemblance of the

living animal to the northern species, to use the name given by Heller. In the absence of other skulls and photographs, one can only speculate vaguely as to whether the unexpected physiognomy of the Galapagos seal might be the result of some infiltration of blood of the northern species in its ancestry. Were more skulls available for comparison some light might be thrown on this point. Might there be *two* types of the *Arctocephalus* skull at the Galapagos? Delano writing in 1800 says, "I think a vessel might procure several thousand." Darwin, at the Galapagos a century ago, did not see the fur seal, but mentions the presence of a sealing vessel "a few years since."

Little is known of the habits of the Galapagos fur seal. Heller, who saw many, says that it is resident, little migratory, the climate has little change, formerly in rookeries, more wary than the sea lion, hides in crevices; no well-defined rookeries now, pups of various sizes in December, and that it was seen on the roughest parts of coasts.

The weather-worn skulls we found at the Galapagos in 1888 were referred by Merriam to *Arctocephalus*. This widely distributed southern genus anciently found its way as far north as Lower California, where a small colony persists.

There is no record of *Callorhinus* being found south of its winter limit at Point Conception in southern California, but its Pribilof breeding base in Bering Sea is no farther from the Equator than that of *Arctocephalus* at Cape Horn. The coloration of the male specimen at hand is similar to that described by Heller: "Above dark brown, sometimes grizzled with grayish, becoming more grayish and yellowish about the face; below lighter, the sides of the belly chocolate brown; limbs above like the back, distinctly becoming lighter brownish; naked parts blackish."

FUR SEALS TAKEN AT THE GALAPAGOS ISLANDS
(Partial Record)

While great numbers of fur seals have been taken at the Galapagos Islands, the records at present available to the writer yield a total of only 22,508 skins. The late Captain Haritwen, at the Galapagos in 1880, informed the writer that several vessels from San Francisco made profitable voyages prior to 1880.

	Number	Value
1816—Fanning ("Voyage").....	8,000	
1825—Morrell ("Voyage").....	5,000	
1843—Ship Hector, whaler, Narborough Island.....	14	
1872—1880—Capt. Chas. W. Reed, four voyages.....	6,000	
1880—Capt. Charles Haritwen of Alameda, Calif. between June 28 and August 30, at Culpepper, Albemarle, Narborough, Tower and Wenman Islands.....	261	\$ 5. each
1882—Capt. Haritwen stated that in 1880 another vessel took.....	800	
1885—Capt. F. M. Gaffney, schr. Hancock, between Aug. 30 and Dec. 8, took.....	1,000	
1887—Capt. Samuel Smith of San Francisco.....	1,200	\$ 7. each
1897—1899—Capt. W. P. Noyes, of San Francisco, schr. Julia E. Whalen.....	224	\$10. each
1906—Mr. R. H. Beck, schr. Academy, Sept. 15. Tower Island.....	1	
1932—1933—Capt. G. Allan Hancock of Los Angeles. Cruiser Valero III. (live specimens).....	8	
Total.....	22,508	

MEASUREMENTS OF PERFECT SKULL OF MALE*

Arctocephalus galapagoensis, Heller

Greatest basal length.....	212 mm.	(In Heller's type 213 mm.)
Same in skull from Straits of Magellan.....	258	mm.
Basal length (gnathion to basion).....	202	mm.
Basilar length of Hensel (basion to incisors).....	198	mm.
Palatine length (gnathion to postpalatal notch).....	99	mm.
Postpalatal length (postpalatal notch to basion).....	103	mm.

* Measurements by C. H. Townsend and H. E. Anthony

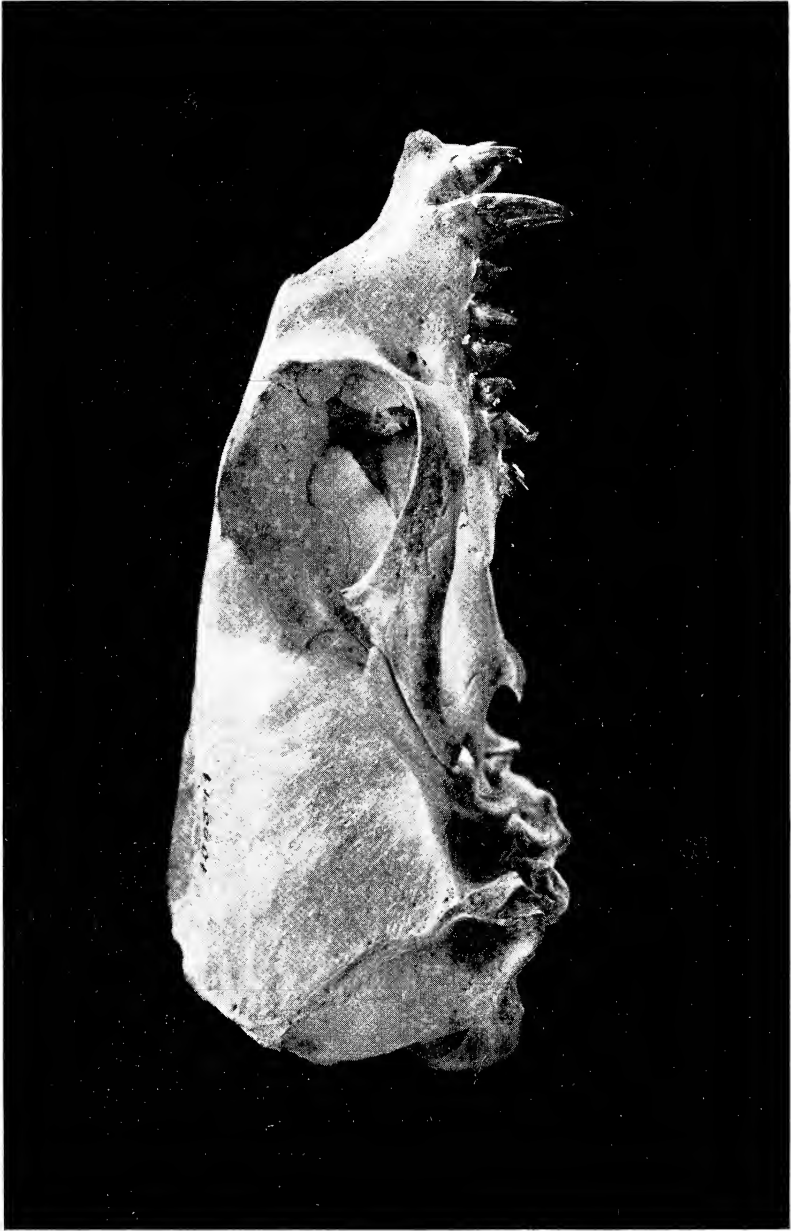


Fig. 16. *Arctocephalus galapagoensis* Heller. Galapagos Islands. 1933. Adult male
Photograph from American Museum of Natural History.

Zygomatic breadth.....	132 mm.	(In Heller's type 135 mm.)
Lateral series of teeth (canine to last molar inclusive).....	68	mm.
Same in skull from Straits of Magellan.....	77	mm.
Distance between canines.....	26	mm.
Distance between 3rd pair of molariform teeth.....	27	mm.
Same in skull from Straits of Magellan.....	31	mm.
Breadth (anteroposterior) of zygomatic root of maxilla between inferior lip of antorbital foramen and orbit.....	18	mm.
Same in skull from Straits of Magellan.....	15	mm.
Least interorbital breadth (anterior to supraorbital processes)....	27	mm.
Least interorbital breadth (posterior to supraorbital processes)....	26.5	mm.
Breadth across supraorbital processes.....	46	mm.
Greatest length of nasals.....	29	mm.
Same in skull from Straits of Magellan.....	46	mm.
Anterior breadth of nasals.....	25.5	mm.
Same in skull from Straits of Magellan.....	25	mm.
Breadth of rostrum (in plane of 2nd molar).....	44	mm.
Mastoid breadth.....	117	mm.
Breadth of brain case at fronto-parietal suture.....	77	mm.
Greatest length of ramus.....	152	mm.
Length of mandibular tooth row from incisors.....	69	mm.
Same in skull from Straits of Magellan.....	75	mm.

MEASUREMENTS OF THE CARCASE

(Sex ♂, weight minus viscera 111 pounds)

Dorsal length, tip of nose to tip of tail.....	4 feet 6	inches
Ventral length, tip of lower lip to base of tail.....	4 feet 3	inches
Girth of head around eyes.....	1 foot 4	inches
Girth at neck immediately behind ears.....	1 foot 10	inches
Girth at shoulders.....	3 feet 1½	inches
Girth at axillae within lateral flippers.....	2 feet 10¼	inches
Girth at tip of lateral flippers, approximate.....	2 feet 4½	inches
Girth at base of tail just anterior to rear flippers.....	1 foot 1¼	inches
Length lateral flippers, axilla to flipper tip.....	1 foot 3	inches
Girth of lateral flipper at shoulder.....	1 foot ½	inch
Length rear flippers, base of tail to flipper tip.....	1 foot 2¼	inches
Length of tail including hairs on tip.....	3¾	inches
Length of bare surface of fore flipper, anterior border.....	11½	inches
Length of bare surface of fore flipper, posterior border.....	10	inches
Breadth of fore flipper at 4th claw.....	6	inches
Length of exposed scratching claws, hind flipper.....	1	inch
Length of ear.....	1⅞	inches

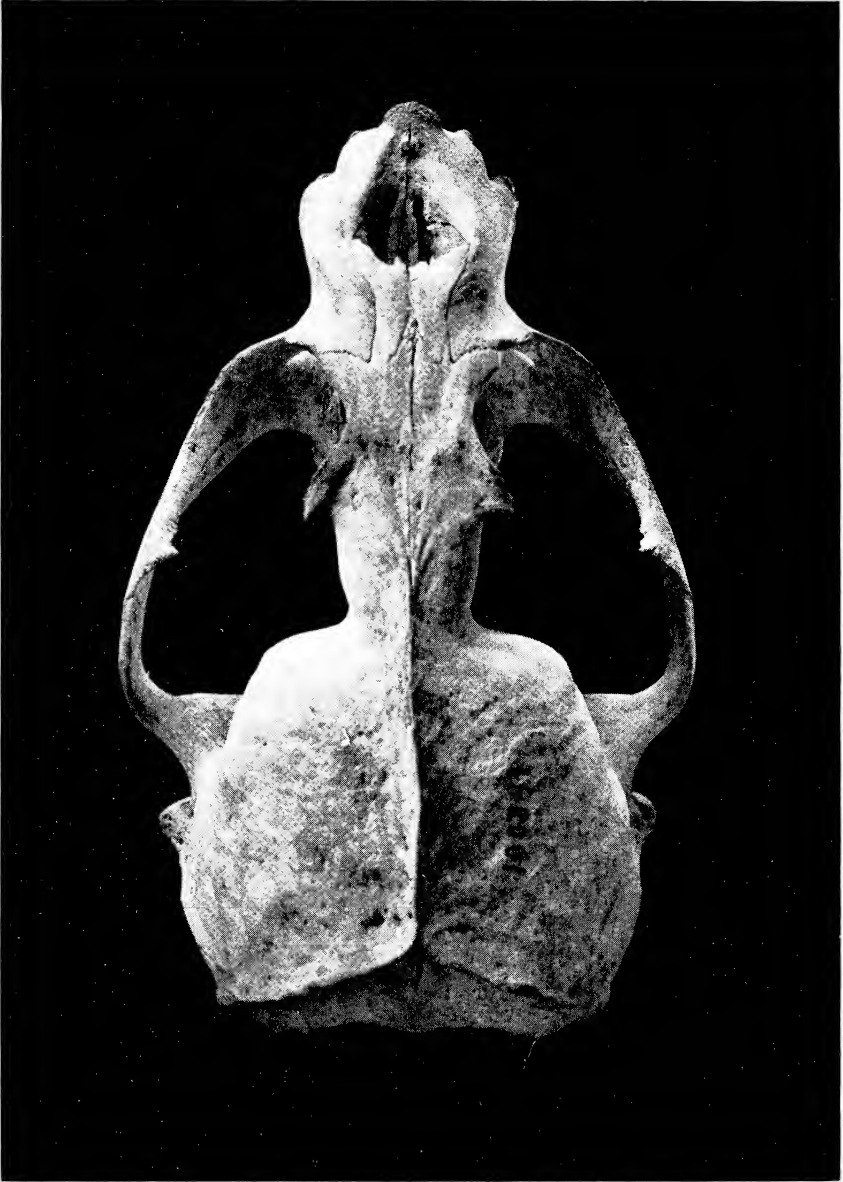


Fig. 17. *Arctocephalus galapagoensis* Heller. Galapagos Islands. 1933. Adult male. Photograph from American Museum of Natural History.

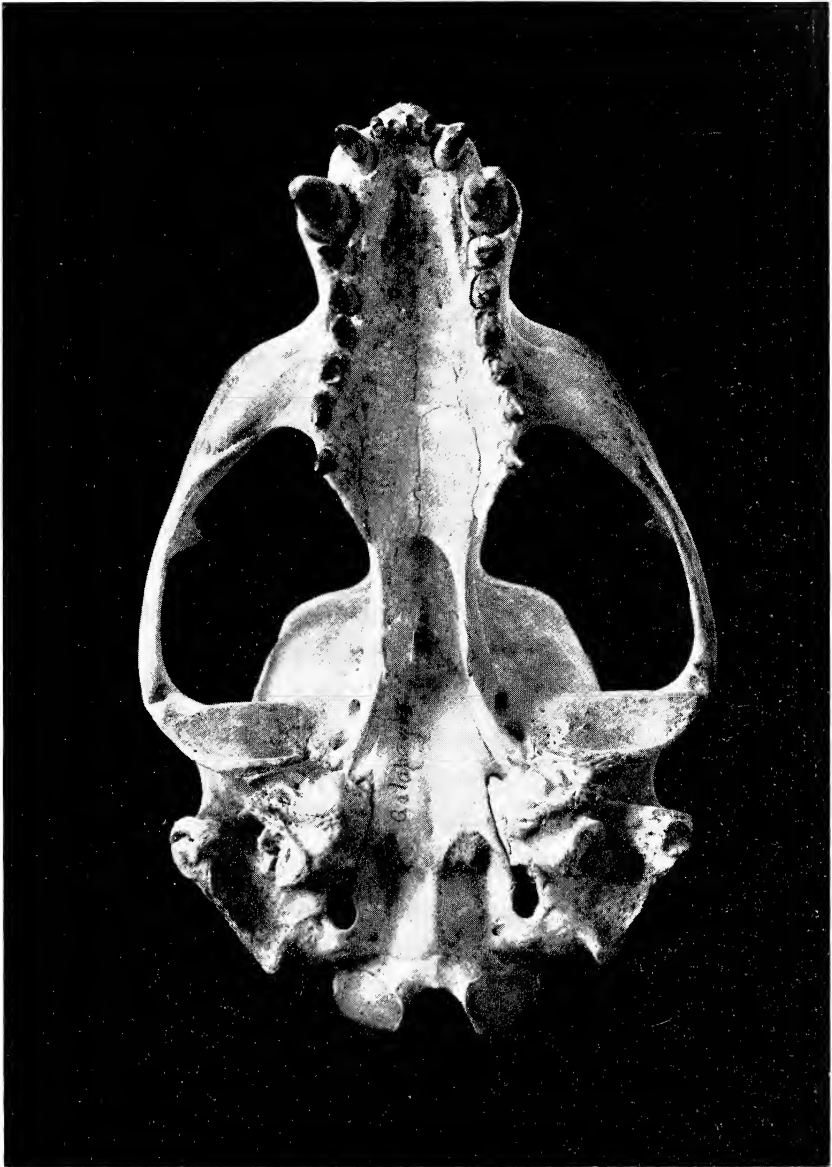


Fig. 18. *Arctocephalus galapagoensis* Heller. Galapagos Islands. 1933. Adult male. Photograph from American Museum of Natural History.



Fig. 19. Galapagos fur seal, *Arctocephalus galapagoensis* Heller. Adult male, female and pup. Zoological Garden, San Diego, California.



Fig. 20. Galapagos fur seal, *Arctocephalus galapagoensis* Heller. Adult male. Zoological Garden, San Diego, California.



Fig. 21. Galapagos fur seal, *Arctocephalus galapagoensis* Heller. Adult male female and young male. Zoological Garden, San Diego, California.

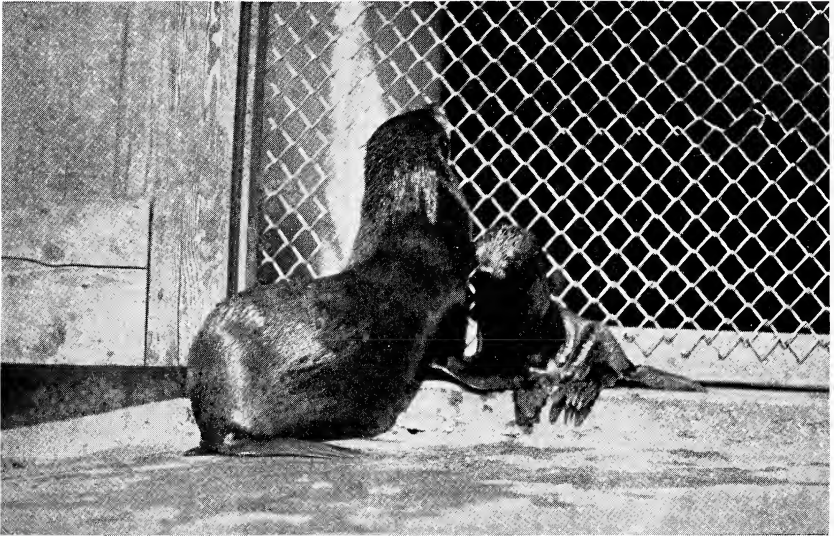


Fig. 22. Galapagos fur seal, *Arctocephalus galapagoensis* Heller. Adult female and young. Zoological Garden, San Diego, California

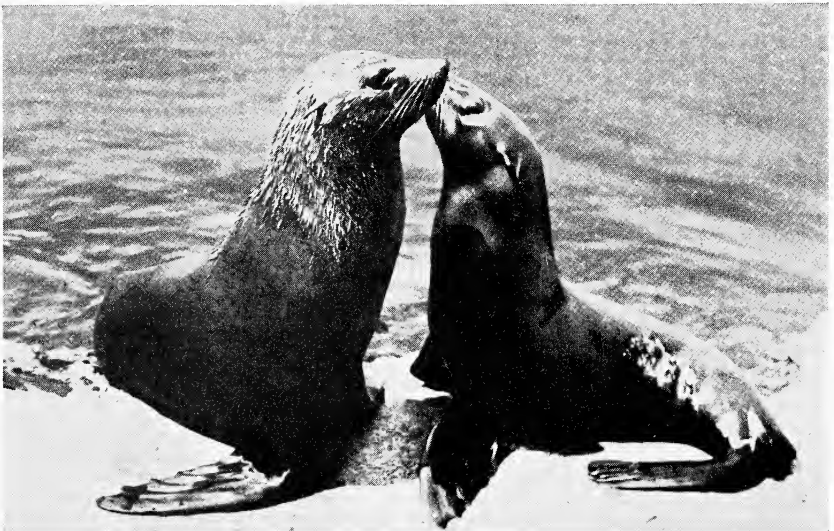


Fig. 23. Fur seals, *Arctocephalus capensis*, in East London Aquarium, South Africa.



Fig. 24. *Upper*. Northern fur seal, *Callorhinus alascanus*. Adult male. Pribilof Islands, Bering Sea.



Fig. 25. *Lower*. California fur seal, *Arctocephalus townsendi* Merriam. Adult male. Zoological Garden, San Diego, California.

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ANDROS ISLAND, BAHAMAS,

WITH SPECIAL REFERENCE TO ITS FISHES

BY C. M. BREDER, JR.

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ECOLOGY OF AN OCEANIC FRESH-WATER LAKE,
ANDROS ISLAND, BAHAMAS, WITH SPECIAL
REFERENCE TO ITS FISHES

BY C. M. BREDER, JR.

(Figs. 26-35 incl.)

INTRODUCTION

Andros Island, the largest of the Bahama group, represents a certain ecological condition that should be of particular interest to biologists. It is the purpose of the present paper to call attention to this, and discuss the inferences that have been suggested by two short expeditions into the interior of the island. Although it is the closest to the mainland of the larger Bahama Islands, it is also, interiorly, the least known. This apparent paradox is exaggerated by the fact that it is also the only one supporting any considerable amount of fresh water. In spite of this attraction, its human inhabitants are few and mostly Negro, living a very primitive sort of life. One of the chief reasons for this sparseness of population on Andros Island is doubtless the lack of really good harbors for any but very small craft. The Bahamas generally, are not remarkable for excellent harbors, but even among them this large island is noted for its inhospitable coast.

The expeditions, of which this paper is the chief report,¹ were made possible through the generosity and scientific interest of Mr. Daniel Bacon. At considerable effort and expense he arranged for practically everything, leaving the writer largely free for his field studies. The visits to Andros Island extended from January 20 to January 30, 1932, and from January 20 to January 27, 1933. We are greatly indebted to Mr. E. Forsyth, Commissioner of Andros Island, who is one of the few white residents, living at Mangrove Cay, for his excellent advice and service in supplying us with an exceptionally able, native guide. Mr. Lawrence D. Huntington accompanied the party in 1932. His untiring efforts were invaluable to the success of the trip.

¹ See Breder, 1933a, for a general account of these trips.

The itinerary of the first expedition, after the east side of the island was reached, by way of the Middle Bight, follows. The launch *Escape* which brought our party from Nassau, New Providence, was anchored off Wide Opening. This body was entered by skiff and dory powered by an outboard motor. The first camp was pitched in an attractive grove of mahogany trees on the River Lees. Ducks and other water fowl were abundant at this place. The roots of the mangroves were found to be populated largely by *Lutianus griseus* and *Spheroides testudineus*. Small *Anolis* were not uncommon, and a single *Hyla septentrionalis* was found here. Behind the camp were found numerous small ponds of fresh water, which probably accounts for the presence of frogs so near salt water. The trip was continued out into Turner Sound. On entering this body, numerous large *Tarpon atlanticus* were seen disporting themselves. Milk River was found to be closely overgrown, necessitating the use of machettes to allow passage of the boats. This dense growth was only along the immediate shore line, rapidly falling away on either side to a prairie-like country. The entrance into the fresh water of Lake Forsyth, which, judged by the current of Milk River, must be considerably higher than Turner Sound, brought the party into a distinctly different type of country of a particularly desolate aspect. Birds were practically negligible. A single Maryland yellow-throat was seen, and what was thought to be a night heron was heard one night. Otherwise, the only evident birds were two very attentive buzzards that perched on a dead tree at the camp, or followed the party on seining excursions. On full moonlight nights, the eerie quiet was emphasized by the long shadows cast by the jagged, eroded, old coral snags, and the three patiently waiting buzzards silhouetted against the moon. Other details of this environment are given in the body of the paper.

The return was made by way of Goose River. This stream, considerably wider than the River Lees was found to be populated by large *Ginglymostoma cirratum* (Gmelin) and various *Dasyatis*. As soon as Turner Sound was entered, various birds began to reappear, the Lake Forsyth region being distinctly separated from the salt water environment of this island.

The itinerary of the second expedition, which did not go through to the east side of Andros, follows. After a short stop at Mangrove Cay the South Bight was penetrated to a nearly dry creek which was

reported to drain a fresh water pond during the rainy season. A skiff took us up this about a mile. Here it was necessary to abandon it and walk the remaining distance to the lake, about a mile, although the creek was not completely dry and had a fair flow. In South Bight and in the salt parts of the creek the following species of fish were noted: *Ginglymostoma cirratum*, *Cyprinodon baconi*, *Tylosurus* sp., *Lutianus griseus* and *Abudefduf marginatus* (Bloch). A young hawksbill turtle was also seen. The South Bight lake region was found to be essentially similar to the Lake Forsyth area. The details of this will be discussed further on.

Returning to South Bight, Grassy Creek, near the southern end of Andros, was next visited. This was entirely marine as far up as penetrated. At the farthest point inland that we visited, a deep hole of indigo blue was found to be filled with a variety of haemulids and lutianids. *Haemulon sciurus* (Shaw), *Lutianus griseus* and *apodus*, at least could be definitely identified. Other fishes, seen or collected in Grassy Creek, were: *Ginglymostoma cirratum*, *Hypopryon brevirostris* Poey, *Albula vulpes* (Linnaeus), *Cyprinodon baconi*, *Hemiramphus brasiliensis* (Linnaeus) (at the mouth), *Sphyræna barracuda* (Walbaum), *Epinephelus striatus* (Bloch), *Eucinostomus californiensis*, *Calamus banjanado* (Bloch and Schneider), *Lutianus griseus*, *Ocyurus chrysurus* (Bloch), *Haemulon sciurus*, *Haemulon album* Cuvier and Valenciennes, *Pomacentrus leucostictus* (Muller and Troschel), *Scarus* sp., *Echeneis naucrates* Linnaeus, *Spheroides testudineus*. On the reef, immediately off Fresh Creek, were caught: *Lutianus analis*, *Haemulon album*, *Balistes vetula* Linnaeus and *Calamus banjanado*. This region is much more broken and irregular than northern Andros.

A tide pool yielded the following: *Eucinostomus californiensis*, *Lutianus apodus*, *Haemulon* sp., *Pomacentrus leucostictus*, *Abudefduf marginatus*, *Abudefduf analogus* (Gill),² *Halichoeres bivittatus* (Bloch) *Gobius soporator* Cuvier and Valenciennes, and *Auchenopterus* sp.

Deep Creek, a little to the north, was next entered for a very short distance. At this place the following species were seen or collected. *Sardinella macrophthalmus* (Ranzani), *Lactophrys bicaudalis* (Linnaeus), and *Echeneis naucrates*.

Mangrove Cay was then returned to and a small fresh water pool seined, in which *Tarpon atlanticus* (Cuvier and Valenciennes)

² A new distributional record. See Breder, 1933c.

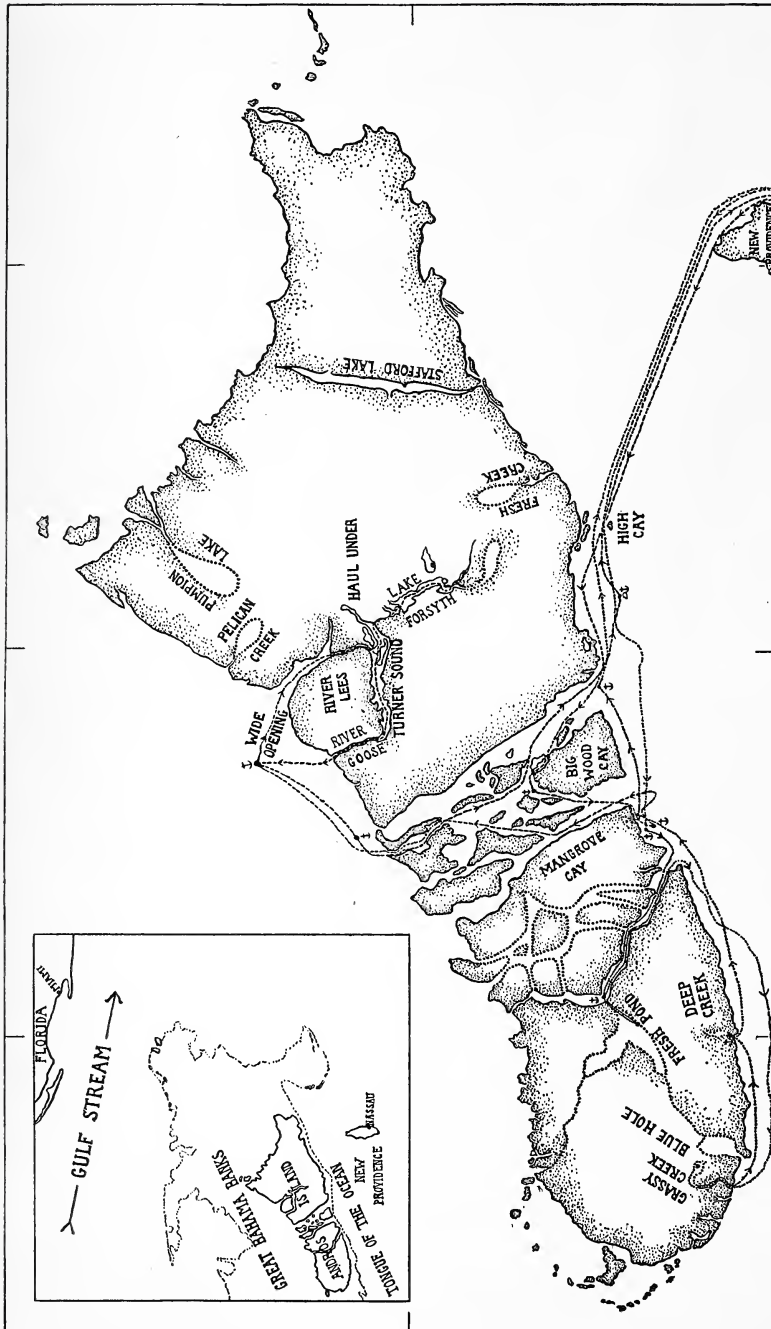


Fig. 26. Chart of Andros Island showing known and reported fresh waters. The latter are indicated by dotted lines. Excepting on Mangrove Cay where they indicate the extensive dissection of the island. Actually, there are many other bodies of water, the reports of which were too vague to permit indicating on a chart. Drawn by T. Schewe.

were taken. This place is fully discussed by Breder, 1933a and 1933b. The full itinerary is indicated in Fig. 26.

THE HABITAT

A more complete description of Andros Island, than that given in the introduction, is necessary to understand the biological relationships. This island, which is truly oceanic and of old coral reef formation, is separated from the mainland by the Straits of Florida through which the Gulf Stream sweeps northward. At its narrowest part this represents a stretch of open ocean of about one hundred and twenty miles. The island, actually, is in the nature of an archipelago at the present time, but evidently existed as a single land mass sometime ago. Roughly, it is about as long as Long Island, N. Y., and about twice as wide. It is dissected into three main islands of considerable size, and a host of smaller ones grading down to tiny rocks just awash. On the eastern shore it slopes down abruptly to the very considerable depths of the Tongue of the Ocean which separates it from New Providence and the other more eastern islands. This coast is protected by a well developed, fringing reef, which has few good passes. Inside the reef, navigation is not particularly easy because of the irregular bottom and the general abundance of scarcely submerged coral heads. The western slope is vastly different, grading off gradually in a great marl flat that extends for miles to sea, making a close approach possible, even in small boats, only at a few localities. The exposed portion of the island is composed entirely of eroded coral rock, except where it is covered with marl either desiccated or in a pasty condition. The greatest height of this low island, about one hundred feet, is close to the eastern shore, and most of the drainage is to the westward. The coast line is well known to both naturalists and others, but the interior is inadequately charted and but one body of fresh water is indicated on present day maps. Actually, there are large amounts of fresh water, as well as salt and brackish inlets. If a full survey were made it might actually show nearly one-third the area to be covered with water. Such an impression is obtained when the island is viewed from the seaplane connecting Nassau with Miami. Besides the bodies of water we visited, known as Lake Forsyth and South Bight Lake, another has been indicated by Pilsbry and Black, 1930, (Lake Stafford), and a third was visited by Mr. Bacon some



Fig. 27. The densest stand of trees encountered in the Lake Forsyth region.

years ago, entering by way of Fresh Creek. In addition to these, questioning of the natives revealed consistent answers of other fresh water bodies. These are indicated in Figure 26. In addition, many of the smaller islands are groups much dissected by inlets of the sea.

Dr. Maurice Black, in a personal communication, stated that he did "not see how the land surface of the Great Bahaman Bank can be older than the early Pleistocene, since the fresh water and terrestrial deposits of Andros and the other islands on that part of the Bank all appear to lie with a nonsequence on hard limestone without any Pleistocene species amongst their fossils." He further remarks that according to his studies "the land area on the Great Bahama Bank has, quite recently, been vastly more extensive than it is at present, and that the distribution of the land molluscs is related to this 'greater Andros,' rather than to the present configuration of the island." Also, "that the mollusc fauna of Lake Forsyth includes a large proportion of endemic species which must mean that there have been bodies of fresh water continuously present on the Bank for much longer than has been generally supposed." This water, which is truly fresh but naturally very "hard," being bedded on either old coral rock or marl mud, is not unpleasant as drinking water. Lake Forsyth is exceedingly turbid because of the great amount of fine marl mud in suspension.

The Lake Forsyth region, as noted in the introduction, is distinctly different from the seacoast. Stands of pine are not uncommon but they are rather dismal groves of small dimension for most part, and show the unmistakable ravages of numerous hurricanes. The densest stand encountered is illustrated by Fig. 27 but this is quite exceptional. A more typical grove is shown in Fig. 28 which well illustrates much of the shore line of Lake Forsyth. One of the waiting buzzards, already alluded to, is here seen circling ahead of the party as it was returning to camp from a seining trip. Where the shore line was not as rugged as at the camp site, it was covered with a thick layer of partially dried marl, such as shown in Fig. 29. This was found to be treacherous in spots and must be of a very considerable thickness, in some places at least. These areas represent the greater extent of the lake during times of high water. The stream, Milk River, that connects this lake with the sea, is excessively turbid with marl, from which fact it derives its

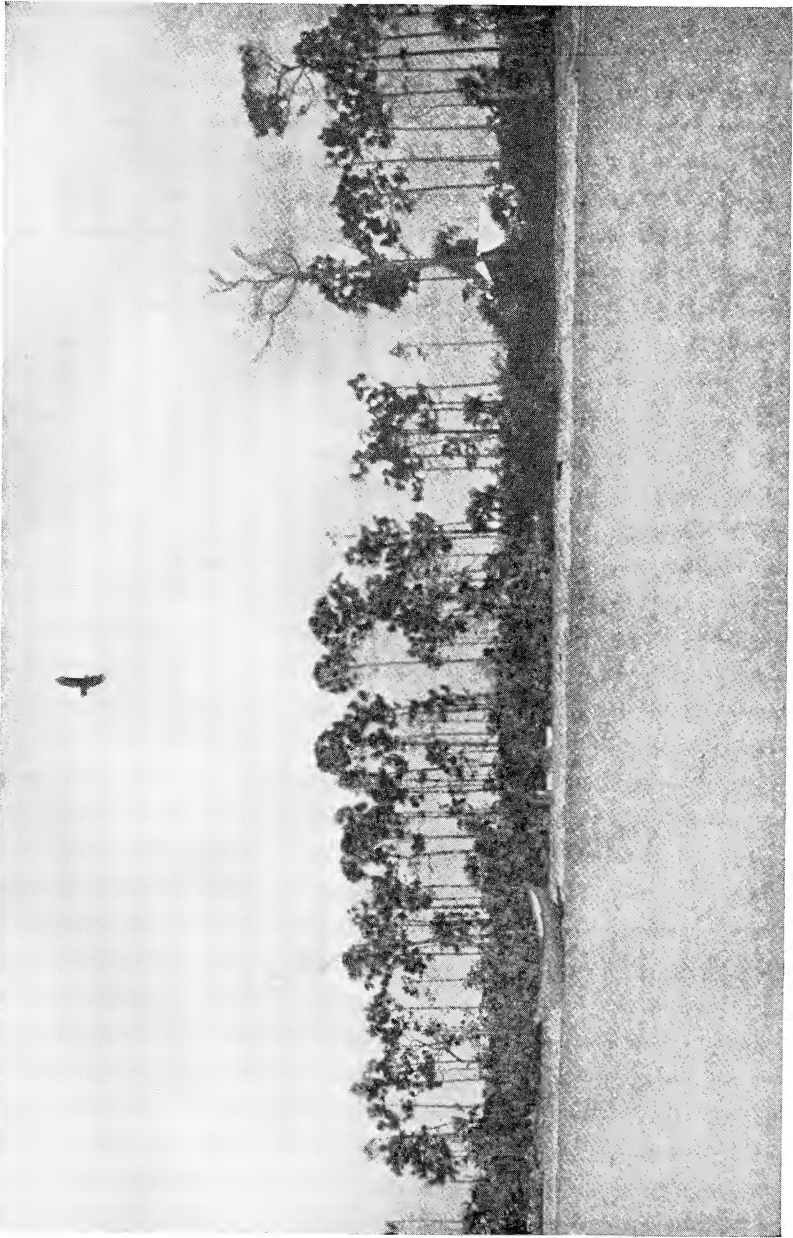


Fig. 28. Lake Forsyth, showing a typical stretch of shore line, including the expedition's camp, as well as one of the constantly attending buzzards.

local name. This turbidity is accounted for by the rather rapid movement of the water through it. One of the wider parts of this stream is illustrated by Breder, 1933a.

The lake, approached via the South Bight, is essentially similar to Lake Forsyth, but appears to be considerably larger. The general form of it is indicated on the chart, Figure 26. Reports have it that there is another drainage into the lagoon near Grassy Creek, and a third to the west side of the island. The shore line and vegetation is reminiscent of Lake Forsyth but does not seem quite so dismal. This is probably accounted for by its greater proximity to the sea, although actually there is more evidence of recent hurricane damage here than at the former locality.

THE INVERTEBRATE FAUNA

While it is not the purpose of the present communication to discuss the invertebrate fauna of the region under consideration, there are certain features of it that are of considerable importance to the ecology of the vertebrates.

Insects of the camp-pest type were pleasingly absent. Mosquitoes and flies were rare. A few wood roaches were uncovered in preparing camp and gathering firewood. Some butterflies and dragon-flies were constantly about. Spiders were scarce. A single scorpion was seen. It was a matter of some wonderment just what the lizards and frogs managed to find to support life. A few large land crabs and some terrestrial hermits were present but not numerous. Land snails, both *Cerion*s and other genera, were decidedly common. See Pilsbry and Black, 1930.

Aquatic invertebrates of macroscopic size likewise were scarce. Probably the most common were the nymphs of the dragon-flies, usually found half buried in the soft marl. A few dytiscids and red aquatic arachnids were seen. A few small crabs hid in rock holes. The only mollusks encountered were the empty shells of *Physa*. Regarding the aquatic species, it is especially to be borne in mind that all, except possibly the few crabs, are distinctly fresh water forms. This condition will be referred to later as these represent the only invasion of organisms that can be properly thought of as marking a fresh water environment. There has thus been little, if any, successful attempt of the abundant and nearby sea invertebrates to occupy this environment. The reasons therefor



Fig. 29. Flats of partially dried marl, studded with straggling mangroves, are not uncommon about Lake Forsyth and represent the extent of the enlarged lake during times of high water.

will appear subsequently. It may be mentioned in this connection that a fresh-water plant, *Utricularia* has been reported from Andros. None whatever could be discovered in the territories visited, although the peculiar brackish-water algae, *Batophora*, was abundant.

REPTILES

The lizards were naturally more in evidence than frogs, giving what probably is only an appearance of greater abundance. However, they could not be considered as common, as the lizards found in such places go. Such forms as were collected near Lake Forsyth have been identified by Dr. Noble of the American Museum of Natural History. They are *Leiocephalus carinatus* Gray, *Anolis distichoides* Rosen, and *Anolis brunneus* Cope. Most of these were found not more than fifty or seventy-five feet back from shore on broken aeolian rock which made collecting them difficult if not actually hazardous, to one's lower extremities at least.

It was noted that the specimens of *Leiocephalus* at no time were

seen to curl their tails. According to the natives, a form living along the seacoast persistently carries its tail curled up tightly, which they distinguish from ordinary lizards by the descriptive appellation, "curly-tailed lizards." None of these was seen or collected, but on another trip with Mr. Bacon to the Berry Islands (1930), where, because of their small size no great distance can be reached from the sea, this type of lizard was abundant and no straight-tailed *Leiocephalus* was encountered. A typical example of *Leiocephalus carinatus* at Lake Forsyth is illustrated by Breder, 1933a, as well as a Berry Island *Leiocephalus*. Even those with regenerating tail-stubs at the Berry Islands, consistently showed this tendency. Furthermore, at no time were these Berry Island lizards seen to completely unwind their tails. When frightened, or interested in an insect, they would alternately tighten and relax this spiral, much after the fashion of the hairspring of a watch, but not quite so rapidly.

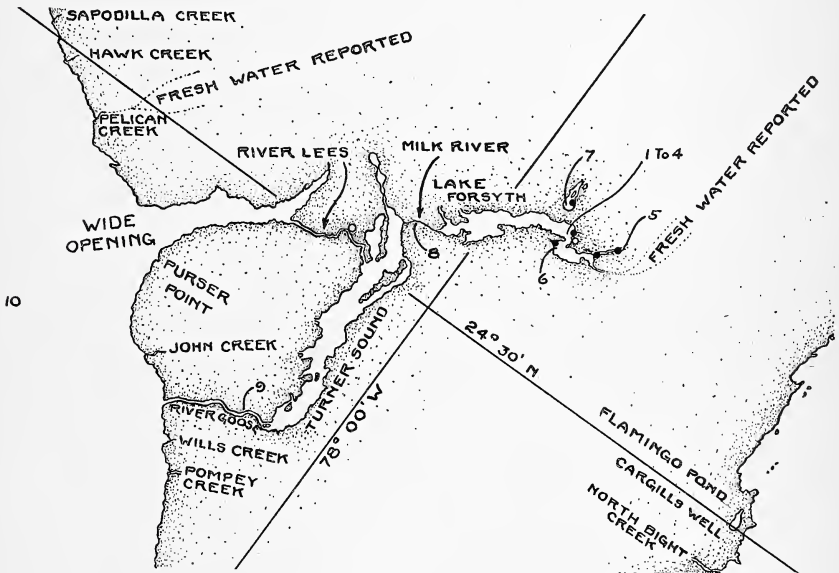


Fig. 30. The Lake Forsyth region. Light circles indicate camp sites. Black circles indicate seining sites. Numerals indicate localities of water samples similarly numbered in Table II. Milk River marks the separation of the fresh water of Lake Forsyth and the sea water of Turner Sound.

On the southern part of Andros, there occurs *Cyclura baealopha* Cope. The natives know of this larger lizard and run it down with dogs, but apparently it is not sufficiently numerous to enter into their food economy to any extent at the present time. None was seen on our visits.

Contrariwise, one of the buzzards that persisted in watching us at Lake Forsyth was seen to catch a live lizard (*Leiocephalus*?). This act, unusual for such a bird, may be taken as indicative of the paucity of the larger forms of animal life in this region.

A number of objects, thought to be lizard eggs, were found on the leaves and stems of the stunted mangrove bushes. On opening, these were seen to be the pupae of moths. The species, identified by Dr. C. H. Curran, is *Alaradia slossoniae* Packard. One of these is illustrated by Breder, 1933a.

By obtaining the aid of small boys on Mangrove Cay, a considerable series of reptiles was secured on the second expedition.

Lizards: *Anolis distichooides* Rosén; *Anolis brunneus* Cope; *Ameiva thoracica* Cope.

Snakes: *Tropidophis pardalis androsi* Stull; *Alsophis vudii*³ Cope.

AMPHIBIANS

As would be expected in a region showing such a relatively sparse insect life, few amphibians were encountered. Such frogs as were collected were taken at night or by tearing open such scrubby palms as were to be found. Only two species were taken, *Hyla septentrionalis* Boulenger and *Eleutherodactylus ricordii* (Dumeril and Bibron). These determinations have also been made by Dr. Noble who, in a personal communication, writes as follows. "I have carefully checked your *Hyla* against our large series of *septentrionalis* and find that your specimens actually fall within the range of variation exhibited by this form. They are certainly much rougher than any specimens which have passed through my hands, but I find some specimens collected by Nichols in New Providence agree in every particular with your specimens." *Hyla septentrionalis* was also present on Mangrove Cay.

Conversation with numerous natives uniformly revealed that in early May all of the small pools of Andros are exceedingly noisy with the calls of frogs. Those boys more given to prowling around

³ Apparently a new record from Andros.

inland were most emphatic. Consequently, it may well be that frogs are actually more common than the season of our visit would indicate. On the other hand it does not take many individuals to make up a chorus of an impressive volume on such silent nights as those encountered on inland Andros.

FISHES

The fishes collected in Lake Forsyth have already been listed, Breder, 1932, and discussed from the taxonomic standpoint. The fishes are the only vertebrate group that can be considered abundant in this environment, at least in the season of our visit. The following data were not considered in the purely taxonomic list above mentioned. The information concerning size and number is relegated to Table I. Collecting sites are indicated in Fig. 30.

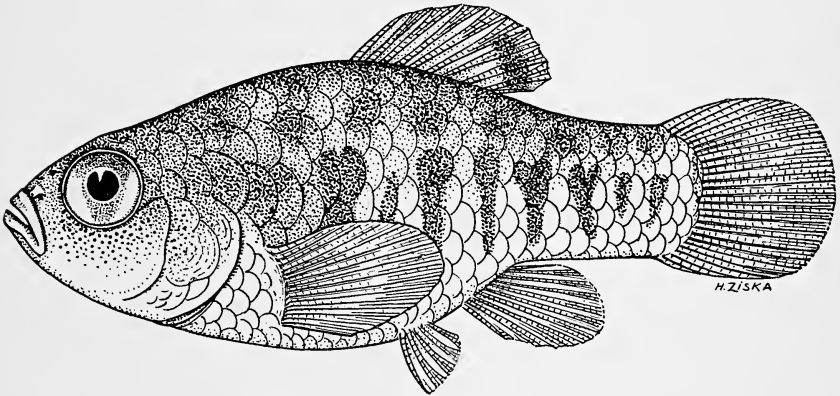


Fig. 31. *Cyprinodon baconi* Breder.

1. *Cyprinodon baconi* Breder

All specimens examined were uniformly packed with *Batophora* generally broken down to little more than a brown paste. In quiet pools males could frequently be seen pursuing females, in a manner not unlike that of *C. variegatus* in the latitude of New York, a short time before the full nuptial colors are assumed. Fig. 31.

2. *Gambusia manni* Hubbs

Food in this species was essentially similar to that of the preceding. Courtship activity could be frequently observed.

3. *Strongylura notata forsythia* Breder

Undeveloped sexually. The intestinal contents consisted of fish remains, and one dragon-fly nymph. Fig. 32.

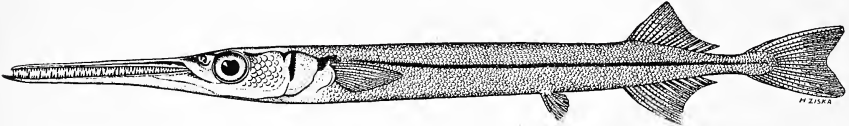


Fig. 32. *Strongylura notata forsythia* Breder.

4. *Strongylura timucu* (Walbaum)

The single specimen of this species, a female of 290 mm. s. l., was approaching ripeness. The intestinal contents consisted of the badly macerated remains of some small fish, (*Gambusia* or *Cyprinodon*?). The body cavity held two *Filaria* (?).

5. *Chriodorus atherinoides* Goode and Bean

This species was seen to leap on occasion and showed considerable agility in escaping the seine by passing over the cork line in a mullet-like fashion. The gonads were nearly ripe. The food was similar to that of *Eucinostomus*. *Batophora* either breaks down with extreme rapidity or else most of it is "mouthed" and rejected, only the adherent organisms being retained.

6. *Caranx latus* Agassiz

The largest were undeveloped sexually. The stomach was packed with large numbers of small *Acanthocephalans*. The only food found consisted of the triturated remains of fishes.

7. *Lutianus griseus* (Linnaeus)

Both specimens (175 and 124 mm. s. l.) were undeveloped sexually. The body cavity contained numerous nematodes. The digestive tract contained the mangled remains of fishes and one dragon-fly nymph.

8. *Eucinostomus californiensis* (Gill)

None of these fishes appeared to be mature. The intestinal tracts were packed for most part with fragments of *Batophora*, diatoms, and to a lesser extent the remains of associated animal organisms, mostly small crustaceans.

9. *Eucinostomus gula* (Cuvier and Valenciennes)

On detailed examination of the large series of this genus (587), about fifty proved to be the present form. As their stomach contents was identical with that of *E. californiensis*, and their range of sizes not nearly so great, these two related species are considered together in Table I.

10. *Spheroides testudineus* (Linnaeus)

The single specimen of 155 mm. s. l. was a male approaching ripeness. There was no food in the digestive tract.

11. *Gobiomorus dormitor* Lacepede

Remains of very small fish. Nematodes in body cavity. Sexually undeveloped.

12. *Lophogobius androsensis* Breder

Males with a small genital palp. Nearly ripe. Remains of small insects and crustaceans in digestive tract. Fig. 33.

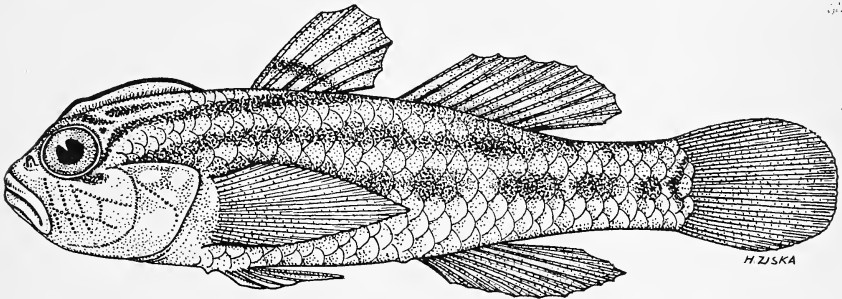


Fig. 33. *Lophogobius androsensis* Breder.

Two very striking peculiarities about these fishes are apparent. The one is their very presence in such large quantities in a lake of fresh water, since they are typically marine or at least brackish-water forms. The other is the problem of the basic food supply, in a region relatively barren of objects which could form such a basis, as is indicated under the previous heading. Insects or other life falling into the water could not possibly support the evidently well fed and numerous fishes, some of which are strictly predacious. Stomach examination reveals the source at once, however, for at least five of the species feed directly on the mat of *Batophora* flooring

the bottom of this lake, even to the deepest parts sounded (about six feet). Breder, 1933a, illustrates this plant. The species subsisting on this vegetation include both the smallest and the most numerous. *Gambusia manni*, *Cyprinodon baconi*, *Chriodorus atherinoides* and *Eucinostomus californiensis* and *gula*, were all found to be well filled with this plant. The first two were not found near larger forms, keeping for most part to shallow water or in pools cut off from the main lake, and consequently do probably not form an important source of food for piscivorous species. *Chriodorus*, while freely ranging and occasionally seen to leap as if pursued by other fishes, are probably not numerous enough to be of any particular importance. *Eucinostomus*, however, is ubiquitous and a great variety of sizes is available, specimens having been collected that ranged from 27 to 127 mm. in standard length. This species clearly forms the connecting link in the food chain between vegetation and the purely predacious forms, such as *Caranx*, *Lutianus* and *Strongylura* either directly or through the intermediary of other predacious fishes. Table I clearly indicates this. An examination of specimens of *Batophora* showed it to be well coated with diatoms and a generally rich fauna of micro-organisms, both animal and plant, many of which certainly go to enhance the general food value.

The data given in the foregoing annotated list and in Table I, form the basis for a consideration of the food chain in this isolated lake. If the number of species, number of specimens collected; their weight, or their maximum, minimum or average lengths are grouped according to the three types of food consumed, certain consistent conditions are at once apparent. The second part of Table I shows these relationships, and the remainder gives them calculated from a proportional viewpoint. The data need hardly be elaborated upon. While the collection is not sufficiently extensive to assume any great degree of accuracy for the figures as standing, they certainly represent a numerical approach to the proportions of the various elements in the food chain. That is to say, the number of specimens and the total weight of the vegetable eaters are greater than that of the piscivorous, while the average weight and maximum, minimum and average lengths are all greater in the latter. This is the expected relationship between predators and their food. If those few forms which feed on invertebrates are considered included as food objects for the fish-eating species,

TABLE I. THE FISH POPULATION AND ITS FOOD

No.	Species	No. of Specimens	Weight in Grams		Standard length in mm.			
			Total	Average	Max.	Min.	Mode	Average
1	<i>Cyprinodon baconi</i>	47	13.8	0.3	33.5	12.0	17.5	17.1
2	<i>Gambusia manni</i>	15	3.4	0.2	25.0	15.0	18.5	17.9
3	<i>Strongylura notata</i>	22	316.7	14.4	245.0	105.0	180.0	188.6
4	<i>Strongylura timucu</i>	1	32.0	32.0	—	—	290.0	—
5	<i>Chriodorus atherinoides</i>	5	26.8	5.4	105.0	77.0	—	89.8
6	<i>Caranx latus</i>	23	1246.0	54.2	180.0	92.0	130.0	131.3
7	<i>Lutianus griseus</i>	2	163.9	81.9	175.0	124.0	—	139.5
8	<i>Eucinostomus californiensis</i>	587	2231.1	3.6	127.0	27.0	65.0	83.2
9	<i>E. gula</i>							
10	<i>Sphoeroides testudineus</i>	1	955.7	955.0	—	—	155.0	—
11	<i>Gobiomorus dormitor</i>	3	23.6	7.8	110.0	87.0	—	59.0
12	<i>Lophogobius androsensis</i>	4	9.6	2.4	43.0	29.0	—	38.2

Nos.	Food	No. of species							
1, 2, 5, 8, 9,	Vegetation	5	654	2265.1	3.5	127.0	12.0	—	52.0
3, 4, 6, 7, 11	Fishes	5	51	1782.2	34.9	290.0	87.0	—	161.7
10, 12	Invertebrates	2	5	965.3	193.0	155.0	29.0	—	86.6

Proportional calculations with invertebrate feeders reduced to unity

Food								
Vegetation	2.5	130.8	2.3+	0.0+	0.8+	0.4+	—	0.6+
Fishes	2.5	10.2	1.7+	0.2-	1.8+	2.9+	—	1.8+
Invertebrates	1.0	1.0	1.0	1.0	1.0	1.0	—	1.0

Proportional calculations with fish feeders reduced to unity

Vegetation and Invertebrates	1.4	12.9+	1.8+	5.6+	0.9+	0.5-	—	0.9-
Fish	1.0	1.0	1.0	1.0	1.0	1.0	—	1.0

which they doubtless are, the differences become still more marked. However, mollusk and insect eaters are few, as indeed they must be in such an environment, and their importance is relatively slight. Very likely the food requirements determine to a considerable measure just what fishes may successfully establish themselves in such a lake. First, with the establishment of a dense vegetative growth, the plant-eating forms should appear, to be followed by the predacious species. As the marine invertebrates do not enter, for reasons to be subsequently discussed, those fishes which feed on them must be held off until such a time when fresh water substitutes

can establish themselves. Although the data derived from the examination of stomach contents of the specimens collected can hardly be considered as sufficient to warrant such conclusions, the foods of the types represented—in some cases the exact species—are well known. It is thus evident that the fishes of Lake Forsyth, in the final analysis, are almost entirely supported by the dense beds of *Batophora* and the microscopic and nearly microscopic organisms dwelling in its fronds. The fishes in the lake at South Bight were similar to the Forsyth fishes.

Cyprinodon baconi Breder. Fairly common but none as large as the type specimen. In the nearly salt water this species was also present, probably due to the short creek connecting this lake with the sea. The marine localities are noted in the introduction.

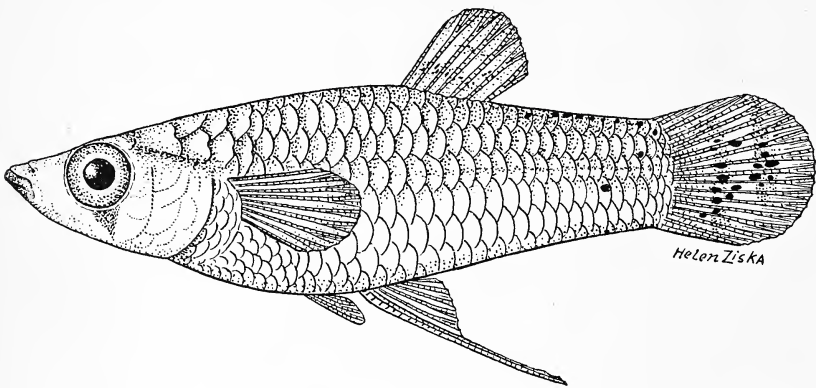


Fig. 34. *Gambusia hubbsi* Breder.

Gambusia hubbsi Breder. Common at one spot only. As noted in the original description (Breder, 1934), this species presented a much different appearance in the field than its close relative *G. manni* seen in Lake Forsyth and in Lake Killarney on New Providence. They were tinted with a definite steel blue and were decidedly larger. Aside from this their behavior was notably different. *G. manni*, as seen by us, was a very timid fish, whereas *G. hubbsi* was comparatively very tame. Fig. 34.

Strongylura notatus forsythia Breder. Four examples were all entirely within the range of variation, marking this race. It is

noteworthy that no *S. notatus* were seen on Andros in either year excepting these in fresh water.

Eucinostomus californiensis (Gill). Common wherever seining was carried on.

Lutianus griseus (Linnaeus). Much more common and larger than in Lake Forsyth. As there is probably a similar food chain in this body of water it seems likely that the presence of these larger and more numerous snappers may account for the relative paucity of the other species.

The fishes of a small pool on Mangrove Cay are fully discussed by Breder, 1933b. They consisted solely of small *Tarpon atlanticus*. In the stomach of some were found fragments of *Cyprinodon baconi*? This pool differed from the other fresh water localities encountered, in that it was foul and turbid with dark colored detritus and agreed with other West Indian localities harboring young tarpon. For a discussion of this specialized and restricted type of environment, the paper above mentioned should be referred to.

CHEMICAL NATURE OF LAKE FORSYTH

The most striking feature of the fish fauna of Lake Forsyth is that bearing on the chemical nature of these peculiar waters. The analytical data are given in Tables II and III, from which it is at once apparent that the water is "fresh" in the ordinary sense of the term. The freezing point and specific gravity alone are enough to establish the small amount of salts in solution. Comparisons with various municipal waters of the continental United States (Clarke, 1924) shows, however, that although the amounts of material in solution are not very evident by the two above mentioned methods, there is still considerably more in solution than in most fresh waters of North America. There are, however, several river waters with a considerably greater amount of dissolved material (*e. g.* Arkansas, Pecos and Santa Maria Rivers). They are all in the middle or southwestern sections of the continent. The Atlantic coast drainage is very definitely lower. Waters of closed basins and mineral springs are mostly higher, and in many cases very much higher.

Furthermore, a study of the table shows the substances in solution to be substantially in the relative proportion that they occur in the sea, with the notable exceptions of chloride and the

TABLE II. CHEMICAL ANALYSIS *

No.†	Date	Locality	Δ	pH	mM per liter							Σ B+	Fixed resid- due	
					Cl †	SO ₄	Σ A ⁻	CO ₂ ‡ H ₂ CO ₃	K	Na	Ca			Mg
1	Jan. 24	Lake Forsyth, surface	-.04	7.6	12.995	4.00	20.995	2.0407	1.452	18.037	.998	0.057	21.599	—
2	Jan. 25	" "	-.05	7.6	12.995	3.75	20.495	2.1457	1.089	18.037	.998	0.055	21.232	—
3	Jan. 25	" " bottom	-.05	7.5	12.995	4.00	20.995	2.1607	1.452	20.993	1.248	0.094	25.129	—
4	Jan. 25	" "	-.05	7.5	13.91	3.50	20.910	2.1607	1.634	20.993	.998	0.082	24.787	—
5	Jan. 25	" " farthest east	-.10	7.6	19.40	3.50	26.900	2.3032	1.634	22.572	1.123	0.128	26.708	—
6	Jan. 27	" " Old Camp	-.05	7.6	13.60	3.00	19.600	2.2507	1.634	20.537	1.497	0.095	25.355	—
7	Jan. 27	Land-locked Pool	-.04	7.3	9.33	2.50	14.330	1.9291	1.271	13.527	.874	0.032	16.610	—
8	Jan. 28	Milk River	-.07	7.7	13.60	4.00	21.600	2.1000	2.179	15.560	1.248	0.102	20.439	—
9	Jan. 28	Goose River	-2.08	8.1	545.70	28.80	603.300	2.3778	8.030	517.000	10.444	40.517	625.9	—
10	Jan. 28	Off Purser's Point	-2.16	8.0	561.00	30.40	621.800	1.9357	10.130	521.500	13.476	40.517	639.6	—
11	Feb. 2	Lake Killarney	-0.39	8.2	123.74	3.50	130.735	2.1457	2.179	107.770	1.996	3.843	121.627	—

No.	atm.	Sp.|| Grav- ity	Parts per thousand									
			Cl †	SO ₄	Σ A ⁻	CO ₂ ‡ H ₂ CO ₃	K	Na	Ca	Mg	Σ B+	Fixed resid- due
1	0.482	1.0015	.460	.384	.844	.089	.056	.414	.039	.0014	.510	.95
2	0.603	1.0015	.460	.360	.820	.094	.042	.414	.039	.0014	.496	.902
3	0.603	1.0025	.460	.384	.864	.095	.056	.481	.050	.0022	.589	1.02
4	0.603	1.0025	.493	.336	.829	.095	.064	.481	.039	.0020	.586	1.02
5	1.206	1.0015	.687	.336	1.023	.101	.064	.519	.044	.0031	.597	1.43
6	0.603	1.0010	.482	.288	.770	.099	.064	.472	.059	.0023	.597	1.06
7	0.482	1.0010	.342	.240	.582	.084	.049	.311	.035	.0025	.397	.836
8	0.844	1.0010	.482	.360	.842	.092	.084	.357	.050	.0025	.493	1.05
9	24.99	1.0290	19.348	2.764	22.012	.104	.313	11.891	.417	.985	13.606	39.71
10	25.99	1.0300	19.391	2.918	22.809	.085	.395	11.994	.539	.985	13.913	40.312
11	4.7	1.0046	4.387	.336	4.723	.094	.084	2.478	.079	.093	2.734	8.69

* Determinations made by J. Hanache. † These numbers refer to localities shown in Figure 10, excepting No. 11 which is on New Providence.

