THE BIOLOGY OF DALAG (OPHICEPHALUS STRIATUS BLOCH)[1]

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ELEVEN PLATES

ABSTRACT

This paper consists of two parts. Part I deals with the ecology of the fish. Distribution, local and foreign, is given; habit and habitat are described. Part II discusses spawning and breeding habits; various stages in the early life history of the fish are described.

INTRODUCTION

Ophicephalus striatus Bloch known locally as Dalag (Plate 1) is a freshwater fish of very wide distribution. Its natural homes are bodies of fresh water such as lakes, rivers, swamps, marshes and rice paddies. The species is hardy and is adaptable to both lowland and mountain streams and lakes. Dalag constitutes one of the mainstays of inland fisheries in the Philippines.

Except its systematic position, not much information is known about the biology of this fish. Locally, few observations were made. Aldaba (1931) investigated the dalag fisheries of Laguna Lake in relation to its habits in breeding and spawning. Day (1914) worked out the skeletal system; Roxas and Umali (1937) and Villaluz (1953) merely mentioned the distribution, economic value, habits and some outstanding characteristics of the fish. In Ceylon, Willey (1909) described the larval development, nesting habits and parental care of the fish. Smith (1945) described nesting and development of the young. In spite of this, many phases in the natural history of the fish still remained to be studied and worked out. Compared with milkfish (*Chanos chanos*) dalag is less bony; well adapted to rice paddies; thrives and grows therein with comparative ease. The fish is hardy enough to survive varying types of water ranging from relatively clear to silty; from non-polluted to polluted. In addi-

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tion, dalag can live for days with little water. It can be transported for long distances and still stay alive. These are characteristics found only in labyrinthine fishes of freshwaters.

With proper technique and know-how, dalag can be raised and propagated profitably in ponds. Despite its good characteristics and its commercial potentialities, very little is known about the dalag, less so in the ways of properly cultivating it for profit. With this in mind, a program of studies involving its biology is being undertaken. This paper constitutes a segment of the series. This study is direly needed to properly evaluate and understand the fish and its potentialities. Any information or knowledge gained therefrom can furnish a solid basis for the propagation of the species. In addition, appropriate measures to protect and conserve the species may be obtained from results of such studies.

For convenience, the program of studies has been divided into the following headings. Each is deemed important to supplement the others so that completion of the series may give a fairly adequate biological picture of the fish.

The headings:

Part I. Ecology.
Part II. Spawning, Breeding Habits and Early Life History.
Part III. Food and Feeding Habits and Postlarvae and Adults.
Part IV. Embryology.
Part V. Factors Governing Abundance.
Part VI. Population Studies.
Part VII. Pond Culture.
Part VIII. Predators and Diseases.

This paper consists of Parts I and II.

NOMENCLATURE

The murrel or snakehead as the dalag is more commonly known, was first described by Bloch in 1793 as *Ophicephalus striatus*. He based his description on type *Ophicephalus punctatus*. Cuvier and Valenciennes in 1831, Jordan and Seale in 1905 used *Ophicephalus striatus* Bloch in all their publications for this species. However, Cantor in 1850 use *Ophicephalus striatus* Bloch. In succeeding publications, Gunther in 1861; Weber and de Beaufort in 1922; Jordan and Seale in 1927 used likewise the specific name *Ophicephalus striatus* Bloch to designate the murrel.

The reason for the change from *Ophicephalus to Ophiocephalus* is not known to the writers. It is possible that the change might have been due to typographical error, which was left uncorrected and so was followed by succeeding authors or it was possible that it might have been changed for the sake of euphony.

Notwithstanding the change, the writers are adapting *Ophicephalus striatus* Block in pursuance to the Law of Priority.

TAXONOMIC DESCRIPTION

Inasmuch as the original description of the fish is not now available to the writers, the description of Herre (1924) is hereby quoted:

Dorsal 37–43; anal 23–23; ventral 6; lateral line 52–58; scales in transverse series 4/8–10, not counting the lateral line.

Depth 5 to 6, head 3 to 3.3 in length without caudal and 3.6 to 4 in total length; eye 4.4 to 8.5 in head, 1.6 to 2 in interorbital space and 1.2 to 1.75 in snout.

The large broad head is flat between the eyes, upper profile but little convex more like an inclined plane; trunk hardly cylindrical but more or less flattened in sides, even just behind head and strongly compressed posteriorly; eyes large, prominent and somewhat projecting in life; the slightly oblique mouth large, the maxillary reaching well beyond the eye, except in the very young (in a specimen 32 millimeters long it extends but a little beyond the pupil); snout, broad, rounded, lower jaw projecting; teeth in upper jaw (intermaxillaries) very small, recurved, in broad bands, tapering posteriorly of from five or six to eight or nine rows, those behind symphysis fewer, coarser, longer and some of them canine-like; teeth of vomer and palatine in about three or four rows, much larger than those of vomers, some of them canineförma teeth of mandible in a patch of from three to five rows of teeth near symphysis, posteriorly with but one row of widely spaced canines larger than any of the other teeth in either jaw; pectorals shorter than postorbital part of the head; lateral line with a downward curve, usually including three scales at sixteenth to twentieth scale.

The adult is brownish-gray to almost black dorsally and white or grayish ventrally on the sides, vertical processes of black bands pass diagonally toward belly which occasionally may be spotted with flecks of brown. Pectoral and ventral fins are usually of the same color as the belly but some exhibit patches of dark spots all over. The anal, caudal and dorsal fins have oblique dark streaks forming crossbars of white and dark bands.

Part I. Ecology

Part I of the Biology of the Dalag is largely field study involving observations of the fish in its natural environment. The senior author spent many years off and on in the field gathering data. He observed reactions of the fish to changing conditions and looked into its habits as well as its movements from one season to the next. The following is a modest appraisal of these observations, which by no means, should be considered exhaustive. In addition to Part I, Part II, which deals with the early Life History of the fish, is included in this paper.

Ecology as herein described includes distribution, habit, and habitat.

DISTRIBUTION

PHILIPPINES

Ophicephalus striatus Bloch is a labyrinthine fish belonging to the family Ophicephalidae. The family has two genera, namely, *Ophicephalus* and *Channa*. The latter genus has no representative species in the Philippines. On the other hand, *Ophicephalus* is reported to be represented by two species, namely, *O. striatus* and *O. melasoma* Bleeker, the latter species having been reported only in Balabac, Palawan province. Only *O. striatus* is positively known to be found in the Philippines.

The murrels have become so well adapted to Philippine conditions such that they have established a firm foothold in the country. They are scattered throughout the Islands from Aparri in the North to Siasi in the South and from East to West. The hardiness together with the ability of the fish to remain alive for long periods of time, even in very little amount of water, favors its very wide distribution. The ease of handling and maintaining the fish alive greatly enhanced its introduction to different areas. These are characters that are biologically important in preserving the species. Evidences on hand show that the wide dispersal of the fish from one island to another and from one country to another is not so much due to natural migration of the fish but largely through man's efforts to fortify his fish supply. Wherever he goes, he takes along the fish with him and his efforts succeed because of the unbelievable capacity of the fish to survive.

FOREIGN

The sturdiness of the snakehead was partly responsible for its wide distribution. It is reported in Ceylon where Willey (1909) made studies on certain aspects of its biology. Herre (1924) reported it in Hindustan east to Flores extending as

far South as Halmahera, Amboina and Batjan and from there, upward to southern China. Likewise, the species was introduced eastward by the Chinese as far as Hawaii, where they received the name—China fish (Norman 1931 and Jordan 1907). From the Hawaiian Islands, it was but one more step to San Francisco, California. This distribution definitely marked the fish as a truly tropical form. Herre expressed the opinion that despite its wide distribution no natural dispersal of the fish may extend farther than Mindanao and Borneo.

HABIT

Studies made in the field revealed that dalag has fixed habits. At leisure the fish swims almost aimlessly. Normally the fish is nongregarious. At times, two or more may form groups and play close to the surface of the water. On warm days and in shaded areas, it is their habit to reach for the upper layer of the water periodically to engulf little amount of air from the surface. This habit is associated with the respiratory processes. The fish possess a big and well developed air bladder, which is an effective accessory respiratory organ. It is strange that though the fish is aquatic, yet it drowns when denied access to the free surface of the water. Specimens kept in the laboratory in glass aquaria (20 x 24 x 36 inches) behave actually as if they were in their natural habitat. Frequent coming to the surface is a general tendency but when wire mess is placed two inches below the surface of the water so that free air was denied them, the fish died the following day. Others which were kept in unwired aquaria remained alive. Fish hooked by the mouth and entangled among submerged vegetation gets drowned also after several hours.

The dalag is highly migratory. In Central Luzon, which has only two distinct seasons, (wet and dry) the migratory behaviour of the fish can easily be observed and studied. Migration is not peculiar to the murrels. It is common and universal among other fishes. Bañgos (*Chanos chanos*) being catadromous, move out to the sea to spawn. Likewise, the European and American eels migrate to the Atlantic Ocean somewhere near the Sargasso Sea to spawn. Conversely, the Pacific salmon *Onchorynchus* of the United States leave the sea to ascend rivers in order to spawn. The Pacific mackerels and the sardines are also well known for their movements up and down the western shores of North America.

The murrels may not permanently reside in any given body of water unless the water is completely land-locked. Two migratory movements are conspicuous during the year, each one coinciding with a season.

SPAWNING RUN

In the Philippines the southwest monsoon may begin as early as May or June of each year. This marks the beginning of the wet season, characterized by heavy rainfall that floods rivers, swamps, lakes, and other areas. The dalag, consequently, spreads widely over rice paddies, valleys or plains, moving along ditches, canals, gullies or along any passageways where water either flows in volume or merely trickles downstream. Where obstacles occur in the continuity of water passages, the dalag may overcome it by leaping, much like salmon leaping over fish ladder or falls. Wriggling of the body with rowing movement of the pectoral fins is a potent locomotion over-land. This is rendered easier when the ground or grass is moist. The extent of migration is such that shortly after spawning run has started, rice paddies or even valleys are completely occupied.

At the beginning of the spawning run, the migrants are generally lean, emaciated with tough meat. The head appears big while the rest of the body is much reduced in size. This is an indication of a starved condition in their previous habitat. Other species notably the cat-fish *Clarias batrachus* appear in a similar condition as the dalag at the time they ascend paddies from rivers and swamps. Few weeks after migration, the fishes regain their robustness and the head and body now merge smoothly. At this time the quality and palatability of the meat of the fish is much improved. Simultaneously with these physical changes in the fish is the maturation of the ova for very soon, spawning is to take place in the new environment. It is interesting to note that migrants are not strictly limited to the spawning individuals. Migrants actually consists of mixed population: sexually mature individuals, yearlings, and juveniles from previous year classes. In composition this is diametrically opposite that of the Pacific salmon (*Onchorhynchus*), in which only spawning members ascend the rivers.

The young migrants spread over a wide area to escape crowded conditions prevalent in the previous environment. With a wider feeding ground, where food-getting is comparatively less competitive, they grow much faster.

Field studies showed that migration is biologically significant in several respects. Firstly, for the adults, field migration is a definite spawning run. It is a means to attain wider or a more extensive area for a more successful distribution of the species. In permanent bodies of water as in lakes, dalag can spawn throughout the year; those in shallow rivers and swamps breeding is restricted if not suppressed completely during the hot months (dry season) of the year when water volume is at its lowest. At this time, temperature soars high, a big factor that was found to be a strong deterrent to spawning. The senior author, who visited Alimanon Creek in Bukidnon province, Mindanao, in the summer of 1954, found the water temperature in the creek to be relatively low, due undoubtedly to lush vegetation growth on both sides of the Creek. But volume of water in the Creek was low; there were many dry areas along the riverbed and in places water was confined only to the deeper pools. Dalag was plentiful in the pools as shown by big hauls made therefrom. Examination of the bed showed complete absence of spawn. Apparently, this indicates that water volume is another member that forms a complex of factors determining the spawning activity of the fish.

