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ON THE BIOLOGY OF ANCHOVIES (*STOLEPHORUS LACEPEDE*) IN PHILIPPINE WATERS

By

K. TIEWS
Institute für Küsten- und Binnenfischerei der
Bundesforschungsanstalt für Fischerei
Hamburg, Germany
and
I.A. RONQUILLO and L.M. SANTOS
Bureau of Fisheries
Manila, Philippines

ABSTRACT

This paper analyses the results obtained from 397 samples of achovies totalling 208,530 specimens from Manila Bay and 81 samples totalling 54,530 specimens from other parts of the Philippines. It notes the inclusion in the catches of up to eight species of *Stolephorus* and derives some conclusions concerning growth rates, age at maturity, fecundity and spawning season for these fish. Levels of association of the different species in the catches of commercial vessels are indicated.

INTRODUCTION

The family Engraulidae (Anchovies) is represented by 5 genera in Philippine waters (Herre, 1953), namely *Thrissocles* (3 species), *Thrissina* (1 species), *Scutengraulis* (3 species), *Engraulis* (1 species) and *Stolephorus*. However, only the genus *Stolephorus* is of appreciable economic importance. The Philippine catches of *Stolephorus* species were 5,000 metric tons in 1956 and accounted for about 12 percent of the total yield of the important commercial fisheries (Anon. 1957). The 1966 landings of anchovies were about 11,500 metric tons (Anon. 1967). Although anchovy ranked third in importance among commercial fish resources in the Philippines

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in 1956, its biology had not been a subject of study. It was therefore decided to include the biology of the genus *Stolephorus* in the research programme of the Bureau of Fisheries, initiated in October 1956 under the assistance of the senior author, FAO Marine Fisheries Biologist (Tiews, 1959).

The present paper deals with most of the results obtained from 1956-58. This biological study has been continued since then and some length composition data were collected up to December 1959. In the meanwhile, one of the authors (I.A. Ronquillo) has undertaken a review of the genus.

MATERIALS AND METHODS

The biological researches were concentrated on the Manila Bay stock and mainly on *Stolephorus heterolobus,* the most abundant species, although detailed researches were carried out also on materials from the other species whenever they were available. Due to lack of a suitable research vessel, sampling of biological materials were almost exclusively done at the San Andres Retail Market in Manila and only occasionally at the Navotas Fish Market, the largest fish landing centre in the country. Samples were only taken from catches of known localities. In as much as nearly all samples were taken from catches of BASNIGAN vessels, which attract fish schools during dark nights by artificial light, the sampling design was adjusted to the phases of the moon, on which the BASNIGAN (or lift net) fishery widely depends (Rasalan & Villadolid, 1955). In general, samples were taken every other week for 5 to 6 successive days. On every sampling day, samples of about 2 kg. of fish were purchased from each available lot of the catches. The fish looked different in composition either with regard to species or size. On days when only one type of anchovies catch was available, only one sample was secured while on other days, from 4 to 6 samples were purchased.

From November 1956 to September 1958, 397 fresh samples of 208,530 specimens were collected from the Manila Bay area. Another 81 fresh samples of 54,530 specimens were also collected from other regions of the archipelago by fieldmen of the Bureau of Fisheries. This latter sampling programme was started in April 1957 to obtain some data on the distribution of the genus in the archipelago, and preliminary conclusions were reached on the distribution

of the different species. All the fish samples were studied by the staff of the pelagic fish laboratory of the Central Research Station in Dagat-dagatan, Malabon, Rizal. Because the fishes were small, all measurements were done to the nearest millimeter. The total length (tip of snout to tip of caudal fin) was used in this study except where otherwise noted.

When counting the rays of the dorsal and anal fins for species differentiation, the counts included the unbranched rays. Pectoral fin ray and gill raker counts were taken from the left side of the fish. The vertebral counts included the atlas and the urostyle.

IDENTIFICATION AND DIAGNOSIS OF THE DIFFERENT SPECIES OF STOLEPHORUS

Herre (1953) records the following 5 species in the Philippines: *S. commersonii Lacepede* 1803; *S. heterolobus* (Ruppell, 1837; *S indicus* (van Hasselt, 1823); *S. tri* (Bleeker, 1852) and *S. zollengeri* (Bleeker, 1849). Unfortunately, the key on *Stolephorus* by Weber and de Beaufort (1913) cannot be used to differentiate all species that were found.

Eight species were distinguished from the materials, some of them apparently new to the Philippines and to science. However, the available literature was not sufficient to definitely determine the species.

Special researches were necessary to describe the individual species. This work was based on meristic characters. From the fins, only the anal fin has been found to be useful for species separation. The numbers of vertebrae, of epi-, cerato- and hypobranchial gillrakers of the first gill arch and of ventral scutes are useful also in separating the species. (I.A. Ronquillo, 1968).

A key to the genus *Stolephorus* based on the preliminary results of his study is given in the following. Of the eight species studied one was described subsequently as *S. buccaneeri* by Strasburg (1960) from Hawaii. This species has escaped proper identification in this study because it was believed to be Bleeker's *S. zollingeri.* Whitehead (1965) reports that Bleeker's eleven syntypes of *Stolephorus zollingeri* are all *Engraulis. S. celebicus* Hardenberg is an example of this *Engraulis.*

Three species have been found to be new to science, i.e. **Species A,** which is very closely allied to *S. heterolobus;* **Species B,** related

to *S. purpureus* of Hawaii, and is quite rare, while **Species C** is similar to *S. macrops* Hardenberg (*S. baganensis* Hardenberg, authors) but consistently lacks a pre-dorsal spine. *S. tri* was not collected in our sampling programme. *S. bataviensis* Hardenberg (*S. insularis* Hardenberg, authors) is very similar to *S. commersonii* Lac. and although the meristic studies show an evidence enabling a separation of these species now (Table I), the majority of samples studied then may have been a combination of these two species and proper notation has been made on such data.

A summary of the meristic characters with the mean and ranges for each species is shown in Table I. This part of the study is based on approximately 32 samples varying from 50 to 1,956 individuals.

*Key to the Genus Stolephorus Lacepede, 1803**

I. Anal origin under or behind last dorsal ray; muscular portion of isthmus not reaching to hind border of branchiostegal membrane, leaving portion of urohyal exposed, alar scales pigmented and readily discernible.

A. Maxilla tapering posteriorly, reaching at least to anterior border of preoperculum, lateral expansion of urohyal plate bony.

1. Total lower gill rakers 48 (43-53); head short and less deep; its length mostly more than 4 times in S.L., body sub-cylindrical and slender; posterior frontal fontanelles small; preoperculum narrow, about half width of operculum; body depth 5.4 — 6.5 in S.L. maxilla with fine teeth of the same size, except 3 or 4 last ones in some juveniles. . . . .

. . . . . 1. *S. heterolobus* (Ruppell, 1837)

2. Total gill rakers 43 (38-49); head long and deep, its length mostly less than 4 times in S.L.; body deeper, posterior frontal fontanelles larger, triangular; pre-operculum wider, its width about equal to that of operculum; body depth 4.5 — 5.4 in S.L.; maxilla with coarse teeth between the regular fine ones in posterior half.

. . . . . 2. **Species A**

* (Excerpt from: An Illustrated Key to the Genus *Stolephorus* (in press).