‡ Cl -0.35 for Br₂ and I₂ gives slightly lower values. § Includes traces of NO₂ and NO₃, and 0.2 mM of PO₄. || Reduced to 15° C.

sulphate radical, the former of which plays such an important role in the ocean. This comparison is more forcefully brought out in Table III, which gives the same data reduced to terms of percent. While there is always a considerably greater amount of chlorine than sodium detectable in ocean water, indicating the presence of other chlorides,⁴ the excess is very slight in water from Lake Forsyth. In ocean water less than three-fifths of the Cl can be opposed to the Na, necessitating that other chlorides must account for the rest. In Lake Forsyth the Cl in excess of the Na is exceedingly slight, something less than one-tenth of the total Cl not being opposed by Na. The sulphate radical, on the other hand, is about

TABLE III. CHEMICAL PROPORTIONS OF LAKE FORSYTH*

	Ocean † Average	Logger- head ‡ Key	Ocean Nos. 9-10 Average	Lake Killarney No. 11	Milk River No. 8	Lake Forsyth Nos. 1-7 Average
Cl	55.29	55.24	54.03	58.08	33.77	33.16
Br	0.19	.17				
SO ₄	7.69	7.54	7.82	4.45	25.22	22.91
CO ₃	0.21	.34	.26	1.24	6.44	6.47
Na	30.59	30.80	32.89	32.83	25.01	30.43
K	1.11	1.10	.98	1.12	5.89	3.89
Ca	1.20	1.22	1.32	1.05	3.50	3.00
Mg	3.72	3.59	2.70	1.23	0.17	0.14
Salinity p.p.m.	100.00 33,010.0 to 37,370.0	100.00	100.00	100.00	100.00	100.00
		35,490.0	36,313.0	7,551.0	1,427.5	1,451.8

* Calculated by J. Hanache. † Mean of 77 samples. From Clarke, 1924, after Dittmar, 1884. ‡ Sample off Loggerhead Key, Fla. From Clarke, 1924, after Steiger, 1910.

three times as great in Lake Forsyth as in the ocean. The carbonate radical shows an even greater discrepancy, being over twelve times as large. The other items are also larger except magnesium which is exceptionally low.

These remarks obviously refer to the relative amounts as expressed in Table III. The quantities of salts in Lake Forsyth are of course all much less than in the ocean, as is indicated in the expression of salinity. This is likewise indicated in Table II in terms of absolute quantity excepting the comparatively uniform

⁴ This is true even after a deduction has been made for other halogens which in the analysis have not been separated.

carbonate radical which is only relatively increased in Table III. It is clear that this water is then deficient in chlorides, as compared with the sea, and high in sulphates and carbonates which give the lake a decidedly different chemical constitution.

Despite the low concentration of salts in this lake, a variety of marine fishes was found to inhabit it, as already mentioned. In order to better understand these conditions, certain laboratory experiments were carried on which are discussed in a latter section.

In addition to the foregoing chemical peculiarities of this body of fresh water, a rather striking phenomenon could be seen almost at any time in any cove into which the wind happened to be blowing. A thick layer of white scum would rapidly accumulate under such conditions, generally proportional to the strength of the wind and the consequent wave action as well as the duration of its prevalence from one quarter. A typical cove so clogged is illustrated by Breder, 1933a. With a continued wind this froth would pile up on the shore, in places to the depth of two feet. As it dried, great chunks of it would be torn away in the breeze and be carried further inland, the small masses caught by an erratic gust sometimes lodging far up in the pine trees.

When piled up on the shore, the new froth when still white greatly resembled a well-made meringue. Breder, 1933a, shows an example of this formation. Due to the accumulation of dust on the sticky surface, the mass soon takes on a grayish tinge. This and the desiccating effect of the dry air causes a firm crust to form, somewhat protecting the interior. In time the material does thoroughly dry, due to cracking of the crust, and there remains a soft cake-like material. This substance is smooth and slippery, distinctly giving the impression of soap fragments.

Analysis yielded no fatty acids or other saponified or saponifiable substances. Although the samples were inadequate for a complete analysis, it is safe to infer that much of the material was CaCO_3 (marl). CaCO_3 and NaHCO_3 in a test tube will produce a froth not dissimilar in appearance and with the same soap-like feeling. No matter what may be the exact nature of the material, it represents a peculiar return of substances direct from a body of water to the land. Commonly, the run-off of the soil is thought of in its effect in supplying materials to the aquatic environment. Here, contrariwise, is a case where material is spread out on the shore directly

from the water. The rain in turn dissolves or dislodges the material and eventually carries it back to the lake.

There has been considerable discussion as to the manner of formation of the extensive marine marl beds on the west side of Andros Island and elsewhere. The present data on Lake Forsyth are suggestive, in connection with these large deposits of CaCO_3 . Harvey, 1929, and Clarke, 1924, both discuss such views at some length. The current ideas concerning the origin of these flats may be summarized as follows.

Origin	Process	Result			
Organic					
Bacterial activity Albumen of animals	<table border="0" style="display: inline-table; vertical-align: middle;"> <tr> <td style="font-size: 2em; vertical-align: middle;">{</td> <td style="padding: 0 10px;">Releases Ammonium Carbonates</td> <td style="padding: 0 10px;">Precipitates CaCO_3</td> </tr> </table>	{	Releases Ammonium Carbonates	Precipitates CaCO_3	Marl Aragonite (unstable and largely disappears)
{	Releases Ammonium Carbonates	Precipitates CaCO_3			
Remains of CaCO_3 —shells, etc.	Ground up by wave action				
Inorganic					
Streams entering the sea carry	<table border="0" style="display: inline-table; vertical-align: middle;"> <tr> <td style="font-size: 2em; vertical-align: middle;">{</td> <td style="padding: 0 10px;"> CaCO_3 in suspension Ca in heavy solution which precipitates CaCO_3 when added to sea water </td> </tr> </table>	{	CaCO_3 in suspension Ca in heavy solution which precipitates CaCO_3 when added to sea water		
{	CaCO_3 in suspension Ca in heavy solution which precipitates CaCO_3 when added to sea water				

Possibly all of them contribute, as none seems to be mutually exclusive. Since the highest land is close to the eastern shore and the drainage mostly to the west, practically all of the run-off drains in that direction. Since, as above noted, this island at some earlier date was larger than it now is, and as an abysmal depth occurs to the east—Tongue of the Ocean—it follows that the island's extent must have been largely to the westward, probably giving even more drainage in that direction. This, together with the indications of a larger amount of fresh water than has been generally credited, which is necessarily charged heavily with lime, would suggest that such in itself might be a sufficient causation. Additional CaCO_3 is taken into solution with every rainfall and precipitated, as evaporation progresses, between rains. Both that in solution and suspension is continually urged seaward into a medium already saturated in respect to Ca. Wave action remains to account for its spreading evenly over this relatively shoal area.

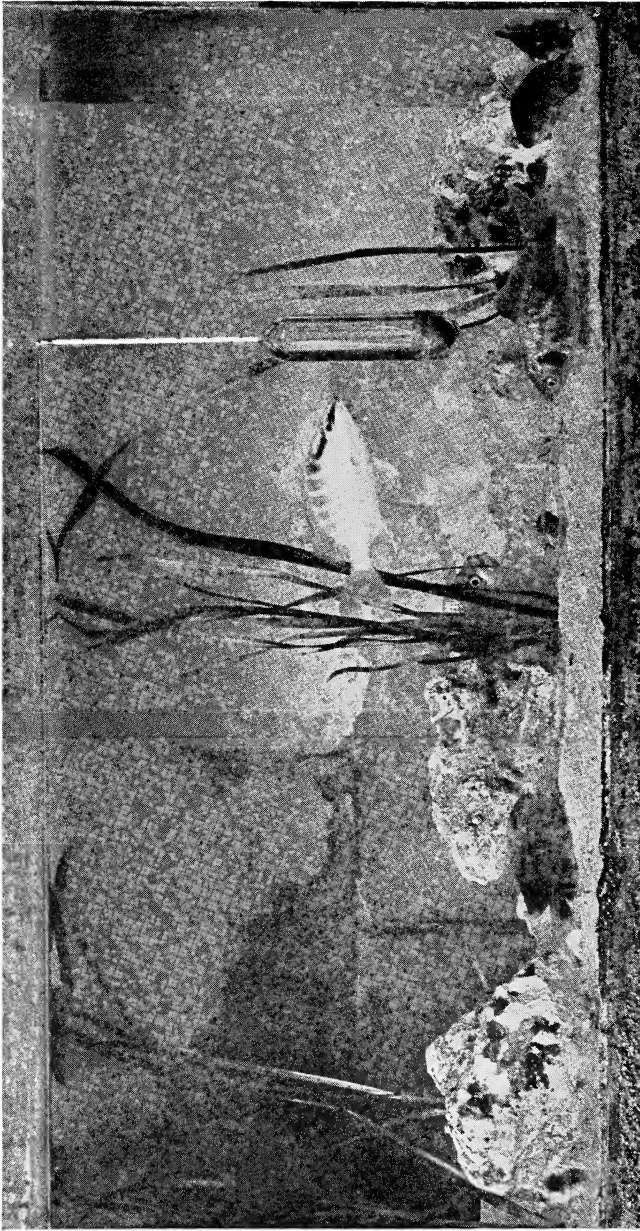


Fig. 35. Aquarium set up to simulate the Lake Forsyth water condition. The hydrometer may be seen resting at the top of its scale at 1.000 sp. g. The lowest mark on the scale, just above the bulb, reads 1.030. The density of the water from which the marine fishes were taken was a little less than this, about 1.028. The marine fishes had been living in this water for twelve days when this photograph was taken. They are as follows. *Pomacentrus leucosfictus*, to left of center; *Lutjanus apodus*, to left of hydrometer in midwater. The fresh water fishes living with them are located as follows. *Carassius auratus*, under hydrometer and under tail of *Lutjanus*; *Eupomotis gibbosus*, two in extreme lower righthand corner. Photograph by S. C. Duntton.

EXPERIMENTAL DATA

Since it has been shown that Lake Forsyth is not a body of salt water and that it does harbor a variety of truly marine fishes, it remains to explain this anomalous condition. Although there are numerous fishes capable of dwelling in either fresh or salt water, the majority of marine fishes expire shortly if transferred to fresh water even if the transfer is gradual. As Lake Forsyth is bedded in coral rock and contains much calcareous marl in suspension, one would naturally look to this as a possible reason for the conditions earlier described. In order to test this hypothesis a number of experiments were undertaken at the New York Aquarium, Breder (1933c). While it is hardly necessary to describe them all in full detail at this place, the following abridgment may serve to clarify the point. Water was approximately synthesized according to the following formula.

NaCL	0.795 gms. per liter
CaCO ₃	0.1099
CaSO ₄	0.3376
K ₂ SO ₄	0.1265
MgSO ₄	0.0094

Other water was made up by placing in New York City tap water a considerable excess of calcium carbonate and calcium sulphate. This and the more carefully compounded solution gave indistinguishable results. This is to say, that the presence of calcium is enough to account for such effects. Fishes transferred immediately from sea water to this type of fresh water died in a very short time; in fact, nearly as short a time as when immersed in "soft" fresh water. Transfer consuming about three days was found to be adequate to accommodate the following species:

<i>Hippocampus hudsonius</i>	<i>Anisotremus virginicus</i>
<i>Centropristes striatus</i>	<i>Bathystoma striatum</i>
<i>Stenotomus chrysops</i>	<i>Angelichthys ciliaris</i>
<i>Lutianus synagris</i>	<i>Pomacentrus leucostictus</i>
<i>Lutianus apodus</i>	<i>Abudefduf saxatilis</i>

The experimental set-up was not entirely satisfactory and it is felt that much greater success could have been obtained if a more elaborate arrangement had been made, but for the present purposes

the demonstration is adequate. The fish that gave the greatest satisfaction was the single specimen of *Lutianus apodus*. This fish lived for twenty days after accommodation to fresh water. At that time the experiment was terminated unintentionally, due to an accident in the water supply. A photograph of this fish is shown in Fig. 35, together with other species both fresh and salt. The hydrometer serves to indicate the lack of density of the water. The water used for the experiment was "hardened" simply by placing coral sand on the bottom, together with lumps of plaster of paris. It may be noted in passing that the fresh water fishes *Carassius auritus* and *Eupomotis gibbosus* were introduced directly from New York City water and thrived exceedingly well. Other investigators, such as Keys, 1931, transferred fishes from salt to fresh water, but the species used in the case cited, *Fundulus*, are all unusually adaptable and frequently endure indifferently well in either; so much so that it may almost be considered a generic characteristic. Such is not the case, however, with the species used in the present experiments, especially such as *Pomacentrus*, *Angelichthys*, et cetera. It thus appears to be clear, from the investigations of others and the present field and laboratory studies, that a large variety of marine fishes are able to exist in fresh water saturated with respect to calcium, while the "soft" fresh waters are quickly disastrous.

This view calls attention to a controversy between students at the Plymouth Aquarium and those associated with the New York Aquarium. The former institution uses quicklime for the correction of stored sea water, while the latter uses sodium bicarbonate. See Atkins, 1931; Breder and Howley, 1931; Breder and Smith, 1932, and Cooper 1932. While agreement has been reached in these contributions concerning the theoretical validity of the use of NaHCO_3 , the data presented herewith support the use of calcium as a practical means if so desired. Certainly if sea fishes can be made to exist in fresh water by its presence, the partial replacement of sodium by it in sea water could hardly be expected to have serious consequences except after long periods, if at all.

It appears, however, on further consideration, that the matter is not quite as simple as the above would indicate, for it so happens that an abundance of lime salts was always present in the New York Aquarium circulation. The tanks themselves are for most part

concrete, lined with tufa rock and bedded with coral sand. Calcium is also added to the system by way of the foods.⁵ Consequently it is inferred that the improvement in general health and longevity, noted by Breder and Howley, 1931, is a measure of the difference between the calcium and sodium treatments rather than a measure of the difference between sodium and no treatment at all. It is doubtful, to the writer, if an aquarium such as the New York institution, could endure for any length of time if it were not for this unintentional introduction of Ca.

The behavior of the fishes transferred to fresh water merits some consideration in this connection. Although they were active and ate normally, their peculiar reaction to shock was entirely unexpected. Most of the deaths were actually seen taking place by one or another observer. On quiet approach to the tank all would appear to be well with the fishes, but a smart blow on the tank would invariably cause one or more to go into a convulsion. This consisted of disorganized swimming movements in which the equilibrium would be upset alternating with rapid quivering of the entire fish. The mouth would open spasmodically to its full extent and seem to lock in that position. Recovery would usually take place within an hour or death would ensue in a few minutes. It would seem that this effect was most likely induced indirectly by the great dilution of the body fluids coupled with the relatively high, but absolutely low, concentration of calcium. A study of this is out of the present province but the physiological processes involved should be of interest.

Although in the field nothing peculiar about the seined fishes was noted, it is unlikely that under such conditions, with the catches half buried in soft mud, anything of this sort would have been observed. Also it may be that the behavior is only a passing condition of newly introduced specimens. It may be pointed out, however, that for laboratory purposes this fact works against any practical application in which the use of lime might be involved.

As the saturation point of Ca is lower in fresh than in sea water, it follows that the experimental fishes were actually suffering from a calcium deficiency. The behavior on shock was consequently not unlike that described for higher animals.

⁵ It may be noted in this connection that in all "balanced" fresh water aquaria so far examined there is a distinct increase in the calcium content with age.

DISCUSSION

The data concerning the conditions obtaining in Lake Forsyth suggest items in the establishment of fresh water environment. Starting with coral formations projecting through the surface of a tropical sea and entirely disconnected with any continental or other land, the fauna, as well as the flora, establishing itself must necessarily come from either of two sources. Species may be transported over the intervening ocean or may be evolved from intruding marine forms.

Considering the Bahamas generally, it is clear that the herpetological fauna has been established by the chance oversea transport of relatively few species that since gave rise to a considerable number of slightly differentiated endemic forms. This view is given by Dunn, 1932, in a consideration of the origin of the Greater Antilles fauna, and certainly a similar condition is apparent in the Lesser. The mammals present an essentially similar picture and the birds, with their ready means of self transportation, a normal condition for them. This may likewise be argued, with the appropriate variations, for all of the terrestrial invertebrates as well as the flora. The aquatic forms of life adjacent to these shores are of course all marine and typically West Indian.

With these two conditions it appears that the terrestrial fauna and flora are established to about their present limit of abundance, on such an alkaline soil. As pointed out earlier, most of the Bahamas are too small to support any considerable amount of fresh water for a number of reasons. They are low and not infrequently flooded by storms; the surface drainage is small although rainfall is abundant, and the lack of a deep soil does not encourage the collection of pools. For this reason, so far as known, waters are all salt or at best brackish, on even such large islands as Great Inagua and Great Abaco. In Table II, sample 11 serves as an example of one of the lakes on New Providence. The invasion of such waters by sea fishes is not remarkable and occurs regularly when there are no obstacles of other kinds. A similar invasion occurs even when the water is distinctly fresh, as on Andros Island, which is possible because of its large calcium content. Marine invertebrates in general do not share this adaptability with the fishes. Broadly considered the macroscopic marine invertebrates are peculiarly susceptible to slight chemical

changes in sea water, as anyone associated with an aquarium operated on a closed circulation can testify. Consequently it is not surprising to find the invertebrates in Lake Forsyth to be chiefly insects with considerable powers of flight such as dragon-flies, and fresh water snails such as *Physa* (See Pilsbry, 1930). This condition is likewise true of the aquatic plants, no strictly marine forms being encountered. Only the peculiar brackish and hardwater *Batophora* was found by the writer. *Utricularia* and *Sagittaria* have been reported from other islands in brackish water (Coker, 1905). It is evident that the fishes, for most part, invaded directly from the sea. This is excepting the cyprinodonts and the gobies, whose distribution throughout the West Indies follows fairly closely the brackish shores of all islands, extending well into both salt and fresh water when the latter is present at all. Most of these fishes are notoriously resistant to even rapid changes from fresh to salt, or vice versa.

While it is a fact that sea fishes on occasion will enter rivers for a greater or lesser distance, there is not ordinarily any such influx, on the seaboard of the United States at least, to a point where the salinity is as low as that of Lake Forsyth. For rather extensive data on this, see Hildebrand and Schroeder, 1928. Another locality that has an extensive invasion of marine fishes is the Tuyra basin of eastern Panama, with which the writer is familiar. This drainage to a large extent runs through limestone. No studies were made of its water chemistry but there certainly must be a considerable amount of calcium present, although of course not nearly as great as in the Bahamas. In regard to this, in describing the habitat, Breder, 1927, states: "The upper reaches, above the effect of tide, are bottomed chiefly by a soft, decomposing, calcareous rock." All other streams that have been examined in their lower reaches by the writer show a practically negligible calcium content. Sea fishes do not enter to a notable degree and then only for brief excursions. This is making allowance for the frequently disregarded overriding of fresh water on a bottom layer of salt at extreme high tide which may extend a considerable distance inland.

An examination of the rivers of the world, considering the intrusion of marine fishes with regard to their calcium content, should be illuminating. The present studies suggest that the amount of invasion of this sort may vary directly with the quantity of Ca present.

The conditions on Andros Island are suggestive of the next step in the development of an insular fauna. To further such establishment a slow rising of the land with the consequent increase both in area and altitude would go far to the development of a fresh water habitat. A detailed comparison with a similar but comparatively high oceanic island should be highly instructive.

SUMMARY

1. The Lake Forsyth region of Andros Island supports only a relatively poor fauna of terrestrial vertebrates.
2. The lake itself, which is fresh water, supports a considerable fish fauna (12 species), all of which are marine types.
3. The main food chain traces back clearly to the heavy flooring of the algae *Batophora*.
4. Marine invertebrates have not invaded this fresh water to any extent, the few invertebrates present being mostly fresh water types.
5. The presence of marine fishes may be accounted for by their ability to withstand fresh water in which a sufficient amount of calcium is present.
6. Lake Forsyth may be considered as representing a "new" fresh water environment in which invading forms are just commencing to establish themselves.
7. Various gradations from this condition backward to purely marine conditions are represented in other Bahama Islands, Andros Island representing the most advanced position chiefly because of its greater drainage area.

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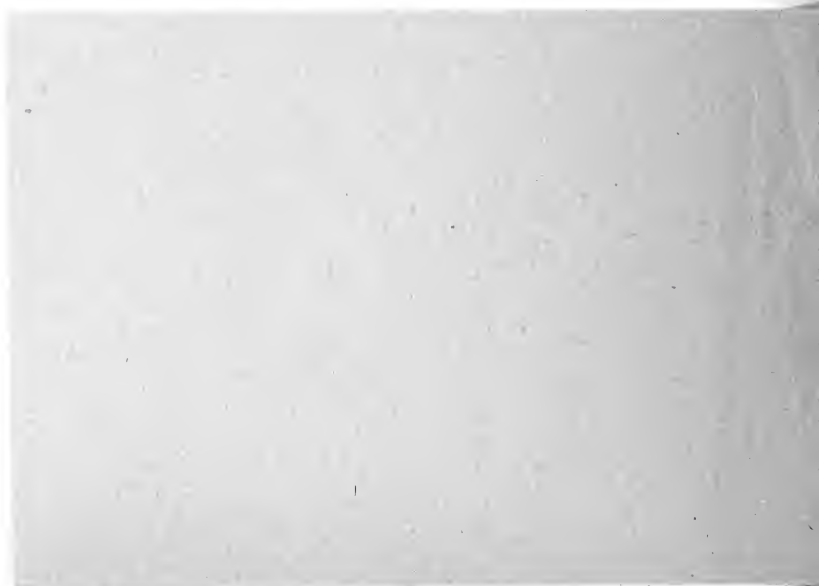
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NEW YORK ZOOLOGICAL SOCIETY



VOLUME XIX. NUMBER 1

THE DISTRIBUTION OF CERTAIN WHALES
AS SHOWN BY LOGBOOK RECORDS OF
AMERICAN WHALESHIPS

CHARLES HASKINS TOWNSEND

Director of the New York Aquarium

PUBLISHED BY THE SOCIETY
THE ZOOLOGICAL PARK, NEW YORK

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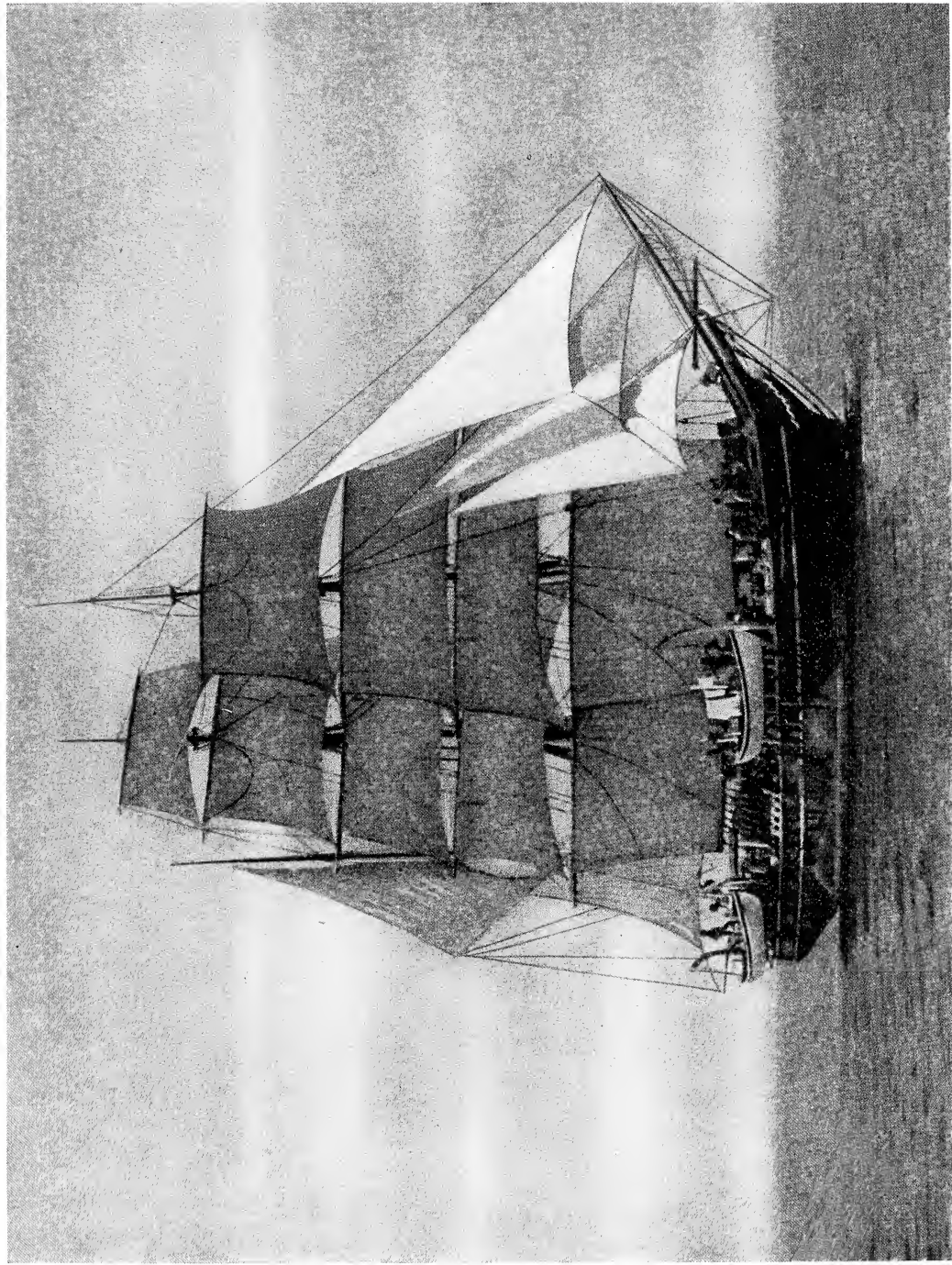


Fig. 1. A Nineteenth Century Whaler, the Bark *Morning Star*, of New Bedford. A Sperm Whaler of 305 Tons, Built in 1858. She Made 10 Voyages Between 1857 and 1912, Taking 1,130 Whales. Photograph by Tripp, New Bedford.

THE DISTRIBUTION OF CERTAIN WHALES AS SHOWN BY LOGBOOK RECORDS OF AMERICAN WHALESHIPS

By CHARLES HASKINS TOWNSEND, Sc.D.

Director of the New York Aquarium

(Figs. 1-2; Plates I-IV incl.)

While examining logbooks of old-time whaling vessels in the New Bedford Public Library a few years ago, it became apparent to the writer that they represented a supply of hitherto unused records available for much additional information on the distribution of whales.¹ The logbooks, hundreds in number, show clearly where the Nineteenth Century whaler made his catches of sperm, bowhead, right and humpback whales. It appeared that by plating on charts the positions where large numbers of whales had been taken, much could be learned of their distribution and something of their migrations.

Other collections of Nineteenth Century logbooks were found in the Whaling Museum of Old Dartmouth Historical Society in New Bedford and also at Nantucket, Salem, Stonington and other New England ports celebrated in the history of the whaling industry. Many privately-owned logbooks were also accessible.² The compilation of records found in these logbooks was undertaken on behalf of the New York Zoological Society. Posi-

¹ In the present document the writer has included parts of his earlier paper on the same subject. "Where the Nineteenth Century Whaler Made His Catch." (Bull. N. Y. Zool. Soc., Vol. XXXIV, No. 6, Nov.-Dec., 1931).

² The collections of logbooks found in the libraries and other institutions of old whaling towns had been acquired both by gift and purchase. Those in the possession of individuals were regarded as family heirlooms. A few logs were found in the collections of individuals interested in the history of American whaling.

Little difficulty was encountered in getting permission to copy records from logbooks privately owned. The simple explanation that the records showing where whales had actually been killed were for the making of new charts, was usually sufficient, and the whaler-ancestor's log would be laid before us. The present generation has apparently not lost interest in that now extinct phase of American life.

tions where 53,877 whales were taken are platted by latitude, longitude and month on the four charts presented herewith. Each month's captures being distinctively colored, the charts present evidence of considerable movement of whales according to season. They also show the positions and extent of "whaling grounds" and the seasons when they were visited.

A study of the two sperm whale charts shows that the catch of sperm whales by the Nineteenth Century whaler was made chiefly between the north and south latitudes of 40°. The known distribution of this species both northward and southward is somewhat wider. It is in general an inhabitant of tropical and temperate seas, ranging into cold waters only in very limited numbers. A few stragglers are now being taken in Antarctic waters. The sperm whaler made voyages lasting from two to four years. He sailed all tropical and temperate seas and operated at all seasons, being continuously at sea except when driven to port for supplies or repairs. The "whaling grounds" as shown on the four accompanying charts are naturally very widely scattered, whales being found in cold, temperate and tropical seas both north and south. Some species are of limited distribution, while others migrate extensively according to season, breeding range or food supply.

We are here dealing with whaling operations as conducted when sailing vessels were employed and whales were killed with harpoons thrown by hand from open boats. The whales taken were the slower species that could be captured by such methods and that did not sink, or seldom sank, when killed. The Nineteenth Century whaler did not take the great blue whale, the finback and other kinds now being captured in great numbers by more effective equipment, and his logbooks contain little about them except that they were frequently seen. Such whales were too speedy for his small boats and usually sank when killed—a difficulty he could not surmount. Most of the species he was able to capture are now greatly reduced in numbers as a result of his long-continued activities. The bowhead whale is considered a rarity and does not figure in the annual catch today.

Twentieth Century whaling at present involves the killing of many thousands of whalebone whales a year, largely in Ant-

arctic waters. It is vastly more destructive, 42,874 whales having been taken during the season of 1930-31. The catch is made by large steam-powered hunting boats carrying small cannon and whales are towed to a limited number of stations on shore, or to large cruising factory steamers equipped to haul whales on board. Forty factory steamers and a smaller number of shore stations are sufficient for the enormous annual catch of today, whereas the old-time sailing fleet numbered hundreds of vessels. In 1846 there were 735 whaling vessels sailing under the flag of the United States. Not one of them remains afloat today. The sole survivor has been hauled ashore and is now a whaling museum. At its best period that great fleet probably captured less than 10,000 whales a year.

The plattings on the two sperm whale charts are divided—one for the April-September season, the other for the rest of the year. They show where 36,909 sperm whales were killed.

The charts also show a seasonal oscillation of most of the sperm whales between north and south latitudes, or at least toward or away from the Equator.

The sperm whale is an inhabitant of tropical and temperate seas—a straggler elsewhere. The north Atlantic, for instance, above latitude 35° N. would not be classed as “temperate” during the northern winter season by either navigators or meteorologists. There is much evidence that there is an extensive southward movement of sperm whales as the northern winter season comes on. A reverse movement is indicated for the winter season south of the Equator.

According to the many thousands of plattings on the charts, the April to September sperm whaling above latitude 25° N. in both Atlantic and Pacific waters was largely discontinued after that season. Whaling operations in this region of the Atlantic were continued to a limited extent during October and November and to a lesser degree in the north Pacific. While some whaling continued in January and February north of the Equator in both oceans, the most of it was conducted “along the line” or far to the south of it.

Our examinations of the records of more than 1,600 voyages indicate that regardless of all but the most adverse weather con-

Carte Générale Des Courants Marins, D'Après Krümmel

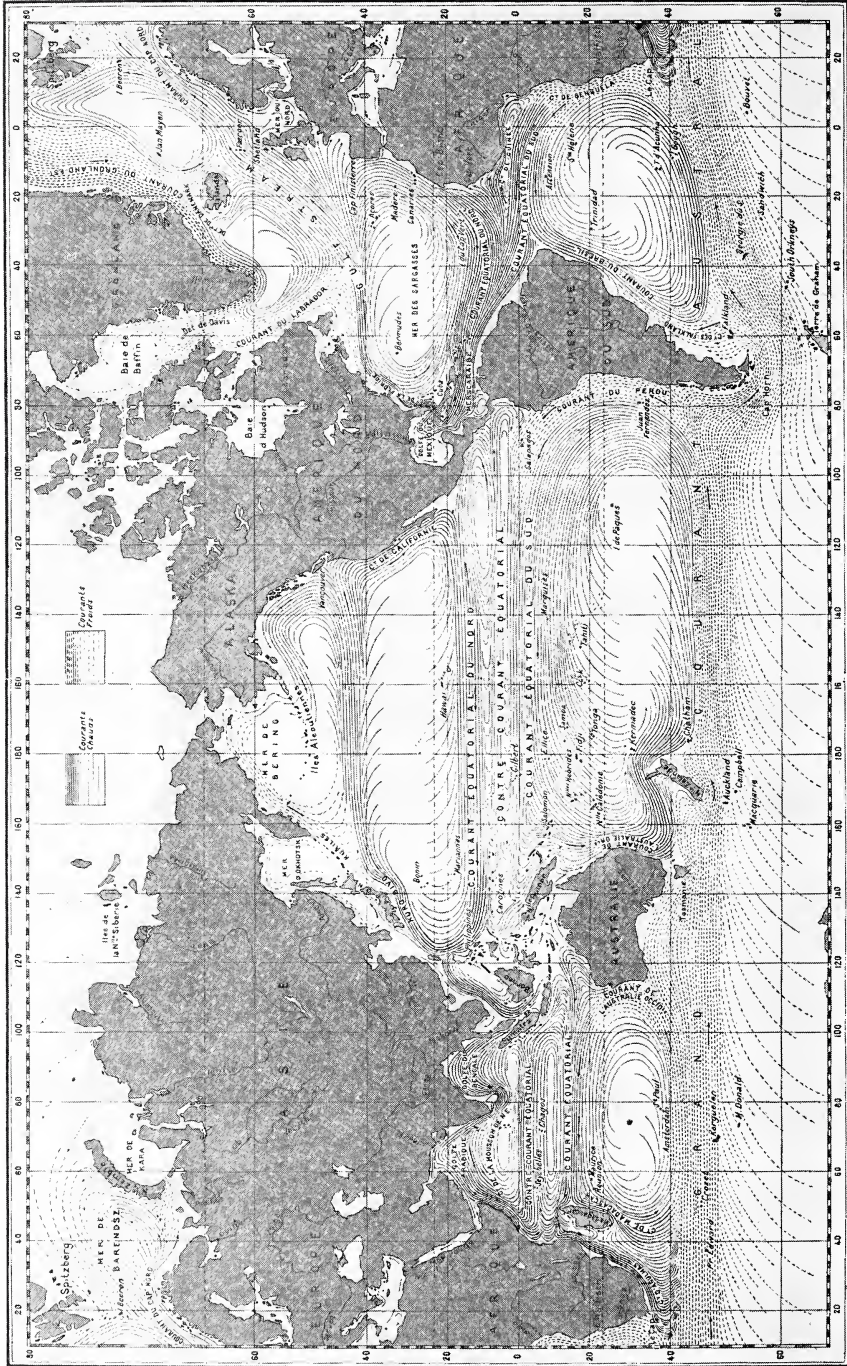


Fig. 2. The positions of whaling grounds as affected by ocean currents were discussed at considerable length by Wilkes (1845) and Maury (1855). The present writer, after much study of recent oceanographic literature, abandons his attempt to set forth what is known of their relationship. A chart of ocean current is presented here in the hope that the task may be undertaken by someone more competent.

ditions, the hardy whalers of the period visited "whaling grounds" in various latitudes according to season, as experience and whaling traditions had taught them. Where and when to hunt for whales was the vital topic in their conversation.

A whaling ground is occupied by whales so long as it is a feeding ground. It continues to be a feeding ground during the season when the animal life on which whales subsist is most abundant. Whalers of today are better informed on this point as a result of modern scientific investigations.

The sperm whale feeds chiefly on cephalopods and at greater depths than other whales. The bulk of the food of whalebone whales consists of small crustaceans and other plankton. Certain of the smaller fishes, when schooling, are taken by some of the whalebone whales.

The migrations of whales from one region to another are influenced by the search for food and the needs of reproduction. Some of the whalebone whales, feeding extensively in cold seas, seek temperate waters to bring forth their young. Their seasonal movements are also influenced by ocean currents to a degree not yet well understood.

The seasonal movements of sperm whales in the broad Pacific do not correspond very closely with those of the much narrower Atlantic. The great currents of the two oceans differ in direction and force and there are great climatic differences. The movements of sperm whales in the Indian Ocean are geographically limited at the north. Most of the catch there was made south of the Equator. They were seldom taken north of it except in the Autumn months.

It will be seen that in the north Atlantic (Sperm Whale Chart A) the platted areas above latitude 25° are with a few exceptions for the April-September period. The massed platings in the Sargasso region are almost entirely those pertaining to the summer season of the northern hemisphere. Between north latitude 25° and the Equator, sperm whales were taken chiefly during the October-March season. Along the east coast of South America (Sperm Whale Chart B) the catches were largely made during the same season, or summer-time in the southern hemisphere. Along latitude 35° S., toward the Cape

of Good Hope, whaling data are also for the October-March season.

Off Japan and along latitude 30° N., the plattings are those of the April-September season. In the Pacific equatorial belt, catches for all months of the year are represented. Off the west coast of South America south of the Equator, the plattings pertain mostly to the summer season of the southern hemisphere. There was much whaling off Peru at this season. Off the west coast of South Africa, the extensive whaling during all months of the year probably may be attributed to the effect of the cool, northward-flowing Benguela Current. The massed areas off the west coast of northern South America, where whaling was also carried on at all seasons, may be similarly explained by the cool northward-flowing Humboldt Current. This current, deflected westward at the Equator, is responsible for the uniformly cool sea temperatures about the Galápagos Archipelago, where large numbers of sperm whales were taken during more than half a century at all seasons of the year.

NORTHERN RIGHT WHALE (*Balaena sieboldii*). CHART C.

In the Pacific, the area of distribution of the northern right whale lies almost entirely to the northward of 40° N. latitude. It narrowly overlaps sperm whale territory in the Sea of Japan. Other points of contact are negligible. Whaling for this species, off the Asiatic coast, extended from the Sea of Japan into the head of Okhotsk Sea, and along the east side of the Kamchatka peninsula, with considerable offshore hunting to the eastward of the Kurile Islands as far as longitude 170° East.

On the American side, right whaling was practised from southeastern Bering Sea to and throughout the Gulf of Alaska. Other right whale plattings in Bering Sea are few and do not extend above Bering Strait. There are only a few scattered offshore positions just below latitude 40° North. Practically all north Pacific right whaling was carried on during the summer season of the northern hemisphere. According to the logbook records at hand, 2,118 right whales were taken in the regions above described.

SOUTHERN RIGHT WHALE (*Balaena australis*). CHART C.

Comparison of the right whale chart with the two sperm whale charts shows that the narrow belt of distribution of the southern right whale in the Atlantic overlaps the very broad sperm whale belt only as far north as 30° south latitude, except for two small areas off South Africa. Its southern border of distribution extends, at a few points only, beyond that of the sperm whale.

In the Pacific Ocean, the chart devoted to positions where northern and southern right whales were taken, shows no platings between latitudes 30° N. and 30° S. except for a few stragglers. The same may be said of the Atlantic, except for a restricted area adjacent to Woolwich Bay, South Africa, and eight mid-ocean stragglers. In the Indian Ocean, right whales were not taken north of 30° South latitude, except at Delagoa Bay about 25° South.

Therefore, so far as right whales are concerned, the limits described above (within 30° N. and 30° S.) represent a vacant tropical belt. There are no records in the logs of the 1,670 voyages examined, to indicate any mingling of northern and southern right whales.

In the south Pacific, right whaling was carried on between latitudes 30° and 53° South. An area of intensive right whaling lay to the eastward of northern New Zealand, its center being in latitude 35° South and longitude 172° East. To the southward of this area there was a rather wide belt of right whaling ground extending from southeastern New Zealand to about 142° west longitude. Below latitude 30° South there are, with few exceptions, no records showing the capture of whales of any species in the South Pacific between 140° West longitude and the sperm and right-whaling ground known as "Coast of Chile." The name "Middle Ground," as used by whalers, seems to apply to all of the area between New Zealand and eastern Australia, where both right and sperm whales were taken, the latter predominating. "Coast of New Holland" is a logbook term applied to all right and sperm whaling areas west and south of Australia.

In the south Atlantic, the right whale was taken along nearly the same lines of latitude as in the Pacific, with an addi-

tional coastwise strip extending as far as Cape Horn, including the Falkland Islands. Numerous captures of right whales were made in the vicinity of Woolwich Bay, Africa, between latitudes 20° and 24° South. In the Indian Ocean, right whales were taken within the same latitudinal limits as in the Atlantic and Pacific, but not north of Delagoa Bay or south of the "Desolation Ground" around Kerguelen Island. Thus the distribution of the southern right whale extends—within the above latitudes—from the meridian of 100° East, practically around the world, with a break only between longitudes 90° and 140° West. The chart shows where 6,262 southern right whales were taken.

As for the North Atlantic Right Whale (*Eubalaena glacialis*) and the Bowhead (*Balaena mysticetus*) in the Atlantic Arctic, the chart remains a blank. Only a few of the 1,670 whaling voyages considered here, extended above the sperm whale limit in the north Atlantic. Their records for bowhead and right whale are so few that they add nothing to what is already known of the distribution of these two species in this region. The positions recorded for bowhead were all in the vicinity of Southampton Island, Hudson Bay, and in Cumberland Sound, Baffin Island. These localities are lettered BOWHEAD on Chart C. The records are chiefly those of New Bedford and New London whalers. The bowhead fishery, beginning about 1860, was an important one. Were the records of British whalships available for plating on charts, they would doubtless supply the information lacking.

Of the 53,879 positions on the charts showing where whales were taken, 36,910 relate to the sperm whale, which was the chief object of capture of American whalemens during the period covered by our records. While the few records for right whale and bowhead in the north Atlantic have been omitted from the chart, they have been included in the general tabulation of voyages and catches. Similarly, while the few records showing where gray whales were taken, were not platted on charts, they have been included in the tabulation of voyages.

In the section of this document devoted to records of captures, the list of whalships is arranged alphabetically. The catch for each voyage is recorded by species. This yields infor-

mation, hitherto lacking, on the average catch per voyage during the Nineteenth Century.

BOWHEAD WHALE (*Balaena mysticetus*). CHART D.

The whaling grounds for the bowhead in Bering Sea and adjacent waters, as indicated by the 5,114 plattings on chart D, are included within latitudes 53° to 73° North, and longitude 120° West to 135° East. In the Arctic, they extended from Wrangel Island, Siberia, to Point Barrow, Alaska, with a scattered distribution as far eastward as Amundsen Gulf, British America. In Arctic waters the catch was made chiefly during the months of August and September. In Bering Sea—mostly its western part—whaling continued from April to July, while in the Okhotsk Sea it was carried on throughout the northern summer season, but largely in August and September.

Scammon (1872) states that "no bowheads of the Okhotsk Sea have ever been seen passing out of the passages of the Kurile Islands, or from the Okhotsk to Bering Sea, or Arctic whales passing to the Okhotsk." It should be noted, however, that in these latitudes, whaling, both for the bowhead and the northern right whale, was carried on during the summer season. The whalers were *not there in winter* when ice conditions, both in the Bering and Okhotsk seas, should have forced the bowhead somewhat farther south. Although the logbook records at hand—covering a period of more than half a century of summer whaling—show no winter whaling, it is probable that the bowhead passed freely around the end of the peninsula of Kamchatka during the winter season.

HUMPBACK (*Megaptera nodosa*). CHART D.

It is of interest to note that the 2,883 humpbacks taken by the ships whose records are at hand were captured chiefly in five principal regions where sperm whales were taken in great numbers. These are the west coast of Africa (Equator to 12° S.), coasts of Colombia and Ecuador, around the Tonga Islands, in the Coral Sea northwest of New Caledonia and off northwest Australia. All of these areas are south of the Equator except in

the case of those taken between the Equator and Panama Bay. Elsewhere the records of catches of humpbacks are few and widely scattered, except off Lower California, the West Indies and around Madagascar.

WHALING GROUNDS—NORTH ATLANTIC

There is frequent mention in the logs of sperm whaling "grounds," nine of which were in the North Atlantic. "Western Ground" (31° N. 50° W.) is in the great mid-ocean Sargasso region, its center being in the latitude of Bermuda, and nearer Bermuda than Madeira. Whaling was carried on here almost entirely during the season from April to September, inclusive. Extending northeastward, it nearly merges with the Western Islands Ground around the Azores. Parts of the Western Ground were known to some whalers as "The Two Forties" and "The Two Thirty-sixes." "Southern Ground" (33° - 40° N. 60° - 75° W.) northwest of Bermuda, and "Charleston Ground" (28° - 33° N. 67° - 78° W.) southeast of Cape Hatteras, were, like the Western Ground, influenced by the Gulf Stream. Another name, "Hatteras Ground," was sometimes applied to the region off the Cape. In the "Southern Ground" whaling was seldom practised later than September, while on the "Charleston Ground" it often continued until January. The southwesterly part of this area was sometimes called "The Bahamas."

The "Commodore Morris Ground" (47° - 51° N. 20° - 25° W.), farthest north of the sperm whaling areas, and the southwest of the British Isles, was a summer field. Its moderate sea temperature was influenced by the North Atlantic Drift of the Gulf Stream. There are but few records of sperm whaling by American vessels on the Newfoundland Banks, an area usually referred to as "The Shoals." Sea temperatures here are lower than elsewhere in the same latitude because of the southward flowing Labrador Current. These grounds were fished mainly toward the end of the Eighteenth Century.

The name "Steen Ground" was occasionally applied to whaling carried on in summer west of Madeira. Between the Canary Islands and the coast of Africa, considerable whaling was done

in autumn. The whaling area about Cape Verde islands was known as the "San Antonio Ground," but sometimes called "The Twenty-Twenties." The name "Cornell Ground" (4° N. 22° W.) was applied to a winter sperm whaling area near the Equator, between the coast of Africa and the mid-ocean island of St. Paul. A mid-ocean whaling ground known as "The Twelve-Forty" (12° N. 40° W.), between the West Indies and Cape Verde islands, was visited from February to May, inclusive. This area is frequently mentioned in the logs.

Sperm whaling in the Gulf of Mexico and West Indies regions was practised to a very limited extent during the season from February to May only.

WHALING GROUNDS—SOUTH ATLANTIC

There was an important sperm whaling ground in the western south Atlantic called "Coast of Brazil" (unfortunately not lettered on our charts). It extended from the Equator to Uruguay and was occupied from October to March, with a little whaling during April.

South of it, off the mouth of the La Plata River, was the "Platte Ground" where sperm whales were taken. To the southward and near this ground were the so-called "Brazil Banks," chiefly a right whale area. "False Banks" lay to the eastward of Brazil Banks. No name appears for the sperm whaling ground between the latter and the Falkland Islands.

The Atlantic sperm whaling ground off the African coast from 3° to 23° S. was called "Coast of Africa," where hunting was done at all seasons.³ Our records show comparatively little whaling about St. Helena. "Pigeon Ground" (31° - 39° S. 16° - 28° W.) was chiefly a right whaling area. On "Tristan Ground" (Chart C) around Tristan da Cunha, both sperm and right whales were taken. From here, eastward to the Cape of Good Hope, there was long-continued hunting for both sperm and right whales, the latter greatly predominating in the catch. The whaling season for this south Atlantic region was chiefly

³The plattings of this area were extended a little too far to the west and numerous records were omitted for lack of space.

during the months from October to January inclusive. At the "Woolwich Bay Ground" (20°-24° S.), sperm and right whales were taken from December to March inclusive.

WHALING GROUNDS—PACIFIC

Japan Ground (28°-35° N. 150°-179° E.), discovered about 1820, was a summer ground and fished to a limited extent in autumn. The "Coast of Japan" ground (34°-40° N. 142°-149° E.), east of northern Japan, afforded sperm whaling from May to July inclusive. During the same months and in about the same latitude there was much hunting for right whales to the westward in the Inland Sea of Japan. (See Chart C.)

The "Northwest Coast," mostly above 49° N. and extending from 130° to 170° W. (Chart C), was a right whaling ground from April to July inclusive. Our records do not show that sperm whales were taken there except as stragglers. Southeast of southern Japan there was a sperm whaling area about the Bonin Islands, where considerable hunting was done from May to August.

North of the Hawaiian Islands sperm whaling was continued to a limited extent until January. This is also true of the region of Lower California down to the latitude of Central Mexico. On the grounds known as "Panama," "Galápagos," "Off Shore," "On the Line" and almost across the equatorial Pacific, sperm whales were taken in great numbers during all seasons of the year. The same is true of the grounds known as "Sulu Sea," "Celebes Sea," "Molucca Passage" and "Coast of New Holland" (western and southwestern Australia). On "Middle Ground," between Australia and New Zealand, sperm whaling was done chiefly during the season from December to March inclusive. Whaling on the "Vasquez" and "French Rock" grounds, north of New Zealand, was continued from December to May inclusive. Sperm whalers operated on the "Callao Ground" off Peru and on the "Coast of Chile Ground" from December to March, but there was some hunting during other months.

On all of the Pacific whaling grounds below latitude 30° S., the whalers took both sperm and right whales in about equal numbers, pursuing the latter in January as far as 50° S. The

hunting of whales was by no means limited to grounds supposed to be most favorable, as both sperm and southern right whales were frequently taken at points remote from them.

INDIAN OCEAN

Sperm whaling in the Indian Ocean was practiced at all seasons, extending from 18° N. to about 40° S., with occasional voyages as far south as Crozet and Kerguelen islands. The principal grounds were known as "Coast of Arabia," "Zanzibar," "Mahe Banks" and "Delagoa Bay." There was also sperm whaling in Mozambique Channel, east of Madagascar, south of Ceylon and from the Andaman Islands to Sumatra. Most of the sperm whaling in the Indian Ocean, however, was in its western half. Right whales as well as sperm whales were taken in the Indian Ocean between 30° and 40° S., the former greatly predominating. There was also much hunting of right whales on "Crozet" and "Kerguelen" (or "Desolation") grounds (42°-50° S.).

As the work of plating the positions where whales were killed proceeded, the areas called whaling grounds steadily expanded. Had the search for logbook records been continued far beyond the total of 1,665 voyages considered here, it is probable that in some regions the local "grounds" would have practically merged. The positions of captures fell so thickly upon the favorite grounds that they could not all be platted. Consequently from 10 to 20 per cent. of the available records were omitted from each densely platted area of the charts.

None of the whales in the records were caught by "modern methods," strictly speaking. The New Bedford tradition, into the Twentieth Century, was against anything like the Norwegian methods or those now used at shore stations. Some shoulder guns for shooting harpoons were tried out by the New Bedford whalers in the 1850s and 1860s, but did not gain much popularity. The swivel gun, mounted on the bow of the oared whaleboat, was used occasionally, but that was in the earlier days of American whaling, rather than in the more recent.

The only improvements that originated early and remained permanent fixtures were the bomb-lance shoulder gun (which came in around 1850) and the darting-gun (combination hand-

thrown harpoon with bomb attached, which came in in the 1870s). The introduction of these devices was not strictly revolutionary, as some ship-owners were too conservative to supply them. Even ships which had them would use them only for the larger whales, particularly the bowheads. Even in recent times the darting-gun was not used on small whales.

There are occasional records in the logbooks of exceptionally large catches, such as the Bark *Bertha*, 1905-1907, 138 whales, 3,100 bbl. sperm; Bark *Greyhound*, 1903-1906, 155 whales, 4,625 bbl. sperm.

These would show that the average sperm whale taken by the *Bertha* yielded $22\frac{1}{2}$ barrels of oil, and by the *Greyhound*, 30 barrels. The figures showing the numbers of whales include not only the whales turned into oil, but also those killed and brought alongside but subsequently lost. At times a whale would be shared with another vessel. This would tend to increase the average number of barrels, if taken into consideration.

Acknowledgments: The work of compiling records from logbooks of whaleships was begun by the author and later entrusted to Mr. Arthur C. Watson, formerly connected with the Whaling Museum of New Bedford, and now with the Massachusetts Institute of Technology. While the great mass of the records should be credited to the energy of Mr. Watson, many were copied by the writer from logbooks found in New York and Washington.

The work of platting on charts the positions where whales were taken was done by Mr. R. W. Richmond of New York, a draughtsman, under the direction of the writer.

The tabulation showing names of vessels and catch of whales was arranged alphabetically by Mrs. Eleanor Roddan of the Aquarium staff.

Following are lists of institutions and individuals whose logbooks were kindly made available for examination.

LIST OF INSTITUTIONS WHOSE LOGBOOKS HAVE BEEN EXAMINED

- Congressional Library, Washington, D. C.
D. A. R., Edgartown, Mass.
Dukes County Historical Society, Edgartown, Mass.
Essex Institute, Salem, Mass.
Harvard Business School, Boston, Mass.
Mariners Savings Bank, New London, Conn.
Massachusetts Institute of Technology, Cambridge, Mass.
Nantucket Historical Society, Nantucket, Mass.
New London County Historical Society, New London, Conn.
Old Dartmouth Historical Society, New Bedford, Mass.
Peabody Museum, Salem, Mass.
Public Library, Easthampton, L. I.
- Public Library, New Bedford, Mass.
Public Library, New London, Conn.
Public Library, Westerly, R. I.
Provincetown Historical Society, Provincetown, Mass.
Rhode Island Historical Society, Providence, R. I.
Stonington Historical Society, Stonington, Conn.
The Athenaeum, Nantucket, Mass.
The Oldest House, Nantucket, Mass.
U. S. National Museum, Washington, D. C.
Vineyard Haven Historical Society, Vineyard Haven, Mass.
Whalemens' Club, New Bedford, Mass.
Widener Library at Harvard University, Cambridge, Mass.

LIST OF INDIVIDUALS WHOSE LOGBOOKS HAVE BEEN EXAMINED

- Mr. Charles Baker, New Bedford, Mass.
Mrs. Joshua Baker, South Dartmouth, Mass.
Mr. Everett Barns, Westerly, R. I.
Mr. W. W. Bennett, New Bedford, Mass.
Captain H. H. Bodfish, Vineyard Haven, Mass.
Mr. Edward S. Brown, New Bedford, Mass.
Miss Elizabeth Cannon, Vineyard Haven, Mass.
Mr. G. L. Carlisle, Jr., Norfolk, Conn.
Mr. James E. Chadwick, Edgartown, Mass.
Mrs. W. O. Clark, New Bedford, Mass.
Mr. Orville Coffin, Nantucket, Mass.
Captain Geo. Comer, East Haddam, Conn.
Dr. Charles E. Congdon, Nantucket, Mass.
Mrs. Benjamin Cromwell, Vineyard Haven, Mass.
Mr. M. J. Curran, New Bedford, Mass.
Mrs. R. W. deForest, Cold Spring Harbor, L. I.
Mr. Austin Dunham, Provincetown, Mass.
Mr. Charles Q. Eldredge, Old Mystic, Conn.
Mrs. Tappan Fairchild, Cold Spring Harbor, L. I.
Colonel E. H. R. Green, South Dartmouth, Mass.
Mrs. M. H. Green, Southampton, L. I.
Mr. Wm. D. Halsey, Bridgehampton, L. I.
Mrs. James Hammond, Mattapoisett, Mass.
Mr. Francis R. Hart, Boston, Mass.
Mr. J. A. Herrick, Southampton, L. I.
Mr. Chester Howland, New Bedford, Mass.
Mr. Lawrence W. Jenkins, Salem, Mass.
Mrs. Charles Jones, New Bedford, Mass.
Miss Sylvia Knowles, New Bedford, Mass.
Mr. G. Kranzler, New Bedford, Mass.
Mr. R. M. Kuechler, New Bedford, Mass.
Mr. H. G. Leavitt, Lynn, Mass.
- Mrs. Julius Mallory, Mystic, Conn.
Miss Catherine W. Mason, Stonington, Conn.
Mr. Paul C. Nicholson, Providence, R. I.
Mr. Frank Norton, Edgartown, Mass.
Miss Lucretia Norton, Edgartown, Mass.
Mr. Francis Olejink, Sag Harbor, L. I.
Mrs. E. I. Omev, New Bedford, Mass.
Miss Christine Pease, Edgartown, Mass.
Misses Clara and Alice Perkins, Riverhead, L. I.
Mr. William C. Phillips, New Bedford, Mass.
Miss Carrie Potter, N. Dartmouth, Mass.
Mr. William H. Potter, New Bedford, Mass.
Mr. Fred Riesdorff, Riverhead, L. I.
Mr. Harold L. Rogers, Watermill, L. I.
Miss Mary H. Rogers, Southampton, L. I.
Misses Mary and Helen Seabury, New Bedford, Mass.
Mr. Marshall Shepard, Edgartown, Mass.
Mr. Arthur B. Sherman, New Bedford, Mass.
Mr. Wilbur Sherman, New Bedford, Mass.
Ship Model House, Provincetown, Mass.
Captain William I. Shockey, New Bedford, Mass.
Mr. Austin Strong, Nantucket, Mass.
Mr. Frank Swift, Jr., New Bedford, Mass.
Mr. Frederick H. Taber, New Bedford, Mass.
Mr. Charles H. Taylor, Boston, Mass.
Mr. W. H. Tripp, New Bedford, Mass.
Mr. F. C. Turner, New York, N. Y.
Mr. Alexander Victor, Edgartown, Mass.
Dr. James Weeks, Stonington, Conn.
Mrs. Johnson Whiting, West Tisbury, Mass.
Dr. Charles Mallory Williams, Stonington, Conn.
Mr. William Williams, New York, N. Y.
Mr. Herbert Wing, South Dartmouth, Mass.