Secondly, search for food is universally recognized to initiate movements. This is not only true with fishes but true as well with other animals, man himself included. It is not strange nor singular, therefore, for the dalag to move about in search of food in wider feeding ground. It is axiomatic to say that marine fishes keep moving about for the same purpose. Salmon spawn in rivers and lakes. The young eventually move downstreams to the sea where they spend the greater part of their life feeding, growing and reaching sexual maturity. Expanded feeding ground afforded more food per capita to the dalag, adults and young alike, and as a consequence of this, the rate of growth, particularly of the young, is boosted.

Thirdly, migration is a means to avoid or escape predators not excluding their own kind and other fishes with similar tendencies. The dalag, being entirely carnivorous in food habits, snaps with sweeping agility at all moving objects in the water; cannibalism is strongly developed in the fish and in times of food scarcity will unceremoniously prey on its own kind—the bigger ones on the smaller ones. Greater dispersion and consequently fewer population per unit area reduces to the minimum cannibalism if not to completely obviate it.

Danger to dalag in the field is the ease of subjecting them to intense fishing. In inland regions where the dependable staple fish food is dalag, in addition to other species such as hito (*Clarias batrachus*), gourami (*Trichogaster pectoralis*), tilapia (*Tilapia mossambica*) fishing is easily carried intensely, especially at about the end of the rainy season. Doubtlessly, many succeed in burrowing in mud pockets but still a great many of the fish—big and small are caught. Fishing is pursued day and night by employing native gears of various kinds—bamboo traps, cast nets, pound nets, hook and line and spears. Carbide lamp is a great aid in night fishing. When reflected light hits the fish in the eye, the fish stops dead on its tract and becomes sitting ducks to expert spearmen. What is surprising is, despite the heavy drain on their number, the species manages to survive and preserve its own kind.

Fourthly, domicile in the field is a period of relatively rapid growth; wider dispersion reduces intensity of population per area, resulting in less keen competition for food acquisition and consequently more food per fish; conversely, the rate of mortality from cannibalism is reduced correspondingly. It is believed that barring extraneous factors (poisoning, wholesale fishing) normal mortality rate will be insufficient to materially alter the character of the dalag fishery. On the other hand, with greater abundance of food accompanying an increased rate of growth, a greater yield in the fishery may be expected at the end of the run, not only in number and size but also in weight as well per fish. A bigger percentage of survival will mean more fish can succeed in going back to permanent bodies of water so that by subsequent seasons more spawners can return.

The dalag stays in the rice paddies of Central Luzon several months from May or June up to as late as October or early November of each year. This is the duration of the rainy season. Unless caught or marooned by insurmountable barriers, the fish goes back into rivers, swamps or lakes by December or at most by January of the following year.

Soil erosions from mountain sides make the northwest monsoon water heavy with yellowish-brown silt suspension that makes the water muddy and excessively turbid. As the season

wears on, the silt gradually settles to the substratum so that the water clears up. At about the end of the season, conditions change; temparature goes down; weather is breezy, days are shorter and generally sunny; water dries up fast and the dalag reacts accordingly by showing signs of restlessness. The clear water exposes the fish to bright light but protects itself by stirring the water and beating the muck under to produce a circular area of very turbid water many inches across. The fish stays within the area most of the time thus protecting itself against bright light and possibly against predators. This habit is well-known to farmers and fishermen alike; to them it means more fish for less time of fishing efforts, for each such area harbors a fish or two. Experience has shown that this habit foreshadows the coming of the next season.

NORTHEAST MONSOON RUN

The northeast monsoon sets in as early as October (in Central Luzon), ushers in cooler, dry weather with no more rainfall and continues into the dry months of January to April or May with hot spell in the later part of the season. Rice paddies dry up rapidly impelling the dalag to move down to permanent bodies of water. Early migrants reach permanent bodies of water; late migrants may be marooned in the plains, in small canals or in small land depressions. Man-made traps and weirs set across natural waterways impede effectively downward movement of the fish. Insurmountable barriers as tall dikes and drying-up of water at several places along the water course also prevent successful fish movement downstream. As a consequence, the fish thus impounded are subjected to wholesale fishing regardless of size and weight. Those which by wriggling deep into the mud, escape capture, begin the long period of aestivation during the hot months of the year. Aestivation, as a standard habit of the species, no doubt, plays an important role biologically for from it alone, a great number of the fish manages to survive. In Thailand, this habit is so well known that fishermen simply dig them out (from holes) with long knives cutting through the hardened earth layer by layer until the pocket is exposed from which the fish is scooped out. This phenomenon is relatively unknown in the Philippines, although many have suspected it. This phenomenon is the only plausible biological explanation to what appears to many a layman, as good examples of spontaneous generation.

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HABITAT

While the dalag is definitely a freshwater form, the writers were surprised, one summer in 1953, finding them in a small creek that empties directly into the sea some two hundred yards away. This was in Puerto Galera, Oriental Mindoro, the site of the Marine Biological Station of the University of the Philippines. It was suspected that since the creek directly empties into the sea, its waters can be reasonably assumed to be strongly brackish. This idea was given some attention and salinity tests were done accordingly. The tests gave unexpected results. Salinity determination made in the summer of 1953 gave an average of only 0.36 gram per mile. The amount is too small to make any material change in the degree of freshness of the creek water. Determination was repeated in the summer of 1954 but the result was even smaller (0.173 to 0.194 gram per mille) at high tide, although it turned out slightly more salty at low tide (average of 0.276 gram per mille). The over-all picture showed a very small amount of *miscibility* between the creek water and the sea water. This resulted in very low salinity that was not sufficient to hamper the normal living processes of the fish. However, there were no serious attempts made to determine the precise reasons why the sea water did not increase the salinity of the creek water. To explain the unusual phenomenon only surmises were made. There was the possibility that the incoming tide was not strong enough to make a stir in the original water and so the heavier water might have rolled upstream en masse with but slight diffusion between the two. Secondly, the constant seepage in the upper reaches of the creek might have possibly counterbalanced whatever adulteration the sea water had on the creek water. If the assumption above is true then this is the principle of immiscibility of Wyville-Thomson and Carpenter, according to which two bodies of water of different temperature and salinity will not mix when in great masses (Le Danois).

In Central Luzon, notably Bulacan and Pampanga, the dalag in bañgos pond has become and still is a management problem during the rainy season of each year. Due to heavy rainfalls, the pondwater turns fresh and becomes the natural environment of the dalag once more. Due to floods, the carnivorous and highly predacious dalag strays into the pond and causes enormous harm to bañgos fingerlings. So, loss of time and profit

as well is incurred. This condition, however, does not prevail throughout the year for, by March or even earlier each year, reconditioning of the water in the pond takes place so that by April brackish water affects the fish adversely with progressively deleterious effect. A marked loss of vitality is noted in the fish; activity is reduced, characterized by erratic and sluggish swimming movements; the cornea of the eyes gradually turns opaque; swimming spurty with the belly up; movement shows no coordination nor direction; finally the fish sinks to the bottom and dies.

In this connection, physiological studies may be made to determine precisely what processes of metabolism are affected by the brackishness of the water. Reports on trouts showed that when water contains a large amount of nitrogen, the respiratory processes of the fish are adversely affected in such a way that the nitrogen gas bubbles form a layer around the gills serving as buffer against the intake of oxygen.

As part of ecology studies, the pH of the water were taken in the habitats of the fish. On three separate localities in Luzon and one in Mindanao, pH were determined using pH comparator with chlorophenol as indicator. Tests made in Aliaga, Nueva Ecija in the wet season of 1953 gave an average of pH 7.3; in Bigaa, Bulacan 1953, pH also was 7.3; in Laguna Lake, 1953 to 1954, pH of the water ranged from 7.3 to 7.9. In April of 1954 similar determinations were made at Alimanon Creek, Managok, Malaybalay, Bukidnon, Mindanao. The test showed the water was slightly alkaline—pH being 7.2 with temperature at 27°C at high noon. These findings tend to show that Philippine freshwater bodies are slightly on the alkaline side.

The tabulation below is a series of readings of pH and incidentally of temperatures taken from Laguna Lake, Laguna Province, from August, 1953 to May, 1954. All readings were made in waters not more than 20 meters off the shoreline. A glance at the table will show that the pH reading along the western side of the lake, varies from 7.3 to 7.9 with 0.6 variation between extremes. Temperature readings were surface temperatures and are variable from time to time and from place to place.

TABLE 1.—*Showing temperature and pH reading August 1953 to May 1954.*

Locality	Date	Temperature	pH	Time
Calamba	August 29	31.8°C	7.4	4:00 p. m.
Calamba	September 5	31	7.3	10:00 a. m.
Masili, Los Banos	September 12	33	7.9	
Calamba	September 27	30	7.4	10:00 a. m.
Calamba	October 11	33	7.4	2:00 p. m.
Landasan, San Pedro	October 23	32	7.4	1:00 p. m.
Calamba	October 25	32	7.4	2:00 p. m.
Calamba	November 18	30	7.4	
Calamba	November 29	31	7.3	
Calamba	December 12	31.5	7.4	
Calamba	December 23	32°C	7.4	
Calamba	January 3	32	7:35	
Calamba	January 24	32	7.4	
Calamba	February 7	31	7.4	
Calamba	February 28	31.5	7.4	
Calamba	March 14	31	7.3	
Calamba	March 29	32	7.4	
Calamba	April 6	30	7.4	
Calamba	May 9	28	7.4	Morning
Calamba	May 30	27	7.4	Morning

It is interesting to note that the dalag, generally inhabiting bodies of water at sea level, may occasionally find themselves transplanted to waters at higher altitude and survive equally well. The fish were planted in Crater Lake of Sebu in Cotabato and Balinsasayao in Negros Oriental (both lakes are about 3,000 feet above sea level). Tadlac lake in Los Baños and mountain streams in Bukidnon plateau have their own dalag population. In all these places, the dalag are doing well.

For average habitat, (Plate 2, figs. 1 and 2) there is a strong preference for waters with growing vegetation—submerged, floating or both, scattered or growing indiscriminately along the water line. The aquatic vegetation serves three-fold purposes: (1) Protection against enemies and predators. Thick growth of vegetation extends to the species ample protection in that when in danger, the fish swiftly and easily swims into the growth. Therein the fish becomes less accessible with better camouflage in addition. Criss-crossing growth of the submerged plants serves as effective screen against the bigger members of its own species as well as against fishermen and other enemies. (2) Feeding: Dalag is carnivorous and highly predacious to many aquatic organisms. Fry of other fishes including their own, fingerlings, shrimps, larvae of aquatic insects, and others live among and shelter themselves under the growing vegetations. Dalag snap at these organisms while swimming leisurely among the submerged or floating plants. (3) Spawning: The spawn is laid within a circular nest. The spawning couple builds the nest only in fairly shallow water where lush vegetation is growing. Nest is made out of this vegetation by both male and female. Grass leaves and stems are bent or cut and arranged into a circular garland that will protect and prevent the unwieldy dispersion of the spawn and the fry after hatching.

Part II. Early Life History

As mentioned elsewhere, the murrel or dalag has been from time immemorial, of major economic importance to the fresh water fisheries of the Philippines and other oriental countries. It is this importance that served as the motive interest to learn more about the life history of the snakehead or murrel. Previous works on the fish in the Philippines so far have been meager so that the present work has been pursued with a view of supplementing what is already known and of giving whatever worth it may bear on the species. Thus this portion of the series is an attempt to throw more light on certain phases in the life history of the fish.