TABLE I. *Variation in meristic characters of different species of* Stelophorus *in the Philippines.*

	S. buccaneeri	Species A	*S. heterolobus*	Species B	*S. indicus*	*S. commersonii*	Species C	*S. bataviensis*
Pre-pelvic spines	5 (2 – 7)	5 (2 – 7)	5 (4 – 7)	6 (5 – 6)	4 (2 – 6)	4 (1 – 6)	6 (4 – 8)	6 (3 – 7)
Gill rakers Epi-	18 (15 – 22)	20 (16 – 24)	23 (19 – 26)	14 (13 – 15)	17 (15 – 22)	20 (19 – 22)	20 (18 – 23)	17 (14 – 21)
Cerato-	12 (11 – 14)	12 (10 – 14)	12 (12 – 14)	9 (8 – 10)	12 (10 – 14)	14 (13 – 16)	15 (13 – 17)	12 (11 – 15)
Hypobranchial	12 (9 – 14)	11 (10 – 14)	12 (11 – 15)	8 (7 – 9)	12 (9 – 13)	13 (11 – 15)	14 (11 – 15)	11 (9 – 13)
Total	42 (35 – 48)	43 (38 – 49)	48 (43 – 53)	30 (29 – 32)	41 (36 – 46)	47 (45 – 51)	49 (45 – 53)	41 (35 – 45)
Fin rays Dorsal	15 (13 – 18)	15 (13 – 16)	15 (13 – 17)	15 (14 – 15)	16 (14 – 17)	16 (15 – 17)	16 (13 – 17)	16 (13 – 17)
Anal	16 (14 – 19)	19 (17 – 22)	18 (16 – 20)	17 (16 – 19)	20 (17 – 22)	21 (19 – 23)	20 (17 – 23)	21 (17 – 24)
Ventral	7 (6 – 8)	7 (6 – 8)	7 (6 – 8)	7	7 (5 – 7)	7	7 (6 – 8)	7 (6 – 8)
Pectoral	14 (12 – 16)	14 (12 – 15)	14 (11 – 16)	13 (12 – 14)	14 (12 – 16)	14 (12 – 15)	12 (11 – 15)	13 (12 – 15)
Vertebrae	42 (39 – 44)	42 (39 – 43)	42 (40 – 44)	42 (41 – 43)	41 (38 – 44)	38 (37 – 39)	39 (37 – 41)	39 (36 – 42)
No. of localities represented	3	4	1	1	4	3	2	3
No. of samples	10	5	2	1	5	3	3	3
No. of individuals	362 – 1956	292 – 6910	124 – 1181	50	314 – 690	144 – 150	299 – 303	411 848

B. Maxilla truncate posteriorly, not reaching beyond anterior border of pre-operculum; urohyal plate fleshy; head long, its length less than 4 times in S.L.

1. Maxilla 4-5 times in S.L., straight, just reaching to anterior border of pre-operculum;

a. Lower gill rakers 23-24; pre-pelvic scutes poorly developed, may be absent; posterior frontal fontanelles not clearly discernible.

. . . . 3. *S. purpureus* Fowler, 1900

b. Lower gill rakers 16-18; pre-operculum narrow; 4-7 pre-pelvic scutes well developed; posterior frontal fontanelles clearly discernible.

. . . . . 4. **Species B**

2. Maxilla 5-6 times in S.L., curved upwards, shorter than the lower jaw, not reaching to anterior border of pre-operculum; lower gill rakers 23-27 (mostly 24-26) . . . .

. . . . 5. *S. buccaneeri* Strasburg, 1960

II. Anal origin under dorsal base; muscular portion of isthmus extending forward beyond hind border of branchiostegal membrane.

A. Hind border of pre-operculum indented near maxilla tip.

1. Double pigment line on back behind dorsal bases; body deep, its depth equal to upper jaw; snout short and blunt; posterior frontal fontanelles with lateral borders partly sigmoid; supra-orbitals projecting laterally from frontals; maxilla expanded above mandibular articulation.

a. Pre-dorsal spine present but no spine on pelvic scute; lower gill rakers 20-27.

. . . . . 6. *S. macrops* Hardenberg, 1933
(*S. baganensis* Hardenberg, authors)

b. Pre-dorsal spine absent; lower gill rakers 23-30.

. . . . . 7. **Species C**

2. No double pigment line on back, melanophores absent or at most irregularly scattered; body slender, its depth less than upper jaw; snout longer, pointed; posterior frontal fontanelles with lateral borders not sigmoid; supra-orbitals barely projecting laterally from frontals; maxilla not enlarged above mandibular articulation.

a. Head large, its length 4.0-4.2 in S.L.; lower gill rakers 26-30; pre-pelvic scutes 6-9; posterior frontal fontanelles broad anterior angles scute.
. . . . . 8. *S. holodon* (Boulenger, 1902)

b. Head smaller; its length 4.2-4.5 in S.L.; lower gill rakers 19-21; pre-pelvic scutes 5-6; posterior frontal fontanelles narrower, anterior angles, more rounded.
. . . . . 9. *S. andhraensis* Babu Rao, 1966

B. Hind border of pre-operculum evenly rounded near maxilla tip.

1. Pre-dorsal spine present, a spine on pelvic scute; lower gill rakers 20-27; posterior frontal fontanelles very broad, their length about 1/3 eye diameter; scales adherent, with reticulate striae
. . . . . 10. *S. tri* (Bleeker, 1832)

2. No pre-dorsal spine, no spine on pelvic scute.
   a. Maxilla tip reaching to or just beyond anterior border of pre-operculum; posterior frontal fontanelles narrow, lateral borders straight, 4-5 pre-pelvic scutes.
   . . . . 11. *S. indicus* (Van Hassett, 1823)
   b. Maxilla tips reaching to or beyond posterior pre-opercular.
      i. Posterior frontal fontanelles broad, lateral borders sigmoid; supra-orbital projecting laterally from frontals; lower gill rakers more than 21; more than 23 on whole of 3rd arch.
      Pre-pelvic scutes 3-5 (rarely 5 or more); head large, its length about 4 times in S.L.; two broad pigment lines on back, from head to dorsal; lower gills rakers 23-27; maxilla hardly expanded beyond mandibular articulation.
      . . . . 12. *S. commersonii* Lacepede, 1803
      ii. Posterior frontal fontanelles narrow, lateral borders straight; supra-orbital not projecting from frontal, lower gill rakers not more than 23; less than 23 on whole of 3rd arch.
      . . . . 14. *S. bataviensis* Hardenberg, 1933

Based on the foregoing key, the identity of the different species of *Stolephorus* in the report of Tiews (1959) is rectified as follows: *S. indicus* being the largest of the species was properly identified. *S. heterolobus* = **Species A:** Whitehead (1965) and Ronquillo (Ms.) have shown that the descriptions of Hardenberg's *S. pseudoheterolobus* fits the types of *S. heterolobus* Rüppell, hence *S. pseudoheterolobus* = *S. heterolubus; S. commersonii* has been mixed with *S. bataviensis* which is very common in Philippine samples; *S. zollingeri* = *S. buccaneeri* described in 1960 by Strasburg; *S. tri* = *S. commersonii; S. baganensis* = **Species C;** and the unknown species = **Species B**. *S. celebicus* Hardenberg 1933 is a good example of *Engraulis japonicus*. The type of Bleeker's *E. zollingeri* may be this species.

