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THE LIFE HISTORY AND HABITS OF THE GOBY, SICYOPTERUS EXTRANEUS HERRE (ANGA) GOBIIDAE WITH AN ACCOUNT OF THE GOBY-FRY FISHERY OF CAGAYAN RIVER, ORIENTAL MISAMIS.[1]

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THREE PLATES AND TEN TEXT FIGURES

INTRODUCTION

ECONOMIC IMPORTANCE AND SCOPE OF THE FISHERY

The term goby fry, which is locally known as *hipon* (Visayan), or *ipon* (Ilocano), is generally applied to the young of a certain group of gobies and electrids that periodically appear in large swarms at the mouths of swiftly flowing streams in various parts of the Philippines. In the rivers of northern Mindanao, particularly in Cagayan River, the annual runs of this group of fish are so enormous in quantity that their catching and utilization constitute an important industry. There is a similar and equally important fishery in the north and northwestern parts of Luzon and in the southwestern part of Mindanao. But for lack of a systematic record of catch, the value of the fishery in Cagayan River can be estimated only roughly. The consensus of these estimates, as furnished by the fish traders, fishermen, and the local government officials, places the value of the goby fry fishery of Cagayan River at no less than

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20,000 pesos annually. This same kind of fishery in northern Luzon, however, produces annually about 500,000 pesos worth of salted fish (Herre, 1927); that of northern Mindanao as a whole including that of Cagayan River, under the prevailing low level of exploitation, produces at least 100,000 pesos worth of catch annually. Were this fishery in northern Mindanao to be extensively and intensively exploited as is being done in northern Luzon, its production would possibly approach the yearly production of the latter place.

A relatively low production of the hipon fishery in northern Mindanao is to be expected from the way the fishery is exploited, for the fish are only taken for the commercial preparation of the salted fish paste (*bagoong*). This is done while the goby fry are still in the sea. When they begin to enter and ascend the fresh-water streams, a limited amount is taken for consumption in the fresh state. Such a practice, although not conducive to the extensive development of the fishery, is apparently a sound conservation policy, for it allows a large number of fry to escape upstream to replace the breeding stock.

Cagayan is a typical goby-fry producing river in the Philippines, characterized by being "boulder-strewn" and moderately flowing. It rises from the mountainous interior of Bukidnon Province at an elevation of from 5,000 to 6,000 feet above sea level. From these upland plateaus, it passes through deep gorges and over low falls through the coastal range which is about 30 kilometers from the sea. The coastal reaches of the river are chiefly characterized by pebbly beds with moderately swift-flowing currents, the depth of water varying from half a foot to 10 feet. In its upper reaches, the deep gorges have approximately 10 to 15 feet of water. All these conditions obtaining in this river are apparently ideal for the growth and multiplication of the species forming the chief sources of the goby fry fishery. The lower portion of the river passes close to the town of Cagayan, and finally empties into the head end of Macajalar Bay. The shallow approaches of Cagayan River including the tidal flats of Lapasan Cove cover the principal fishing areas of the goby fry. The river is fairly navigable during high tide, and launches having 7 feet draft can enter the river and proceed to the town of Cagayan, a distance of about 2 kilometers from the mouth. Above this point, or, specifically, above the Cagayan steel bridge, the river becomes shallow and rocky.

REVIEW OF LITERATURE

Although a number of investigations of the goby-fry fishery of the Philippines has been conducted by previous workers, no previous attempt has been made to study the unique life history and habits of any of the species forming this important fishery. Taylor (1919) made the first study of the kind in the ipon fishery of Abra River, northwestern Luzon. His report was chiefly a survey of the extent and commercial importance of the fishery, with some notes on the fishing methods used, and the seasonal appearance of the goby fry.

Herre (1927) made the first exhaustive taxonomic study of the Order Gobiodea of the Philippines and the China Sea in which the species forming this important fishery were definitely described. He made mention of the fact that the chief sources of the ipon fisheries in northern Luzon are the following species: *Chonophorus melanocephalus, Eleotris melanosoma, Glossogobius giurus, G. celebius, Ophiocara aporos,* and *Sicyopterus lacrymosus.* This statement was corroborated in later separate reports of the same fishery by Montilla (1931) and Blanco (1938). According to Dr. Herre's monograph and as far as is known to date, *Sicyopterus* is represented by at least five species in the Philippines. Three of them, namely, *Sicyopterus lacrymosus, S. fuliag* and *S. extraneus* are considered the most important sources of the hipon fisheries in the different parts of the Philippines (Herre, 1927). The first-named species is evidently the principal source of the ipon fishery along the Ilocano coasts of northern Luzon; the second species of Cagayan River, Cagayan Province; and the last of Cagayan River, Oriental Misamis Province, and possibly other rivers of northern Mindanao.

Sicyopterus extraneus, locally known as *anga* (Visayan) which was first described by Herre (1927) in Cabalian, Leyte Province, was later discovered by the writer to be the most important commercial species inhabiting Cagayan River, Oriental Misamis Province. This statement is corroborated in the present investigation. As a matter of fact, the major catch of both the young and adult in Cagayan River consists chiefly of this species.

Most of the published reports on *Sicyopterus extraneus* and related species both in the Philippines and in foreign countries, deal with the nomenclature, distribution, and some general notes on the breeding and feeding habits of the group. Ac-

cording to Herre (1927), the distribution of the various species of *Sicyopterus* ranges from Japan to Samoa and to the Society Islands, and from Hawaii to Burma and Isles of Reunion, the center of distribution being in the East Indies.

Very few previous studies of the spawning habits of *Sicyopterus* have been made. Most of these previous accounts were passing comments or records of random faunistic notes. Herre (1927) made the following remark in his review of the Order Gobiodea of the Philippines and the China Sea: "Although authors state that 'they are confined to fresh water near the sea' they really go down to the sea to spawn in common with many other fresh-water gobies". Montilla (1930) and Blanco (1938) also gave similar observational notes with regard to the spawning habits of some other related species in their surveys of the ipon fisheries of Ilocos and Cagayan Provinces, respectively. The general consensus of reports of these workers was that from August to February, *Sicyopterus* and other species successively make their way down to the sea to lay their eggs, and from about the middle of September to March, vast shoals of tiny, colorless gobies make their appearance at the mouths of Philippine rivers, especially in northern Luzon. Deraniyagala (1937), in his description of a related species, *Sicyopterus gymnauchen* of Ceylon, also reported this parallel phenomenon regarding the catadromous habit of the fish.

Annandale and Hera (1925), in their description of *Sicyopterus garra,* from streams of the Andaman Islands, noted among other things the peculiar mode of feeding of the adults, which consists of scraping organic matter and minute algae on the surface of rocks to which the fish adhere tenaciously with their ventral suckers. Herre (1927) also gave vivid account of the habitat and feeding habits of adults *Sicyopterus.* He says:

> These dull colored inconspicuous fishes abound in boulder-strewn mountain streams where the current is moderately swift. They love to lie above large rocks where they bask in the sunshine, protected by a shallow stratum of rippling water. Here they nibble at minute algae, ready to slip out of sight beneath the boulder at the first movement made by man or bird ..... In both Mindanao and Luzon, they ascend to an altitude of 1,000 meters or more.

THE PROBLEM

The commercial importance of the goby fry fishery which has been observed both by the fishermen and fish traders alike to be on a continuous decline led to the preliminary investigation of the fishery in the early part of 1937. In 1938, a more vigorous and intensive study of the various phases of the life-history and habits of the commercial species forming the fishery was undertaken in Cagayan River, Oriental Misamis Province, a typical and one of the more important goby-fry producing centers in the Philippines. This study was prosecuted with the purpose of answering the following questions:

1. What are the species forming the goby fry fishery in Cagayan River?
2. When does *Sicyopterus extraneus* (anga) spawn?
3. How frequently do they spawn?
4. At what size does the first spawning occur?
5. What are the spawning habits of the fish?
6. What is the embryonic development and early larva of *S. extraneus?*
7. When does the periodic appearance of the fry take place, and what is the duration of the runs of goby fry?
8. What are the food and feeding habits of the adult (anga)?

The present paper attempts to answer these questions insofar as the evidence gathered by the writer shows.

The data presented have been obtained for the most part from field work done and collections made by the writer, especially in the upper Cagayan River, Oriental Misamis Province. In addition, samples were also taken from the commercial hauls of fishermen operating in the mouths of Cagayan and Tagoloan Rivers of the same province. The collections of adult specimens were also gradually augmented by the specimens taken from the different commercial fishing operations along the Cagayan River.

Two measurements of length were taken in the examination of the fish. They are the total and the standard lengths. The latter, which was measured from the tip of the snout to the base of the caudal fin, has been used throughout the paper, unless otherwise stated. The total or over-all length was measured from the tip of the snout to the tip of the longest ray of the bluntly rounded caudal fin. All measurements were recorded to the nearest millimeter. Other methods used in the different parts of the investigation are described under the sections dealing with these phases of the work.

ACKNOWLEDGMENT

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I. THE COMMERCIAL FISHERY

FISHING SEASONS

Unlike most other fisheries in which the adult forms are usually exploited, in the goby fishery the fry or juvenile stages constitute the principal catch. The adults of this group of fishes, which are generally confined in the boulder-strewn and rocky or pebbly beds of the upper streams of Cagayan River, are seldom, if ever, taken in any quantity. Most of this insignificant number taken are utilized for household consumption by river-bank inhabitants. When the adults are fished for, they are usually taken during the period from December to March, because at this time most of them are egg-bearing, consequently, they are fat and more palatable than when they are taken at other seasons of the year.

The fishing season of the goby fry may be classified into two periods, namely; the yearly (*panuig*), and the monthly (*bulan-bulan*). Fig. 1 shows the average monthly landing, expressed in number of cans[2] during the three-year period ending 1939. These catch data were based on five selected *baling* fishermen who had a complete record of catch for that period. A complete picture of the total landings of goby fry

[2] One petroleum can is equivalent to five gallons. This is the standard unit of catch used in the fishery equivalent to 15 kg. net weight of fresh fish.

cannot be presented here on account of the regretable fact that most fishermen do not keep any record of catch, either through lack of interest, or to evade any possible taxation. However, it has been estimated that the total annual landings in Cagayan River alone is between 40 and 50 thousand cans.

Despite this limited data on hand, the "monthly" and "yearly" fishing seasons were easily differentiated on the bases of number of landings and duration of the "migration run". It may be seen in the foregoing figure that the yearly fishing period extends from about the middle of January until the end of March, the season commencing earlier or later depending upon the lunar period. (This lunar fishing period of the goby fry is discussed more fully under the topic "periodicity and duration of the goby fry runs.") However, the peak of fishing activity occurs in February. These three months, January through March, cover the yearly or principal fishing season which the fishermen call *panuig* (literally, yearly), and the rest of the season, *bulan-bulan* (literally, monthly).

In other parts of the Philippines, as in the north and northwestern parts of Luzon, the principal fishing season appears to be protracted, extending from October through March (Herre, 1927); Montilla (1931), and Blanco (1938). No mention of distinction or occurrence of the two seasons, was, however, made by the aforementioned authors. In the other goby-fry-producing regions of northern Mindanao, it was observed in an earlier report (Manacop, 1940) that the principal fishing season may be short or prolonged from one to two months, depending upon the extent of the fisheries, or indirectly upon the size of the rivers where the fishery is found to exist.

Although it cannot be demonstrated here that the size of the rivers has some correlation with the magnitude and seasonal duration of the fisheries, it seems probable that the yearly season is more prolonged in large rivers than in small streams. The fact that larger rivers, under normal conditions, can sustain a larger fish population than the small ones because of more extensive living space, it appears to be a logical assumption that the larger space, will show more spread in spawning.

FISHING AREAS

The goby fry are caught in or near the mouths of rivers and all along their banks and shallow portions, and toward their sources or head waters. In Cagayan, Oriental Misamis, the fishing areas extend from two to three miles on both sides

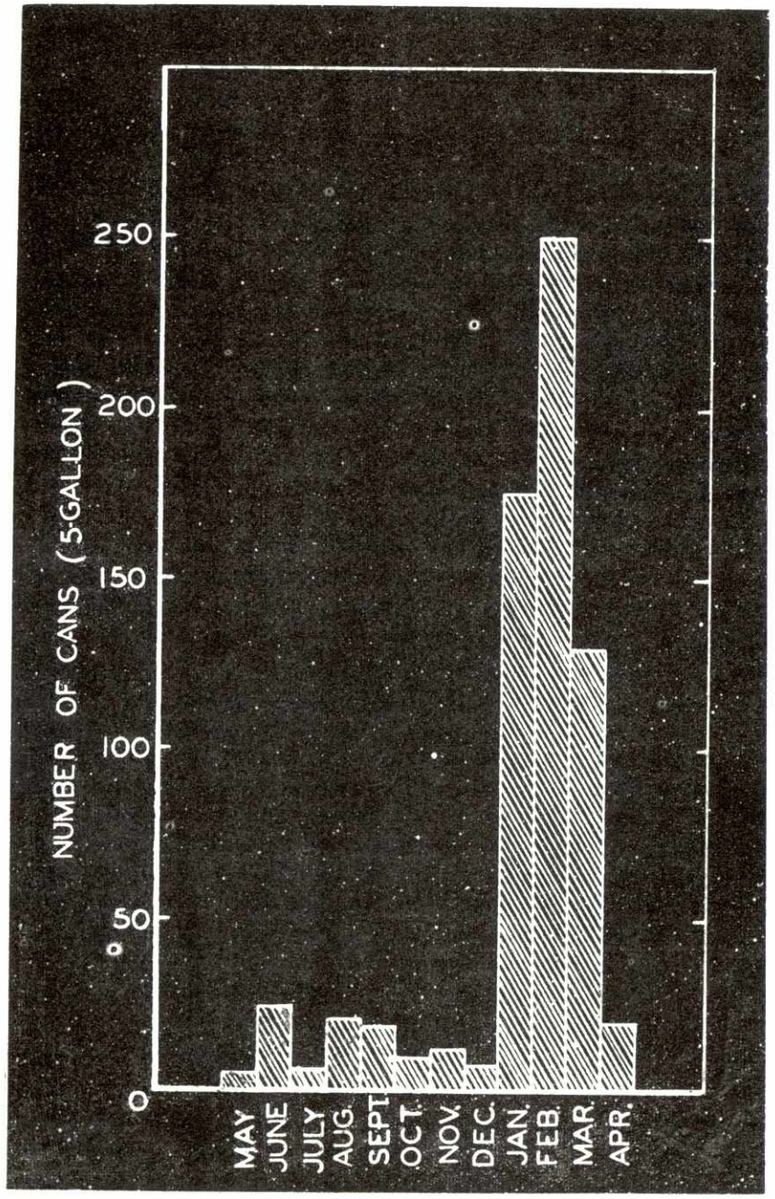

FIG. 1. Average monthly landings (1937–1939) in Cagayan, Oriental Misamis Province (data based on 5 baling outfits).

of the mouth of Cagayan River. When the goby fry start their upstream migration, the commercial fishermen do not usually catch them inside the rivers, except a few river fishermen, who generally fish for the fresh-fish markets.