MATERIALS AND METHODS

Collection of the eggs and fry was made on the shores of Laguna de Bay adjoining the town of San Pedro, Laguna. In this town, the people have an ingenious way of catching the murrel. They build artificial nests with which to trap not only the female but also the male fish as well. The "pugad-pugad" (Plate 3, fig. 1) is made up of a crown of grasses fastened securely on the rim of a basket-like structure with an opening on one side for the entrance of the fish. Another type of trap is a horse-shoe dugout in the mud or rock where the water is knee-deep (Plate 3, fig. 2). These ready-made nests are planted with water hyacincth, *Eichornia crassipes,* and covered with dried branches of "camachile," *Pithecolobium dulce,* and banana leaves. These nests attract spawners and their mates.

The junior author collected the materials for study from such artificial nests. The succeeding collections were made during the months of August, September, October and November, 1952; June and October of 1953; April, May and June of 1954.

Developing eggs were kept in balanced aquarium; others in finger bowls. Water in the finger bowls were frequently changed to replenish oxygen supply and to prevent possible growth of fungal contamination. Microscopic examinations were made at decided intervals to check the time and stages of development.

Adult dalag were collected from Puerto Galera, Mindoro, in the summers of 1953 and 1954. Some adults came from Laguna de Bay. These collections were studied to find out if any sexual dimorphism exists in the species. In the measurement of eggs and fry, a vernier calipher, binoculars, microscopes, and a micrometer ocular were used.

All observations and studies were made in the laboratory. The eggs were placed in glass aquarium. As soon as the eggs were hatched, samples were taken and observed alive under the low-power binocular microscopes. Each sample was then preserved in 10 percent formalin with sufficient glycerine to prevent unnecessary harding of the specimen. Sampling of several hours intervals in the early stages and days in more advance stages was taken. The rest of the larvae were reared up to the time they assumed adult configuration and characteristics. Postlarvae were fed with *Moina,* a cladoceran caught in big numbers in standing pools and ditches, fish meal, dried shrimps and mosquito wrigglers. Of these feeds, *Moina* seemed to be the first choice of the larvae.

Sections of testis and ovary were also prepared. Both were fixed in formalin. Clove oil as clearing agent proved good only in the testis and not for the ovary. Sections were stained with Delafield's Haematoxylin.

All sections were cut 10 micron thick and mounted in balsam.

SEXUAL DIMORPHISM

Previous works on dalag did not mention much about the existence of sexual dimorphism except for the difference in size between the sexes, the female being the larger of the two. Other distinguishing features are hard to determine especially in the field. Closer examinations in the laboratory, however, indicate that there are other features aside from size. The following tabulation lists characteristics found in males and females. These are not sure-fire indices even to those already quite familiar with the fish. Thus they are offered for whatever worth they have.

Features	Female	Male
Standard length	Longer	Shorter.
Head across nape	Stouter and wider	More slender and narrower.
Body diameter	Body exhibits pronounced tapering towards the caudal peduncle.	Body hardly tapers posteriorly-hence diameter remains al, most the same all throughout the body length.
Caudal peduncle	Wider (as measured from mid-dorsal to midventral).	Narrower.
Habit	Sluggish	Relatively active and swim about most of the time.

BREEDING HABITS

The murrels can breed throughout the year in places where water does not dry up even in summer and in waters where the temperature remains relatively cool. In Laguna de Bay, peak spawning coincides with the warmer months to early part of the rainy season. Along the southern shore of the lake, spawning starts in May, reaching the peak by June and July. Northwesterly winds delay spawning on the western shores; in the grassy regions of the eastern side spawning reaches its height in March, April, and May.

During the spawning time, adult murrels go in pairs and build their nest of grasses and weeds. In Laguna de Bay, man-made artificial nests are common and often, spawning pair enters therein to spawn.

The writers have no direct observations as to which of the pair builds the nest. Aldaba (1931), however, mentioned the common belief in the region that the female assumes the burden of nest building, although there are some fishermen who maintained the opposite. Some fishermen volunteered the observation that in nest building the male takes the initiative only to be aided later on the process by the female; thus both share in a common task. Gill (1905) observed that in freshwater fishes, the eggs are laid in crude receptacle prepared by the male.

The nest is usually built in quiet, shallow places, where the water is 30 to 100 cms. deep and where aquatic vegetation is abundant. According to Aldaba *op. cit.* nest building by the fish is done by beating the aquatic plants sideways with the tail to produce a circular area freed of vegetation about 30 cms. across. The fish bites off grasses in the middle and files them along the periphery of the nest. The writers had similar observations in the laboratory. In a big aquarium with growing *Hydrilla*, where a male and a female were kept, the fish were seen to bite off the plant and filed to form a circular area within which to lay the eggs. Nest building and care of the young resemble that of the *Amia calva*. Dean (1898) reported that in this fish "the eggs are scattered over the nest thickly in varying number from a few hundreds to possibly a hundred thousand. A single male tends the nests, keeps away intruders and by vigorous breathing produces a current of water which probably retards the growth of the fish fungus. The fish stands guard, sometimes for hours motionless, save its movements in balancing and breathing; at other times it appears restive, turning about in the nest making short detours and returning by the runaway, which it provides. A favorite position is for the fish to lie in runway with its head projecting the nest. It usually remains in the shaded side of the nest, but appears occasionally in the bright sunlight, so that it can be seen quite a distance away."

In Ceylon, Willey *op. cit.* reported that the murrel has the same runway to and from the nest. The natives knew this habit and made use of this knowledge in catching the fish during the breeding season by means of a conical basket they called "Kuda." It is, likewise, reported that the nesting murrel does not readily take to the bait during the season.

In the aquarium, the male was seen to keep vigil over the eggs and the fry immediately below them, assuming a slant position of about 45°. Aldaba *op. cit.* reported that one of the parents is often seen with the nest where its presence is betrayed by movements and swaying of the plants around the eggs or fry. It was even reported to bite water buffaloes that happen to intrude into the nest. Some fishermen in Laguna Lake reported that the male is always inside the nest while the female stands by outside but in close proximity to the entrance of the nest. Furthermore, only the males have been caught inside the nest; this fact strengthened our observations mentioned earlier. The female may also be caught, but usually, it is outside of the nest or it may escape altogether. Our observations in the laboratory showed that the male actually protects the eggs and the young while the female retires at the bottom. Willey *op. cit.* reported a similar behaviour on the part of the male. On some occasions, the canibalistic tendency of the parents may prevail over parental instincts

Nest building is done usually at twilight and oviposition follows the next day at early dawn. All eggs collected between eight and twelve o'clock in the morning never showed stages of development earlier than the blastula stage. It is quite obvious segmentation is so rapid that by the time the sun is up, cleavages are practically over.

Eggs are laid by the thousands. According to Aldaba *op. cit.* the eggs are extruded as the female lies flat on its back at the bottom; thus spurting eggs become visible as they come out zooming to the surface. Only a few eggs are extruded at each spawning act so that completion of the act will require several repeated processes with proper interval periods in between acts.

Laboratory observations revealed that spawning requires several preliminary amplexuses before actual oviposition takes place. A female seen amplexing with a male late in the afternoon does not actually begin laying eggs until early dawn of the following day. Amplexus is an interesting phenomenon to watch. The couple takes on a head and tail (head of male towards tail end of female and vice versa) positions, parallel with each other and close to the water surface. As the pair approaches each other both swing around two or three times whence body contact is made. As contact is established, both fish bend upon the other ventral to ventral such that vents are juxtaposed. As amplexed close to the surface and both excitedly quivering in the act, the pair slowly sinks to the bottom from where presently ejaculation takes place and the eggs may be seen rising slowly to the surface.

In confinement, the dalag matures sexually in about eighteen months when it is about 25 cm. in length (Villaluz 1953). Smith (1945) reported a fish laying eggs at 21 cms. in length.

THE GONADS

The ovary is a large bilobed organ, which during the breeding season occupies the greater portion of the body cavity. The organ is asymmetrical, the left member being longer than the right member. The right lobe is situated more ventrally while the left lobe projects dorsally.

The mature ovary is big and bulky. It is bright yellow-orange in color. The ovarian wall is transparent and eggs can be seen through clearly; immature ovary is pale and may be distinguished from the testis only by its granulated appearance

The testis is white in color. Kendall (1926) and Yapchiongco (1949) noted in American smelts the asymmetry of the testis. *Ophicephalus striatus* presents a similar condition. Each testis continued posteriorly into a duct that opens into the urogenital sinus.

The spermatozoon is 0.0018 mm. in length and has a globular head with a short flagellum. (Plate 4, fig. 1).

THE EGGS

The eggs are spherical, small and pelagic. It is partly due to the unobtrusive size that eggs may escape predators and it is due to their roundness that eggs owe their mechanical strength. Ova requiring buoyancy have thinner and lighter shell. Some pelagic eggs have an incubation period of only twenty four hours in the tropics, but may require two or three days to complete their embryonic development. Newly laid eggs take in water rapidly and eventually become water hardened. Phenomenon of this kind is well known and is very well demonstrated in trout and salmon eggs.

The eggs are pelagic and owe their buoyancy to the presence of a large oil globule, which occupies the greater portion of the egg. The floating eggs are directly influenced by the sun and air. The light buoyancy of the eggs makes them almost unique among eggs of fresh water fishes. The eggs are bright yellow or amber in color.

Eggs are laid in big numbers in the nest but are spread in a single layer like a sheet on the surface of the water. Live fertilized eggs are transparent; dead eggs are opaque; likewise dead fertilized eggs turn opaque too. Removing the dead ones becomes an easy task to do.

The egg is spherical with a diameter of 1.4 mm. This is slightly greater than that reported by Willey (1909) 1.25 mm. but still within the range (1.25–1.5) reported by Smith (1945) (Plate 4, fig. 2).

SOME ASPECTS IN DEVELOPMENT

CLEAVAGE

Segmentation of the eggs is typical of teleostean eggs. Active cell divisions occur at the blastodisc resulting into the formation of a dome-shaped blastoderm that hangs below the surface of the yolk. (Plate 5, fig. 1).

BLASTULA UP TO HATCHING

The incubation period varies with temperature and may be completed from two to four days (Smith 1945; Aldaba 1931; Villaluz 1953); or from one to three days (Willey 1909). From our observations, the period of incubation from the blastula stage ranged from 30 hours (June, 1954) to 40 hours (November, 1953).

The earliest developmental studies made on embryonic development started with the blastula stage. Earlier stages were unavailable due primarily to the fact that dalag spawned only at night or at best at early dawn. Thus by sunrise or later, all eggs were in advance stages of cleavage.

The blastodermal cap is a lenticular dome hanging below the surface of the yolk. The walls of the cap show quite abrupt edges where it meets the yolk sphere. The peripheral cells over the yolk form a narrow collar of cortical periblast surrounding the proximal portion of the yolk. The marginal blastodermal cells contribute nuclei to the syncytial periblast. These multiply and migrate centripetally into the thin layer of protoplasm which intervenes between the adjacent surface of the yolk and the blastoderm. The periblast nuclei have a special physiological function in making the yolk easily assimilated by the growing embryo. (Wilson, 1891).

At one and a half hours later, the segmentation cavity is completely formed. The outer surface of the blastodermal cap begins to shape. It is more convex on the outer surface, the periblast. The development of the segmentation cavity causes a thickening of its periphery. By this time the edge of the blastoderm has migrated to the half of yolk ball. (Plate 5, fig. 2).

After 4½ hours, the thickened edge of the blastoderm known as the germ ring is found approaching the junction of the yolk and the oil globule. This results in a definite constriction of the advancing germ ring. (Plate 5, fig. 3).

At 8½ hours the axis of the future embryo is apparent. The germ ring has advanced over the oil globule and within the next hour of development, the blastopore closes. During the next few hours, differentiation is very rapid.