THE FREQUENCY OF *STOLEPHORUS* SPECIES IN SAMPLES TAKEN FROM MANILA BAY AREA DURING THE SURVEY

According to the sampling most species of *Stolephorus* were widely distributed throughout the Archipelago, except **Species B** which was obtained only in Manila Bay after 20 months (341st sample). The most abundant species are obviously *S. heterolobus,* **Species A,** *S. buccaneeri, S. commersonii/bataviensis,* **Species C** and *S. indicus.*

All species were caught in Manila Bay and vicinity nearly throughout the year (Table II). The first 3 sampling months, (November 1956 to January 1957), were disregarded in this synopsis since the sampling design described in chapter II was not yet fully developed. The distinction between *S. heterolobus* and **Species A** was made since August 1957, so that the previous months only one type, i.e. *S. heterolobus* was recorded. While for the species *S. heterolobus, S. buccaneeri* and S. indicus no particular trend in the seasonal abundance can be revealed from the collected materials, there seems to exist a predominant cycle in the accessibility of *S. commersonii/bataviensis* to the fisheries. The last mentioned species were more abundant during the rainy season from August to December and were scarcely available in other months. The decreasing percentage for *S. heterolobus* and **Species A** during the rainy season reflect the main abundance of the former species. The figures do not allow any conclusion as regards, the absolute abundance of species in each area.

However, from the catch statistics prepared by the Statistics Section (Table III) it can be concluded that the main catches were

TABLE II. *Composition change (in %) of the anchovy samples taken from San Andres Market, Malate, Manila from February, 1957 to March 1958.*

Month	Species A	*S. heterolobus*	*S. heterolobus* like	*S. buccaneeri*	*S. commersonni bataviensis*	*S. indicus*	Total fishes
Feb. 1957			74.1	9.4	13.4	3.1	4,337
March			81.3	7.9	4.9	5.9	6,219
April			95.7	0.9	—	3.4	8,528
May			84.5	6.4	—	9.1	5,314
June			71.6	15.8	5.9	6.7	6,659
July			81.4	14.6	3.9	0.1	9,277
August	56.4	13.6	70.1	5.2	24.2	0.5	7,622
September	42.0	11.7	53.7	66.1	31.8	8.4	8,507
October	44.8	17.7	62.6	6.4	23.8	7.2	13,144
November	36.6	5.6	42.2	21.5	26.4	9.9	8,008
December	59.3	13.3	72.6	2.7	13.8	6.2	9,994
Jan. 1958	59.5	46.4	85.9	10.5	3.6	—	13,873
February	49.0	34.8	83.8	7.1	6.4	2.7	7 608
March	62.6	22.2	84.8	9.5	1.5	4.2	15,402

TABLE III. *Anchovy catches in Manila Bay area from January, 1956 to December, 1957 (metric tons).*

Yr.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec	Total
1955	48.1	22.8	3.7	62.3	34.4	50 6	112.2	123.8	95.5	109.1	44.4	15.6	722.5
1956	6.9	4:0	18.1	10.5	8.5	11.7	59.1	27.8	23.2	147.4	134.5	95.3	449.0
1957	5.0	2.0	2.5	0.4	6.5	8.2	38.2	39.5	6.5	32.9	389.5	—	—

made during the second half of the year (June to December) which is characterized by the rainy or southwest monsoon season. It seemed probable that the observed predominant abundance of *S. commersonii/bataviensis* (Table II) during the months from August to December has a strong bearing on the seasonal change in the anchovy fishery, and that further investigations would confirm the preliminary working hypothesis that the success of the anchovy fishery which is strongly seasonal in any locality, depends widely upon the species which gain the largest biomass thereat. On the other hand, research should be made to determine where other species especially *S. commersonii/bataviensis* can be fished during the months of general scarcity.

Remarkable changes in the frequency of appearance of each species of *Stolephorus* were observed in the monthly analyses during the period of research. They are separately computed for each species in Table IV.

From 140 samples taken from August 1957 to March 1958, 71 samples contained specimens of **Species A**, 67 of *S. commersonii/bataviensis*, 63 of *S. heterolobus*, 45 of *S. buccaneeri* and 37 of *S. indicus*. From the 71 samples which contained **Species A**, 35 samples also included *S. commersonii/bataviensis*, 34, *S. buccaneeri;* 33, *S. heterolobus* and 8, *S. indicus*. From the 67 samples in which *S. commersonii/bataviensis* was present, 51 included *S. heterolobus;* 35, **Species A;** 27, *S. buccaneeri;* and 13, *S. indicus*. *S. commersonii/bataviensis* was associated with *S. heterolobus* in 81% of all cases. The second abundant co-species with *S. heterolobus* was **Species A** followed by *S. buccaneeri* and *S. indicus*.

S. buccaneeri was closely associated with the two *S. heterolobus* and **Species A** and also with *S. commersonii/bataviensis*, while it very seldom appeared together with *S. indicus*. The data showed that *S. buccaneeri* had the smallest alliance with *S. indicus*, compared with the other species.

TABLE IV. *Frequency of appearance of* Stolephorus *species in the monthly samples taken from Manila Bay 1957 — 1958.*

Month	Total No. of samples taken	Species A present in following No of samples	*S. heterolobus*	In following No. of samples together with		
				S. buccaneeri	*S. commersonii/ bataviensis*	*S. indicus*
August	11	10	7	3	9	3
September	17	7	6	4	7	0
October	23	11	8	7	7	3
November	19	5	1	2	3	1
December	23	10	1	3	0	0
January	15	7	3	2	3	0
February	12	7	5	5	4	0
March	20	14	2	8	2	1
	140	71	33	34	35	8
		S. heterolobus	Species A	*S. buccaneer.*	*S. commersonii/ bataviensis*	*S. indicus*
August	11	7	7	3	7	2
September	17	11	6	5	11	3
October	23	14	8	6	11	3
November	19	5	1	3	4	1
December	23	8	1	2	7	0
January	15	8	3	6	5	0
February	12	8	5	6	5	1
March	20	4	2	2	2	1
	140	65	33	30	51	11

TABLE IV. *(Cont'd.)*

Month		*S. buccaneeri*	*S. heterolobus*	Species A	*S. commersonii/ bataviensis*	*S. indicus*
August	11	3	3	3	3	0
September	17	5	4	5	5	0
October	23	7	7	6	5	1
November	19	6	2	3	2	1
December	23	5	3	2	2	0
January	15	5	2	3	4	0
February	12	6	5	6	4	1
March	20	8	8	2	2	1
	140	45	34	30	27	4
	Total No. of samples taken	*S. commersonii/ bataviensis*	*S. heterolobus*	Species A	*S. buccaneeri*	*S. indicus*
August	11	10	9	7	3	3
September	17	15	7	11	5	4
October	23	13	7	11	5	3
November	19	9	3	4	2	2
December	23	8	0	7	2	0
January	15	5	3	4	4	0
February	12	5	4	5	4	0
March	20	2	2	2	2	1
	140	67	35	51	27	13

TABLE IV. (*Cont'd.*)

		S. indicus	*S. heterolobus*	Species A	*S. commersonii/ bataviensis*	*S. buccaneeri*
August	11	3	3	2	0	3
September	17	6	0	3	0	4
October	23	9	3	3	1	3
November	19	7	1	1	1	2
December	23	5	0	0	0	0
January	15	0	0	0	0	0
February	12	2	0	1	1	0
March	20	5	1	1	1	1
	140	37	8	11	4	13

S. indicus, although appearing in smaller mixture with the other species, was found in most of the samples with *S. commersonii/bataviensis*, *S. heterolobus* and also with **Species A** but very seldom with *S. buccaneeri*.