PREPARATION OF THE CATCH

The bulk of the goby fry catch is pickled in table salt, fermented, and packed in air-tight 5-gallon tin containers. This salted fish paste (*guinamus* in Visayan, or *bagoong* in Tagalog and Ilocano) is prepared simply by mixing two parts by volume of table salt and five parts of fish. The mixture is then allowed to ferment for a few days in the packing containers (5-gallon cans or earthen jars) after which it is packed by soldering, in the case of the cans, and by covering the mouth of the earthen jars with cheesecloth. In Cagayan, Oriental Misamis, the use of earthen jars for packing and fermenting has been totally replaced by the 5-gallon tin cans (empty petroleum or gasoline cans).

After three to five months or so, the salted fish paste is considered to be "ripe" and ready for the table. It is, however, generally claimed by fishermen and fish traders that the longer the curing process the better is the quality and flavor of the product. In other words, as in the curing of wine, the quality of the product improves with age. The *bagoong* is either eaten raw with a sprinkle of lemon juice, or fried with fresh tomatoes. But it is often served as a sauce or condiment with boiled vegetables, meat or fish, and, of course, with the common staple food—rice or corn. Among the majority of the laboring class, this *bagoong* generally supplies the necessary animal protein. The by-products of bagoong, such as *heko* and *patis* (kinds of fish sauce) are, however, becoming popular among the more fastidious Filipino epicures.

FISHING METHODS

As in other parts of the Philippines, the goby fry in Cagayan River are caught by three general types of fishing gear, namely, (1) beach seine (*baling*), (2) scissor nets, and (3) fish barricades (*golgol*). Of the three types of gear, the beach seine is the most important, for it contributes the major portion of the commercial haul of goby fry that is salted and fermented. The other types of fishing gear are of minor importance, and cater only to the fresh-fish markets of the locality.

In the ipon fishery of northern Luzon, however, all the above-mentioned types of gear are extensively used in the commercial fishery. Here the fishery is exploited not only while the fish are in the sea, but also when they enter and ascend the fresh-water streams. Consequently, a more extensive and apparently more destructive method of exploitation of the fishery is being prosecuted in northern Luzon than in northern Mindanao. Such a situation is to be expected because of the demand on the fishery, brought about by the increasing density of population in the northern part of Luzon, especially along the Ilocos regions.

Beach seine (*baling*).—This fishing gear is generally used in any kind of fishery—for catching young sardines, anchovies, teuthids, and other larval fishes. The baling outfit consists of a net proper (*baling*), a mother vessel (*balingan*), and a small dugout for scouting (*manungdaan*). The balingan, with a capacity of 2 to 3 tons gross, is operated by 15 to 25 men, usually 20, the number depending upon the size of the outfit. This vessel, which is provided with outriggers on both sides and a landing platform for the net amidship, is not powered, but is provided with racks for oars and a lateen sail for navigation when necessary. Because most of the fishing operation is carried on close to the shore, usually within the 1-mile limit parallel to the general coastline, the employment of powered vessels becomes unnecessary. The scouting dugout (manugdaan), which is usually operated by one man, serves both for fish scouting and as a "skiff-end" of the net during the actual fishing operation.

The net proper consists of a rectangular curtain of fine-meshed [3] webbing of woven abaca cloth (product of *Musa textilis*), with a length of 300 to 400 feet, and a depth of about 6 feet at the wings to about 18 feet at the central portion (bunt). It is provided with a conical bag, 30 feet long, flanked by two converging wings on both sides. The ends of the wings are provided with wooden brails for spreading the net and for convenience in hauling-in operation. The upper selvage of the net is provided with wooden floats, and the lower with lead weights, studded at about a foot interval. In actual operation, the net is laid out in a semicircle, and then the two brail ends and wings are hauled to the shore until the fish are impounded in the sack or bag. For detailed construction and mode of operation of the net, reference should be made to previous reports of Montilla (1931), Umali (1934), Talavera and Montalban (1932), and of Manacop (1940).

[3] In the wings about 8 threads to the inch; in the bag, about 25 threads to the inch.

The adult anga and other gobioid fishes of the mountain streams are taken by special kinds of fishing gear. These are: (1) cast net (*taclob*); (2) fish barricade (*golgol sa anga*); and (3) spear gun (*pusil-pusil*).

Cast net (*taclob*).—The cast net is the most handy and effective fishing gear used in catching these wary and agile fishes. It is a diminutive replica of the age-old conical cast net which is operated on the same principle. This net has a diameter of about 60 centimeters when stretched, with the lower selvage studded with globular lead sinkers, and with seamed pockets or bags along the inside edges. It is simply operated by casting it with the right hand, aided by the left hand, to make a perfectly circular throw. The net is operated in water 6 inches to 2 feet in depth in those portions of the streams where the current is moderately swift. After every cast of the net, every loose stone enclosed by it is overturned in order to drive the fish into the pockets.

Fish barricade (*golgol sa anga*).—This gear consists of a triangular barricade of stones and coconut leaves, set somewhat parallel to the direction of the current of the stream, where the water is about a foot deep. Once the gear is set, the fish are driven into a previously set bag at the apex of the barricade by turning over all loose stones within the inclosed area. The driving of the fish continues to the mouth of the landing bag after which the mouth is immediately lifted, thereby impounding the fish.

Spear gun (*pusil-pusil*).—This is an improvised wooden gun that is operated on the principle of a sling, using a sharpened $\frac{3}{16}$ inch iron spear as the projectile. Strands of rubber bands (taken from an inner tube of an automobile tire), ingeniously rigged on the gun, give the necessary driving force to the spear. Similar spear guns used by sea bathers are now becoming common sights along beach resorts in many places, where their use has become a popular aquatic form of recreation. To be effective, this method of fish spearing must be aided by the use of a pair of good water-goggles, which insures good vision under the water.

II. SPAWNING

SPAWNING SEASON

In order to ascertain approximately the spawning season of *Sicyopterus extraneus,* extensive examinations of the gonads of all fish taken were made in every fortnightly sample. Most of the fish examined were specially collected for the purpose, since, as stated in the early part of this paper, the adults do not usually enter the commercial catch of the fishermen. These materials were further augmented from samples taken from the catch of fish barricades (*bisig*) in the upper Cagayan River. The following results were obtained from 3,345 adults and several thousand young taken from January, 1938 to August, 1940, inclusive.

DESCRIPTION OF THE GONADS

Female.—After examining a large number of females, three following developmental stages were observed to be clearly marked: (1) Immature stage; (2) intermediate or early maturing stage; and, (3) mature or ripe stage. For the determination of the spawning season, discussion of the development of the last two stages of the ovary will be given more emphasis.

1. *Immature stage.*—This is the primordial or immature stage of the ovary which is characterized by the presence of only immature, undeveloped ova, measuring from 0.00 to 0.038 of a millimeter in diameter. This is an infallible sign of sexually immature females. These tiny, creamy ova appear transparent white in preserved material (in three per cent formaldehyde) and are held together by the connective tissue of the ovary. The ova, which on account of their minute size are visible only under a compound microscope, do not impart the granulated appearance to the ovary which are indicated in the later stages.

2. *Intermediate or early maturing stage* (*Plate 1, fig. 1*).—The presence of intermediate or early maturing groups of eggs is a sign of approaching maturity and indicates that spawning will take place in the subsequent spawning run. This stage appears to be analogous to the intermediate stage of the ovary as found by Clark (1925) in *Leuresthes tenius*; Mane (1929) in *Arius* spp.; Villadolid and Manacop (1934) in *Gulaphallus mirabilis;* and by other workers in different kinds of fishes with a prolonged spawning season. The occurrence of this group of eggs apparently has some relation to the prolongation of the spawning season, as will be seen in the latter part of the discussion under this topic. These intermediate eggs measure

from 0.053 to 0.203 of a millimeter in diameter. They distinctly differ from the immature eggs from which they have been derived by being more opaque in appearance. At this stage also, the characteristic gelatinous threads begin to develop. These first appear as short strands of threads, presumably differentiated from the cell walls, and later gradually increasing in length and number over the surface of the egg. Eggs preserved in three per cent formaldehyde appear slightly orange, and they impart a somewhat granulated appearance on the external walls of the ovary. These groups of eggs are still held together by the connective tissue of the ovary.

In the advanced intermediate stage, the eggs appear more or less translucent toward the periphery, but remain opaque centripetally. The rapid increase of the maturing group of eggs which now become visible to the naked eye, imparts a distinct granulation to the ovary walls. The gelatinous threads, which by this time have also become fully developed, appear to be closely wound around the eggs in a more or less labyrinthine arrangement. The large and numerous oil globules of the eggs also become discernible at this stage, especially in freshly mounted specimens.

3. *Ripe stage* (*Plate 1, fig. 3*).—At the approach of maturity the ripe eggs lose their opacity and become distinctly translucent and yellowish-orange in color. They measure from 0.248 to 0.368 of a millimeter in diameter. The ovary which has greatly increased in size, brought about by the ripening and enlargement of the maturing eggs, now occupies almost two-thirds of the abdominal cavity (Plate 2, fig. 1). At this stage also the ovary becomes distinctly lobulated. The ripe eggs become loosened from their attachment with the connective tissues of the ovary and become lodged in its lumen, preparatory to oviposition. The characteristic gelatinous threads enveloping the eggs become loosely unwound and when the belly of a ripe female is pressed, ripe yellowish-orange eggs ooze out from the genital opening.

Males.—On account of the difficulty of determining the different development stages in the male, the mature spermatozoa, being minute, were simply classified as immature and mature. The testis of a sexually immature male is so fine and thread-like that it is often overlooked in the examination of the gonads. As sexual maturity approaches, the testis becomes less firm and somewhat lobulated. When a portion is teased out on a slide and examined under a compound microscope,

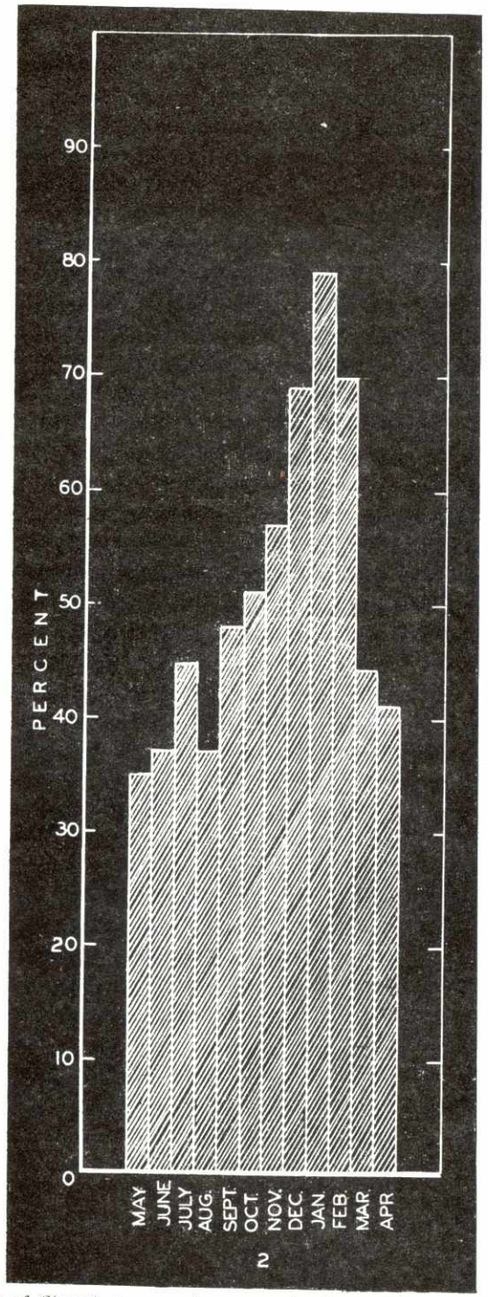

FIG. 2. Summary of *Sicyopterus* spawning season in Cagayan River as indicated by the percentage relation between spawning females and all females.

actively swimming spermatozoa become discernible. Externally, the mature males were easily distinguished from the immature by the appearance of oozing milt from the genital opening when pressed.

DURATION AND PEAK OF THE SPAWNING SEASON

The results of the examination of a large number of females undertaken throughout the three-year period of investigation showed that the anga spawns almost every month throughout the year, with varying percentages of actually spawning females every month (Table 1, text fig. 2). This continuity of spawning activity is evidenced by the finding of spawning females in every monthly sample. It was observed that a minimum spawning activity occurred in May when only about 35 per cent of all the females examined during the month were found in spawning or maturing condition. Since then the percentage of spawning females gradually increased as shown by the rising graph with some minor fluctuations in July and August, and finally attained its maximum in January when about 79 per cent of the total number of females examined were in spawning condition. In February, spawning activity seemed to abruptly decrease until April when only about 41 per cent were found in spawning condition. These varying percentages of the spawning activity seem to indicate definite "spawning groups" in the entire population which spawn every month. However, it was not definitely ascertained whether one spawning group that spawn this month will spawn the following month.

The principal spawning months extend from December through February, covering a period of about three months, apparently coinciding with the early part of the dry season months, while the minimum months, May and June, cover the commencement of the rainy season in Cagayan regions. As a general rule, the principal spawning period of most Philippine fishes occurs during the warmer months of the year (February through April).

The other evidences of the continuity of the spawning activity of anga are: (1) the simultaneous occurrence of intermediate and mature groups of eggs in the samples of mature females examined every month throughout the year; and, (2) the periodic appearance of hipon runs every month throughout the year.

The occurrence of a prolonged or a continuous spawning season is not an unusual phenomenon in tropical fresh-water

fishes. Mane (1934) reported a similar condition in *Mesopristes plumbea* of Laguna de Bay. In *Gulaphallus mirabilis* of Molawin Creek, Laguna Province, an almost identical phenomenon was also observed (Villadolid and Manacop, 1934). Fulton (1899) in his classification of teleostean eggs, as cited by Clark (1925), states that the presence of the intermediate group of eggs is almost always associated with a prolonged spawning season.

TABLE 1.—*Percentage of female anga with maturing or ripe eggs in monthly samples, collected from January 18, 1938 to March 24, 1940.*

Date	Total number	Number mature	Per cent mature
January 18, 38	45	45	
January 9, 39	82	62	
January 21, 39	102	84	
January 22, 40	114	82	
Total	343	273	79.30
February 4, 38	98	70	
February 12, 38	88	72	
February 16, 39	80	56	
February 25, 39	98	68	
February 7, 40	116	70	
Total	480	336	69.99
March 9, 38	78	46	
March 9, 39	114	52	
March 10, 40	86	30	
March 24, 40	90	36	
Total	368	164	44.63
April 26, 38	98	42	
April 18, 39	86	33	
April 30, 39	128	62	
April 25, 40	88	28	
Total	400	165	41.25
May 2, 38	112	41	
May 19, 38	80	27	
Total	192	68	35.20
June 5, 38	84	26	
June 27, 38	102	42	
June 17, 39	108	44	
Total	294	112	38.09
July 5, 38	188	36	
July 27, 38	102	42	
July 14, 39	86	28	
July 22, 39	92	60	
Total	364	166	45.60
August 7, 38	112	34	
August 17, 38	73	31	
August 25, 39	65	29	
Total	250	94	37.60
September 9, 38	88	36	
September 18, 38	90	56	
September 28, 38	110	48	
Total	288	140	48.61
October 10, 38	102	66	
October 26, 38	110	35	
Total	212	111	51.41

SPAWNING AND FISHING SEASONS

Figure 3 shows the relation between the fishing season and spawning seasons of anga. The data on the spawning season are shown as a histogram in terms of percentages of spawning females for each month. Superimposed on this graph is one of the monthly catch in terms of the number of cans. This graph shows that there is apparently a close association between the spawning and fishing seasons. The principal spawning months extended from December until February, and this period almost coincided with the fishing season with the latter commencing and closing a month later. However, the peak of spawning activity occurred in January and that of the fishing activity a month later—February.