At 9½ hours the embryo lengthens and extends nearly half way around the yolk. The embryo has a thickened cephalic region and the faint outline of the optic vesicles appears. After 30 minutes more, the optic vesicles have increased in size and become more prominent. Eight mesodermal somites can be seen in the embryo (Plate 6, fig. 1).

Thirteen hours after the typical blastula stage is reached, the embryo developed 17 somites. The optic capsule appears as a pair of small vesicles posterior to the eyes. Chromatophores make their first appearance and are scattered sparsely on the body. The embryo remains whitish in color and is fairly transparent. The larval fin can be discerned at this stage. The embryo increases its thickness and extends two-thirds around the yolk ball (Plate 6, fig. 2).

At 15 hours, the heart starts to beat as soon as it is formed. The smaller end of the heart lies at the tip of the notochord, which can be seen extending from below the posterior portion of the eyes to the tip of the tail. The blood, still colorless, may be seen by following the flow of a few corpuscles. The olfactory capsules put in their appearance anterior to the eyes. The embryo now has 22 somites. The tail has now grown beyond the confine of the yolk sphere (Plate 6, fig. 3).

Seventeen hours after the blastula, 30 somites are fully established and completed; the brain now clearly indicates the five main parts of the adult brain. The optic lens is present but the optic cup still remains open ventrally as inverted "U". The choroid slit (Reighard, 1890) is seen running along the lower edge of the optic cup. The tail, now longer, projects half of it free off the yolk surface and occasionally may be seen lashing and stretching, which are the indications of first movements in the growing fish. (Plate 7, fig. 1).

Twenty-one hours afterwards, the embryo has almost encircled the yolk completely. Pigmentation has grown heavier. The tail can now lash violently from side to side and body twitching becomes more frequent. Approximately there are 37 to 39 somites . (Plate 7, fig. 2).

HATCHING

Hatching in fishes depends upon temperature (Reighard, 1890). In dalag, the length of time from oviposition to hatching varies primarily upon the "narrow limits of temperature of the water and amount of sunlight" (Smith, 1945).

At a temperature of 29° C. or 84.2° F., the embryo shows restlessness inside the egg membrane a few hours before hatching. Twitching of the tail is very frequent and as it lengthens, movement becomes more and more vigorous; it can swing sideways violently. Breakage of the egg membrane starts at the head region and is the result of the pressure exerted by the head against the membrane plus the force exerted by the young fish in its attempt to straighten out the tail. The head of the larva breaks through and with a sudden push against the opposite wall of the shell, the fish comes out of its case. The empty shell then sinks to the bottom. The entire process of the larva's escapement from its shell takes approximately five minutes to accomplish. A similar method of hatching was reported in the American flatfish, *Parophyrs vetula* (Budd, 1940). On the other hand, hatching of *O. striatus* can also differ from other fishes.

Such process like this, however, may produce big mortality among the young due to rupture of the yolk mass in the attempt of the larvae to tear away from their cases. In the walled-eyed Pike, *Stizostedion vitreum* rupture of the egg membrane is caused by the vigorous movement of the tail that finally protrudes out of the egg case. Combined movement of body and tail finally frees the larva of its shell.

NEWLY HATCHED LARVA

The newly hatched larva is slender, fragile and transparent. Yolk at hatching is amber colored with big oil globule within, both of which are instrumental in producing larval buoyancy. The fry is at the outset completely helpless and floats upside down so that the yolk is on top with the body held parallel to to the surface of the water. The larva hardly makes any movement; when disturbed, it swims away by feeble trashing of the tail and wriggling of the body. Smith (1945) observed "on the day of hatching, the larvae are between 3.5 to 4 mm. long with the brown sac measuring 1 to 1.6 mm. The young remained at the surface with the yolk sac uppermost."

The body of the larva fits snugly over the surface of the yolk mass. The gently rounded head shows no indications of the mouth and strongly hugs the surface of the yolk sac. The optic cup resembles an inverted "U" and is devoid of pigments. Posterior to the eye is an oval structure—the optic capsule.

The median larval fin folds are confluent with the caudal fin. They originate at the nape of the head and continue posteriorly around the tail, then ventrally terminate at the region of the vent. They are broad toward the middle portion of the tail where the depth of the dorsal fin is equal or almost equal to the ventral fin and about one-half as wide as the body. No paired fins are present.

The notochord is transparent and straight. The chromatophores, in the form of very fine, irregular, broken, wavy strands seen only under the microscope, are scattered all over the body, fin and the yolk sac. However, to the naked eye, the larvae appear devoid of pigments. The yolk sac is one half the entire length of the embryo. The larvae range from 2.6 to 3.2 mm. in length (Plate 7, fig. 3).

LARVAE THIRTEEN HOURS AFTER HATCHING

The larva still floats on the surface of the water in an upside down position. Sometimes, it rests on its side. Movement is effected by the trashing of the tail and wriggling of the body. At this stage, the head is slightly deflected towards the elongated yolk mass and the body has straightened out. Stellate pigments sparsely scattered over the body, fins and yolk sac have appeared, but the yolk sac showed heavier pigmentation than any other parts of the larva. The edges of the inverted U-shaped optic capsule show the presence of pigment cells imparting a greyish appearance. A depression on the ventral tip of the snout, which is the beginning of the stomodaeum, may now be seen. Likewise, just posterior to the yolk mass on the ventral side is another depression. This is the proctodaeum. Behind the auditory vesicle and above the yolk sac is a pair of small stubs. These are the rudiments of the pectoral fins which have developed on the second day after hatching (Willey, 1909) (Plate 8, fig. 1).

LARVA AT TWENTY-NINE HOURS

(1 day; 5 hours)

The head extends free from the yolk mass. The larva still rests on its sides. The ventral ends of the optic cup have come still closer at this stage so that an incomplete black ring forms around the optic lens. To the naked eye, the ring presents a region of heaviest pigmentation. Large stellate chromatophores whose ends anastomosed with each other forming a reticulum are seen almost evenly distributed on the yolk sac, dorsal and abdominal portions of the body, on the upper and lower boarders of the myotomes. The larval fins exhibit delicate stellate-like pigment cells. As a result of heavier pigmentation, the larva has lost its transparency and now appears gray to the naked eye (Plate 8, fig. 2).

The yolk sac is one-third the total length of the embryo. The myotomes have acquired the chevron pattern. The larva has grown to 4.2 mm. long with yolk sac circulation nicely shown.

Willey (1909) seeing such circulation in a similar stage described it thus: "The anterior cardinal vein is seen issuing from the head behind the auditory vesicle and passing across the front part of the yolk sac joining the sinus venosus. The caudal vein pours its blood into the sub-intestinal system which is joined by the posterior cardinal vein at the level of the angle contained between the projecting yolk sac and the hind body. The blood is at least the hinder moviety of the posterior cardinal vein which flows backwards into the sub-intestinal vein in conjunction with the caudal circulation—a fact which has been observed in other larvae."

Similar circulation has been observed in our specimens.

Reighard *op. cit.* described the larval circulation in the Wall Eyed Pike as follows: "The current of blood which issues from the smaller end of the heart passes along underneath the notochord. When it has reached the middle of the length of the tail, the stream turns abruptly and runs towards the head parallel to its first course and a little along the opposite side of one yolk to that occupied by the embryo until it comes to the oil globule. When it reaches the oil globule, the blood stream spreads out and moves here and there irregularly, as though there were no well-marked channel in which it flowed. In this way, it passes about the oil globule, on its left side along the line where it joins the yolk. Finally, it reaches the starting point at the broad end of the heart. By such circulation, it is probable that the nourishment which is afforded by the yolk is carried into the body of the embryo.

About the oil globule, the blood flows in a broad, very shallow and irregular channel and since the oil globule lies uppermost in the egg, the blood there is brought into close contact with the external water and being spread out in a thin layer, exposes a large surface to the water. It is likely then that the exchange of gases between the water and the blood, which constitutes breathing or respiration, is carried on at this point."

FORTY-TWO HOURS

(1 day; 18 hours)

The larvae now assume the natural position with the body upward and the yolk sac downward. The fry leave the surface of the water and swim actively throughout the entire level of the water by flapping the fan-shaped pectoral fins. They frequent the bottom of the jar as if in search for food, then they go to the surface of the water again. Occasionally, they still rest on their sides.

The head is very distinct and separated from the yolk mass, the latter having decreased to one-fourth the total length of the larva. Posterior to the "U" shaped eyes is the operculum under which the gills may be seen, beating in regular rhythm. The movement of the lower jaw, gasping movements, in conjunction with operculum indicates that respiratory movements have commenced. Both ends of the alimentary canal are open. No differentiation of the digestive tract has taken place. It seems to be almost a straight tube beginning with a slight enlargement beneath the anterior end of the notochord and continues back for a little distance into the tail. The external nares anterior to the eyes can be seen too.

The air bladder can be seen as two lateral bulges on each side of the body immediately posterior to the pectoral fins. In his study of *O. striatus,* Willey *op. cit.* noted that the appearance of the air bladder, flapping of the pectoral fins, and respiratory movements have begun on the third day. Obviously, the differences noted between Willey's larvae and ours, are due to environmental conditions existing in the two countries. As a matter of fact, some differences may be shown by the fry even in the same locality but with varying environmental factors.

The essential pattern of pigmentation is the same except for an increase in chromatophores so that the larvae are a little darker than the previous stages (Plate 8, fig. 3).

FIFTY-THREE HOURS

(2 days; 5 hours)

The fry form clusters and move about in schools. The pigmentation has increased because under the naked eye the fry appear black. Big chromatophores are found on the upper and

lower jaws, on the rim of the operculum, on the ventral side of the abdomen up to the base of the ventral fin. The inter-orbital area of the head is without pigmentation. The jaws are well defined but apparently are still not functioning up to this time. No attempt at feeding was observed. The yolk sac further decreases to one sixth of the total length of the fry. At this stage, the larvae averaged 5.3 mm. long while the pectoral fin is one tenth of the total length (Plate 9, fig. 1).

Further differentiation of the circulatory system has taken place. Our observations concur with Willey's description of the circulatory system in the second and third day "lula"[1] as compared with the very young hatchlings where the caudal vein passes alongside the hindgut into the subintestinal system, there it is seen to give rise to a capillary system which is joined by the posterior cardinal vein and discharges into the subintestinal vein behind and below the yolk sac instead of just passing along side the hindgut into the subintestinal system. Connected with this and with two anterior vessels is a marvelous yolk sac circulation, forming a perfect system of capillary irrigation. During the early days of larval life, neither the aorta nor the caudal vein extends backward as far as the end of the notochord, but opens directly into the latter behind the free end of the septum which otherwise separates the two vessels at this stage, and at this point of confluence lies some distance in front of the end of the notochord. After the 12th day, the vessels are carried farther backward and a capillary network forms on the caudal fin beyond and below the tip of the notochord.

SEVENTY-SEVEN HOURS

(3 days; 5 hours)

The larvae have now increased to a length of 5.5–5.7 mm. and are very active. The ventral ends of the optic cup have fused completely to form a dark ring around the optic lens. The rim of the cup has acquired a light golden tinge. The alimentary canal shows slight coiling but up to this stage no differentiation has been noticed. The posterior tip of the notochord is still straight but near the ventral tip is a mass of vacuolated tissues. Pigmentation is the same as in previous stages except

[1] *Lula,* local term for O striatus in Ceylon.

for a heavier concentration on the ventral fin. The larva has approximately 39 myotomes (Plate 9, fig. 2).

NINETY-NINE HOURS

(4 days; 3 hours)

The larvae have attained a length of 5.7 to 6.8 mm. Yellow pigment cells in addition to the black chromatophores on the dorsal part of the body and the tail give the larvae yellowish color. The notochord is straight and there is an increase of vacuolated embryonic tissues on the ventral posterior tip of the notochord. The absence of pigment cells on the lateral side of the body produces a pale longitudinal band parallel to the notochord.