SUMMARY OF LOGBOOK RECORDS PERTAINING
TO CATCH OF WHALES

Number of Vessels	744
Number of Voyages	1,665

WHALES TAKEN

Sperm	36,908
Bowhead	5,114
Northern Right Whale, Pacific Ocean.....	2,118
Southern Right Whale, Pacific Ocean.....	1,685
Northern Right Whale, Atlantic Ocean.....	35
Southern Right Whale, Atlantic Ocean.....	2,981
Southern Right Whale, Indian Ocean.....	1,596
Humpback	2,883
California Gray	557
	<hr style="width: 100%;"/>
Total Number of Whales.....	53,877

LOGBOOKS OF NINETEENTH CENTURY WHALESHIPS
FROM WHICH RECORDS WERE OBTAINED

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pac)	So. Rt. (ific)	No. Rt. (Atla)	So. Rt. (ntic)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
A. Houghton, <i>bk</i>	1876-1877	..	4	..	..	..	..	..	..	..	4
A. E. Whyland, <i>schr</i>	1915	17	..	..	..	..	..	..	..	..	17
A. J. Ross, <i>br</i>	1877	..	..	..	..	4	..	..	..	..	4
"	1878	1	..	..	..	..	..	..	..	..	1
A. R. Tucker, <i>bk</i>	1853-1857	28	..	..	..	..	..	..	..	..	28
"	1858-1860	37	..	..	..	..	..	..	..	..	37
"	1861-1863	31	..	..	..	..	..	..	..	..	31
"	1864-1865	14	..	..	..	..	..	11	..	..	25
"	1866-1868	19	..	..	..	..	3	..	..	..	22
"	1869-1870	6	..	..	..	..	..	6	..	..	12
"	1871-1874	33	..	..	..	..	..	..	..	..	33
"	1875-1876	30	..	..	..	..	..	..	..	..	30
"	1877-1879	39	..	..	..	..	..	..	..	..	39
"	1880-1883	18	..	..	..	1	1	..	6	..	26
"	1887-1890	60	..	..	..	..	8	..	..	..	68
"	1891-1892	1	6	..	..	..	..	..	..	..	7
"	1894	..	5	..	..	..	..	..	..	..	5
"	1895-1896	1	1	..	..	..	..	..	..	..	2
"	1898	..	2	..	..	..	..	..	..	..	2
"	1899-1901	66	..	..	..	..	..	..	..	..	66
"	1901-1903	64	..	..	..	..	..	..	..	..	64
"	1903-1906	86	..	..	..	..	..	..	..	..	86
A. T. Gifford, <i>schr</i>	1910	..	5	..	..	..	..	..	..	..	5
Abbie Bradford, <i>schr</i>	1878-1879	..	6	..	..	..	..	..	..	..	6
"	1880-1881	..	2	..	..	..	..	..	..	..	2
"	1883	..	2	..	..	..	..	..	..	..	2
"	1883	..	4	..	..	..	..	..	..	..	4
"	1887	..	1	..	..	..	..	..	..	..	1
Abbott Lawrence, <i>br</i>	1880	..	1	..	..	..	..	..	..	..	1
Abigail, <i>ship</i>	1832-1835	69	..	..	..	..	..	..	..	..	69
"	1836-1838	83	..	..	..	..	..	..	..	..	83
"	1844-1847	49	..	2	..	..	..	..	..	..	51
"	1856-1859	9	..	..	..	..	..	7	27	..	43
Abraham Barker, <i>bk</i>	1866-1870	55	..	..	..	..	2	..	..	..	57
"	1871-1875	53	..	..	..	..	..	..	142	..	195
Abraham Barker, <i>ship</i>	1846-1847	6	..	1	4	..	..	..	..	..	11
"	1850-1852	4	23	..	1	..	..	..	..	..	28
"	1855-1857	3	1	1	..	..	..	..	..	..	5
"	1857-1860	9	2	11	7	..	..	1	..	..	30
Active, <i>bk</i>	1856-1860	62	..	..	..	..	..	..	2	..	64
Acushnet, <i>ship</i>	1845-1847	20	..	3	5	..	..	..	..	..	28
Addison, <i>bk</i>	1867-1868	12	..	..	..	..	..	..	..	..	12
Addison, <i>ship</i>	1870-1873	21	..	..	..	..	1	..	29	..	51
Adeline, <i>ship</i>	1850-1851	1	5	..	..	..	..	..	..	..	6
"	1857-1859	2	13	3	..	..	..	..	1	..	19
"	1860-1865	4	19	..	..	..	1	..	2	36	62
"	1865-1869	11	7	6	..	..	..	..	..	1	25
"	1869-1874	25	..	..	1	..	1	5	15	..	47

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pac)	So. Rt. (ific)	No. Rt. (Atla)	So. Rt. (ntic)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Andrew Hicks, <i>bk.</i>	1906	18	..	..	..	..	..	..	..	..	18
"	1907-1908	15	..	..	6	..	..	..	..	..	21
"	1908-1910	77	..	..	..	..	18	..	..	..	95
"	1911-1913	92	..	..	..	..	6	..	..	..	98
Andrews, <i>bk.</i>	1865-1866	..	10	..	..	..	..	..	..	..	10
Ann, <i>ship.</i>	1792	..	..	..	..	..	60	..	2	..	62
Ann Alexander, <i>ship.</i>	1842-1845	45	..	..	..	..	..	..	..	..	45
"	1845-1849	47	..	..	..	..	..	..	..	..	47
Ann Maria, <i>br.</i>	1838	4	..	..	..	..	..	..	..	..	4
Ann Maria, <i>ship.</i>	1835-1836	3	..	..	..	..	1	36	..	..	40
"	1837-1838	4	..	..	..	..	14	22	..	..	40
Ann Parry, <i>bk.</i>	1842-1845	45	..	..	..	..	..	..	..	..	45
Annawan, <i>bk.</i>	1860-1862	15	..	..	..	..	..	..	2	..	17
"	1868-1870	20	..	..	..	..	..	..	..	..	20
Annawan, <i>br.</i>	1856-1857	18	..	..	..	..	..	..	1	..	19
"	1858-1859	18	..	..	..	..	..	..	..	..	18
Annawan II, <i>br.</i>	1854-1855	9	..	..	..	..	..	..	..	..	9
Ansel Gibbs, <i>bk.</i>	1864	..	18	..	..	..	..	..	..	..	18
"	1867-1868	7	..	..	..	..	..	..	..	..	7
"	1868-1869	..	8	..	..	2	..	..	..	..	10
"	1869	8	..	..	..	..	..	..	..	..	8
"	1872	1	8	..	..	..	..	..	..	..	9
Ansel Gibbs, <i>ship.</i>	1840-1842	66	..	..	..	..	..	..	..	..	66
"	1860-1861	..	5	..	..	..	..	..	..	..	5
Antarctic, <i>schr.</i>	1891-1892	48	..	..	..	..	..	..	..	..	48
Antelope, <i>bk.</i>	1856-1858	11	2	..	..	..	..	..	..	..	13
"	1864-1865	..	17	..	..	..	..	..	..	..	17
Antilla, <i>br.</i>	1858	..	2	1	..	..	..	..	..	1	4
Arab, <i>ship.</i>	1842-1845	95	..	..	..	..	2	11	..	..	108
"	1852	14	..	..	..	..	..	..	..	..	14
Arabella, <i>ship.</i>	1830-1833	85	..	..	..	..	..	..	..	..	85
"	1833-1837	72	..	..	1	..	..	..	..	..	73
"	1837-1839	6	..	..	3	..	8	..	..	..	17
"	1850-1851	8	..	3	..	..	..	..	..	..	11
Archer, <i>ship.</i>	1856-1860	29	..	..	..	..	..	..	..	..	29
Argus of London, <i>ship.</i>	1832-1834	152	..	..	..	..	..	..	..	..	152
"	1835-1836	23	..	..	..	..	..	..	..	..	23
Arnolda, <i>bk.</i>	1867-1870	39	..	..	..	..	..	..	..	..	39
Arnolda, <i>ship.</i>	1860-1863	33	..	..	..	..	..	..	..	..	33
"	1864-1866	..	14	1	..	..	..	..	..	..	15
Asia, <i>ship.</i>	1792-1793	9	..	..	..	..	..	18	8	..	35
Atkins Adams, <i>bk.</i>	1859-1861	13	..	..	..	..	..	..	..	..	13
Atlantic, <i>bk.</i>	1851-1854	34	..	..	..	..	1	..	..	..	35
"	1866-1868	31	..	..	..	..	3	19	..	..	53
"	1868-1871	39	..	..	..	..	1	5	..	..	45
"	1876-1879	26	..	..	..	..	4	11	..	..	41
"	1881	..	7	..	..	..	..	..	..	..	7
Atlas, <i>ship.</i>	1813	3	..	..	..	..	..	..	..	..	3
"	1825-1826	1	..	..	..	..	21	..	..	..	22
"	1826-1827	7	..	..	..	..	15	..	..	..	22
Atlas of Lynn, <i>ship.</i>	1830	2	..	..	..	..	19	..	..	..	21
Attleboro, <i>bk.</i>	1881-1882	19	..	..	..	..	..	..	19	..	38
Aurora, <i>bk.</i>	1866-1870	16	44	..	..	..	..	..	1	..	61

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pac ific)	So. Rt.	No. Rt. (Atla ntic)	So. Rt.	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Bertha, <i>bk.</i>	1911	35	..	..	..	..	..	..	..	..	35
B. D. Nickerson, <i>schr.</i>	1906-1908	112	..	..	..	..	..	..	..	..	112
"	1909-1911	100	..	..	..	..	..	..	..	..	100
Betsey, <i>sloop.</i>	1761	5	..	..	..	..	..	..	..	..	5
Betsey Williams, <i>ship.</i>	1849-1851	5	16	1	..	..	3	3	..	..	28
Bevis, <i>bk.</i>	1851-1853	46	..	..	..	..	..	..	..	..	46
"	1856-1857	6	..	..	..	..	..	..	4	..	10
Black Eagle, <i>bk.</i>	1862-1863	..	21	..	..	..	..	..	..	..	21
"	1864-1865	..	16	..	..	..	..	..	..	..	16
"	1866	1	4	..	..	..	..	..	..	..	5
Blackstone, <i>bk.</i>	1843-1844	3	..	13	2	..	..	6	..	..	24
Blackstone, <i>ship.</i>	1833-1834	6	..	..	..	..	9	..	..	..	15
"	1835-1836	1	..	..	..	..	20	..	..	..	21
"	1837-1838	4	..	..	..	..	14	13	..	..	31
Bogota, <i>br.</i>	1840-1842	22	..	..	..	..	..	..	..	..	22
"	1842-1843	10	..	..	..	..	..	..	..	..	10
Bohio, <i>bk.</i>	1868-1871	19	..	..	..	..	..	..	9	..	28
Bourbon, <i>ship.</i>	1823-1824	..	..	..	..	..	22	..	..	..	22
Braganza, <i>ship.</i>	1841-1842	16	..	28	..	..	1	..	..	..	45
Brandt, <i>ship.</i>	1838-1839	6	..	..	..	..	9	5	..	..	20
"	1850-1852	43	..	..	..	..	..	..	..	..	43
Brewster, <i>bk.</i>	1863-1865	66	..	..	..	..	..	..	..	..	66
Brighton, <i>ship.</i>	1848-1849	..	2	15	..	..	..	..	..	..	17
Bruce, <i>bk.</i>	1848-1850	36	..	..	..	..	..	..	..	..	36
Brunswick, <i>ship.</i>	1859-1861	19	..	..	..	..	..	2	..	..	21
"	1862-1865	4	11	..	..	..	..	..	..	16	31
By Chance, <i>br.</i>	1825-1826	9	..	..	..	..	..	..	..	..	9
"	1826-1827	5	..	..	..	..	..	..	1	..	6
C. W. Morgan, <i>bk.</i>	1856	11	..	..	..	..	..	..	..	..	11
"	1867-1870	27	..	..	5	..	..	..	6	..	38
"	1871	3	..	..	..	..	..	..	..	..	3
"	1881-1886	8	..	..	13	..	1	..	..	..	22
"	1893-1895	80	..	7	..	..	..	..	..	..	87
"	1897	4	..	1	..	..	..	..	..	..	5
"	1900-1901	37	..	4	..	..	..	..	..	..	41
"	1902-1903	58	..	..	..	..	..	..	..	..	58
"	1904	46	..	2	..	..	..	..	..	..	48
"	1906-1908	25	..	..	..	..	..	8	..	..	33
"	1908-1910	52	..	..	..	..	1	10	..	..	63
"	1911-1913	122	..	..	..	..	1	..	..	..	123
C. W. Morgan, <i>ship.</i>	1845-1848	53	..	..	..	..	..	..	..	..	53
"	1864-1866	1	13	..	..	..	..	..	3	5	22
Cabinet, <i>ship.</i>	1843-1844	1	..	18	10	..	..	..	..	..	29
"	1852-1853	14	73	2	..	..	..	..	..	..	89
Caledonia, <i>ship.</i>	1837-1838	4	..	..	27	..	..	..	..	..	31
"	1839-1840	..	..	..	25	..	..	26	..	..	51
"	1846-1848	11	..	15	8	..	..	..	..	..	34
California, <i>bk.</i>	1899	38	..	3	..	..	..	..	..	..	41
California, <i>ship.</i>	1854-1858	7	32	3	1	..	..	..	..	..	43
"	1862-1865	1	18	..	..	..	2	..	..	18	39
"	1866-1869	7	21	..	..	..	2	..	..	1	31
"	1870	3	13	..	..	..	..	..	3	..	19

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pacific)	So. Rt. (Atlantic)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
E. B. Conwell, <i>schr.</i> . . .	1906-1907	10	..	..	..	..	..	..	10
"	1907	14	..	..	..	..	..	..	14
E. H. Hatfield, <i>schr.</i> . . .	1861-1862	6	..	..	..	..	8	..	14
"	1867-1868	3	..	..	..	..	..	..	3
"	1876	13	..	..	..	..	..	..	13
"	1877-1878	11	..	..	..	..	1	..	12
"	1880	4	..	..	..	..	..	..	4
"	1881-1882	9	..	..	..	..	1	..	10
Eagle, <i>bk.</i>	1867-1869	..	11	5	..	..	1	24	41
Eagle, <i>ship.</i>	1841-1843	10	..	13	6	1	..	..	30
Edith May, <i>schr.</i>	1868	3	..	..	..	..	..	..	3
Edward, <i>bk.</i>	1860-1862	14	..	..	..	..	..	..	14
Edward, <i>br.</i>	1816	7	..	..	..	..	..	..	7
"	1817	1	..	..	..	..	..	..	1
Edward Carey, <i>ship.</i>	1854-1858	32	..	..	..	..	..	..	32
"	1859-1864	35	..	..	..	..	32	..	67
Edward Everett, <i>bk.</i>	1868	6	..	..	..	..	..	..	6
"	1873-1874	12	..	..	..	..	..	..	12
Eliza, <i>bk.</i>	1869-1873	36	..	..	..	2	..	..	38
Eliza, <i>ship.</i>	1838-1840	10	..	..	22	..	..	..	32
Eliza Adams, <i>ship.</i>	1836-1838	74	..	..	..	..	..	..	74
"	1846-1848	10	..	31	..	1	..	..	42
"	1867-1870	48	..	..	7	9	..	..	64
"	1872-1876	27	..	..	1	1	1	..	30
"	1877-1878	23	..	..	..	..	..	..	23
"	1879-1883	50	..	..	..	6	5	..	61
Elizabeth, <i>bk.</i>	1831-1832	1	..	..	..	22	..	..	23
"	1844-1846	11	..	..	..	2	..	..	13
"	1849-1850	23	..	..	..	..	..	..	23
Elizabeth, <i>ship.</i>	1837-1839	64	..	..	..	..	..	..	64
"	1841-1844	53	..	..	..	..	..	..	53
"	1845-1847	20	..	12	..	..	2	..	34
"	1851-1855	68	..	..	..	..	..	..	68
Elizabeth Firth, <i>bk.</i>	1848-1849	4	11	1	1	..	..	..	17
Elizabeth Swift, <i>bk.</i>	1859-1863	36	..	..	1	..	..	..	37
"	1866-1867	4	38	..	..	..	9	..	51
Electra, <i>ship.</i>	1862-1863	1	..	1	..	1	..	..	3
Ellen, <i>bk.</i>	1852-1856	54	5	..	..	..	..	..	59
Emerald, <i>bk.</i>	1838-1839	8	..	..	..	..	34	..	42
"	1840-1842	16	..	..	14	..	6	..	36
"	1844-1845	34	..	..	..	..	..	..	34
Emerald, <i>ship.</i>	1835-1836	..	..	..	..	15	38	1	54
"	1844-1847	34	..	..	1	..	..	..	35
Emigrant, <i>bk.</i>	1845	9	..	..	..	2	..	..	11
Emily Morgan, <i>ship.</i>	1842-1845	81	..	4	..	..	..	..	85
"	1863-1866	23	6	12	..	3	..	..	44
"	1866-1868	19	..	7	..	..	..	..	26
"	1869-1871	9	6	4	..	..	..	5	24
Emma Jane, <i>schr.</i>	1879-1881	47	..	..	..	1	..	..	48
"	1881	5	..	..	..	..	..	..	5
"	1882-1883	24	..	..	..	..	..	..	24
"	1883	12	..	..	..	..	..	..	12
Emma C. Jones, <i>ship.</i>	1849-1852	29	..	..	..	20	..	..	49

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pacific)	So. Rt. (Atlantic)	No. Rt. (Atlantic)	So. Rt. (Indian)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Emma C. Jones, <i>ship</i> ...	1860	2	..	..	..	..	7	..	..	..	9
"	1875-1879	67	..	..	..	..	..	..	..	..	67
Empire, <i>ship</i>	1844-1846	81	..	..	..	..	..	..	..	..	81
Endeavor, <i>bk</i>	1841-1843	19	..	..	..	..	1	6	..	..	26
"	1854-1856	2	11	..	..	3	..	..	..	..	16
Enterprise, <i>ship</i>	1837-1840	57	..	..	..	..	..	..	..	..	57
"	1843-1844	4	..	..	..	..	..	20	..	..	24
"	1855	1	..	6	..	..	..	..	..	..	7
Enterprise, <i>sloop</i>	1760	1	..	..	..	..	..	..	..	..	1
Equator, <i>bk</i>	1839-1842	20	..	..	..	..	..	..	..	..	20
"	1844-1846	43	..	..	..	..	..	..	..	..	43
Equator, <i>ship</i>	1828-1831	48	..	..	..	..	..	..	..	..	48
Era, <i>schr</i>	1895-1896	..	3	..	..	..	..	..	..	..	3
"	1898-1899	..	13	..	..	..	..	..	..	..	13
"	1900-1901	..	9	..	..	..	..	..	..	..	9
"	1905	..	8	..	..	..	..	..	..	..	8
Erie, <i>ship</i>	1848-1849	2	15	13	..	..	..	..	..	..	30
"	1852	4	18	..	..	..	..	..	..	..	22
Eugenia, <i>bk</i>	1851-1853	49	..	..	..	..	..	7	..	..	56
"	1856-1859	34	..	..	..	..	4	..	..	..	38
"	1860-1864	30	..	..	..	..	..	..	..	..	30
"	1865-1868	12	15	..	..	4	..	..	1	..	32
"	1870-1871	6	8	..	..	..	..	..	..	..	14
Eunice H. Adams, <i>br</i> ...	1884	2	..	..	..	..	..	..	..	..	2
"	1884-1885	7	..	..	..	..	..	..	..	..	7
"	1885-1887	57	..	..	..	..	..	3	..	..	60
"	1888-1889	16	..	..	..	..	..	..	..	..	16
"	1893-1894	19	..	..	..	..	..	..	..	..	19
Euphrates, <i>ship</i>	1846-1848	2	..	24	2	..	..	..	..	..	28
"	1855-1857	7	34	..	..	..	..	..	1	..	42
"	1858-1860	3	26	..	..	..	..	..	1	..	30
Europe, <i>bk</i>	1885	1	..	16	..	..	..	..	..	..	17
Europa, <i>ship</i>	1866-1870	19	20	1	..	2	..	5	6	..	53
*Europa, <i>ship</i>	1867-1871	24	..	..	..	..	..	49	..	..	73
"	1872-1873	..	5	..	..	..	..	..	..	..	5
Exchange, <i>bk</i>	1844-1846	22	..	..	..	..	..	..	..	..	22
"	1847-1849	15	..	..	..	..	..	1	..	..	16
Exile, <i>schr</i>	1850	..	..	..	..	..	10	4	..	..	14
Express, <i>schr</i>	1878	1	..	..	..	..	..	7	..	..	8
F. Bunchinia, <i>bk</i>	1852-1853	20	..	..	..	..	..	21	..	..	41
"	1857-1858	7	..	..	..	..	..	1	..	..	8
Fabius, <i>ship</i>	1857-1861	17	16	2	2	..	..	..	40	..	77
"	1862-1865	4	9	..	..	..	..	8	3	..	24
Fair Helen, <i>ship</i>	1824-1826	3	..	..	..	..	21	..	..	..	24
"	1825-1826	2	..	..	..	..	16	..	..	..	18
Fairy.....	1845-1846	21	..	..	..	..	..	1	..	..	22
Falcon, <i>bk</i>	1876-1878	28	..	..	..	..	..	4	..	..	32
Falcon, <i>ship</i>	1836-1837	18	..	..	..	..	..	38	..	..	56
"	1846-1849	..	..	2	8	..	..	1	..	..	11
"	1852-1853	5	3	..	..	..	..	..	..	..	8
Fame of Hull, <i>ship</i>	1820	..	11	..	..	..	..	..	..	..	11
"	1822	..	6	..	..	..	..	..	..	..	6

* Not duplicated

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pac)	So. Rt. (ific)	No. Rt. (Atla)	So. Rt. (ntic)	South. Right (Inaian)	Hump-back	Calif. Gray	Total Per Vessel
Helen Snow, <i>bk.</i>	1872	3	1	..	..	..	..	..	..	..	4
Henrietta of Whitby...	1792	..	18	..	..	..	..	..	..	..	18
"	1793	..	6	..	..	..	..	..	..	..	6
"	1794	..	6	..	..	..	..	..	..	..	6
"	1795	..	24	..	..	..	..	..	..	..	24
"	1796	..	9	..	..	..	..	..	..	..	9
"	1797	..	14	..	..	..	..	..	..	..	14
Henry, <i>bk.</i>	1845-1847	11	..	..	10	..	..	..	2	..	23
Henry, <i>ship</i>	1839	1	..	..	..	1	..	..	..	..	2
Henry Astor, <i>ship</i>	1835-1839	34	..	..	13	..	..	..	1	..	48
Henry H. Crapo, <i>bk.</i>	1852-1853	34	..	..	..	..	..	..	..	..	34
Henry Taber, <i>bk.</i>	1855-1859	52	..	..	..	..	..	..	1	..	53
"	1859-1862	16	..	..	..	..	..	..	..	..	16
"	1869-1871	..	30	..	..	..	..	..	..	1	31
Henry Trowbridge, <i>br.</i> ..	1880-1882	9	..	..	..	..	..	..	..	..	9
Herald, <i>ship</i>	1829-1830	3	..	..	..	..	23	..	..	..	26
"	1830-1831	7	..	..	..	..	24	..	..	..	31
"	1832-1833	4	..	..	..	..	8	..	..	..	12
"	1833-1834	27	..	..	..	..	2	..	..	..	29
"	1835-1837	57	..	..	..	..	2	5	..	..	64
"	1838-1840	98	..	..	..	..	..	..	..	..	98
"	1848-1852	56	..	..	..	..	..	..	..	..	56
"	1865	6	..	..	..	..	..	..	..	..	6
Heroine, <i>ship</i>	1831	..	..	..	..	..	36	..	..	..	36
"	1832	2	..	..	..	..	14	..	..	..	16
"	1835-1836	4	..	..	..	..	13	..	..	..	17
"	1836-1837	3	..	..	..	..	22	..	..	..	25
"	1837-1839	12	..	..	..	..	23	..	..	..	35
Hercules, <i>ship</i>	1830	12	..	..	..	..	..	21	..	..	33
"	1831	16	..	..	..	..	15	1	..	..	32
"	1834-1836	27	..	..	..	..	3	14	7	..	51
*Hercules, <i>ship</i>	1831	7	..	..	..	..	34	..	..	..	41
Hercules II, <i>ship</i>	1847-1850	9	..	..	..	..	..	..	..	..	9
Herman, <i>stmr</i>	1909	..	2	..	..	..	..	..	..	..	2
"	1910	..	4	..	..	..	..	..	..	..	4
"	1911	..	6	..	..	..	..	..	..	..	6
Hero, <i>bk.</i>	1808-1809	15	..	..	..	..	8	..	..	..	23
Hesper, <i>bk.</i>	1834-1838	30	..	..	..	..	..	..	..	..	30
Hesper, <i>ship</i>	1831-1834	54	..	..	..	..	..	..	1	..	55
Hibernia, <i>ship</i>	1840-1842	18	..	..	..	..	..	..	..	..	18
"	1842-1843	19	..	..	..	..	..	22	8	..	49
"	1844-1845	1	..	13	..	..	..	7	..	..	21
"	1851	4	8	..	..	..	..	..	..	..	12
"	1853-1856	12	9	2	..	..	..	..	..	6	29
"	1861	..	15	..	..	..	..	..	..	..	15
"	1866-1869	14	13	7	1	..	4	1	..	..	40
Highlander, <i>bk.</i>	1845-1848	41	..	..	..	..	..	..	..	..	41
Hobomok, <i>ship</i>	1844-1848	29	..	3	2	..	..	..	1	..	35
Honqua, <i>ship</i>	1835-1836	11	..	..	..	..	5	23	..	..	39
Hope, <i>bk.</i>	1845-1847	39	..	..	..	..	..	..	..	..	39
Hope, <i>ship</i>	1839-1840	14	..	..	..	..	..	23	..	..	37
"	1844-1848	44	..	4	..	..	..	..	..	..	48
"	1861-1862	3	..	..	..	..	..	..	..	..	3

* Not duplicated

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pacific)	So. Rt. (Atlantic)	No. Rt. (Atlantic)	So. Rt. (Indian)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Hope, <i>ship</i>	1863	1	..	..	..	..	..	..	..	..	1
Hopeton, <i>br</i>	1862	8	..	..	..	..	..	..	..	..	8
Horatio, <i>ship</i>	1877-1881	34	..	..	9	..	..	..	..	..	43
"	1885-1889	45	..	..	3	..	..	..	..	..	48
Hortense, <i>br</i>	1864	4	..	..	..	..	..	..	..	..	4
Howard, <i>ship</i>	1841-1844	65	..	..	..	..	..	..	..	..	65
Hunter, <i>bk</i>	1868-1871	48	..	..	..	..	..	..	2	..	50
"	1876	6	..	..	..	..	..	..	..	..	6
Hunter, <i>ship</i>	1859-1863	34	..	..	3	..	..	6	..	..	43
"	1864-1865	..	..	..	..	..	26	..	..	..	26
Huntress, <i>bk</i>	1856-1857	2	..	..	..	..	1	..	..	..	3
Huntress, <i>ship</i>	1843	3	..	..	..	..	..	..	..	..	3
"	1844-1846	2	..	4	12	..	..	6	..	..	24
Illinois, <i>ship</i>	1856-1857	1	3	..	..	..	..	..	..	..	4
Independence, <i>ship</i>	1825-1828	144	..	..	..	..	..	..	..	..	144
India, <i>ship</i>	1838-1839	11	..	..	..	..	8	..	..	..	19
Indian Chief, <i>ship</i>	1851-1854	1	34	1	1	..	..	..	..	..	37
Ionia, <i>bk</i>	1855-1857	8	..	..	..	..	..	..	..	..	8
Iris, <i>ship</i>	1844-1847	23	..	4	4	..	..	..	..	..	31
Isaac Howland, <i>ship</i>	1835-1838	63	..	..	..	..	..	..	..	..	63
"	1855-1858	58	..	..	..	..	..	..	..	..	58
Isaac Walton, <i>ship</i>	1846	..	..	14	..	..	..	..	..	..	14
Isabella, <i>bk</i>	1852-1854	5	11	1	..	..	..	..	..	..	17
Isabella, <i>br</i>	1879	..	4	..	..	..	..	..	..	..	4
"	1880-1881	..	3	..	..	..	..	..	..	..	3
"	1882-1883	..	6	..	..	..	..	..	..	..	6
Isabella, <i>ship</i>	1831-1834	57	..	..	..	..	..	..	..	..	57
Israel, <i>ship</i>	1846-1847	2	..	..	..	..	1	..	..	..	3
Izette, <i>ship</i>	1832	1	..	..	..	..	..	..	..	..	1
"	1841-1842	12	..	..	..	..	..	3	49	..	64
J. E. Donnell, <i>bk</i>	1851-1852	3	15	..	..	..	..	..	..	..	18
James Allen, <i>bk</i>	1877-1881	26	..	..	7	..	..	..	..	..	33
"	1881-1884	20	..	..	..	..	3	..	..	..	23
James Allen, <i>ship</i>	1844-1847	73	..	..	..	..	..	..	..	..	73
James Arnold, <i>ship</i>	1853-1856	55	..	..	1	..	..	..	1	..	57
"	1857-1859	18	..	..	..	..	..	..	..	..	18
"	1866-1869	51	..	..	..	..	..	..	..	..	51
"	1869-1873	21	..	..	..	..	1	..	2	..	24
"	1874-1878	32	..	..	..	..	..	..	1	..	33
"	1878-1882	27	..	..	..	..	2	..	8	..	37
"	1883-1886	39	..	..	..	..	1	..	..	..	40
"	1892-1894	50	1	1	..	..	..	..	..	..	52
James D. Thompson, <i>bk</i>	1856-1858	6	13	4	3	..	..	..	..	..	26
James Munroe, <i>ship</i>	1841-1843	35	..	9	..	..	..	..	1	..	45
James Maury, <i>ship</i>	1841-1844	57	..	..	3	..	..	..	..	..	60
"	1852-1855	4	20	6	..	..	..	..	..	31	61
"	1856-1858	10	6	10	10	..	..	..	..	..	36
"	1860-1862	14	..	..	23	..	..	4	..	..	41
"	1864-1867	7	15	1	4	..	..	1	1	..	29
Janet, <i>bk</i>	1852-1854	9	..	..	..	..	..	..	..	..	9
"	1875-1876	41	..	..	..	..	..	..	..	..	41
"	1877-1879	54	..	..	..	..	..	..	..	..	54
Janus, <i>ship</i>	1833-1834	14	..	..	..	..	23	..	..	..	37

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pac)	So. Rt. (Ife)	No. Rt. (Atla)	So. Rt. (ntic)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Maria, <i>bk.</i>	1836-1838	7	..	..	..	..	1	..	..	..	8
"	1838-1840	22	..	..	..	..	..	..	..	..	22
"	1846-1849	56	..	..	..	..	..	..	..	..	56
"	1862	11	..	..	..	..	..	..	..	..	11
Maria, <i>ship.</i>	1785-1786	16	..	..	..	..	4	..	..	..	20
"	1833-1834	42	..	..	..	..	..	..	..	..	42
Maria Theresa, <i>ship.</i> ...	1848-1851	8	10	19	..	..	..	..	..	..	37
"	1859-1860	2	3	..	..	..	..	..	..	1	6
Mariner, <i>ship.</i>	1841-1844	60	..	..	..	..	..	..	..	..	60
Marengo, <i>ship.</i>	1849-1851	7	29	2	..	..	..	..	..	..	38
Maringo, <i>ship.</i>	1859-1862	2	..	16	3	..	..	1	..	..	22
"	1871-1874	16	20	..	..	..	..	..	..	..	36
Marion, <i>bk.</i>	1856-1858	55	..	..	..	..	..	..	2	..	57
Mars, <i>bk.</i>	1841-1844	38	..	..	..	..	..	1	..	..	39
"	1844-1845	4	..	..	..	..	..	..	..	..	4
"	1845-1848	10	..	..	..	..	2	..	52	..	64
"	1852-1855	27	..	..	..	..	..	..	..	..	27
"	1856-1859	13	..	..	..	..	1	6	2	..	22
"	1878-1881	31	..	..	..	..	7	..	40	..	78
Mars, <i>ship.</i>	1807-1808	..	..	..	..	..	35	..	..	..	35
"	1817	..	5	..	..	..	..	..	..	..	5
Martha, <i>bk.</i>	1850-1853	44	..	..	..	..	..	..	..	..	44
"	1854-1858	16	..	..	..	..	..	1	..	..	17
"	1858-1862	3	27	..	..	..	..	2	1	9	42
"	1864-1866	3	8	..	..	..	..	..	2	..	13
"	1867	3	3	..	..	..	..	..	..	..	6
"	1868-1872	28	..	..	..	..	..	..	..	..	28
"	1873-1874	8	..	..	..	..	..	..	63	..	71
Martha, <i>ship.</i>	1828-1829	..	..	..	..	..	6	..	..	..	6
"	1834-1836	5	..	..	..	..	29	2	..	..	36
"	1841	2	..	..	..	..	..	..	..	..	2
"	1846-1848	1	..	10	17	..	..	..	..	..	28
"	1849-1852	45	..	..	..	..	..	..	..	..	45
Martha II, <i>ship.</i>	1836-1838	17	..	..	..	..	7	2	..	..	26
Martha of Fairhaven, <i>ship.</i>	1838-1856	55	..	..	11	..	..	..	..	..	66
Mary, <i>ship.</i>	1855	1	16	1	..	..	..	..	..	..	18
Mary Ann, <i>ship.</i>	1854-1858	47	..	..	..	..	..	..	..	..	47
"	1859-1863	57	..	..	..	..	..	..	..	..	57
Mary & Helen.....	1879-1880	9	27	..	..	..	..	..	..	..	36
Mary & Martha.....	1852-1854	1	13	5	..	..	..	..	..	..	19
Mary & Susan, <i>bk.</i>	1874-1877	47	..	..	..	..	..	..	..	..	47
"	1878-1881	19	..	..	..	..	..	..	..	..	19
"	1887	..	9	..	..	..	..	..	..	..	9
Mary & Susan, <i>ship.</i> ...	1847-1849	2	15	13	..	..	..	..	..	..	30
Mary D. Hume, <i>stmr.</i> ...	1891-1892	..	39	..	..	..	..	..	..	..	39
Mary E. Simmons, <i>sch.</i>	1889-1892	120	..	..	..	..	..	..	..	..	120
"	1897	15	..	..	..	..	..	..	..	..	15
"	1897-1899	31	..	..	..	..	..	..	..	..	31
"	1900-1902	62	..	..	..	..	..	..	..	..	62
"	1903-1904	100	..	..	..	..	..	..	..	..	100
"	1904	3	..	..	..	..	..	..	..	..	3
Mary Frazier, <i>bk.</i>	1877-1880	23	..	..	..	..	1	..	20	..	44

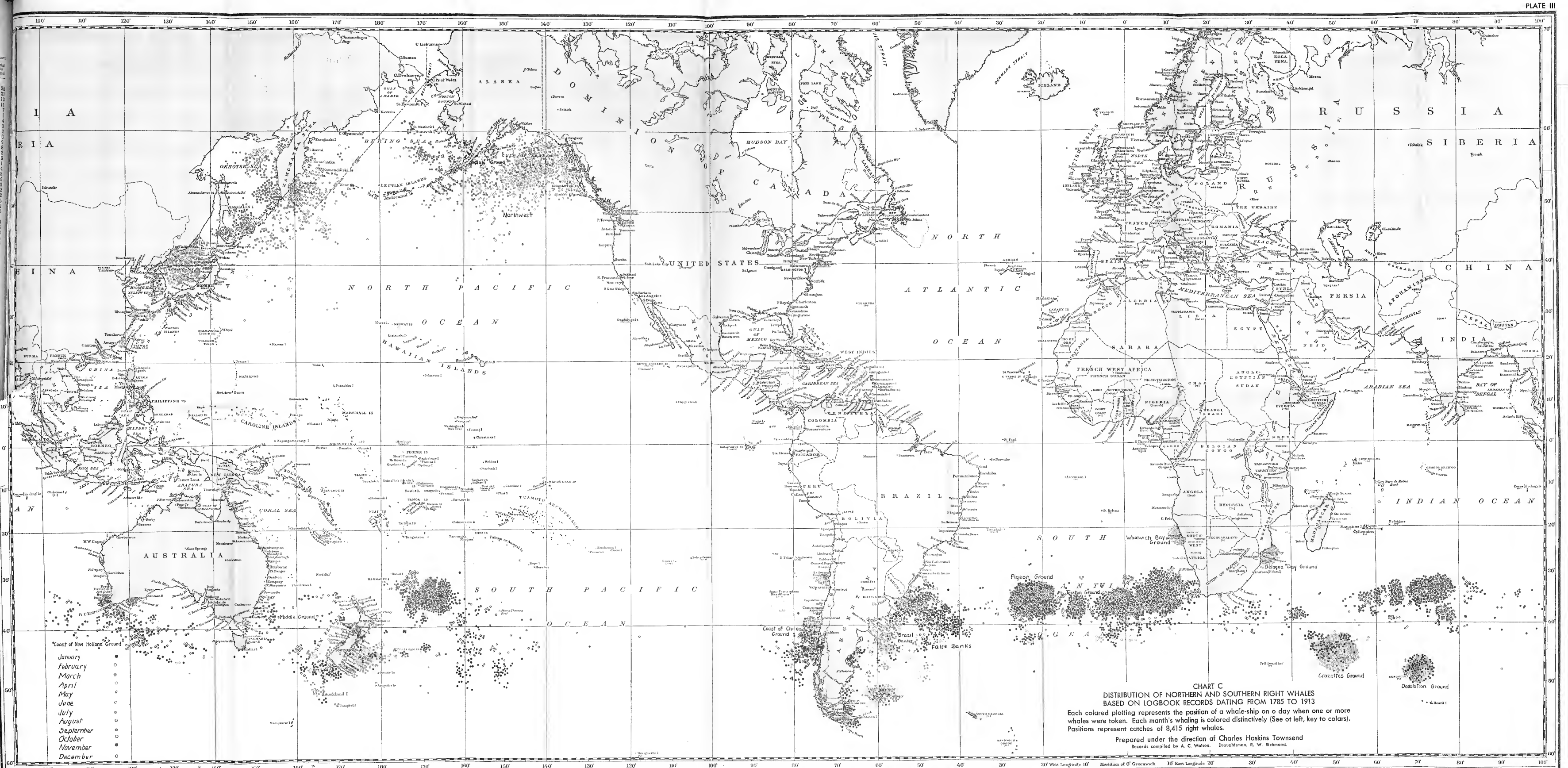
Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pac)	So. Rt. (ific)	No. Rt. (Atla)	So. Rt. (ntie)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Mary Frazier, <i>bk</i>	1884-1886	30	..	..	..	..	..	..	..	..	30
Mary Frazier, <i>ship</i>	1854-1856	2	36	..	..	..	..	..	..	..	38
"	1857-1860	8	30	1	..	..	..	..	..	3	42
Mary Gardiner.....	1856-1859	12	..	..	..	..	..	..	..	..	12
Mary Mitchell, <i>ship</i>	1835-1837	15	..	..	48	..	..	5	..	..	68
Massachusetts, <i>bk</i>	1860-1864	7	47	1	2	..	..	..	..	..	57
"	1865-1868	4	29	..	..	..	..	..	..	..	33
Massachusetts, <i>ship</i>	1849-1850	3	..	..	..	..	..	..	..	..	3
"	1852-1856	8	82	..	..	..	..	..	..	1	91
"	1857-1860	9	61	..	..	..	..	..	..	..	70
Matilda Scars, <i>bk</i>	1860-1864	16	..	..	5	..	..	..	..	..	21
"	1870-1873	22	..	..	2	..	..	..	..	..	24
"	1873-1877	18	..	..	..	..	..	1	19	..	38
"	1877-1882	21	..	..	..	..	..	..	56	..	77
Mattapoisset, <i>bk</i>	1862-1864	13	..	..	..	..	..	..	1	..	14
"	1864-1866	16	..	..	..	..	..	..	..	..	16
"	1867-1868	13	..	..	..	..	..	..	..	..	13
"	1870	11	..	..	..	..	..	..	..	..	11
"	1873-1874	10	..	..	..	..	..	..	..	..	10
"	1879-1881	7	..	..	..	..	..	..	..	..	7
"	1882-1884	19	..	..	..	..	..	..	37	..	56
"	1886-1888	59	..	..	..	..	..	..	..	..	59
Mattapoisset, <i>br</i>	1841-1842	23	..	..	..	..	..	..	..	..	23
Menkar, <i>ship</i>	1849	5	..	7	..	..	..	..	..	..	12
Mentor, <i>ship</i>	1843-1844	3	..	20	..	..	..	11	1	..	35
"	1845-1847	10	..	21	..	..	..	9	..	..	40
Mercury, <i>bk</i>	1873-1876	24	..	..	..	..	1	1	5	..	31
Mercury, <i>ship</i>	1851-1852	15	..	..	..	..	..	..	..	..	15
"	1859-1860	13	..	..	..	..	..	..	..	..	13
Merlin, <i>bk</i>	1872-1876	46	..	..	..	..	..	..	..	..	46
Mermaid, <i>bk</i>	1869-1873	27	..	..	..	..	..	..	..	..	27
"	1880-1882	16	..	..	..	..	..	..	..	..	16
"	1883-1885	19	..	..	..	..	6	..	..	..	25
"	1885-1887	37	..	..	..	..	4	..	..	..	41
"	1887-1889	39	..	..	..	..	4	..	..	..	43
Messenger, <i>ship</i>	1838	3	..	..	..	..	..	10	..	..	13
Miantonomi, <i>ship</i>	1853-1854	7	..	..	..	..	..	..	..	..	7
Midas, <i>bk</i>	1857-1859	5	8	..	..	..	..	..	1	..	14
"	1866-1868	4	11	20	..	..	..	..	1	14	50
Midas, <i>ship</i>	1845-1846	2	..	5	..	..	..	..	..	..	7
"	1854-1856	8	..	..	..	..	..	..	..	..	8
"	1861-1865	13	..	..	..	..	..	..	6	..	19
Miles, <i>ship</i>	1831-1832	1	..	..	..	..	27	..	..	..	28
Millwood, <i>bk</i>	1862-1863	13	..	..	..	..	..	..	..	..	13
"	1866	1	..	..	..	..	..	..	..	..	1
"	1867	1	..	..	..	..	..	..	..	..	1
"	1869	3	..	..	..	..	..	..	..	..	3
Milo, <i>ship</i>	1850-1851	6	21	..	..	..	..	..	..	..	27
"	1851-1854	7	35	3	..	..	..	..	..	..	45
Milton, <i>ship</i>	1844-1847	6	..	11	12	..	..	..	..	..	29
"	1847-1851	78	..	..	..	..	..	..	..	..	78
"	1851-1855	57	..	..	..	..	1	..	..	..	58
"	1856-1859	4	36	6	..	..	..	..	..	..	46

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pacific)	So. Rt. (Atlantic)	No. Rt. (Atlantic)	So. Rt. (Indian)	South Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Milton, <i>ship</i>	1861-1864	..	55	5	..	..	..	..	3	6	69
"	1865-1869	44	..	..	..	..	..	..	2	..	46
"	1869-1873	29	..	..	..	..	..	..	57	..	86
"	1886-1887	2	..	..	2	..	..	..	..	..	4
Minerva, <i>ship</i>	1845-1848	14	..	19	1	..	2	2	..	..	38
"	1848-1850	16	2	8	..	..	..	..	..	..	26
*Minerva, <i>ship</i>	1845-1847	21	..	15	5	..	..	..	..	..	41
Minerva Smith, <i>ship</i>	1855-1857	2	..	..	..	..	4	16	..	..	22
"	1868-1869	23	..	..	..	..	3	..	..	..	26
Minnesota, <i>bk</i>	1869-1872	21	..	..	1	..	..	..	1	..	23
"	1881-1883	32	..	..	..	..	..	..	..	..	32
Mobile, <i>ship</i>	1844-1846	31	..	..	..	..	..	..	..	..	31
"	1847-1848	16	..	..	..	..	..	..	..	..	16
Mohawk, <i>ship</i>	1851-1853	64	..	..	..	..	..	..	..	..	64
"	1855-1858	55	..	..	..	..	..	..	..	..	55
"	1859-1862	17	..	..	..	..	..	..	3	..	20
Monmouth, <i>bk</i>	1844-1845	2	..	9	..	..	4	..	3	..	18
Montano, <i>ship</i>	1829-1832	97	..	..	..	..	..	..	..	..	97
"	1845-1848	5	..	9	13	..	..	..	..	..	27
Montezuma, <i>bk</i>	1847-1849	25	..	..	..	..	..	..	..	..	25
"	1866-1867	1	..	..	..	..	3	..	..	..	4
Montezuma, <i>ship</i>	1844-1847	24	..	12	1	..	2	8	..	..	47
"	1852-1854	..	..	..	..	..	..	15	..	..	15
Montgomery, <i>bk</i>	1855-1857	10	..	..	..	..	..	..	..	..	10
"	1858-1862	39	..	..	..	..	1	..	6	..	46
Montpelier, <i>ship</i>	1848-1850	5	12	4	..	..	3	..	..	..	24
"	1850-1852	4	20	2	..	..	..	1	..	..	27
Montreal, <i>ship</i>	1850-1852	10	39	..	2	..	..	1	..	..	52
"	1853-1856	6	43	..	..	..	..	..	18	19	49
"	1858-1861	3	17	6	..	..	..	..	..	..	63
Morea, <i>ship</i>	1853-1856	4	18	6	..	..	..	..	..	..	28
"	1856-1857	16	..	..	..	..	2	..	..	..	18
Morning Star, <i>bk</i>	1857-1861	35	..	..	..	..	..	..	..	..	35
"	1864-1865	..	15	..	..	..	..	..	..	..	15
"	1883-1888	132	..	..	..	..	10	..	45	..	187
"	1891-1894	85	..	..	..	..	4	..	15	..	104
"	1894-1897	82	..	..	..	..	..	..	..	..	82
"	1898-1901	157	..	..	..	..	..	..	..	..	157
"	1901-1903	109	..	..	..	..	..	..	..	..	109
"	1903-1905	137	..	..	..	..	1	..	..	..	138
"	1906-1908	128	..	..	..	..	3	..	..	..	131
"	1910-1912	87	..	..	..	..	..	..	..	..	87
Morrison, <i>ship</i>	1844-1845	3	..	..	4	..	..	..	..	..	7
Moss, <i>ship</i>	1833-1836	74	..	..	..	..	..	..	..	..	74
Myra, <i>br</i>	1861-1863	7	..	..	..	..	..	..	..	..	7
Napoleon, <i>bk</i>	1864-1867	27	..	..	..	..	..	..	..	..	27
"	1868-1871	37	..	..	..	..	1	..	3	..	41
"	1878-1882	30	..	..	..	..	..	..	18	..	48
Napoleon, <i>ship</i>	1855-1858	56	..	..	..	..	..	..	..	..	56
Narragansett, <i>ship</i>	1844-1845	7	..	..	..	..	..	..	..	..	7
Nassau, <i>ship</i>	1834-1837	82	..	..	..	..	..	..	..	..	82
"	1846	1	..	..	..	..	..	..	5	..	6
"	1859	..	6	..	..	..	..	..	..	1	7

* Not duplicated

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pac)	So. Rt. (Pac)	No. Rt. (Atla)	So. Rt. (ntic)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Nauticon, <i>ship</i>	1849-1851	16	..	..	..	..	..	..	..	..	16
Nautilus, <i>bk</i>	1868	..	..	7	..	..	..	..	..	..	7
"	1877-1881	32	..	..	2	..	..	..	..	..	34
Nautilus, <i>ship</i>	1835-1838	63	..	..	..	..	..	..	..	..	63
"	1839-1840	37	..	..	..	..	..	..	..	..	37
Navarch, <i>stmr</i>	1892-1893	12	11	..	..	..	1	..	..	..	24
"	1894-1896	..	10	..	..	..	..	..	..	..	10
"	1897	..	5	..	..	..	..	..	..	..	5
Navigator, <i>ship</i>	1841-1845	44	..	..	..	..	..	..	..	..	44
"	1849-1853	20	..	..	..	..	..	..	..	..	20
Navy, <i>ship</i>	1852-1854	4	20	1	1	..	..	..	..	..	26
Nellie F. Putnam, <i>chr</i> .	1867-1868	7	..	..	..	..	..	..	..	..	7
"	1869	4	..	..	..	..	..	..	7	..	11
"	1870	1	..	..	..	..	..	..	6	..	7
Neptune, <i>ship</i>	1837-1838	6	..	..	..	..	14	11	..	..	31
"	1841	18	..	..	1	..	11	..	..	..	30
"	1841-1842	..	..	..	7	..	1	7	..	..	15
New Bedford, <i>ship</i>	1844-1847	11	..	8	11	..	..	..	2	..	32
Newport, <i>stmr</i>	1893-1896	..	36	..	..	..	..	..	..	..	36
Niagara, <i>ship</i>	1852-1853	..	33	..	..	..	..	..	..	..	33
Niantic, <i>ship</i>	1844-1846	2	..	20	20	..	..	..	..	..	42
Niger, <i>ship</i>	1853-1855	15	15	1	..	..	..	..	1	1	33
"	1870-1874	32	..	..	..	..	..	..	161	..	193
"	1874-1878	62	..	..	..	..	7	..	..	..	69
"	1887-1890	26	..	..	13	..	..	..	..	..	39
Nile, <i>ship</i>	1833-1835	8	..	..	12	..	1	..	..	..	21
Nimrod, <i>ship</i>	1830	1	..	..	..	..	22	..	..	..	23
"	1832	..	..	..	..	..	1	..	..	..	1
"	1833-1834	5	..	..	..	..	20	..	..	..	25
"	1834-1835	4	..	..	..	..	20	..	..	..	24
"	1843-1844	10	..	30	..	..	..	..	..	..	40
"	1845	..	..	1	..	..	..	2	..	..	3
"	1858-1860	..	5	1	..	..	..	..	..	2	8
Noble, <i>bk</i>	1856-1857	19	..	..	..	..	1	..	1	..	21
Norfolk, <i>ship</i>	1832-1833	1	..	..	..	..	10	..	..	..	11
"	1833-1834	..	..	..	..	..	11	..	..	..	11
Norman, <i>ship</i>	1851-1855	27	..	..	..	..	..	..	..	..	27
"	1855-1859	31	..	..	..	..	..	..	1	..	32
North America, <i>bk</i>	1838-1839	25	..	..	..	..	..	..	..	..	25
North Star, <i>stmr</i>	1881-1882	7	3	..	..	..	..	..	..	..	10
Northern Light, <i>bk</i>	1871-1875	13	19	11	..	..	..	..	..	1	44
"	1876	..	2	2	..	..	..	..	1	..	5
"	1877	4	9	..	..	..	..	..	1	..	14
"	1878	..	3	..	..	..	..	..	..	..	3
"	1879	14	5	..	..	..	..	..	1	..	20
Ocean, <i>bk</i>	1862-1863	14	..	..	..	..	..	..	..	..	14
"	1879-1881	31	..	..	..	..	3	..	..	..	34
Ocean, <i>br</i>	1852	12	..	..	..	..	..	..	..	..	12
"	1853	13	..	..	..	..	..	..	..	..	13
"	1854-1856	29	..	..	..	..	..	..	12	..	41
Ocean, <i>ship</i>	1840-1844	55	..	..	..	..	..	..	..	..	55
"	1866-1868	3	21	..	..	..	..	..	..	10	34
Ocean Rover, <i>bk</i>	1859-1862	27	..	..	..	..	6	..	..	..	33

Vessel	Voyages	Sperm	Bow-head	No. Rt. (Pacific)	No. Rt. (Atlantic)	No. Rt. (Indian)	South. Right (Indian)	Hump-back	Calif. Gray	Total Per Vessel
Safford, <i>bk.</i>	1855	6	..	..	..	..	..	..	..	6
Sally Anne, <i>ship.</i>	1830-1831	7	..	..	..	11	19	..	..	37
"	1833-1834	17	..	..	..	31	..	..	..	48
Samuel Robertson, <i>ship.</i>	1838-1839	11	..	..	31	..	..	..	..	42
"	1846-1847	5	..	1	..	..	..	..	..	6
"	1852-1853	..	3	..	..	..	1	..	..	4
Samuel Robertson, Fairhaven, <i>ship.</i>	1847	..	..	25	..	..	..	..	..	25
"	1848	..	..	9	..	..	..	..	..	9
Sandwich, <i>sloop.</i>	1762	6	..	..	..	..	..	..	..	6
"	1763	1	..	..	..	..	..	..	..	1
Sapphire, <i>ship.</i>	1837-1838	23	..	..	..	..	..	..	..	23
"	1840-1842	26	..	11	..	..	..	2	..	39
Sappho, <i>bk.</i>	1860-1863	27	..	..	1	..	..	..	..	28
Sarah, <i>bk.</i>	1856-1858	7	..	..	..	..	..	1	..	8
"	1863-1864	9	..	..	..	..	..	..	..	9
"	1864	1	..	..	..	..	..	..	..	1
"	1865-1866	11	..	..	..	..	..	..	..	11
Sarah W. Hunt, <i>schr.</i> ...	1893	21	..	..	..	..	..	..	..	21
"	1893-1896	57	..	..	..	..	..	..	..	57
Saratoga, <i>ship.</i>	1849-1852	6	35	2	..	1	..	..	..	44
Scotland, <i>ship.</i>	1860	7	..	..	..	..	..	..	..	7
Sea Breeze, <i>bk.</i>	1866-1870	..	52	..	..	..	..	15	37	104
"	1872	3	2	..	..	..	..	..	..	5
Sea Fox, <i>bk.</i>	1861-1864	28	..	..	..	..	..	..	..	28
Sea Queen, <i>bk.</i>	1862-1865	65	..	..	..	..	..	..	..	65
"	1866-1869	39	..	..	..	..	..	..	..	39
Sea Ranger, <i>bk.</i>	1869-1873	25	..	..	..	..	..	5	..	30
"	1874-1875	25	..	..	..	..	..	..	..	25
"	1876-1879	52	..	..	..	..	15	..	..	67
"	1879-1884	32	..	..	..	1	13	22	..	68
"	1889	1	..	..	..	..	..	..	..	1
Sea Shell, <i>bk.</i>	1853-1856	19	..	..	..	..	..	..	..	19
Seaflower, <i>sloop.</i>	1752	..	..	..	..	..	..	2	..	2
Seine, <i>ship.</i>	1840-1842	12	..	..	..	..	..	..	..	12
"	1842-1844	6	..	..	9	..	1	22	..	38
Seneca, <i>bk.</i>	1869-1871	4	19	..	..	..	..	..	1	24
Seychelle, <i>schr.</i>	1851	1	..	..	..	..	..	..	..	1
Sharon, <i>ship.</i>	1857-1861	1	16	4	..	..	..	1	27	49
Shylock, <i>ship.</i>	1833-1834	..	..	..	..	..	10	..	..	10
Smyrna, <i>bk.</i>	1854-1857	16	..	..	..	..	..	..	..	16
"	1863	2	..	..	..	..	..	..	..	2
Solomon Saltus, <i>ship.</i> ...	1849-1850	9	..	..	..	..	..	20	..	29
Solon, <i>bk.</i>	1859-1860	16	..	..	..	..	..	..	..	16
"	1860-1862	13	..	..	..	..	..	..	..	13
"	1863	5	..	..	..	..	..	..	..	5
"	1865-1866	14	..	..	..	..	..	3	..	17
Solon, <i>br.</i>	1839	5	..	..	..	..	..	..	..	5
South Boston, <i>ship.</i>	1855-1858	4	33	7	..	..	..	..	1	45
South Carolina, <i>ship.</i> ...	1836-1837	1	..	..	..	..	23	..	..	24
Spartan, <i>ship.</i>	1851-1852	24	..	..	..	..	..	..	..	24
Splendid, <i>ship.</i>	1846-1848	5	..	26	..	..	6	..	..	37
"	1859-1861	78	..	..	..	..	..	9	..	87



- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December

CHART C
 DISTRIBUTION OF NORTHERN AND SOUTHERN RIGHT WHALES
 BASED ON LOGBOOK RECORDS DATING FROM 1785 TO 1913
 Each colored plotting represents the position of a whale-ship on a day when one or more whales were taken. Each month's whaling is colored distinctly (See on left, key to colors).
 Positions represent catches of 8,415 right whales.
 Prepared under the direction of Charles Haskins Townsend
 Records compiled by A. C. Watson, Draughtsman, R. W. Richmond.