The inclination to mix with other species was found to differ in each species. It was noted that *S. indicus* was mixed only at a rate of 43% with other species, while this rate was found to be 72% for **Species A**, 88% for *S. commersonii/bataviensis*, 90% for *S. heterolobus* and 93% for *S. buccaneeri*.

The question of whether or not the different species of *Stolephorus* appear also in mixed population in other fishing grounds, was checked in Batangas Bay and Lucena waters. It was shown that the conditions found in Manila Bay were not general. In Batangas Bay, every week-end one or two samples of anchovy catches were taken by an assistant biologist for 11 months. It was noted that *S. buccaneeri* was represented as a rather pure species in the catches during most of the time and only occasionally were the stocks mixed with a few specimens of **Species A** and other species. This phenomenon may indicate that different species have different distribution centers and that the special hydrographic conditions of Manila Bay attract more species than Batangas Bay. *S. buccaneeri* is also found in more saline waters in other regions of the Indo-Pacific (Ronquillo, MS). The analysis of the length composition of Batangas Bay and Manila Bay samples of *S. buccaneeri* specimens shows that the samples from Batangas Bay must have been close to a spawning centre of this species inasmuch as these specimens were considerably smaller in size than the Manila Bay specimens. However, since many specimens of the size groups 20 and 40 mm. were caught in Manila Bay, this stock of *S. buccaneeri* may be directly related to Batangas Bay population or may be recruited from that locality.

BIONOMICS AND LIFE HISTORY

1. *Reproduction*

a. *Size at maturity*

The species of *Stolephorus* are heterosexual. The species reach maturity at different sizes. The minimum size at maturity was found in *S. heterolobus* and **Species A** at 60 mm. in *S. buccaneeri* at 65 mm. in *S. commersonii/bataviensis* at 65-70

mm. and *S. indicus* which appears to move out of the fishing grounds into the deeper water to breed at 90 mm.

b. *Spawning time*

Comprehensive studies on the determination of the spawning time were undertaken by examining 200 specimens of each species separated into sexes of each sample taken.

The following sexual maturity stages were followed in determining the condition of the gonads (modified from Bückmann, 1929).

Stage I: Immature

Testes: Small transparent, colourless to grey.

Ovaries: Glassy transparent, compact wall and small volume. Eggs not visible with the naked eye, but under the microscope they are glossy transparent, polygonal, curved to one another.

Stage II: Quiet stage

Testes: Small, transparent reddish grey colour.

Ovaries: Translucent, of reddish to reddish grey colour, walls compact, volume solid and readily recognized. Under the miscroscope the eggs are polygonal.

Stage III: Preparing stage

Testes: Opaque, rich in blood capillaries.

Ovaries: Opaque, orange to reddish grey. Volume and size are bigger than stage II, but less compact, rich in capillaries. Numerous big orange eggs with yolk being formed visible to naked eye.

Stage IV: Fusing stage

Testes: Still small in length, reddish to white in colour, walls compact, individual blood vessels readily seen.

Ovaries: Ova non-transparent, orange to reddish. Numerous bigger, transparent orange eggs may be seen. Development of yolk in eggs has started.

Stage V: Developing stage

Testes: Longer opaque, non-transparent, white in colour, wall compact, if pressed white milt runs out slowly.

Ovaries: Opaque orange to reddish white, wall richly vascularized. Contents very compact, but loose spherical translucent eggs present.

Stage VI: Mature

Testes: Translucent creamy white. Milt runs out with slight pressure. Walls loose and soft.

Ovaries: Translucent, reddish, some orange to whitish grey in color. Ovaries filled with loose eggs which run out with slight pressure. All eggs are glassy transparent.

Stage VII: Half-spent

Testes: Non-transparent somewhat reddish white. Walls loose and soft. When pressed milt oozes out.

Ovaries: Walls loose, rich in capillaries. Lumen filled with loose eggs, and much solid transparent tissues. Ova grey to dark red and transparent.

Stage VIII: Spent

Testes: Much shorter in length, dark grey to reddish grey, with loose walls, and rich in blood vessels. No milt runs out when pressed.

Ovaries: Transparent, dark red, walls very loose with numerous folds, very much shorter and bloody. Lots of solid materials, but only with few eggs, sometimes already quite similar to Stage II.

Although *S. heterolobus* and **Species A** breeds throughout the year (Table V) a peak spawning was noted during the northeast monsoon season (October to March); *S. heterolobus* during the first half, **Species A** during the second. This can be distinguished from a period of little or no spawning activity from April to July.

The findings in *S. buccaneeri* are similar with respect to the length of spawning season. However, it is probable that the spawning time begins earlier in June and does not extend to February. No spawning was observed in March, April and May (Table V).

No definite conclusion was reached for *S. indicus*. It seemed that this species migrated out of the Bay into deeper and more saline water to breed and is not accessible to fisheries during the spawning time in the Manila Bay area. However, it appears that the fish apparently returns immediately after spawning, at a time when the walls of the large ovaries are very loose, the ovary empty of mature eggs (Stage VIII) that is spent. The frequent presence of Stage VIII permits the conclusion that this species spawns over

TABLE V. *Percentile share of maturity stages VI-VIII calculated on the total number of mature fish I-VIII (n), determined for* S. heterolobus *(above 60 mm),* Species A *(above 60 mm),* S. buccaneeri *(above 65 mm), and* S. commersonii/bataviensis *(above 65 mm), in Manila Bay,* 1956-1959.

Month	*S. heterolobus*				*Species A*				*S. buccaneeri*				*S. commersonii/bataviensis*			
	Male		Female		Male		Female		Male		Female		Male		Female	
	n	VI-VIII in %	n	VI-VIII in %	n	VI-VIII in %	n	VI-VIII in %	n	VI-VIII in %	n	VI-VIII in %	n	VI-VIII in %	n	VI-VIII in %
Nov. 56	—	—	—	—	—	—	—	—	—	—	—	—	—	—		
Dec. "	187	48.1	181	70.1	—	—	—	—	—	—	—	—	—	—		
Jan. 57	630	48.8	565	24.5	—	—	—	—	—	—	—	—	—	—		
Feb. "	281	52.3	411	21.4	—	—	—	—	138	14.4	137	0.7	279	94.3	297	47.8
Mar. "	374	38.8	328	36.6	—	—	—	—	164	9.1	214	3.3	131	50.2	155	49.0
Apr. "	451	8.9	519	4.1	—	—	—	—	24	0	50	0	—	—	—	—
May "	1007	0.4	824	0.1	—	—	—	—	153	0	181	0	—	—	—	—
June "	1126	15.9	951	10.6	—	—	—	—	439	40.1	394	45.9	154	50.6	156	47.4
July "	973	4.2	1001	1.9	—	—	—	—	613	6.0	488	1.8	135	4.4	119	0.8
Aug. "	847	7.6	711	3.4	405	27.2	274	22.3	173	14.4	157	0.7	507	35.7	304	15.8
Sept. "	708	16.8	592	13.2	275	12.7	207	14.0	284	73.9	166	58.4	806	6.9	628	1.2
Oct. "	950	17.8	713	19.6	110[illegible]	28.5	783	39.6	93	37.6	77	29.9	1175	10.5	1043	6.9
Nov. "	423	6.8	492	12.6	152	6.5	157	10.2	305	16.4	279	21.9	701	16.4	649	16.0
Dec. "	781	9.1	627	7.2	391	20.7	309	21.7	121	12.4	71	0.7	791	15.0	679	22.2
Jan. 58	68	0	109	0.9	190	0	372	0.5	357	9.8	334	11.7	118	1.7	98	0
Feb. "	537	10.4	428	16.6	283	9.2	303	9.2	76	9.2	64	14.0	—	—	—	—
Mar. "	697	10.3	562	13.5	94	0	106	5.7	258	12.8	258	12.7	41	0	59	0
Apr. "	448	3.5	365	.2.2	521	1.2	575	2.9	813	20.5	588	17.3	147	5.4	117	9.4
May "	617	0.6	461	0.4	24	0	29	0	41	0	45	0	39	0	48	0

the longest part of the year. Due to mixture of species it is deemed unwise to draw any conclusion regarding the two species *S. commersonii* and *S. bataviensis* (Table V).