Smith (1945) found that on the 4th day, the larvae were 6.75 mm. to 7 mm. in length. The larvae leave the surface and swim freely at different levels and respiratory movements have begun although with the cessation of active efforts, the larvae rise to the surface and cannot remain at the bottom. Most of them assumed normal or upright position.

ONE HUNDRED NINE HOURS

(5 days; 9 hours)

The larvae turned more yellow in color as a result of the increase in yellow pigment cells. The end of the notochord is slightly bent upward and the embryonic fin presents rays. The ventral caudal striations are the beginnings of the caudal fin rays. The ventral base of the myotomes exhibits more pigment cells than the dorsal part. The length of the larvae ranges from 5.7 to 6.9 mm. and has approximately 45 myotomes (Plate 9, fig. 3).

ONE HUNDRED FIFTY ONE HOURS

(6 days; 6 hours)

The larvae now swim briskly and move about vigorously in the aquarium where they are kept. Both the pectoral and unpaired fins are used in typical swimming movements. At this stage, the yolk is completely exhausted and the larvae begin feeding on *Moina*. Feeding is evidenced by the bulging abdomen, a few hours after the feed has been introduced into the aquarium. The alimentary canal shows coiling and differentiation is noticeable. The notochord is transparent with the posterior end slightly bent upward. Arising from the bent part is the beginning of the fasciculation of 4 to 5 caudal striations marking the position of future caudal fin rays. The fin fold remains continuous. The ventral portion of the body presents denser pigmentation but no appreciable increase in length was observed, length being 6.3 to 6.9 mm. There are approximately 50 myotomes.

TWO HUNDRED FORTY SEVEN HOURS

(10 days; 7 hours)

The yellowish orange color of the embryo becomes more intense. A broad band of reddish orange is found along the lateral side of the fish starting from behind the eyes and ending off at the base of the caudal fin. The irridescent and golden orange color of the iris persists. Pigmentation on the ventral fin is still heavier than on the dorsal fin. The swim bladder appears as an oval transparent structure dorsal to the alimentary canal. The posterior tip of the notochord has turned sharply upward and seven caudal fin rays may be seen arising from it (Plate 10, fig. 1).

It may be noted that there is a differential rate of growth operating among the larvae. This is shown by the fry on varying sizes ranging from 6.5 to 7 mm. Such a phenomenon, however, is normally expected for in cases like this, no two individuals can be expected to accelerate growth at the same rate, much less in a big batch of fry such as in *Ophiocephalus striatus.*

TWO HUNDRED AND NINETY FOUR HOURS

(12 days; 6 hours)

The post larvae swim constantly about the aquarium, frequently emitting bubbles to the surface of the water and at the same time gulping some atmospheric air. The swim bladder has further increased its size and extends to as far as one-half posteriorly of the tail region. The fin rays are present on the caudal and pectoral fins only. Prior to the formation of the anal fin rays, the ventral fin is heavily pigmented. The ventral portion of the body from the abdomen to the tip of the tail is intensely pigmented. The caudal fin is heavier in pigmentation than the dorsal fin. At this stage, the average length of the larvae range from 9.2 to 10 mm.

THREE HUNDRED TWENTY THREE HOURS

(13 days; 11 hours)

The unpaired fins show remarkable change. A little anterior to the peduncle of the tail, a constriction is visible which separates the future dorsal, caudal, and anal fins. Dorsal fin now exhibits definite fin rays; pelvic fins start as stubs on the ventral abdominal region behind and in line with the base of the pectoral fin but anterior to the anal fin. The larvae vary in size and the total length ranges from 10 to 14 mm. (Plate 10, fig. 2).

FIVE HUNDRED THIRTY SEVEN HOURS

(20 days; 9 hours)

The caudal end of the body has become symmetrical, dorsoventrally supported by fin rays arising regularly from the rounded end of the tail proper. The last vertebra of the vertebral column is sharply produced upward, otherwise, the column is straight.

The yellowish color of the larvae gradually disappears. The body is now covered with scales. The scales are small and embedded in the skin pockets. The pectoral fins extend up to the anus. The average total length is about 15 mm. (Plate 10, fig. 3).

SEVEN HUNDRED TWENTY HOURS

(one month)

After a month, the characteristic orange color disappears completely. The larvae become pale muddy, greyish in color with a well-defined black spot located at the region of the posterior tip of the dorsal fin. It is also noted that the iris has become deep orange. The total length now averages at 16 to 18 mm.

Willey (*op. cit.*) observed that larvae which are 37 to 40 days old vary in length from 10–13 mm. The length bears no direct proportion to the bulk since a larva of 13 mm. has at least twice the bulk of one of 10 mm. This is the transition period from the larval to the post-larval phase of growth. At 10 mm. there are still no external rudiments of the ventral fin, but these appear when the larva has attained the length of 10.25 mm. they arise *in situ* a short distance behind the plane of the pectoral fins and far in front of the ventral as minute buds close to the middle line of the abdominal surface. The embryonic fins are still continuous, but a shallow constriction, both above and below, separated the future definitive dorsal and anal fins from the caudal fin, the intervening portions of the embryonic fin in the region of the caudal peduncle undergoing reduction and degeneration, accompanied by the appearance of vacuoles in their substance. The primordial formative tissue of the dorsal and anal rays has now invaded the corresponding parts of the larval fin, obscuring the striations, bearing a peripheral rim free, where the primary striations are clearly visible. The anal rays appear in the middle of the substance of the fin, separated by an interval from the basal line and surrounded by dense pigment. The dorsal ray may arise from the basal line and the pigment is sparse.

About the 40th day after the hatching, marks the end of the larval development in so far as this is denoted by the condition of the fins. As soon as the fin rays are properly laid down and their outlines darkened by pigments, the amount of pigments in the dorsal and anal fins becomes equalized. The other characteristic at this stage is the broad yellow lateral stripe, a short yellow band in spot, and a golden yellow mark over each eye (Plate 11).

ONE THOUSAND FOUR HUNDRED FORTY HOURS

(2 Months)

At the second month, the dorsal part of the body becomes darker in pigmentation and the ventral portion maintains the greyish color. Very light dark striations appear from the dorsal portions and extend toward the ventral side. The black spot at the posterior tip of the dorsal fin still persists. The larva stays at the bottom of the aquarium and behaves like an adult.

Smith (1945) noted that on the 9th week (64 days) the larvae have attained the length of 17 to 20 mm. The young ones go to the bottom, hide in the mud, and thenceforth, assume the habits of the adults.

TABLE 1.—*Tabular Comparison of Larvae from the Philippines, Ceylon and Thailand at Similar Ages*

	Philippines	Ceylon[1]	Thailand[2]
Newly hatched embryo.	Newly hatched embryos float upside down with yolk sac uppermost They hardly move at all; are colorless and transparent. Length is from 2.6 to 3.2 mm.	Larvae show very faint pigmentation; eyes devoid of pigmentation.	Newly hatched embryos remain on surface of water with yolk sac uppermost; they measure between 3.5 to 4 mm. Yolk is 1.8 mm
13 hours	Embryos-still:float upside down; stellate pigments present but sparsely scattered on the body; optic cup greyish in appearance; appearance of rudiments of pectoral fin.		
1 day	Larva rests on side; head is freed from yokl mass; larva is 4.2 mm. in length. Larva shows yolk sac circulation.	Length of larva is 3.5 mm; exhibits yolk sac circulation; stellate cells over yolk soon darken and form a pigment reticulum; pigments appear on eye.	Larvae are able to maintain themselves at bottom or below surface of water by active swimming effort; of larvae begin to swim normally, that is, dorsal side up.
2 days	Larvae assume natural, position, dorsal side up yolk sac downward; anus established. Respiratory movements observable; air bladder present. Eyes black; jaws well defined but non-functional larvae make no attempt at feeding; size of larvae 3.5 mm.	Eyes of larvae black; rudiments of pectoral fin present above yolk sac; length of larvae 4.5 mm.; larvae show marvelous yolk sac circulation; remain on surface of water. They rest on their side with yolk sac up; when swimming, they swim away and rotate.	
3 days	Larvae very gregarious size increased to 5.7 mm. Ventral ends of optic cup fused completely to form a dark ring; rim of cup with light golden tinge; a mass of vacuolated tissue present at ventral tip of notochord; heaviest pigmentation on ventral fin.	Mouth now opens; air sac has appeared. Pectoral fin flapping; respiratory movements have commenced. Size of larvae 5 to 5.5 mm.; larvae rest at surface of water; when no swimming, they are incapable of resting at bottom of container. Stellate pigment cels distributed over myotone, especialy along upper and lower borders.	Some larvae have grown to a size of 7 mm.; most have assumed upright positions.
4 days	Larvae attained length of 6.4 to 6.7 mm.; yellow pigments on dorsal part of body and tail in addition to black pigments.	Larvae 6.75 mm. long; swim at all levels of aquarium; sides of body devicd of pigment; with yellowish spot on eyes; presence of vacuolating and massing of embryonic tissue at ventral end of straight notochord.	Embryos range from 6.7 to 7 mm.; larvae swim actively at different levels of aquarium. Respiratory movements now observable; most larvae assumed normal positon.
5 days	Larvae more yellowish in color; end of notochord bends slightly upward; beginning of caudal fin ray apparent, arising	Pigmentation on caudal portion of body more intensed; no increase in length.	

[1] From Willey 1909

[2] From Smith 1945

TABLE 1.—*Tabular Comparison of Larvae from the Philippines, Ceylon and Thailand at Similar Ages*—Continued

	Philippines	Ceylon	Thailand
	from ventral tip of notochord; length from ventral tip of notochord; length ranges from 6.6 to 6.9 mm.		
6 days	Fry brisk swimmers; yolk gone; feeding on plankton starts; no appreciable increase in size noted.	Larvae exceed 7 mm.; slight concentration of pigment and embryonic tissue is seen on ventral fin.	
7 days	Embryonic fin fold remains continuous.	Larvae about the same size as previous day; appearance of first basal cartilage; caudal rays below free end of notochord, likewise appear.	
10 days	Yellow color of larvae becomes more intense; reddish orange band along lateral side of body prominent; iris irridescent; golden pigmentation on ventral fin heavier than on dorsal fin; Swim bladder dorsal to alimentary canal visible; posterior tip of notochord bent shrply upward giving off 7 caudal fin rays ventral. Larvae now range from 6.5 to 7 mm.		
12 days	Frequent surfacing of larvae to whiff air bubbles; further increase or swim bladder noted; fin ray only in caudal, anal and pectoral fins.	End of notochord bends upward; caudal rays begin to show; slight decrease in length from 7 mm. to 6.75 mm; this length is maintained to end of 15th day.	Presence of black pigment
13 days	Constriction at peduncle of tail sets off caudal fin from median fin; already pelvic fin present; size varies from 10 to 14 mm.		
15 days		Larvae display pronounced yellow color associated with further condensation of black cells.	
20 days	Caudal fin shows the true homocercal form; fin rays on dorsal fin. Vertebral column straight except or the last one which turns sharply upwards. Yellow coloring gradually disappearing; fins fully differentiated. Appearance of scales all over body.		