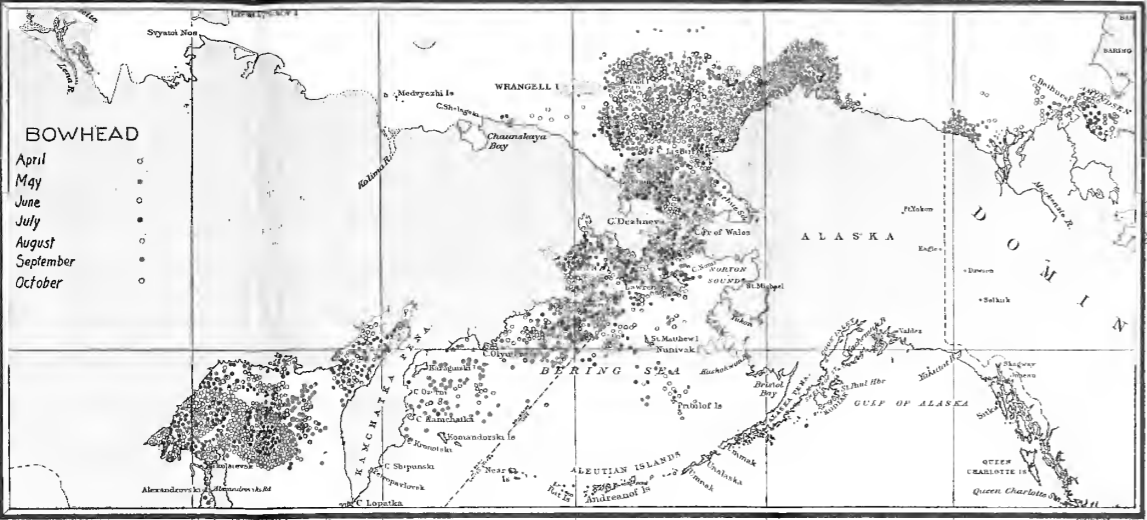
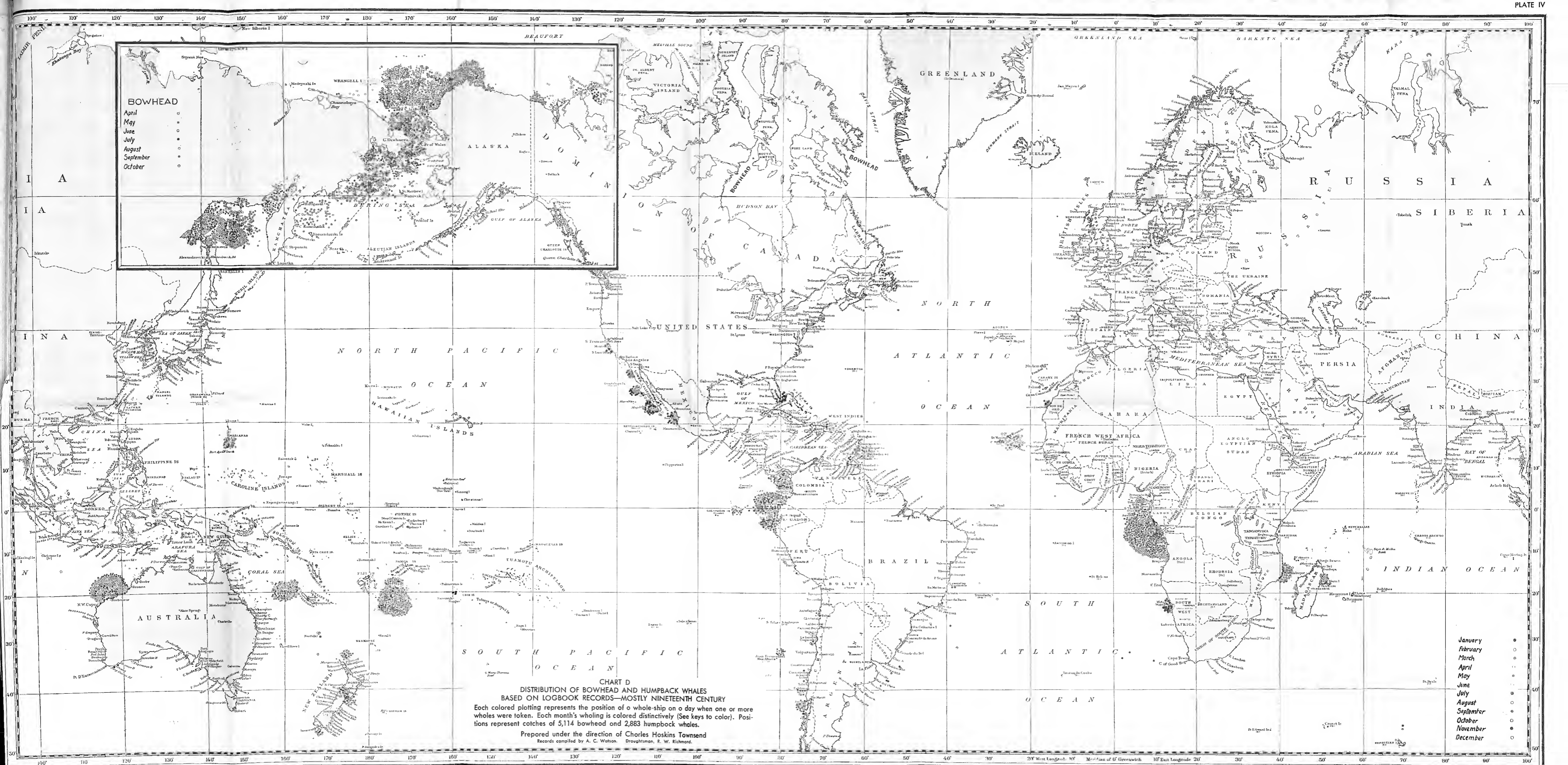
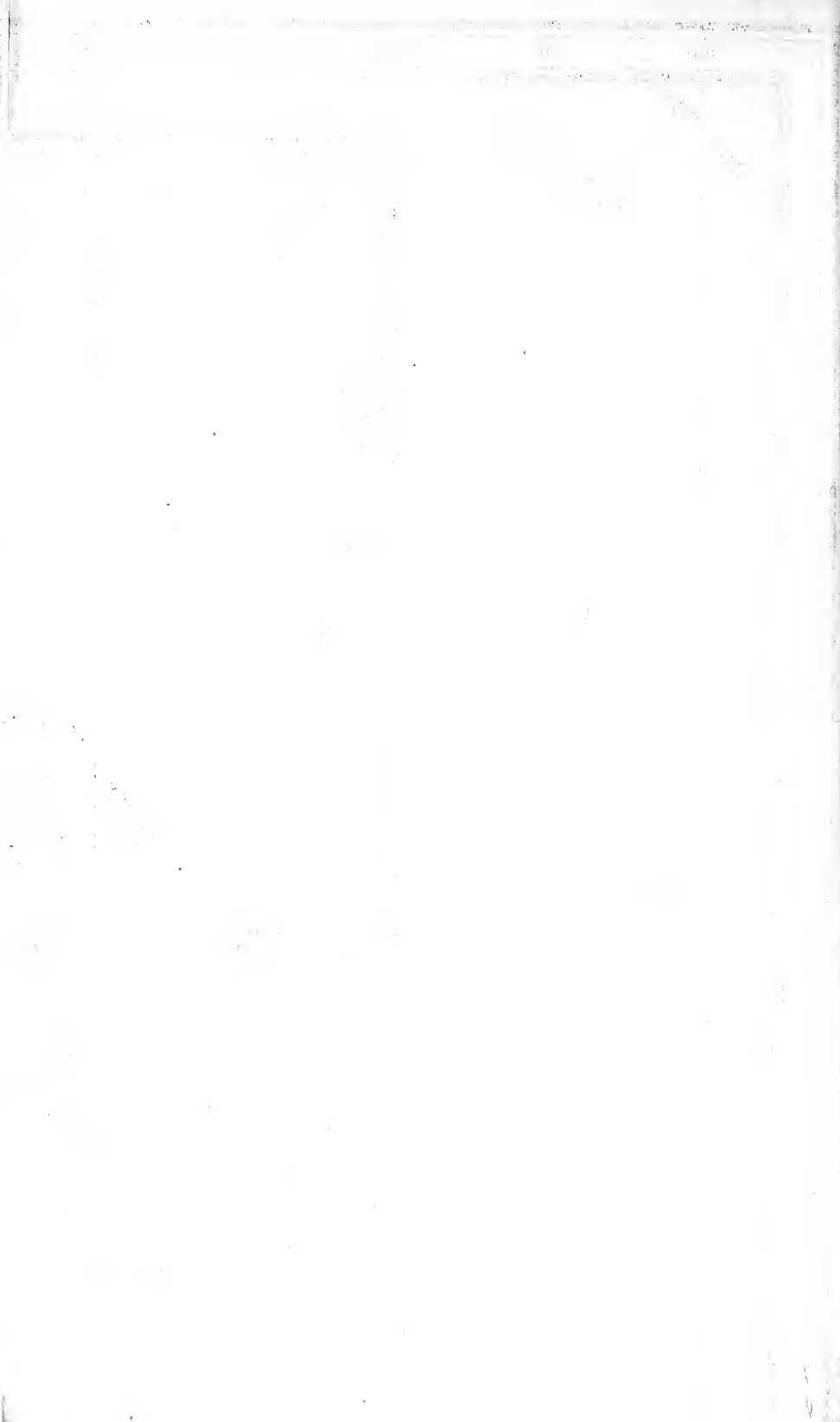
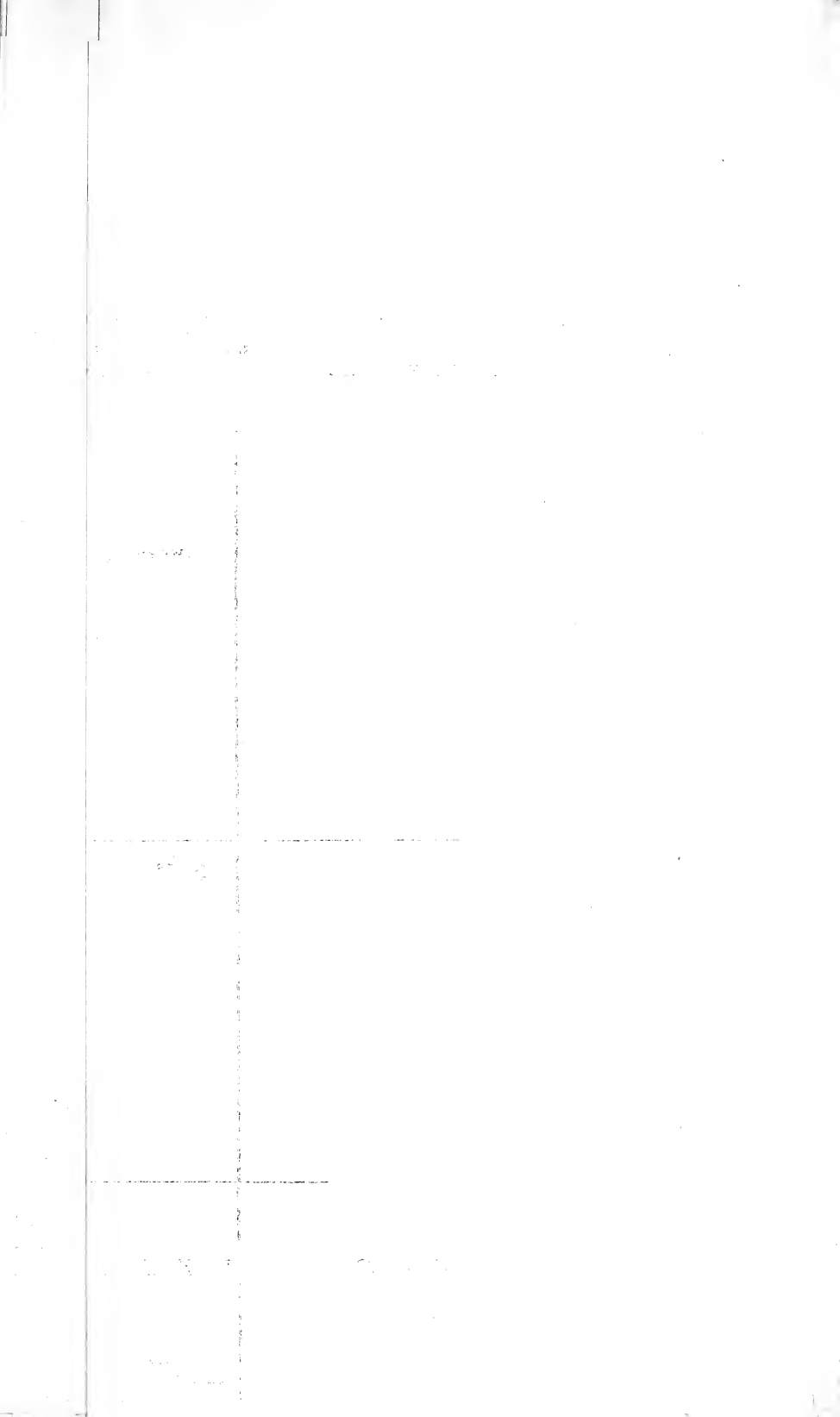
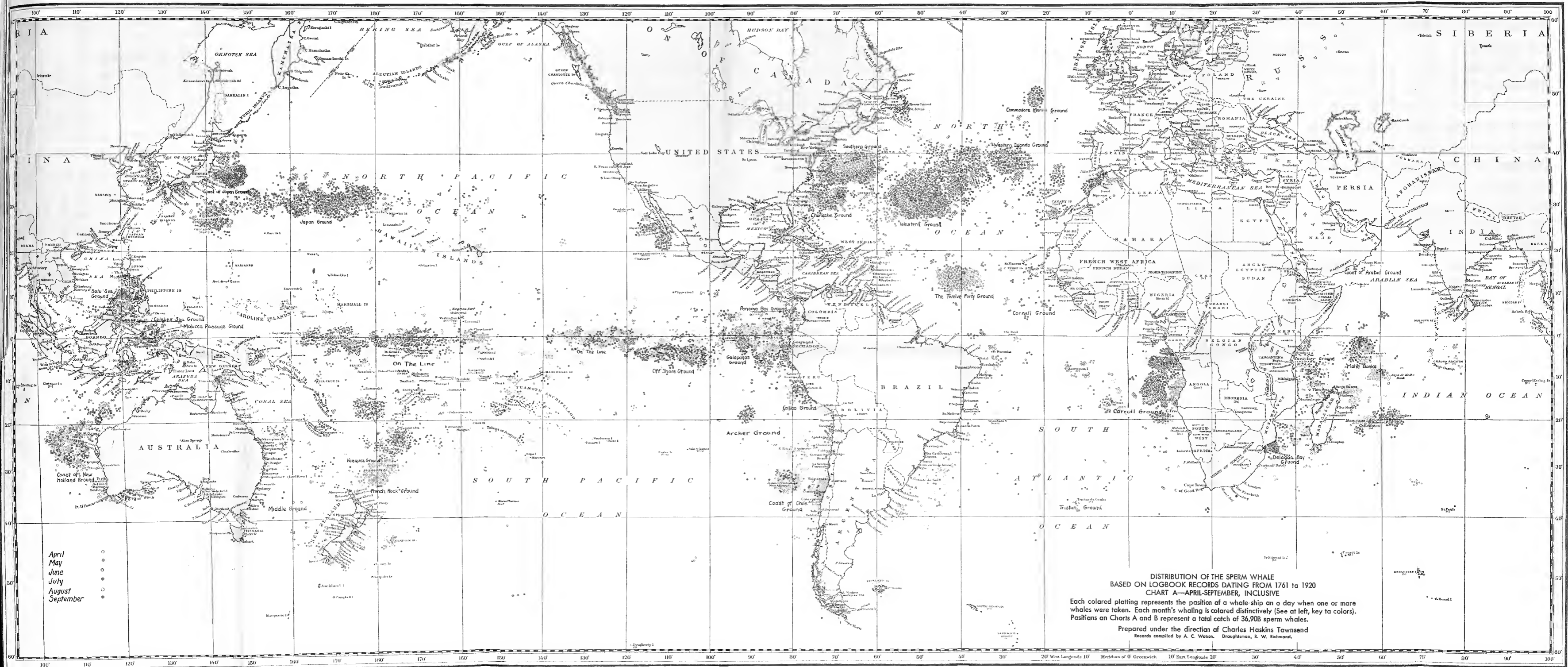


CHART D
 DISTRIBUTION OF BOWHEAD AND HUMPBACK WHALES
 BASED ON LOGBOOK RECORDS—MOSTLY NINETEENTH CENTURY
 Each colored plotting represents the position of a whole-ship on a day when one or more
 whales were taken. Each month's whaling is colored distinctively (See keys to color). Posi-
 tions represent catches of 5,114 bowhead and 2,883 humpback whales.
 Prepared under the direction of Charles Hoskins Townsend
 Records compiled by A. C. Watson, Droughtman, R. W. Richmond.

January
 February
 March
 April
 May
 June
 July
 August
 September
 October
 November
 December



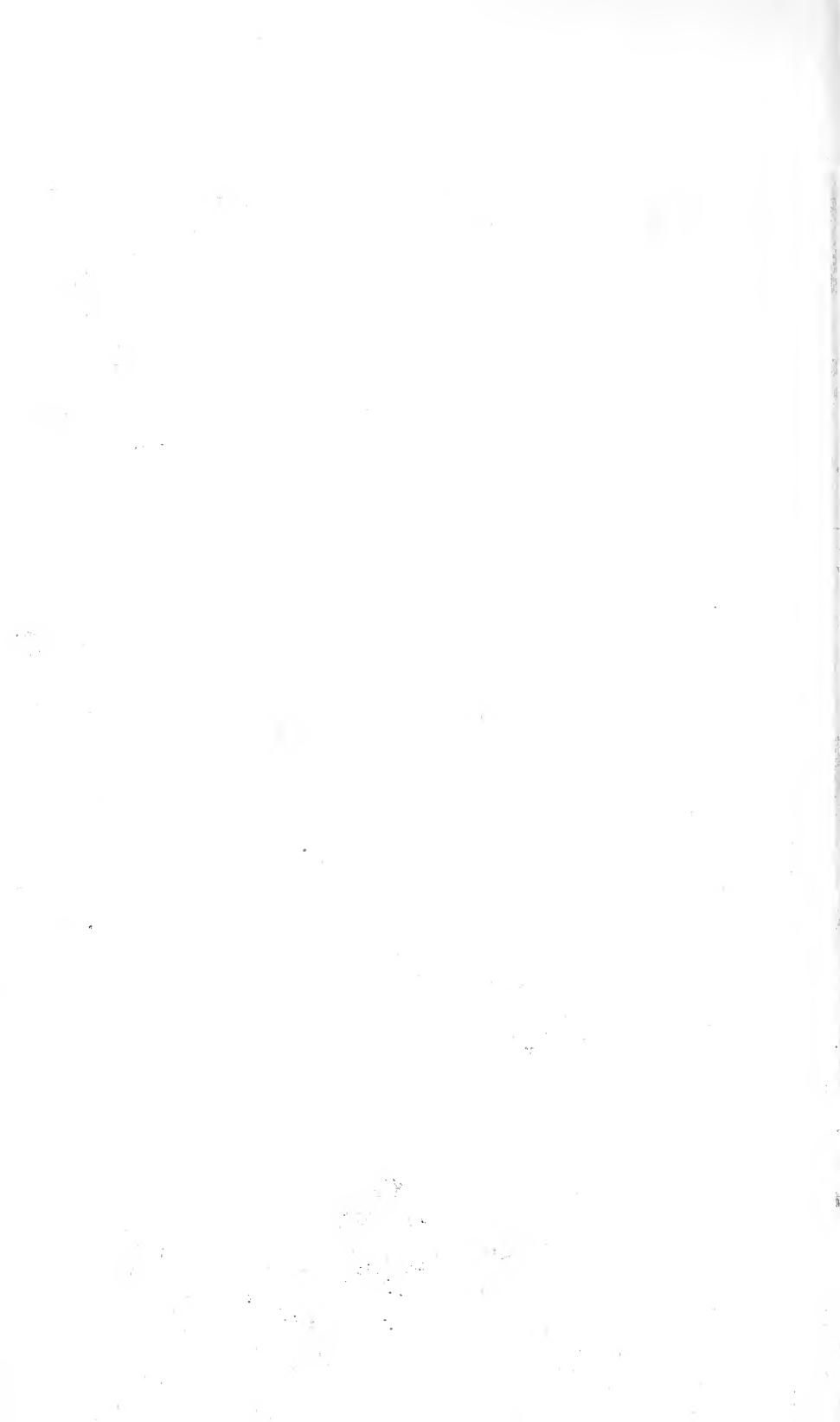


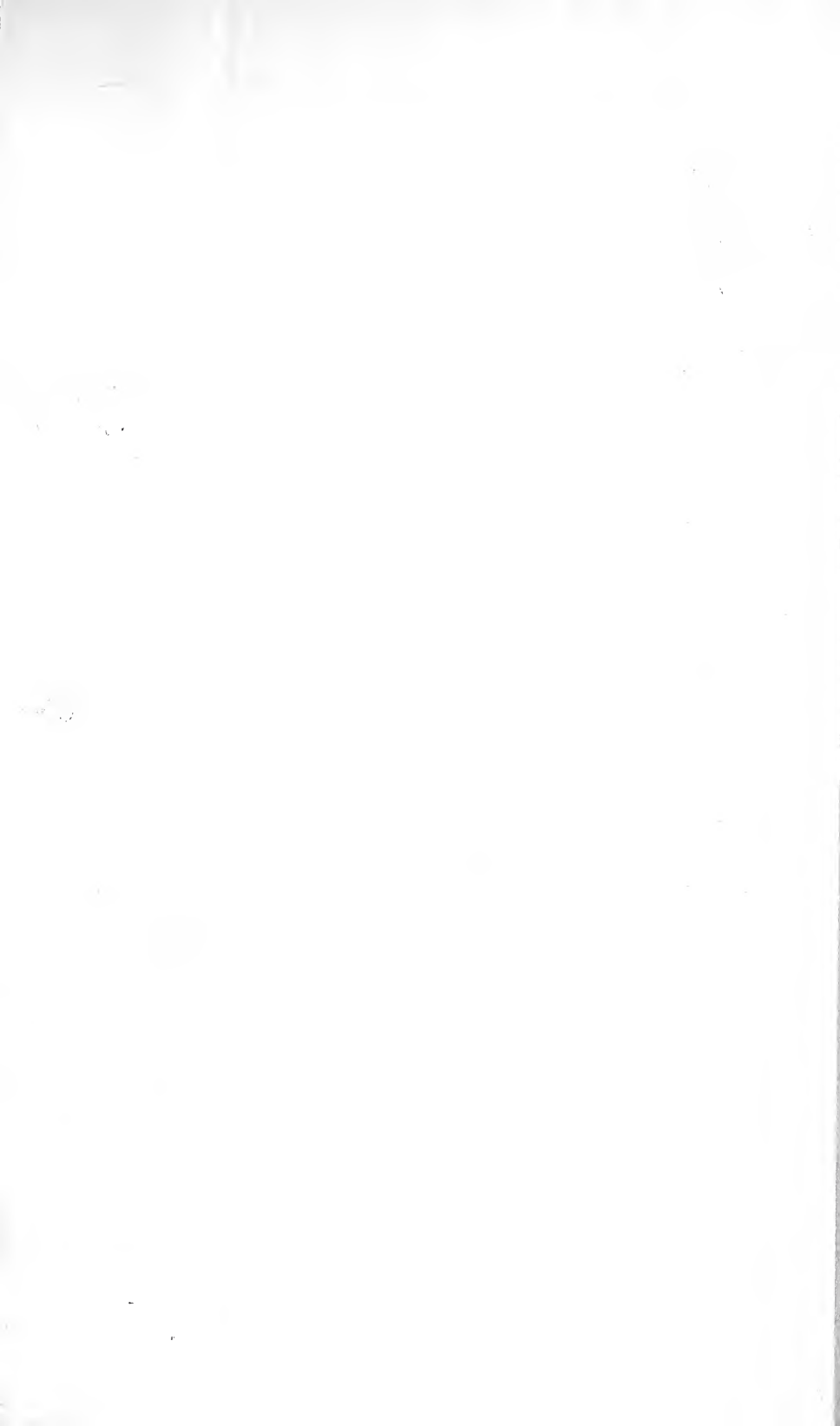


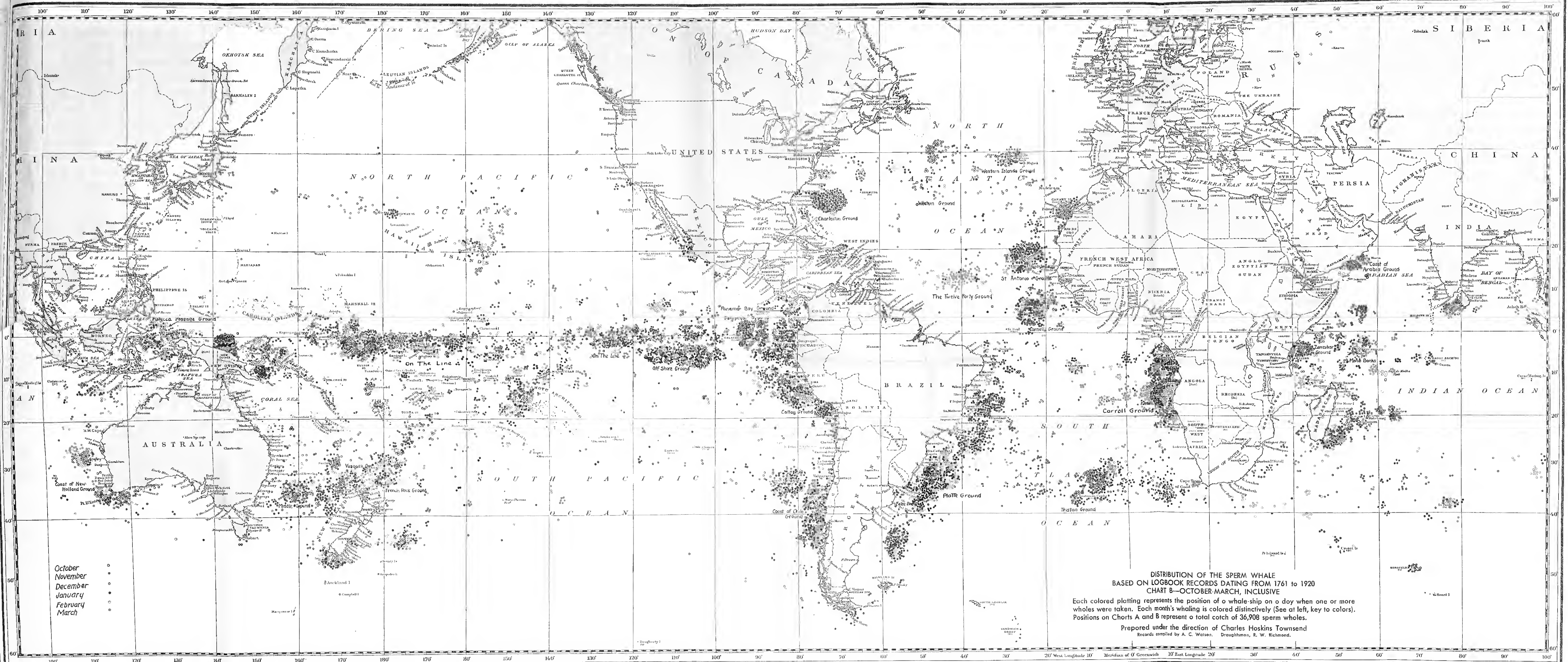
DISTRIBUTION OF THE SPERM WHALE
 BASED ON LOGBOOK RECORDS DATING FROM 1761 to 1920
 CHART A—APRIL-SEPTEMBER, INCLUSIVE

Each colored plating represents the position of a whale-ship on a day when one or more whales were taken. Each month's whaling is colored distinctively (See at left, key to colors). Positions on Charts A and B represent a total catch of 36,908 sperm whales.

Prepared under the direction of Charles Haskins Townsend
 Records compiled by A. C. Watson, Draughtsman, R. W. Richmond.







October
 November
 December
 January
 February
 March

DISTRIBUTION OF THE SPERM WHALE
 BASED ON LOGBOOK RECORDS DATING FROM 1761 to 1920
CHART B—OCTOBER-MARCH, INCLUSIVE
 Each colored plotting represents the position of a whale-ship on a day when one or more
 whales were taken. Each month's whaling is colored distinctively (See at left, key to colors).
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THE VAMPIRE BAT

A PRESENTATION OF UNDESCRIBED HABITS
AND REVIEW OF ITS HISTORY

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(Figs. 3-11; Plates V-VII incl.)

This article follows intensive studies of the Vampire Bat, *Desmodus rotundus*, during trips to Panama and Trinidad during 1933 and 1934, and observations of specimens in captivity from both areas. Between field reconnoiters, a thorough search of the literature has been made. The work has thus produced a quite complete history by bringing together recorded observations, references to studies of important pathogenic significance and notes of studies made by the authors. Thus collectively clad, the vampire assumes a more interesting and specialized form than past description has accorded it.

The studies of *Desmodus* outlined here were suggested to the senior author in the summer of 1932 during a collecting trip in Central America. The trip was concluded with a call upon Dr. Herbert C. Clark, Director of the Gorgas Memorial Laboratory in Panama. Dr. Clark told about his work with Dr. Lawrence H. Dunn in proving the Vampire Bat to be the carrier of a trypanosome existing in the blood of cattle, to which cattle were resistant, but fatal to equines. As cattle ranged in large numbers with horses and mules at night, and bats indiscriminately attacked both, the working out of remedial measures was a highly important problem.¹

¹ Summarized in the American Journal of Tropical Medicine. Vol. XIII, No. 3. May, 1933.

Several vampires were under observation at the Memorial Laboratory. They had been maintained for a number of months on a diet of blood obtained at a nearby slaughter house and defibrinated to keep it in fluid condition. Here was a demonstration of the practicability of maintaining this highly interesting species as an exhibit at the Zoological Park. Dr. Clark, however, could spare none of his specimens. All were needed to demonstrate the susceptibility of the vampire itself after biting infected cattle or being injected with the organisms. It was there indicated, and since proved, by Clark and Dunn, that after biting infected cattle, the bat continues its blood feasts night after night, but itself succumbs in a period of about 30 days.

The senior author decided to return to Panama the following summer and search the caves where vampires had been captured. Hence in August of 1933, accompanied by Arthur M. Greenhall, then a student at the University of Michigan, Panama was again visited and Dr. Clark provided guides to explore the Chilibrillo caves in the Chagres valley. We were informed that the caves were of limestone formation, with horizontal tunnels. In some parts these gave way to large chambers, from which again, other tunnels led into the mountain. We were equipped with headband lamps and batteries carried on our belts.

In a shack near the caves was an illustration of the frequency with which humans may be bitten by Vampire Bats. A boy about ten years old had been bitten five times during a week, and always on the under surface of his toes while he slept. He had bled profusely, and the earthen floor beneath his slatted bed was blood-stained each morning.

The route to the caves led through cattle trails in low, green tangle, with ankle-deep mud most of the way, as the period was the rainy season. There was a steep slope near the caves and a growth of rain-forest. The Panaman guides, pushing through barricades of vines, disclosed a hole in the ground. It appeared to be little more than the entrance to a coal chute. We slid in and found ourselves in a horizontal tunnel in which we could walk upright in single file. The tunnel soon grew wider and higher, the floor slippery with red mud. Through portions of this entering gallery there was swiftly flowing water, knee deep in places. It appeared to come through the sides, then to

seep through crevices in the floor. By pointing a light overhead, a double procession of big bats could be seen, the two streams flying in opposite directions.

After we had worked forward a fair fraction of a mile, the subterranean stream gave way again to the slippery floor. The hallway became larger and now showed side galleries. The guides stopped there to assemble the handles of the nets by which the bats were to be taken. The atmosphere was unlike that of caves in the temperate latitudes; the air was hot, heavy and sweetish, the latter condition resulting from the odor of thousands of bats. Common on the limestone walls were huge roaches, of pale, straw color. Another insect denizen, not apparent without search of nearby crevices, but possibly common enough, was a member of the hemiptera, of the genus *Triatoma*. This is a small, reddish, blood-sucking bug, coming under strong suspicion in recent studies of carrying the organism of Chagas fever, a disease produced by a trypanosome in human blood, diagnosed and discovered by Dr. Emilio Chagas. Here and there, in startling contrast on the walls, were spider-like creatures with a spread of limbs of five inches or more. These arthropods appear to be cave-dwelling members of the *Thelyphonidae*, to which the Whip Scorpion belongs.

We finally entered a big chamber, the arched ceiling of which appeared to rise about 50 feet. The ceiling looked smooth, yet it was rough enough to provide a hanging foothold for thousands of bats of several kinds. Each species hung in a cluster of its own, the smaller, insectivorous kinds and smaller fruit bats on the sides. Near the dome of the ceiling was a mass of spear-nosed bats (*Phyllostomus*), in a cluster about 15 feet in diameter. These bats have a wing spread of about 20 inches and bodies the size of a rat. Our lights disturbed them and caused a great shuffling of wings and movement of innumerable faces. There was considerable chattering from these larger bats, and their teeth showed plainly.

The side galleries were also full of bats and we inspected these in search of the big carnivorous *Phyllostomus* which could not be captured in the high chamber. We caught 18 and "fought" them into a mesh cage. All the while we were watching for vampires, which may be distinguished by their habit of running

along the vertical walls and darting into crevices to hide. In a deep side gallery we found bats of a kind not noted in the large chamber, but again no vampires. After several hours we retraced our way along the subterranean stream until, with a feeling of relief from the oppressive atmosphere, we saw a faint glow that showed we were close to the entrance of the cave.

After a breathing spell we sought and found the entrance to another cave shown on our chart. The route sloped easily toward a circular chamber fully 100 feet in diameter, though not more than eight feet high. Here were hundreds of bats hanging in clusters, and all of one kind—a medium-sized spear-nosed bat of a fruit-eating species. They were not timid and could be closely approached before they took flight. When a hand was waved close to them the result was a pouring of winged bodies from the ceiling until the air was filled. Again we made an unsuccessful search of the walls for vampires.

The third cavern had an almost vertical entrance through a well-like shaft. There was not room enough to get down with the nets. We lowered ourselves into the hole, reached a horizontal turn-off, and on flashing our lamps against the wall, saw several bats run like rodents along the vertical surface, then dart into crevices. We immediately identified them as vampires, but all escaped.

With lights turned out we waited a half hour, but the bats did not reappear. We explored another gallery and found a spot where a slender man might squeeze through. We were too fatigued to continue, however.

The only other passage sheered off at a ledge beneath which ran a channel of water, from wall to wall, which looked as if it were quite deep. There the day's reconnoiter ended.

The following morning we returned to the cave where the vampires had been seen and with much caution descended to the widened area, keeping the lights out and feeling our way. Ready with some small nets we had prepared the previous evening, we flashed the lights on the wall where the bats had been seen, but no vampires were anywhere in sight.

We reasoned that the vampires had retreated into the recesses of the tunnel with the deep water, or into the narrow shaft where only a slender man could get through. Greenhall

worked into this small, horizontal shaft and saw several vampires in a widened space ahead. He captured two and the others made their way into the tunnel with the deep water, which connected with a passage ahead.

Of the two vampires captured, one soon died. It was half grown and possibly had been injured in the net. The other, an adult female, lived for approximately four months after capture and, slightly more than three months after being caught, gave birth to a single vigorous infant. While as yet we do not know the period of gestation, the length of time from capture of the mother to birth of the young shows a surprisingly long period of pregnancy for such a small mammal.

After obtaining the female vampire, we left for the Atlantic side of the Canal Zone. Dr. Clark provided two quarts of defibrinated blood, fresh from the automatic refrigerator of his laboratory, but from that moment until we reached New York the vampire was a problem. We were naturally very keen to get it back alive. We were not worried about the 18 big carnivorous bats; they were feeding ravenously and fresh meat could be readily obtained. With an assortment of crates containing reptiles and amphibians, and cases of preserved specimens for the museums, we boarded a train for Colon. The defibrinated blood was in a package beside us, and the cage containing the vampire was swathed in black cloth. Dr. Clark had cautioned us to get the blood on ice again as soon as possible.

On the Atlantic side it was necessary for the senior author to stop two days at the Navy Submarine Base at Coco Solo to deliver several lectures. The commanding officer invited us to stay at his residence and here the defibrinated blood was placed on ice, while the bat was domiciled in the garage. That night some of the blood was measured out in a flat dish. The amount would have filled a fair-sized wine-glass. The bat hung head downward from the top of its cage when the dish was placed inside and would not come down to drink while we were there. Early the next morning we inspected the cage and found the dish nearly empty.

That routine never varied during the ten days' voyage to New York, with stops at Colombian ports. We never saw the bat drink the blood, but in the quiet of the night she took her meal.

At the Park the senior author decided to keep the vampire in the Reptile House where the temperature was automatically maintained and the atmosphere was damp, like a greenhouse. In roomy quarters she quickly settled down. Blood was defibrinated in the Park's research laboratory and the dish was never placed in the cage until dark. For several weeks, however, despite cautious inspections with a flashlight, no observations of her visits to the dish could be made, although at some time during the night the blood was consumed.

At last the vampire became tame enough to show a lively interest when the dish was placed in the cage. She would crawl down the mesh side a few steps, peer at the dish, then creep back to her favorite nook in a corner, where she would hang head downward, by one leg. Each night she came further down and wandered along the sides of the cage before retreating. Her deliberate motions were surprising: a slow stalk, head downward, and a retreat equally deliberate. Her subsequent actions added much to information gleaned from the history of the species.

When the blood had been set in the cage, the observer took his stand in what developed into a series of nightly vigils. Finally there came a night when the bat descended the side of the cage with her usual deliberation. Reaching the bottom, she started across the floor with wings so compactly held that they looked like slender forelimbs of a four-footed animal. Her rear limbs were directed downward. In this way her body was reared a full two inches from the floor. She looked like a big spider and her slow gait increased that effect. Her long thumbs were directed forward and outward, serving as feet. Anyone not knowing what she was would have been unlikely to suspect her of being a bat. In this trip to the dish it appeared that an unpublished habit of the vampire had been observed, and this, possibly, was the method the bat used for prowling over a sleeping victim in seeking a spot to use the highly perfected teeth in starting a flow of blood.

But other revelations were in store. Bending over the dish, the bat darted her tongue into the sanguineous meal. Her lips were never near the blood. The tongue was relatively long. It moved at the rate of about four darts a second. At the instant

of protrusion it was pinkish, but once in action it functioned so perfectly that a pulsating ribbon of blood spanned the gap between the surface of the fluid and the creature's lips. In 20 minutes nothing remained but a red ring at the bottom of the dish. The bat's body was so distended that it appeared spherical. She backed off from the dish, appeared to squat, then leap, and her wings spread like a flash. She left the floor and in a flying movement too quick for the eye to follow hooked a hind claw overhead and hung, head down, in her usual position of rest. Gorged and inverted, she preened herself like a cat, stopping occasionally to peer out of the cage in the light of the single, shielded lamp to which she had become accustomed.

Summarized, these observations appear to add much to the history of *Desmodus*. In less than half an hour it had been demonstrated that the vampire can assume a walking gait as agile as a four-legged animal; that the reason for its long thumb is its use as a foot on the wing stalk; that it is not a blood-sucking creature as has long been alleged; that it can gorge itself prodigiously and assume an inverted position to digest its meal.

The problem of recording these actions on motion picture film was at once considered. The outlook was doubtful. If the vampire had been hesitant about performing up to that evening in the illumination of a single, shielded light, it appeared that lights of enough actinic power for photography, yet tolerable upon the bat, would necessitate a slow introduction and increasing the strength of the lamps. The observer's plan was to build up the illumination, night after night, through a resistance coil, or dimmer.

Two weeks were spent in gradually increasing the strength of the light. Ultimately the bat tolerated three 500 watt bulbs, with a reflector. The scenes were exposed on 35 mm. pan-chromatic film. The lens employed was a 4-inch Zeiss, with long light-cone. Results were clear and satisfactory and the greater number of the illustrations accompanying this article are enlargements from the motion picture scenes.

Since contentions as to new habits, based upon a single specimen, are far more satisfactory if they are afterward substantiated by observations of additional individuals, it was determined that field observations should be continued and addi-

tional vampires obtained during the summer of 1934. Meanwhile the junior author started a search of the literature for observations other than the mere statement that the vampire is a "blood-sucking" animal. This search, conducted in the library of the University of Michigan, revealed an interesting continuity of inferences concerning habits, and some authentic observations.

Beginning with the earliest descriptions of the habits of the Vampire Bat, allegations point to a blood-sucking creature. This is seen in the writings of Aldrovandi, Shaw, Cuvier, Buffon, Geoffroy St. Hilaire, Swainson, Gervais, Hensel, Goeldi, Quelch and others. Recent writers such as Gadow,² Dugés³ and Herrera⁴ have indicated that the vampire applies its lips to the wound made by specialized teeth, in order to pick up the ensuing flow of blood.

Charles Darwin appears to have been the first scientist to observe a vampire in the act of drawing blood and note its procedure with satisfactory clarity. He secured a bat and definitely recorded the sanguineous habits of *Desmodus*. Previous to this, several larger species of bats had been under suspicion. Darwin's observation, however, did not change the belief that *Desmodus* was a blood-sucking type.⁵ Nor could anything to the contrary be found in comparatively recent writing until the publication of an article by Dr. Dunn, in 1932,⁶ containing the following:

"The vampire does not suck blood, as popularly believed, but takes it up with its tongue, seldom placing its mouth on the wound except when the latter is first made or when the bleeding is very slow. If the wound bleeds freely, the bat simply laps up the blood, hardly touching the tissues, while if the bleeding is scant the bat licks the wound."

Thus Dunn's observation, but a few years past, takes precedence, as far as could be found, in rectifying a long procession of erroneous inferences about the feeding habits of the vampire.

² Gadow, H., 1908. Through Southern Mexico. Witherby and Co., London, pp. 440-445.

³ Dugés, A., 1911. La Naturaleza Mexico. Ser. 3. T. I., Fasc. 2, pp. 1-4.

⁴ Herrera, A. L., 1911. La Naturaleza Mexico. Ser. 3. T. I., Fasc. 2, pp. 4-6.

⁵ Darwin, C., 1890. Naturalist's Voyage Round the World. John Murray, London.

⁶ Dunn, L. H., 1932. Journal of Preventive Medicine. Vol. 6, No. 5, pp. 415-424.

In further elucidation is a letter from Dr. Clark, dated April 18, 1934, and reading in part:

"Our vampire does not suck the blood. It uses its tongue to collect the blood, in a back and forth motion, rather than as a dog or cat laps up water and milk. I have seen them feed from the edge of cuts on horses, but, of course, never got close enough under these conditions to see the tongue in action. Animal feedings offered the bats under laboratory conditions establish the fact that they lick the blood."

As to the quadrupedal gait of the vampire, apparently the first mention of it is in the works of the Rev. J. G. Wood,⁷ who states that vampires can walk, rather than grovel like other bats, but the description is insufficient in indicating the habit.

Dr. William Beebe,⁸ in his book outlining experiences in British Guiana, states:

"We ascertained, however, that there was no truth in the belief that they (vampires) hovered or kept fanning with their wings . . . Now and then a small body touched the sheet for an instant, then, with a soft little tap, a vampire alighted on my chest.

"Slowly it crept forward, but I hardly felt the pushing of the feet and pulling of the thumbs as it crawled along. If I had been asleep, I should not have awakened."

Dr. Beebe's observation, though made in the dark, is good substantiation of the senior author's surmise about the soft gait of the bat in reconnoitering its prey. Dr. Beebe's description of the "pushing" of the feet and "pulling" with the thumbs does not however, define the actual action of the vampire, which *walks*, with body well elevated from the ground and the elongated thumbs used as feet.

In further substantiation of the observation that the bat has a walking gait, the senior author was informed by Sacha Siemel, an explorer of the Brazilian jungle, that while he was conducting a party close to the Bolivian frontier, a number of vampires attacked the horses. Mr. Siemel, with a flashlight, carefully noted the actions of the bats. Some he saw lapping blood from fresh wounds, while others, as yet undecided upon areas to bite,

⁷ Wood, J. G., 1869. *Illustrated Nat. Hist.*, pp. 116-118. G. Routledge & Sons, London.

⁸ Beebe, W., 1925. *Edge of the Jungle*, pp. 18-21. Garden City Pub. Co., New York.

stalked back and forth over the animals' backs, walked among the matted leaves of the forest floor, or hopped from one spot to another.

Observations during 1934: For the tropical reconnoiter of this year, the senior author planned a trip along the entire chain of the West Indies, terminating at its southerly end in collecting work in Trinidad and British Guiana. The junior author left a month ahead, on July 19, bearing a letter which put him in contact in Trinidad with Professor F. W. Urich of the Imperial College of Tropical Agriculture. Professor Urich he found engaged in an investigation, operating on a government grant, of the transmission of paralytic rabies by Vampire Bats. The disease was seriously prevalent among cattle and thus far fatal, although vaccine is now being administered to immunize the herds. The disease was also fatal to about 35 humans over a period of years. They were dwellers in the back areas where vampires are commonest, and the bat is not known to attack humans in the cities and towns.

Professor Urich and his field assistant, J. P. L. Wehekind, extended much aid in getting together a collection of various specimens for the Zoological Park and providing transportation to different parts of the island. Several days after arrival in Trinidad the junior author, accompanied by William Bridges, captured seven vampire bats in the Diego Martin cave.⁹

The newly captured bats were taken to the Government Stock Farm and placed in a small framework building with sides of wire screen. In this building was another vampire that had been under the observation of Professor Urich for about three months. He had studied its feeding habits on goats and fowls. This bat was tame enough to come down and feed while observers stood quietly in the room. Notes made by Professor Urich during the studies of himself and his field assistant appeared in the monthly reports of the Board of Agriculture of Trinidad and Tobago. From these, Professor Urich granted permission to quote as follows:

"May Report. (Observation on May 19, 1934). When I got there at 9:40 P.M., found the bat feeding on the left foot

⁹ For details of a month's collecting work in Trinidad and Demarara, note serial account by William Bridges, *N. Y. Sun*, July 30 to Sept. 12, 1934.

of the cock, about 1 inch below the spur. The bat does not suck the blood, but laps it. Bat fed for twelve minutes from the time I arrived, the cock standing absolutely still. Then the cock started to walk, the bat following along the ground, and fed again. The cock became restless and walked away. Then it went into a corner of the cage, on the ground." (Observation by Wehekind).

"June report. (Observation on June 27, 1934). Bat started feeding at 8:30 P.M. and finished at 8:40 P.M., being so gorged that he could scarcely fly. Bat dropped straight on goat and started to feed. No hovering." (Observation by Wehekind).

In a later report. "As the *Desmodus* fed readily in captivity on fowls or goats, Mr. Wehekind was able to ascertain the method of feeding of these bats on fowls. It is quite different as stated in some records, the principal features of which is that the bat does not hover around its victims, does not suck blood, and does a fair amount of walking around on the victim to secure a suitable place for feeding. This is carried out by making a narrow groove in the place selected and lapping up the blood as it exudes from the wound. The bat always returns to an old wound on the same animal on its daily feeding. All these observations were verified by me (F. W. Urich) on several occasions."

The junior author of the present review adds the following notes from observations made in the screened house where the bats were quartered:

"On Friday, August 3, 1934, at 6 P.M., Professor F. W. Urich and myself went to the Government Stock Farm to see the condition of the captive Vampire Bats. One male vampire has been under Professor Urich's observation since May 18. It is known as 'Tommy.' When we caught seven additional vampires, Tommy was placed in a cage by himself, as it was known that he was free from paralytic rabies. Professor Urich then attempted to feed Tommy with defibrinated blood. The bat was used to feeding upon goats and fowls that were introduced into the cage and evidently did not relish the diet of prepared blood in a small dish. It seems to have taken a small quantity, but we thought it best to release it with the others after the necessary quarantine.

“At the time we entered the bat cage we found that a goat had been placed inside for the other vampires to feed on. The goat had been freshly bitten, as I noted three open wounds, two on the left side of the neck and one on the right, from which blood was oozing.

“The goat was calm, standing in one corner and no bats were feeding when we entered. Tommy was released from his quarantine quarters, flew and attached himself by the hind foot on the screening of the house, about a foot and a half from the sill. The goat was standing not far away from the vampire. The bat remained hanging for about five minutes, the thumbs bracing the body, the wings folded close to the arms. After a short interval, the bat showed signs of movement. The head nodded; the lips were drawn back, exposing the large canines and protruding incisor teeth. The bat’s gaze finally rested upon the goat. I was watching approximately four feet away from the bat and the goat was nearer to me. Slowly the bat moved down the screen, a deliberate stalk. The fore and hind feet were lifted high from the wiring and the body was well above the mesh. The bat stalked down and I noticed that the movement of the forearm in the stride was exceptionally slow, the wings folded tightly. From two to three minutes were required to traverse the distance from the original position to the sill. Upon arriving at the edge of the sill, the vampire hung from its hind feet and dangled over the edge into space. There, it remained for about two more minutes. The goat was still standing in the same position. Suddenly and silently the vampire launched itself into the air and lightly landed on the middle portion of the goat’s back. There was still no movement on the part of the goat. I moved quietly forward until I was but two feet from the goat. Tommy stalked to the shoulder and neck regions of the animal. After a minute or so of searching, the bat buried its head close to the skin of the goat. There were a few up and down motions of the bat’s head.¹⁰ The goat then took a few steps forward and turned its head to the right and the left. The bat drew itself up but continued the nodding motions. The goat walked around the room rather rapidly, the vampire hanging on and thus riding its host. The goat passed by me, then stopped, and I noticed that

¹⁰ The act of pushing aside the pelage and of biting.

blood was exuding from a small wound and the bat was lapping it with a rapid darting of the tongue. The goat started to walk again and passed under a sort of table, a board of which brushed heavily against the animal's back. The goat was, in fact, obliged to slightly lower itself to pass under. The vampire quickly scuttled down the shoulder of the goat to avoid being brushed off. When the goat cleared the table the bat as quickly returned to the wound and continued lapping. We then forced the goat to go back under the table several times, the bat dextrously avoiding being hit by dodging down the shoulder. The movement was very agile and reminded me somewhat of the behavior of a crab. The bat could move both forward, backward and sideways, but seemingly preferred head first.

"I then reached out my hand and succeeded in touching the vampire, which attempted to dodge. It did not, however, make any movement to fly. The goat by now was exceptionally restless and ran back and forth around the room. It was a timid animal and it was of us that it was afraid. When we left, the bat was still riding the goat."

Later visits to the enclosure showed some of the other bats flying down from the ceiling, landing on "all fours" upon the floor, then hopping like toads from one spot to another, instead of assuming the walking gait. On one occasion a bat was seen to be so gorged and heavy from its sanguineous meal that it slid off the back of a goat to the floor. It was unable to launch itself in flight from the floor, hence climbed the wall, with head inverted, and when midway up launched itself in flight, returning to its customary hanging place on a ceiling beam.

When the senior author arrived in Trinidad, he spent considerable time observing the bats during the early evening, in the screened room. His notes on feeding actions would be nothing more than repetition of what has already been brought out. What he noted particularly, was the general tolerance of the goat to bats which crawled over its back or even wandered up the neck to the head. For a time after alighting on a goat, the vampire was not inclined to bite, but rested on the dorsal area, a bit forward of the shoulder, or clung to the side, where it looked like a big spider. This latter position is shown among the plates accompanying this article. The wandering of the bat upon the

strangely tolerant host, the occasional lifting of the bat's head, the leer that disclosed its keen teeth, and the observer's realization that all of this pointed to a sanguineous meal, produced a sinister and impressive effect.

When the wound had been made, the tongue of the bat seemed to move slower than when lapping blood from a dish, and was extended far enough to come well in contact with the tissue. Goats of the laboratory herd, which had been previously bitten while heavily haired, showed bare spot surrounding the area of former wounds. The wounds themselves had healed as a slightly indicated ridge, from three-sixteenths to a quarter of an inch in length, but the area devoid of hair was as large, or larger, than one's thumb nail. Apparently the hair had been shed in the area of the wound. Here may be a condition of "desensitization" in a vampire bite, with attending destruction of hair follicles. It has been suggested, though not with satisfactory evidence, that the saliva of the bat contains an anticoagulant, which might account for many bites bleeding for several hours. The term "desensitization," as here used, may be rather a loose one, but it signifies that something abnormal has happened to the tissue besides the opening of a mere wound by specialized and lancing incisor teeth. There can certainly be no injection of an anticoagulant, but there is a possibility of the application of some salivary secretion during the action of the bat's lapping tongue—a secretion retarding the formation of a clot about the wound. This matter will be considered in a treatment of physiological characteristics in following paragraphs relating to investigations now under way with four vampires in possession of the senior author.

Field observations in Trinidad indicated vampire bats to be fairly common, but not generally distributed. Near the base of the Aripo heights, particularly, frequent bites were reported. The bats attacked cattle, swine and poultry. Sows were bitten upon the teats and the wounds in healing so shrivelled these members that the animals were unable to nurse their young. Most fowls were unable to survive the loss of blood and were found dead in the morning.

Around a dish of defibrinated blood, the feeding motions of the four vampires brought back from Trinidad duplicated the

notes made upon the Panama specimen of the preceding year, though the latter represented a different subspecies. The animals so gorge themselves that their bodies become almost spherical. This gorging consumes from 20 to 25 minutes.

In some experiments with large fowls, weighing up to eight pounds, the bats were observed to be extremely cautious in their approach, slowly stalking in a circle wide enough to keep out of reach of the bird's bill. An action of that kind might readily kill a light-bodied bat. After several circular manoeuvres, an approach was made to the fowl's feet, the bat feeling its way forward, inch by inch, and finally nibbling gently at the under surface of the toe. This appeared to serve the purpose of getting the fowl accustomed to its toe being touched. If the fowl made an abrupt move, the bat would dart backward, then slowly stalk forward to resume its attack. Whether any slight "shaving" of the tissue was taking place and a salivary secretion was being applied by the tongue it was impossible to determine, as the bats were too timid to bear extremely close inspection. After these preliminaries, however, the mouth was rather slowly opened as if to gauge precisely the sweep of the incisor teeth, and then there was a quick and positive bite. While it has been customary to allege the utter painlessness of vampire bites, in several instances where fowls were under observation, there was a decided reaction of motion on the birds' part, showing that the bite was sharply felt. If the fowl moved, the bat darted back, but immediately returned to the wound, now freely bleeding. From this point the bat continued its meal and the fowl paid no further attention to it.

Physiology: Desmodus is no larger than the larger insectivorous bats. A particularly good female example of *D. rotundus rotundus*, from Brazil, shows a length of body of four inches and a wing spread of 13 inches.

The incisor teeth are extremely sharp and have a curvature that forms a scoop-like mechanism. The incisors are well in advance of the canines. The lower incisors are widely separated, forming a partial channel for the darting motion of the tongue in taking up blood from a wound. Examination of bites shows a crater-like wound. The sharp upper canines, being set far behind the incisors, appear to play little part in most wounds.



Fig. 3. Head of Vampire Bat, *Desmodus rotundus murinus* Wagner. The specialized dentition includes sharp upper incisors for lancing and inducing a flow of blood, the crowding backward of the upper canines, and separation of the lower incisors to form a channel for the narrow and elongate tongue.

Experiences of reliable observers point to a remarkable painlessness of the average vampire bite. There are statements that victims knew nothing of the attack, and would have remained ignorant of such a happening had they not found blood stains the following morning. An expedition from the University of Michigan in Santa Marta, Colombia, may be cited:¹¹

“We did sleep, but so soundly that it was not until morning that we discovered that we had been raided during the night by Vampire Bats, and the whole party was covered with blood stains from the many bites of these bats. It may seem unreasonable to the uninitiated that we could have been thus bitten and not be disturbed in our sleep, but the fact is that there is no pain produced at the time of the bite, nor indeed for some hours afterward.”

In a previous paragraph it has been noted that a fowl introduced into a cage with vampires, flinched upon being bitten, this observation being made by the senior author. Examining some of the recent studies of Dunn it appears that the younger bats are not so expert in effecting their bites and that experimenters

¹¹ Ruthven, A. G. 1922. Misc. Publ. Mus. Zool., U. of M. No. 8, p. 10.

PLATE V

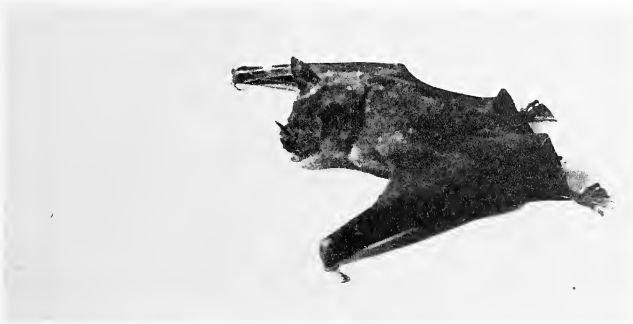


Fig. 4 (Upper). Spear-nosed Bat, *Phyllostomus hastatus panamensis* Allen. This is the position assumed by the greater number of bats in traversing horizontal surfaces. Such bats, when seeking to fly, usually ascend a vertical surface, in inverted position, before taking wing.

Fig. 5 (Center). Vampire Bat, *Desmodus rotundus murinus* Wagner. The quadrupedal gait, with body well elevated from the ground, illustrates how the animal lightly stalks and manoeuvres over the body of its victim.

Fig. 6 (Lower). The position of the thumbs, turned outward and serving as padded feet on the wing stalks, illustrates the facility of the stalking gait. From this position, a Vampire Bat can leap upward and take flight.

testing the bites of various specimens upon the human forearm occasionally found bats that dealt decidedly painful bites.

There is controversy as to whether the bat carries an anticoagulant in its saliva, introducing it into the freshly-made wound to keep it bleeding, or whether a specialized type of bite induces prolonged bleeding. Bier of the Biological Society of São Paulo, Brazil, experimented with extracts of the salivary glands of *Desmodus* and also with a species of *Phyllostomus*¹² (*P. hastatus*). His published results indicate that *Desmodus* possessed anticoagulating properties in its saliva, while the non-hematophagus bat's saliva was completely inactive. In October, 1934, Dr. Barry King of Columbia University began experiments with the four Vampire Bats now in the care of the senior author. This work points to an anticoagulant in the salivary secretion of *Desmodus*, but time and checking will be required to define its activity.

Although mosquitos, blood-sucking flies, ticks and lice have long been known to harbor disease organisms in their saliva, the Vampire Bat only recently came under suspicion. The work of Clark and Dunn at the Gorgas Memorial Laboratory has confirmed the guilt of the bat.¹³ These investigators demonstrated that *Desmodus rotundus murinus* is a vector of the equine disease "murrina," prevalent in Panama and produced by *Trypanosoma hippicum* Darling. It is interesting to note that the disease also proved to be fatal to all of the bats carrying the trypanosome, although they live long enough after becoming infected to produce grave damage.

While there have been statements that vampires appeared to be unable to endure a fast of not much more than 36 hours, Urich states that vampires can fast as long as three days. The senior author fasted four specimens for 48 hours, seemingly without harm.

As early as 1865 Huxley¹⁴ made a detailed study of the stomach of *Desmodus* and found that its extremely intestiform shape was apparently specialized for rapid assimilation. This, together with the specialized dentition and peculiar type of

¹² Bier O. G. 1932. C. R. Soc. Biol. Paris. Vol. 110, pp. 130-131.

¹³ Dunn, J. H. 1932. Journal Preventive Medicine. Vol. 6, No. 5, pp. 415-424. Clark and Dunn. 1933. Am. Jour. Trop. Medicine. Vol. 13, No. 3, pp. 274-281.

¹⁴ Huxley, T. H. 1865. Proc. Zool. Soc. London. pp. 386-390.

quadrupedal gait, make the vampire especially adapted to its sanguinary mode of living.

Tradition: The term Vampire originated long before civilized man's knowledge of a so-called blood-sucking bat. In later years the discovery of a sanguineous bat appears to have inspired elaboration of the tradition. This history has been traced by the junior author through approximately 200 titles, a partial bibliography of which appears at the end of the article. Surmise, theories and observations of various naturalists in building up the history of the Vampire Bat have also been searched, as well as scientific nomenclature.

The term Vampire is apparently of Slavonic origin and was first applied in eastern Europe to alleged blood-sucking, supernatural beings and persons abnormally endowed with hematosia. The preternatural Vampire was supposed to be the soul of a dead person which left the interred body at night, in one of many forms, to suck the blood of sleeping persons and sometimes animals. Of the numerous shapes thought to be assumed by the Vampire, it is of interest to note that in early history the bat form was not mentioned. It later found its way into the legends, as brought out in Bram Stoker's "Dracula." The preferred form seems to have been the werewolf, dog, cat, horse, birds of various kinds, snakes and even inanimate things such as straw and white flame.

Superstition about blood-sucking forms has been widespread and of dateless origin. It was known in many ancient cultures of the Old World. The tendency of blood-sucking creatures to produce legends is to be noted among the Mayans even before the arrival of Cortez in the early Sixteenth century brought contact with Old World superstitions. In this case of New World exaggeration, there was a basis for it—the actual presence of sanguineous bats. Here was reverence of a blood-sucking bat god,¹⁵ undoubtedly founded on the existence of a sanguineous bat common in most of the Mayan areas of habitation. Then again, the return of Cortez's followers to Europe with tales of blood-sucking bats, founded on acquired knowledge of an actual blood-drinking creature, appears to have strengthened the superstitions of Europe. From chronological examination of the old

¹⁵ Mythology of All Races. 1930. Vol. XI, p. 177. Archeol. Inst. Amer.

PLATE VI

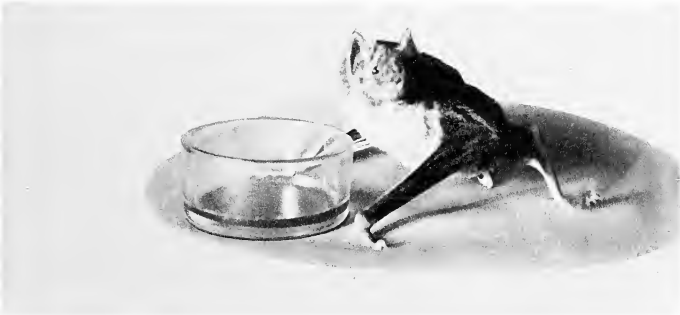


Fig. 7 (Upper). Vampire Bat, *Desmodus rotundus murinus* Wagner. The beginning of a nightly meal of defibrinated blood. The contents of the dish was consumed in slightly more than 20 minutes, being lapped up by the tongue.

Fig. 8 (Center). Completion of the meal, showing spherical distension of the body. The action of the tongue is shown.

Fig. 9 (Lower). Preparing to leap upward for flight; this is preceded by a slight bending of the limbs.

literature, it seems that it was not long after the return of the Spaniards that allegations appeared about blood-sucking habits of the bats of Europe, where no sanguivorous bats have ever occurred.

After the return of the early explorers from the New World tropics, a "Vampire" epidemic broke out in Europe about 1730,¹⁶ especially in the Slavonic countries. All sorts of works, scientific and philosophical, related incidents and cases of those unfortunate people who became afflicted with vampirism and sucked the blood of men and animals. Up to this time, although bats were associated with supernatural happenings, they were not associated with vampirism. Slowly the tradition of vampirism added the bat form to its list and later fiction, founded on vampirism, included allusion to bat wings, bat-like movements and the actual bat form as portrayed in the really classic "Dracula."¹⁷

Early naturalists visiting Central and South America arrived there with definite knowledge of a bat of some sort that fed upon blood. The exact bat was unknown. This led to various inferences. The ugliest and largest bats were thought to be the vampire. Actual observations of these early travellers, thrilled by the strange New World tropics, appear to be in the minority as compared to the acceptance of tales they heard, or their deductions from dead specimens. Hence, we find in the old records weird descriptions of vampires hovering over their sleeping victims, fanning them with their wings to induce profound sleep, inserting long tongues into a vein and sucking the man or beast dry.

Taxonomy: The actual vampire was accorded a place in the formal, binomial lists before it was individually known to be a sanguineous bat. Prince Maximilian Wied separated the vampire from the genus *Phyllostoma* of E. Geoffroy and placed it in a separate genus, *Desmodus*, with the specific name of *rufus* in 1826.¹⁸ This application of a new specific name in the removal of the vampire from *Phyllostoma* failed to hold, as Geoffroy had already established the species as *P. rotundum* in 1810.¹⁹ The

¹⁶ Encyclopaedia Britannica, 1910, 11th edit., Vol. 27, pp. 876-877.

¹⁷ Stoker. Bram. 1929. *Dracula*. Doubleday, Doran & Co., Inc., Garden City. N. Y.

¹⁸ Wied. M. 1826. Beiträge zur Naturgesch. Brazillien. Vol. 2, p. 231.

¹⁹ Geoffroy, E. 1810. Ann. Mus. Hist. Nat.. p. 181.

generic separation, however, was clearly indicated by the specialized dentition, although *Desmodus* still retained a place in the family of Spear-nosed Bats, *Phyllostomidae*. Waterhouse in 1839 referred to the vampire as *Desmodus d'orbigny*.²⁰ Wagner in 1840 proposed the specific name of *murinus*.²¹ To bring the taxonomy to date we quote from Osgood, 1912:²²

"In selecting specimens of *Desmodus* for comparison, I find a noticeable difference in size between examples of typical *D. rotundus* from Paraguay and specimens from Mexico and Central America. In typical *rotundus*, the forearm measures 60-64 mm., while in Mexican and Guatemalan specimens the maximum is 55. A corresponding difference is shown by the skulls. It would seem advisable, therefore, to recognize a northern subspecies, using Wagner's name *murinus* (Suppl. Schreb. Säügeth., I, p. 377, 1840) which would stand as *Desmodus rotundus murinus* Wagner."

It now appears that the only known sanguineous bats of the world occur in the American tropics, forming the family *Desmodontidae*. This is composed of three genera, each with a single species, as follows: *Desmodus rotundus rotundus* Geoffroy; *D. rotundus murinus* Wagner; *Diphylla centralis* Thomas, and *Diaemus youngi* (Jentink).

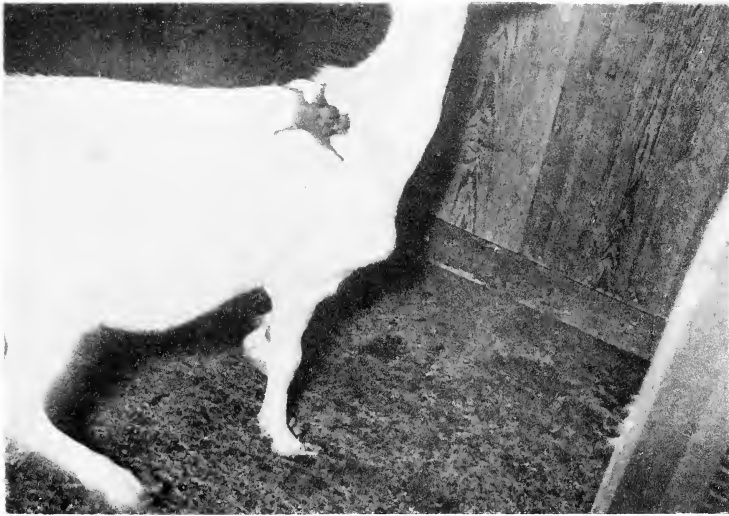
The habits of *Diaemus youngi*, appearing to be a rare species, have not as yet been authentically noted. The dentition, however, points to it being of similar habits to the two former sanguineous species.

²⁰ Waterhouse, G. R. 1839-42. Voyage of the Beagle, Mammalia, pp. 1-3.

²¹ Wagner. 1840. Schreber's Säügethiere, Suppl., Vol. I, p. 377.

²² Osgood, W. H. 1912. Field Mus. Nat. Hist., publ. 155, Zool. Ser., Vol. 10, p. 63.

PLATE VII



Figs. 10 and 11. Positions assumed by the Vampire Bat, *Desmodus rotundus murinus* Wagner, in clinging to an animal with thick pelage. The claws of the hind feet grasp the hairs of the victim's body and enable the bat to move nimbly over vertical surfaces.

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A SECOND LIST OF ANTILLEAN REPTILES AND AMPHIBIANS

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INTRODUCTION

In December, 1930, I published a List of the Antillean Reptiles and Amphibians in ZOOLOGICA. Since that time such a host of additional discoveries has been made that the list is now completely out of date. I have, therefore, prepared a new one since I believe that the usefulness of these lists is pretty well shown by the number of people who write me asking for copies.

For an account of the dispersal of the destructive mongoose and its effect on the status of Antillean reptiles cf. Barbour, "Some Faunistic Changes in the Lesser Antilles," Proc. New England Zool. Club, January 10, 1930, Vol. 11, pp. 73-85.