The biological significance of this difference of a month between the peaks of spawning and fishing seems to show that the young hipon fry entering the commercial haul are probably about a month old. In other words, the hipon fry that appear in the February "run" are presumably derived from eggs laid sometime in January, and those hipon fry runs in subsequent months which appear in the river shores with almost precise regularity every four weeks were probably derived from eggs laid a month earlier.

After the principal spawning months, the spawning activity of anga declined to a range of from 35 per cent in May to about 57 per cent in November. A similar decrease in the fishing activity likewise followed, although the catch in every month did not correspond closely with the fluctuation of the monthly spawning activity. This may be due to some biological factor or factors affecting the rate of mortality. However, there is one thing that is quite significant in the graph, that is, a decrease in spawning activity seems to be followed by a similar decrease in fishing activity and in yield.

FREQUENCY OF SPAWNING

While a detailed study of the history and development of the different stages of the ova was not undertaken in the present investigation, there is some evidence that each individual anga spawns more than once throughout the year. This is shown by the following: (1) the simultaneous appearance of the three

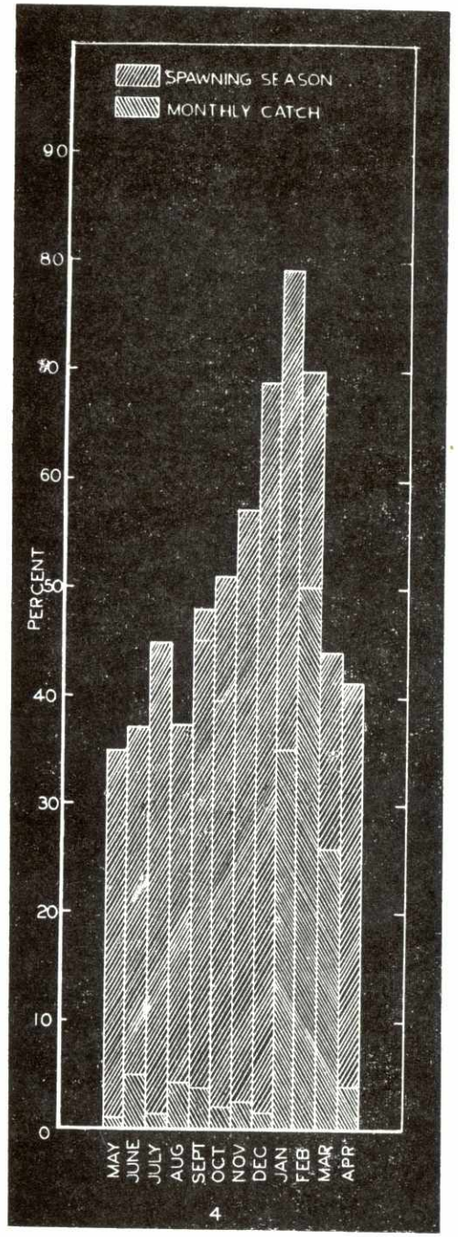

FIG. 3. Comparison between the monthly catch and the spawning season.

groups of eggs, namely, immature, intermediate, and mature—in mature female fish at all times throughout the year; (2) the regular periodic runs of goby fry about a month old at approximately twenty-eight day intervals almost throughout the year.

This apparently multiple spawning habit of anga, although it may appear unique, is not at all an unusual occurrence in fishes. Parallel phenomena have been reported in a number of other species of fish, such as in *Leuresthes tenius* (Thompson, 1919a and 1919b), reaffirmed by Clark (1925); in *Atherina californiensis* (Clark, 1929); and in *Arius* spp. (Mane, 1929). Among these fishes, the most striking multiple spawning phenomenon is exhibited by *L. tenius*, the fish with tide controlled spawning habits (Clark, 1925). But since the anga spawns in the upper streams, the tide factor cannot be associated with its spawning habits. However, there appears to be some apparent association of the tide with the frequency and periodic appearance of the goby fry runs, as will be seen under the discussion of this topic.

Further and conclusive evidence with regard to the multiple spawning habit of anga is provided by the fact that by the time one intermediate or maturing group of eggs attain maturity, a new batch of the early intermediate group of eggs, differentiating from the upper size limit of the immature group, becomes evident (figs. 4*a* and 4*c*). In recently spawned, or "spent," fish, as well as in ripe ones, this early intermediate group of eggs is clearly shown. In a graph it appears as a mode centered at an egg diameter of about 0.068 millimeter. This group of eggs continues to increase in size and dispersion until it becomes a distinct, homogenous group, developing at an apparently accelerated rate towards maturity. This distinctly differentiated intermediate group consists of eggs measuring from 0.098 to 0.203 of a millimeter in diameter. The rate of transformation of the immature group of eggs to the intermediate and from the intermediate to complete maturity was not definitely ascertained, although it is presumed to be rapid as indicated by the breaks in the continuity of the frequency histograms of ova taken from intermediate and mature females.

There is a probability that, during the principal spawning months extending from December to February, an individual female fish may spawn more frequently than during the other months of the year. The occurrence during the principal fishing

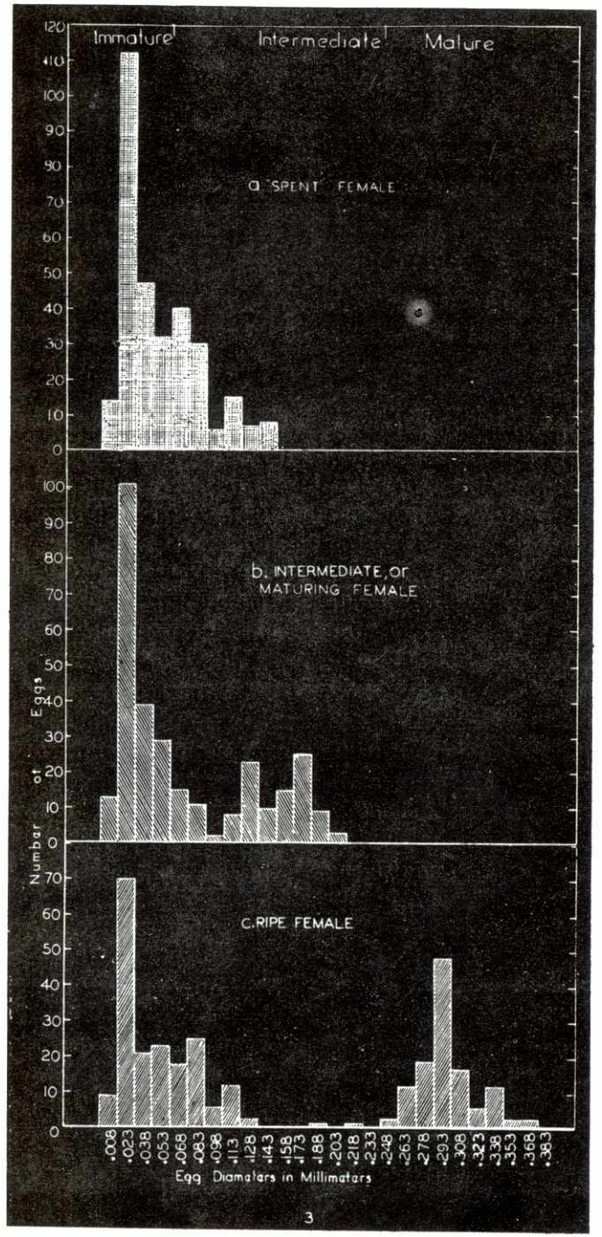

FIG. 4. Diameter frequencies of 300 ova, each taken from the three developmental stages of the ovary, all collected on August 21, 1940, from Cagayan River; (*a*) "spent" female, 7.4 cm. long; (*b*) intermediaite or early maturing female, 7.3 cm. long; and (*c*) ripe female, 6.9 cm. long.

season of the two to three distinct batches[4] of goby fry in every monthly run and of about 69 to 79 per cent of ripe fish among the mature females indirectly substantiates this assumption of more frequent spawning. During the other months of the year, when there usually occurs only one batch of goby fry in the monthly run, it seems plausible that a single female may spawn only once in a month, skip for a month or so and then resume spawning. This presumption is supported by the following evidence: (1) About 35 to 50 per cent of the females examined were in actual spawning condition during the rest of the year, outside of the principal spawning months; (2) "Spent" and actually spawning females were found simultaneously in every sample collected in every month throughout the year; and, (3) "spent" females were found in varying degrees of "spentness". Those which were found partly "spent" may spawn the second or third batch in the run of the same month, and those almost fully "spent" and showing an apparently rapid development of the intermediate group of eggs may spawn the next month or later.

PERIODICITY OF SPAWNING

The available data strongly suggest, although they are inadequate to prove, that there is a definite monthly cycle in the spawning of the population of anga. First, the periodic appearance of the hipon fry runs, which occur at almost every twenty-eight day interval, shows that the fish must have spawned periodically a month previous. If spawning were not periodic, there would not be this periodic appearance of almost one-month-old fry at every definite lunar period (fig. 10).

It will be seen further in fig. 10 that a more regular periodic appearance of the hipon fry runs was observed during the principal spawning months than during the other months of the year. This phenomenon may possibly be related to the fact that a much higher percentage of the females are in spawning condition at this time (69 to 79 per cent) than at other times (35 to 50 per cent). Efficiency may be increased by concentration of the spawning activity.

SPAWNING HABITS

The question as to where the anga and its close relatives of the same family spawn has been the subject of much con-

[4] A batch is a shoal of goby fry hatching from the same batch or group of eggs laid at almost the same time.

troversy among fishery biologists and ichthyologists who have worked in one way or another on this group of fishes. It has been the general claim that, although they are "confined to the fresh-water near the sea, they really descend to the salt water to spawn". This is the opinion expressed, among other things, in the reports of Taylor (1919); Herre (1927); Montilla (1931); Blanco (1938); and Villadolid and Blanco (1939) in their observations on the goby fry fisheries of the north and northwestern parts of Luzon. Deraniyagala (1937) came to the same conclusion in his observations and description of a related species, *Sicyopterus gymnauchen*, in Ceylon, India. The claims of these workers are not, however, in accord with the observations of the writer, which show clearly that spawning occurs in fresh water. The finding of the breeding grounds as well as the eggs in the upper streams, and a complete knowledge of the early life history, are conclusive evidence on this point. It may be possible, however, that the species studied by the foregoing workers are really catadromous, but it is very doubtful that these closely related species, under practically the same tropical conditions, would exhibit such different spawning habits. The collection of some specimens of the adults of this group of fishes in salt waters, as well as the regular appearance and upstream migration of the goby fry in a similar fashion as those of the other known catadromous fishes as reported by these previous workers, cannot fully substantiate their claim that these fishes are really catadromous. It cannot be denied, of course, that during heavy freshets some of the adults in the upper reaches of the streams are liable to be carried down to the sea. Normally, however, they spend their existence in fresh water, letting only their eggs and larvae be washed down by the river current to the sea, and later, after attaining a certain stage, the fry return "home", so to speak.

The fresh-water spawning of the anga is not an unusual occurrence in the family Gobiidae. As a matter of fact a similar phenomenon is known to occur in the other members of the same family, such as the common white goby *Glossogobius giurus*, of Laguna de Bay, Luzon and of Lake Mainit, Mindanao; *Mirogobius lacustris* of the first-named lake; *Mistichtys luzonensis* of Lake Buhi, Camarines Sur Province, Luzon, and a number of others. Those fishes, which are apparently geologically recent migrants from salt water, evidently spend their whole existence in fresh water.

SPAWNING GROUND

The female anga was observed to spawn in varying depths of water, from half a foot to about four feet, with the largest fish apparently preferring the deeper places, and the smaller ones, the shallows. Like the Pacific salmon (*Onchorynchus*), the fish prefers to spawn under gravel and loosely set stones in the shallow, swift, upper reaches of the rivers. However, the eggs of *S. extraneus* are not buried in the sand as in the case of the salmon. As a matter of fact, during the extensive collection of eggs for embryological study, the writer frequently found batches of newly laid eggs in these preferred portions of the stream, and seldom, if ever, were found in the still portions. There seems to be an obvious reason for such a preference, as will be seen in the discussion of the fate of the newly laid eggs.

The actual procedure of laying the eggs on the undersurface of the loosely set stones was not observed. It is, however, presumed that the female anga, when ready to spawn, wriggles under a loosely set stone. As the fish holds fast to the under surface of a stone with the aid of the ventral sucking disc, the eggs are spread into a flat mass (Plate 2, fig. 2). As the eggs are extruded their gelatinous threads covering them adhere to the undersurface. Fertilization undoubtedly takes place externally, with the male probably following the spawning female and ejecting his milt on the mass of eggs.

No conclusive indication of parental care over the newly laid eggs was obtained. However, the information of experienced anga fishermen, including the collector for the writer, was that both parents seem to watch their eggs after laying and probably until the eggs are hatched. It is not an uncommon occurrence to find paired fish under a stone bearing eggs or likely "nesting" place.

REPRODUCTIVE CAPACITY OF AN AVERAGE-SIZED FEMALE

To estimate the number of eggs produced in one spawning, a maturing ovary of an average-sized female (6.6 centimeters long) was preserved in five per cent formalin solution. The whole ovary, after being removed from the fixing solution and the excess moisture drained off, was weighed to the nearest milligram. Following this procedure, the middle portion of the ovary was taken and weighed to the nearest milligram. The number of maturing eggs in the lot was then counted and the resultant number multiplied by the entire weight of the ovary.