TABLE 1.—*Tabular Comparison of Larvae from the Philippines, Ceylon and Thailand at Similar Ages*—Continued

	Philippines	Ceylon	Thailand
25 days		Larvae 7.5 mm. long; median fin still continuous; ventral fin more pigmented than dorsal. Fasciculation of caudal ray more developed but are not yet provided with basal prongs.	
28 days		Fry swim near bottom of aquarium, gulping air every minute and each time leaving small air bubble at surface. Fry vary arc, 8.5 to 10 mm. in length; 10 to 12 caudal rays attached below upturned end o notochord. Fin rays are controlled by special diverícator muscle.	
1 month	Characteristic orange color totally dis appears; ry appear pale, muddy and greyish; black ocellus located at posterior tip of dorsal fin; iris deep orange; size varies rom 16 to 17 mm.	Larvae from 10 to 13 mm. long. Embryonic fin still continuous but exhibiting constrictions above and below indicating separation between future definitive dorsal and anal fins from caudal fin.	Larvae measured from 10 to 12 mm.; can swim comfortably at or near bottom of small aquarium; periodic surfacing to sniff in air evident.
37 days to 40 days.		Fin rays on dorsal and anal fins appear, their outline darkened by pigment; pigmentation on dorsal and anal fins equalized. Presence of broad, yellow lateral stripe, a short yellow band in front of dorsal fin, culminating into a shining golden occipital spot and a golden yellow mark on each eye.	
2 months	Dorsal part o body becomes darkly pigmented; ventral side maintains its greyish color; dark striations appear diagonnally across the body.	Fry incessantly swimming up and down the water; general color effect is made by band stripe from eyes to base of caudal fin; iris is golden with red flush; length from 15 to 17 mm.	The fry seek the bottom or hide in the mud and henceforth assume adult habits. Length now is from 17 to 20 mm.
2½ months			Young fingerling is 25 mm.; they continue hiding in the mud.

LITERATURE CITED

ALDABA, VICENTE. 1931. The dalag fishery of Laguna de Bay. Phil. Jour. Sci. 45 (1).

BUDD, PAUL. 1940. Development of the eggs and early larvae of six California fishes. Fish Bull. (6). Dept. Nat. Res. Div. of Fish and Game, Calif.

CANTOR, THEODORE E. 1850. Catalog of malayan fishes. Jour. Asiat. Soc. Bengal 18: 983–1443.

CUVIER, G. S. F., and A. VALENCIENNES. 1831. Histoire naturelle de poisons, 8.

DAY, A. L. 1914. The osseous system of *Ophiocephalus striatus* Bloch. Phil. Jour. Sc. IX, D: 19–56.

DEAN, BASHFORD. 1898. Habits and breeding of Bowfin *Amia calva.* Fourth Ann. Rep. Comm. Fish., New York State.

GILL, THEODORE. 1905. Parental care among fresh-water fishes. Ann. Rep. Smithsonian Inst. 403–531.

GUNTHER, ALBERT. 1861. Catalog of the Acanthopterygian fishes in the Collection of the British Museum 111: 474–

HERRE, ALBERT. 1924. Distribution of true fresh-water fishes in the Philippines. Phil. Jour. Sci. 24 (6): 683–691.

JORDAN, D. S. 1907. Fishes. Henry Holt & Co., New York.

JORDAN, D. S. and A. SEALE. 1905. List of fishes collected by Dr. Bashford Dean on the Island of Negros, Philippines. Proc. U. S. Nat. Mus. 28: 769–803.

JORDAN, D. S. and A. SEALE. 1927. Fishes of the Island of Luzon and Panay. Bull. U. S. Bur. Fish. 26, 1906: 1–48.

KENDALL, W. C. 1926. The smelts. U. S. Bur. Fish. 42 (1015): 217–385.

LE DANOIS, Ed. et al. 1957. Fishes of the World. George G. Harrap & Co., Ltd. London.

NORMAN, J. R. 1931. A History of Fishes. A. A. Wyn, Inc., New York.

REIGHARD, JACOB. 1890. Development of the wall-eyed Pike, *Stizostedion vitreum.* Bull. Mich. Fish. Comm.

ROXAS, HILARIO and A. UMALI. 1937. Fresh-water farming in the Philippines. Phil. Jour. Sci. 63(4): 433–465.

SMITH, HUGH. 1945. Fresh water fishes of Siam or Thailand. Smiths. Inst., U. S. Nat. Mus. Bull. No. 188:465–470.

VILLALUZ, DOMICIANO. 1953. Fish farming in the Philippines. Unpublished monograph.

WEBER, MAX and L. F. DE BEAUFORT. 1922. The Fishes of the Indo-Malayan Archipelago 4.

WILLEY, ARTHUR. 1909. Observations on the nest, eggs, and larvae of *Ophiocephalus striatus.* Spolia Zeylanica 6:108–123.

WILSON, H. V. 1889. The embroyology of the sea bass (*Serranus atrarius*). Bull. U. S. fish Comm. 9: 209–277.

YARCHIONGCO, JOSE V. 1949. Hypomesus pretiosus: Its development and

ILLUSTRATIONS

PLATE 1

Photograph of preserved dalag: Adult female.

PLATE 2

FIG. 1. Natural habitat among rice paddies. Bulacan province.

2. Another habitat set-up: A creek overgrown with nipa palm. Puerto Galera, Oriental Mindoro.

PLATE 3

FIG. 1. Panoramic view of Laguna de Bay Lake, showing well-spaced man-made artificial nests ("pugad-pugad"). Note one at foreground and many others at the background.

2. Close-up one nest looking down, showing a batch of young dalag fry (white arrow).

PLATE 4

FIG. 1. Photomicrogram of an X-section of testis, showing stages in the maturation of the spermatozoa.

2. Photomicrogram of an X-section of the ovary, showing stages in ova differentiation.

PLATE 5

FIG. 1. Early blastodermal cap (1½ hours).

2. Late blastodermal cap stage.

3. Germ ring approaching equator. Side view (4½ hours).

PLATE 6

FIG. 1. Embryo nearly halfway around yolk mass (9½ hours).

2. Embryo two-third around yolk mass (13 hours).

3. Embryo with tail already freed from yolk mass (15 hours).

PLATE 7

FIG. 1. A more advance embryo showing the optic cap with the optic lens (17 hours).

2. The embryo 3 hours before hatching (21 hours).

3. The larva at hatching; natural size, 2.6 mm.

PLATE 8

FIG. 1. The larva 13 hours after hatching, natural size, 3.5 mm.

2. A twenty-nine hour old larva; natural size, 4.5 mm.

3. The larva at forty-two hours; natural size, 4.8 mm.

PLATE 9

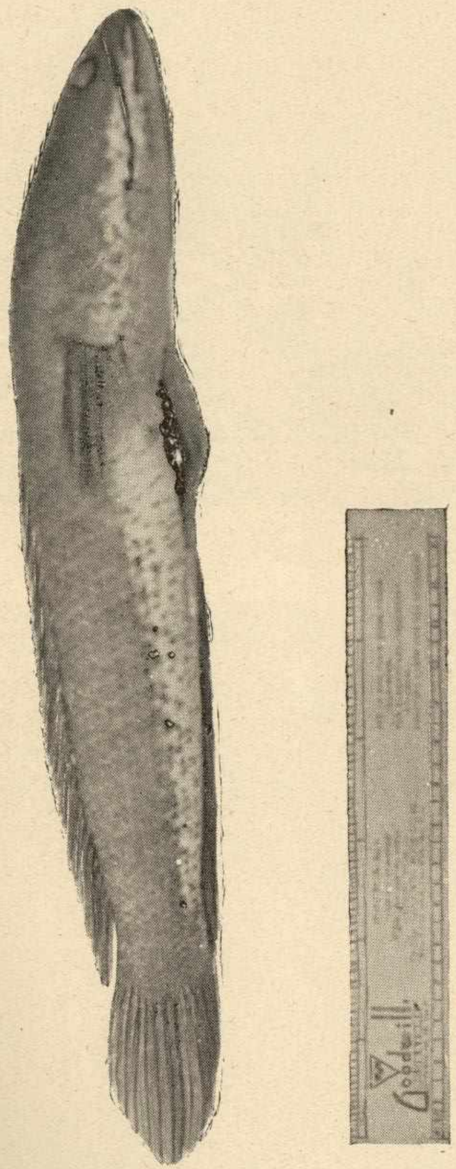
FIG. 1. The fifty-three hour old larva. Size: 5.3 mm.
2. The larva at slightly over three days old (77 hours). Size: 5.5 mm.
3. One hundred-hour old post larva yolk completely gone. Size: 5.7 mm.

PLATE 10

FIG. 1. The post larva at two hundred forty-seven hours. Size: 6.6 mm.
2. The young at three (23 hours). Size: 14 mm.
3. A twenty-day old young. Size: 15 mm.

PLATE 11

The fingerling (one month old). Size: 18 mm.



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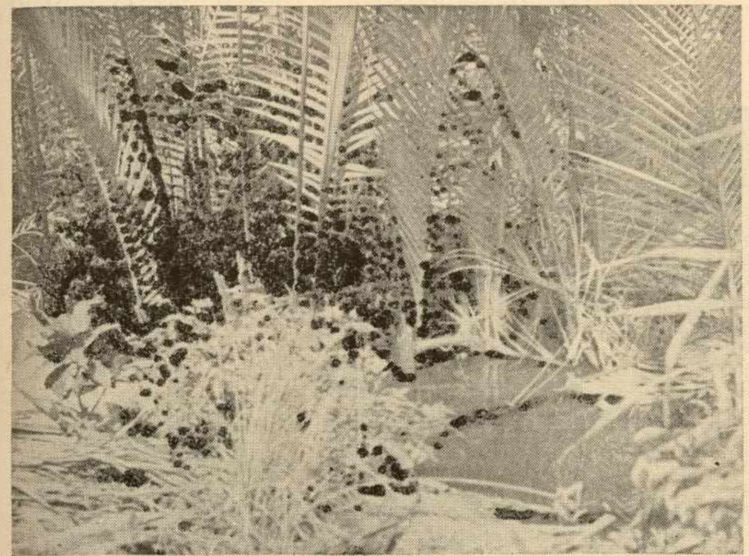

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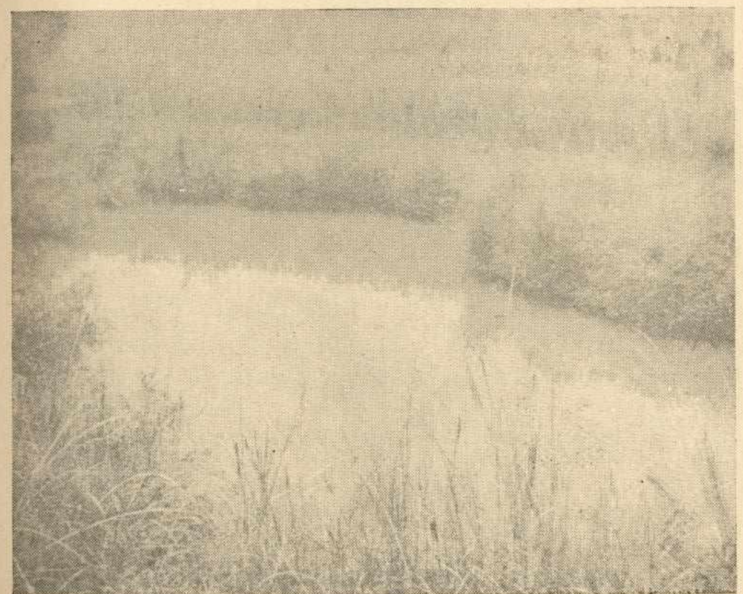

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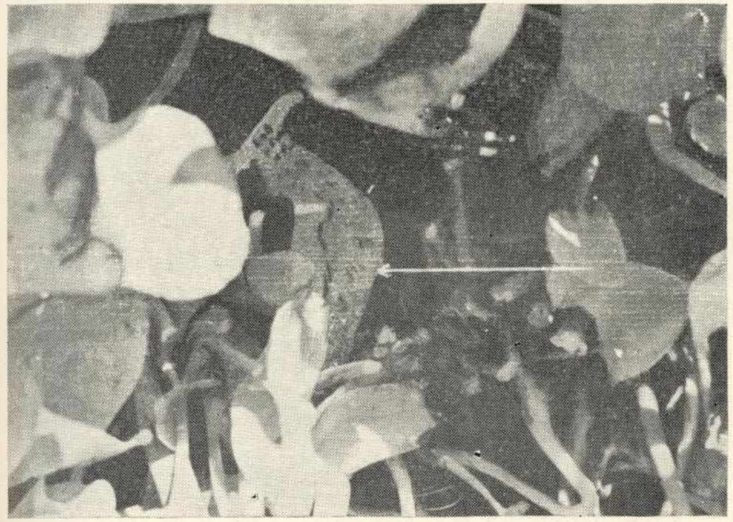