The Antilles as considered faunistically comprise the West Indian Islands, except Trinidad, Tobago and the islands off the coast of South and Central America.

I wish most particularly to thank my friends Messrs. Arthur Loveridge and Benjamin Shreve of the Department of Reptiles and Amphibians of the Museum of Comparative Zoology for constant advice concerning many knotty problems.

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Class AMPHIBIA
Order *SALIENTIA*
Family HYLIDAE

Hyla septentrionalis Boulenger

Cuba; also (perhaps accidentally) the Cayman Islands and Northern Bahamas.
A common species.

Hyla dominicensis (Tschudi)

Hispaniola.

A common ally of *Hyla septentrionalis*.

Hyla brunnea Gosse

Jamaica.

The common vicarious representative of *H. dominicensis* and *H. septentrionalis*.

Hyla vasta Cope

Hispaniola.

Formerly little known, now well studied by Noble. Not uncommon in some wet mountainous ravines in San Domingo.

Hyla lichenata (Gosse)

Jamaica.

Probably of the stock of *Hyla vasta* but well differentiated. This species has been studied by Dunn who finds that it lives in hollow limbs of trees. Its head is modified to close the opening of its retreat.

Cf. *Bufo empusus* and the discussion of phragmotic modifications in amphibians and reptiles. Barbour, Reptiles and Amphibians, Boston, Houghton Mifflin & Co., 1926, p. 73 et seq.

Hyla pulchrilineata Cope

Hispaniola.

Formerly considered to be related to the *Hyla arborea* series, but erroneously. It may have Jamaican affinity with *Hyla wilderi* or it may be anthonously developed from *Hyla dominicensis* as Dunn suspects.

Hyla wilderi Dunn

Jamaica.

I collected this species commonly in 1909 but did not realize that the specimens were adults of a new species, not young of the common *Hyla brunnea*. It is found in the "wild pines," epiphytic bromeliads.

Hyla marianae Dunn

Jamaica.

Apparently not common anywhere and found in the highlands only.

Hyla heilprini Noble

Hispaniola.

Found by Noble in 1922, among stones in the ravines of mountain torrents in Pacificador Province, San Domingo.

Hyla squirrella Latreille

Southeastern United States; Stranger's Cay, Northern Bahamas.

Found in the Bahamas in 1903 by Allen, Bryant and Barbour. Accidental, no doubt.

Hyla rubra Daudin

South America and St. Lucia.

Reported years ago, 1891, from St. Lucia where it was doubtless accidentally introduced. We have no recent information as to its persistence.

Family BUFONIDAE

Bufo longinasus Stejneger

Western Cuba.

Known from the type only, taken during the summer of 1900 on the bank of a stream in the lowlands near El Guamá, a ranch near Pinar del Rio city. This species and the two following vicarious forms are not closely related to any existing toad. Many characters, however, suggest an affinity with *Bufo quercicus*. It is possible that all may have descended from some common ancestral type which occurred in what is now Central America.

Bufo dunnii Barbour

Central Cuba.

Found abundantly after heavy rains in the mountains between Trinidad and Cienfuegos.

Bufo ramsdeni Barbour

Eastern Cuba.

Found by C. T. Ramsden only. Taken after heavy rains in isolated localities in the mountains about the Guantanamo basin.

Bufo peltacephalus Tschudi

Cuba.

Generally distributed but nowhere abundant. I believe that this species may be a surviving representative of the same stock from which *Bufo punctatus* Baird & Girard is descended.

Bufo empusus (Cope)

Cuba.

This is the Cuban representative of the *Bufo lemur* series. It occurs in widely scattered colonies of burrows. I have described its mode of occurrence at some length elsewhere. (Mem. Mus. Comp. Zool. 44, 1914, p. 242).

Bufo gutturosus Latreille

Hispaniola.

A much more common species than its Puerto Rican ally.

Bufo lemur Cope

Puerto Rico.

For forty years after its description but six of these toads were found. Modern collectors have recently secured a larger number. The four toads of this series may be allied to *Bufo canaliferus* Cope of the mainland of Central America.

Bufo turpis Barbour

Virgin Gorda.

A very rare form. No other toad has ever been found in the Virgin Islands. It is very closely allied to *Bufo lemur* of Puerto Rico.

Bufo marinis (Linné)

Jamaica, Bermuda, Barbados, St. Lucia, St. Kitts, Martinique, Nevis and Montserrat, introduced. Native of South and lower Central America.

A favorite species for haphazard introduction.

Family LEPTODACTYLIDAE

Eleutherodactylus auriculatus (Cope)

Cuba.

Dunn believes that this form is confined to the Guantanamo region.

Eleutherodactylus sonans Dunn

Cuba.

An arboreal form of Central Cuba allied to *E. auriculatus* of Eastern Cuba.

Eleutherodactylus auriculatoides Noble

Hispaniola.

Found by Noble in bromeliads along the Constanza-Jarabacoa trail, Paso Bajito, San Domingo.

Eleutherodactylus portoricensis Schmidt

Puerto Rico and Tortola.

The representative of *E. auriculatoides* and *E. auriculatus*.

Eleutherodactylus cooki Grant

Puerto Rico.

A well defined species living in the boulder filled stream beds of the Pandura Mountains in S. E. Puerto Rico.

Eleutherodactylus audanti Cochran

Haiti.

Known only from the high La Selle massif.

Eleutherodactylus wetmorei Cochran

Haiti.

Known only from Fonds des Nègres, Haiti, where the types were taken from Palm Chat (*Dulus*) nests. Related to the preceding species.

Eleutherodactylus armstrongi Noble & Hassler

San Domingo.

Related to the two preceding forms and known only from Southern San Domingo.

Eleutherodactylus jamaicensis Barbour

Jamaica.

Taken at Mandeville in 1908, it has since been found in many other parts of the Island.

Eleutherodactylus weinlandi Barbour

Hispaniola.

A lowland species widely distributed in the eastern areas.

Eleutherodactylus richmondi Stejneger

Puerto Rico.

A virgin forest form allied to *E. weinlandi* of Hispaniola and *E. lentus* of St. Thomas.

Eleutherodactylus lentus Cope

St. Thomas and St. Croix.

This still seems to be a common species. Its subterranean habits protect it against capture by the mongoose.

Eleutherodactylus glandulifer Cochran

Haiti.

A form recently found by Dr. Darlington on the northeastern foothills of the Massif de La Hotte between 1,000 and 4,000 ft. Not nearly related to any other Antillean species.

Eleutherodactylus schmidti Noble.

Hispaniola.

Another of Noble's interesting discoveries at Paso Bajito. He says it is allied to *E. weinlandi* of the Dominican Republic and to *E. richmondi* of Puerto Rico and so on to *E. lentus* of the Virgin Islands.

Eleutherodactylus inoptatus (Barbour)

Hispaniola.

A large species which barks when handled and which is found in both Haiti and San Domingo. This by far the largest and finest species of the genus was discovered by Dr. W. M. Mann at Diquini, Haiti. It resembles superficially *E. insignitus* from the Sta. Marta Mts. of Colombia. This may be a good case of convergence.

Eleutherodactylus darlingtoni Cochran

Haiti.

Another very distinct form from the high La Selle Range, 5,000-7,000 ft.

Eleutherodactylus ruthae Noble

Hispaniola.

Noble described this species from Samana, R. D., and he considers it allied to *E. inoptatus*.

Eleutherodactylus urichii (Boettger)

St. Vincent, Grenada, Trinidad.

Mr. Benjamin Shreve tells me that the Grenada and St. Vincent specimens seem to be separated by color characters and may be worthy of a name.

Eleutherodactylus martinicensis (Tschudi)

Saba, Montserrat, St. Kitts, St. Eustatius, St. Martins, Martinique, Guadeloupe, Grenada, St. Vincent, Jamaica (introduced near Kingston about 1890).

This little frog is so easily carried about that its true original distribution will never be known.

Eleutherodactylus brittoni Schmidt

Puerto Rico.

Another from the forest on El Yunque.

Eleutherodactylus abbotti Cochran

Hispaniola.

Said to be a very common species throughout San Domingo.

Eleutherodactylus bakeri Cochran

Haiti.

Another of Dr. Darlington's recent finds from Mt. La Hotte, 5,000-7,800 ft.

Eleutherodactylus montanus Schmidt

Hispaniola.

A species from the Cibao Mountains.

Eleutherodactylus pictissimus Cochran

Haiti.

Another new form from Mt. La Hotte, 3,000 ft.

Eleutherodactylus femur-laevis Cochran

Haiti.

Another form just found and known only from the type locality, Morne La Hotte, 4,000 feet.

Eleutherodactylus minutus Noble

Hispaniola.

On ferns in palm thickets on trail near Paso Bajito, San Domingo; fide Noble.

Eleutherodactylus ruffemoralis Noble & Hassler

San Domingo.

Found in the hills near Barahona.

Eleutherodactylus orcutti Dunn

Jamaica.

Another of the recently found and apparently very local forms; from Arntully in St. Thomas Parish.

Eleutherodactylus cunctator Dunn

Jamaica.

Known only from Arntully in St. Thomas Parish.

Eleutherodactylus nubicola Dunn

Jamaica.

Found high in the Blue Mountains, 3,000-5,100 feet.

Eleutherodactylus luteolus (Gosse)

Jamaica.

Common and widely distributed; from Port Antonio to Montego Bay.

Eleutherodactylus gossei Dunn

Jamaica.

Widespread at altitudes of about 1,000 feet.

Eleutherodactylus pantoni Dunn

Jamaica.

The largest Jamaican species.

Eleutherodactylus junori Dunn

Jamaica.

Known only from Spaldings, Clarendon Parish, altitude 2,900 feet.

Eleutherodactylus cundalli Dunn

Jamaica.

A woodland species, as yet but little known.

Eleutherodactylus grabhami Dunn

Jamaica.

A small species with a wide range, as to both area and altitude.

Eleutherodactylus varleyi Dunn

Cuba.

Known from Central and Eastern Cuba and said by Dunn to be allied to *E. minutus* and *E. abbotti* of San Domingo.**Eleutherodactylus atkinsi** Dunn

Cuba.

A handsome species found throughout the Island.

Eleutherodactylus varians (Gundlach & Peters)

Cuba.

Known definitely only from Soledad, near Cienfuegos.

Eleutherodactylus eileenae Dunn

Cuba.

The "Kolin" of western and central Cuba.

Eleutherodactylus dimidiatus (Cope)

Cuba.

A widespread species.

Eleutherodactylus emiliae Dunn

Cuba.

Known only from the Mina Carlota, in the mountains not far from Cumanayagua, Sta. Clara Province.

Eleutherodactylus pinarensis Dunn

Cuba and Isle of Pines.

Known in Cuba from the Province of Pinar del Rio only.

Eleutherodactylus greyi Dunn

Cuba.

The largest Cuban species, so far known only from the mountains between Cienfuegos and Trinidad.

Eleutherodactylus brevipalmatus Schmidt

Cuba.

A form from the mountains of the province of Oriente.

Eleutherodactylus sierrae-maestrae Schmidt

Cuba.

Another mountain species from eastern Cuba.

Eleutherodactylus ricordii (Duméril & Bibron)

Cuba and Bahama Islands; S. Florida.

Found in all parts of Cuba and on New Providence, Abaco and Andros Island. It is extending its range in Florida, as I reported some years ago. It has now reached Gainesville. (Proc. Biol. Soc. Wash., 23, 1910, p. 100.)

Eleutherodactylus cuneatus (Cope)

Cuba and Isle of Pines.

Common in western and central Cuba.

Eleutherodactylus gundlachii Schmidt

Cuba.

An eastern mountain form. I originally described this species but used the specific name *plicatus*, which proved to be preoccupied.

Eleutherodactylus casparii Dunn

Cuba.

Another species of the Trinidad Mountains.

Eleutherodactylus gryllus Schmidt

Puerto Rico.

A minute, highland species.

Eleutherodactylus cochranæ Grant

St. John and Hassel Island.

Perhaps akin to the preceding species. Hassel Island is a small Cay near St. Thomas.

Eleutherodactylus locustus Schmidt

Puerto Rico.

Another species from El Yunque forest.

Eleutherodactylus cramptoni Schmidt

Puerto Rico.

A rare species from the mountain forest of El Yunque Peak.

Eleutherodactylus antillensis (Reinhardt & Lütken)

Puerto Rico, St. Thomas, Tortola, Vieques.

A widespread and common species.

Eleutherodactylus wrightmanae Schmidt

Puerto Rico.

A form "probably confined to the coffee belt and the wet forest above it."

Eleutherodactylus unicolor Stejneger

Puerto Rico.

From El Yunque.

Eleutherodactylus monensis (Meerwarth)

Mona Island.

Eleutherodactylus flavescens Noble

Hispaniola.

From bushes along streams near La Bracita, found by Noble in 1922.

Eleutherodactylus karlschmidti Grant

Puerto Rico.

Known only from the Luquillo Mountains in eastern Puerto Rico and said not to be very closely related to any other Antillean member of the genus.

Leptodactylus fallax Muller

Dominica, St. Kitts, Guadeloupe, St. Lucia.

The giant "crapaud" has been recently separated specifically from the mainland *L. pentadactylus*. Now to be found on Dominica only where it is called the "mountain chicken." Elsewhere it has been exterminated by the mongoose. It may have occurred upon islands other than those recorded above. I am not convinced that it is really very distinct from the mainland species.

Leptodactylus dominicensis Cochran

Hispaniola.

The Dominican representative of *L. albilabris* of Puerto Rico and the Virgin Islands.

Leptodactylus albilabris (Günther)

St. Thomas, St. Croix, Tortola, Anegada, Just van Dyke, Puerto Rico, Vieques, Culebra.

This common form no doubt occurs on other islets in this general area.

Leptodactylus darlingtoni Cochran

Haiti.

Another of Dr. Darlington's recent surprises from near La Visite, Morne La Selle, taken at 5,000 to 7,000 feet.

Leptodactylus validus Garman

St. Vincent, Grenada, Venezuela.

There is a great question whether this form is distinct or identical with *L. caliginosus* from Brazil and just what the relationship may be with *L. labialis* or *L. melanonotus* from Central America.

Family BRACHYCEPHALIDAE

Phyllobates limbatus Cope

Cuba.

Locally abundant. This species has been separated from the mainland species of this genus, as *Sminthillus*, on a trivial skeletal character of divergence. It is, however, I now believe, essentially a *Phyllobates* in all important respects except perhaps in life history. The species of "*Sminthillus*" described from Peru is quite certainly wholly unrelated to the Cuban form. I believe that we may generally agree that *Sminthillus* (type *limbatus*) is a straight synonym of *Phyllobates*. The Peruvian species in any case required a new name, and I called it *Noblella*, type *N. peruviana* (Noble) in the first edition of this check list.

Class REPTILIA

Order *SQUAMATA*

Suborder SAURIA

Family GEKKONIDAE

Gymnodactylus fasciatus Duméril & Bibron

Martinique.

I know nothing of this species and have often wondered what it is. The type in Paris was said to be from the Plée Collection and taken at Martinique. The Plée Collections have caused endless confusion by having so often erroneous data as to locality. I suspect that I would have done better to have omitted this species altogether.

Gonatodes albogularis (Duméril & Bibron)

Martinique, Curaçao.

This, another Plée type from "Martinique," may have come from almost anywhere in the Caribbean basin. Many of the members of this genus are in confusion and await a reviser.

Gonatodes notatus (Reinhardt & Lütken)

Hispaniola.

Apparently a valid species which may be confined to Haiti. It seems to be rare.

Gonatodes fuscus (Hallowell)

Cuba and Central America.

This house lizard is known from the seaports of Santiago, Havana and Mariel, which are in constant schooner communication with Havana. I suspect the species was long since accidentally introduced into Cuba.

Phyllodactylus spatulatus Cope

Barbados.

Collected years ago, about 1861, in fact, by Dr. Theodore Gill. I have no recent information as to its status.

Phyllodactylus martini Van Lidth de Jeude

Venezuela, Curaçao, Bonaire, Puerto Rico and Caja de Muertos.

Major Grant found three specimens from these two last mentioned islands. Of course, above all other lizards, geckos are distributed without rhyme or reason. This form was first described from Caracas. Grant recorded the species as *P. pulcher*.

Hemidactylus mabouia (Moreau de Jonnés)

Cuba, Jamaica, Hispaniola, Vieques, St. Thomas, St. Croix, Just van Dyke, Tortola, Dominica, St. Lucia, St. Vincent, Barbados, Martinique, Grenada and the Grenadines; Northern South America, Trinidad; West Africa from Liberia to Angola, East Africa from Italian Somaliland to the Zambesi.

This lizard, one frequenting the street lamp areas of towns and cities, is, I believe, accidentally introduced. It is rare in the Greater Antilles, and in Cuba very local.

Hemidactylus brookii Gray

Asia; tropical Africa; Cuba, Hispaniola, Puerto Rico.

I believe this is another accidental introduction.

Hemidactylus turcicus (Linné)

The Eastern Mediterranean Islands.

Introduced to Key West, Cuba, and Yucatan (cf. *Hemidactylus exsul* Barbour & Cole, Stuart, Copeia, No. 4, 31, Dec. 1934, p. 185).

Thecadactylus rapicaudus (Houttuyn)

Saba south to Grenada, tropical South and Central America.

Nocturnal or crepuscular. Found under bark, behind shutters and in old buildings, also in the forest in crevices of rocks and sometimes under decaying vegetable trash. It is known from almost every single island, all indeed which have been in any sense completely explored.

Aristelliger praesignis (Hallowell)

Jamaica, Grand Cayman and Cayman Brac.

An abundant, if not actually common, species.

Aristelliger lar Cope

Hispaniola.

Apparently rather widely distributed. It has recently been collected in larger numbers than the earlier investigators uncovered.

Aristelliger expectatus Cochran

Haiti and La Gonave.

A small species related to the one on Navassa. Known from Southern Haiti and La Gonave Island.

Aristelliger cochranæ Grant

Navassa Island.

Allied to Miss Cochran's species from Haiti.

Aristelliger barbouri (Noble & Klingel)

Inagua.

Known from Southwest Point, Great Inagua, only.

Tarentola cubana Gundlach & Peters

Cuba and Bahamas.

Shy and retiring in rocky crevices, this species is rarely seen. I suspect it to be widespread in the Bahamas, though I have seen it from Andros and Exuma Islands only. In Cuba it is more common in the northeastern region than elsewhere.

Sphaerodactylus roosevelti Grant

Puerto Rico.

Said by the describer to be the only species in the genus with keeled scales on the chest.

Sphaerodactylus decoratus Garman

Bahama Islands.

Common on Andros, rare on New Providence. The type came from Rum Cay.

Sphaerodactylus stejnegeri Cochran

Haiti.

A species known from several different parts of the Republic of Haiti.

Sphaerodactylus gibbus Barbour

Bahama Islands.

Known only from the Exuma Cays.

Sphaerodactylus torrei Barbour

Cuba.

Known from the Province of Oriente only. It is not rare.

Sphaerodactylus cinereus Wagler

Cuba, Navassa, Hispaniola and extreme south Florida.

A common form in houses and in woodlands. It passes through a number of color phases during growth and the young and half-grown were once thought to be distinct species and bore specific names, *elegans* and *intermedius*.

Sphaerodactylus mariguanae Cochran

Mariguana Island.

This form is said by the describer to be much like the following.

Sphaerodactylus oxyrrhinus Gosse

Jamaica.

A rare form but one widespread through the Island.

Sphaerodactylus armstrongi Noble & Hassler

San Domingo.

Known only from the Province of Barahona.

Sphaerodactylus difficilis Barbour

Hispaniola.

Common and widely distributed.

Sphaerodactylus altavelensis Noble & Hassler

Alta Vela Island.

Represents the stock of the preceding species on Alta Vela.

Sphaerodactylus notatus Baird

Florida Keys and extreme southern Florida, Cuba, Isle of Pines and Bahama Islands.

A very common house lizard. No doubt often carried about and rapidly extending its range.

Sphaerodactylus macrolepis Günther

Congo Key, Little St. James, St. Croix, Water Island, St. Thomas, St. John, Tortola, Virgin Gorda, Anegada.

Widespread and common.

Sphaerodactylus danforthi Grant

Culebra and Vieques.

Representing the preceding species on this Island.

Sphaerodactylus grandisquamis Stejneger

Puerto Rico.

Another representative of this same stock which Grant believes valid and confined to Puerto Rico.

Sphaerodactylus monensis (Meerwarth)

Mona.

Grant believes this species should be held as distinct.

Sphaerodactylus townsendi Grant

Northeastern Puerto Rico and Caja de Muertos.

A form close to *S. monensis*.

Sphaerodactylus richardsoni Gray

Jamaica.

A fine big form but one which is distinctly rare.

Sphaerodactylus becki Schmidt

Navassa.

I am not sure, judging from the second known specimen recently collected, that this species is really separable from *S. scaber* of Cuba.

Sphaerodactylus inaguae Noble & Klingel

Inagua, and Watlings Island.

Common in and about Matthewtown.

Sphaerodactylus gilvitorques Cope

Jamaica.

I know nothing of this species. I have never found it; nor has any of our various collectors in Jamaica. The types were taken "during the forties" by Dr. Pennock of Philadelphia.

Sphaerodactylus nigropunctatus Gray

Cuba.

A rare species from Eastern Cuba.

Sphaerodactylus caicosensis Cochran

The Caicos Islands.

Recently described from South Caicos Island. Apparently most like the following.

Sphaerodactylus corticolus Garman

Bahama Islands.

Known from Watlings Island and Rum Cay. No doubt it occurs in many other islands beside these.

Sphaerodactylus festus Barbour

Martinique.

Known from but few specimens but no doubt common.

Sphaerodactylus goniorhynchus Cope

Jamaica.

A very common woodland species.

Sphaerodactylus argus Gosse

Jamaica.

An excessively common species both in houses and out of doors. Possibly introduced casually into Cuba and the Bahamas.

Sphaerodactylus bartschi Cochran

Little Cayman.

A recently described form allied to *S. argus* of Jamaica.

Sphaerodactylus argivus Garman

Cayman Brac.

A derivative of *S. argus* of Jamaica. A fairly well defined species. It is apparently known from the type series only.

Sphaerodactylus anthracinus Cope

Bahama Islands.

Only known from Andros Island.

Sphaerodactylus copei Steindachner

Hispaniola.

A fine, big, rough-scaled species which is rare and apparently confined to Haiti.

Sphaerodactylus scaber Barbour & Ramsden

Cuba.

Found in the hills of central Cuba.

Sphaerodactylus samanaensis Cochran

San Domingo.

Known only from the vicinity of Samana Bay.

Sphaerodactylus fantasticus Duméril & Bibron

Guadeloupe.

Very abundant.

Sphaerodactylus pictus Garman

St. Kitts, Nevis.

Probably abundant, and possibly a synonym of the following.

Sphaerodactylus sputator (Sparman)

St. Eustatius.

The types in Stockholm were long the only specimens known but recently the Museum in Cambridge has received many freshly captured specimens.

No *Sphaerodactyli* are as yet known from St. Martin, Saba, Redonda and other small islands in this neighborhood.**Sphaerodactylus elegantulus** Barbour

Antigua.

An ally of *pictus* and *sputator*. Brilliantly banded when young and less ornamented in adult life—like so many of the curious little beasts.**Sphaerodactylus microlepis** Reinhardt & Lütken

St. Lucia.

I know little of the status of this and several others of the Lesser Antillean forms.

Sphaerodactylus klauberi Grant

Puerto Rico.

One of the small series of species with keeled belly scales.

Sphaerodactylus vincenti Boulenger

St. Vincent.

No information available as to present status.

Sphaerodactylus nicholsi Grant

Puerto Rico.

Said to be somewhat similar to the species from St. Vincent. A chance resemblance no doubt.

Sphaerodactylus monilifer Barbour

Dominica.

Probably abundant but I have no real information about this species.

Family IGUANIDAE

Iguana iguana iguana (Linné)

St. Thomas, Water Island, Hassel Island, Tortola, Peter Island, Guana Island, St. John, Saba, Grenada, Tobago, Trinidad, tropical islands of South America from western Panama to Brazil.

Dr. Dunn has recently examined all available material of the genus *Iguana* and this arrangement is based on his conclusions. (Copeia, 1934, p. 1.)

Iguana iguana rhinolopha (Wiegmann)

? St. Kitts, ? St. Lucia, Swan Island, lowlands of tropical Central America from Costa Rica northward in rain forest areas to the states of Guerrero and Vera Cruz, Mexico.

The Swan Island specimens are unstable and many possess and many lack the nasal spines. The Antillean specimens are probably based on specimens incorrectly labelled as to locality. If there really ever were iguanas on these islands, the mongoose has exterminated them. There is what may be an iguana egg from St. Lucia in the Mus. Comp. Zool. It is so labelled, and it was taken many years ago.

Iguana delicatissima Laurenti

Anguilla, St. Martins, St. Bartholemew, St. Eustatius, Nevis, Guadeloupe, Les Saintes.

This species has been recorded from Swan Island, where it is not now found and from the Caymans where it is either very rare or occasionally brought in by the very widely seafaring people.

Chamaeleolis chamaeleonides (Duméril & Bibron)

Cuba.

The most peculiar of all the offshoots from the Anoline stock. A rare species and beyond doubt a monotypic genus, in spite of several names applied with the idea of multiplying the forms.

Xiphocercus valenciennesii (Duméril & Bibron)

Jamaica.

Not uncommon in woods and fruit plantations. It may be related to *Phenacosaurus* of Colombia or be simply a chance offshoot from *Anolis* in Jamaica and Haiti and only fortuitously similar to the South American genus.

Xiphocercus darlingtoni Cochran

Haiti.

A surprising discovery, made in 1935 by Dr. Darlington of Harvard at Roche Croix, Massif de La Hotte, 5,000 ft. Another Jamaican genus in Hispaniola.

Chamaelinorops barbouri Schmidt

Navassa.

Not found during the careful exploration of Clench, Schevill and Rehder during January, 1930. Possibly exterminated by introduced animals.

Chamaelinorops wetmorei Cochran

Hispaniola.

The unique type is from near Miragoane, Haiti.

Audantia armouri Cochran

Haiti.

Recently discovered on the Morne La Selle. It resembles *Plica* or *Leiocephalus* superficially but more probably it represents the stock of the following genus. More recently still found by Dr. Darlington on Morne La Hotte.

Deiroptyx vermiculata (Duméril & Bibron)

Cuba.

Bank of streams of Pinar del Rio Province, taking refuge in the water and hiding among submerged rocks and stones when pursued.

Deiroptyx bartschi Cochran

Cuba.

Long unrecognized but not rare in western Cuba.

Anolis equestris Merrem

Cuba and Isle of Pines.

The finest and largest species of the genus. Rather uncommon but wide ranging. Less common than its allies, *A. garmani* of Jamaica and *A. ricordii* of Hispaniola, and about equally abundant with *A. cuvieri* of Puerto Rico. These are the "Giant Anoles" of the Antilles and they may be related to the *A. insignis* group of Central America.

Anolis cuvieri Merrem

Puerto Rico, Vieques and Tortola.

A rather uncommon member of the series of "Giant Anoles."

Anolis roosevelti Grant

Culebra.

Apparently a very fine and distinct form.

Anolis ricordii Duméril & Bibron

Hispaniola.

One of the "Giant" series. Found throughout the whole Island and next to *A. garmani* of Jamaica the most abundant of the tribe.

Anolis garmani Stejneger

Jamaica.

The beautiful great green or barred "Venus Lizard" of Jamaica. A common woodland form, by far the most abundant of the group of the "Giant Anoles."

Anolis porcatus Gray

Cuba and Isle of Pines.

A very abundant species. The "Chamaeleon" now sold iniquitously by thousands at "the circus." It has replaced its ally, our southern "Chamaeleon," *A. carolinensis* (Voight) in this hateful traffic.

Anolis maynardi Garman

Grand Cayman.

This extraordinary lizard, the most extreme member of the long-headed *A. porcatus-carolinensis* series, is by no means common.

Anolis brunneus Cope

Crooked Island, and the neighboring islands, and probably also Watlings Island.

A fine series of topotypes defines this beautiful species, long confused for lack of topotypes.

Anolis smaragdinus Barbour and Shreve

Bahamas.

The species which has been called *A. porcatus* and *A. brunneus* by recent authors but which is a perfectly distinct species inhabiting the islands of the Great Central Bahama Bank, Andros, New Providence, Eleuthera, Long, etc. The common green anole of the Central Bahamas.

Anolis fairchildi Barbour and Shreve

Cay Sal Group, Bahamas.

A green anole of the *porcatus-principalis-smaragdinus-brunneus* series, perfectly distinct and confined to this isolated group of islets.

Anolis bohorucoensis Noble & Hassler

San Domingo.

A fine species apparently confined to the Sierra de Bohoruco, southern San Domingo.

Anolis longiceps Schmidt

Navassa.

Apparently the only species at present to be found in any number on this Island.

Anolis chloro-cyanus Duméril & Bibron

Hispaniola.

A widespread and not uncommon form.

Anolis mestrei Barbour & Ramsden

Cuba.

A rather rare species of the higher woods in the limestone hills of western Cuba. It belongs with *A. ahli* and *A. allogus*.

Anolis allogus Barbour & Ramsden

Cuba.

This fine form has a wide distribution in the mountains of eastern Cuba. Its ally in western Cuba is *A. mestrei*; in Central Cuba, *A. ahli*.

Anolis ahli Barbour

Cuba.

Confined to the mountains between Trinidad and Cienfuegos. It is related to *A. mestrei* and *A. allogus*. Not uncommon in high damp woods.

Anolis abatus Ahl

Cuba.

This species may be valid; it is more probably a synonym of *Anolis mestrei*.

Anolis bimaculatus Sparrman

St. Eustatius, St. Kitts and Nevis.

Abundant. A strictly arboreal species.

Anolis newtonii Günther

St. Croix.

I have never seen this species and know nothing about it.

Anolis evermanni Stejneger

Puerto Rico.

A highland species which may be related to *A. leucophaeus* of Inagua. An abundant form.

Anolis krugi Peters

Puerto Rico.

A little, well dispersed species belonging to what I call the rupicolous as against the arboreal Lesser Antillean series—viz. *A. watsi*, *A. sabanus*, and allies.

Anolis acutus Hallowell

St. Croix.

This may still be an abundant form. I have just received a fine series.

Anolis watsi Boulenger

St. Kitts, Nevis, St. Eustatius and Antigua.

A pretty little species found on the outcrops of igneous rock and, insofar as my experience goes, not in trees. It is one of the *A. acutus* allies.

Anolis forresti Barbour

Barbuda.

Only known from the types but obviously a small rock-inhabiting species most nearly allied to the species standing directly before it.

Anolis gundlachi Peters

Puerto Rico.

Apparently an abundant species.

Anolis gingivinus Cope

St. Martins, St. Barts, Anguilla and St. Eustatius.

Common. A member of the series of small sized Lesser Antillean species.

Anolis sabanus Garman

Saba.

A most remarkably differentiated form, a rock lizard, pure and simple. The males with really leopard-like spotting. It is one of the *A. watsi*-*A. acutus* tribe but very distinct and uniquely marked.

Anolis antiquae Barbour

Antigua.

A beautiful and common arboreal species.

Anolis lividus Garman

Montserrat.

All the lizards are said still to be common on this Island.

Anolis barbudensis Barbour

Barbuda.

Known from the type only but no doubt common, as are its relatives on Antigua and Nevis.

Anolis asper Garman

Marie Galante.

A bizarre and gorgeous species common on the old mango trees—about the only trees still standing over a large part of this hurricane-stricken isle.

Anolis leachii Duméril & Bibron

Guadeloupe.

One of the large species. Found abundantly by Noble in 1914, it was rare after the fearful hurricane of Sept. 12, 1928.

Anolis terrae-altae Barbour

Les Saintes; near Guadeloupe.

A fine big species which Noble found abundant in 1914.

Anolis alliaceus Cope

Dominica.

I was surprised in 1929 to find that this species seemed much less conspicuous and common than its allies on other islands nearby. So much for what may have been a most erroneous conclusion drawn from the visit of a few days only. It is, however, by no means rare.

Anolis nubilus Garman

Redonda.

A beautiful great lizard; one of the finest in the genus. It is known only from the original series.

Anolis griseus Garman

St. Vincent.

This lizard was formerly abundant. It is now rare. It may have been more or less terrestrial and hence have been a prey to the mongoose. In sending two to the Museum of Comparative Zoology on December 18, 1934, Dr. J. G. Myers stated that they were locally known as "Cocoa Bay Lizards" or "Cocoa Toms."

Anolis richardii Duméril & Bibron

Grenada and Tobago.

A splendid great lizard; a strict tree-dweller.

Anolis rubribarbus Barbour & Ramsden

Cuba.

Known only from a very few specimens from Puerto Cananova on the north coast of the oriental province.

Anolis quadriocellifer Barbour & Ramsden

Cuba.

Known only from the Cape San Antonio region of extreme western Cuba.

Anolis patricius Barbour

Cuba.

Only known from a series taken by Dr. Ramsden at Mina Piloto, near Sagua de Tanamo, northern coast of Oriente Province. The eastern representative of *A. quadriocellifer*.

Anolis cristatellus cristatellus (Duméril & Bibron)

Puerto Rico, Vieques, St. Thomas, Anegada, Fallen Jerusalem, Tortola, Virgin Gorda, Guana Island, Peter Island, Water Island and Mosquito Island.

A common and handsome species. It has been suggested that a separate genus be established for the fin-tailed species, but as a matter of fact this character appears in various phyla and it may not always be a token of relationship.

Anolis cristatellus wileyi Grant

Culebra.

A form differing in color, and apparently constantly, from the typical race and found on Culebra and the surrounding Cays.

Anolis cristatellus cooki Grant

Southwestern Puerto Rico.

A well defined race confined to the desert area about La Brea Point.

Anolis monensis Stejneger

Mona.

The local derivative of *A. cristatellus*. Apparently, like it, a common species.

Anolis alutaceus Cope

Cuba and Isle of Pines.

Known from all parts of the Island but nowhere abundant. A species of the low scrublands.

Anolis spectrum Peters

Cuba.

A not uncommon lizard in woodlands during the rainy season. It disappears completely during the dry portion of the year. It ties in with one of the *A. semilineatus*, *A. olssoni*, *A. hendersoni* series of Haiti as does also, I think, *A. alutaceus* and PERHAPS *A. cyanopleurus*.

Anolis cyanopleurus Cope

Cuba.

A marvelously beautiful species which Dr. Ramsden has rediscovered in the old type locality, the mountains about Guantanamo. I suspect from its habit that it must be terrestrial. It is said to be local and uncommon.

Anolis semilineatus Cope

Hispaniola.

An abundant, cursorial grass-living form.

Anolis olssoni Schmidt

Hispaniola.

Apparently a not uncommon member of the group of slender terrestrial species long confused with *A. semilineatus* and allied to *A. spectrum* of Cuba.

Anolis hendersoni Cochran

Hispaniola.

A small terrestrial species mostly, if not wholly, from the western portion of the Island.

Anolis pulchellus Duméril & Bibron

Puerto Rico, Vieques, Virgin Gorda, Tortola, Peter Island, Guana Island, Anegada, St. Thomas, St. Croix, Just van Dyke.

A common ground-living species. Doubtfully recorded from Haiti.

Anolis poncensis Stejneger

Puerto Rico.

A rare local species. One which is terrestrial and almost *Norops*-like in habit.

Anolis latirostris Schmidt

Navassa.

Known from the unique type only. Now apparently extinct. Possibly a terrestrial form, hence a prey to the cats left when the lighthouse was made automatic and the keepers were moved away. Most lizards and all snakes have probably gone from Navassa except *Anolis longiceps* which is strictly arboreal.

***Anolis stratulus* Cope**

Puerto Rico, Vieques, Culebra, St. Thomas, Tortola, Peter Island, Guana Island, Fallen Jerusalem and Just van Dyke.

A common lowland species.

***Anolis coelestinus* Cope**

Hispaniola.

I have seen this form from Haiti only and have no recent information to offer.

***Anolis dominicensis dominicensis* (Reinhardt & Lütken)**

Hispaniola.

This species is not uncommon in Haiti but seems to be rare on La Gonave. I secured a small series in 1929—but in a very dry time.

***Anolis dominicensis caudalis* Cochran**

La Gonave Island.

Representative of a plastic stock on La Gonave.

***Anolis dominicensis wetmorei* Cochran**

Beata Island.

Confined to this island where it seems to be very rare. Beata is now swarming with feral dogs, cats and goats—fauna and flora are suffering as one might expect. Ground lizards with whole tails are now rare—as soon the lizards will be also.

***Anolis dominicensis altavelensis* Noble & Hassler**

Alta Vela Island.

A rather poorly defined form.

***Anolis dominicensis juliae* Cochran**

Isle Vache.

A recently discovered form.

***Anolis distichus* Cope**

Bahama Islands.

Common on the ceiba trees on New Providence Island. It occurs on Eleuthera, Long Island, Rum Cay and Watlings Island as well. Mr. Shreve is of the opinion that the Rum Cay form may be distinct but I only got a single specimen there in 1934.

***Anolis distichoides* Rosén**

Andros Island.

A poorly defined form replacing *A. distichus*. It is very abundant.

Anolis sagrei Duméril & Bibron

Cuba and Isle of Pines; probably introduced in Jamaica and Belize.

The commonest Anolis and, as its range is wide in Cuba, perhaps this form has the largest species population in the genus. The commonest fence, house-wall and brush lizard in Cuba, by far.

Anolis ordinatus Cope

Bahamas.

Known from Turks Island to New Providence. Common everywhere. This is a derivative of the *A. sagrei* stock and only a moderately well defined species. It is much more distinct in life than in preserved form.

Anolis luteosignifer Garman

Cayman Brae.

Probably as abundant as it ever was.

Anolis longitibialis Noble

Beata Island.

The decidedly rare but well defined local representative of the *A. cybotes* stock.

Anolis lineatopus Grey

Jamaica.

The common fence lizard of the dry Liguanea Plain about Kingston. It swarms here but occurs nowhere else, so far as anyone knows at present.

Anolis homolechis Boulenger

Cuba and Isle of Pines.

A widespread and not uncommon species found in wooded ravines or lowland woods and heavy scrub.

Anolis greyi Barbour

Cuba.

Only known from a small number taken in the town of Camaguey and in the Cubitas range of hills not far away.

Anolis cybotes cybotes (Cope)

Hispaniola.

Common as are the allies of *A. sagrei* wherever they occur. This is one of a series of dominant and successful species.

Anolis cybotes doris (Barbour)

La Gonave.

I have now seen a good many specimens of this lizard. We may follow

Miss Cochran in giving it subspecific rank. This accords with current usage for these obviously derived island forms.

***Anolis angusticeps* Hallowell**

Cuba and Isle of Pines.

I consider this a really rare species in western Cuba where, however, it occurs quite widely. It is more abundant in the Isle of Pines.

***Anolis oligaspis* Cope**

Bahamas.

Found upon New Providence (Hog Id. type), Andros I., (U.S.N.M.) and Long Island (Barbour). It is the rare representative of *A. angusticeps* of Cuba. It may occur also upon other islands. Much intensive herpetological work remains to be done in the central and southern Bahama Islands.

***Anolis isolepis* Cope**

Cuba.

An excessively rare species. It occurs in the mountains of Oriente Province and apparently replaces *A. angusticeps*.

***Anolis lucius* Duméril & Bibron**

Cuba.

The abundant lizard of the limestone cliffs and open caves of central Cuba from Matanzas and Santa Clara Provinces, especially.

***Anolis argenteolus* Cope**

Cuba.

Found in the Province of Oriente. Far from rare, it occurs on rocks, cliffs and often also on building walls and fences. I have taken it on the trunks of the great *Ficus nitida* (Sp. Laurél de la India) trees which used to stand in the Plaza at Santiago.

***Anolis argillaceus* Cope**

Cuba.

I have never seen this species in life. Dr. Ramsden says it is not uncommon in the old coffee plantations high in the mountains about Guantanamo.

***Anolis bremeri* Barbour**

Cuba.

A fine, striking species, known only from the type which I took years ago at Herradura in Pinar del Rio Province. One of the most distinct species in Cuba. Its great maroon-brown gular fan is wholly unlike that of any other Anole.

Anolis loysiana Cocteau

Cuba.

A rare and bizarre little lizard. It is found sparingly all over Cuba on trees having a light colored bark. It is extraordinarily like rough bark in appearance. Some believe that the genus *Acantholis* proposed to contain this species is really valid. It becomes more common during the summer rains than it is in the dry season, our winter.

Anolis leucophaeus leucophaeus (Garman)

Inagua.

A common species.

Anolis leucophaeus albipalpebralis (Barbour)

Turks and Caicos Islands.

This species seems plastic like *A. dominicensis*.

Anolis leucophaeus mariguanae Cochran

Mariguana Island.

Another good representative race.

Anolis leucophaeus sularum Barbour and Shreve

Atwood's Cays, Bahamas.

A race, about as good as the others, which Mr. Greenway recently found on West Booby Cay in the Atwood's Cay group.

Anolis speciosus Garman

Marie Galante.

Known from Garman's types only. I did not find it in 1929.

Anolis marmoratus Duméril & Bibron

Desirade.

I know nothing of this form. Garman found it abundant in 1882.

Anolis roquet (Lacépède)

Martinique.

An abundant representative of the *A. vincentii*-*A. luciae* set of allied forms.

Anolis luciae Garman

St. Lucia.

Apparently, like so many Antillean species, whether from one reason or another much less common than formerly.

Anolis vincentii Garman

St. Vincent.

Like most of the reptiles of this Island, this species is now rare. It may descend to the ground from time to time and so fall prey to the mongoose. I should have said that most of the species of this Island are extinct.

Anolis gentilis Garman

Grenada and the Grenadines.

A rather small, inconspicuous lizard which is still abundant.

Anolis opalinus Gosse

Jamaica.

A rather rare, woodland species, most often seen in western Jamaica.

Anolis iodurus Gosse

Jamaica.

A beautiful and not uncommon little woodland species. It is found widely distributed on the Island.

Anolis grahami Gray

Jamaica.

Common in the woods of eastern Jamaica.

Anolis conspersus Garman

Grand Cayman.

A derivative of *A. grahami* of Jamaica. It is not common, but I have only been to Grand Cayman three times and it always happened to be very dry.

Norops ophiolepis (Cope)

Cuba and Isle of Pines.

A common terrestrial species usually found hiding in the heavy tufts or bunches of pasture grasses.

Cyclura figginsi Barbour

Bitter Guana Cay, near Great Guana Cay, Exuma group.

This little colony is now, I learn, almost certainly exterminated.

Cyclura portoricensis Barbour

Puerto Rico.

Extinct but relatively recent bones found in several caves.

Cyclura mattea Miller

St. Thomas.

Recently extinct, known from recent osseous remains only.

Cyclura pinguis Barbour

Anegada.

Excessively rare.

Cyclura stejnegeri Barbour & Noble

Mona.

Another rare species. This may be the same as *C. cornuta*.**Cyclura nigerrima** Cope

Navassa.

Extinct. I am not sure that this was really distinct from *C. cornuta*; in fact, I rather doubt it, but material is lacking to settle the question.

Cyclura cornuta (Bonnaterre)

Hispaniola, La Gonave, Petit Gonave and Beata Island.

Persisting only in isolated colonies on the larger island but common on Beata, although only old individuals are now to be seen. The eggs are dug up by feral dogs and if any young hatch they are devoured by the feral cats.

In the New York *Times* of Monday, February 11, 1935, there is a somewhat flamboyant account of a proposed visit of Mr. Hassler, sailing under the auspices of a large New York museum, to what is evidently Beata Island, although it is not mentioned by name. The declared purpose of the Expedition to secure the "Cannibal Iguanas" was followed by a lurid account of the fearsome mien of these peaceful old codgers. Apparently no other explanation but cannibalism could occur to the New York scientists to account for the absence of young individuals. I had just written the answer to this question by a curious chance the day before I read this issue of the *Times*. To talk of cannibalism is nonsense and this sort of publicity reflects no credit on any Museum, howsoever much it may crave notoriety.

Cyclura collei Gray

Jamaica.

Almost extinct. There are a few on Goat Island, off the Bushy Park property, and a few on the Cays about Montego Bay.

Cyclura carinata carinata (Harlan)

Turks Island.

Abundant still on some Cays near Turks Island and in the Caicos group.

Cyclura carinata bartschi Cochran

Booby Cay, east of Mariguana Island.

Said to be more or less intermediate between the preceding and following species.

Cyclura nuchalis Barbour & Noble

Fortune Island; North Cay, Fish Cay in Acklin's Bight. Tracks also seen on Guana Cay of the same group.

Abundant on Fish Cay but rare on the other islets of Acklin's Bight.

Cyclura rileyi Stejneger

Cays and west and south shores of the lagoon of Watlings Island; (Green Cay and White Cay).

Still common. *Cyclura cristata* Schmidt (type loc. White Cay) seems to be a synonym. Mr. Armour collected a series on Green Cay during the 1934 cruise of the *Utowana*.

Cyclura inornata Barbour & Noble

U Cay in Allen's Harbor near Highborn Cay, Bahamas.

Once widespread, no doubt now extirpated through use by the negroes for food. This was the only specimen which Maynard could find—a relict on a tiny islet.

Cyclura baeolopha Cope

Andros Island.

Reported to be considerably decreased in numbers.

Cyclura caymanensis Barbour & Noble

Cayman Brac and Little Cayman.

Reported still to be not uncommon.

Cyclura macleayi Gray

Cuba and Isle of Pines.

Rare. Persisting in only the wildest and most inaccessible districts.

Cyclura ricordii (Duméril & Bibron)

Hispaniola.

Long known from the type only, until rediscovered by Dr. W. L. Abbott. Now known to be not uncommon in a few scattered localities in San Domingo.

Leiocephalus carinatus carinatus (Gray)

Cuba, Isle of Pines, and Cayman Brac.

Widespread about rocky shores, headlands and sea cliffs. So far as I am aware, seldom or never seen inland, certainly never in Cuba. With its tail tightly curled over its back this lizard jumps and hops about its haunts in a most unreptilian manner. The Cayman Brac specimens may represent a separate form but material is too scant to be sure.

Leiocephalus carinatus armouri Barbour & Shreve

North Bahamas.

A distinct race confined to Grand Bahama, the Abacos and nearby Cays.

Leiocephalus carinatus punctatus Cochran

Acklin's Island, Crooked Island and the Cays in Acklin's Bight.

A good, distinct form, probably a species rather than a subspecies.

Leiocephalus carinatus picinus Barbour & Shreve

Atwood's Cay, Bahamas.

An apparently strictly localized form.

Leiocephalus carinatus helenae Barbour & Shreve

Mira por vos Cays.

Another very local race.

Leiocephalus melanochlorus Cope

Hispaniola.

Known from Jeremie in southwest Haiti to Puerto Plata in northern San Domingo.

Leiocephalus schreibersii (Gravenhorst)

Hispaniola.

A common species on Haiti. We have not seen it from San Domingo.

Leiocephalus personatus personatus (Cope)

Hispaniola.

Allied to *L. cubensis*. Miss Cochran informs me that the typical race of this species is from southwestern Haiti. I SUSPECT *L. lherminieri* (Duméril & Bibron) to be a synonym of this species. It was said to have come from Trinidad and Martinique, L'herminier, and Plée collectors, but both these gentlemen caused confusion on more than one occasion by either labelling their material incorrectly or else by shipping the results of a visit to several islands home to Paris in one lot shipment, after receipt of which the whole consignment was entered in the records of the Jardin des Plantes as having been collected at the point of shipment. This sort of thing has caused confusion for modern workers on a host of occasions.

Leiocephalus personatus aureus Cochran

Haiti.

Known only from the region about Jacmel.

Leiocephalus personatus mentalis Cochran

San Domingo.

Apparently confined to the eastern portion of the Republic.

Leiocephalus personatus scalaris Cochran

Haiti.

From the wet, heavily forested part of northern Haiti.

Leiocephalus personatus louisae Cochran

Saona Island.

Confined to this small island.

Leiocephalus eremitus Cope

Navassa.

Not found by Beck or the Clench party last year. Cats and dogs, now feral, may be to blame for the disappearance of this and other species.

Leiocephalus cubensis Gray

Cuba and Isle of Pines.

The common lizard of the canefields. I believe that investigation will show it to be very highly beneficial in controlling insects which are injurious to the industry.

Leiocephalus greenwayi Barbour & Shreve

Plana Cays, Bahamas.

A very distinct form abundant on East Plana Cay, and probably the same form occurs on the western island.

Leiocephalus psammodromus Barbour

Turks Island.

A common species and one which I at first called *L. arenarius* but found that that name had been obscurely given by Tschudi to a Peruvian species that apparently had escaped all notice of subsequent authors.

Leiocephalus varius Garman

Grand Cayman.

When on Grand Cayman the last time, four years ago, I could not find this species, but that may have been because of the terrific drought, widespread that year, over the whole Antillean region.

Leiocephalus virescens Stejneger

Green Cay, Bahamas.

Said still to be common.

Leiocephalus raviceps Cope

Cuba.

I once doubted the validity of this species but it seems to be really well defined and confined to eastern Cuba.

Leiocephalus loxogrammus loxogrammus (Cope)

Rum Cay, Bahamas.

This species will probably prove to be much more widespread than we now know it to be.

Leiocephalus loxogrammus parnelli Barbour & Shreve

Watlings Island, Bahamas.

A well defined local race.

Leiocephalus macropus Cope

Cuba.

A species found abundantly throughout the Province of Oriente but, so far as we now know, not westward of, let us say, a vertical line drawn north and south and passing about through Holguin.

Leiocephalus inaguae Cochran

Great Inagua.

Common around the coastal region of the island.

Leiocephalus semilineatus Dunn

Hispaniola.

Known only from Thomazeau, Haiti.

Leiocephalus barahonensis Schmidt

Hispaniola.

Known only from the southeastern portion of San Domingo.

Leiocephalus beatus Noble

Beata Island.

Common and the only representative of the genus which either Noble or I was able to find on the Island.

Leiocephalus vinculum Cochran

Gonave Island, Haiti.

Apparently far from abundant—at least about Anse à Galets.

Hispaniolus pratensis Cochran

Hispaniola.

Taken by Milles at St. Michel, Haiti.

Family ANGUIDAE

Celestus de la sagra (Cocteau)

Cuba.

A widespread but excessively rare and perhaps disappearing species.

Celestus rugosus Cope

Hispaniola.

Whether or not this species is really valid remains to be determined when more material comes to hand.

Celestus costatus (Cope)

Hispaniola.

This species may be the same as *C. occiduus* of Jamaica. These species all change greatly during growth and are rather in confusion taxonomically.

Celestus badius Cope

Navassa.

This species may still occur on Navassa. I have a specimen taken but a few years ago. It may be identical with *C. costatus*.

Celestus maculatus (Garman)

Cayman Brac.

A rather poorly defined but, I think, valid form apparently known from the type only.

Celestus occiduus (Shaw)

Jamaica.

A form which was once common and of which old adults reached a great size—like *Tiliqua* of Australia or *Corucia* of the Solomon Islands. No such giants now occur and the species is rare.

Celestus impressus Cope

Jamaica.

A smaller and commoner species than *C. occiduus* but still one of which we know very little.

Celestus pleii (Duméril & Bibron)

Puerto Rico.

A species which is much like its Cuban congener but apparently rather less rare.

Sauresia sepoides Gray

Hispaniola.

I once sunk this genus into *Celestus* but the consensus of opinion is that I was wrong. It seems really to be not uncommon.

Wetmorena haetiana Cochran

Hispaniola.

Known from a few examples taken by Wetmore in the higher regions of the La Selle massif in Haiti.

Family XANTUSIIDAE

Cricolepis typica (Gundlach & Peters)

Cuba.

Confined to the area, of a few square miles at most, between Belig and Cabo Cruz, Oriente, Cuba.

Family TEIIDAE

Kentropyx intermedius Gray

Northern South America, Barbados.

This species apparently was formerly common on Barbados but it is now wholly extinct on that Island. Garman named (*K. copei*) but did not describe this species. I have recently seen material from Demarara and there is no doubt as to the identity of the Barbados lizards with those from British Guiana. It may have been artificially introduced into Barbados.

Ameiva aquilina Garman

St. Vincent and Grenada.

Extirpated on St. Vincent but still persisting on Grenada.

Ameiva fuscata Garman

Dominica.

Owing to the absence of the mongoose this, the finest of all the Antillean Ameivas, is still a common species.

Ameiva cineracea Barbour & Noble

Guadeloupe.

Extirpated except for a few individuals which persist on the tiny islets off the coast.

Ameiva atrata Garman

Redonda.

A black species superficially like *A. corvina* and living under similar conditions. It has not been collected recently, probably only because the Island is now almost never visited.

Ameiva pluvianotata Garman

Montserrat.

I have just learned that this species is still very common all over the Island.

Ameiva erythrops Cope

St. Eustatius.

Peters found this form abundant in 1922.

***Ameiva griswoldi* Barbour**

Antigua and Nevis.

Extinct on Nevis, it is also almost gone on Antigua where it persists only right in the town of St. John in yards and gardens.

***Ameiva erythrocephala* (Daudin)**

St. Kitts.

Extirpated from the wilder parts of the Island; it still occurs in the gardens and yards of Basseterre. Here it is safe from the mongoose.

***Ameiva garmani* Barbour**

Anguilla.

This species is still abundant. It is closely allied to *A. pleii*.

***Ameiva pleii* Duméril & Bibron**

St. Barts and St. Martin.

We have again no recent information to indicate that this is not still an abundant species.

***Ameiva corvina* Cope**

Sombrero.

A black form which, like so many Lacertids and some species of *Chemidophorus* and indeed another *Ameiva*, has this peculiar coloration associated with isolation on a very small, arid, sunbaked and rocky island.

***Ameiva polops* Cope**

St. Croix.

Extinct, but very few specimens have been preserved.

***Ameiva wetmorei* Stejneger**

Puerto Rico.

Rare and confined to the arid zone about Guanica. Schmidt defines its range as the limestone hills about Ensenada and on Caja de Muertos Island. This species also belongs to the *lineolata-maynardi-polops* stock, which thrives only in arid areas.

***Ameiva eleanorae* Grant and Roosevelt**

Caja de Muertos.

A rather ill-defined form confined to this tiny islet off the coast of Puerto Rico.

***Ameiva maynardi maynardi* Garman**

Great Inagua.

A beautiful species of the *A. lineolata* series, north and west coasts of Inagua. *A. leucomelas* Cope 1894 is a synonym.

Ameiva maynardi uniformis Noble & Klingel

Great Inagua.

Found commonly from Southwest Point to Couch Shell Point, replacing the typical form.

Ameiva alboguttata Boulenger

Mona Island.

According to recent accounts still abundant. Closely related to the Puerto Rican form next following.

Ameiva birdorum Grant

Diablo Key near Fajardo, Puerto Rico.

A good, distinct form confined to a tiny island of but about ten acres, but what a horrid name it bears!

Ameiva exsul Cope

St. Thomas, Water Island, St. John, Peter Island, Buck Island, Guana Island, Vieques, Anguilla, St. Croix and Puerto Rico.

Now exterminated on St. Thomas. I have always doubted the St. Croix record. It is common where it still occurs at all.

Ameiva vittipunctata Cope

Hispaniola.

A very beautiful and apparently not very common form.

Ameiva taeniura Cope

Hispaniola.

When Dr. Noble and I prepared our Revision of *Ameiva* in 1915, I think I was principally to blame for concluding that this species was the young of *A. lineolata*. Miss Cochran has shown that this is untrue and that the species is perfectly valid.

Ameiva lineolata Duméril & Bibron

Hispaniola.

Widespread and abundant.

Ameiva chrysolema chrysolema Cope

Hispaniola, La Gonave.

A very common and widely spread species. A large series taken last year at Anse à Galets, La Gonave Island.

Ameiva chrysolema abbotti Noble

Beata Island.

Common on this beautiful and generally uninhabited Island.

***Ameiva chrysoleama juliae* Cochran**

Haiti, Isle Tortue.

***Ameiva barbouri* Cochran**

La Gonave Island: La Source.

Taken only by Eyerdam in 1927. I did not find it when on La Gonave in 1929 and November, 1934. Although I secured a great number of *Ameivas*, all were *A. chrysoleama chrysoleama*.

***Ameiva thoracica* Cope**

Bahama Islands.

Now known to be widespread in the northern and central portion of the Bahama archipelago.

***Ameiva dorsalis* Gray**

Jamaica.

Formerly abundant, then, after the mongoose came, pretty well reduced—almost exterminated. Now recovering slightly in numbers in the cities and settlements where the mongoose population is kept in hand.

***Ameiva auberi* Cocteau**

Cuba and Isle of Pines.

Nowhere abundant but very widely distributed. Perhaps most frequently seen along railway embankments.

***Ameiva rosamondae* Cochran**

Saona Island.

A most beautiful and very distinct species. The most brilliantly colored of the entire genus. It is distinctly a rare form.

***Ameiva beatensis* Noble**

Beata Island.

I found this species much less common than *A. chrysoleama abbotti* on recent visits to Beata.

***Ameiva navassae* Schmidt**

Navassa.

Known from the type only, taken by R. H. Beek in 1917. Not found by the last collectors in 1930.

***Scolecocaurus alleni alleni* (Barbour)**

Grenada.

A distinct and not uncommon species of the wet spice gardens. This little creature is most commonly found under heaps of half decayed cocoa pods.

Scolecosaurus alleni parviceps Barbour

Cannouan Island.

Known from a single specimen taken by Dr. David Fairchild while on the *Utowana*. The genus probably occurs on all the Grenadines.

Gymnophthalmus pleei Bocourt

St. Lucia and Martinique.

Extinct on Martinique. Excessively rare on St. Lucia.

Whether *G. luetkenii*, also of Bocourt, from "St. Lucia" is really distinct or whether it ever came from St. Lucia will, in part, be solved finally only by examination of the type. Only *pleei* was found on these two islands by Garman, who took a good series before it was exterminated. Parker, who records the one specimen taken in 1932, remarks that its characters tend to confirm the supposition that there is only one West Indian species.

Family AMPHISBAENIDAE

Cadea palirostrata Dickerson

Isle of Pines.

A very distinct and abundant species.

Cadea blanoides Stejneger

Cuba.

Rare and confined to Matanzas, Havana and Pinar del Rio Provinces.

Amphisbaena fenestrata Cope

Tortola, St. Thomas, St. Croix and St. John.

This form may be found to be still more widely distributed.

Amphisbaena bakeri Stejneger

Puerto Rico.

Rare and local.

Amphisbaena caeca Cuvier

Puerto Rico.

Not very uncommon.

Amphisbaena manni Barbour

Hispaniola.

This form seems to be about equally abundant with *innocens*.

Amphisbaena innocens Weinland

Hispaniola.

Not uncommon in Haiti.

Amphisbaena cubana Peters

Cuba.

Common in Central Cuba. Best found by following plows.

Amphisbaena caudalis Cochran

Grande Cayemite Isl., Haiti.

Known from but two examples taken by Eyerdam in 1927. It is allied to *A. innocens*.

Family SCINCIDAE

Mabuya mabouia (Duméril & Bibron)

From Mexico and the Bahamas through the West Indies and on the mainland south to Trinidad and Patagonia. Absent from Cuba.

Any number of races have been recognized and named from time to time, some confined to single islands and others to island groups, but with large series all of these forms break down. Incipient races there are beyond doubt but apparently the inherent fluidity or variability within the species has prevented these races from becoming fixed. My friend, Professor E. R. Dunn, supplies me with this information *in litteris*.

Skinks are apparently extinct on the following islands where once they were known to occur: St. John, St. Lucia, St. Vincent, Grenada, Barbados, Martinique.

Mabuya lineolata Noble & Hassler

San Domingo.

A fine distinct species which has recently been found. It must be very rare to have eluded collectors for so long. The mongoose is abundant in San Domingo to be sure, but the early collectors all failed to find the skink.

Suborder *OPHIDIA*

Family TYPHLOPIDAE

Typhlops tenuis Salvin

Mexico, Guatemala and Andros Island.

Rosén got what he called this species at Mastie Point in 1910. I have never felt very sure that it was not an undescribed form wrongly identified.

Typhlops rostellatus Stejneger

Puerto Rico.

Seems to be related to *T. dominicana*. Perhaps other species remain to be uncovered in the Lesser Antilles.

Typhlops richardii Duméril & Bibron

St. Thomas, Tortola, St. John.

Typhlops pusillus Barbour

Hispaniola.

Not uncommon in Haiti.

Typhlops dominicana Stejneger

Dominica and Guadeloupe.

The specimens from Martinique should belong here, one would suppose, rather than to *T. jamaicensis*. More material is highly desirable from all of the islands.

Typhlops platycephalus Duméril & Bibron

Puerto Rico, Vieques, Culebra.

Apparently fairly well differentiated though long confused with *T. jamaicensis*.

Typhlops sulcatus Cope

Navassa.

May not really be a valid species. It has not been found by the recent collectors.

Typhlops jamaicensis (Shaw)

Jamaica.

A common form.

Typhlops monensis Schmidt

Mona Island.

A little known member of the *T. lumbricalis* series. This species is not very sharply defined. Only two specimens are known and more material is desirable and no doubt still obtainable.