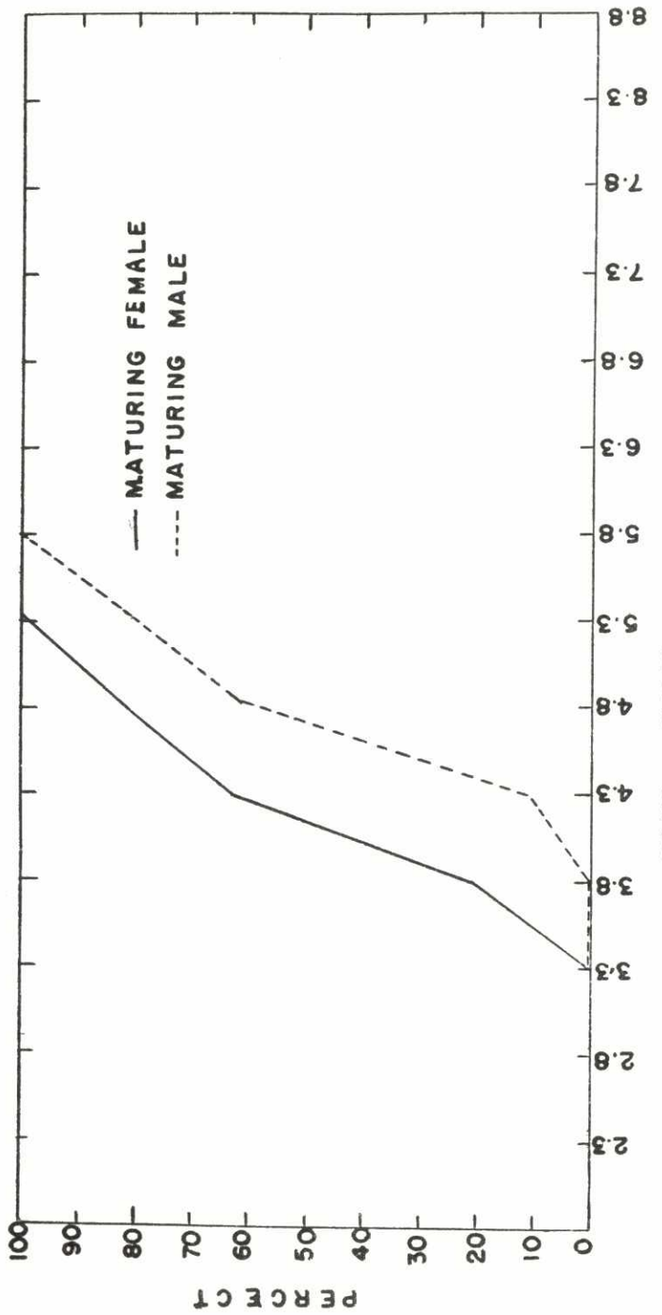

Fig. 5. Showing the sign when maturity occurs. The solid line represents the percentage of maturing females and the broken lines the percentage of males which mature at the indicated sizes.

With this procedure, the approximate number of maturing eggs contained in the whole ovary of the average-sized female was estimated at no less than 46,000.

SIZE AT FIRST SPAWNING

In determining the size at sexual maturity, the gonads of all adult fish were examined and their condition of maturity ascertained. In the females, the presence of intermediate, mature or ripe eggs was used as a criterion to indicate the sexual maturity of the fish. In the males, however, the presence of milt and the advanced development of the testes were considered signs of sexual maturity.

Table 2 shows the results of these determinations which are graphically illustrated in fig. 5. Of the 2,764 females examined, 2,631 were found sexually mature and 133 immature. The smallest mature females were found in the size group from 3.6 to 4.0 centimeters long, in which about 20 per cent were found sexually mature. However, the minimum length of actually spawning females was found to be about 4.0 centimeters. About 61 per cent of the females of the size group of 4.1 to 4.5 centimeters long and about 81 per cent of 4.6 to 5.0 centimeters were mature. All fish examined above 5.1 centimeters long were found to be sexually mature.

TABLE 2.—*Size groups of sexually mature anga.*

Body length	Female				Male			
	Mature		Immature		Mature		Immature	
cm.	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*	*Number*	*Per cent*
2.1- 2.5								
2.6- 3.0			8	100.00				
3.1- 3.5			21	100.00			22	100.00
3.6- 4.0	12	20.68	46	79.32			24	100.00
4.1- 4.5	52	61.90	32	38.10	5	13.16	33	86.84
4.6- 5.0	114	81.44	26	8.56	54	62.79	32	37.21
5.1- 5.5	256	100.00			90	80.35	12	19.65
5.6- 6.0	332	100.00			184	100.00		
6.1- 6.5	548	100.00			366	100.00		
6.6- 7.0	430	100.00			402	100.00		
7.1- 7.5	338	100.00			492	100.00		
7.6- 8.0	334	100.00			216	100.00		
8.1- 8.5	186	100.00			94	100.00		
8.6- 9.0	18	100.00			36	100.00		
9.1- 9.5	2	100.00			4	100.00		
9.6-10.0	0	00.00			0	00.00		
9.1-10.5	2	100.00			0	00.00		
10.6-11.0	4	100.00			4	100.00		
11.1-11.5	0	00.00			2	100.00		
11.6-12.0	1	100.00			4	100.00		
12.1-12.5	2	100.00			0	00.00		
12.6-13.0					1	100.00		
13.1-13.5					2	100.00		
13.6-14.0					2	100.00		
Total number	2,631		133		1,758		123	
Mean	6.602†	0.0208 cm.			6.82	0.023 cm.		

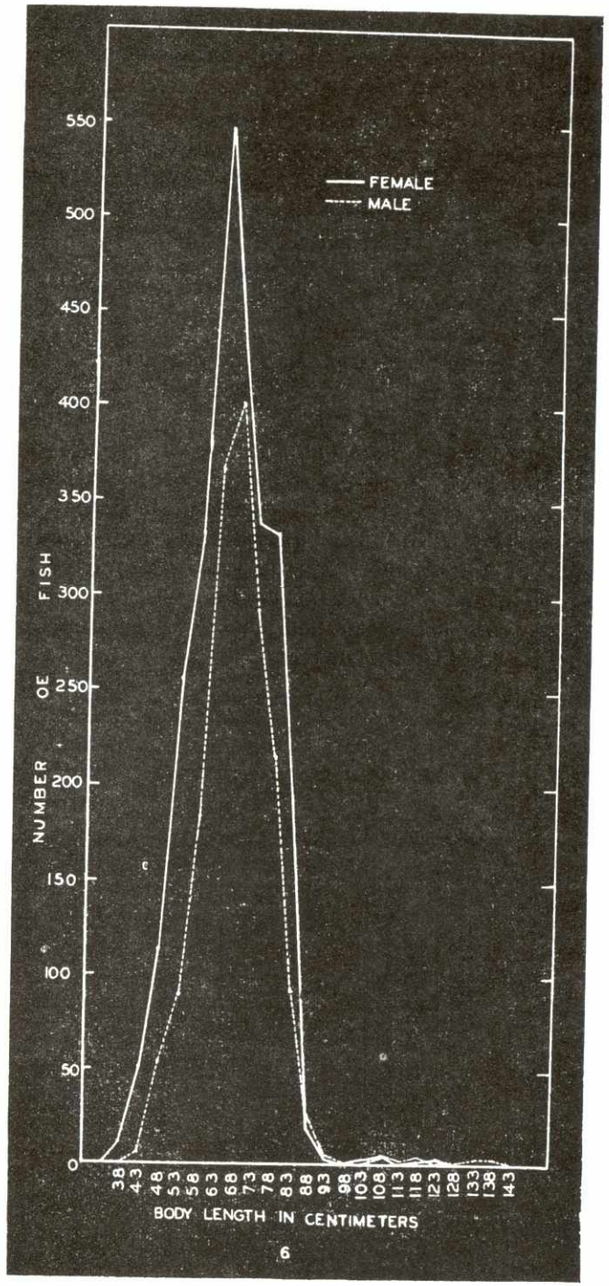

FIG. 6. Body length frequencies of males and female *Sicyopterus* (data based on all materials collected during the period of investigation).

With the males, out of 1,881 dissected, 1,758 were found to be sexually mature and 123 immature (fig. 6). As regards size, the males apparently are longer than the females at sexual maturity. About 13 per cent of the males in the group from 4.1 to 4.5 centimeters long were evidently mature as compared with 61 per cent in the females. About 62 per cent were found mature in the size group of 4.6 to 5.0 centimeters and 80 per cent at 5.1 to 5.5 centimeters. All males examined above 5.6 centimeters were found to be sexually mature.

It is evident from the foregoing discussion that in both sexes, as in most animals, the sizes of maturing individuals vary, starting from a more or less definite minimum and gradually increasing to a group in which all the fish are sexually mature. These variations may be the result of variations in food and other environmental factors, or they may be hereditary.

With regard to the determination of the age groups, some preliminary attempts in the examinations of the scales were undertaken, in an effort to find some indications of annuli. The scales were taken from behind the operculum of the fish and were mounted in dilute glycerine for examination. After examining a fair number of scales from fishes ranging in size from 3.0 to 4.0 centimeters long, some apparent markings or annuli were found, but there had been no opportunities to carry the study further. Only future study will show what these markings signify, whether they are breeding "checks" or annuli, each of indeterminate origin and significance.

III. SEXUAL DIMORPHISM

The anga presents a distinct sexual dimorphism, so distinct that even without examining the gonads, the sexes are easily separated. The males are characterized by the prolongation of the second, third, and fourth spines of the first dorsal fin, which in the females are not so well marked. The membrane almost extends to the tip of these prolonged spines. As a rule, the males have more slender and longer bodies than the females. In other respects, body coloration, scalation, and so forth, both sexes resemble each other in almost every detail.

Color in life.—The body in both sexes is marked by about 6 or 7 dark-gray transverse bars along the sides. These bars are wider than the interspaces, become indistinct toward the head region, but remain fairly distinct toward the caudal fin. In older specimens, these transverse bars become diffused and appear like dark-gray blotches along the dorsal and lateral parts

of the body. This may be so on account of the surrounding environment since the adults live under the big boulders and rocks in the river beyond the reach of constant sunlight.

A heavy spot, resembling a black teardrop, descends from the eye to angle of the mouth. Another wavy black line, crosses the interorbital space. In older specimens this heavy line, however, becomes a distinct skin fold, appearing like a wavy wrinkle or wart on the forehead. From this point toward the snout are scattered dashes of dark violet. The first and second dorsals are dark olive-brown, with numerous cross bars of dusky, brownish-violet lines or spots running diagonally downward and backward. The caudal fin is dull olive-violet, with its upper and lower margins yellowish-orange; anal fins, same color as body, with bluish margins like the caudal, ventral fins, yellowish, distinctly semicircular and adherent to the belly. The body scales are small and distinctly ctenoid. As a rule, the fin markings, especially those on the dorsals and anals, are more vivid in the males than in the females.

Morphological differences between the sexes.—As to body length, the males are comparatively longer [than the females, the average measurement being 6.82 ± 0.023 [5] centimeters and 6.30 ± 0.021 centimeters, respectively. The difference between the average lengths of the two sexes is highly significant, as is shown by the value of 6.7 for "t"][6] (see Simpson and Roe, 1939, and Table VI). As mentioned in the foregoing paragraphs, the most significant distinguishing characteristic of the male is the elongation of the second, third, and fourth spines of the first dorsal fin into long terminally free spines. In the males the average length of the longest spine, which may be either the second or third, seldom the fourth, is about 32.5 millimeters from the base. In the females it is about 26.0 millimeters long. This longest spine, when stretched over the mid-dorsal toward the caudal fin, extends to about the sixth and seventh ray of the second dorsal fin in the male, and to the second and third of same in the female.

When in breeding condition, the bellies of the females are more round than those of the males, because of the ripening ovaries in the former. The genital papilla is long, slender, and bluntly pointed in males, and distinctly short, thick, and cylindrical or subglobose in the females.

[5] Standard error of the men.

[6] "t" is the ratio of the measure being tested to its standard error.

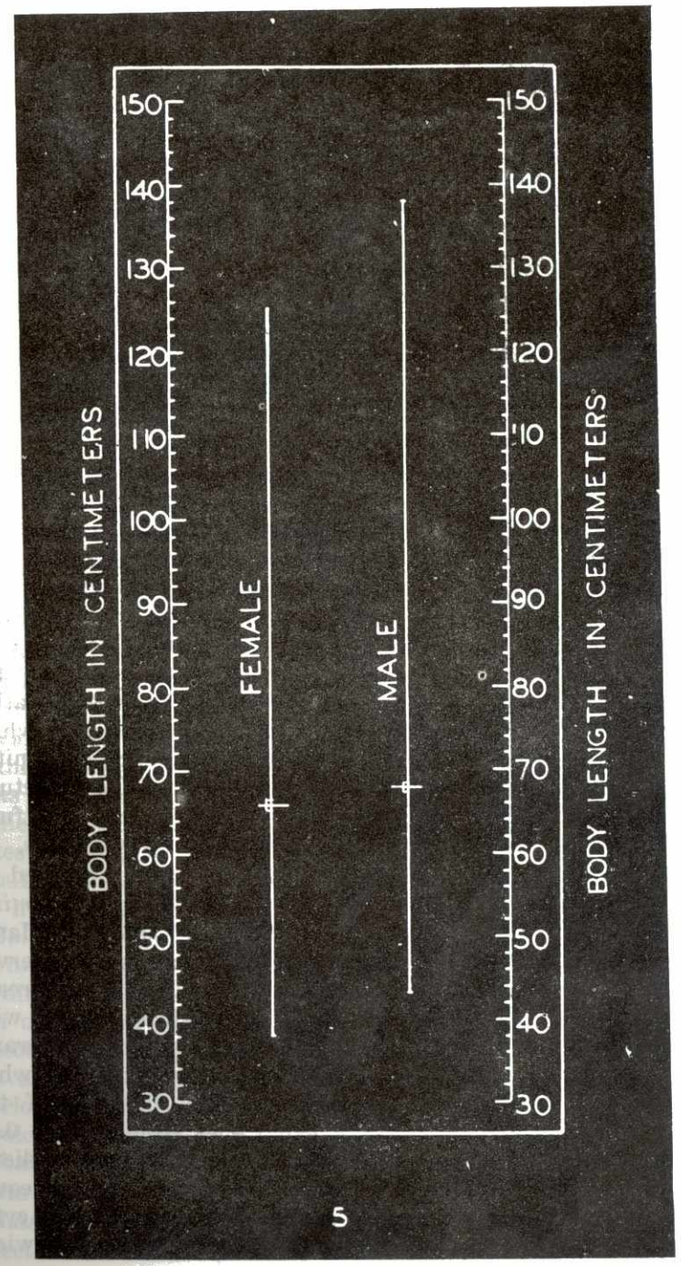

FIG. 7. Graphic estimation of the significance of the difference between the average body lengths of male and female *Sicyopterus*.

IV. EMBRYONIC DEVELOPMENT AND EARLY LARVAE

All attempts to artificially fertilize the eggs in order to secure the early embryonic stages failed. So, all the materials used in this study were collected directly from the spawning grounds and must have been naturally fertilized. The delicate eggs, which were firmly attached to the undersurface of stones, were removed without much injury by carefully scraping them off with a wet hen's feather. These eggs were then immediately transferred to glass jars and taken to the laboratory for study. They were kept in clean finger bowls and petri-dishes containing fresh river water. Constant aeration of the eggs was provided by the frequent changing of the water in the culture dishes during the incubation period. During this time microscopic examinations were made at frequent intervals to determine the changes of embryonic development (see Plate 1, figs. 1 to 17).

Newly laid eggs (figs. 3 and 5).—The newly laid eggs are demersal and are held together in a solid flattened, yellowish-orange mass by inter-twining gelatinous threads which adhere to the stone substrate. Upon closer examination each egg reveals the presence of tuft of these adhesive threads arising from the pointed pole of the egg. These threads appear neatly arranged within a calyxlike cap at this pointed pole of each egg. The specialized type of egg filaments, based on the classification made by Clark (1925), consists of a "specialization in the structure of the whole tuft of adhesive threads in which the filaments are arranged in a circle around one pole, united in a network the whole tuft forming a funnellike structure. Pagenstecher (1861) cited by Clark (1925), described fully the occurrence of this type of eggs, in *Atherina hepsetus*. A similar type of adhesive thread has also been observed in *Menidia menidia* by Hildebrand (1922). In *Gulaphallus mirabilis* and *G. falcifer* (Villadolid and Manacop, 1932 and Manacop, 1936, respectively) similar adhesive threads were observed and fully described, although in this form the gelatinous threads were decidedly few in number and comparatively longer, with their roots arising from different parts of the egg membrane.