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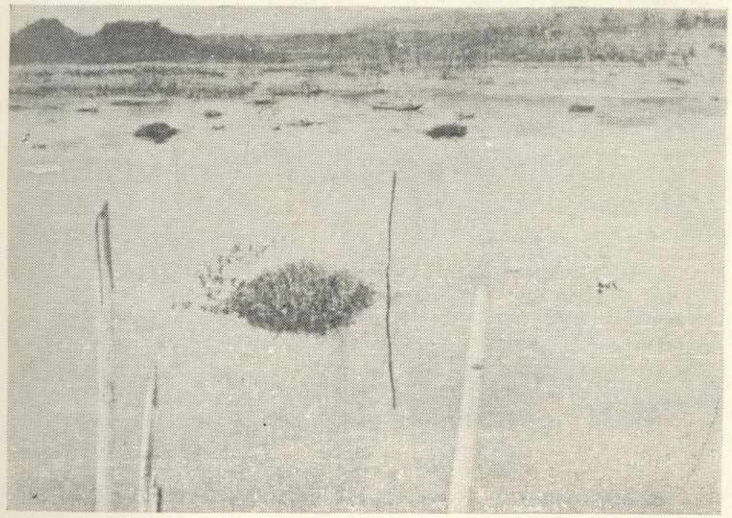

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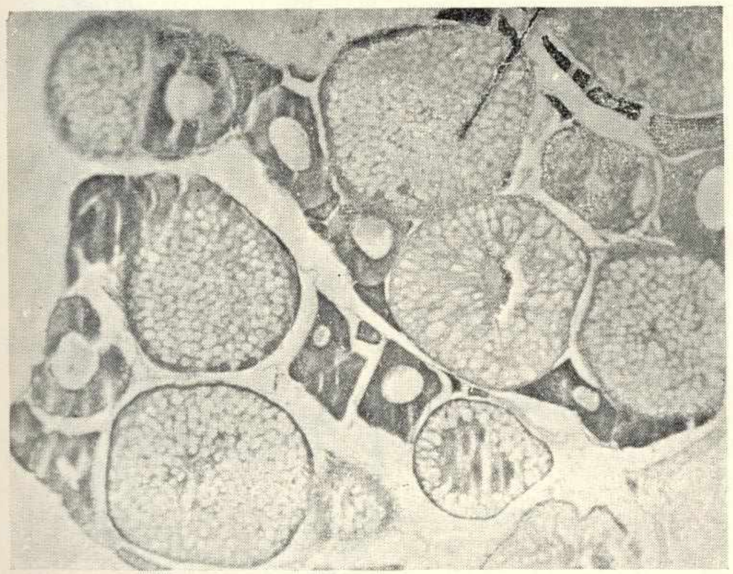

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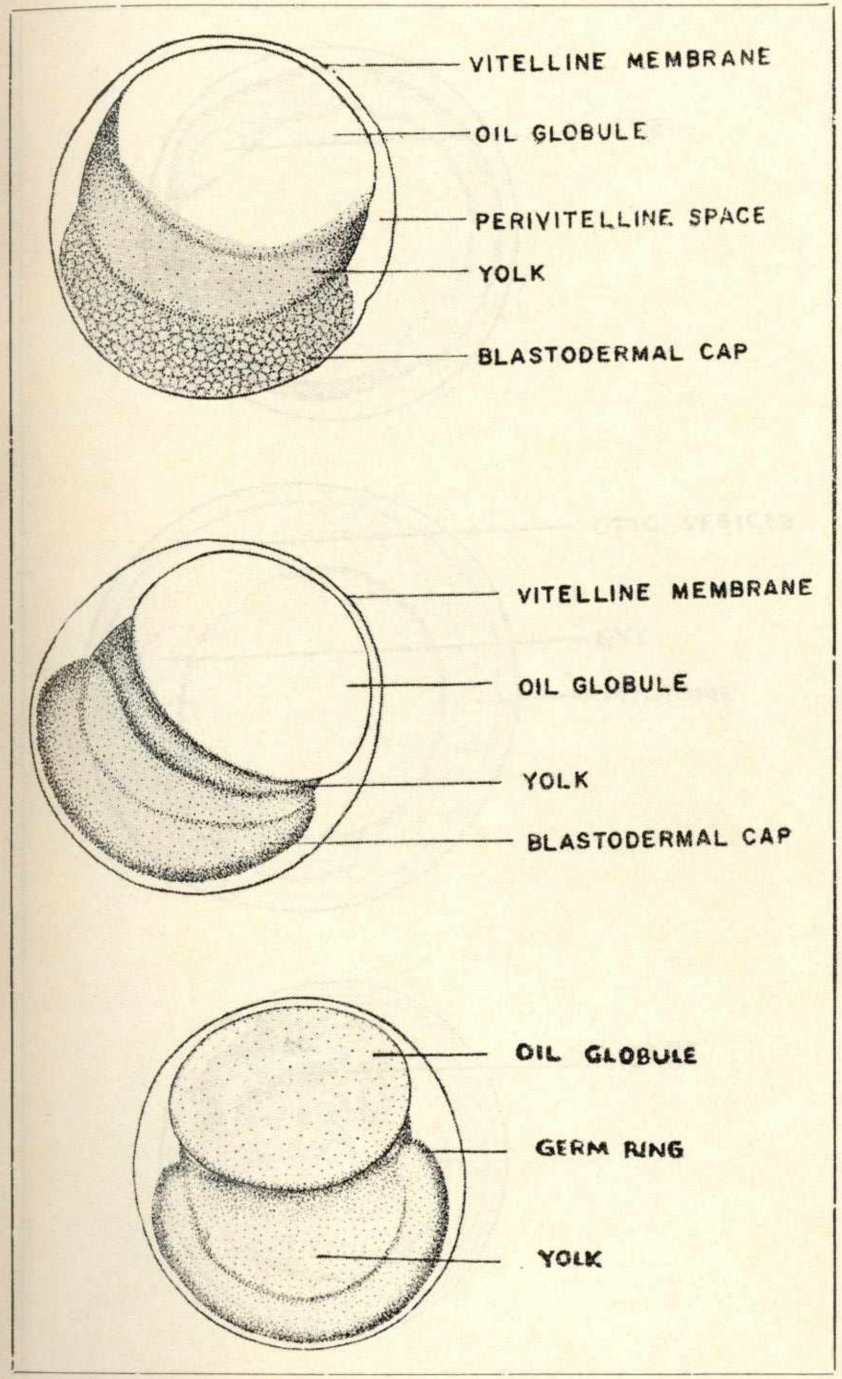
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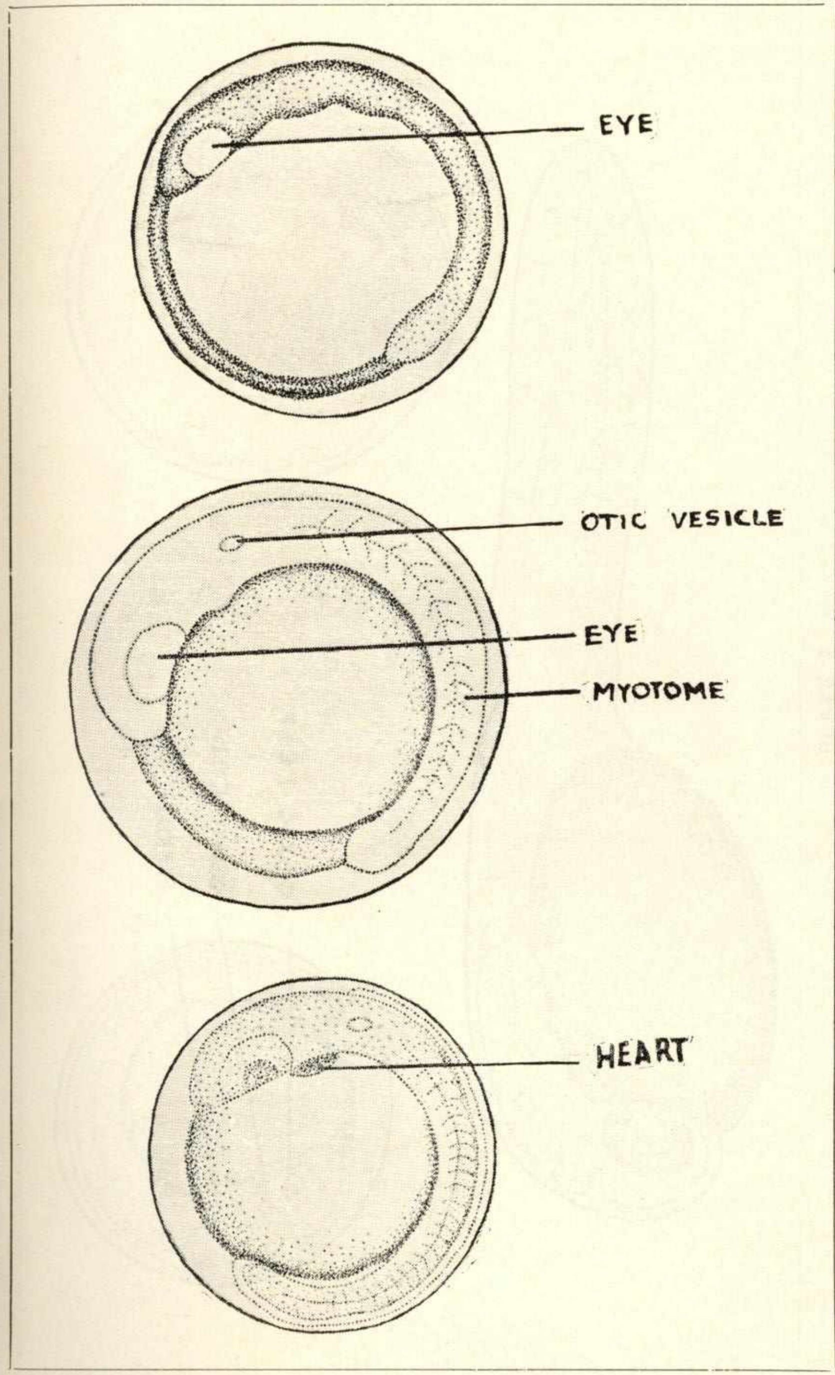
OIL GLOBULE
GERM RING
YOLK