In Table V, the spawning time of four species is roughly represented, based on the compilation of the percentage of maturity Stage VI and above on all specimens longer than the minimum size in which maturity has occurred. A size of 60 mm. was considered the minimum in the case of **Species A** and *S. heterolobus* and 65 *mm for S. buccaneeri.*

c. *Fecundity*

Ovaries of Stages V and VI of the different species were individually preserved in Gilson's solution to separate the eggs. The separated eggs of each ovary were cleaned from the rest of the mesenteries under the binocular miscroscope and were volumetrically measured. The number of eggs was determined by counting a known volume of eggs in a counting chamber under the binocular microscope.

The mature eggs of each species of *Stolephorus* can be distinguished by its shape and size as also found by Delsman (1931). While the eggs of *S. buccaneeri, S. heterolobus* and **Species A** are of

TABLE VI. *Relationship of length and number of eggs in mature ovaries of 3 species of* Stolephorus.

Species	Total length	No. of eggs
S. buccaneeri	72	7956
	77	11294
	78	7510
S. indicus	124	9617
	129	10266
	130	14100
	134	10690
	136	9077
S. commersonii/bataviensis	82	5416
	83	5804
	85	5540
	85	10033
	85	10033
	86	7294
	87	7837
	87	8430

oval shape, without a knob, the eggs of *S. indicus* and *S. commersonii/bataviensis* are characterized by the presence of a knob on one pole of the oval eggs.

The fecundity of 16 fishes were determined in October 1957, and Table VI shows the number of eggs in mature ovaries in relation to the fish length in three species. In *S. buccaneeri* the number of eggs varied from 7,000 to 11,000; in *S. commersonii/bataviensis* from 5,000 to 10,000 and in *S. indicus* from 9,000 to 14,000.

d. *Spawning grounds*

Species A, *S. heterolobus* and *S. buccaneeri* spawn in the deep part of Manila Bay near the fishing grounds. This is supported not only by findings on the maturity stages of the ovary, but also by experimental catches with a Hensen egg net. *Stolephorus* has pelagic eggs. With reference to the egg catches made in a hydrographic survey of Manila Bay (Tiews, 1959) it was found that the greatest number of *Stolephorus* eggs was caught at Station B, situated at the centre of the Bay, followed by Station D and Station C. No eggs were found in Station E, which is far out off the Manila Bay entrance and only few in Station A near Manila (Fig. 1 Table VII).

The planktonic egg catches indicate a peak of spawning from June to August, which do not correspond with the checking of maturity stages of catch samples. However, egg catches as a representation of spawning activity of fish in tropical waters might not be too conclusive because of the very speedy development of such eggs into larvae, due to the high temperature.

2. *Growth estimates and population structure*

The Petersen method was used in this study for determining the growth rate of the most common species, as no other means for an age determination could be detected. A comparison of the length composition of males and females indicated a very similar length composition (Table VIII) in both sexes, and thus, their similar growth; so that the monthly length-frequency curves were based on combined sexes. This could be done especially since studies on the sex ratio for a period of 15 months for 5 species showed a rather even distribution of the sexes in the samples, with males slightly more abundant (Table IX).

The length composition of catch samples from Manila Bay is given in Figs. 2 to 6. The graphs are based on a total of 126 samples of 36,713 specimens of **Species A;** of 213 samples of 119,788

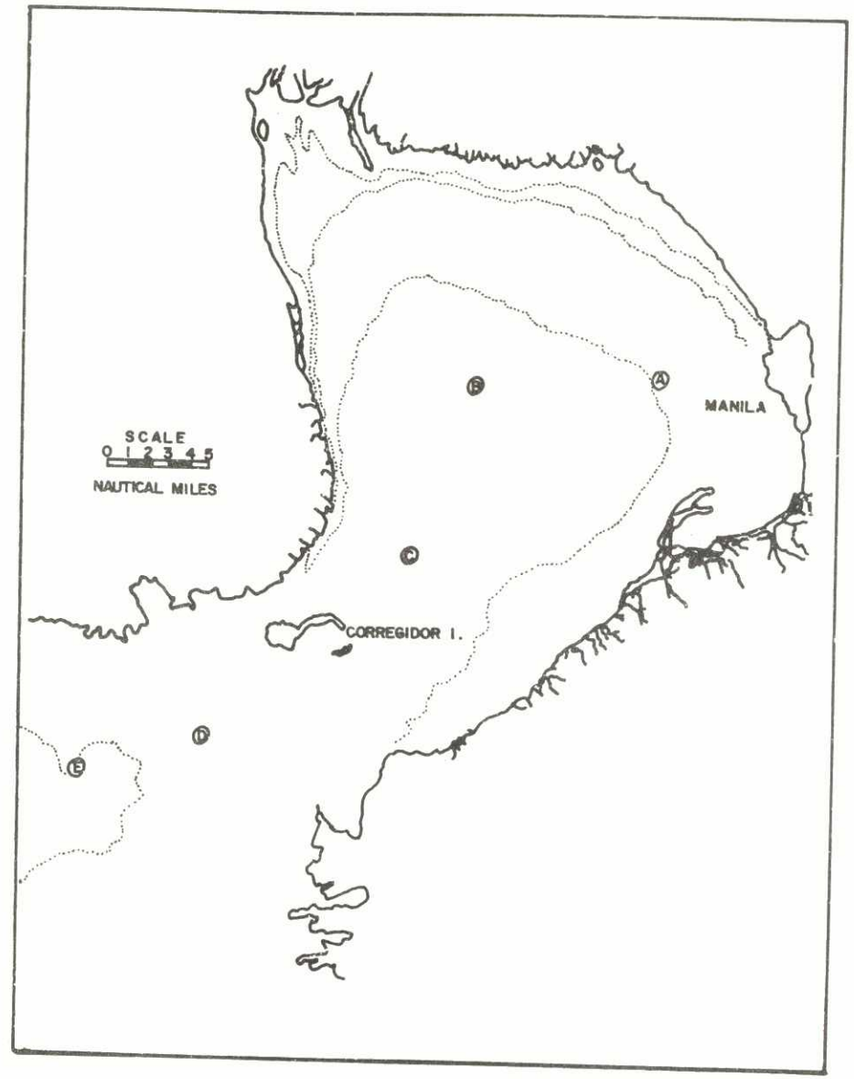

Fig. 1. Station map of MANILA BAY.