The eggs are bluntly ovoid and highly transparent when examined singly under a microscope. The diameter of the newly laid eggs across the blunt end varies from 0.37 to 0.44 of a millimeter. The egg membrane is thin but fairly resilient. The yolk sphere contains from 60 to 80 oil globules of unequal sizes and numerous small ones scattered throughout the cytoplasmic mass. The translucent yolk mass bears the yellowish-orange coloring of the egg.

Fate of the newly laid eggs.—The eggs were observed to hatch in about 1 to 2 days under laboratory conditions. In repeated collections of eggs for embryological studies, it was observed that when the eggs are about to be hatched, they apparently become loosened from the stone. Upon closer examination of the eggs, it appears that the threads have gradually lost their gelatinous property, due possibly, either to degeneration or continuous washing by the currents of water that seep under the stone "nest". Consequently, when a stone bearing a batch of eggs at the hatching stage happens to be overturned, the swift rush of the river current immediately washes off the eggs and carries them downstream to the sea. Since this observation on the washing off of the hatching eggs by the river current was accidental, it is presumed that under normal conditions, the hatching eggs would remain under sheltered stone "nest" until they are completely hatched. When the newly hatched fry are able to swim they leave their stone "nest" and migrate downstream to the sea.

Further evidence in support of this presumption that the hatching eggs and newly-hatched fry are carried down to the sea is shown by the findings of these stages in the plankton hauls made in the lower reaches of the river during the peak of the breeding season (Table 3). As a provision of Nature, therefore, it is necesary for the female anga to lay her eggs in swifly flowing portions of the stream in order that they may be carried down to the sea—a normal phase of the life cycle. In the laboratory the newly hatched fry were reared until their yolks had been fully absorbed, but beyond this stage they began to die. Some fry hatched in the laboratory were placed in live boxes set out in salt water, but these also succumbed, due possibly to lack of food and absence of constant aeration in the live boxes.

Embryonic development.—The embryonic development of *S. extraneus* is typical of demersal teleostean eggs. The only notable difference lies in the rate of development and the differentiation of the various embryological stages. Although extensive collections of the naturally fertilized eggs were made, the early cleavage stages were taken and observed due to the rapid development of these early stages. Judging from the rate of development of the egg in the later cleavage stages, it seems probable that the earliest stage found was approximately 3 hours after fertilization.

Blastodermal cap stage (fig. 6).—The earliest embryonic stage collected was an early blastodermal cap stage. The result of

TABLE 3.—*Daily surface plankton hauls at the lower reaches of Cagayan River during the height of the breeding season*

Date	Weather and river condition	Remarks
1939		
February 11	Sunny, no flood, water clear	No eggs and larvae of anga found.
February 12	do	Do.
February 13	do	Do.
February 14	do	Do.
February 15	do	Do.
February 16	do	Do.
February 17	do	Few dead eggs and larvæ found.
February 18	do	Do.
February 19	do	Do.
February 20	do	Do.
February 21	do	Do.
February 22	do	Do.
February 23	Rainy, slight flood	Do.
February 24	Sunny, water slightly muddy	Do.
February 25	do	Do.
February 26	do	Do.
February 27	Sunny water clear	Do.
February 28	do	Do.
March 1	Rainy, slight flood	Do.
March 2	Cloudy, water muddy	Do.
March 3	Cloudy and rainy, slight flood	Do.
March 4	do	Do.
March 5	Sunny, but still flooding	Large number of eggs and larvæ found.
March 6	do	Do.
March 7	do	Few were found.
March 8	Sunny, water clear	Do.
March 9	do	Do.
March 10	do	Do.
March 11	do	Do.
March 12	do	Large number of eggs and larvæ found.
March 13	do	Do.
March 14	do	Do.
March 15	do	Do.
March 16	do	Do.
March 17	do	None found.
March 18	do	Do.
March 19	do	Do.
March 20	do	Do.
March 21	do	Do.
March 22	do	Do.
March 23	do	Do.
March 24	do	Large number eggs and larvæ found.
March 25	do	Do.
March 26	do	Do.
March 28	do	Few were found.
March 29	do	Do.
March 30	do	Large number found.
March 31	do	Few were found.

the early cleavage processes is a dome-shaped blastodermal cap made of about 44 visible cells. The blastoderm now covers practically two-thirds of the yolk sphere.

Cleavage continues and at approximately 7 hours after laying, a more or less completed blastodermal cap has been formed. The subsequent cell division results in a large number of very minute blastomeres, so small that the outline of the internal cells cannot be traced. At this stage, the completed blastodermal cap appears as rounded lenticular dome hanging over the surface of the yolk sphere. The edge of the blastoderm seems

to thin out so that in profile the cap forms a gentle curve which appears almost a continuation of the curvature of the yolk sphere. A dark region (by transmitted light) along the edge of the blastodermal cap is the periblast. The formation and differentation of the periblast from the marginal cells of the blastoderm has been fully observed by Aggasiz and Whitman (1885), cited by Kuntz and Radcliffe (1918) and by Budd (1940). This process has also been observed by Kuntz and Radcliffe (1918) in the eggs of *Tautoga onitis*. The special physiological function of the periblastic nuclei in making the yolk easily assimilable by the developing fish embryo has been reported by Wilson (1891) in *Serranus atrarius*. In all probability these embryological changes and processes must have taken place in the eggs of *S. extraneus*, but they were not discernible in the living materials.

"Segmentation cavity" (fig. 8).—Nine hours after laying, the segmentation cavity and the early germ ring become differentiated. The blastodermal cap, preparatory to invagination, gradually changes its shape. The outer surface becomes more convex, covering practically the entire yolk, while the inner surface becomes more concave. This space created between the blastodermal cap and the yolk has been called the "segmentation cavity," and the thickened peripheral zone of the blastoderm, the germ ring. This formation and development of the germ ring has been fully described by Wilson (1891), and cited by Budd (1940).

Embryonic shield (fig. 9).—After the germ ring has been fully formed, the embryonic shield starts to differentiate. This becomes evident approximately 11 hours after laying. It appears as a broad tongue of cells extending forward from the thickened area of the germ ring. This thickened portion is the posterior or embryonic pole. Viewing the blastoderm from above, this triangular mass of cells which is apparently thicker than the adjacent areas marks the early stage in the differentiation of the embryonic shield. By this time, the germ ring has almost entirely covered the yolk sphere.

Primitive streak stage (fig. 10).—Shortly after the embryonic shield has advanced about one-third of the way around the yolk, there occurs a linear thickening along its anteroposterior axis. This is the primitive streak and marks the axis of the future embryo. The further differentiation of the fish embryo begins in the head region and gradually advances posteriorly.

Advanced embryo (*figs. 11, 12, and 13*).—About 13½ hours after laying, the embryo becomes fully formed and the blastoderm has entirely covered the surface of the yolk sphere with the yolk blastophore completely closed. On account of the congestion of the oil globules around the tail region during this stage, Kuffer's vesicle cannot be seen. According to Summer (1900), Kuffer's vesicle is a postanal gut and has an important influence on certain phases of embryonic growth. The free nuclei of the periblast, which are apparently more concentrated about Kuffer's vesicle than elsewhere, no doubt contribute largely to the absorption of the yolk. It is most likely that the concentration of the supply of food about the Kuffer's vesicle is responsible for the rapid growth and development of the tail region.

The fish embryo at this stage becomes highly transparent without any evidence of pigmentation. Even the extraembryonic area is devoid of any sign of pigmentation which is evident in many fishes at this stage. About three somites begin to differentiate and the yolk is gradually reduced in size. At approximately 16 hours after laying, the optic vesicles become evident and about 14 to 16 somites become discernible. The heart, which has attained a fair size, begins to pulsate occasionally. The anteroposterior circulation of the blood is evident. At this stage the fairly developed tail is still attached to the yolk sphere. The oil globules are apparently decreasing in number, being gradually utilized by the rapidly growing embryo. The first sign of muscular movement was observed at this stage.

About 22 hours after laying, constant movement of the embryo was observed. The embryo has now considerably increased in length, so much so that it has almost encircled the much reduced yolk. The auditory capsules become differentiated and the adherent tail becomes completely free from its posterior attachment to the yolk sphere. The embryo remains transparent until this stage without any sign of pigmentation. The vetebral column now becomes discernible, extending from below the auditory capsules to about the tip of the tail.

Hatching.—A few hours before hatching, the movement of the embryo becomes more violent, exhibited by the constant twitching of the body and the swinging of the tail from side to side, as if trying to break out of the egg shell. The twitching and straightening of the embryo possibly results in the rupture of the egg shell and liberation of the young fish. It is well known that the egg shells of fishes are weakened previous to hatching by enzymic action. This process of hatching takes place from about an hour to three hours under laboratory conditions. In nature, it is presumed that the period of hatching is very much reduced on account of the rolling and aerating action of the river current. As a matter of curiosity, a number of hatching eggs were pricked by a sharp needle and the liberated young were found to be just as healthy and normal as those hatched under natural conditions.

Under laboratory conditions, the eggs were found to hatch between 20 and 50 hours after laying, the eggs having been kept at an almost constant water temperature of 27.5° C. during the period of incubation. The majority, however, of the eggs were found to hatch between 20 and 30 hours after laying.

Larvae (*figs. 14 and 15*).—On account of the weight of large yolk sac of the newly hatched larvae, they fall to the bottom of the culture dishes and remain there for a few hours before they commence to swim toward the surface, and then drop to the bottom by the weight of the body and the unabsorbed yolk. At this delicate stage of the larvae, the tails are still curved as in the shell. The caudal portion of the body gradually straightens out after which they start to swim by using their tails for propulsion. The large head appears to be slightly deflected on account of the fairly large, ovate-elliptical yolk sac. The body appears entirely transparent without any sign of pigmentation. The vent is discernible just a short distance and posterior to the yolk sac. The fully straightened larva measures about 1.1 millimeters long. The fin fold becomes distinctly defined from the middorsal region of the nape toward and around the caudal to the posterior margin of the yolk sac. The optic vesicles and the fin fold remains entirely free from pigments.

A day after hatching (fig. 16) the larva has grown to about 1.5 millimeters long. The large and elongated head is no longer deflected on account of the greatly reduced yolk sac. The eyes are large and prominent. The body across the nape is fairly thick on account of the yolk sac, tapering gently to a long pointed tail. The numerous large somites become very visible from a point just posterior to the primordial pectoral fin to the end of the caudal. The chief characteristic of this stage is the appearance of distinct pigments. Grayish black melanophores become visible across the occiput, on the upper lip, on the anterior and posterior areas of the yolk sac, and about the

the posterior gut region. A series of melanophores one each on the 20 visible somites, extending from the anal opening toward the tail, becomes also evident. Those melanophores across the occiput, upper lip and along the vent produce pseudopodialike extensions, connect one melanophore to another simulating a necklace.

The primordial pectoral becomes visible at this stage. It appears as a protrusion a short distance posterior to the auditory capsules. The fin fold has also widened along the mid-ventral and middorsal regions of the body.

Two days after hatching (fig. 17) the larva has attained a length of about 1.7 millimeters. The thickness of the nape region becomes considerably reduced so that the head region appears now to be quite rounded and the body tapers slightly to the long pointed tail. Below and behind the jaw, the heart can be seen beating regularly in the fairly transparent pericardial cavity between the lower jaw and the comparatively reduced ovoid yolk sac, which still contains a large and a small oil globule.

The general color of the larva at this stage becomes transparent amber, with the prominent iridescent bluish-black eyes. The pupils are jet black. The melanophores on the occiput, and on the upper lip become expanded and a large number of small new ones begin to appear, giving a more or less opaque appearance to the head region. The pectorals become fairly developed.

On account of the transparency of the body, the vertebral column with their ventral and dorsal spines and other internal organs become visible. The fin fold becomes fenestrated, which is an apparent sign of degeneration, while the fin rays of the future caudal fin begins to differentiate. The posterior gut opening (the future anus) has moved farther back. All other features are practically the same as in the first day of the larva.

The larval stages of *S. extraneous* was not carried further than the fourth day stage after hatching, because they started to die after this stage, possibly due to lack of food. They become thin and emaciated after the complete absorption of the yolk on the second day after hatching.

The young larvae hatching from the eggs in the upper streams eventually find their way to the sea, where they grow at a tremendously accelerated rate, due to the enormous amount of food readily available for them. In about a month these larvae attain a length of about 26.5 millimeters, the average

size of the commercial hipon fry; this is a relatively short time and a fast rate of growth, considering the fact that the newly hatched larvae are only about 1.1 millimeters long. Three to four days after their appearance at the river shores, they begin to enter the fresh-water streams, presumably the same streams where they were born. Although this "home stream" phenomenon, which has been conclusively proven in the case of the Pacific salmon and which is now a matter of common knowledge, cannot be demonstrated here in this fish, some indirect evidences seem to justify this assumption.

The occurrence of distinct species of gobies forming the various fry fisheries in different parts of the Philippines, as has been mentioned in the early part of this paper, may lend some support to this claim. It is also probable that most of the larvae of *S. extraneus* do not linger in the sea for more than a month, and in all likelihood, they remain close to the "parent stream". Under these conditions, the location of the identical stream, using some heretofore unknown biological or chemical factors as guide, would not at all be a problem on the part of the anadromous fry. If the salmon, which is known to linger for a few years in the sea and up to several hundred or a thousand miles from the "parent stream" and still return without mistake to the same place, there is very little doubt that *S. extraneus*, with probably as much "intuition" or "intelligence" as the salmon and under a more favorable condition, as enumerated above, could find their way home.

V. DESCRIPTION OF THE GOBY FRY

Two kinds of goby fry enter the fishery; namely, the "hipon" fry which are the young of *Sicyopterus extraneus*, the species under consideration, and the "muli" fry, the young of *Chonophorus ocellaris*. The morphological differences in the two kinds of fry, as well as the difference in their periodic time of appearance, clearly show that they are derived from entirely separate and distinct species. However, there had been some difficulties in determining the species of the young goby fry when they enter the fishery. In order to ascertain the species composing the fishery, the fry were reared in separate glass aquaria in the laboratory until a certain stage when their diagnostic characters were discernible. The comparative length frequencies of these two kinds of fry and the later stage of the hipon fry—the *ankal*—as recorded in Table 4 are graphically shown in fig. 8.