PLATE 5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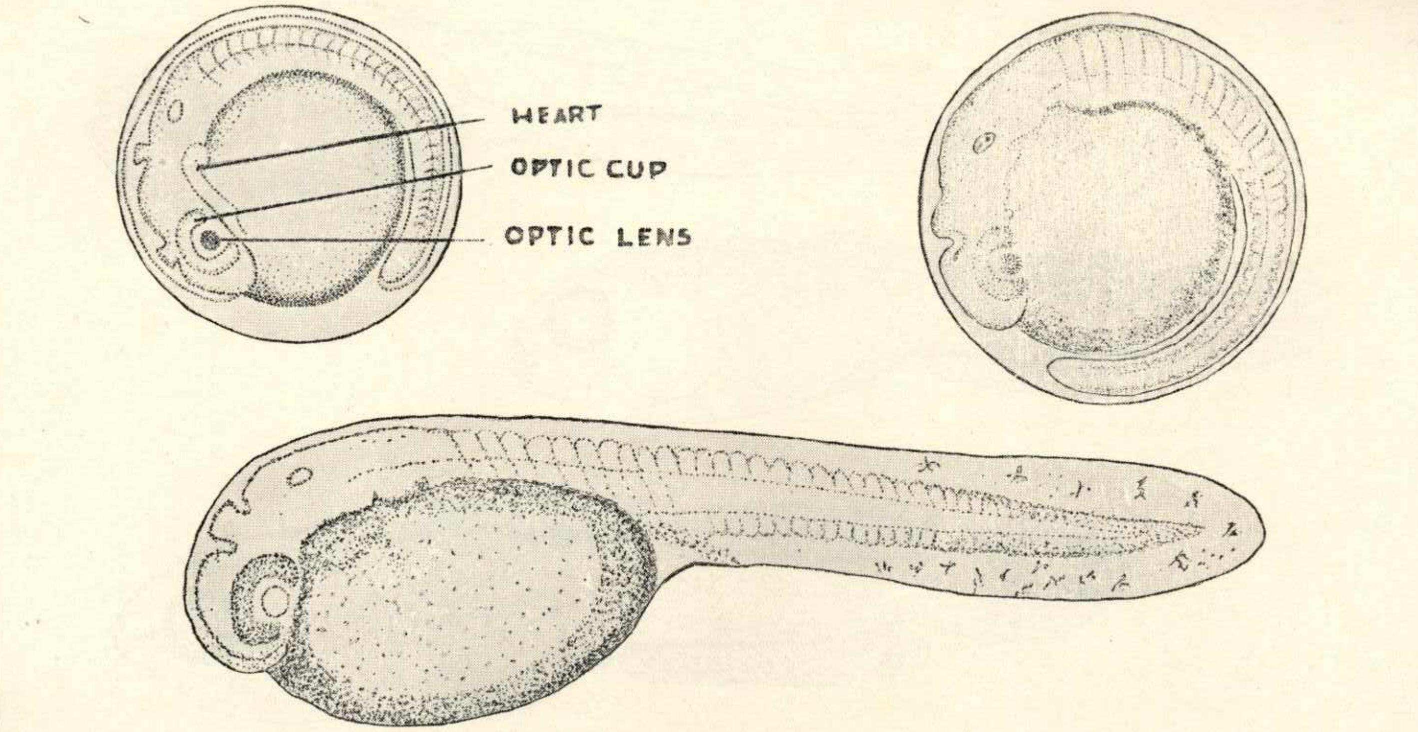
MYOTOME
HEART



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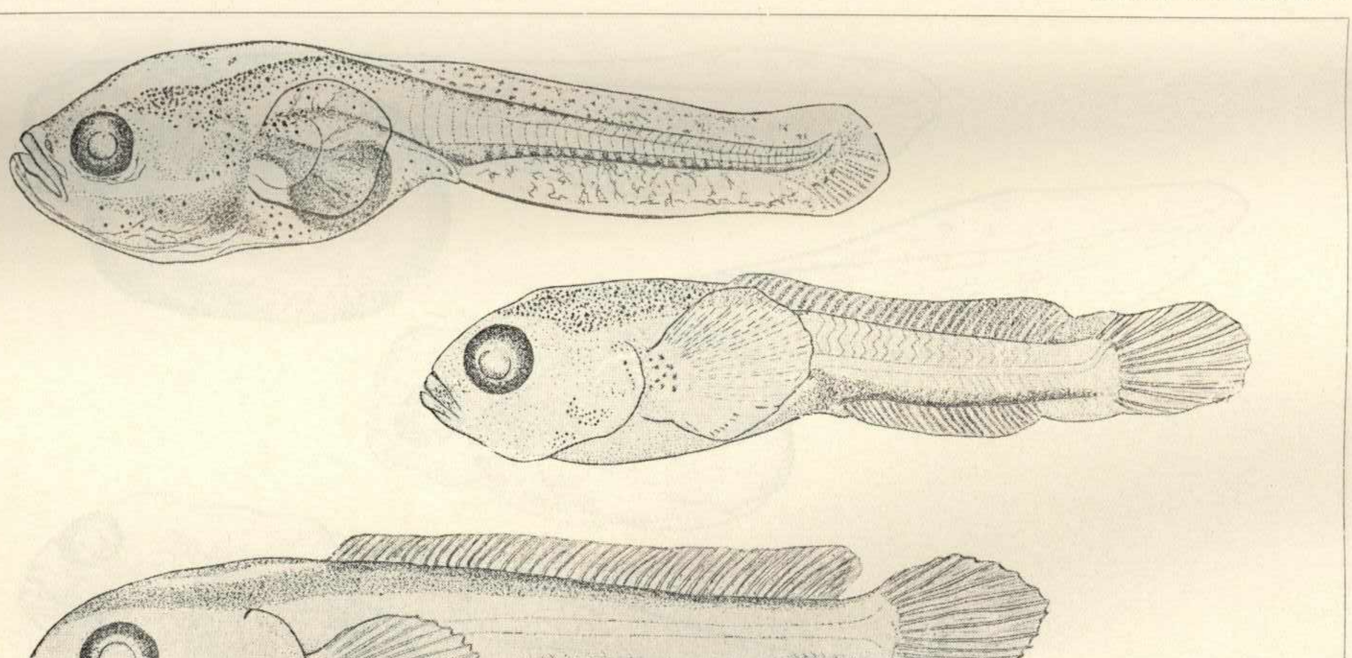

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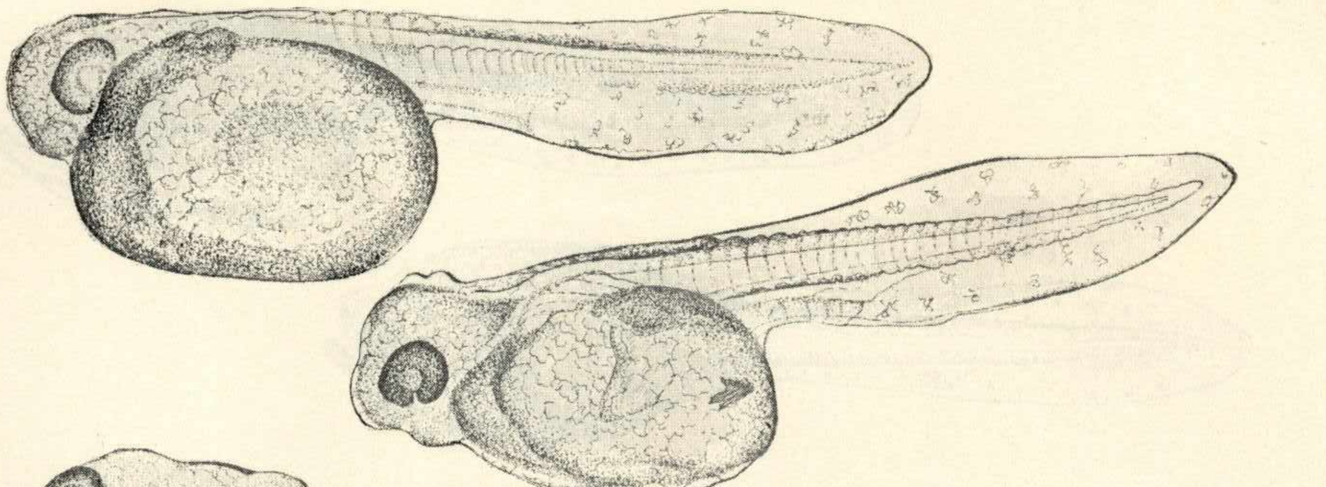

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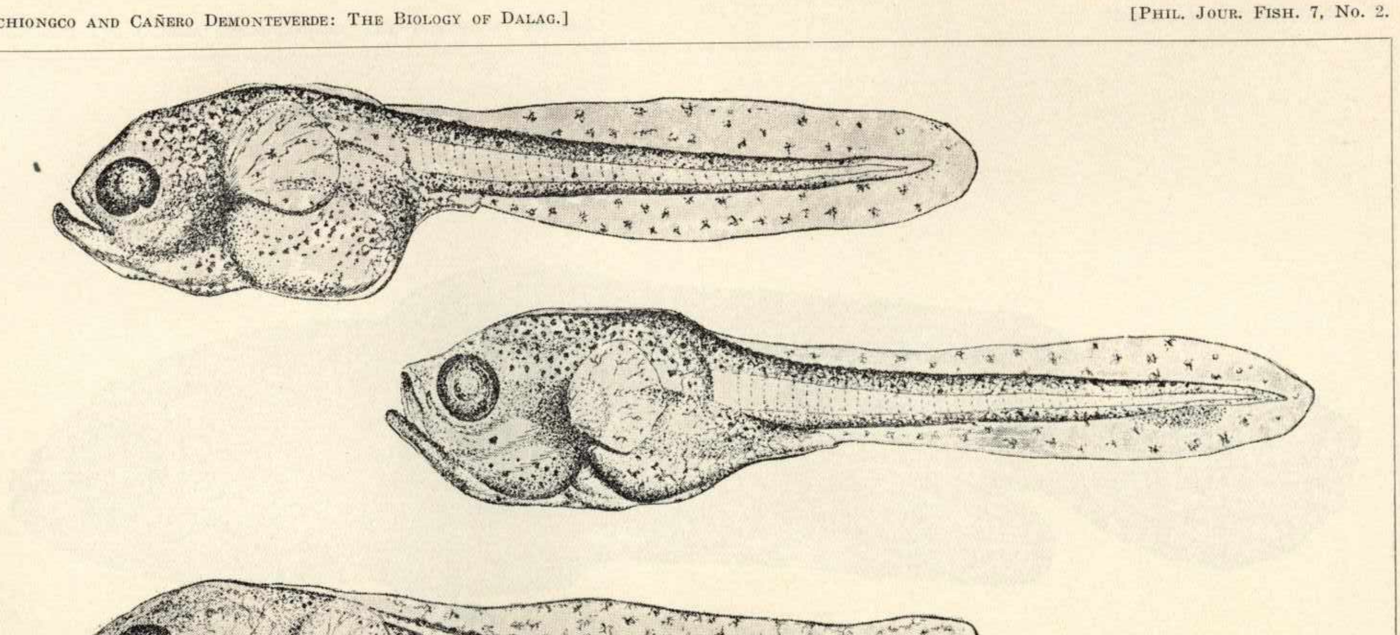

PLATE 10

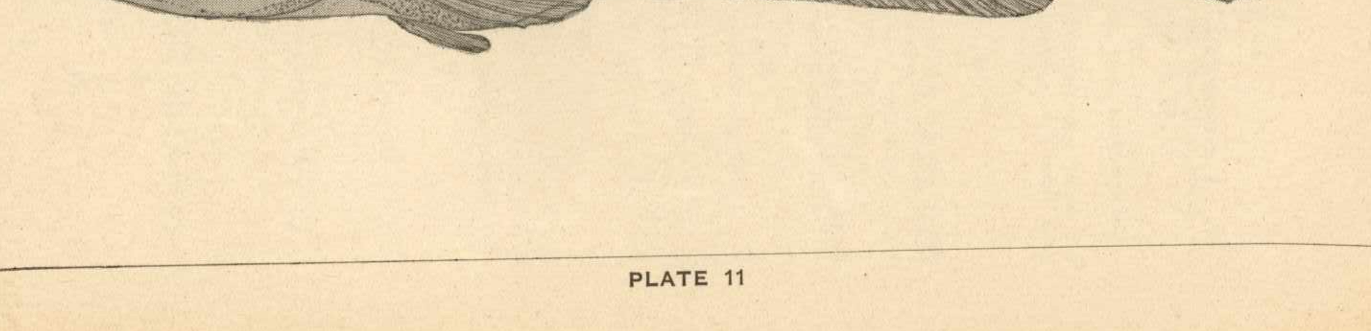

PLATE 11