TABLE VII. *Average number of* Stolephorus *spp. eggs below 1 m. collected with a Hensen egg net (opening 0.83* m²) *in Manila Bay at Stations A — E (Fig. 1).*

Month	A	B	C	D	E
	Ave. per m²	Ave. per m²	Ave. per m²	Ave. per m²	Ave. per m²
April 1597	0	0	4.0	0	—
May "	4.0	32.4	14.0	0	0
June "	10.0	108.8	27.2	32.3	0
July "	23.6	119.2	0	0	0
Aug. "	10.8	226.2	57.7	2.8	—
Sept. "	14.8	12.3	23.9	157.3	0
Oct. "	0	1.6	0	0.8	0
Nov. "	8.4	0	20.7	0	0
Dec. "	0.4	7.2	0	0	0
Jan. 1958	1.6	17.6	10.8	0	0
Feb. "	8.4	0	0	0	0
Mar. "	1.6	0.8	0	0	0
Total average	7.0	44.3	14.1	16.3	0

specimens of *S. heterolobus;* of 66 samples of 13,141 specimens of *S. commersonii/bataviensis;* and of 89 samples of 8,578 specimens of *S. indicus.*

It appears that for most species, the smallest fishes entered the fishery during the dry season (February to April and even until May which is the end of N.E. monsoon season), although some recruitment were also noted in September, at the end of the S.W. monsoon season. In *S. heterolobus,* the smallest fish were 18 mm.; in **Species A,** 26 mm.; in *S. buccaneeri* and *S. commersonii/bataviensis,* 38 mm.; in *S. indicus,* 66 mm. The findings may be directly related to the distance of the main spawning centers of the different species from the fishing grounds.

The largest specimen of **Species A** found was about 96 mm.; of *S. heterolobus,* 98 mm.; of *S. buccaneeri,* 130 mm. (caught in Batangas Bay, 110 mm. in Manila Bay); of *S. commersonii/bataviensis,* 108 mm. and of *S. indicus* 146 mm. **Species C** was found to have had the least maximun size (172 mm.).

Fig. 2 shows that in the case of *S. heterolobus* up to 5 peaks (May 1957) were noticeable. However, most curves are charac-

TABLE VIII. *Comparison of mean total length (in mm.) of males and females of* Stolephorus *spp. collected in Manila Bay January 1957 to April 1958).*

Species	Month	Male		Female	
		n	x	n	x
S. heterolobus	Jan.-Feb. 1957	1506	65.4	1518	65.8
	Mar.-Apr. "	2573	55.6	2381	57.2
	May-June "	2585	70.7	2148	71.1
	July-Aug. "	1916	70.2	1771	70.7
	Sept.-Oct. "	1681	71.2	1418	71.4
	Nov.-Dec. "	1652	65.6	1444	66.9
	Jan.-Feb. 1958	777	66.8	766	65.6
	Mar.-Apr. "	1464	72.5	1044	74.0
	Jan. 1957-Apr. 1958	14154	67.3	12490	67.8
Species A	July-Aug. 1957	409	71.8	274	72.5
	Sept.-Oct. "	1302	73.4	998	73.8
	Nov.-Dec. "	541	76.3	464	78.4
	Jan.-Feb. 1958	1067	63.5	1093	62.6
	Mar.-Apr. "	980	65.8	890	68.9
	July 1957-Apr. 1958	4299	70.2	3719	71.2
S. buccaneeri	Jan.-Feb. 1957	180	69.9	225	68.0
	Mar.-Apr. "	233	80.2	314	80.2
	May-June "	604	79.7	579	80.4
	July-Aug. "	1063	68.5	870	68.2
	Sept.-Oct. "	588	70.0	426	68.5
	Nov.-Dec. "	1140	68.1	485	69.1
	Jan.-Feb. 1958	728	68.7	611	69.1
	Mar.-Apr. "	1140	79.6	1011	80.0
	Jan. 1957-Apr. 1958	5676	73.1	4521	72.9

TABLE VIII *Continued* . . .

S. commersonii/bataviensis	Jan.-Feb. 1957	283	84.6	297	84.8
	Mar.-Apr. "	140	90.0	163	90.2
	May-June "	185	78.3	207	76.5
	July-Aug. "	642	79.7	487	80.5
	Sept.-Oct. "	1987	80.7	1686	80.7
	Nov.-Dec. "	1503	85.6	1351	85.3
	Jan.-Feb. 1958	202	68.5	217	66.7
	Mar.-Apr. "	192	71.8	182	72.0
	Jan. 1957-Apr. 1958	5134	79.9	4590	79.6
S. indicus	Jan.-Feb. 1957	165	117.8	510	101.4
	Mar.-Apr. "	308	113.1	311	112.1
	May-June "	438	125.2	483	125.7
	July-Aug. "	18	112.4	12	112.2
	Sept.-Oct. "	708	111.1	653	109.8
	Nov.-Dec. "	671	117.2	569	117.7
	Jan.-Feb. 1958	104	124.8	99	130.3
	Mar.-Apr. "	669	122.1	561	121.8
	Jan. 1957-Apr. 1958	3081	118.0	3198	116.4

TABLE IX. *Sex ratio* $\frac{males}{(total)}$ *for Stolephorus species from Manila Bay 1956 — 1958 N = number of samples, n = number of specimens.*

Month	*S. heterolobus*			Species A			*S. buccaneeri*			*S. indicus*			*S. commersonii/ bataviensis*		
	N	n	Sex ratio	N	n	Sex ratio	N	n	Sex ratio	N	n	Sex ratio	N	n	Sex ratio
Nov. 1956	4	822	0.50	—	—	—	—	—	—	2	101	0.49	—	—	—
Dec. "	2	372	0.52	—	—	—	—	—	—	2	289	0.40	—	—	—
Jan. 1957	7	1393	0.55	—	—	—	—	—	—	4	539	0.24	—	—	—
Feb. "	8	1631	0.45	—	—	—	3	405	0.44	1	136	0.26	4	580	0.49
Mar. "	15	2956	0.50	—	—	—	3	473	0.44	3	365	0.52	3	303	0.46
Apr. "	11	1998	0.54	—	—	—	1	74	0.32	4	254	0.46	—	—	—
May "	13	2397	0.54	—	—	—	2	340	0.46	4	475	0.47	—	—	—
June "	12	1336	0.54	—	—	—	5	843	0.53	4	446	0.48	2	392	0 47
July "	12	2097	0.56	—	—	—	12	1592	0.55	—	—	—	2	254	0.53
Aug. "	8	1600	0.54	6	683	0.60	3	341	0.51	1	30	0.60	6	875	0.57
Sept. "	7	1299	0.55	6	479	0.55	3	450	0.63	3	546	0.51	12	1437	0.56
Oct. "	9	1800	0.54	13	1821	0.57	5	564	0.54	6	815	0.52	13	2236	0.53
Nov. "	5	1000	0.49	3	309	0.50	4	812	0.53	5	671	0.55	7	1356	0.52
Dec. "	11	2096	0.55	6	696	0.56	3	255	0.60	5	569	0.52	8	1498	0.53
Jan. 1958	6	524	0.41	8	1477	0.48	5	877	0.54	—	—	—	—	419	0.42
Feb. "	5	1019	0.55	5	683	0.52	4	462	0.56	2	203	0.51	—	—	—
Mar. "	9	1599	0.58	1	200	0.47	4	529	0.49	4	542	0.55	1	107	0.46
Apr. "	6	909	0.60	10	1670	0.53	9	1622	0.54	6	688	0 53	2	267	0.56