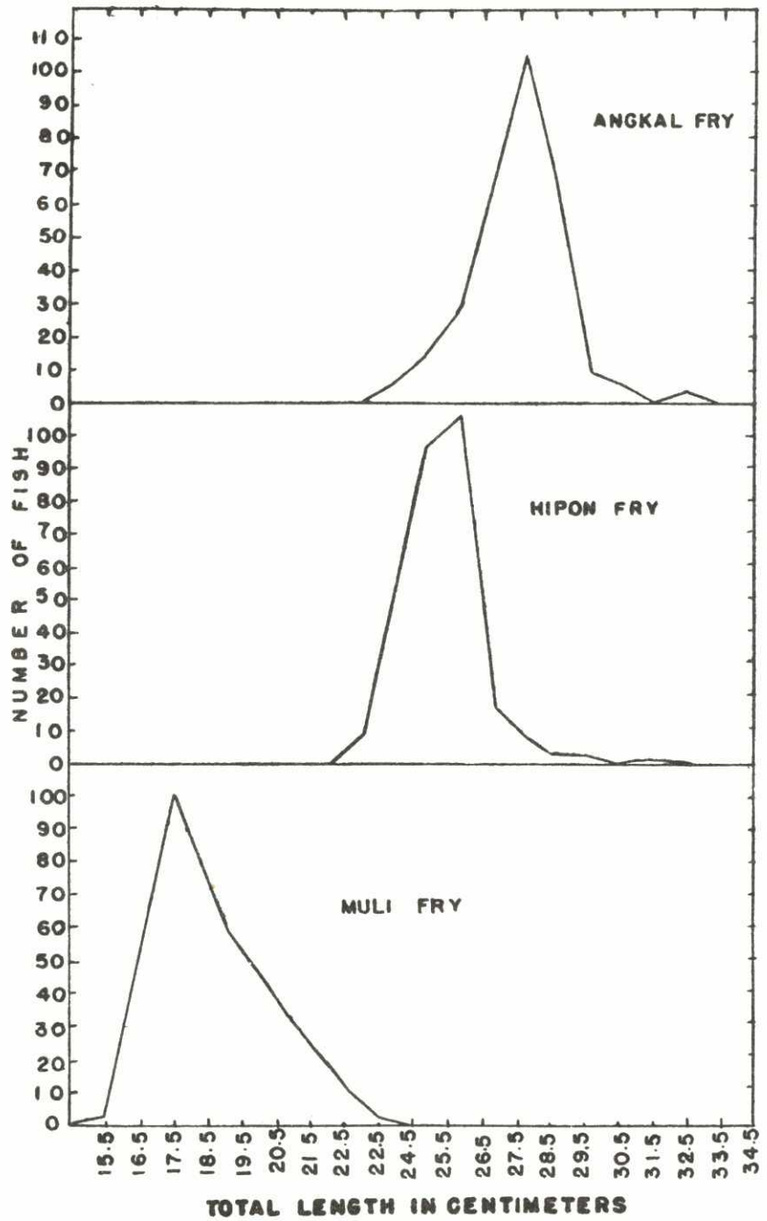

FIG. 8. Total body length frequency polygons of about 300 each of muli, hipon and ankal fry.

Hipon fry (*Plate 2, fig. 4*).—The hipon fry have an average measurement of 25.92 ± 0.74 [7] millimeters total length on the first day of their appearance. They come in innumerable numbers to the shallow river shores, where they appear as a dark-red mass, moving beneath tne surface of the water.

TABLE 4.—*Length frequencies of the three kinds of goby fry.*

Total length	Muli[a]	Hipon[b]	Ankal[c]
mm.	*Number*	*Number*	*Number*
15.1–16.0	3		
16.1–17.0	41		
17.1–18.0	101		
18.1–19.0	57		
19.1–20.0	44		
20.1–21.0	24		
21.1–22.0	10	9	
22.1–23.0	2	58	
23.1–24.0		115	6
24.1–25.0		96	14
25.1–26.0		06	30
26.1–27.0		8	58
27.1–28.0		3	107
28.1–29.0		3	69
29.1–30.0		1	8
30.1–31.0			
31.1–32.0		1	6
32.1–33.0			0
33.1–34.0			2
34.1–35.0			
Total	300	300	300

[a] Collected February 18, 1940, Cagayan River, Oriental Misamis Province.
[b] Collected February 2, 1940, Barrio Macabalan, Cagayan, Oriental Misamis Province.
[c] Collected February 5, 1940, Cagayan Province, Oriental Misamis Province.

Here and there one may notice "flips" on the surface of the water when some predatory fish surge into the school of fry. It is during this stage that the fishermen watch for them with much interest, and when they are spotted every fishing outfit in the community sets out to catch them. All these signs of activity indicate that the goby fry season has commenced.

In life, an individual fry appears transparent amber, with only the jet black eyes prominent. About six to seven transverse V-shaped lateral bands are discernible, extending from above the base of the pectoral to the base of the caudal fins. These bands become indistinct ventrally, especially those towards the head region. The elongated and more or less rounded body appears to be deeper below the first dorsal and tapers gradually posteriorly. There are two fairly distinct gray blotches on the vertex; both lips are covered with dark grey melanophores, these being more prominent on the upper lip; the base of the pectoral is spotted with distinct dark melano-

[7] Standard error.

phores. There are about 20 to 22 series of dark gray melanophores, extending from the base of the anal fin to the base of the caudal peduncle, those along the anal being paired on each side of the belly and becoming single posteriorly. The caudal base is lined with a few dark melanophores, with those on the upper and lower angles of the hypural region being more prominent.

To the naked eye, the body of the fry appears to be entirely scaleless, but closer examination under a compound dissecting microscope reveals the presence of distinctly ctenoid scales. The head, nape, and pectoral regions are naked, and distinct scalation becomes evident from a point just below the posterior margin of the first dorsal fin where the rows of scales converge. Posterior to this point the entire body is definitely scaled.

All the fins at this stage are fairly well developed and are distinctly hyaline. The fin rays, however, have not started to branch, except those of the caudal. The sucking ventral fin is spatulate.

Ankal fry (*Plate 2, fig. 5*).—The *ankal* fry are the advanced stage of the hipon fry and are about a week older. This is evidently the stage of the fry that starts the fresh-water life of the fish. At this time they measure, on the average, about 28.31 ± 0.08 millimeters in total length. When they enter fresh water their flavor changes. In some species, according to Herre (1927), they become actually bitter.

On entering fresh water there is a notable change in the mode of life of the fry from the free-swimming stage, characteristic of the hipon fry, to the creeping and demersal stage of the ankal. Because of this change in the mode of life of the ankal fry, the goby fry fishermen seldom catch them with their fine-meshed beached seines. They hold fast with their sucking ventral fins to the sand and mud on the fishing ground.

The ankal fry are easily distinguished from the hipon fry by their darker color; their tougher, more compact and longer body; and their comparatively distinct scales, which are easily visible even with the naked eye. The dark color of the ankal fry is brought about by the increased dispersion and thickness of the dark gray bands of chromatophores. About seven or eight of these transverse bands are clearly evident both in fresh and preserved specimens, with those toward the posterior half of the body, especially the last five, being more distinct. In some specimens, these bands become distinctly V-shaped, widening dorsally and tapering ventrally, while in others they

are constricted medially. Anteriorly, the third and fourth bands may or may not become fused along their latero-medial line. However, the seventh and eighth bands on the caudal peduncle are often fused, thereby forming an anchor-shaped band on the caudal base.

Muli fry (*Plate 2, fig. 3*).—These fry, which are derived from another distinct species of goby, *Chonophorus ocellaris*, are easily distinguished from the hipon and ankal fry of *Sicyopterus extraneus* by the comparatively small size and slenderness of the former. The muli fry measure on the average about 18.5 ± 0.021 millimeters long (total length). Although they form an insignificant portion of the goby fry catch in Cagayan River, they are, however, considered delicacies, especially in the preparation of special kinds of fish sauerkraut, because they are much finer, more tender, and with better flavor than the other goby fry. On the first day of their appearance in the sea, an individual fry appears translucent whitish-amber, with only the large jet black eyes prominent. The body is elongated and rounded, becoming slightly flattened toward the caudal fin. It is practically devoid of any distinct cross bands, save for a fairly distinct dark spot just above the last fin ray of the anal fin. A large, dark melanophore is evident at the upper angle of the caudal base. In life, two yellowish-orange chromatophores are visible at the upper and lower angles of the caudal base, but these disappear after the fry have been fixed in 3 per cent formaldehyde or in 70 per cent alcohol. There is a series of about 10 to 12 fairly large paired melanophores on each side of the pelvic region. In some specimens this series of melanophores is continued to the base of the anterior margin of the anal fin. There is also a series of smaller melanophores, about 10 pairs, along the base of the anal fin; these are contained on each side of the belly to the last anal fin ray, where they form a single series to the caudal base.

In advanced stages of the muli fry, commonly called *ankal sa muli*, which is equivalent to the migrating stage (*ankal*) of the hipon fry, the fry become fairly distinctly barred. About 5 to 6 dark-gray, narrow transverse bands become evident when the fry start their anadromous life. In general appearance, like the ankal fry, the body becomes darker, tougher, and more compact than its early stage.

All the fins of the young muli fry are hyaline and devoid of any markings, and none of the fin rays have yet started to branch. With the exception of the anterior half, the body

is covered with quite indistinct and fine ctenoid scales. These are so minute that they can be seen only under the high magnification of a compound dissecting microscope.

In the muli fry there is no apparent change of mode of life from the purely swimming stage to the creeping stage, as has been observed in the hipon fry. It was observed that the muli fry continue their pelagic swimming habit from their first appearance until they are far upstream, when they live like the adults of *S. extraneus* under rocks and boulders in swiftly flowing portio .s of the stream. The migrating fry may be observed to be moving in patches or groups of 10 to several hundred or more, braving the river current, preferably taking the back eddies along the banks of the river in their upstream migration.

VI. PERIODIC APPEARANCE AND DURATION OF GOBY FRY RUNS IN CAGAYAN RIVER

To determine the periodic appearance and duration of the goby fry runs in Cagayan River, which is equivalent to the fishing period, actual observations and examinations of the specimens were made from time to time during the entire period of investigation. These observations were corroborated by the records of catch and the verbal information of experienced fishermen. The results of this study are recorded in Table 5 and graphically shown in figs. 9 and 10. Fig. 9 shows, for each month, the duration in days of the hipon and muli fry runs in Cagayan River, and fig. 10, the monthly lunar fishing periods of goby fry for 1938 and 1939. The time of the first catches of the hipon fry fishermen has been taken as the date of first appearance, and the end of the run has been taken as either the time the runs cease along the river shores or the time the fry enter the river in their upward migration.

Hipon fry.—The date of first appearance of the first batch of the monthly run of hipon fry varies from one to nine days, usually between the second and fifth day after the full moon, or shortly after the highest tide of the series. They may appear early or late, depending probably upon certain environmental factors. An early appearance of the first and subsequent batches during the lunar month occurs when there had been heavy rain and freshets a month earlier. This condition is usually followed by a good run of fry. Such is the general belief of the fishermen. Although this apparent association between freshets and the amount and time of first appearance

TABLE 5.—*First appearance and duration of goby fry runs in Cagayan, Oriental Misamis Province (1937–1940).*

Goby	1937*	1938	1939	1940	Average	Remarks
	Days	*Days*	*Days*	*Days*	*Days*	
January						
Hipon	8–13	24–27	12–17	30–31	5.70	Principal fishing season (panuig).
Muli	17–18	6–7	26–27	15–16	2.00	
February						
Hipon	3–8	20–26	10–17	1–5	6.75	
Muli	15–17	6–7	23–24	18–19	2.00	
March						
Hipon	2–7	21–25	7–17	1–3	5–85	
Muli	17–18	6–7	22–23	14–15	2.00	
April						Monthly fishing season (bulan-bulan).
Hipon	7–8	25–26	14–15	2–3	2.00	
Muli	.....	.....	22–23	14–15	2.00	
May						
Hipon	9–10	25–27	15–16	1–2	2.00	
Muli	.....	6–7	23	.....	1.50	
June						
Hipon	6–7	22–24	12–13	.....	2.30	
Muli	.....	.....	23	.....	1.00	
July						
Hipon	8	23–24	12	29–30	1.50	
Muli	.....	.....	.....	.....	.....	
August						
Hipon	.....	22–23	12–13	.....	2.00	
Muli	.....	7–8	.....	.....	2.00	
September						
Hipon	2–3	20–21	12–13	.....	2.00	
Muli	.....	.....	21–22	.....	2.00	
October						
Hipon	.....	20	12–13	.....	1.50	
Muli	.....	.....	.....	.....	.....	
November	**					
Hipon	.....	21–22	9–10	.....	2.00	
Muli	.....	.....	.....	.....	.....	
December	**					
Hipon	.....	20–21	9–10	.....	2.00	
Muli	.....	.....	20–21	.....	2.00	

* No record of appearance
** No observation made

of the runs a month later was not verified in this present investigation, it appears to be plausible. Since the hatching eggs and larvae are carried down to the sea by the river current, the occurrence of rain and consequent freshets would wash down more of them than during the normal condition of the river. In view of this situation, the run of goby fry a month later would be increased.

It will be seen in fig. 10 that the hipon fry appear with almost periodic regularity in every lunar period, or approximately at four week intervals. The significance of this is that their periodic appearance seems to be directly associated with the tides. The runs of hipon fry were observed to be most abundant during or shortly after the highest tide of the series. The only decided advantage accruing to the fry by following the movement of the tide seems quite evident. The high series of tides flood up the river mouths and even as far as 2 to 3 miles upstream. These conditions afford the migrat-

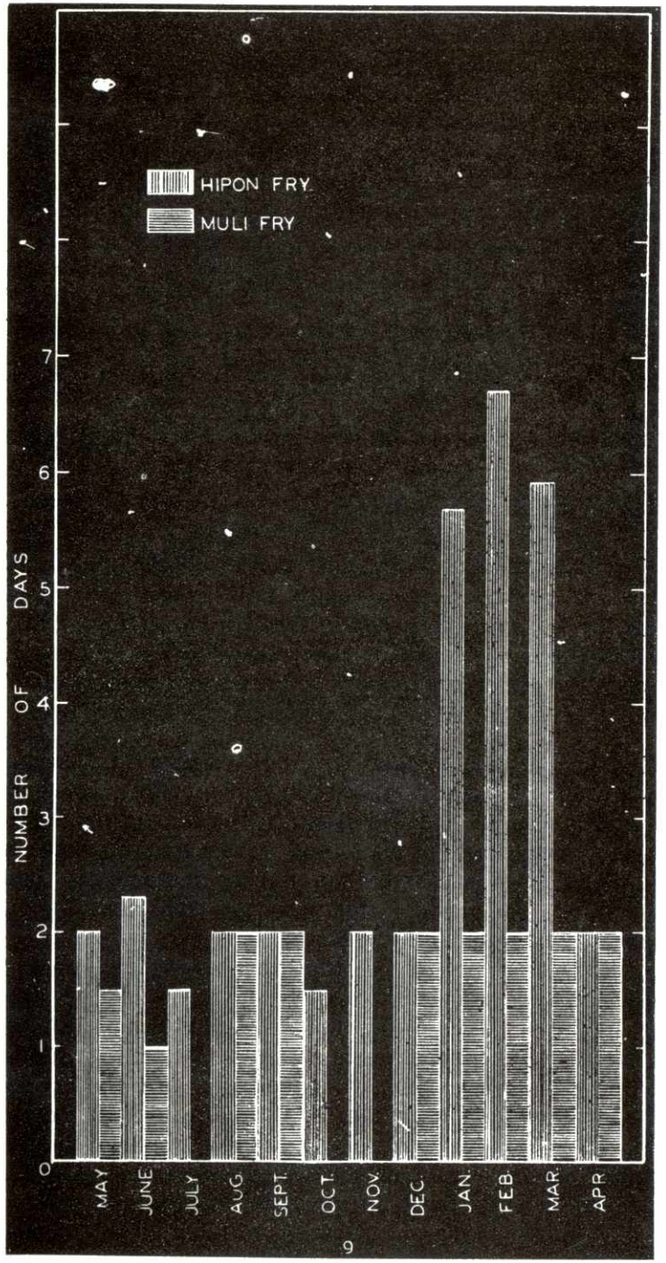

FIG. 9. Average monthly duration in days of hipon and muli fry runs in Cagayan River, Oriental Misamis Province.

ing fry an easier start and a more favorable situation than those existing during the periods when the tides are low and there are no favoring currents for the migrating fish.