Typhlops lumbricalis (Linné)

Cuba, Hispaniola, Andros, New Providence and Abaco.

Common everywhere and no doubt fortuitously introduced into the Bahamas.

Typhlops granti Ruthven & Gaige

Caja de Muertos, 18 miles off Ponce, Puerto Rico.

Family LEPTOTYPHLOPIDAÉ

Leptotyphlops albifrons (Wagler)

Watlings Island, Antigua, Grenada and with a wide range in tropical America.

This tiny burrowing snake has an erratic distribution and has probably been carried about by primitive man, being occasionally introduced with material intended for garden planting.

Leptotyphlops bilineata (Schlegel)

Martinique, St. Lucia, Guadeloupe and Barbados.

This, another tiny species, may have a considerably wider range among islands than we now know.

Family BOIDAE

Epicrates angulifer Bibron

Cuba and Isle of Pines.

Formerly common everywhere, now confined to the wilder regions, although individuals occasionally stray into the cultivated areas. The great extension of cane cultivation has decimated this species. Every cane cutter carries a machete all the time and uses it on every snake.

Epicrates striatus striatus (Fischer)

Hispaniola.

This form seems to be really uncommon.

Epicrates striatus strigilatus (Cope)

Andros and New Providence in the Bahamas.

The fowl snake of the Bahamas was formerly abundant and may still be found but it is ruthlessly killed by the natives on account of its fondness for poultry. Stull believes these two forms to be separable.

Epicrates striatus chrysogaster (Cope)

Turks Island.

Of this form I have no recent information, except that it is said to be rather common on some of the Turks Island Cays.

Epicrates relicquus Barbour & Shreve

Sheep Cay off Gt. Inagua Island, Bahamas.

This is no doubt the extirpated boa of Great Inagua, persisting on this islet to which no feral animals have been carried.

Epicrates inornatus inornatus (Reinhardt)

Puerto Rico.

Now a really rare species and one which is related to the large boas of Cuba, Jamaica and Hispaniola.

Epicrates inornatus granti Stull

Tortola and Guana Island.

Known from the single specimen taken by Major Chapman Grant on Tortola. He learned that it occurs in the rocky cliffs of Guana Island also.

Epicrates fordii fordii (Günther)

Hispaniola.

More information concerning this species will be awaited with interest. It is certainly very rare. I recently got one at Cap Haitien.

Epicrates fordii monensis Zenneck

Mona.

A very little-known species but one which I believe to be most closely allied to *E. fordii*. This combination of names is by Stull, the most recent reviser of the Boidae.

Epicrates subflavus Stejneger

Jamaica.

I had supposed this species gone in Jamaica itself but Mr. Frank Cundall of the Institute of Jamaica at Kingston has one alive, from the southeast part of the Island. It persists on Goat Island off the south coast, in small numbers.

Epicrates gracilis (Fischer)

Hispaniola.

I have never seen a specimen of this form in all the Haitian material which has passed through my hands. As described it has a very peculiar and unique color pattern but modern material would be very welcome.

Boa cookii grenadensis (Barbour)

Grenada.

I may not have been justified in separating this form from *B. cookii*. I am, however, inclined to believe that it is fairly well differentiated and stabilized.

It is not very rare.

Boa hortulana Linné

St. Vincent, Grenada, The Grenadines and Trinidad, widespread on the mainland.

The species still occurs on Grenada and may, being arboreal, persist on St. Vincent. This, however, I am inclined now to doubt.

Constrictor constrictor orophias (Linné)

St. Lucia, Dominica.

The "tête chien" is rare on St. Lucia but still occurs—and even, occasionally at least, eats a mongoose. On Dominica it is less uncommon. There is a Zoological Park (Phila.) record for St. Kitts which I believe to be incorrect; captive snakes get carried far and wide and dealers convey notoriously inaccurate locality records. There are also records from Trinidad but my friend, Mr. Urich, a most competent resident authority, told me that the species does not occur in Trinidad. It is confined to two islands only.

Tropidophis maculatus maculatus (Bibron)

Cuba and Isle of Pines. Found sparingly in western Cuba and the Isle of Pines.

I am following Miss Stull's conclusions in the taxonomy of this genus. I am not wholly convinced of the relationships implied, but her work has been most painstaking and is based on all available material.

Tropidophis maculatus jamaicensis Stull

Jamaica.

Excessively rare, almost extinct, since the introduction of the mongoose.

Tropidophis maculatus haetianus (Cope)

Hispaniola.

Not uncommon all over the Island.

Tropidophis pardalis pardalis (Gundlach)

Cuba and Great Abaco Island.

This is a most unlikely distribution. Artificial introduction is possible but most improbable. Convergence to identity or persistence of a type on Abaco, which has differentiated on other Bahama Islands from a once widespread form, is a scarcely satisfactory explanation, either.

Tropidophis pardalis canus (Cope)

Great Inagua, Eleuthera Islands, Cat Island, and Long Island.

Common on Eleuthera but now very rare on Inagua.

Tropidophis pardalis curtus (Garman)

New Providence, Bahamas.

A common form. It occurs under stones of walls and in the rocks heaped about the orange trees. Since it at times sallies forth after heavy rains, it is locally called "thunder snake." Like all its congeners, it is nocturnal.

Tropidophis pardalis androsi Stull

Andros Island.

Apparently abundant but I have never happened to see a specimen.

Tropidophis pardalis bucculentus (Cope)

Navassa.

Known from but three specimens, it has not been found by recent expeditions.

Tropidophis wrighti Stull

Cuba.

Known, so far as I am aware, from the type only. This was taken by

Charles Wright, the botanist, who collected for a long time in the Guantanamo Basin and, I think, nowhere else in Cuba.

Tropidophis melanurus (Schlegel)

Cuba.

The largest member of the genus, reaching a length of nearly a yard. It is abundant and widespread. It feeds on frogs, lizards and birds. Although more inclined to be arboreal than the other species of the genus, it is equally nocturnal and perhaps the most abundant of them all.

Tropidophis semicinctus (Gundlach & Peters)

Cuba and Isle of Pines.

Widespread but distinctly uncommon.

Family COLUBRIDAE

Natrix compressicauda Kennicott

Cuba, Florida Keys, extreme southwestern Florida.

My finding this species in mangroves near Caibarien on the north coast of Cuba established the specific identity of the excessively rare Cuban *Natrix* and relegated several long questioned names to a definite synonymy.

Tretanorhinus variabilis Duméril & Bibron

Cuba.

Not uncommon in fresh-water ponds and rivers. A nocturnal species. Its mainland ally, *T. nigroluteus*, is rather partial to mangrove swamps.

Tretanorhinus insulae-pinorum Barbour

Isle of Pines.

This species seems to have regularly 19 rows of scales while the Cuban snakes have 21. This is, at first sight, a trivial character but one which is apparently really diagnostic.

Drymobius boddaerti bruesi (Barbour)

St. Vincent and Grenada.

Extinct on St. Vincent but still to be found on Young's Island off its coast and very rare in Grenada. Mr. Shreve believes that with more material from Young's Island another race might be named. My friend, Mrs. Gaige, advised me to resurrect my name *bruesi* for this race which I first applied with the idea that the Grenadian snake was an *Alsophis*.

Uromacer oxyrhynchus Duméril & Bibron

Hispaniola and Isle Tortue.

A form found all over the Island, i.e., both Haiti and San Domingo. I have seen it from Port au Prince and Samana.

Uromacer frenatus (Günther)

Hispaniola and Isle Tortue.

We now have a fine series of this species.

Uromacer wetmorei Cochran

Beata Island.

A valid form related to the preceding.

Uromacer catesbyi (Schlegel)

Hispaniola and La Gonave.

A widespread but rather rare species.

Uromacer scandax Dunn

Isle Tortue, near Haiti.

An abundant ally of *U. catesbyi*.

Uromacer dorsalis Dunn

La Gonave Island.

Apparently a derivative of the Haitian *U. frenatus*.

Alsophis anomalus (Peters)

Hispaniola and Isle Tortue.

I have but little information to give concerning this species. Dr. G. M. Allen took one at Port au Prince in 1919. I took one on Isle Tortue during the *Utowana* cruise of 1934, besides which I have received no other recent specimens.

Alsophis leucomelas leucomelas (Duméril & Bibron)

Guadeloupe and Marie Galante.

Extinct on both islands.

Alsophis leucomelas sanctorum (Barbour)

Les Saintes Is. near Guadeloupe.

No doubt abundant still.

Alsophis leucomelas sibonius (Cope)

Dominica.

With no mongoose on this island, the species should be abundant still. There are still great areas of wild land on Dominica.

Alsophis leucomelas manselli Parker

Montserrat.

Still to be found.

Alsophis leucomelas antiguae Parker

Antigua.
Extinct.

Alsophis sanctae-crucis Cope

St. Croix.
Extinct.

Alsophis melanichnus Cope

Hispaniola.

We await more information concerning this snake with great interest. Its non-appearance in any of the collections which have come before me is perhaps indicative that it is fast disappearing.

Alsophis ater (Gosse)

Jamaica.

Very rare indeed. A species which has suffered fearfully from the ravages of the mongoose. Dunn has shown that this is related to *A. melanichnus* Cope of Haiti.

Alsophis rijgersmaei Cope

St. Martins, St. Barts and Anguilla.

No herpetologist has visited St. Martins in recent years, but Dunn has re-examined the types and considers that Garman's name of *Alsophis cinereus* cannot stand as valid.

Alsophis variegatus (Schmidt)

Mona Island.

Probably still abundant.

Alsophis portoricensis (Reinhardt & Lütken)

Puerto Rico, Desecheo and Caja de Muertos Island.

A distinctly rare form.

Alsophis anegadae Barbour

Anegada.

I still feel that this form warrants recognition as valid. Its peculiar pattern is characteristic of every Anegada specimen which I have seen, even though it occurs very sporadically elsewhere, where other patterns are the place mode.

Alsophis antillensis (Schlegel)

St. Thomas, Salt Island, Peter Island, St. John, Tortola, Virgin Gorda and Puerto Rico, also Culebra, Pinero and Dog Island.

Extinct on St. Thomas, rare on Puerto Rico, elsewhere abundant.

Alsophis rufiventris (Duméril & Bibron)

Saba, St. Kitts, St. Eustatius and Nevis.

Still abundant on Saba and St. Eustatius but extinct on the other two islands.

Alsophis vudii vudii Cope

Bahama Islands.

This racer is common throughout most of the middle group of Bahama Islands:—New Providence, Eleuthera, Long Island, Green Cay, the Exuma Cays, Andros Ids. and no doubt upon many others.

Alsophis vudii aterrimus Barbour & Shreve

Grand Bahama.

A black racer, not brown or grayish, perhaps confined to this little-known island.

Alsophis vudii raineyi Barbour & Shreve

Crooked Isl., Bahamas.

A well defined local form.

Alsophis vudii utowanae Barbour & Shreve

Sheep Cay off Great Inagua Isl., Bahamas.

Another distinct relict on Sheep Cay which was no doubt common on Great Inagua before the introduction of so many domesticated animals which have become feral.

Alsophis fuscicauda Garman

Cayman Brac.

I will not feel certain of the status of this species until much more material is secured.

Alsophis caymanus Garman

Grand Cayman.

I have never seen sufficient material to decide whether this form is really different from that of Cuba.

Alsophis angulifer Bibron

Cuba and Isle of Pines.

A very common species in all open plains, pastures and savannas.

Dromicus andreae andreae Reinhardt & Lütken

Cuba.

A common snake at pastures and open fields.

Dromicus andreae nebulatus (Barbour)

Isle of Pines.

Another common form. It is closely related to the foregoing species, indeed closely similar specimens occur also in extreme eastern Cuba. We should probably recognize three races or abandon this name.

Dromicus callilaemus Gosse

Jamaica.

Small and more retiring, this species is not so near extermination as *L. ater*. Nevertheless it is a distinctly rare snake.

Dromicus juliae Cope

Dominica.

Probably still not uncommon.

Dromicus melanotus (Shaw)

Grenada, Trinidad and Venezuela.

Extinct apparently on Grenada but common elsewhere.

Dromicus perfuscus Cope

Barbados.

Extinct.

Dromicus mariae (Barbour)

Marie Galante.

Extinct.

Dromicus boulengeri (Barbour)

St. Lucia.

Extinct.

Dromicus cursor (Lacépède)

Martinique.

Extinct.

Dromicus anegadae (Barbour)

Anegada.

We have no recent information concerning this form but no reason to suppose that it is not still abundant.

Dromicus exiguus Cope

St. Thomas, St. John and Culebra.

Extinct on St. Thomas, it is probably not uncommon on the other islands.

Dromicus stahli (Stejneger)

Puerto Rico.

Still not uncommon, widely distributed and confined to this Island.

Dromicus alleni (Dunn)

La Gonave Island.

A distinct and striking island form.

Dromicus parvifrons parvifrons (Cope)

Hispaniola.

One of several races which appear to be common, reasonably well localized in southwest Haiti and probably valid.

Dromicus parvifrons niger (Dunn)

Hispaniola.

This form inhabits most of San Domingo.

Dromicus parvifrons protenus (Jan)

Hispaniola.

A common widespread form. Known from many localities in northern and central Haiti and the higher plateau of San Domingo.

Dromicus parvifrons lincolni (Cochran)

Beata Island.

A slightly differentiated form.

Dromicus parvifrons tortuganus (Dunn)

Isle Tortue.

Another well marked form of which we took a good series during the visit of the *Utowana* to this island in 1934.

Dromicus parvifrons rosamondae Cochran

Isle Vache.

A fairly well defined form based on a good series of specimens.

Hypsirhynchus ferox Günther

Hispaniola.

This species is strictly nocturnal and oviparous. In my experience, it is restricted apparently to the Cul de Sac area not far from Port au Prince. Dunn has discarded the genus *Hypsirhynchus*. I believe that this sluggish, nocturnal form is well worthy of generic distinction.

Arrhyton taeniatum Günther

Cuba.

An uncommon species, like its fellow, found by day under stones or while plowing. At night it is sometimes met with abroad.

Arrhyton vittatum (Gundlach & Peters)

Cuba.

I now consider that there are but two species of this genus peculiar to Cuba. Several other names have been given, as I believe, to individual variants only. These snakes are probably allies of *Contia* of the mainland.

Darlingtonia haetiana Cochran

Haiti.

An extraordinary new genus recently found by Dr. Darlington of Harvard at Roche Croix, in the northeastern foothills of Morne La Hotte, at 5,000 ft. altitude. Its affinity may be with the preceding genus but it is very well defined.

Pseudoboa cloelia (Daudin)

Dominica, St. Lucia, Grenada, Trinidad and tropical America generally.

This species is surely extinct in St. Lucia, probably excessively rare on Grenada and its status on Dominica is still, no doubt, unchanged. I have never, however, seen or heard of recent specimens from any of the islands. Nevertheless, I think the records are really based on valid wild-caught specimens.

Pseudoboa neuweidii (Duméril & Bibron)

Grenada, Trinidad and with a wide range in tropical America.

Garman took three examples on Grenada during the Blake Expedition about 1883. So far as I can learn it has never been taken before or since.

Ialtris dorsalis (Günther)

Hispaniola, Isle Vache.

A large and uncommon species which has been found in both Haiti and San Domingo. It seems to have no close allies among Antillean reptiles and to be very rarely collected indeed.

Ialtris parishi Cochran

Haiti.

Known only from southwestern Haiti.

Family CROTALIDAE

Bothrops atrox (Linné)

Martinique and St. Lucia.

Whatever may be the origin of the Fer-de-lance's appearance on these islands, one thing Amaral has definitely proved—the snake is the common wide-ranging form of tropical America.

Order *CHELONIA*

Family TESTUDINIDAE

Testudo tabulata Walbaum

Tropical South America, feral on Lovango Cay and Water Island, near St. Thomas.

Often carried to most of the islands from South America. By no chance a native element of the true Antillean fauna.

Family EMYDIDAE

Pseudemys ssp.

Cuba, Jamaica, Hispaniola, Puerto Rico.

Unfortunately it is not yet possible to settle the taxonomic status of the various Greater Antillean pond tortoises. There may be several forms on each of the larger islands but until sundry type specimens are located in European museums it is silly and futile to try to allocate names.

Pseudemys felis Barbour

Cat Island.

A recent extraordinary surprise from the Bahamas.

Order *LORICATA*

Family CROCODYLIDAE

Crocodylus rhombifer Cuvier

Cuba and Isle of Pines.

Found in the Zapata Swamp in Cuba and no doubt still also in the Cienaga of the Isle of Pines. Specimens more than six feet long are now much less often seen than a generation ago.

Crocodylus acutus Cuvier

Cuba, Jamaica and Hispaniola; as well as extreme southern Florida and the Keys and Central America.

Crocodylus intermedius Graves

Orinoco Basin.

Accidental in Grenada, Sept. 6, 1910.

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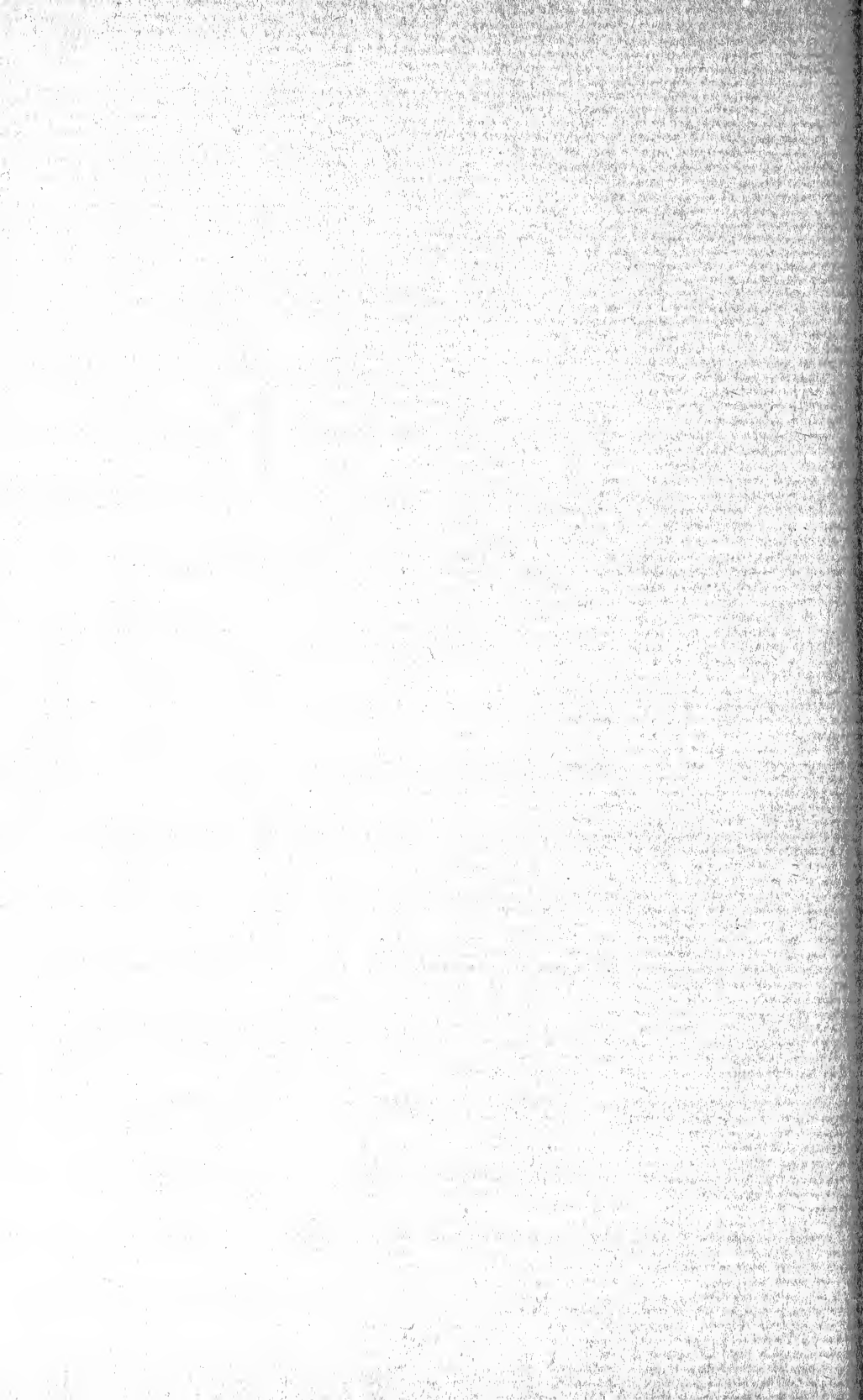
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THE REPRODUCTIVE HABITS OF THE COMMON
CATFISH, *AMEIURUS NEBULOSUS* (LE SUEUR),
WITH A DISCUSSION OF THEIR SIGNIFICANCE
IN ONTOGENY AND PHYLOGENY.

C. M. BREDER, JR.

New York Aquarium.

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(Figs. 12-23 incl.)

INTRODUCTION.

A considerable number of students have observed and described the reproductive habits of the common catfish, *Ameiurus nebulosus* (Le Sueur). They have in no case, however, attempted to analyze critically the possible ontogenetic and phylogenetic significance to be attached to the various details of the procreational behavior. It is the purpose of the present communication, therefore, to consider the biological import of the various items involved, especially in the light of detailed observations on four successive seasons of activity by two pairs of fish. These observations are supported by others in less detail, both in the laboratory and in the field, as well as by general agreement with the observations of Girard (1854), Eycleshymer (1901), Smith (1903), Smith and Harron (1904), Gill (1907 a and b), Hankinson (1908), Forbes and Richardson (1909), Wright and Allen (1913), McAtee and Weed (1915), Fowler (1917), and Adams and Hankinson (1928). A general account of the observations made the first year has already been published. (Breder 1932.)

Another reason for pursuing this study was to facilitate a comparison of reproductive habits between unrelated groups of fishes that have superficially similar behavior patterns. For example, the nest building habits of certain cichlids seem to be rather similar in the principal design. A study of one of these, *Aequidens latifrons*, has already been published, Breder (1934 a). In this the present study has been mentioned. The details of comparison, however,

have been withheld for the present paper and are here treated in full. A further reason for making the present study involves the problem of the genesis of oral incubation in fishes. The mode of origin in the Cichlidae has already been discussed in the paper above referred to. (See also Breder 1933 b.). Details of its probable origin in the Nematognathi are discussed herein, while the origin of this habit in the labyrinth fishes will appear in a subsequent paper based on a similar study of the genus *Betta*.

All of the observations here described refer to studies made in the tanks of the New York Aquarium, unless mention is made to the contrary. The photographs of *Ameiurus* are all the work of S. C. Dunton of the Aquarium staff, whose intelligent efforts made possible these pictures of an intrinsically difficult subject. Appreciation is also expressed for the helpfulness of Mr. H. E. Dixon, in charge of temperate fresh water fishes at the Aquarium. The data concerning *Opladelus* were kindly supplied by Mr. W. H. Chute, director of the Shedd Aquarium, at which institution the observations were made. The photographs of this species were taken by L. Tutell.

INFLUENCE OF CAPTIVITY.

Under the conditions in the exhibition tanks in which the catfish are displayed at the New York Aquarium, their health and activity appear to be entirely normal. Reproductive activity, however, was formerly unknown. This condition was under the author's personal observation from 1921 to 1930 inclusive, a period in which ten reproductive seasons passed with no such activity. The fishes usually numbered from eight to twelve mature specimens. They were confined in a glass-fronted aquarium measuring 44 inches deep, 51 inches long and 34 inches wide at the surface, the back sloping down to a width of 26 inches at the bottom. The water supply, New York City tap water, fluctuated with the season between an extreme winter low of 4.4° C. and a summer high of 23.3° C. Food consisted chiefly of fish flesh and beef heart. During the colder months little or no food was taken.

As the spawning season approached some of the specimens, presumably females, became larger in girth, seemingly with developing roe. Occasionally one or more fish made what appeared to be a desultory effort at fanning detritus from a corner. These two facts were the only ones that even suggested the passing of the spawning

season. An effort to induce spawning, when such activity had been noted, was made on August 12, 1931. Breder (1932) wrote, "In order to encourage them as much as possible, two days later a few rocks were so arranged as to form a shelter to which they might retire. Almost at once they began to investigate the structure and apparently satisfied with it cleared away all the gravel under the most sheltered part down to the bare concrete base of the tank." Spawning occurred on August 18.

The attention of the parents was so largely occupied in defending the nest against the attempted depredations of their tank mates that the latter were removed and the breeding pair were left alone in the same aquarium until the next season, when they spawned twice in 1932. Two other fish, which appeared to be a male and female, were taken from the original group now housed in another tank, in the spring of 1932. These spawned almost immediately, under a similar rock structure, and a second spawning followed. They were left alone in their tank through the season of 1933, when spawning occurred once and twice in 1934. The original pair spawned twice in 1933. The data concerning these specimens are listed in Table I, with the pairs designated A and B, respectively. Other specimens, more than two to an aquarium, showed no spawning activity, nor did specimens of *Ameiurus natalis* (Le Sueur) or *A. catus* (Linnaeus) which could not be given exclusive quarters because of limitations in the number of available aquaria. It has been noted previously by Kendall (1910) that *A. nebulosus* may spawn more than once a season.

It would consequently appear that under such conditions the chief inhibition to the reproduction of *Ameiurus* is the lack of a suitable spawning site, and crowding. While it might well be supposed that spawning occurred every year, and that the products were simply immediately engulfed by the tank mates of the parents, there is reason to believe that no spawning took place in these relatively crowded tanks. Since the known spawnings took place in the early morning or forenoon, it is extremely unlikely that in ten years the keeper would have failed each time to find even a remnant of the egg mass or any other evidence of spawning. Further, the immediate collapse of the female's sides on spawning is very noticeable and not readily overlooked, while those fish distended in a crowded tank were noted to reduce slowly in girth over a period of about two months, as though the eggs were being resorbed.

If this interpretation can actually be shown to be the case then some reflex, operating through some neuro-endocrine mechanism, would have to be invoked. If such could be shown to be in operation it would have a significant bearing on many problems concerned with the effect of population density and its relation to the reproductive rate. At least this study has demonstrated that given two healthy *Ameiurus*, physiologically capable of reproduction, isolation in an aquarium provided with a rock or similar shelter will practically insure their spawning.

TABLE I. DATA ON THE SPAWNING OF *AMEIURUS NEBULOSUS*.

Spawning	Pair	Spawning Date	Hatching Date	Date young fish left bottom	Temp. ° C. ³	Days to hatch	Days to swim	Refers to figure
1	A ¹	Aug. 18, 1931	Aug. 24	Sept. 3	21.1	6	10	20 and 21
2	A	July—1932	—	—	20.7 (mean)	—	—	18 and 19
3	B	July—1932	—	—	22.0 (mean)	—	—	—
4	A	Aug.—1932	—	—	21.1 (mean)	—	—	—
5	B	Aug.—1932	—	—	21.1 (mean)	—	—	—
6	A ²	July 15, 1933	July 25	Aug. 10	21.1	10	16	12 and 13, 17
7	B	July 22, 1933	—	—	21.1	—	—	—
8	A	Aug. 13, 1933	Aug. 22	—	21.1	9	—	14 and 15, 16
9	B	July 5, 1934	July 11	July 18	23.3	6	7	—
10	B	Aug. 7, 1934	Aug. 15	—	23.3	—	—	—

¹ Other fishes present in the aquarium at this spawning.

² Eggs removed to laboratory, the dates of hatching et cetera, referring to the artificially incubated eggs.

³ Temp. read at time of ovaposition except "means" which are for the current month.

SPAWNING.

The details of the reproductive act as here described are a composite of observation for four consecutive seasons compared with details given in the literature by others. The data covered by the spawnings studied are given in Table I.

On finding a spot to her liking, a gravid female catfish will proceed to modify it further to suit her purpose. The male will also partake in this activity, at least in some cases. In the aquarium studied, only a thin layer of sand and pebbles covered the concrete bottom. Consequently these fishes had little excavating work to do. The results of their labors may be seen in Figure 12 and in all subsequent pictures. The differences between the three successive years may be noted, as Figures 12 to 17 inclusive are of 1933, Figures

18-19 of 1932, and Figures 20-21 of 1931. The removal of the sand and gravel, so far as seen, was accomplished exclusively by pushing and exerting vigorous swimming motions close to the bottom. The size of the objects dislodged may be judged from the illustrations.

Others, with different conditions, made various observations; the difference probably represented merely the degree of adaptability, in the matter of nest building, that these fishes possess. Smith (1903) writes, "They made a nest on July 3, 1902, by removing in their mouths upwards of a gallon of gravel from one end of the tank leaving the slate bottom bare." Fowler (1917) remarks of this species, "It nests in various situations, or in water from several feet in depth to that of but a few inches. Though only a few nests were noticed in a restricted area, sometimes a dozen or more may be found on one shoal and close to one another. Frequently the fish take advantage of any objects, such as logs, rocks, et cetera, for sheltering the nest. There is always a great range of variation in many of these features, especially due to the individuals and conditions. No two nests were ever found exactly alike, and the same was true of the spawners." Gill's (1907a) drawing of an *Ameiurus* nest (ideal) is not like any described in the literature or seen by the author, but more nearly resembles a centrarchid nest.

Sex recognition is not understood in this species and there seems to be no fighting for mates. However, Kendall (1910) describes marks on males that suggest fighting. It would seem that when moved by the developing gonads, the fishes seek out holes and begin excavating. This is apparently the primary basis, but just how a male and a female come to occupy a single cavity, instead of two fish of the same sex, is not clear. Pearson and Miller (1935) describe large aggregations of mature and nearly ripe *Ameiurus natalis* in Florida on May 6 along the shore line. This would seem to be a preconnubium. Injuries were noted on the dorsal and caudal fins, as well as elsewhere. These, the writer suggests, may be due to the attacks of garfish, specimens of which were numerous. It would seem likely, however, that some of the injuries, at least, were due to the catfish mauling each other. It is suspected that tactile, olfactory and gustatory senses play a part, since a pair may be frequently seen going over one another with their highly sensitive barbels. Since *Ameiurus* is such a chemically sensitive fish, as is well-known, and since its optical apparatus is so poorly developed,

this suspicion becomes not unlikely. If such is the case it is not remarkable that the detection of acts of sex recognition is difficult to humans. The transliteration of the impulses received, and the corresponding reactions of an animal living largely in a world of tactile and chemical stimuli to another living largely in a world of visual and auditory stimuli, is certainly apt to be difficult except in the simplest cases. That *Ameiurus* is capable of sound production is well known, as is the fact that most, if not all, Nematognathi are well marked in this respect. If the sounds that the common catfish produces have any significance in sex recognition, no evidence of it has yet been discovered.

After the nest has finally been completed the prospective spawners spend much time lying side by side with their tails to the opening of the nest, as shown in Figure 12. At such times they are usually in contact. This quietude is interrupted by swimming in a nearly circular path, the one fish following close to the other, as shown in Figure 13. Not infrequently at such times the tail of one fish, apparently accidentally, slips into the mouth of the other. If the latter closes down on the intruded tail, and it usually does, the bitten fish leaves the nest as though shot from a gun. After swimming about for a while it returns to resume the activities. This, so far as the present interpretations go, seems to be nothing more than a quite accidental byplay, caused by these circling movements and the large mouth of the species that is so frequently opened wide. As spawning becomes more imminent these circling movements occur with increasing frequency. Finally they flatten so as to merge into a simple quiescent side to side position, with the fish facing in opposite directions and with their bodies in close contact, as shown in Figure 14. In this position spawning takes place. A large number of "spawning acts" occur until the female is emptied of her eggs. The first few attempts produce few eggs, possibly not more than three or four with each effort. Figure 14 was photographed after a few spawning attempts had been made, and immediately in front of the fish two lone eggs may be seen. Finally the eggs begin to flow freely and hundreds are shed at a time. This condition is shown in Figure 15 where a conical pile of eggs just shed may be seen under the body of the female. They are of a pale cream color, and average about 3 mm. in diameter.

Between every spawning effort the fishes rest, the male in a

seemingly exhausted state. The fishes separate slightly at this time, as is shown in Figure 16, sometimes the male half falling to one side. In this picture the eggs are entirely hidden by the anal and ventral fins of the female as she has settled down over them. The spawning here described occurred on August 13, 1933, but on the two days previous more or less continued efforts were indulged in. On August 12, about a dozen eggs were actually deposited but were eaten by the parents. Between 11:15 A. M. and 2:00 P. M. on that date, the fishes went through the motions of spawning six times.

While it is difficult to be certain about the identity of the sexes of these fish, it appears that the female does most of the actual incubating and the male most of the guarding, as has already been suggested by Kendall (1910). Both fishes were seen to defend their nest against other fishes, but unlike *Aequidens* (See Breder 1934a) showed little disposition to attack hands or other objects. Both parents were seen to incubate the eggs, although there was little of a regular exchange of labors. Occasionally both would incubate at the same time, as shown in Figure 20. This did not occur often. The efforts extended were directed more toward an actual manipulation of the eggs than the circulation of water over them, the latter being common in various other nest building fishes, *e. g.* *Lepomis*, *Cichlasoma*, *Pomacentrus* and *Gasterosteus*. Most commonly the parent fish would settle down on the eggs with the ventral fins wide-spread so as to cover the mass as well as possible. Then these fins would be paddled up and down alternately, actually striking the eggs with considerable force. In a few days, generally, this action was sufficient to loosen the mass entirely from its place of attachment, so that subsequent fanning caused the entire mass to slap up and down against the floor of the tank in rhythm with the fins. Sometimes this kind of motion was alternated with a swimming movement in which the long anal fin served to swirl the mass about, or even break it up. At other times the mass of eggs, or parts of it, would be taken into the mouth and "chewed" in such a fashion as to roll them over and over, after which they would be ejected with considerable violence. Rarely at such times would the cluster be swallowed. This has also been observed by Dean (1891).

Sometimes parts of the cluster, or the entire set of eggs, would be ejected from the nest. After a mass of eggs was thus evicted, apparently accidentally, the fish would frequently come out and

go over them with her barbels, as is shown in Figure 17. This would be repeated again and again but it appeared that the fish had no clear set of responses invoked by this condition. Nevertheless, on several occasions the eggs were later seen to be back in the nest, with the parent incubating as before. Unfortunately we have no observations to show how they got there. It may be that they were transported orally, as has been observed by Smith (1903) in the matter of transporting gravel, or it may be that they were incubated in place, and again accidentally knocked back into the nest. The latter seems unlikely, for only once were the fish observed to incubate eggs out of the nest, although they continually returned to stroke them with their barbels. Both Eycleshymer (1901) and Kendall (1910) mention much variation in the attitude of the parent fishes to their eggs.

A typical brooding posture of *Ameiurus* is given in Figure 18. In this case the fish has an unusually large batch of eggs. During incubation prodigious yawns are frequent. At one time these were counted and found to occur about once every fifteen minutes or less. With the large mouth capacity that this species has, it may well be that the syringe action of this yawning aids in renewing the water in the immediate vicinity of the eggs. A typical yawn is illustrated by Figure 19. The continued and strong activity indulged in by *Ameiurus* in manipulating the eggs may be shown to have a distinct and necessary function. One of the batches of eggs was removed to the laboratory and the following results obtained: All eggs died in less than twenty-four hours in standing water (at the same temperature). All but the few outermost eggs of a cluster died in a flow of water at least equal to that used in trout culture. Eggs lived and hatched when placed in a flask with an inlet reaching to the bottom and with a flow strong enough to keep them in a constant state of violent tumbling. This, a remarkable condition in a fish marked by its ability to survive low oxygen concentrations, is well-known to fish culturists. Eycleshymer (1901) had similar difficulty with the eggs. It does, however, supply an adequate explanation of the violent activity of the parents. Possibly the heavy, gelatinous coating of these eggs serves to protect them from mechanical injury, on one hand, and on the other causes a demand for an unusual amount of aeration. These eggs were found to be as susceptible to daylight as trout eggs, possibly more so, which is certainly not to be

unexpected considering the normal positions of catfish nests. No actual counts were made of the eggs, but their numbers were obviously close to those given by others, such as given in Table II.

The parents of those eggs removed for the preceding studies, continued for ten days to incubate the site from which the eggs had been taken. Their performance was identical, especially the ventral fin paddling, with that displayed toward the eggs themselves, and distinctly different from the earlier described cleaning activity. It is to be especially noted that incubation ceased the same day that the eggs hatched in the laboratory. It would seem that the spawning act "wound up" some mechanism that then simply ran down. The fresh cleaning of the nest for the second spawning did not begin until about two weeks later. Table I gives the details of the data here referred to, the spawning entered as item "6" being the one referred to above.

After the eggs hatch the activity of paddling stops and the parent fish are more gentle in their movements, confining themselves mostly to swimming about over the young that huddle in a compact mass encumbered by large yolk sacs. They keep up a constant beating of their colorless tails and as they advance manage to "skate" about on the bottom to a certain extent. By the time they are able to rise off the bottom they have attained most of their coal black coloration. When this time comes the young fish rise in a cloud that often has been described. The parents then endeavor to keep them in a compact school by swimming about, more or less in circles, as shown in Figure 21, and as described by Mellen (1926). The tropisms of the young *Ameiurus* themselves also tend to keep them together. These have been studied in much detail by Bowen (1930) and (1932) for *Ameiurus melas* (Rafinesque) who found they were almost entirely visual. As the present author has noted nothing at variance with those studies, the details of the features need not be discussed here. It may be pointed out, however, that the eye seems to become a much less important organ with age, as has already been indicated for the adults. A study of this change should be interesting. As the young fish grow and become more adventurous with the weakening of the early tropisms, the parents, in the aquarium at least, catch them in their mouths and return them to the school. Probably in a state of nature most of them escape parental solicitude about this time, but in confinement we found them all dying at this

point. This is practically identical with the observations of Smith and Harron (1904). The conclusion that the young fish were victims of too much and continued handling by over-zealous parents could not be avoided, especially since on another spawning the removal of the parents allowed the young to develop with only nominal loss. An item of behavior valuable in a state of nature would thus have to be considered lethal in the relatively close confines of an aquarium.

The data concerning spawning, temperatures and related items, as found in the literature, are given in Table II for comparison with the present data. Although there is good general agreement throughout, it will be noted that the spawning dates of the New York Aquarium observations are considerably later than any of the others. This is apparently due to the fact that the water reaches a suitable temperature at a later date because of the extremely large, deep lakes serving New York City as reservoirs, and the depth in the ground of the water mains. The observations of others refer either to small ponds, the shallow margins of lakes, or aquaria with a normally warmer water supply. Further, the temperatures given by others are all actually higher than those found in the present case with one exception—Greeley (1930). A slow rise to about 21° evidently permits spawning which might otherwise take place at a relatively rapid rise to about 25°. Moreover, it is to be noted that Hildebrand and Towers (1929) examined a 235 mm. female from Greenwood, Tennessee, taken on August 27, that contained about 3,000 ovarian eggs of about 1.25 mm. in diameter. As they suggest, there may be a much larger spread to the spawning season than generally assumed. On the other hand, the single record of spawning in a lower temperature than found at the Aquarium is well to the north, in the cooler waters of the Lake Champlain region.

COMPARISON WITH OPLADELUS.

The literature contains no description of the reproductive habits of the related but much larger mud-cat *Opladelus olivaris* (Rafinesque). Presumably, they would be rather similar to those of *Ameiurus*. It is with considerable satisfaction, therefore, that it can be reported at this time that there is a great similarity. The following descriptive matter and pertinent illustrations have been made available through the kindness and generosity of Mr. Walter H. Chute, Director of the John G. Shedd Aquarium in Chicago. A

TABLE II. COMPARISON OF REPRODUCTIVE DATA ON AMEIURUS NEBULOSUS.

Reference	Locality	Spawning Date	Hatching Date	Free Swimming Date	Time of Spawning	Temp. ° C.	No. of Eggs	Size of Eggs	Water Depth
Dean (1891)	New York	April	In one week	In a few days	—	—	—	1/8"	6" to 5'
Eycleshymer (1901)	Mass. & Mich.	June 1-11	—	—	—	—	—	—	—
Smith (1903) and Smith & Hannon (1904)	Wash., D. C.	July 3	July 8	July 15	10-11 A.M.	25°	2,000 ±	—	1 1/2'
Kendall (1904 & 1910)	General	May 8- July 6	In twenty hours	—	—	24.6°-25.7°	—	—	—
Hankinson (1908)	Mich.	—	—	Before June 28	—	—	—	—	—
Forbes and Richardson (1909)	Ill.	May	—	—	—	—	—	—	6" to 2'
Wright and Allen (1913)	Ithaca	May 20- July 12	—	—	—	—	—	—	—
McAtce and Weed (1915)	Maryland	Spring	—	—	—	—	—	—	—
Fowler (1917)	Pa.	—	—	—	—	—	50-500 +	—	Few in. to several ft.
Evermann and Clark (1920)	Indiana	May-June	In five days	—	—	25°	—	—	—
Adams and Hankinson (1928)	Syracuse	May-June	May-June	June 19	—	—	30,000 ± ovarian	—	—
Hildebrand and Towers (1929)	Miss. Champlain Region	Later than August?	—	June 20	—	18.5°	—	—	4"
Gredley (1930)	New Jersey	July	July	Aug. ¹	—	25°	—	—	—
Original	N. Y. Aquarium	July 15- Aug. 18	July 25- Aug. 24	July 18- Sept. 3	11:15 A.M. to 2:00 P.M.	20.7°-22.0°	500- 2,000 ±	3 mm.	4'

¹ On Aug. 7, 1926 twenty young fish ranged from 15 to 20 mm. in standard length with a mode at 17 mm. and one fish of 58 mm.

pair of this species successfully spawned at that institution in 1934 and the following remarks are quoted directly from Mr. Chute's notes on the case. The photographs are the work of Mr. Loren Tutell of the Shedd Aquarium staff.

"July 6 & 7. Activity in the mud catfish tank was first noticed. This tank contains two mud catfish, each about four feet long, five large alligator gars, one blue catfish about the same size as the mud catfish, and five sturgeon ranging in size from two to six feet. The catfishes selected a corner of the tank close to the glass. Both of them used their tails and mouths to make a hollow in the sand down to the bare gravel and rock. The completed nest was approximately five feet in diameter.

"On the 7th they were seen several times in an embrace, suggestive of the embrace used by the Bettas, although the male fish was unable to completely encircle the female. I did not see this embrace but was told about it after the eggs had been laid.

"July 8. When the attendant came to work at eight o'clock in the morning he found the eggs in the nest. They apparently had been laid some time that morning.

They were adhesive and made a mass in the bottom of the nest approximately sixteen inches in diameter, six inches thick in the center tapering to the thickness of one egg on the outside edge of the mass.

"In appearance the egg mass suggested a tapioca pudding. The individual eggs were just about the size of boiled tapioca and the yolks of the eggs gave the entire mass a custard color which heightened the similarity. Both parents were hovering over the nest.

"July 10. Male only was guarding the nest. When one of the big gars swam close to the nest the male would swim under the gar and push upward until the gar was near the surface of the six foot deep tank. If one of the little sturgeon approached the nest the catfish would chase him clear to the other end of the tank, which is thirty feet long. When the female attempted to approach the nest the male bit her and chased her into a hole under a log in the background. It was interesting to note that he fought fishes of his own size or smaller and gently 'eased' the larger fishes away without starting an argument.

"We took out about four hundred of the eggs from the nest and measured one cubic inch, which counted 175 eggs. On this basis I estimated the total mass to be in the vicinity of 100,000 eggs. The few eggs that we took out were put into a glass bowl and hung under running water.

"In caring for the eggs, the male would settle over the mass and agitate the eggs strongly by using the ventral fins alternately. At the same time he repeatedly vibrated his anal fin, creating a current

of water which washed away the dirt loosened by the beating of his ventral fins. The entire mass would shake like a bowl of jelly and at times he kneaded the eggs so hard that the edges of the egg mass would rise an inch or two above the bottom.

"In the later stages of development, when the eggs started to hatch, the young fishes would be swept away from the egg mass and lodged in the crevices around the edges of the nest.

"July 12. Some of the eggs in the bowl under running water started to hatch. The young fish were very tiny and weak. A number of egg shells were noticeable in the egg mass in the nest, but no young were visible.

"July 13. The young in the bowl were all dead and the remaining eggs in the bowl were turning white. The eggs in the nest were starting to hatch and the male was kept very busy between agitating the mass and chasing off the sturgeon, which apparently sensed the fact that food was near.

"July 15. Eggs were hatching very rapidly in the nest. Apparently the current caused by the agitation of the fins of the male carried off the young fish but left the adhesive shells still adhering to the mass. The largest sturgeon kept raiding the nest and eating all the young that were near the edge of the nest, so we removed a thousand or more young fishes. Some of these were put into a reserve tank with a depth of forty inches of water and about five hundred were put into an ordinary trout hatching box which had a layer of sand on the bottom.

"July 16. The egg mass had entirely disappeared. The male was still guarding several hundred of the young in a corner of the nest up against the wall. The young fish put in the reserve tank and the trout hatching trough had gathered in groups with all their tails rapidly vibrating in the same direction.

"July 18. Pigment beginning to develop in the young, Very prominent blood vessels, bright red in color, encircling the yolk, giving the entire mass of young a pinkish color.

"July 19. Male still guarding the nest with about two hundred young. The young fish in the reserve tank and trout trough much more active and showing signs of growth.

"July 20. Male still on the nest guarding a few young that are still in crevices among the rocks. The young fish under observation in the reserve tank and trough are becoming quite active, occasionally swimming short distances but always returning to the group. The head is exceptionally well developed and when viewed from above is as wide as the yolk sac. They are now recognizable as catfishes, as the maxillary barbels are about 1/16 inch long and easily discernible. Black pigment is starting to gather on the head, and on a saddle-like spot across the back and on the yolk, but the tails are still pale pink."

A comparison of the above remarks with the previous ones on *Ameiurus* reveals them to be nearly identical in their major aspects: the manner of working over the eggs; the failure of them to hatch successfully under ordinary running water; the matter of embracing several times before the eggs flow; the period of incubation, and time to free swimming. The items not in apparent agreement are discussed separately below.

The embrace as described for *Opladelus* would appear to be rather different, although Mr. Chute in a subsequent communication emphasized the fact that he did not personally see this act but based his description on the account of one of his employees. It may even be, however, that this is the normal silurid mating position, and that the position observed in *Ameiurus* at the New York Aquarium may be a distortion of it, because of the close confinement of the cavity which these fishes always choose for spawning purposes.

The spawning of *Opladelus* occurred in an aquarium containing other fishes, whereas we have had success only where pairs were isolated. It is to be noted, however, that only one pair of the spawning species was present. At this writing no attempt has yet been made to see if *Ameiurus* only resents its own kind. Although the *Opladelus* were large, "about four feet long," they were in a very large aquarium, 30 feet long, 6 feet deep and 10 feet wide. On the other hand the present studies were made for most part on fish one foot long in a tank 5 feet long, 4 feet deep and 3 feet wide. These proportions are not at great mathematical variance either as to bottom area or volume per length of fish. However, these matters do not usually correlate along a straight line, the factor for absolute size causing a considerable deflection in tanks so relatively small in relation to the fishes.

The rejection by the male of the services of the female is unlike the behavior of *Ameiurus* studied in detail by the author. It may be pointed out, however, that there is probably considerable individual variation in this matter. In spawning No. 10 of Table I, one of the fish drove and succeeded in keeping the other away from the nest. The driver was believed to be the male. This pair had both incubated the prior batch of eggs in the same site, No. 9 of Table I. It is noted, moreover, that in *Ictalurus*, according to Shira (1917a and b), only the male incubates.

COMPARISON WITH OTHER NEMATOGNATHI.

So far as known there are but four basic methods of reproduction employed in the entire order Nematognathi. There is the method involving the incubation of the eggs in a nest, as here described and illustrated for *Ameiurus nebulosus* and *Opladelus olivaris*, which may be taken as basically typical of the entire ameiurid aggregation. Other species are essentially the same, Ryder (1883), and Koller (1926), and Greeley (1929). The only other method known to be employed by the typical "naked" cats is that of oral incubation which seems to be confined to the ariids, and there is some reason to suppose that it may be true of nearly all those species. Semon (1899) describes the nesting of *Hexanematichthys australis* (Günther), which is the only apparent exception. This fish makes a circular nest as a cavitation in the gravel of rapidly flowing streams in which the eggs are deposited. They are then buried in a mound of gravel. *Tandanus tandanus* (Mitchell), one of the plotosids, also of Australia, Stead (1906) and Hale (1920), likewise builds a nest in the form of a mound. The other habits are apparently very similar to those of *Ameiurus*, including the oral transportation of gravel and the fanning movements to remove detritus. Also both sexes attend the nest. According to Bowers (1913) and Shira (1917a and b), the spawning of *Ictalurus punctatus* (Rafinesque) is essentially similar to that of *Ameiurus* except that only the male tends the eggs. With the exception of *Silurus glanis* which is discussed subsequently, the two other methods seem to be confined to the much more specialized and generally "armored" cats. One of these is that of sticking separate adhesive eggs on plants, and the other that of carrying the attached eggs to the ventral surface of one of the parents. Since the data on these various specializations are inadequate, as yet, to the making of truly significant comparisons, they are simply mentioned in passing. The literature is large and will not be fully discussed at this time, as for most part the descriptions are fragmentary. Gudger (1916), (1918) and (1919) gives all the important references on oral incubation in the ariids to that time. These are not included here. Since then many others have been mentioned as displaying oral incubation; e. g., Pellegrin (1919), Mane (1929), Herre (1926), Aldaba (1931), Delsman and Hardenberg (1934) and Hardenberg (1935). See also Lee (1931). It has been shown that the Aspridinidae allow the eggs

to become attached to the ventral surface, and certain of the Callichthyidae lay separate adhesive eggs. For abundant references to nematognath reproduction, see Dean (1916).

Oral incubators.

For present purposes it is sufficient to point out that the reproductive habits of *Ameiurus* involve both excavation of gravel by use of the mouth, and taking into the mouth the developing eggs, presumably for purposes of cleaning and aerating and possibly for returning dislodged eggs to the nest. This would clearly seem to be a necessary forerunner to the establishment of oral incubation. Gudger (1918), on a basis of the literature, has already indicated that such habits might well be expected to lead to oral incubation. After giving his evidence Gudger writes as follows: "It seems hardly necessary to argue the question as to the origin of the habit of oral gestation after the presentation of the facts above given. In the mind of the present writer there is no doubt that having begun by taking up the eggs and young for purposes of transportation, the fish have presently learned to retain them for longer periods of time; we have a record of at least one minute's retention; and as the fish that would retain their young even for short spaces of time and transport them to safer localities are more likely to leave descendants, through the action of natural selection, these fish and this habit will be perpetuated. Hence we may conjecture that as time has gone on the habit of retention has become more and more fixed until finally oral gestation has become an established habit." With the general idea expressed, this author of course concurs. The chief purpose in mentioning it here is for comparison with other habits also foreshadowed in ameiurid reproduction to be discussed later. It may also be mentioned at this place that there is need of a reconsideration of all the data concerning oral incubation and its origin, since the literature is full of inadequate and misleading statements, a considerable number of which are simply untrue. A single example may serve by way of illustration. Even Gudger (1918) mentions without criticism the description of Carbonnier (1874) of oral incubation in *Fundula cyprinodonta*, which fish Gill (1906) referred to *Umbra pygmaea*. Since all three species of *Umbra* stick their separate eggs securely on some object, such as a rock or plant, Carbonnier, it would seem, had some other fish, perhaps not even North American

as he thought. Abbott (1874), (1890) was familiar with the breeding of *Umbra pygmaea*; Anon. (1918) and Gray (1923) described it in aquaria, and the present author robbed the nests of *Umbra* for developmental studies, Breder (1933a). With conditions of which the above serves as an example, it is clear that unsupported statements regarding oral incubation require more than the usual critical examination, and should be carefully checked before acceptance.

The development of oral incubation in the nematognaths would seem thus to be decidedly parallel to that found in the Cichlidae, as already discussed by Breder (1934a). In the present case the progress is clearly paralleled by unrelated structural changes, and change in habitat. The direction of evolution can scarcely be questioned in this case, with the curious chondocranium of the ariids that certainly was derived from some ameiurid-like ancestor. See Gregory (1933). Likewise the development of a marine habit is certainly secondary in the Nematognathi, and even yet their invasion of the sea can only be considered a weak one, since all the Ariidae are hardly more than estuarine. The building of the ameiurid type of nest in tidal and usually muddy waters could hardly be a successful method. The largely mud flat habitat described by Gudger (1918) for *Felichthys* certainly would be unfriendly to such a nest, as he clearly indicated. Furthermore, this catfish could scarcely be expected to defend its eggs successfully against marauding marine crustaceans, whereas possibly the worst that *Ameiurus* has to contend with is *Cambarus*. Marine fishes that do build nests somewhat comparable to those of *Ameiurus*, generally use a substantial retreat that renders protection relatively easy; e. g., *Opsanus*, *Pholis* or *Pomacentrus leucostictus*. Other forms use other methods. For example, more numerous eggs may be produced; they may be pelagic or situated in some relatively inaccessible place. Such a situation might be up from the bottom on a smooth vertical surface, as in the case of *Pomacentrus leucoris*, Breder and Coates (1933). Furthermore, these latter do not live in mud flat environments. In this connection information on the reproduction of *Plotosus* should be valuable.

The eggs of orally incubating species are comparatively larger than those of related nest building species in cases studied by the author. These include the Cichlidae, Breder (1934), the Nematognathi and the Labyrinthidae; the orally incubating *Betta picta*

(Cuvier and Valenciennes) having larger eggs than the nesting *Betta splendens* Regan. Breder (1933b) and (1934b). This latter case will be discussed in a subsequent communication. The increased size of the egg of *Felichthys* is an extremely striking case. Gudger (1919) gives the average diameter as about 20 mm. The egg of *Ameiurus*, on the other hand, is about 3 mm. In the other two cases mentioned the orally incubating fishes have egg diameters about twice that of their nest building relatives, in species of comparable sizes. The problem of this shift to larger and proportionately fewer eggs is not readily explained. In each case the nest builders could hardly engulf all their eggs in a normal spawning. Gudger (1919) gives 55 eggs as the maximum he found for *Felichthys*, and certainly the ovaries of a female could hardly produce many more at one time. Compare this with the size of the egg masses of *Ameiurus* shown in the accompanying photographs. Figures 20 and 21 are especially pertinent. Semon (1899) states that *Arius australis* lays eggs about one-eighth of an inch in diameter. These are much smaller than any other known ariid eggs and this is the only species definitely known to be not an oral incubator.

It would seem that there is less wastage of eggs in the oral incubation method. Consequently, following the well-known reduction of young in proportion to the hazards of the species, it may be that the need for more numerous eggs has disappeared. Since there is no indication of a reduction in the size of the ovary, or any seemingly reasonable need of such, the potential ovarian activity would presumably remain about the same. This in turn might go to the production of eggs of increased size. This suggestion is the equivalent of saying that in some way the need of less numerous offspring is involved in not only the production of fewer but larger offspring. Certainly, in a broad phylogenetic sense at least, such is true of vertebrates generally.

Gudger (1918) takes the opposite view, *i. e.*, that the increased egg size has encouraged oral incubation. He writes: "Let it be recalled that these eggs are of enormous size (the average diameter of 327 eggs being 19.5 mm.) and that when in middle embryonic stages they are very attractive to the eye because of their blood-red vascular yolk investment. For these reasons, if laid like other fish eggs are, they could hardly be expected to escape the eyes of marauding fishes, but if any were so fortunate they would almost certainly be

eaten by crabs, those scavengers from which practically nothing escapes. The result would be the inevitable extinction of the species. These catfish spawn and spend the hatching season on mud flats. If the eggs were discharged on such bottoms they would (because of their great weight, averaging 3.5 grams) sink into the mud and be smothered. To avoid these various dangers, these fish have to do one of two things to insure their perpetuity, *i. e.*, to practice mouth gestation or to lay eggs in nests which are guarded by one or both the parents. Some fresh-water catfishes have adopted the latter habit; the gaff-topsail the former." Since there is concurrence between Gudger and the present author, that the ariid type of reproduction was derived from some habit similar to the ameieurud type, his above quoted view must be able to explain away the following objections to be accepted as valid:

1. Since *Ameiurus* successfully defends its large mass of eggs against marauders, there is no particular reason why it could not equally defend eggs the size of *Felichthys* (if amounting to the same total bulk) in an identical environment. The color differences cannot be significant, since bright red eggs are not more visually evident than cream white ones, if as much, under such conditions. Then too, there is the question of the importance of the various receptors to the enemy species.

2. If *Ameiurus* attempted to reproduce in the environment of *Felichthys*, the relatively small size of its eggs would confer no immunity from suffocation on a mud flat not possessed by *Felichthys*. In other words, size of egg (of identical type) has little to do with suffocation in the same mud. Both types of eggs sink rapidly in sea water.

Stating it another way, while it is agreed that nest building is out of the question on mud flats, it is objected that an increased egg size may have led to the development of oral incubation. On the other hand the present view, which refers increased size to a need for fewer eggs because of better general protection, does not suffer from these same objections. This is given added support by the fact that other oral incubators have not resorted to mud flat environments, although in each case there is some size increase and number reduction.

Conorhynchus nelsoni Evermann and Goldsborough, an oral incubator of Mexico, has been referred to the Pimelodinae. At this

writing we can see no reason for not considering it an ariid. The nares are as closely approximated as in many in that group (according to the type figure) and the adipose fin is too short for the former. Dr. G. S. Myers, of the U. S. National Museum, kindly examined the type specimen and stated in a personal communication that it "is an undoubted ariid, probably of a new genus." Dr. C. L. Hubbs, who has recently collected this species, also writes in a personal communication that he is of a like opinion.

Hardenberg (1935) describes and figures the hook-like thickening of the inner part of the female's ventral fins in *Arius maculatus* (Thunb.), and suggests that "this is a sexual character, which has something to do with spawning and mating. It is clear that the male is attached by these hooks and the fertilization of the eggs takes place perhaps inside the body of the female or more probably outside the body just at the moment when they leave the genital opening." However true this may be, it is certain that most of the ariids have some such secondary character. At the New York Aquarium the females of *Galeichthys milberti* (C. & V.) develop similar structures which are apparently resorbed every fall. Thus far we have been unable to induce reproduction, however, in this species. Dr. Hubbs found similar structures in "*Conorhynchus*" but could not find them in *Arius aqua-dulce* Meek. Occasionally a female *Ameiurus nebulosus* shows a slight ridge that may be an abortive form of this structure.

Alleged gastric incubation.

Devincenzi (1933) in a most interesting paper describes a condition in *Tachysurus barbatus* (Lacépède) which he interprets as establishing what he terms "incubation gastrica." He found males with eggs in their stomachs in various stages of development. Histologic sections of the stomach walls showed an absence of the folds in the mucosa normal to non-breeding fish, and a general thinning of the stomach wall. This he interprets as representing a cessation of the digestive function while the eggs are so carried. He believes that this condition was responsible for the alleged viviparity in such fishes by early workers; e. g., Schomburgk (1841). In this latter view we are in complete accord but cannot admit the fact of gastric incubation. The proper interpretation of the conditions that Dr. Devincenzi describes is believed to be as follows:

It is well known that various orally incubating fishes will frequently swallow their eggs when frightened. This is especially apt to be the case when such fishes are caught in a net or otherwise handled. In fact one of the greatest difficulties in the aquarium breeding of various orally incubating cichlids, and orally incubating species of the labyrinthine genus *Betta*, is their tendency to swallow their eggs on fright. It is consequently not surprising that some of Devincenzi's fishes swallowed their eggs. It is to be especially noted that he also describes oral incubation in the same species. Apparently not all of his specimens swallowed their eggs. One could hardly expect a single species to show two methods of incubation. Further, it is inconceivable that a single kind of egg could survive in the well aerated mouth cavity and also in the relatively anerobic stomachic pouch. In reference to the latter, a figure is given by Devincenzi which purports to show that the stomach has an unusual degree of vascularization. This is unconvincing, since many fish stomachs of diverse species possess an even greater supply of blood vessels and are found to contain nothing more unusual than a large amount of food. It is to be particularly noted that the first feeding after a fast in most fishes will induce a marked distention of the blood vessels in the stomach wall. The finding of eggs in various stages of development, in different individuals, interpreted as an accidental ingestion, indicates the advancement of the eggs at the time of swallowing and has no bearing on their time of entry. It may be noted that whole eggs are rather resistant but as the fish were either preserved and later studied, or examined fresh, the effects of digestion would be slight, especially in a stomach that has not contained food for some time.

The histological differences shown in the stomach walls are only those to be seen between a normal functioning fish stomach, and one which has been under starvation for some time and then stretched by cramming with food. A close examination of the photographs of the sections show all the cellular elements present in both. The functional stomach in a relaxed condition shows the folds normally present, while in the stomach filled with eggs these are flattened out and the sac itself, because of stretching, shows thinner walls. A remarkable feature of the fish stomach in this connection is the changes that it undergoes during starvation. A more or less bulky sac reduces typically to be almost cord-like in structure and stretches

as a thin membrane on the first feeding, subsequently thickening to its original condition. At this time the vascularization is especially evident. It is just these features that Devincenzi shows in his figures but on which he places an interpretation with which we cannot agree.