terized by not more than one or two modes. The findings that from June to November 1957 only larger specimens, over 45 mm. and mainly over 60 mm. were caught, might be related to the hydrographical condition in the bay. It may be that the younger specimens are sensitive to the lower salinity in the Bay during the rainy season and avoid the fishing grounds. Confusing is the fact that the trend of the shifting of the individual modes in these months is backwardly directed indicating discrete small populations available simultaneously into the fishery. These findings may also have bearings on the different accessibilities of different age groups to the fishery. The absence of smaller fishes during the rainy season and also of larger fishes (over 80 mm.) is certainly a handicap for reaching a definite conclusion on the growth rates of these fishes. Furthermore, the large difference sometimes found in the length composition between successive months considerably complicates the interpretation of the data. Certain eminent groups disappeared in the succeeding period of observation and occasionally appeared again several months later. The only way to interpret the data was therefore to suggest different growth rates and to check hypothetical growth rates against the actual data.

The yearly growth rate was roughly calculated to be about 30 mm. The first mode AA showed a growth from 34 mm. (March 1957) to 70 mm. (June 1958), about 2.4 mm. a month. A second mode BB led to the same result, i.e., this species had grown from 40 mm. (March 1957) to 70 mm. in March 1958 showing a difference of 30 mm. in 12 months (2.5 mm. a month). A third example mode CC at 55 mm. (March 1958) moved to 73 mm. (October 1958) after 7 months with a difference of 17 mm. showing also a growth rate of about 2.4 a month.

Roughly estimated *S. heterolobus* was 30 mm. at the end of its first year, about 60 mm. at the end of the second year and did not get much older than 3 years. Largest specimen found measured 98 mm.

Certainly the above interpretation can be considered only a first attempt to estimate the growth. So, for instance, the growth of the fish was certainly not linear. This example excellently demonstrates the existing difficulties encountered in estimating the age of small tropical fishes which appear to have a protracted breeding period. However, looking at the graph, there is much evidence for the validity

of the calculation, for a total of 9 regressive lines could be arbitrarily drawn.

In the light of this growth estimates *S. heterolobus* most likely spawns in its second year of life and may probably spawn at least twice during its life.

As in *S. heterolobus* growth estimates were carried out also in the other species (Figs. 3-5). It was found that *Species A* (Fig. 3) had a similar growth rate of 30 mm. per annum as *S. heterolobus*. This is in agreement with the growth potential of these two species as indicated by the maximum sizes attained (= little more than 90 mm.).

S. buccaneeri and *S. indicus* showed greater growth rates, of 38-40 mm. per annum in accordance with their respective larger size attained in both species (130 mm. and 146 mm.).

It is likely that fishes less than one year are only caught occasionally by BASNIGAN in Manila Bay during the dry months of February to April and that fishes of less than one to one and a half years old most likely leave Manila Bay during the rainy season when the salinity decreases below 29°/00. Younger fishes return to the bay after the rainy season. The relative length compositions of the catches during the rainy season, from July to November/December 1957 and 1958 is explained by the successive appearance of fishes of the same age but probably of separate spawning groups. This is the only interpretation in this respect as the mode of corresponding length frequencies shifts backward instead of forward.

Presuming the correctness of the interpretation of Figs. 2-5 the conclusion can be reached that the young fishes which leave the fishery during the rainy season return after the rainy season correspondingly older. In fact a regular seasonal rhythm can be concluded in all species.

SUMMARY

1. The genus *Stolephorus* is undoubtedly, the most important group of anchovies in the Philippines, where it was for many years (to 1956), third in importance among the commercial species.
2. Eight species of *Stolephorus* were recognized in this study in 1956-58. One of the authors (Ronquillo) has reviewed

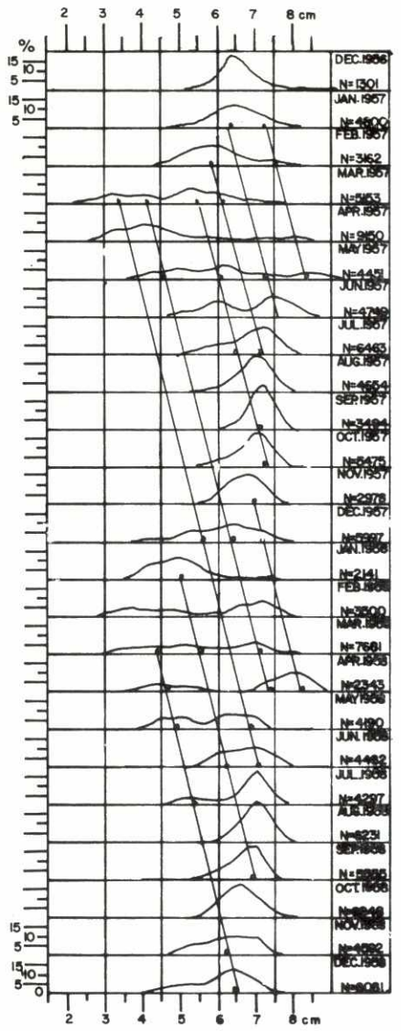

Fig. 2. Length composition of Stolephorus heterolobus.

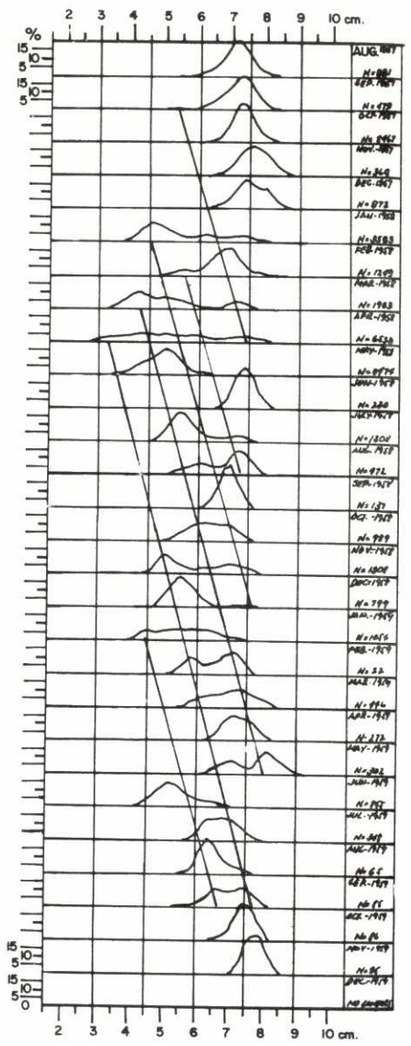

Fig. 3. Length composition of Stolephorus Species A.