In the hipon fry fisheries of the other important rivers of northern Mindanao, such as in Surigao River, Surigao Province; Agusan River, Agusan Province; Tagaloan River, Oriental Misamis Province; and Mandulog River, Lanao Province, a similar association between the tides and hipon runs occurs, as gleaned from the reports of goby fry fishermen in these places. In an earlier report (Manacop, 1940), it was noticed that the appearance of the hipon runs in these places, including those in Cagayan River, often occur simultaneously, sometimes varying only a day or two. In northern and northwestern Luzon, this periodic appearance of the hipon fry was likewise reported by Taylor (1919) in the *ipon* fisheries of Abra River; Montilla (1931), Herre (1927), Blanco (1938), and, Villadolid and Blanco (1939), in similar fisheries of Cagayan River, Cagayan Province, and of the Ilocos Regions. However, the date of the first appearance of the run appears to vary in different places. The ipon fry of the northern and northwestern parts of Luzon usually appear with the incoming tides about nine days after the full moon, being most abundant about three days after the full moon when the tides are highest. Any slight variation in the date of the first appearance of the hipon runs in different parts of the Philippines may be accounted for by the following factors: (1) the time of high and low water varies in different parts of the Philippines on account of the varied effects of the currents in the Pacific Ocean and the China sea; (2) the fisheries are derived from entirely diffrent species and even genera; and, (3) the environmental conditions vary in these places.

With regard to the duration of the hipon runs in Cagayan River, Oriental Misamis Province, it was found to vary from 5 to 7 days during the principal fishing months, and from 1½ to 2 days during the "monthly" fishing seasons (fig. 9). The duration of the hipon runs appears to be prolonged during the principal fishing months due to the fact that two to three batches of hipon fry appear successfully during this period, while during the other months of the year only one batch of fry usually occurs. A batch of hipon fry (*tugnos*) usually

runs from two to four days after its first appearance in the sea before it begins to ascend the fresh-water streams. Shortly after the cessation of the run of the first batch, the second batch appears, and then the third, if there is any.

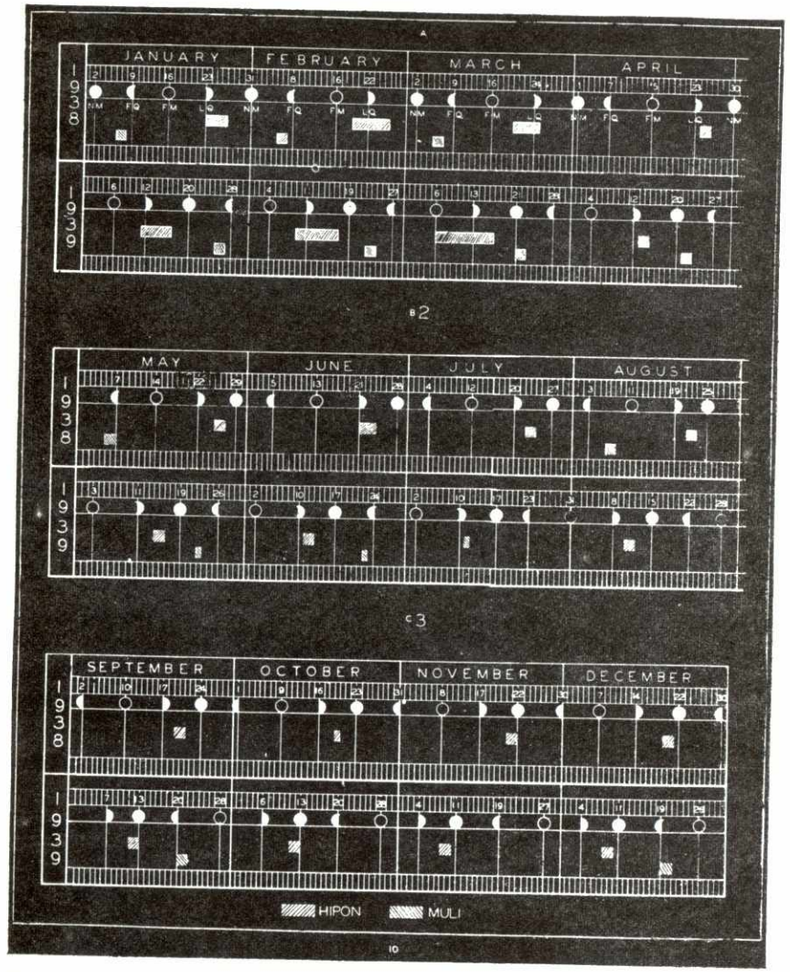

FIG. 10. Monthly lunar periods (1938-1939) and duration of hipon and muli fry runs in Cagayan River, Oriental Misamis Province.

As to the relative size of each batch, no definite comparative study has been made. However, the concensus of hipon fishermen is that it is either the first or second batch that yields the biggest haul.

In northern Luzon, according to Villadolid and Blanco (1939), the duration of the monthly runs during the six months fishing period (September through as late as March) is about 15 days for every month. Although no mention has been made by the foregoing authors regarding the number of batches of goby fry occurring in each monthly run, it is probable that not less than two batches successively appear every month.

The nonappearance of the hipon fry run during certain lunar periods may be ascribed to certain factors, such as: (1) failure in spawning or excessive mortality rate of the eggs or young fish, as mentioned in the early part of this discussion; or; (2) the run was so insignificant that it was not observed in the catch of the hipon fishermen.

Muli fry.—The muli fry runs usually appear on the third day after the new moon, or approximately after the second series of high tides of the month. The run usually extends from one to two days, seldom three, on account of the fact that only one batch of fry has been observed to occur in each monthly run. This run appears to be periodic although quite erratic throughout the year. As in the case of the hipon fry runs, the occurrence of a break in the periodicity of appearance of the muli fry may be accounted for as due to spawning failure or some spawning recess (resting period) of the fish. These statements can only be considered tentative because the life history and habits of the muli (*Chonophorus ocellaris*) have not been sufficiently studied to warrant definite conclusions.

The periodic appearance of the hipon fry runs in Cagayan seems to be conclusive evidence that *S. extraneus* and probably *Chonophorus ocellaris* spawn periodically. If spawning were not periodic, this regular appearance of these one-month-old goby fry every lunar period would not occur.

In view of this apparently close association between the periodic appearance of the runs of goby fry and lunar period, it is not surprising that the fishermen can forecast with fair accuracy the probable date of the first appearance of the two kinds of goby fry on the river shores, using the phase of the moon as their only guide. A few days before the expected appearance of the fish, necessary preparations of all fishing outfits will be observed all along the fishing communities not

only in Cagayan, Oriental Misamis Province, but also in many other parts of the Philippines where the fishery occurs.

VII. NOTES ON THE FOOD AND FEEDING HABITS

The food and feeding habits of both the adults and the fry were observed in the field and in the laboratory. Observations in the field and the rearing of both stages of the fish in glass aquaria in the laboratory were undertaken. For the determination of the food, examinations of the stomach contents of the adults were made. Table 6 shows the results of this study of about 20 filled stomachs of anga, collected on June 14, 1940, from Cagayan River. On account of the extreme minuteness of the food organisms, it was difficult to determine the proportion of the food organisms contained in each stomach. Therefore, relative degrees of occurrence of the food organisms, indicated by plenty (P), common (C), few (F), and rare (R), were used. The species of the different food organisms could not be determined because of their macerated and digested conditions.

TABLE 6.—*Examination of the stomach contents of adult anga, collected June 14, 1940 in upper Cagayan River*

Number of fish	Diatoms	Lyngbya	Calothrix	Spirogyra	Stigeoclonium	Penium	Sygnema	Oedogonium	Cosmarium	Organic matter
1	[1]P	P	P	[2]C	C	[3]R	R	R	[4]F	P
2	P	P	P	C	C			F	F	P
3	P	P	C		F			R	F	C
4	P	C	C	F	F	R		C	R	P
5	P	C	C	C		R	R	R	R	P
6	P	C	C	F	F		C	C		P
7	P	C	C			R	P	R		P
8	P	C	P	F	C	R	R	C	R	P
9	P	C	R	F	F		R			P
10	P	C	P	F	F	R	R	R	R	P
11	P	C	C			R	R		R	C
12	P	C	C	C	C	R	F	F	F	P
13	P	C	C			R	F		R	P
14	P	C	C	F	C	R	F	F		P
15	P	C	C		C	F	F		R	P
16	P	C	C	C	C	F	F	C	F	P
17	P	C	C			F	F	C	R	P
18	P	C	C	C	C	F	F	C	R	P
19	P	C	C			F	F	C		P
20	P	C	C	C	F	F	F	C	R	P

[1] Plenty (P). [2] Common (C). [3] Few (F). [4] Rare (R).

The adults were found to feed principally on various kinds of algae, the pennate diatoms predominating. *Lyngbya*, *Stegioclonium*, *Calothrix*, and *Spirogyra* were the common food organisms found in the stomach contents of the adults, and

Penium, *Sygnema*, *Oedogonium* and *Cosmarium* the rare forms. The greatest bulk of the stomach contents, however, consisted of an unidentifiable mass of organic matter. The ankal fry that were reared for some time in the laboratory were observed to feed voraciously and live on those kinds of algae which were collected from Cagayan River.

In the field, the adults and the migrating fry in the upper streams were observed to be feeding on the accumulated, thin layer of organic matter on the surface of stones under water. Upon closer examination of this organic matter, it was found to consist chiefly of various species of diatoms, with some scattered colonies of green, and blue-green algae.

Both the adults and the migrating fry (*ankal*) have a very interesting mode of feeding. The ventral mouth, characteristic of bottom feeders, suggests that the peculiar mode of feeding similar to the mechanical action of a lawn mower or scraper. The hardened, wide, dentate-crenate lips perform this mowing or scraping action. Using the sucking ventral fin for clinging firmly to rocks, the busy mouth scrapes off the diatom accumulation on the stones. After going over one stone, the fish move to another and begin feeding again. The area fed upon by the fish presents a characteristic cleared patch, like a newly mowed grass lawn or scraped path. During this mode of feeding, every now and then particles of sand accidentally get into the mouth, and when this occurs the foreign body is immediately ejected with an apparently spitting action of the tongue and lips. The canine teeth and lips probably keep the food particles from falling off.

The change in the mode of life of the hipon fry, as mentioned in the early part of the paper, is probably brought about by the change in the range of feeding habits. There has been observed a notable change in the position of the mouth of the goby fry from terminal, characteristics of the hipon fry stage which are surface or top feeders, to inferior, characteristic of the ankal or migrating stage which are bottom feeders. A parallel phenomenon has been reported by Steward (1925) in his study of the development, growth, and food habits of the white sucker, *Catostomus commersonii* Lesueur.

Annandale and Hora (1925) described this interesting mode of feeding as well as the food of a related species, *Sicyopterus*

garra, in streams of the Andaman Islands. Quoting the authors:

> . . . They cling to rocks in rapidly-running water by means of a ventral sucker, and feed by scraping organic matter, mainly minute algæ, from the surface of rocks to which they adhere. Rocky beds of stream is covered by a thin film of deposit and this is cleared away by *Sicyopterus* by its fringed lips and then clinging by its ventral fins (cup-like suckers), it scrapes off algæ with a pair of horny pads on its lower jaw, assisted probably by its strong canine teeth. Upper lip pendant and fringed to prevent the falling of food particles.

This unique and interesting mode of feeding of *Sicyopterus* with the characteristic structure of the mouth has actually to be observed in order to appreciate the peculiar mechanical operation of the lips.

SUMMARY

1. The goby fry fisheries occur in many places in the Philippines, but they are commercially exploited chiefly in the northern and northwestern parts of Luzon, and in the northern and southeastern parts of Mindanao. As a whole, the total estimated value of the product of this fishery may be placed at no less than 500,000 pesos annually, with Cagayan River, Oriental Misamis Province, ranking as one of the principal producing centers in the southern part of the Island.

2. The principal species entering the goby fry fishery in Cagayan River are *Sicyopterus extraneus* Herre (anga) and *Chonophorus ocellaris* (Broussonet), *muli,* with the former making the major part of the commercial catch of hipon fry and the latter the minor element of muli fry.

3. The fishing season may be classified into two periods; namely, "yearly" (*panuig*) or principal, and the "monthly" (*bulan-bulan*), The principal fishing season extends from January to March, the period concurring closely with the spawning season of the fish. The rest of the year, which has a very insignificant amount of hipon fry catch, covers the "monthly" season.

4. The globy fry are chiefly caught by beach seines (*baling*), scissors nets (*sarap*), fish barricades (*golgol sa hipon*), and other similar gears which are considered to be of minor importance, their catch being intended principally for the fresh-fish markets, while those of the baling are for the preparation of the commercial salted fish paste (bagoong). The adults are commonly taken by a number of forms of gear, such as the cast net (*taclob*), fish barricade (*golgol sa anga*), and spear gun (*pusil-pusil*).

5. All the materials used in this study were collected mostly from Cagayan River, Oriental Misamis Province, unless otherwise stated.

6. A detailed study of the life history and habits of *Sicyopterus extraneus* Herre, has been dealt with in this investigation, and the results are summarized as follows:

a. S. extraneus (*añga*) spawns throughout the year, with the principal spawning months extending from December to February.

b. Each fish probably spawns more than once during the season, with every fish either actively spawning or developing mature eggs at all times during the year.

c. Indirect evidence seems to indicate that the anga spawns with regular periodicity, at approximately every full moon.

d. A distinct sexual dimorphism has been found in the anga, the male being longer than the female on the average, and having the first dorsal fin spines much more prolonged than in the females'. Males measure 6.82 $\pm$ 0.023 centimeters and the females 6.3 $\pm$ 0.021 centimeters long.

e. The eggs are demersal and are laid on the under surface of stones in moderately flowing portions of the river. They are held together to the substrate by numerous tufts of gelatinuous threads.

f. The eggs hatch in a day or two. In the upper reaches of the river where they are laid, and when they are about to be hatched or fully hatched, they are carried down stream by the river current to the sea. After a month or so, they reappear on the river shores as the commercial form of goby fry (*hipon, or muli*).

6. The goby fry that enter the commercial haul are estimated to be about a month old.

7. The runs of these goby fry were observed to appear with almost regular periodicity, the hipon fry usually between the second and fifth day after the full moon of every month, and the muli fry about the third day after the new moon.

8. These periodic runs are apparently associated with the movement of the tides, with the hipon fry appearing during or shortly after the highest tide of the series, and the muli fry during the second highest tide of the series of the same lunar period.

9. The hipon fry runs appear to be much prolonged during the principal fishing months, being from about 5 days to 7 days, as compared with the rest of the year when the usual duration is about 2 days.

10. Each "batch" (*tugnos*) or hipon fry run usually lasts from 2 to 4 days, sometimes 5, along the river shores.

11. The duration of the runs, which is equivalent to the lunar fishing period, depends primarily upon the number of batches of goby fry occurring in every monthly run.

12. Two to three batches of goby fry occur during the runs of the principal fishing months while only a single batch appears each month throughout the rest of the year.