The question might be raised as to whether it is possible for such fish to regurgitate the eggs after danger has passed, thus using the stomach temporarily for protection. While there is no observational or other data on such a possibility, there is certainly no reason to imagine that such might be the case. Other fishes of many kinds have never been known to regurgitate eggs once swallowed. These include all forms that have been personally observed in any way to manipulate their eggs with the mouth. They include *Ameiurus*, herein discussed, a variety of cichlids both nest building and orally incubating, a variety of labyrinth fishes both nest building and orally incubating, as well as a scattering variety of other forms, such as nandids, centrarchids and pomacentrids. Theoretically considered there is furthermore no likely reason why a fish carrying eggs in its mouth could escape any faster with them in its stomach. It of course could be imagined that respiration might be a little more free but, at this time, such a concept is pure speculation. It seems more likely that an involuntary gulp, on fright, places the eggs in a position beyond recall. At least this is the impression derived from other species of oral incubators in aquaria, although obviously such a question is difficult of experimental verification.

Eggs adherent to abdomen.

While it might be straining a point to compare ameiurid reproduction with that of the nematognaths that attach their eggs to their ventral surface, such as *Aspredo*, (*Platystacus*) Cuvier and Valenciennes (1842), Green (1858), and Wyman (1859a and b), *Bunocephalus*, Bloch (1837), there are nevertheless certain suggestive features. It has been shown in this paper both by descriptions of detailed acts and by photographs, that *Ameiurus* literally lies on its eggs. See, especially, Figures 18 and 19. In addition this species strikes its eggs violently with its ventral fins as previously discussed. The eggs are of themselves distinctly adhesive. In the case of *Ameiurus* the integument is extremely slippery and no adhesion is possible. In the case of *Aspredo*, however, the mucus production is

slighter, as is also true of the more fully armored loricariates. This statement is not meant to imply that this condition alone explains the egg carrying of *Aspredo*, as it has been shown that the specialized integument is structurally modified to accommodate the eggs. See the work of Vaillant (1898). However, the lack of excessive slime production must have preceded it, since it is difficult to see how any fish integument bathed in the particularly slippery mucus of the naked cats could function in the manner described for that of *Aspredo*.

The actual conditions in this case involve a structural change of the integument, and differ from the habit of oral incubation in that the development of the latter has so far not been shown to be accompanied by any functional change in structure. It may be, however, that the structural change in the integument may be induced by the adhesion of the eggs. If a means could be devised to cause the eggs of *Ameiurus* to adhere to the ventral surface of the fish, a study of the histological changes of the skin, if any, should be extremely illuminating.

It has been suggested by Eggert (1930) that *Macrones gudio* Ham. Buch. may carry its eggs on its ventral surface in folds on the abdomen. This is based on anatomical and histological data. Females with advanced ova were found to have these folds highly vascularized and large, whereas in unripe fish they were small. As Eggert suggests, these structures at the very least are probably associated with the reproductive habits, even if not as above indicated. They may represent the first step in this direction toward egg carrying, so highly developed in the aspidinids.

Eggs cast free.

Among the various specialized members of the Nematognathi there are several that are reported to deposit separate adhesive eggs. Such forms as *Astroblepus*, *Otocinclus* and *Corydoras* are known to breed in that fashion. This may be considered either as the retention of a primitive character, since it is typical of the generality of both the Heterognathi and Eventognathi, or as the secondary development of it. If the first possibility be considered, it follows that these fishes, not especially close to one another, all by-passed the ameiurid type of reproductive activity. Unfortunately, we do not know enough about the details of the reproductive habits of

these fishes to find useful clews. However, since the nematognaths are all possessed of a highly specialized musculature of the pelvic appendages, we have some grounds for tentative speculation. The relatively primitive Ameiuridae make use of these ventral fins, as earlier described, in a distinctly definite manner in their reproductive activity. It so happens that both *Astroblepus* and *Otocinclus* have highly developed ventrals which they use for non-reproductive purposes. *Astroblepus marmoratus* is capable of scaling eighteen foot walls by means of its suctoral mouth and ventral fins, Johnson (1912), and *A. longifilis* is probably capable of similar performances. At least it was seen to use its ventrals to a considerable extent in climbing, Breder (1926). *Otocinclus* grasps more or less vertical plant stems between its ventrals in aquaria and rests for long periods, holding on in that fashion. *Corydoras*, on the other hand, with somewhat similar ventrals, so far as the author is aware, uses them as specialized organs in reproductive activity only, Carbonnier (1880a and b) and Vipan (1886). At such times they are cupped together to act as an inseminating basket for holding the eggs during fertilization, which eggs are then cast off to adhere separately to plants. *Hoplosternum*, according to Vipan (1886) and Hancock (1828), builds an elaborate nest of froth and plant fragments at the surface as does *Callichthys*, Devincenzi (1933). Carter and Beadle (1931) confirm this and give excellent illustration of the nest of *Hoplosternum*.

If the assumption is made that these fishes passed through some ameiurid-like breeding pattern and then discarded it, the above use of the specialized ventral musculature becomes understandable. They then take on a new useful function, differing in each group, when the original one is no longer applicable. The only other interpretation would be that the primitive nematognaths used their peculiar pelvic musculature for some purpose we know nothing about, and that it has simply been developed to a scattered variety of uses. This would be hard to establish, and it is rather difficult to imagine what type or use there might be, considered as a starting point, that would be simpler than the paddling movements of *Ameiurus*.

Floating nests of froth.

As has already been indicated, *Hoplosternum* constructs a floating nest of froth. The most recent and full description of this type of nesting has been given by Carter and Beadle (1931) for *H. litorale*

Hancock. This species spawns in the nearly anerobic waters of the Paraguayan Chaco. They write of the region: "Rain at the beginning of summer is the stimulus for the breeding of many of the fishes of these swamps (*Lepodisiren*, *Symbranchus*, *Hoplias*, etc.) and of many of the amphibia. After the rain the water is often cooler than usual, but rapidly heats in the following days. The amount of oxygen is not greatly altered by the rain except for a short time and at the surface. The most definite abnormality of the water at this time is the less amount of carbon dioxide in it, but this also passes rapidly. Possibly a combination of all these changes provides the stimulus for reproduction."

Under these conditions *Hoplosternum* constructs a raft about one foot in diameter of floating weeds and other aquatic plants. The mass of eggs is placed at the center of the underside of the raft and "the eggs are glued together and to the raft by a secretion which also prevents the materials of the raft from falling apart. Below the eggs and covering the whole of the underside of the nest is a mass of foam, probably made by the fish by taking air in at the mouth and bubbling it out again. The nest is guarded by the parent fish which is always to be found swimming below it, but it is readily deserted if the fish is disturbed in any way." Unfortunately, the sex of the guarding parent is not designated.

Little can be said regarding the possible evolution of this bubble blowing habit, but it may be pointed out that it also occurs in other fishes and a similar construction is made by several genera of frogs; e. g., *Eupemphix* and *Leptodactylus*. Of the fishes, only one belongs to the Ostariophysii, the African characin, *Hydrocyanoides odoe* (Bloch), which was first described by Budgett (1901). A variety of the entirely unrelated labyrinthine fishes, such as *Betta*, *Macropodus*, *Ctenops*, *Colisa*, et cetera, erect such constructions. An eel, *Fluta alba*, has also been credited with such a habit by Smith (1934) but needs confirmation. Living as it does in association with various froth-making labyrinth fishes, it seems likely, to the present author at least, that the observations may actually refer to a raid on such a labyrinth nest by a family of young *Fluta* still under the influence of their parent. This interpretation would imply parental care on the part of this eel, but not froth nest construction.

All these nests are to be found in waters of low oxygen content, and however they arose are apparently one solution to the problem

of reproduction under such conditions. A remarkable feature of them is the essential similarity that they all bear one another.

Ancestral habits.

Thus far only the types of reproduction that the ameiurid habit may have led to have been considered. If we attempt to trace backward, to ascribe a point of origin to the breeding activity of *Ameiurus*, the evidence is very scant and unconvincing. Probably scattering loose non-adhesive eggs which sink, is the most primitive method of reproduction in the entire ostariophysid aggregation. Since they in turn lead back to isopondyles, in which the most primitive condition is probably that of scattering loose non-adhesive eggs which float, little in the way of clues can be found. The difference between floating and sinking of eggs in this case probably is simply the matter of relative specific gravity, since the isopondyles that lay floating eggs spawn at sea, and the Ostariophysi spawn in fresh water except for the orally incubating nematognaths. This, then, may be an almost purely environmental matter. It must be pointed out in this connection, however, that the eggs of both *Felichthys* and *Ameiurus* sink rapidly in sea water. Eggs of the latter were found to sink in sea water concentrated to the high specific gravity of 1.027. Since there is no known intermediate between casting eggs, adhesive or not, and incubating them with elaborate activity, except that of simply lying with them, as in *Schilbeodes*, Fowler (1917), on which further observation is needed, little can be adduced. We consequently can only guess what led to the origination of aerating activity in the nematognaths. Gill (1907a) discusses the nesting habits of *Parasilurus aristotelis* (Garman) based on Aristotle's description and the non-nesting of *Silurus glanis* Linnaeus, a relatively unspecialized silurid. In the latter the male simply mounts guard over the eggs, which are attached to plants.

The plotosid catfishes, representing the only other invasion of the sea found in this order, are little known in regard to their reproductive habits. *Plotosus* possesses a curious gland-like structure posterior to the genital pore which is present in both sexes. Broch (1887) suggested that it might form an egg receptacle. Hirota (1895) with more data indicated that it might be a gland of some unknown function. Eggert (1929) is of the opinion that whatever its function it probably would be found to be associated with the reproductive behavior. He suggested that it might be a scent organ. On this we

can only speculate. The plotosids invading the fresh waters of Australia have developed at least one nest builder, *Tandanus*, which has already been mentioned. It may be that this is a secondary acquisition of the habit, for it would seem unlikely that such a habit would be found in the marine plotosids. They sometimes are found to inhabit environments similar to those of the marine ariids, and for the reasons set forth in the discussion of them could hardly be expected to build ordinary catfish nests. Otherwise they are apt to be associated with coral reefs, a type of habitat generally favorable to nesting.

If the various habits of the nematognath fishes are considered in reference to phylogenetic classification, the great gaps in our knowledge become apparent. So large are these that any attempt to trace the descent of habits becomes almost hopeless at this time. However, a consideration of the known facts may nevertheless have value in pointing to possibilities and indicating desiderata for further researches. Table III gives a list of families and subfamilies

TABLE III. REPRODUCTIVE HABITS OF THE NEMATOGNATHI.

CLASSIFICATION	MAJOR ASPECTS OF REPRODUCTION	GENERA KNOWN
DIPLOMYSTIDAE	(?)	—
ASPRIDINIDAE	Eggs carried on ventral surface of female.	<i>Aspredo</i> , <i>Bunocephalus</i>
SILURIDAE		
Ariinae	Oral incubation by males in all marine forms? <i>Hexanemitichthys australis</i> builds a nest.	<i>Netuma</i> , <i>Arius</i> , <i>Osteogeniosus</i> , <i>Galeichthys</i> , <i>Hexanemitichthys</i> , <i>Felichthys</i>
Callophysinae	(?)	—
Pimelodinae	(?)	—
Silurinae	Eggs deposited on plants by <i>Silurus</i> . Nest built by <i>Parasilurus</i> .	<i>Silurus</i> , <i>Parasilurus</i>
Malopterurinae	Oral incubation has been suggested?	—
Plotosinae	Unknown in marine forms. <i>Tandanus</i> builds a nest.	<i>Tandanus</i>
Clariinae	(?)	—
Bagrinae	All build nests (?) except <i>Macrones</i> which may carry eggs on ventral surface.	<i>Ameiurus</i> , <i>Opladelus</i> , <i>Vilarius</i> , <i>Schilbeodes</i> , <i>Ictalurus</i>
Doradinae	Builds a nest.	<i>Doras</i>
HYPOTHALMIDAE	(?)	—
TRICHOMYCTERIDAE	(?)	—
CALLICHTHYIDAE	Eggs deposited on plants by <i>Corydoras</i> . <i>Hoplosternum</i> and <i>Callichthys</i> build a floating froth nest.	<i>Corydoras</i> , <i>Hoplosternum</i> , <i>Callichthys</i>
LORICARIIDAE		
Argiinae	Eggs deposited on plants.	<i>Astroblepus</i>
Plecostominae	Eggs laid in holes.	<i>Ancistrus</i>
Loricariinae	Eggs carried in folds of lip (male).	<i>Loricaria</i>
Hypoptopomatinae	<i>Otocinclus</i> may lay free eggs (?).	—

based chiefly on Eigenmann and Eigenmann (1890) and Boulenger (1904), which are used here chiefly for reasons of convenience. Opposite each group is given the major characteristic of the reproductive habits. All of these features have been mentioned in some detail in the foregoing discussion. Consequently, the suggestion of relationship of habit need only be indicated at this place. Of those forms of which there is anything known regarding reproduction, the following inferences would seem to follow.

The Aspridinidae, a highly specialized offshoot of the early stem, are uniform, so far as known, regarding the carrying of eggs on the ventral surface. This, now a highly developed integumentary involvement, may have arisen from the habit of lying on the eggs in a manner similar to that seen in *Ameiurus* today.

The Ariinae, generally considered a primitive form, although extending back to Eocene times, would nevertheless seem to have been derived from some ameiurid-like stock. This view is held by Gregory (1933), based chiefly on skull structure. Certainly at least the habit of oral incubation was derived from an ameiurid-like breeding habit at a time when they invaded estuarine waters. The nest building of the *Hexanemitichthys australis* would seem to be clearly associated with a secondary invasion of streams. This nest is a mound and to that extent differs from the excavations of the Bagrinae.

The Silurinae has both a nest building form, *Parasilurus*, and a non-nester, *Silurus*. On the latter there is not a great amount of data even today, which moves Long (1929) to call for more observation of the common European catfish.

Oral incubation has been reputed in the Malopterurinae, but the data are inadequate, Gill (1907a). Svensson (1933), studying Gambian fishes, states he could add nothing to the details of reproduction.

Nothing is known of all the marine Plotosinae except that they possess a curious gland-like organ which would seem to be associated with reproduction. *Tandanus*, an Australian invasion from the sea, of this group, constructs a mound. It is striking that the invasion of the fresh waters of Australia by two unrelated types of silurids should both be represented by mound-building forms.

All the Bagrinae build nests consisting of excavations, so far as known, with the possible exception of *Macrones* which it has been suggested may carry them on the under surface. This suggestion, however, needs further study for confirmation.

The Astroblepidae cast their eggs free, and from their relationships would seem to have lost rather than never had a brooding habit.

The Callichthyidae have nesting and non-nesting members *viz.*: *Callichthys*, *Hoplosternum*, and *Corydoras*.

The Loricariidae have some members, at least, which carry their eggs in labial folds, Steindachner (1879), Gill (1907a), Ribeiro (1918), Ihering (1928) and Devincenzi (1933): *Loricaria vetula* C. & V. and *L. anus* C. & V. The carrying of eggs under the large everted lips of these fish may again be associated with the presumably ancestral habit of lying on the eggs. The males alone engage in this habit and have the posterior portion of the everted lips appropriately enlarged.

Many of the Loricariidae have a marked amount of sexual dimorphism. The males in some genera have enlarged bristles; *e. g.*, *Oxyloricaria*, *Farlowella*, *Ancistrus*. In others the males possess dendritic appendages on the head; *e. g.*, *Xenocara*. See Regan (1904). The males of the naked Argiinae possess an elongate genital papilla. The function of these structures is not understood.

Ancistrus anisitsi Eigenmann and Kennedy, according to Carter and Beadle (1931), lays its eggs in holes in banks at the edges of swamps. The eggs "are glued together by a secretion." This rather suggests the ameiurid type of reproduction, but it is to be noted that the eggs must have a much lower oxygen requirement, since the waters in which they are found are notable for their low oxygen content. Furthermore, Carter and Beadle write of the eggs that "they were found to live well in dishes" which, as previously indicated, is not true of ameiurid eggs.

COMPARISON WITH CERTAIN CICHLIDS.

A study of the development of oral incubation in the Cichlidae, based on similar but more extensive data, has already been published by Breder (1934a). This has been referred to in the preceding section in passing, but a close comparison of the nest building habits of the two groups forms the basis of further consideration. In Table IV the chief items are listed in parallel columns for comparison. A consideration of this table will show at once that while the general pattern is fairly similar, not a single item is identical, from the details of courtship and spawning to the care of resulting young. It forms a splendid illustration of how superficially similar characters

of habit may on critical examination actually be shown to be composed of distinctly different elements. Oral incubation can clearly be traced back to both of these reproductive types, with both involved in taking their eggs in their mouths but for entirely different reasons. Except for this there is no direct physical contact between eggs and parents in the cichlids, and no other habit but oral incubation has been found to develop in that family. In the ameieurids there is additional and close contact with the ventral surface and the ventral fins. In this group has also developed species that carry the eggs adherent to the ventral surface, and those that employ the ventral fins as holding organs for fertilization. It is difficult to believe that all this is merely coincidental.

It should be borne in mind that in Table IV the species compared receive their sensory impression by rather different channels. *Aequidens* is primarily a visual type and entirely diurnal in its habits, whereas *Ameiurus* is chiefly a tactile chemico-sensory type and to a considerable extent nocturnal. At least the first, third and ninth items may have to do with the different role that light plays in the lives of these two species. The second, seventh and ninth items, at least, are associated with the major receptors in each case.

TABLE IV. COMPARISON OF THE REPRODUCTIVE HABITS OF AMEIURUS WITH THOSE OF THE CICHLID, *AEQUIDENS LATIFRONS*.¹

	<i>Ameiurus</i>	<i>Aequidens</i>
1. Sex recognition	Tactile or chemical?	Differential behavior.
2. Spawning position	Pair head in opposite directions in close contact.	Pair usually with male following female, but never in contact.
3. Location of nest	In a cavity.	Not in a cavity.
4. Nature of eggs	Slightly adhesive, adhere in a mass.	Strongly adhesive, no eggs in contact.
5. Need of aeration	Necessary for respiration of the eggs.	Not essential for respiration of the eggs. A protection from silting and enemies only.
6. Roles of parents	Female does most of the incubating, while male guards (sometimes both incubate).	Male does most of the incubating, while the female guards (sometimes both incubate).
7. Incubating method	Chiefly the ventral fins by means of a vertical motion aided by the anal.	Chiefly the pectoral fins aided by the anal, or swimming motions of the whole body.
8. Eggs taken in mouth	For churning, to insure adequate aeration (and cleaning?).	For removal of hatching young to the "nursery" only.
9. Care of young	Kept in or close to nest, but for which there is no special construction.	Removed to a shallow hole especially prepared.

¹ The details of behavior of *Aequidens* are set forth by Breder (1934a).

SUMMARY.

Breeding Behavior.

1. *Ameiurus nebulosus* may spawn at least twice a season after a temperature of 21° C. has been reached.

2. A natural, sheltered hollow is cleaned out by both sexes for the reception of the eggs. In the absence of such, a hole may be dug in gravel. The gravel may be transported by the mouthful.

3. Spawning occurs within the nest cavity. So far as known the fishes face in opposite directions during spawning.

4. The eggs are constantly attended, lain upon by either or both parents, violently agitated, beaten with the ventral fins, or taken into the mouth and ejected violently.

5. The young fish are guarded in a more gentle manner. When they are able to swim freely they are still guarded for a considerable time.

The Eggs and Young.

6. The eggs are large, about 3 mm., adhesive and covered with a soft, gelatinous covering, somewhat resembling frog eggs.

7. They will not hatch away from their parents unless continually agitated, in a manner approximating the activities of the parents. The oxygen requirement would seem to be unusually high, and the gelatinous envelope may account for it, while at the same time protecting the embryo from mechanical injury due to the necessary rough handling.

8. The young fish have a large yolk and are cream white in color. After about 12 days they are able to swim up from the bottom and are heavily pigmented by that time.

9. The young fish move in a dense school, kept together almost entirely by visual stimuli.

10. The reproductive habits of *Opladelus* are strikingly similar to those of *Ameiurus*.

Inferences.

11. The oral gestation of the Ariidae appears to be foreshadowed in the breeding behavior of the Ameiuridae, since the latter have already established the use of their mouths for churning their eggs about.

12. Neither viviparity nor gastric incubation has been satisfactorily established for the Nematognathi, both being apparently based on erroneous interpretations.

13. The adhesion of eggs to the ventral surface of the Aspredinidae is suggested by the position frequently assumed by the Ameiuridae in incubation. If they were not so slippery the eggs would undoubtedly adhere to their stomachs as may be the case in *Macrones*. This would seem to be a first step, leading to the advanced condition with modified integument, as found in *Aspredo*.

14. The well coordinated activity of the ventral fins of *Ameiurus* and *Opladelus* in working over the eggs, suggests a starting point possibly culminating in habits of those forms, such as *Corydoras*, that use the same fins as an inseminating basket.

15. The specialized nematognaths, such as *Astroblepus*, *Otocinculus* and *Corydoras*, that deposit separate adhesive eggs, would seem to have passed through some breeding habit similar to that of *Ameiurus* rather than have escaped it entirely. Since the specialized musculature of the nematognath pelvic appendages is clearly used for reproductive purposes in such relatively primitive forms as *Ameiurus*, it would seem to be a point of origin for such now used, in the three genera mentioned, for a distinctly different purpose.

16. It thus becomes apparent that, starting with *Ameiurus*, a clue to all of the reproductive habits of the more advanced nematognaths may be found. Further knowledge of the details of habits as yet unknown are necessary before it will be possible to trace the full history of any single mode of reproduction.

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Fig. 12 (Upper). *Ameiurus nebulosus*. After a site for the nest is selected, the pair of catfishes spend much time resting quietly side by side with the tails pointing out. 1933.

Fig. 13 (Lower). As spawning becomes more imminent the fishes become active and circle continually in an agitated fashion. 1933.



Fig. 14 (Upper). *Ameiurus nebulosus*. Just before spawning the circle that their two bodies form flattens so that the fish are in contact, head to tail. 1933.

Fig. 15 (Lower). At the moment of egg laying. The accumulating pile of large eggs may be seen under the female. Note that the head-to-tail position is retained. 1933.



Fig. 16 (Upper). *Ameiurus nebulosus*. Immediately after spawning the fishes separate slightly and rest. In this photograph the ventral fins of the female entirely obscure the eggs. 1933.

Fig. 17 (Lower). Sometimes a clump of eggs is dislodged and knocked out of the nest. Here the female is feeling them with her barbels. 1933.

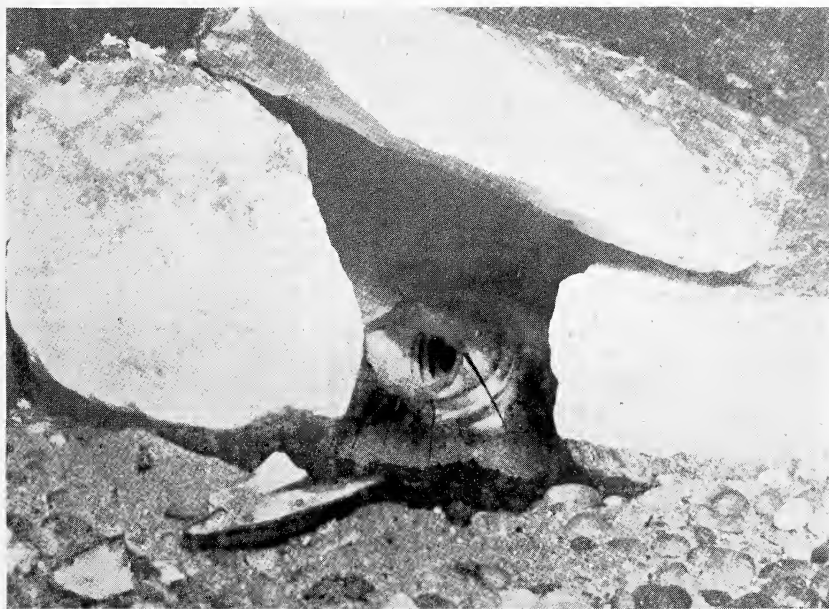
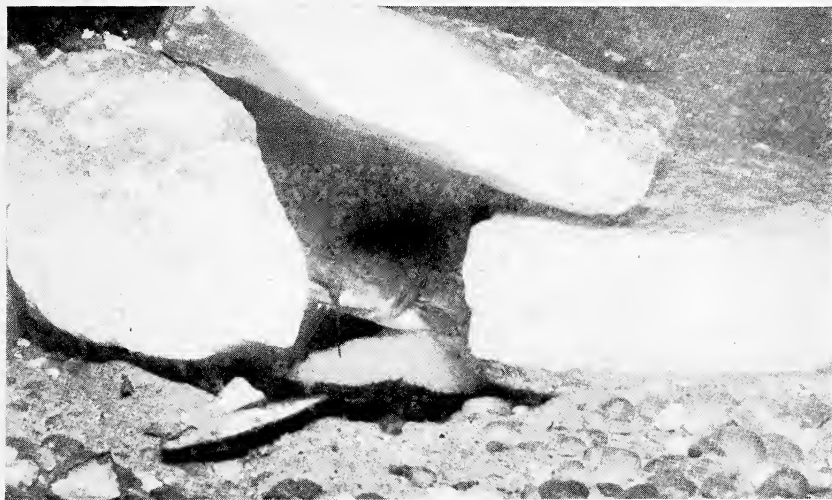


Fig. 18 (Upper). *Ameiurus nebulosus*. A typical pose of the female on her eggs. 1932.

Fig. 19 (Lower). The yawning of the brooding fish which is characteristic and may aid in aeration. 1932.

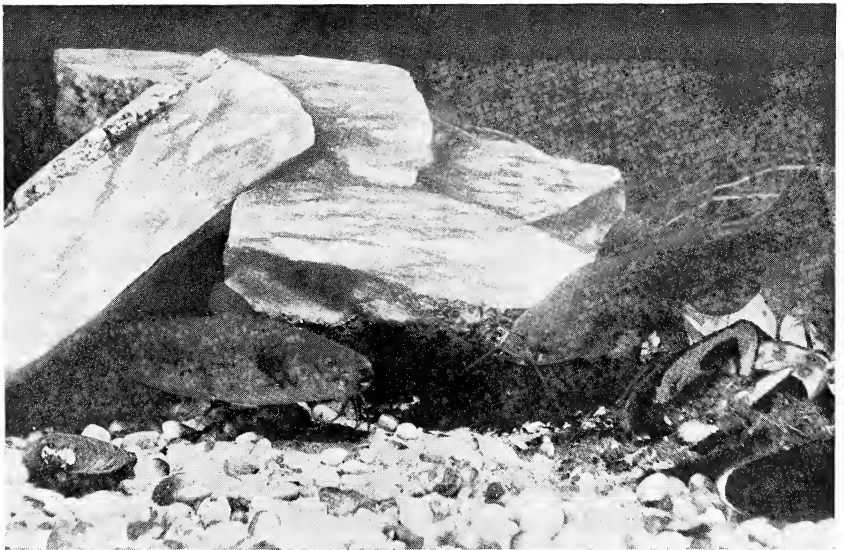
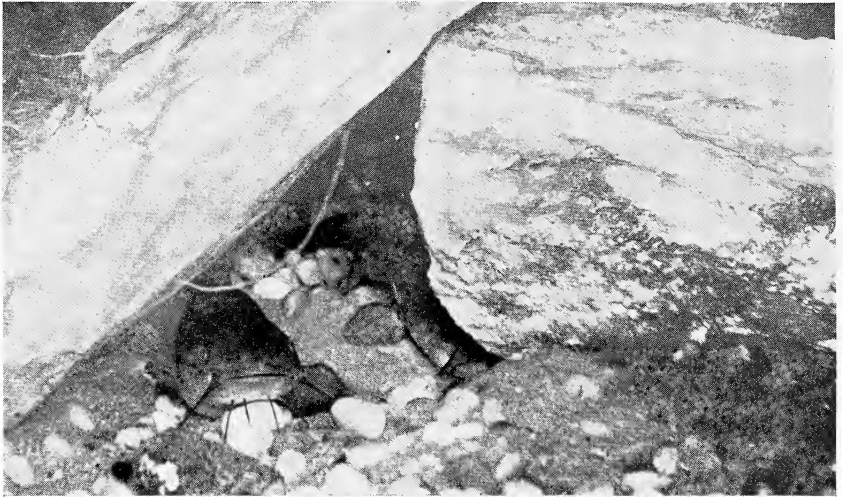
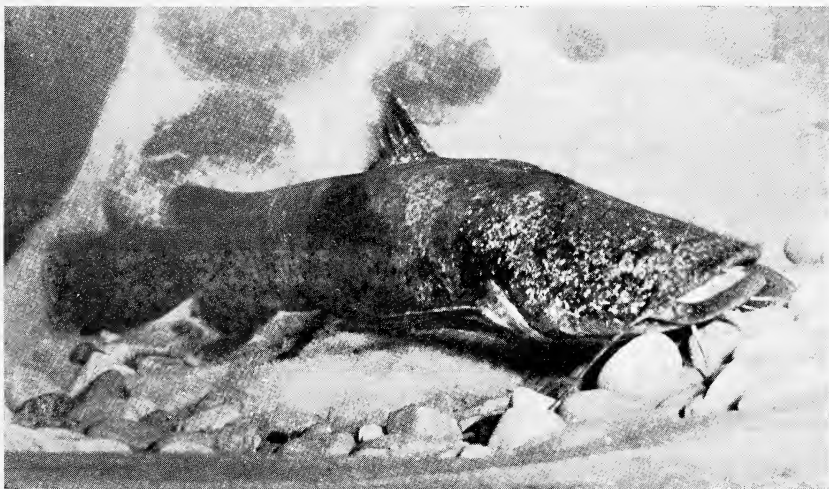


Fig. 20 (Upper). *Ameiurus nebulosus*. Both parents incubating at the same time. 1931.

Fig. 21 (Lower). Both parents "rounding up" the young fish, which may be seen as an oval black spot between them. 1931.



Figs. 22 and 23. *Opladeus olivaris*. Two typical postures of an incubating male. Note especially the application of the ventral fins to the egg mass.

These two photographs were taken at the John J. Shedd Aquarium in Chicago by Loren Tutell of the staff of that institution. The other photographs reproduced in this paper, of *Ameiurus nebulosus*, were taken at the New York Aquarium by S. C. Dunton of the Aquarium staff.

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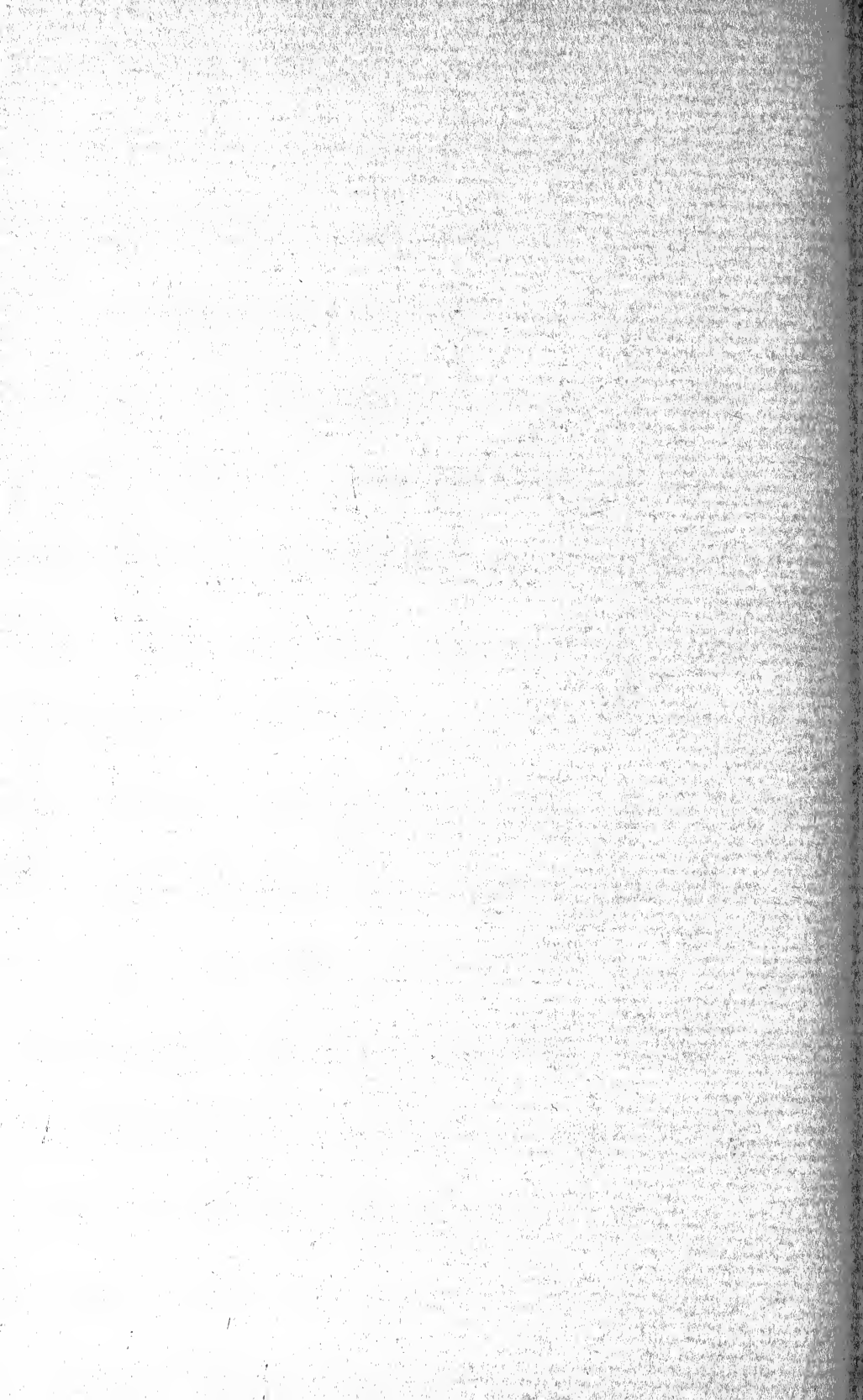
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SEX RECOGNITION IN THE GUPPY, *LEBISTES* *RETICULATUS* PETERS

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New York Aquarium

and

C. W. COATES

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SEX RECOGNITION IN THE GUPPY, *LEBISTES RETICULATUS* PETERS

C. M. BREDER, JR., AND C. W. COATES

New York Aquarium

(Figs. 24 and 25)

INTRODUCTION

Descriptive studies of the reproductive habits of fishes comprise a large literature but analytical consideration of the factors involved is relatively scant. This paucity of critical examination is especially marked in the matter of sex recognition. Those papers which do go into the subject at all are confined to a discussion of species in which nest building or some other intricate behavior pattern is an accompaniment of mating. In such cases the females are necessarily obliged to take some active part in the reproductive act, since they are oviparous and fertilization is coincident with the shedding of the female genital products. The species at present under consideration, *Lebistes reticulatus* Peters, differs from these in that it represents a group of viviparous fishes in which mating takes place at a time prior to extrusion of the genital products from the female and in which the act of fertilization is successful without any apparent cooperation on the part of the female.

Considering the findings on oviparous fishes, the actual act of recognition is based chiefly if not entirely on the difference in behavior between a female ready to spawn, and others. This appears again and again in various guises, depending on the physical equipment of the specific form and its particular mating requirements. Such studies on the lamprey have been made by Young and Cole (1900) and Reighard (1903); on a darter by Reeves (1907); on a dace by Smith (1908); on the chubs and minnows by Reighard (1910 and 1920); on the log perch (1913) and on the stickleback by Wunder (1927 and 1930); on the

Siamese fighting fish by Lissmann (1932); on a cichlid by Breder (1934) and on a sunfish by Noble (1934). In addition, various unpublished observations have been made on Cyprinidae, Siluridae, Labyrinthidae and Centrarchidae which indicate the same type of behavior. It is unnecessary to enter upon a full discussion of sex recognition in such forms at present, and this mention is made chiefly to call attention to the differences in the mode of reproduction in such forms and the one under consideration. The fish *Lebistes* presents a most striking form of sexual dimorphism concerning color, pattern, body form and size. It is, in fact, much more marked than in any of the above-mentioned species that have been published on or studied. Nevertheless, cooperation by the female is not an apparent element.

The reason for undertaking the present study was to determine if the methods of recognizing a suitable mate in *Lebistes* differed in accordance with the physical differences from other species and with other matters concerning reproduction. These include the mode of mating, the role of sexual dimorphism, the significance of the courtship and the attitude of the female toward courting males.

The mating of *Lebistes* may be described as follows: An active male on approaching a female usually spreads his fins widely, bends his body slightly and vibrates, accompanying this by a curious backing motion. This usually takes place slightly below and to one side of the head of the female but may occur in almost any spot relative to the female. Almost always this is interrupted by the female swimming rapidly away. In a small aquarium, with few fish, a more or less vigorous pursuit may follow. More often, however, the male is distracted by other females which he then proceeds to court. Under usual aquarium circumstances the males are generally outnumbered about two to one, as shown by Breder and Coates (1932). The behavior described above is commonly accompanied by a more or less energetic movement of the exceedingly mobile gonopodium to the side next to the female. This behavior may almost always be found in a tank of *Lebistes*. Normal, healthy males seem to be almost continually active in this regard, interrupting it only for feeding, but without considerable observation this is about all that can be usually noted in such an aquarium.

Prolonged observation will reveal, however, that eventually the male gives up this procedure and directs a rather violent thrust of the gonopodium toward the genital pore of the female. A momentary contact effects the transfer of the encapsuled spermatozoa. This actual transfer of material seems only to occur after the male has slipped up to the seemingly unsuspecting female. Not infrequently a male may be seen to court one fish and as she flees succeed in fertilizing another and hitherto unnoticed one. No females at any time have been observed to show other than escape reactions to the male attentions. Never were they observed to evince the slightest evidence of interest in the proceedings. The significance of these elements of the reproductive act are examined in the discussion.

The experimental parts of this study were directed toward the actual *modus operandi* of sex recognition on the part of the male *Lebistes*.

EXPERIMENTAL STUDIES

Preliminary to the experiments, males were isolated in aquaria from which they could not see other fishes for a period of at least six days, and fed adequately with *Daphnia*. This was done on the supposition that such confinement would insure an active "sex appetite," although it must be admitted that male guppies have never been noted by the authors to be deficient in that regard. The males were then placed in a series of observation chambers, one fish to each. There were six "stalls," each large enough to hold one rectangular battery jar (5"x3"x8") completely shielded from outside interference, lighted from the top, and with a carefully screened observation peep-hole cut through one wall. To these fishes various stimuli, such as females, were introduced in different manners. For purposes of analysis the reaction of the male was considered positive when the male erected the gonopodium, vibrated the dorsal fin and displayed directly before or in the immediate vicinity of the stimulus, whether or not copulation was effected. All other activity was considered negative. The responses were noted and timed. In every case the stimulus was removed from the subject after four minutes had elapsed, except as otherwise

noted. No response in that period was entered as negative. Not more than four tests of a subject were made in any one day and a period of at least thirty minutes was allowed between each experiment on any one fish. As will be further developed, this was necessary because of a peculiarly rapid conditioning that early became apparent.

Reactions to female Lebistes: As is well known, male *Lebistes* normally court females on sight. Consequently, it is not surprising that in all cases positive reactions were secured when females were presented directly (Test 1, Table I). Females floated in a small beaker gave less than 100% response. Of the 78 tests, 48, or 62%, elicited a positive reaction (Test 2, Table I). Females exhibited in another aquarium placed beside the test aquarium resulted in only a 17% response (Test 3, Table I). When removed to a distance of 150 mm., no response was obtained (Test 4, Table I). This series of tests shows clearly that vision alone may serve to account for sex recognition in *Lebistes*. As a check on this, females were placed in the aquarium confined in a perforated but opaque container (Test 9, Table I), and water from an aquarium containing females was added (Test 10, Table I). Both yielded no response, indicating the lack of a possible chemical stimulation operating in sex recognition. See also Table IV, which gives the data of Table I recalculated in detail showing the behavior of individual males to their various trials.

It is to be noted that the percentage of response falls from 100% to 0% in tests Nos. 1 to 4. If the average random positions possible for the female in relation to the test male are plotted, a chart expressing this relationship may be constructed. Such a diagram is given in Figure 24. Thus Test 1 is practically 0 distance because of the small size of the test aquarium. Test 2 had an average distance of 50 mm. This is further complicated by the partial obscuration of vision due to the curving of the beaker as well as its position more or less above the test male, because of its being floated in the aquarium. Test 3 had an average distance of 100 mm. (center to center of the two tanks). Test 4 similarly represents a measured distance (center to center). The line "Female *Lebistes*," in Figure 24, probably thus represents merely a falling off of visual acuity with distance.

This may be further demonstrated with any aquarium of *Lebistes*. Practically any object moved in front of such an aquarium will attract all the fishes to that side if the object is not more than 150 mm. away. This, obviously, refers to conditions of bright light falling in such a direction as not to cast a shadow on the aquarium. In the latter case distance of object has little to do with visibility. In conditions of poor light or slight difference between color of object and background, the distance of visibility is less.

Females anesthetized with chloretone,¹ lying on the bottom of the aquarium (Test 5, Table I), and suspended by a hair so that some imitative motion was possible (Test 6, Table I), both produced some response. It is perhaps remarkable that the first gave a 53% response, while the second, with motion, gave only 14%. It may be that the movements were so unlikelike that some fright was induced (?). It is to be noted that the presumable exudation of the chloretone did not inhibit attempts at mating, again emphasizing the lack of a chemical element in matters of sex recognition.

Freshly dead, suffocated females, direct in the test aquarium (Test 7, Table I) or in the beaker (Test 8, Table I), failed to evoke the mating reaction. In the former, three out of twelve test males attempted to feed on the dead female. At this writing it is not clear just how this "food recognition" operates, or how the difference between an anesthetized and a dead fish is detected.

Reactions to other fishes: Since *Lebistes* have been seen to attempt to mate with other males, especially if the latter were large, and with other fishes, no tests were made with males directly in the same aquarium. Males were exhibited in the beaker (Test 11, Table I) and produced a large percentage of positive reactions, 75%, while females under the same conditions produced only 62% on the same test males. As male *Lebistes* are rather more active than the females, it may be that under such conditions the former are simply more conspicuous.

Three foreign species—*Cyprinodon*, *Barbus* and *Fundulus*—tested direct and in the beaker gave rather interesting results.

¹ Chloretone 1 cc. sat. sol. to 5 H₂O. The reaction period averaged about two minutes and recovery occurred in about thirty minutes. No mortality or ill effects were noted.

TABLE I

Results of Exposures of female *Lebistes* under various conditions to 24 test males in 179 trials

Exp. No.	Exposure to test male of:	No. of Tests	No. Pos.	No. Neg.	% of Tests Positive
1	Female <i>Lebistes</i> direct in same aquarium.....	36	36	0	100
2	Female <i>Lebistes</i> in a beaker floated in aquarium..	78	48	30	62—
3	Female <i>Lebistes</i> in an immediately adjacent aquarium	6	1	5	17—
4	Female <i>Lebistes</i> in an aquarium 15 cm. distant..	6	0	6	0
5	Anesthetized female direct in same aquarium, lying on bottom	15	8	7	53+
6	Anesthetized female direct in same aquarium, suspended by hair	7	1	6	14+
7	Freshly dead female direct in same aquarium....	12	0	12	0
8	Freshly dead female in a beaker floated in aquarium	6	0	6	0
9	Female in perforated opaque box in aquarium...	7	0	7	0
10	Water from aquarium containing many females added to aquarium	6	0	6	0

Results of Exposures of male *Lebistes* and fish of other species, under various conditions to 12 test males in 72 trials

11	Male <i>Lebistes</i> in a beaker floated in aquarium....	12	9	3	75
12	<i>Cyprinodon variegatus</i> direct in same aquarium..	6	3	3	50
13	<i>Barbus conchoniui</i> direct in same aquarium.....	12	3	9	25
14	<i>Fundulus heteroclitus</i> direct in same aquarium..	12	4	8	33+
15	<i>Cyprinodon variegatus</i> in a beaker floated in aquarium	6	1	5	17—
16	<i>Barbus conchoniui</i> in a beaker floated in aquarium	12	8	4	67—
17	<i>Fundulus heteroclitus</i> in a beaker floated in aquarium	12	7	5	58+

Results of exposure of models, shadows and other objects under various conditions to 12 test males in 78 trials

18	Model of female <i>Lebistes</i> suspended immediately outside aquarium	6	0	6	0
19	As in 18, but moving.....	6	0	6	0
20	As in 18, but suspended in side aquarium.....	6	0	6	0
21	As in 20, but smeared with mucus from living female	12	0	12	0
22	As in 21, but moving.....	6	0	6	0
23	Mirror attached to outside of aquarium.....	12	0	12	0
24	Empty beaker floated in aquarium.....	18	2	16	11+
25	Projected shadow of living fish on screen attached to aquarium	12	2	10	17—

All gave a percentage of positive reactions. The degree of activity of these three fishes is in the ascending order of *Cyprinodon*, *Fundulus*, *Barbus*. The percentage of response direct in the aquarium was in the reverse order of this: 50%, 33%, 25% (Tests 12, 13, 14, Table I). The active and fast moving *Barbus* scarcely gave the male a chance to organize its courting display before it was off in another corner with the male in pursuit. The more sedate *Cyprinodon* usually permitted the male to go through a recognizable positive display before moving off. *Fundulus* was somewhat between these two. When confined in the beaker an inversion of these relationships was found; *i.e.*, the order of reaction stood *Barbus*, *Fundulus*, *Cyprinodon*, with reactions 66%, 58%, 16%, respectively (Tests 16, 17, 15, Table I). These fish closely confined in a beaker had scant range of movement but preserved their specific degree of activity. This, then, instead of acting as deterrent as before, attracted greater attention in a manner analogous to that in which a male *Lebistes* in a beaker attracted more than a female (Tests 2 and 11, Table I). From this it may be fairly inferred that degree of activity and movement are important in stimulating mating activity.

Reactions to other objects: A very carefully made model of a female *Lebistes*² was tested in various ways but in no case was a response obtained. It was suspended quietly outside the aquarium (Test 18, Table I) and with movement (Test 19, Table I). It was suspended in the aquarium without motion (Test 20, Table I) and was smeared with mucus of a living female, still (Test 21, Table I) and moving (Test 22, Table I). These latter two experiments again indicate the lack of involvement of a chemical sense. Like the distinction of a dead from an anesthetized female, the lack of courting of this model is not explainable at this writing. Certainly other fishes will attempt displays before models. For example, *Betta splendens* Lissmann (1932) and *Eupomotis gibbosus* Noble (1934).

A mirror placed outside of the aquarium produced no response, but mirrors *in* an aquarium will do so frequently (not part of Table I). Lissmann has also noted this for *Betta*. This is referred to the apparent distance of the mirror image rather

² We are indebted to Mr. Edward Howell, sculptor of miniatures, for the preparation of this model.

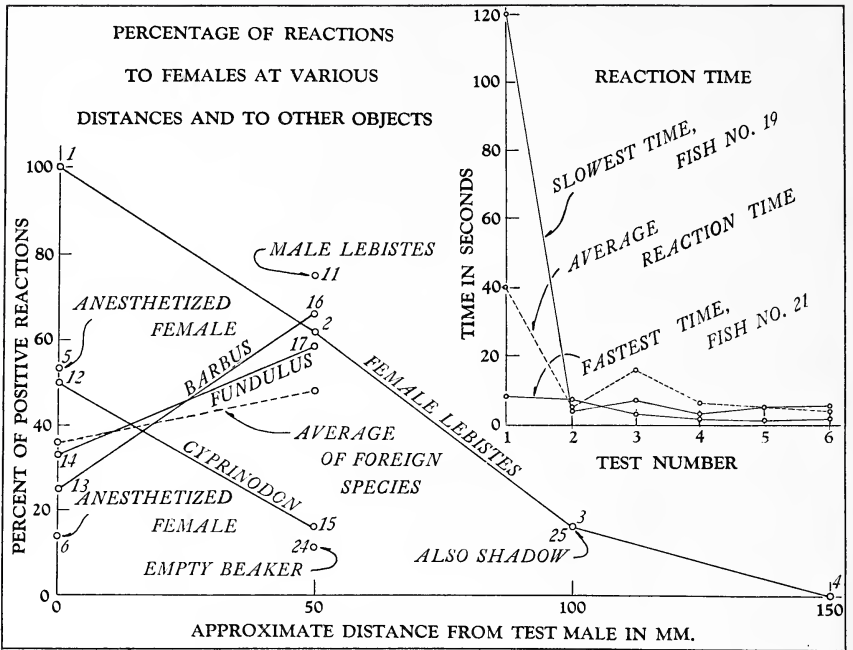


Fig. 24. Graphic arrangement of reactions of male *Lebistes* in a study of sex recognition.

Main graph: Percentage of courting reactions of test males to objects named in italics. Numbers in italics refer to the test numbers of Table I. Test yielding zero reactions omitted, except to female *Lebistes*.

Insert graph: Time in seconds for test males to display courtship activities in successive trials. Italics indicating fastest, slowest and average time refer to Table II.

than any other factor, as suggested by the data on the female reactions shown in Figure 24. For example, the mirror's actual distance was about 100 mm. but the apparent distance was about twice that.

A projector was so arranged as to allow a narrow aquarium to be placed between the lens and the light source. The silhouette image of a fish placed in this tank was projected on a piece of parchment affixed to the side of the test aquarium. For this purpose a *Barbus* was used, because of its activity. The response elicited by this image was exactly the same as brought forth by a female at the same distance, 17% (Test 25, Table I). See Figure 24.

A most peculiar response was obtained in checking the possible extraneous effects of introducing a beaker into the test

aquarium. This was introduced eighteen times empty. On two such trials a positive reaction was obtained (Test 24, Table I). Two males out of the six so tested reacted. This reaction included thrusting the gonopodium vaguely at the curve of the bottom and side of the beaker, at the place where the females usually come to rest. This is referred to a rapid conditioning, since it only occurred after the males in question had been attracted by a beaker containing a female.

The details of this behavior are set forth in Table II. These data arranged graphically are given in Figure 25. It will be noted that the closely analyzed data, considering the reactions to females in beakers alone, rose from 0% to 100% in three test periods at similar times on three successive days. Most likely the failure to respond at first had to do with initial fright on the disturbance of introducing the beaker. As this passed off, the attractive powers of the contained female very rapidly overcame it, coupled with a conditioning to a repeated stimulus that was followed by no "punishment." Four days later females were again presented in this fashion and then only two of the six males, or 33+%, reacted.³ Apparently in that time the conditioning had partly disappeared, or, at least, the fish had forgotten the association of a possible mate with this type of disturbance. Males presented at 4 P.M. of the last day (8/16) caused a response by five of the six males, or 83+%. This is not thought to be a significant difference, since on other tests (see Table I and Figure 24) the males, considering all tests, showed a stronger attraction, as is discussed in another place. Fish Nos. 7-12 inclusive were exposed to a male in a beaker, a male in a beaker outside the aquarium, and twice to females in beakers in the aquarium in successive hours, and to females in a beaker twenty-four hours later. Comparable results were obtained, considering the slightly differing conditions.

The first exposed (male) and the third and fourth (female) induced a comparable increase in percentage of the test males reacting; *i.e.*, 66+%, 83+% and 100%. The second (male) is not comparable, for the fish was farther away and the percentage was proportionately lower, 16+%. Compare with data

³ These data and that following on this subject were not included in tabular matter because of space limitations.

TABLE II

Conditioning of males to a female in a beaker floated in an aquarium and to an empty beaker. Fishes No. 1 to 6, inclusive, used once in each test

Date and hour of test (P.M.)	No. Positive	No. Negative	% of Tests Positive	Beaker
8/14 2	0	6	0	with female
8/14 3	1	5	17—	with female
8/14 4	2	4	33+	with female
8/14 5	2	4	33+	with female
8/15 3	1	5	17—	empty
8/15 4	0	6	0	empty
8/15 5	5	1	83+	with female
8/16 1	1	5	17—	empty
8/16 2	6	0	100	with female
8/16 3	6	0	100	with female

in Figure 24. The higher level of the first three as compared with data in Figure 25, would seem to be referable to initially less fear on the part of these fish or earlier unintentional conditioning of which no accurate record was kept. Twenty-four hours later a female in a beaker elicited a 66+% response. This set seemed to unlearn what they had learned the day before, whereas the first set of test fish did not. Such differences are naturally to be expected and, if anything, these figures are rather remarkable for their closeness of agreement.

Referring again to Table II and Figure 25, the remarkable response to an empty beaker may be examined. Presenting such a beaker about twenty-four hours after a response to a female, a 16+% reaction was obtained. An hour later it was zero. An hour following this the recognition of a fish in the beaker was demonstrated by 83+%. The next day again, about twenty-four hours later, 16+% was again obtained. An hour later 100% reaction was the response to females in the beaker. From this it may be inferred that the association of a female with a beaker is retained for at least twenty-four hours, but one presentation of the empty beaker is sufficient to break this. It may be built up again on one exposure to a female in the beaker. This discussion could be carried somewhat further, considering the length of time before a positive reaction took place, etc., but it

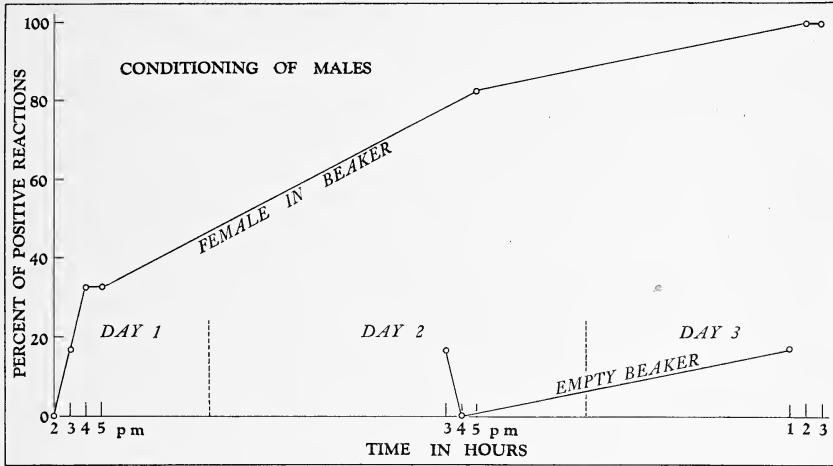


Fig. 25. Graphic arrangement of conditioning of male *Lebistes* to females in a beaker floated in their aquaria, and to empty beakers. The data refer to Table II. Each point represents the percentage of positive responses obtained from one test on each of six fishes (Males No. 1 to 6, inclusive).

may suffice to point out that the reactions to the empty beaker were rapid as compared with an average of the others. Further experiments would be necessary to demonstrate more thoroughly the extent of this apparent “snap judgment” and conditioning, but for the present purposes the above will suffice. It demonstrated the need of care in a study of this kind, which was its only purpose. All subsequent work was carried on with these data as a guide, involving the application of time intervals sufficient to assure the unlearning of any possible conditioning.

This phenomenon leads to an examination of the speed of the reaction times of the males of this species. Six males were exposed to a female direct in their aquaria, six times each. The time in seconds for each reaction is given in Table III. Between each test a period of twenty-four hours elapsed, except between Tests 4 and 5, which was forty-eight hours. It will be noted that the mean reaction time varied from twenty-four seconds (Fish No. 19) to four seconds (Fish No. 21). The average of the reaction times for each successive trial falls in good order from forty seconds to four seconds. Fish No. 20 did not react rapidly on the third trial and then seemed to begin all over. Omitting this one exceptional fish, the curve of descent

would be even more regular. The inset of Figure 24 gives the average reaction time, together with that of the fish with the longest and shortest mean time. It is to be noted that after the initial drop between Tests 1 and 2, there is little further reduction. The introduction of a female from a net seems to be taken for granted almost after one trial. Compared with the "learning curves" of Welty (1934) for goldfish, the present would seem to be in accord, considering the large difference between maze learning and sex recognition which make use of the food and mating "drive," respectively. This is in keeping with the

TABLE III
Reaction Times of Experiment No. 1, Table I

Test Male No.	1	Trial No. 2	Reaction 3	Time 4	in Seconds 5	6	Average
19	120	4	7	3	5	5	24
20	5	7	75	25	11	7	22—
21	8	7	3	2	1	2	4—
22	72	2	1	2	2	3	14—
23	11	4	7	1	2	5	5
24	14	2	4	3	7	2	5
AVERAGE	40	4+	16+	6	5—	4	

speed of learning that *Lebistes* show, regarding in which corner of the aquarium they are commonly fed. We consider this an explanation of the attempt to court an empty beaker by some rapidly learning males, especially since there appears to be considerable spread in the rapidity with which *Lebistes* learn, as is evidenced by data given in Tables II and III.

DISCUSSION

It is clearly evident from the foregoing experiments that vision alone can account for the marked sexual activity of *Lebistes*. Experiments involving the chemical senses, on the other hand, yield nothing but negative results. The same is true of any conceivable mechanical agitation. Experiment No. 9 should have given some such evidence on this sense, as well as olfaction if it were present. In this connection it is noteworthy

that *Lebistes* are purely diurnal and attempt no mating or courting at night, as may be noted by suddenly flashing on a light or examination by a dull red light to which they are not responsive. When the light falls below a certain threshold, they quiet down and rest passively, usually in the shelter of some vegetation.

The items calling forth the display reactions of the courting male may be evoked by a wide variety of optical stimuli so long as they occur within a limit of about 150 mm., provided the light is not behind the subject. This latter, naturally, is rare in a state of nature and probably does not enter at all. It could occur only with an object overhead and since *Lebistes* is so predominantly a surface fish of shallow water, such an occasion would certainly be uncommon.

The apparent distinction between a dead female, a model and an anesthetized one, is not readily explained. Parts can be explained on a reasonable basis, however. Since the males will attempt courting a projected shadow, it may be that the "characteristic" fish movement with its apparent alternate expansion and contraction in size is the important factor. Then, all the experiments involving a moving model, stiff and awkward, might be ruled out as fear-inspiring, rather than attractive. This in no way, however, helps in understanding why a dead female lying on the tank floor was treated as a food object, while a similarly inert anesthetized one was courted. While this peculiarity requires further study, it certainly suggests the entry of some delicate chemical distinctions. Under water, the otherwise disregarded "effluvia" of a dead fish is very likely different from that of one under an anesthetic, although one would suppose that such a substance itself would act as a repellent.

Considering the visual elements involved, we seem to be on much more secure ground. These reactions of the male are clearly conditioned purely by the size, distance and amount of motion of the object involved, as modified by the light conditions affecting the visual acuity of the subject. It is only at exceedingly close ranges that certain features of recognition become confused, as above indicated. A study of the optical system of this fish should be of value in this connection.

TABLE IV
 Behavior of individual test males under the trials of Table I, expressed in percentage of positive reactions.

Test Male	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	% of Tests Re-acted to
1	37	..	..	..	50	0	0	0	..	0	100	0	0	0	0	0	0	..	..	..	0	..	0	0	0	18--
2	50	..	..	..	100	100	0	0	..	0	100	100	0	0	0	100	100	..	..	..	0	..	0	33	0	53--
3	37	..	..	..	50	0	0	0	..	0	0	0	100	100	0	0	0	..	..	..	0	..	0	0	0	24--
4	37	..	..	..	50	0	0-B	0	..	0	100	0	0	0	0	100	0	..	..	..	0	..	0	0	100	29+
5	87	..	..	..	..	..	..	..	..	0	100	100	100	0	0	100	100	..	..	..	0	..	0	33	0	50
6	62	..	..	..	..	..	..	..	..	0	100	100	0	0	0	0	0	..	..	..	0	..	0	0	0	18--
7	33	0	0	0	50	0	0	0	..	..	0	0	0	0	..	0	0	0	0	0	0	0	0	0	0	10
8	100	0	0	100	0	0	0	0	..	100	..	0	100	..	100	100	0	0	0	0	0	0	0	0	0	30
9	100	0	0	0	0	..	0-B	..	0	..	100	..	0	100	..	100	100	0	0	0	0	0	0	0	100	33+
10	100	100	0	0	0	..	0	..	0	..	100	..	0	0	..	100	100	0	0	0	0	0	0	0	0	31+
11	100	0	0	0	..	..	0-B	..	0	..	100	..	100	100	..	100	100	0	0	0	0	0	0	0	0	37+
12	66	0	0	0	..	..	0	..	0	..	0	0	0	0	..	100	100	0	0	0	0	0	0	0	0	19--
13	0	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	0
14	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
15	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
16	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
17	50	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
18	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
19	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
20	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
21	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
22	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
23	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100
24	100	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	100

% 100 of Males Reacting 94+ 17- 0 75 14+ 0 0 0 0 75 50 25 33+ 17- 67- 58+ 0 0 0 0 0 0 0 0 0 0 0 0 33+ 17-
 B = "Bitten",--regarded as a food object by test male.