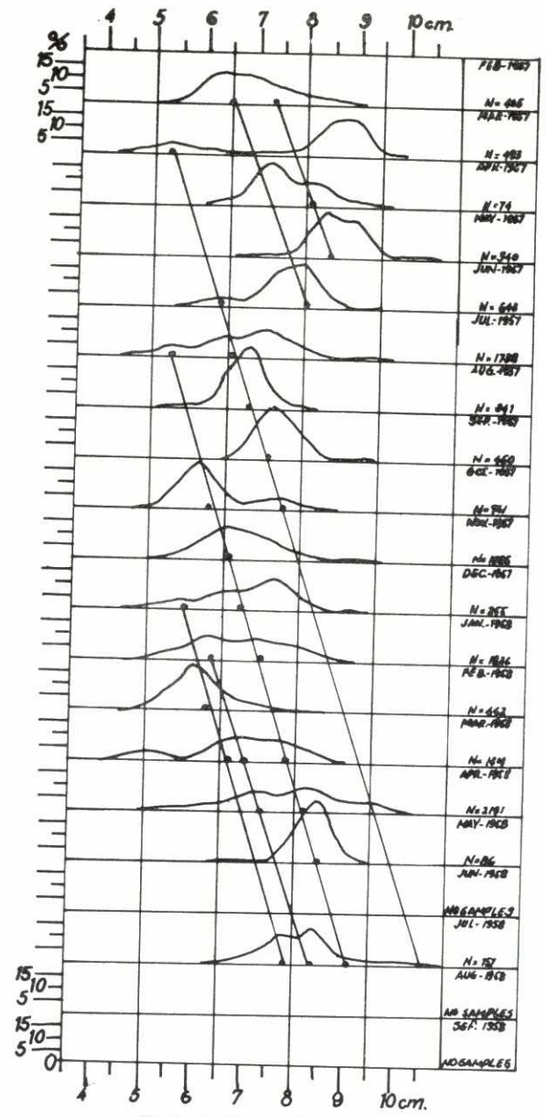

Fig. 4. Length composition of Stolephorus buccaneeri.

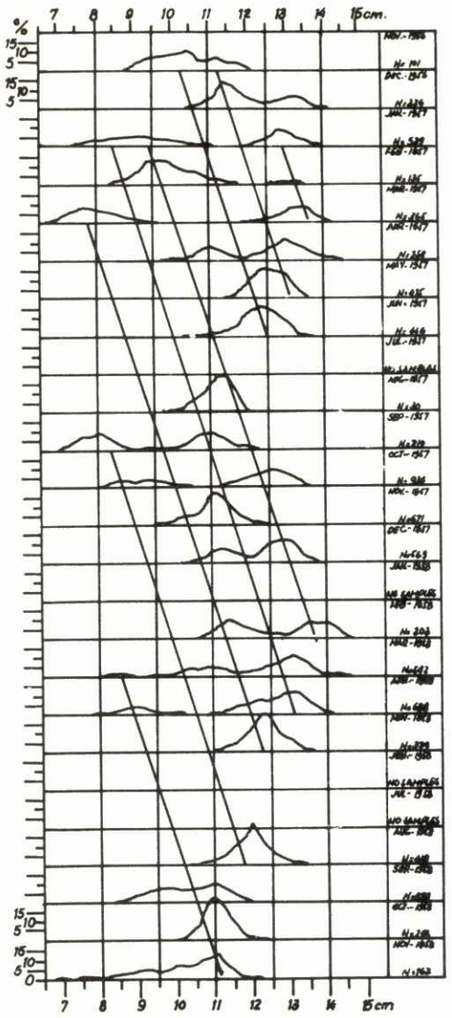

Fig. 5 Length composition of *Stolephorus indicus*.

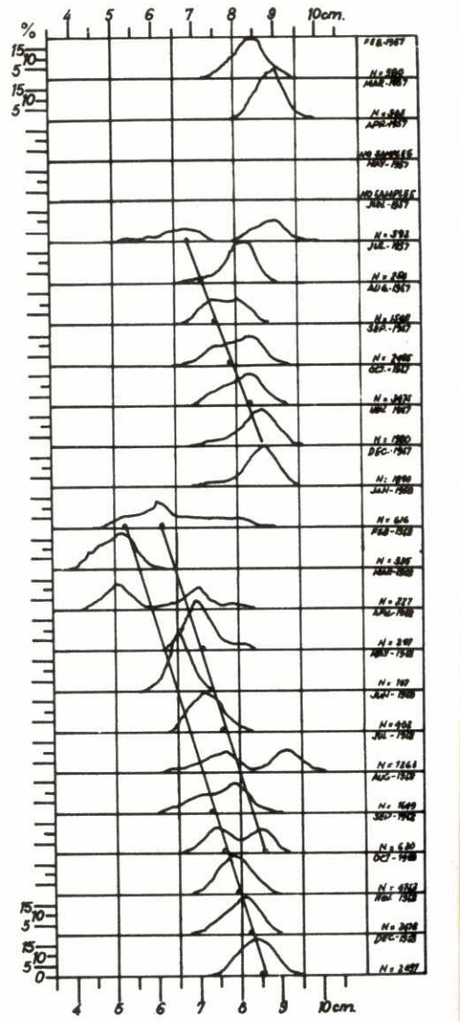

Fig 4. Length composition of *Stolephorus commersonii/bataviensis*.

the genus and a key to the Genus *Stolephorus* based on these preliminary results is herewith included.

3. Most fishes examined were bought in San Andres market from known localities. Additional samples were acquired from the different anchovy fishing grounds. A total of 397 fresh samples totalling 208,530 fishes were studied from Manila Bay area, while 81 samples, totalling 51,530 fishes were collected from other areas of the Archipelago.
4. Our sampling programme showed that most of the eight species of *Stolephorus* were commonly distributed in the country but **Species B** was sampled only once (Manila Bay).
5. The different species of *Stolephorus* tend to intermix in the fishery. There seemed to be a preponderance of *S. heterolobus*, **Species A** and *S. buccaneeri* throughout the year, while *S. commersonii/bataviensis* are more abundant during the rainy season.
6. The anchovy fishery is based primarily on larger fishes, other than one year, in Manila Bay. These fishes appear to breed in their second year of life. Fishes less than 30 mm. are usually not available to the fishery.
7. Maturity is reached at different sizes in each species. The minimum length is about 60 mm. in *S. heterolobus* and **Species A;** 65 mm. in *S. buccaneeri;* 65-70 mm. in *S. commersonii/bataviensis;* and 90 mm. in *S. indicus*.
8. *S. heterolobus*, **Species A** and *S. buccaneeri* have their peak spawning season from August to March with very little spawning during the dry season (April and May). Not enough data were available for the other species, although our samples showed that *S. indicus* may move out of the Bay and not be available to the fishery during its breeding period, only to return soon after.
9. The maturity studies indicate that most species breed inside Manila Bay, in the deeper central part between Corregidor Island and the shallower waters surrounding the Bay. The main concentration of *Stolephorus* eggs was found in the centre of the Bay, thus, confirming the maturity stage studies.
10. Fecundity was studied in few fish. 6,000 — 14,000 eggs were counted.

11. An attempt was made to analyse the growth rate of *S. heterolobus,* the most numerous and prevalent species by means of the Petersen method. It appeared that the smallest fishes were recruited into the fishery from March to May (30-40 mm.). From three examples, the growth increment of this species appeared to be about 30 mm. a year (2.4 mm. a month). A similar growth rate could be concluded for **Species A,** *S. buccaneeri,* and *S. indicus,* with 38-40 mm. per annum, showed a little larger growth rate, the higher growth rate being associated with the greater growth potentiality of the species.

12. The size composition curves showed that there were very numerous discrete population of varying age groups available in the fishery throughout the year, and although the fishery was seasonal due to the prevailing monsoon, unrelated population was available to the fishery.

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