13. The monthly lunar run of muli fry does not last more than two days, usually one day because there often occurs only one batch in each monthly run.

14. Indirect evidence seems to show that, like the Pacific salmon, the goby fry return to the same "parent stream" where they were born.

15. Breaks in the regular periodicity of the runs of either the hipon or muli fry may be ascribed to the following factors: (*a*) the occurrence of some spawning failure brought about by unfavorable conditions; (*b*) the insignificance of the run to be noted, and/or actual cessation of spawning activity (resting period).

16. The adults and migrating fry have a peculiar and interesting mode of feeding, simulating the mechanical action of a lawn mower or scraper. The fish are purely vegetarian, feeding mostly on diatoms, some blue-green algae (*Lyngbya* and *Calothrix*) and a host of green-algae (*Spirogyra, Stigeoclonium, Oedogonium, Sygnema, Penium,* and *Cosmarium,*) each arranged in the order of its relative degree of occurence in the stomach contents of the fish.

17. With the present knowledge of the life history and the breeding grounds of anga, the mooted question as to where the fish spawn has been definitely settled—they spawn in fresh water and are not catadromous as has been previously claimed.

RECOMMENDATIONS

For further study and regulation of the fishery, the following points are recommended:

1. A complete record of the monthly and annual catch of both the hipon and muli fry is urgently needed for statistical analysis in order to determine the present condition of the fishery.

2. For the proper conservation of the goby fry fishery in Cagayan River, Oriental Misamis Province, a closed season in the catching of the adults, consisting of *Sicyopterus extraneus* and *Chonophorus ocellaris* extending from December 1 through March 15, of each year, is recommended. To regulate the catching of the fry, a law should be promulgated prohibiting the catching of the migrating fry (*ankal* of both muli and *hipon*) in the river. This plan, which was tried during the period of investigation of the fishery at Cagayan River, has apparently resulted in a remarkable rehabilitation of the gradually declining fishery.

3. Further studies are needed on the proper preservation and preparation of a better quality of salted fish paste so that it will have a general local appeal, and at the same time serve as export to foreign markets.

4. Similar biological studies of the other goby fry fisheries of the Philippines, especially those of northern Luzon, should be undertaken in order to conserve this commercially important natural wealth.

5. The findings of probably annular markings, or breeding "checks", on the scales of anga should lead to further investigation in order to determine the definite ages of the fish at different size groups.

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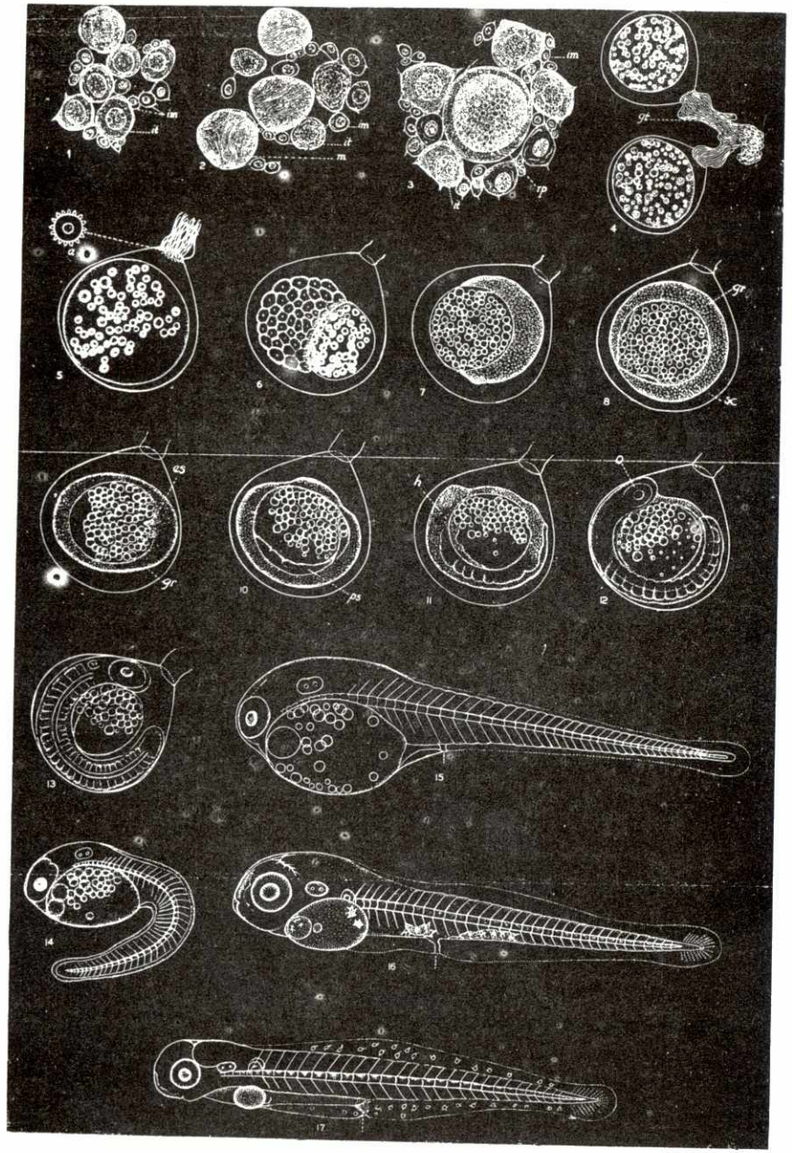


PLATE 1.

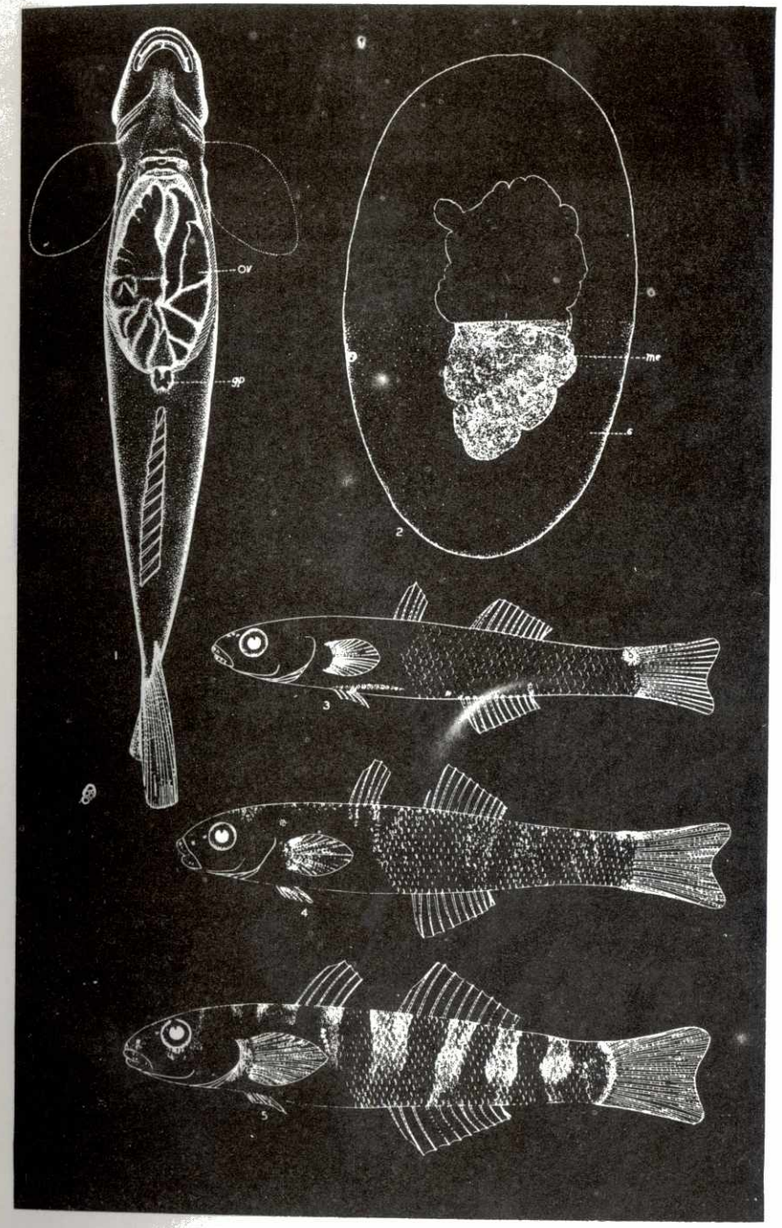
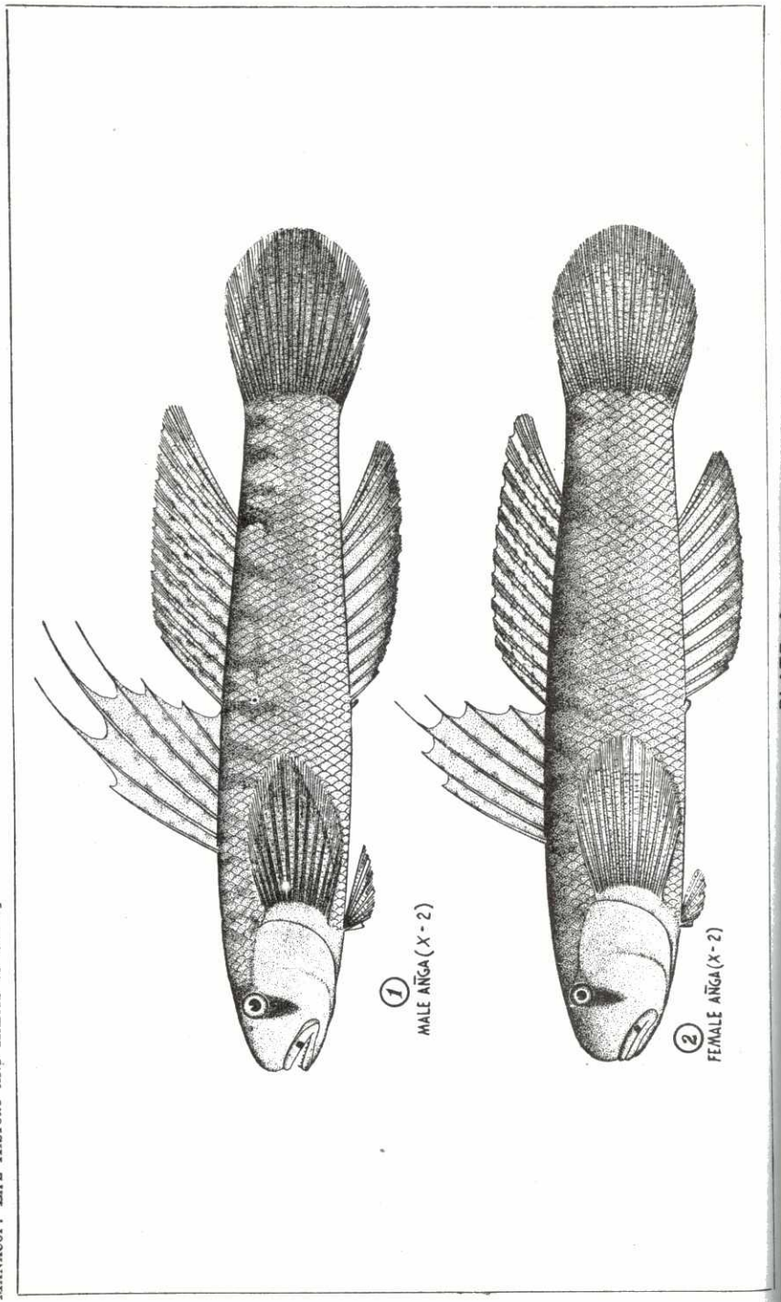


PLATE 2.



ILLUSTRATIONS

PLATE 1

FIG. 1. Early intermediate group of eggs. Taken from a newly extruded "spent") female, 6.0 cm. long, collected from Cagayan River, Oriental Misamis Province, August 21, 1940 (×1000): *im*, immature eggs; *it*, intermediate eggs.

2. Maturing or advanced intermediate group of eggs. Taken from a maturing female anga, 5.5 cm. long, collected from Cagayan River, Oriental Misamis Province, August 21, 1940. (×1000); *m*, maturing eggs.

3. Mature or ripe group of eggs. Taken from a spawning female anga, 6.6 cm. long, collected from Cagayan River, Oriental Misamis Province, August 21, 1940 (× 1000): *rp*, ripe eggs.

4. A cluster of newly laid eggs of anga, *Sicyopterus extraneus* Herre (×112).

5. A newly-laid egg (unfertilized), (×150); 5*a*, calyxlike attachment of gelatinous threads.

6. Early blastodermal cap stage at approximately 3 hours after laying.

7. Completed blastodermal cap stage at approximately 7 hours after laying.

8. "Segmentation cavity" and early germ ring stage, approximately 9 hours after laying: *gr*, germ ring; *sc*, "segmentation cavity".

9. Embryonic shield stage, approximately 11 hours after laying: *es*, embryonic shield.

10. Primitive streak stage, approximately 12½ hours after laying; *ps*, primitive streak.

11. Advanced embryo with 3 to 4 somites, approximately 13½ hours after laying. Note the thoraco-ventrally located heart (*h*).

12. Advanced embryo with increased number of somites, approximately 16 hours after laying. Note the differentiation of the optic vesicles (*c*).

13. Fully developed embryo shortly before hatching, approximately 22 hours after laying.

14. Newly hatched larva, approximately 23 hours after laying (×200).

15. Swimming larva, about 3 hours after hatching (×236).

16. Two-day-old larva (×147).

17. Three-day-old larva (×125).

PLATE 2

FIG. 1. Facial view of abdominal cavity of a spawning female anga. Note the space occupied by the ripe ovary (×6): Ov, ovary; *gp*, genital papilla.

2. A batch of newly-laid eggs still attached to the stone substrate (½ actual size): *me*, mass of eggs; *s*, stone.

3. Muli fry (× 8).

4. Hipon fry (× 7).

5. Ankal fry (× 7).

PLATE 3

FIG. 1. Adult male *Sicyopterus* (× 2).

2. Adult female *Sicyopterus* (× 2).

TEXT FIGURES

FIG. 1. Average monthly landings (1937–1939) in Cagayan, Oriental Misamis Province (data based on 5 baling outfits).

2. Summary of Sicyopterus spawning season in Cagayan River as indicated by the percentage relation between spawning females and all females.

3. Comparison between the monthly catch and the spawning season.

4. Diameter frequencies of 300 ova, each taken from the three developmental stages of the ovary, all collected on August 21, 1940, from Cagayan River; (*a*) "spent" female, 7.4 cm. long; (*b*) intermediate or early maturing female, 7.3 cm long; and (*c*) ripe female, 6.9 cm. long.

5. Showing the sign when maturity occurs. The solid line represents the percentage of maturing females and the broken lines the percentage of males which mature at the indicated sizes.

6. Body length frequencies of males and female Sicyopterus (data based on all materials collected during the period of investigation).

7. Graphic estimation of the significance of the difference between the average body lengths of male and female Sicyopterus.

8. Total body length frequency polygons of about 300 each of muli, hipon and ankal fry.

9. Average monthly duration in days of hipon and muli fry runs in Cagayan River, Oriental Misamis Province.

10. Monthly lunar periods (1938–1939) and duration of hipon and muli fry runs in Cagayan River, Oriental Misamis Province.