Since *Lebistes* is an aggregating species living in communities of sometimes considerable size, a consideration of this habit is necessary in order to understand certain features of recognition. In the experimental portion of this paper, display and courting behavior were considered a positive evidence of sex recognition. Since the males will "court" a diverse number of objects, the question may be raised as to what is sex recognition in such forms, in the first place. It has been shown that males of other fishes, when in the proper physiological state, have a courting display for females indistinguishable from the fighting or "bluff" display. For example, Lissmann (1932) for *Betta*, Breder (1934) for *Aequidens*, and Noble (1934) for *Eupomotis*. Since *Lebistes* is continually ready for mating, there is every reason why these fishes should perform as they do on every occasion presenting itself. Whether these are to be considered bluff at one time and courtship another, seems to us to be almost pointless. Since these fishes do not fight as do the ones mentioned above, the display simply results in a parting of the two males. If both display, it would seem there is a mutually discouraging effect. If the approached fish is a female, it seems to make little difference, for she will flee also. Successful mating seems only to be accomplished by slipping up to the female, as previously pointed out, which interpretation leaves the display without functional significance. Since it might be argued that the display may have value in telling two approaching males what *not* to mate with, it is pointed out that males will sometimes pursue other males that in turn are bent on courting females. Since the latter male has its attention occupied, the former will sometimes apparently effect transfer. This naturally results in a complete but momentary interruption of the latter's courting activity. Before these features become evident themselves, however, the simple, non-sexual, aggregating tendencies of *Lebistes* come into play.

The schools of *Lebistes* are certainly held together by the common means described by Parr (1927 and 1931), Spooner (1931), Bowen (1931) and Breder and Nigrelli (1935) for other fishes. In *Lebistes* the fishes do not head all the same way, as they are neither stemming a current (normally) nor moving in any more or less rectilinear path. Any such tendency is

broken up both by their individual browsing habits and the random sexual efforts of the males. Just as it has been shown that *Lebistes* will attempt to mate with a variety of objects, just so it may be shown that they will attempt to consort with practically any small moving object. In fact, the latter must take place first in order for the former to become operative.

The conclusion cannot be avoided that sex recognition, as such, is non-existent in *Lebistes*. Breder (1934) showed that in *Aequidens* recognition on a basis of behavior existed between ripe females and all other individuals. Because females of *Lebistes* are always capable of being "fertilized," even this distinction disappears. The sperm of this fish is encapsulated, and may be retained for months in a viable state in the female's body, and as the eggs are fertilized for at least as many as six successive broods, it would seem that here a distinct conservation of the male element occurs. This feature is completely nullified by the prodigious energy with which the males dispense their substance. Consequently it would seem that such fish are no more conservative in this regard than fishes that have a less efficient method of uniting sperm and eggs, but in which mating is only possible with physiologically suitable mates. It would seem that some level of effectiveness is reached in fish fertilization, but no matter by what means there always remains a loosely integrated element that makes for a large wastage of sperm. Perhaps this has some general but obscure physiological implication.

With the conditions as described a significance can scarcely be referred to the elaborate but variable pattern of the males. Certainly no female *Lebistes* gives the slightest evidence of ever being in a position to exercise any "sexual selection." As it might be thought that the lack of fixed pattern in the males of this species might be conditioned by this very fact, it may be pointed out that among the Poeciliidae there is a wide range of secondary differences between the sexes as well as many cases of nearly complete similarity. *Gambusia affinis*, for example, shows very little color or pattern differences between the sexes. Others show marked differences, but the male pattern is relatively definite and fixed; for example, *Micropoecilia branneri*. In some species the males carry elaborate ornamenta-

tion other than color, such as *Xiphophorus* and *Mollienisia*. In most, the males are considerably smaller than the females, but in some the corporeal differences are relatively slight, as in *Platypoecilus*. Since there is no reason to suppose that there is any important difference in the courtship and recognition mechanism of the various Poeciliidae, and a considerable amount of observation by both authors shows that the basic performances are similar, we have no reason to assume that their particular habits of courting tend to encourage (1) polymorphism of the male secondary sex characters; (2) fixity of the male secondary sex characters; (3) large differentiation between male and female, or (4) similarity between male and female.

Noble (1934) in discussing the possibility of sexual selection in *Eupomotis*, suggests that brighter males might be visited more frequently than relatively dull ones, or that the females might visit the more actively cleaned and presumably more conspicuous nests. He writes, "Hence it is probable that a true sexual selection may occur in the sunfish, since the females would presumably move into redds which attract their attention first." While this is not the place to discuss this view in detail, it may be pointed out that such a condition would appear to be valid only in the case of a large disparity between the number of males and females. Thus, a relatively few females, if mating with the first available males (on the average, most conspicuous), might become exhausted of roe before all nests received a quota of eggs. Observation by one of us in a scattered variety of places, over a number of years, leads to no such conclusion, however, since what may be called "bachelor" males have never been noted and the proportion of the sexes is certainly not low on the female side.

This matter is mentioned in the present connection to point out that for alleged sexual selection to be operative in fishes, even in forms that require cooperation of the female, there must be a sufficiently small number of females present to allow of the most "unattractive" males going unmated. Consequently in *Lebistes* and the Poeciliidae in general, even if it were not for the disinterest of the females, sexual selection could hardly be expected to be operative by that sex because of the complexion of the population which is so predominately female.

Pertinent to this discussion is the condition found in a large collection of living *Lebistes* sent to the New York Aquarium by Mr. Claudio Urrutia from Venezuela. The males of this strain were found to be strikingly lacking in the usually brilliant pattern of these fish. Some had the faintest suggestion of a yellow or greenish streak, some a dusky spot, but many were virtually of the same drab body tint as the female. These males were found to be, on a four month's observation, as sexually active as those of more brilliant strains and included the frequent completion of the sex act. It was noted, however, that offspring even from isolated females were few and irregular, although the activity of the adults was normal. This condition suggests the view that associates male secondary characters with the appropriate hormones and the corresponding physiological reproductive level, without reference to any possible selective value of ornamentation.

What is probably the most curious feature of the entire study is by what means the male locates the genital pore. In no case was there any hesitancy or any evidence of the employment of a trial and error method. How this is effected is not clear, and this study gives no clue, but it is to be noted that even in the attempted copulation with a shadow, exactly the appropriate region was selected.

Fertilization of an adequate nature by the exceedingly active males of this species is insured (1) by their aggregating behavior, which tends to hold them in a group; (2) by their sexual aggressiveness; (3) by finding females more frequently than males, because of their larger size and consequent greater visibility, and (4) by the countering actions of approached males.

SUMMARY

1. Sex recognition in *Lebistes reticulatus* Peters is feeble, if present at all, and sexually active males will attempt to fertilize a variety of objects.
2. Males isolated for one week reacted positively to: females exposed in the same aquarium; in an adjacent aquarium not more than 15 cm. distant; anesthetized females; males;

specimens of *Cyprinodon variegatus*, *Fundulus heteroclitus* and *Barbus conchoniensis*; and the projected shadows of living fish on the side of the aquarium, but not to carefully made models of females, either moving or still, to a mirror outside the aquarium (apparent distance too great?), or to females behind opaque but perforated screens.

3. Evidently vision alone accounts for the observed behavior.
4. It is inferred that discriminative sex recognition does not exist as such, but any object of appropriate size will stimulate the mating instinct if showing the characteristic motions of a living fish.
5. Female *Lebistes* have not been noted to display any interest in sex activity, as is common in forms that require cooperation of the sexes to insure reproduction.
6. In no case was there any error noted in locating the genital region by a courting male, the gonopodium always being thrust toward the region of the genital pore, including that of the projected shadow. The problem, in this species at least, then shifts from mate recognition to recognition of the genital region. The mechanism of the latter is not evident from these studies.
7. The sexes are primarily brought together by their non-sexual aggregating habits.
8. Adequate fertilization is insured by the great activity of the males and their general disposition to attempt mating with many objects showing slight motion. This is enhanced by both the preponderance of females and their ability to give birth up to six broods on one fertilization.
9. Detection of mating objects is entirely visual; chemical (taste and smell) and tactile (auditory and mechanical) senses do not enter at all.
10. No significance can be attached to the elaborate but variable colors of the males by this study.

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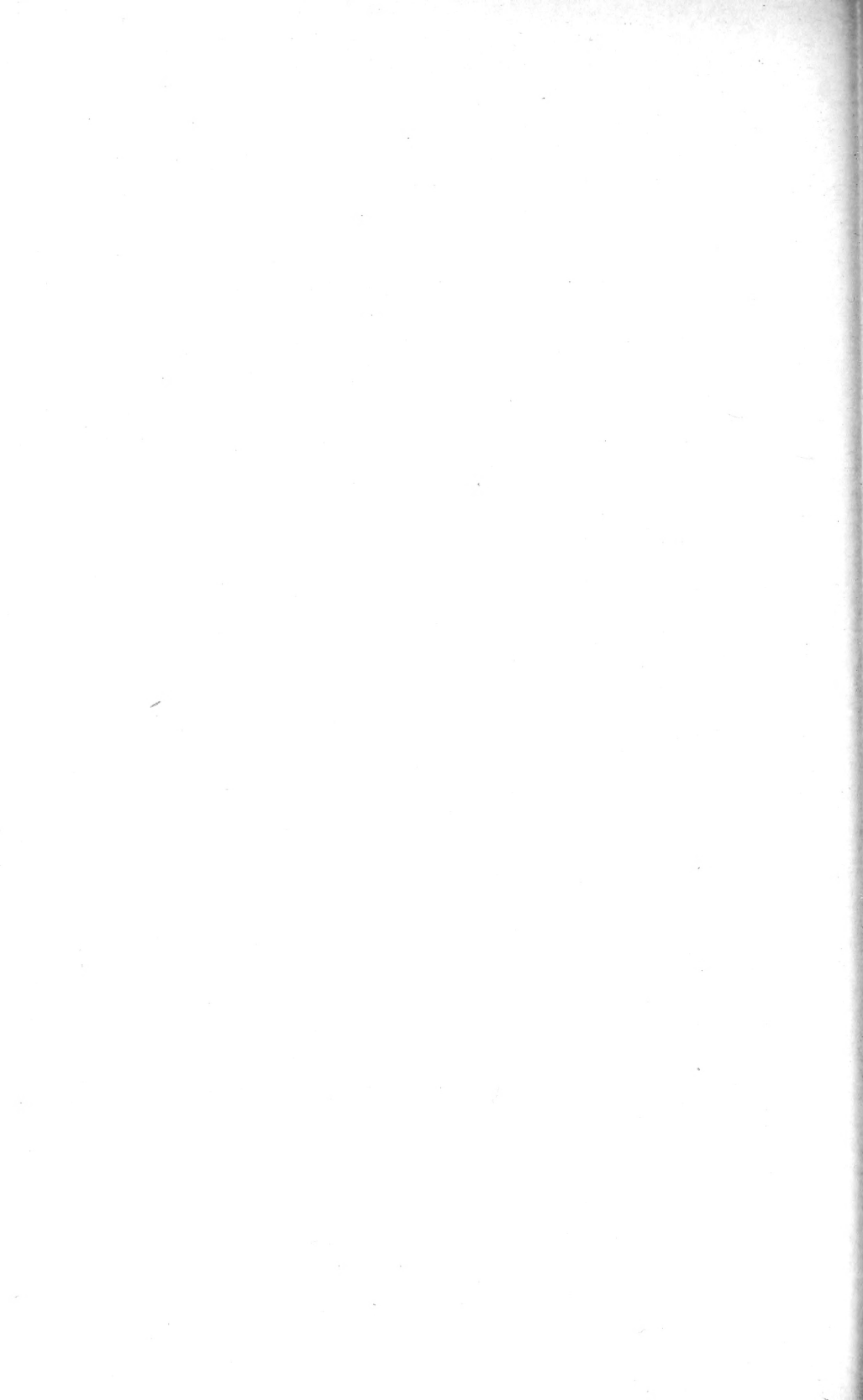
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THE FISHES OF UNION ISLAND, GRENADINES,
BRITISH WEST INDIES, WITH THE DESCRIPTION
OF A NEW SPECIES OF STAR-GAZER

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THE FISHES OF UNION ISLAND, GRENADINES, BRITISH
WEST INDIES, WITH THE DESCRIPTION OF A
NEW SPECIES OF STAR-GAZER.¹

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(Figs. 26 and 27)

INTRODUCTION

Union Island is one of the Grenadines, and one of the few with a satisfactory anchorage. Until now, no faunal fish list of this locality has been published. On the yacht *Antares*, under the aegis of Colonel and Mrs. Edwin M. Chance, we spent parts of six days, July 6 to 11, 1932, anchored in Chatham Bay, off the west shore. In 48 daylight working hours Miss Hollister and myself caught or observed 110 species of fish. We used water-glass and diving helmet, traps, seines, hooks and trolling spoons. The fifteen inches of tide at this place resulted in a complete absence of tidepools.

Two years later, on a second visit of the *Antares* to the island, eight additional species were obtained by the Chances, including a new species of star-gazer. This brings the total number to 118 species. Flyingfish have not been included in this list.

Union Island is well wooded, with a jagged central ridge, one peak of which reaches 1,000 feet elevation. Chatham Bay on the south side, where all the collecting was done, is an open semicircle, the land rising steeply in all directions. The narrow beach is part sandy, part rocky. At the northern entrance is a small islet, which from its complete drapery of *Cereus* we called Medusa Island. Just beyond we found a small bay with a circular coral reef in two to four fathoms. Here we did all of our diving.

Union Island, which is about two miles in diameter, is centered at 12° 36' N. Lat. and 61° 26' W. Long., and it is about twenty miles north of Grenada.

LIST OF FISHES OF UNION ISLAND, GRENADINES

DASYATIDAE

Dasyatis americana Hildebrand & Schroeder

One caught in big seine pulled in Chatham Bay, July 8, 1932. Length disk 290, tail 385, total 675 mm.; width disk 330 mm. Color olive green above.

MOBULIDAE

Manta birostris (Walbaum)

Twelve small devilfish were seen resting on the sandy bottom off Frigate Islet, on July 11, 1932. They moved slowly away as the shadow of our launch struck them. They were four to six feet across.

¹ Contribution No. 480, Department of Tropical Research, New York Zoological Society.

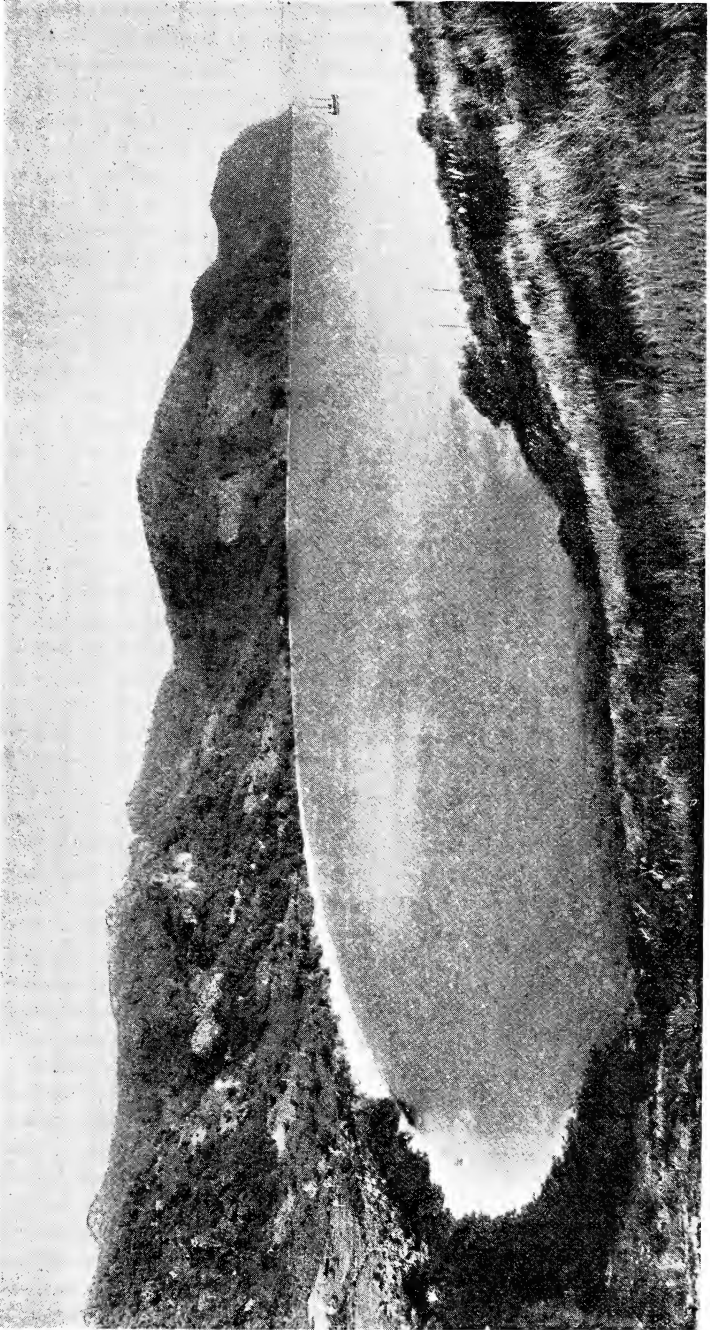


Fig. 26. Panorama of Chatham Bay, Union Island, with the *Antares* at anchor. (Photograph by Gloria Hollister)

MEGALOPIDAE

Tarpon atlanticus (Cuvier & Valenciennes)

Four seen in twenty-five feet of water near shore off Medusa Islet, July 6, 1932, and on several other days. Only visible when we were down in the diving helmet. They were quite fearless, passing within ten feet, and all about the same size, six feet in length.

In spite of every effort on the part of our expert tarpon fishermen, none could be persuaded to rise to any bait or lure.

ALBULIDAE

Albula vulpes (Linnaeus)

Two leptocephalus larvae caught with dip-net near night light, July 6 and 7, 1932. Lengths 57 and 60 mm.

Two adults taken in seine, July 8, 1932. Lengths 177 and 180 mm.

CLUPEIDAE

Harengula macrophthalmus (Ranzani)

Hundreds caught in several seinings, July 6 and 8, 1932. Lengths 80 to 100 mm.

Several taken with dip-net from *Antares* at night light. Length 26 mm. Scutes 17+13.

One specimen, July, 1934. Length 48 mm.

Sardinella aurita Cuvier & Valenciennes

Three caught in seine, July 8, 1932. Length 115 mm.

DUSSUMIERIIDAE

Jenkinsia lamprotaenia (Gosse)

Twenty-one caught with dip-net at night light, July 6 and 7, 1932. Lengths 20 to 26 mm.

ENGRAULIDAE

Anchoviella platyargyrea (Fowler)

One caught in seine, July 8, 1932. Length 54 mm.

Cetengraulis edentulus (Cuvier)

One specimen, July, 1934. Length 90 mm.

MURAENIDAE

Gymnothorax moringa (Cuvier)

One caught in wire trap at night, two fathoms down in Tarpon Bay, July 6, 1932. Length 720 mm.

One unidentifiable larval eel, food of *Parathunnus atlanticus* (Lesson). Length 50 mm.

SYNODONTIDAE

Synodus intermedius (Agassiz)

One caught trolling with a feather hook, July 8, 1932. Length 250 mm.

Trachinocephalus myops (Forster)

Three leptocephalus larval fish caught with dip-net near night light, July 6, 1932. Lengths 37 to 47 mm.

One adult caught in seine, July 8, 1932. Length 168 mm. In full breed-

ing condition, ovaries very large. The color is decidedly a striped, not a blotched, pattern. When viewed from above there are faint indications of nine or ten broad bands extending part way down the sides. The stripes consist of a band of turquoise blue, while above this are several alternating bands of pale straw and blue. Beneath, the bands become fainter until they disappear in the white of the belly. A conspicuous dark blotch lies partly beneath the upper area of the opercle. Eye silvery yellow. The food was a *Xyrichthys infirmus*, length 106 mm.

Two post-larval fish, length 40 mm., from the stomach of *Parathunnus atlanticus* (Lesson).

HEMIRHAMPHIDAE

Euleptorampus velox Poey

Two or three seen skipping over the surface of the water, July 11, 1932.

BOTHIDAE

Platophrys lunatus (Linnaeus)

One caught in seine July 8, 1932. Length 60 mm.

Platophrys spinosus (Poey)

One caught in seine July 8, 1932. Length 84 mm.; depth 46 (1.8); head 22 (3.8); eye 7.7 (3.8); dorsal 84; anal 61; lateral line pores 63.

This species has been synonymized by Metzelaar with *Platophrys ocellatus*, but the characters of our specimen compel us to keep it separate.

Platophrys ocellatus (Agassiz)

Six caught in seine, July 6 and 8, 1932. Lengths 16, 25, 37, 40, 158 and 165 mm.

Citharichthys microstomus Gill

One caught in seine, July 6, 1932. Length 38.5 mm.; depth 19.3 (2); head 9.5 (4); eye 2.7 (3.5); interorbital .8 (11.8); maxillary 2.3 (4); dorsal 71; anal 54; scales 34 pores; gill-rakers 7; pectoral short 6.6; lateral line almost straight; 9 rows of scales between lateral line and anal.

Although the vertical rows of scales are less than in typical *microstomus*, the fish seems to be too close otherwise to this form to be designated as a new species, especially on the basis of a single small individual.

HOLOCENTRIDAE

Holocentrus ascensionis (Osbeck)

Many seen with water-glass and when diving.

Myripristis jacobus Cuvier & Valenciennes

Several seen while diving.

SYNGNATHIDAE

Syngnathus elucens Poey

Four taken with dip-net near night light, July 6, 1932. Length 50 mm. Thirty-three young taken with dip-net at night light, July 10, 1932. Lengths 38 to 45 mm.

AULOSTOMIDAE

Aulostomus maculatus Valenciennes

Two young specimens caught in wire trap at night in two fathoms of water, July 9, 1932. Lengths 105 and 115 mm.

FISTULARIIDAE

Fistularia tabacaria Linnaeus

One caught in seine, July 9, 1932. Length 240 mm. plus a 75 mm. tail filament.

ATHERINIDAE

Atherina stipes (Müller & Troschel)

Twenty-one caught in seines, July 8, 1932. Lengths 40 to 60 mm.

MUGILIDAE

Querimana curema (Cuvier & Valenciennes)

Twenty-three caught in seines, July 6 and 8, 1932. Lengths 19 to 35 mm.

Ten adults taken in seine, July 9, 1932. One saved, length 207 mm.

Twenty-eight caught with dip-net near night light, July 7, 1932. Length 30 mm.

SPHYRAENIDAE

Sphyraena barracuda (Walbaum)

One caught trolling north of Medusa Island, July 9, 1932, at 11 A. M. Length 600 mm.

POLYNEMIDAE

Polynemus virginicus Linnaeus

Fifty-five caught in two seines in Chatham Bay, July 6 and 8, 1932. Lengths 40 to 60 mm.

CYBIIDAE

Scomberomorus regalis (Bloch) "Cero"

Thirteen caught trolling, July 6, 7, 8 and 11, 1932. Lengths 550 to 660 mm. Measurements of specimen 550 mm.: depth 108 mm. (5.1); head 128 mm. (4.4) eye 21 mm. (6); snout 54 mm. (2.3); dorsal XVII, 13-VIII; anal II, 16-VIII; gill-rakers 10.

Scomberomorus cavalla (Cuvier) "Kingfish"

Two caught on trolling line, July 8 and 11, 1932. *Antares* No. 50a: length 760 mm.; depth 140 mm.; head 171 mm.; eye 27 mm.; snout 70 mm.; dorsal XIV, 13-X; anal II, 16-IX; length of pectoral 102 mm.; gill-rakers 8; weight 12 pounds.

KATSUWONIDAE

Euthynnus alletteratus (Rafinesque)

One caught on trolling line, July 11, 1932. Length 700 mm.; depth 156 mm. (4.5); head 167 mm. (4.2); eye 24 mm. (7); snout 48 mm. (3.5); maxillary 62 mm. (2.7); dorsal XVI-12-VIII; anal 12-VII; gill-rakers 28; weight 7 pounds. Five spots below pectorals, not as large as pupil. Large trematode in extreme end of stomach.

THUNNIDAE

Parathunnus atlanticus (Lesson)

One caught on trolling line, July 11, 1932. Female, breeding; length 570 mm.; depth 155 mm. (3.6); head 173 mm. (3.3); eye 32 mm. (5.4); snout 56 mm. (3); maxillary 70 mm. (2.4); dorsal XIV, 13-VIII; anal 10-VIII; gill-rakers 18; length of pectoral 155 mm. (in head 1.1, in length 3.7); weight 4 pounds. Dark bronze above, bright yellow along sides, shading below into silvery from head to tail. Pectoral bright yellow, with broad jet black tip. Many hundreds of caecae. Ovary 130 mm. by 30 mm. Food

in stomach: two post-larval *Trachinocephalus myops* 40 mm. (in the stomach of one of these in turn was a young eel, 50 mm. long); one larval eel 50 mm.; several shrimps and one large carapace of a shrimp.

CARANGIDAE

Caranx (Xurel) latus Agassiz

Thirty-two specimens caught in four seines in Chatham Bay, July 6 and 8, 1932. Lengths 40 mm. to 250 mm. Individual lengths are as follows:

2	fish of	40	mm.
18	" "	50	"
3	" "	70	"
1	" "	80	"
1	" "	135	"
1	" "	140	"
6	" "	250	"

A large, white, parasitic Isopod, *Cymothoa oestrum* (Linnaeus) in the mouth of the 135 mm. specimen.

Four specimens caught with hook and line off *Antares*, July 6, 1932. Length 450 mm.

Five specimens caught on trolling line, July 7 and 8, 1932. Average length 570 mm.

One specimen caught with dip-net near night light, July 7, 1932.

Color note for *Antares* No. 40, length 140 mm.: 1st dorsal dusky and tip of 2nd dorsal black; caudal lemon yellow with dusky tips; anal yellow for basal two-thirds.

One specimen, July, 1934. Length 38 mm.

Caranx (Paratractus) crysos (Mitchill)

One caught in a seine, July 8, 1932. Length 135 mm.

One caught trolling, July 7, 1932. Length 480 mm.; depth 145 mm. (3.3); head 133 mm. (3.6); eye 22 mm. (6); snout 45 mm.; dorsal VII-I, 23; anal II-I, 19; pectoral length 134; gill-rakers 26. Pectoral reaches almost to anal fin.

Caranx (Elaphotoxon) ruber (Bloch)

One caught in a seine, July 8, 1932. Length 90 mm.

Caranx (Elaphotoxon) bartholomaei (Cuvier & Valenciennes)

Two caught in a seine, July 8, 1932. Lengths 102 and 130 mm.

Decapterus punctatus (Agassiz)

One caught in a seine, July 8, 1932. Length 135 mm. Color typical for this species except for a distinct greenish line down the side.

Trachinotus palometa Regan

One caught in seine, July 6, 1932. Length 140 mm. Showed great viability under adverse conditions. Side view wholly silvery with three long vertical dark bands and two very short bands. Falcate portions of vertical fins black, basal part of falcate fins a rich coppery brown. Outer caudal rays black. Iris silvery.

Trachurops crumenophthalma (Bloch)

The most abundant fish in seines. Eight hundred taken in one haul of the seine along shore, July 8, 1932. Lengths 95 to 140 mm. Color steel blue above, a faint golden line down side, remainder silver.

Vomer setapinnis cubensis Nichols

One specimen, July, 1934. Length 75 mm.

APOGONIDAE

Apogon maculatus (Poey)

Several seen with water-glass and when diving.

Apogon sellicauda Evermann & Marsh

One specimen, July, 1934. Length 18 mm.

EPINEPHELIDAE

Trisotropis bonaci (Poey)

Seen many times with the water-glass and when diving.

Rypticus saponaceus (Bloch & Schneider)

Two seen while diving near Medusa Island.

Cephalopholis fulvus (Linnaeus)

Two caught with hook and line off *Antares*, July 6, 1932. Length 180 mm. Color: pale henna body, with small turquoise spots scattered evenly over head, body and dorsal fin; iris scarlet; two small, jet black spots on upper side of caudal peduncle; pectoral with broad margin of orange; terminal half of ventrals and anal dark.

SERRANIDAE

Hypoplectrus unicolor (Walbaum)

Several seen while diving near Medusa Island.

PEMPHERIDAE

Pempheris schomburgki Müller & Troschel

One taken in tidepool near Medusa Island, July 9, 1932. Length 14.2 mm.; depth 6.3 mm.; head 6.1 mm.; eye 2.4 mm.; snout 1.5 mm.; dorsal 13; anal III, 23.

LUTIANIDAE

Lutianus synagris (Linnaeus)

Twenty-three caught in three seines, July 6, 1932. Lengths 22 to 105 mm.

One caught in a trap in Chatham Bay, July 11, 1932. Length 270 mm. Dorsal X, 12; anal III, 8; gill-rakers 9. All fins and iris scarlet; golden lines on side parallel with body; in general it is decidedly a pink fish.

Lutianus mahogoni (Cuvier & Valenciennes)

One dredged near shore in Chatham Bay, July 11, 1932. Length 26.2 mm.

Several adults seen while diving near Medusa Island.

Rhomboplites aurorubens (Cuvier & Valenciennes)

Five caught in a trap in Chatham Bay, in 15 fathoms, July 11, 1932. Length 175 mm.; dorsal XII, 12; anal III, 8; gill-rakers 18. Upper part of head and body deep pink, fading into pinkish white on sides and below; iris scarlet; dorsal fin translucent pinkish with very narrow orange red border; fins tinged with pink; caudal fin deep pink at base deepening into scarlet toward tip; about eight irregular gold lines along body below lateral line, slanting upward and backward. Scales 53.

Ocyurus chrysurus (Bloch)

Three caught in seine, July 8, 1932.

Seventy-three caught in wire trap, July 6, 1932. Lengths 55 to 90 mm.

HAEMULIDAE

Haemulon sciurus (Shaw)

Several seen while diving and with the water-glass.

Haemulon plumieri (Lacépède)

Several seen while diving and with the water-glass.

SPARIDAE

Calamus calamus (Cuvier & Valenciennes)

One caught on hook and line off the *Antares*, July 6, 1932. Length 310 mm.

Calamus bajonado (Bloch & Schneider)

Three caught in seine, July 8, 1932. Length 74 mm. Violet bar extends forward on the snout.

GERRIDAE

Eucinostomus gula (Cuvier & Valenciennes)

Two caught in a seine, July 8, 1932. Lengths 115 and 140 mm.

Eucinostomus californiensis (Gill)

Three caught in three seines, July 6, 1932. Length 90 mm. Tip of high dorsal spine black.

Ulaema lefroyi (Goode)

One caught in seine, July 8, 1932. Length 115 mm.

MULLIDAE

Upeneus maculatus (Bloch)

Three caught in wire trap, July 6, 1932. Length 80 mm.

Four caught in three seines, July 6 and 8, 1932. Lengths 100 and 130 mm.

SCIAENIDAE

Eques pulcher Steindachner

One specimen, July, 1934. Length 35 mm. The filaments of the dorsal reached the caudal peduncle.

CHAETODONTIDAE

Holocanthus tricolor (Bloch)

One specimen caught in trap in Chatham Bay, July 11, 1932. Length 165 mm. Anterior third of body a bright yellow, excepting the jaws which are black, and the spines of the preopercle and the skin margin of the branchiostegals showing under the opercle, which are a bright orange. The first five dorsal spines are bright yellow. The posterior two-thirds of the body is black. This area begins at the 5th dorsal spine and extends downward with a slight slant toward the head, to just above the spine of the opercle. Here the margin of the black slants posteriorly and parallels the base of the pectoral, and then continues in an uneven line, extending downward to the 3rd anal spine. The pectorals and ventrals are bright yellow. The dorsal is solid yellow through the first three spines. The upper third of the fourth web is bright orange. This orange band extends along the whole dorsal fin, becoming narrower posteriorly. The lower third of the web of the 5th spine is black, which color broadens on the sixth web and covers it. The produced tip of the dorsal is bright yellow and the posterior edge of the fin has a narrow yellow band. The 1st and 2nd spines of the anal are

bright orange. The 3rd spine is orange with a dusky tinge. The margin of the ventral fin has a narrow orange band shading into yellow on the produced filament. The posterior margin of the anal fin is bright yellow. The caudal is bright yellow from the vertical of the narrow yellow edge of the dorsal and anal fins. The entire caudal is dotted with many small bright orange dots and the outer edges are banded with orange. The iris has two rich, bright blue bars, one dorsal and one ventral, and two yellow bars, one anterior and one posterior.

Chaetodon striatus Linnaeus

Several seen while diving and with the water-glass.

Chaetodon bimaculatus Bloch

Several seen while diving and with the water-glass. Twice at Medusa Reef saw a *Chaetodon* without bars or ocelli, but this was only a glimpse.

Angelichthys ciliaris (Linnaeus)

Several seen while diving and with the water-glass.

Pomacanthus paru (Bloch)

Several seen while diving and with the water-glass.

Pomacanthus arcuatus (Linnaeus)

Two seen while diving.

ACANTHURIDAE

Acanthurus bahianus Castelnau

Two specimens from a trap, July 11, 1932. Length 95 mm.

Acanthurus hepatus (Linnaeus)

One specimen from a trap, July 11, 1932. Length 190 mm.

One specimen, July, 1934. Length 30 mm.

Acanthurus caeruleus Bloch & Schneider

Several seen while diving and with the water-glass.

Acanthurus heliodes Barbour

Several seen while diving and with the water-glass. Possibly a yellow phase of *Acanthurus caeruleus*.

SCORPAENIDAE

Scorpaena albofasciata Metzelaar

One specimen from tidepool near Medusa Island, July 9, 1932. Length 13.5 mm.; depth 5.7 mm. (2.3); head 6.4 mm. (2.1); eye 2 mm. (3.2); snout .75 mm. (8.5); dorsal XI, 10; anal III, 5; scales 22 (pores); pectoral length 5 mm. Color of the entire body black; broad tips of pectorals and dorsal rays, and caudal white; caudal with bars and subterminal band black; entire caudal peduncle creamy white, including the parts of the dorsal and anal entering the vertical of this area.

POMACENTRIDAE

Abudefduf marginatus (Bloch)

Three caught in tidepools, and two from a very shallow pool made by a raised reef on beach of Chatham Bay. Large sized ones seen while diving and with the water-glass, July 6 and 9, 1932. Lengths 10 and 20 mm.

All of this species had much less green, and were more of a mono-

chrome creamy brown in general than those from Antigua and northward to Bermuda.

Abudefduf analogus (Gill)

Four young caught in tidepools, July 9, 1932. Lengths 13, 14, 15 and 16 mm. Length 15 mm.; depth 6 mm.; dorsal XII, 14; anal II, 10. The general shape is the same as in *marginatus*. The color of the background is pale grayish green turning into a light yellow on upper two-thirds, where there are five broad, dark brown, vertical bands; the top of the head is dark and there is a dark spot on the top of the caudal peduncle; the spiny dorsal is dusky brown; the soft dorsal is white, except the base, which is dusky; caudal and pectorals are white; the pectorals are tinged with dusky, with the outer rays prolonged; the iris is pale iridescent-yellowish green.

One specimen, July, 1934. Length 26 mm.

Stegastes niveatus (Poey)

Several seen while diving and with the water-glass.

Stegastes chrysurus Bean

Several seen while diving and with the water-glass.

Demoisellea cyanea Poey

Several seen while diving and with the water-glass.

Demoisellea marginatus (Castelnau)

Several seen while diving and with the water-glass.

Eupomacentrus leucostictus (Müller & Troschel)

Several seen while diving and with the water-glass.

Eupomacentrus fuscus (Cuvier & Valenciennes)

Several seen while diving and with the water-glass.

Eupomacentrus sp.?

One specimen at night light of *Antares*, July, 1932. Length 10.6 mm.; depth 5.5 mm. (1.93); head 4.9 mm. (2.16); eye 1.61 mm. (3); snout 1.13 mm. (4.75); dorsal XII, 16; anal II, 14½; scales 27; gill-rakers 11; pores in lateral line 17; scales ctenoid, preopercle finely serrate. Scales of anterior upper sides and also upper part of brain-case with dark pigment. Dorsal spines with an occasional pigment spot; small pigment spots on outer portion of pectoral fin; remaining fins colorless; body otherwise colorless except for the pink of the abdomen which shows through the skin.

Eupomacentrus rubridorsalis Beebe & Hollister

The type of this species is a specimen taken in Chatham Bay, near shore, on July 9, 1932. Length 15.5 mm. Described in ZOOLOGICA, Vol. XII, No. 9. Its measurements and coloration are identical with those of a second specimen from Antigua. The body is bluish gray after death, darker blue before; upper head and back above lateral line scarlet, thickly flecked with black; dorsal spines solid scarlet; dorsal rays and anal dusky at base, becoming translucent bluish; very large ocellus, larger than eye, at junction of dorsal spines and rays, consisting of a large, jet black center, surrounded by a ring of turquoise with a narrow outer frame of black. Turquoise spots, framed in black, as follows (number and arrangement identical with those on the second specimen from Antigua): 2 between upper lip and upper eye; 5 surrounding eye; 3 on opercle; 8 in a line from eye almost to ocellus; 3 large spots on each side of top of head, 1 obliquely above and in front of eye, 1 above eye, and 1 on nape; 5 in iris, upper 2 larger and stronger and connecting the dorsal and dorsal lines; 2 at base of posterior dorsal rays; 2 at base of posterior anal rays.

There is a second ocellus, one-third as large as the dorsal one, on the upper peduncle. The iris, aside from the turquoise spots, is golden.

LABRIDAE

Bodianus rufus (Linnaeus)

Several seen while diving.

CORIDAE

Iridio garnoti (Cuvier & Valenciennes)

Several seen through the water-glass and while diving.

Iridio bivittata (Bloch)

One specimen caught in tidepool, July 9, 1932. Length 73 mm. Many others seen while diving and with the water-glass. .

Thalassoma bifasciatum (Bloch)

Two specimens from tidepool; many seen while diving, July 9, 1932. Length 25 mm. Dorsal VIII, 11½; anal 13 elements. Upper dorsal surface, and two-thirds of dorsal fin, black. A very broad black line covers the lores, and extends back through the eye and along the entire body. Upper fifth of dorsal spines and upper half of dorsal rays colorless and transparent. Basal half of anal pinkish, distal half colorless and transparent. Space between dorsal and lateral line black; upper lores and over eye, back to and including upper half of peduncle, bright lemon yellow, this color also extending around base of caudal fin. Lips and back to eye, lemon yellow; anterior under parts dead white; posterior flecked with pink. A faint spot between 5th and 6th dorsal spines. Black band crossing opercles shows distinct pinkish tinge. Iris golden yellow with narrow central ring of red.

Xyrichtys psittacus (Linnaeus)

Two specimens caught in seine, July 9, 1932. Length 113 mm. All fins pink; verticals with irregular alternate blue and yellow stripes. Body olive green on upper back, pale greenish white on sides and belly. Head with irregular oblique lines of turquoise and gold; on the mid-body a broad oblique band of crimson extending from the back three-quarters of the way down. One fish has an irregular elongated patch of iridescent pale turquoise along side of body from half way along the ventrals to beginning of anal.

Xyrichtys splendens Castelnau

Fifteen specimens taken in a seine, July 9, 1932. Length 108 mm. These wrasse have almost no pink on any of the fins.

Xyrichtys infirmus Bean

One specimen from a seine, and one from the stomach of *Trachinocephalus myops*, July 8, 1932. Lengths 95 and 106 mm.

Specimen No. 61: Length 95 mm.; depth 28 mm.; head 26 mm.; eye 5 mm.; snout 11 mm.; dorsal IX, 12; anal III, 12; teeth, two big canines above and below. Color of the body olive green, with deep blue vertical line down each scale below lateral line. Entire side of head lavender blue with eight broad, dark, golden lines extending obliquely forward, that below center of eye branched. Eye glittering gold with broad, circular band of lavender. Pectorals pale greenish with red tip. Ventrals, with outer ray greatly elongated, extending to the 6th anal spine, pale pink. Spinous dorsal pale green with broad coral pink tip. Soft dorsal bright pink. Anal translucent bluish, pale, tipped with pink. Caudal dark green at base changing gradually into yellow green with a broad terminal band of coral pink.

Xyrichtys venustus (Poey)

One specimen, July, 1934. Length 53 mm.

SCARIDAE

Scarus gnathodus (Poey)

Several seen while diving and with the water-glass.

Scarus taeniopterus Desmarest

Several seen while diving and with the water-glass.

Scarus croicensis Bloch

One specimen, July, 1934. Length 23 mm.

Pseudoscarus guacamaia (Cuvier)

Several seen while diving and with the water-glass.

Sparisoma abildgaardi (Bloch)

Several seen while diving and with the water-glass.

Sparisoma chrysopterum (Bloch & Schneider)

Several seen while diving and with the water-glass.

Sparisoma flavescens (Bloch & Schneider)

One specimen caught in a seine, July 6, 1932. Length 32 mm.

Sparisoma radians (Cuvier & Valenciennes)

One specimen, July, 1934. Length 34 mm.

GOBIIDAE

Bathygobius soporator (Cuvier & Valenciennes)

Fifteen caught in tidepools, July 9, 1932. Lengths:

1 fish of 6.8 mm.
1 " " 15.7 mm.
12 " " 25 to 55 mm.
1 " " 58 mm.

In specimens of 6.8 and 15.7 mm. in length, the following observation was made: In the smallest fish the pectorals are homogeneous, there being no hint of the separated upper rays. In the larger there are three rays quite well separated, but all flattened, surrounded with membrane and branching into a Y-shape at the tip. Apparently the young are not dependent on these for respiratory aid as in the adults.

One specimen, July, 1934. Length 22 mm.

DACTYLOSCOPIDAE

Dactyloscopus tridigitatus Gill

Two specimens caught in seine, July 9, 1932. Lengths 50 and 56 mm.

Gillellus, new species

(For description see page 222.)

CLINIDAE

Labrisomus nuchipinnis (Quoy & Gaimard)

Two caught in tidepool, July 9, 1932. Lengths 19.5 and 120 mm.

BLENNIIDAE

Salarichthys textilis Quoy & Gaimard

Twenty-one caught in tidepool, July 9, 1932. Lengths 25 to 55 mm.

Rupiscartes atlanticus (Cuvier & Valenciennes)

Two specimens caught in tidepools, July 9 and 11, 1932. Lengths 40 and 42 mm. Color of eye iridescent, lemon yellow. Cirri on head and lower lip coral pink; brown and black spot immediately behind the eye. Body vinaceous brown faintly mottled, with about nine indistinct upright bands of cream. Pectorals are a dusky cream with tips of lower six rays a coral pink. Dorsal spines with a broad terminal band of pink, basal two-thirds a bright greenish yellow, with spines and rays showing as dark purplish streaks. Most of the terminal half of dorsal rays greenish yellow, upper rays and caudal touched with pink.

Specimen No. 104. Color taken after 24 hours: Upper part of first six dorsal spines bright salmon pink, as is also the lower half of pectorals. Ventrals, dorsal and anal dusky. Caudal grayish like body, with first few upper rays yellow. Ocular and nasal cirri salmon pink. Ocelli back of eyes dark blue with a posterior border of salmon. Body mottled gray with seven narrow vertical lines of light at regular intervals, from pectorals to anterior of caudal peduncle.

After two years in preservative the larger specimen has lost the vertical lines and those of the smaller are very indistinct. These two fish now resemble the more uniform color described by other authors.

Ophioblennius ferox Beebe & Tee-Van

Two specimens taken at night light, July 7, 1932.

Antares No. 53: Length 44 mm.; depth 9.3 mm. (4.75); head 10.8 mm. (4); eye 3 mm. (3.6); snout 3 mm. (3.6); maxillary 3.8 mm. (2.85); interorbital 2.4 mm. (4.5); dorsal XII, 20; anal II, 20; pectoral 16; ventral I, 2; cirri: supraocular, one simple; narial, single with 4 fingers; nuchal, two singles on each side. Lateral line extends to 2nd dorsal ray. Body in life vermillion, after capture becoming almost transparent.

Blennius sp.?

One specimen taken at night light, July 6, 1932. Length 16 mm.

Blennius cristatus Linnaeus

One specimen caught in tidepool, July 9, 1932. Length 24 mm.

BALISTIDAE

Balistes vetula Linnaeus

One seen when diving.

MONACANTHIDAE

Monacanthus tuckeri Bean

Twelve caught in trap in 4 fathoms of water, July 6, 1932. Length 26 mm.

Monacanthus hispidus (Linnaeus)

One specimen taken at night light, July 7, 1932. Length 19 mm.

OSTRACIIDAE

Lactophrys quadricornis (Linnaeus)

One caught in seine, July 6, 1932. Length 222 mm.

Lactophrys triqueter (Linnaeus)

One caught in seine, July 6, 1932. Length 145 mm.

TETRAODONTIDAE

Sphaeroides spengleri (Bloch)

One caught in a dredge, July 11, 1932. Length 31 mm.

CANTHIGASTERIDAE

Canthigaster rostratus (Bloch)

Several seen while diving and with the water-glass.

DIODONTIDAE

Diodon hystrix Linnaeus

One specimen caught in seine, July 8, 1932. Length 280 mm.

A NEW DWARF SPECIES OF STAR-GAZER

FAMILY DACTYLOSCOPIDAE

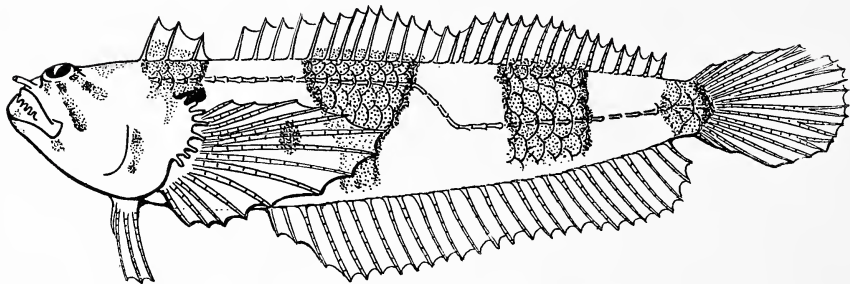
Gillellus quadrocinctus, new species

Fig. 27. *Gillellus quadrocinctus*. (Drawing by John Tee-Van)

TYPE: No. 180, *Antares* Expedition, Union Island, Grenadines, B.W.I., July 12, 1934. Standard length 31 mm. Type in the collection of the Department of Tropical Research of the New York Zoological Society.

FIELD CHARACTERS: A small Dactyloscopid, pale flesh in color, with head slightly dusky, two dusky lines radiating down and back from the eyes, and four conspicuous, vertical, black bands on the body, the second saddle-shaped, the posterior occupying the caudal peduncle. Fins almost immaculate.

MEASUREMENTS AND COUNTS: Total length 37 mm.; standard length 31 mm.; depth 6 mm. (5.15 in length); head 9 mm. (3.43 in length); eye 1.5 mm. (6 in head); interorbital space .75 mm. (12 in head); snout 1.6 mm. (5.6 in head); maxillary 3.3 mm. (2.57 in head); pectoral ray count 14; pectoral fin length 8 mm.; pelvic fin count I, 3; pelvic fin length 4.29 mm.; dorsal fin count III-XIV, 15; anal fin count II, 25; caudal fin length 6.43 mm.; caudal fin rays 16, 9 dorsal and 7 ventral.

GENERAL BODY SHAPE: Head heavy with its dorsal profile sloping gently forward, the ventral steep, following the oblique angle of the mouth. Anterior half of body with profiles almost parallel, narrowing very slightly posteriorly to a thick and abrupt peduncle.

EYES: Typical of the family, larger than usual, well elevated above the surface of the head and directed at an upward angle of about 90 degrees.

TEETH: Small, numerous, even, sharp-pointed, slightly recurved.

NRIL TUBES: Long, slender, directed forward, arising in front of each eye, about one-third of the eye's diameter from the orbit.

SCALES: Type cycloid; count about 40.

LATERAL LINE: Count $20 + 3 + 18 = 41$. Anterior and median part about equal in length, measuring 11.45 mm., respectively. First pore located midway between the first and second spine of the 1st dorsal with two rows of scales between. The lateral line extends with a slight upward curve to the posterior edge of the first dark body band which is below the twelfth spine of the 2nd dorsal. Here there is only one scale between the lateral line and the base of the dorsal fin. At this point it descends rather abruptly to the exact center of the body and then posteriorly in a straight line.

OPERCULAR FRINGES: 8.

LIP FRINGES: 9 upper; 13 lower. The lower cirri are about twice the length of the upper and overlap the upper series with the jaws closed. The upper series is arranged in the following way: right side, there are three evenly spaced along the edge of the pigmented band below the narial tube. There are three between the pigmented bands in the center of the jaw. On the left side there are two on the pigmented band and one just beyond its edge. In length these cirri are all about equal. When the mouth is closed they are directed upward. The skin in the jaw above is very loose and probably can be thrown forward when the mouth is opened, thus throwing the cirri in a downward position to act as a strainer. The lower series is arranged in the following manner: right side, there are three cirri below the eye outside the pigmented band of the upper series. A small pigmented patch is at the base of the outermost cirrus. One is in the center of the upper pigmented patch, and one on its inner edge with scattered pigment on its base. Two are in the center of the jaw. The left series is identical in position. The shortest cirri are those nearest the angle of the mouth, and these are twice the length of the upper cirri. The length of the lower series increases gradually toward the center of the jaw.

BODY BANDS. There are four conspicuous, broad, dark body bands, separated by three white interspaces posterior to the base of the pectorals. Measuring along the dorsal, the dark bands are approximately 3.5 mm. apart. All of the dark bands commence at the base of the dorsal fins, a light shading of the pigment extending for a short distance up the base of the dorsal elements. The first dark band begins just behind the head and extends along the entire base of the 1st dorsal fin; the second begins at the fifth spine of the 2nd dorsal fin and extends posteriorly to the base of the twelfth spine. Its dorsal width is twice that of the ventral (5 mm. to 2.1 mm.). In general appearance it is saddle-shaped and, unlike the two other posterior bands, the lower edge does not extend to the ventral outline of the body. It extends over the fifth, sixth, and seventh anal rays but with a distinct light area between. The third body band is rectangular in shape (3.57 mm. wide) and extends from the fourth to the ninth dorsal ray and, ventrally, from the fourteenth to the nineteenth anal ray. Here the pigmentation fades but there is not the obvious clear area as seen below the second band. The fourth band arises at the posterior edge of the dorsal and anal fins, and covers the entire caudal peduncle. It extends over the bases of the caudal rays and comes to a point, posteriorly, in the mid-line. Anteriorly, the vertical edge is curved slightly forward. The pigmentation is complete dorsally and ventrally.

HEAD PIGMENTATION: Whole head faintly and irregularly dusky back to the beginning of the first dark band. Darker areas occur close around

the eyes, two broad bands extending down and back from the eyes, and two indistinct spots on the center of the opercles.

FIN PIGMENTATION: The caudal, anal and ventrals are clear. The pectorals have an irregular, median, vertical blotch extending over the rays and membrane of the fourth to the seventh ray. The first dorsal is slightly pigmented or dusky above the dusky area of the head. The rest of the dorsal is clear above the white body areas and dusky above the dark body bands.

DORSAL FINS: The origin of the first dorsal fin is on the posterior part of the head. It is a little behind the mid-distance between the posterior edge of the eye and the posterior edge of the dark opercular spot above the base of the pectorals. It is composed of three spines which are all connected with a distinct membrane. The first spine is the longest (2.29 mm.). The second is slightly shorter (2.15 mm.) and the third the shortest (1.43 mm.).

The origin of the second dorsal is directly above the posterior base of the pectoral fin. The anterior spine is heavier and longer (1.72 mm.) than the posterior spine of the preceding fin. This second series is composed of fourteen spines. The length of the spines increases gradually from the anterior to the center of the series where the longest is 2.86 mm. They become gradually shorter toward the posterior where their length (1.43 mm.) is less than the short anterior spines. There are fifteen rays in the second dorsal. The anterior ray (2.57 mm.) is almost twice the length of the posterior spine just in front of it. The length of the rays increases only slightly in the center of the series and, posteriorly, diminishes to a short ray (1.29 mm.).

ANAL FIN: This fin is composed of two spines and twenty-five rays. Its origin is below the third dorsal spine of the second dorsal series. The anal extends posteriorly to below the dorsal posterior ray. The longest and heaviest rays are the anterior ones.

VENTRAL FINS: The ventrals have one spine and three rays. The spine is difficult to distinguish from the base of the first ray. The position of the ventrals is jugular and mid-way between the posterior end of the maxillary and the base of the ventralmost rays of the pectorals.

OPERCULAR PROJECTION: Between the dorsal end of the pectorals and the lateral line are, one on each side, two fleshy tube-like structures which are heavily pigmented; in fact, the darkest area on the body. Anteriorly, they are partly overlapped by the dorsal end of the opercle and its fringes. They project obliquely backward and downward. These structures may be accessory breathing tubes used in conjunction with the labial fringes when the fishes are buried in the sand.

The one specimen of this new species was caught with a dip-net, ten feet from shore, in water one and one half feet deep, with a sandy bottom and overhanging rocks. The color of the bands just after capture was black.

COMPARISON WITH OTHER FORMS: Unless we are to erect a new genus for this individual we must ignore, and rightly we think, some of the characters which are supposed to differentiate the genera *Gillellus* and *Cokeridia*. The discontinuous dorsal fin sets it certainly apart from *Dactyloscopus*. In the presence of well-developed labial fringes it is closer to *Cokeridia*, but this is a distinction of degree, not of kind, for fringes are found, at least slightly developed, in *Gillellus semicinctus*.

It is closest to Longley's recently described *Gillellus rubrocinctus* of unknown length, taken in Florida, but is shorter and more robust and with a smaller eye. It differs radically in color, the bands being maroon in the Florida fish but black in our specimen. Ours has in addition four instead of three post-cephalic bands, and these differ in extent, our second body band being about three times as wide as the corresponding one in *rubrocinctus*.

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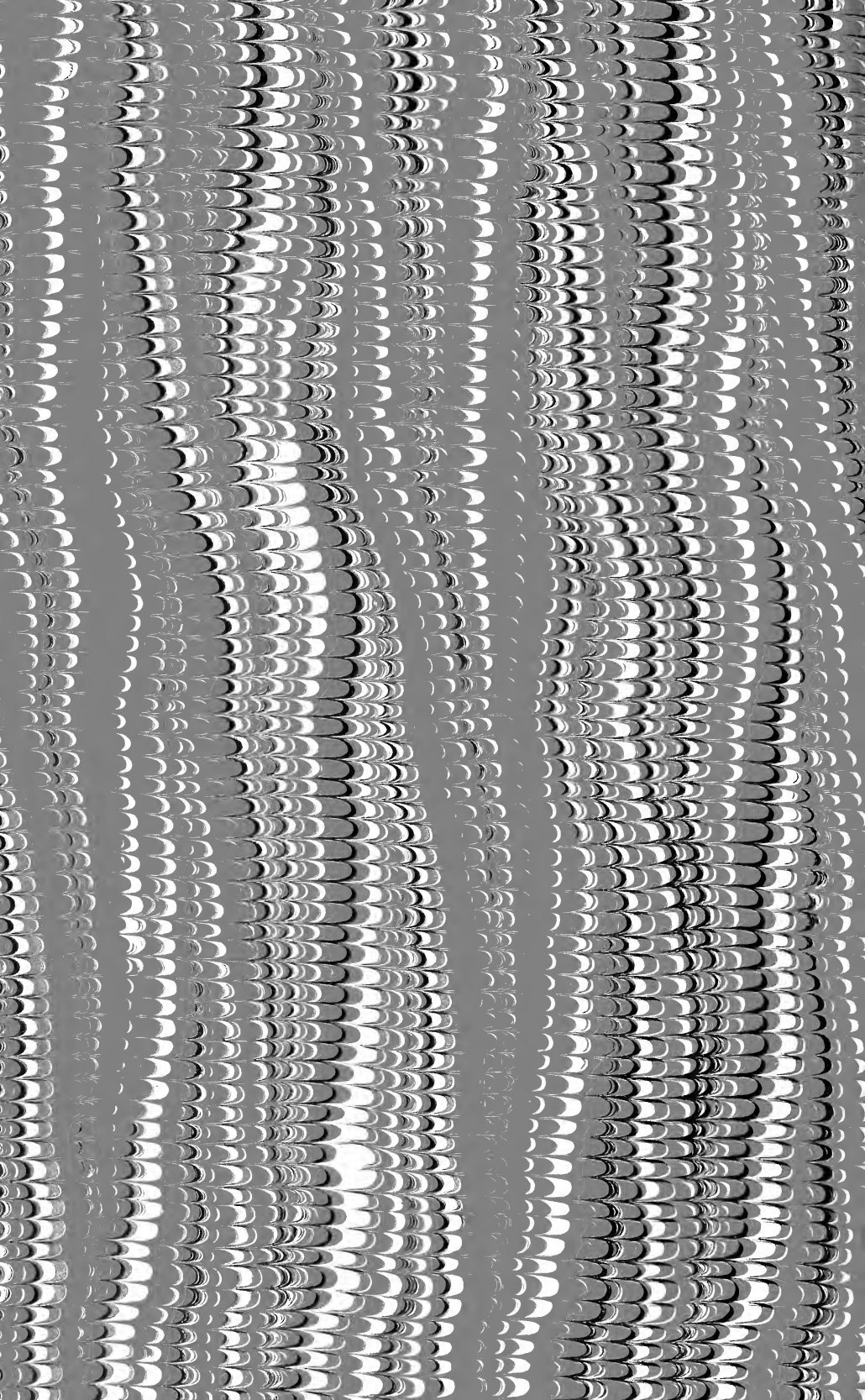
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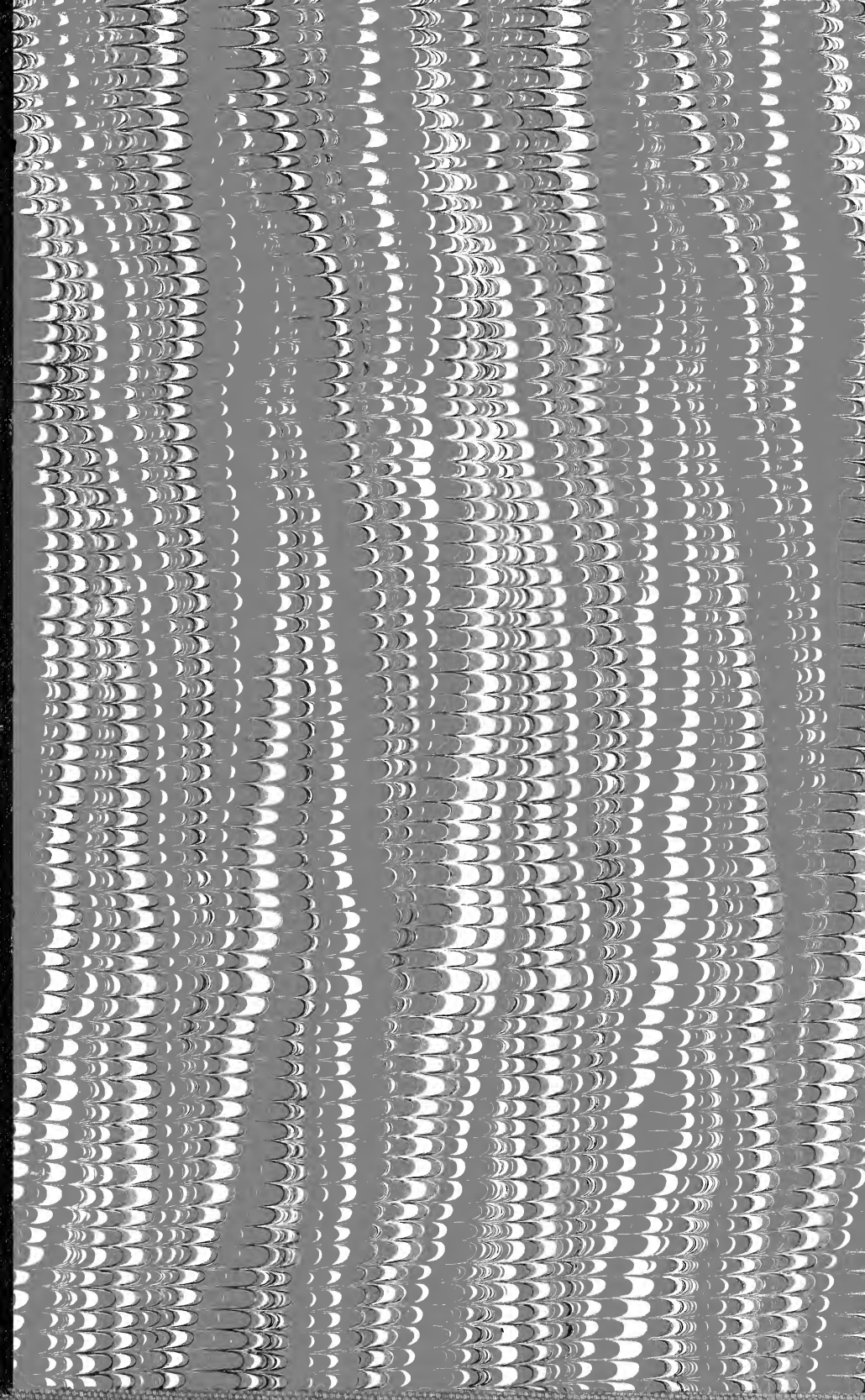
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