CARIBBEAN JOURNAL OF SCIENCE

VOLUME 9 MARCH-JUNE 1969 NUMBERS 1-2

SEASONAL VARIATION OF THE ZOOPLANKTON FAUNA OF SURFACE WATERS ENTERING THE CARIBBEAN SEA AT BARBADOS

JOHN B. LEWIS AND A. G. FISH

ABSTRACT: Seasonal variations in abundance of 10 species of Siphonophora, 6 Chaetognatha, 2 Mysidacea, 23 Copepoda, larval Decapoda, 10 Eupnausiacea, 10 Pteropoda, 5 Tunicata, 17 Amphipoda and larval fish are described. The relationship between seasonal fluctuations and local hydrography is discussed.

INTRODUCTION

SURFACE water masses entering the Caribbean through the Antilles at Barbados are of two distinct types. During the winter the surface water is of North Equatorial current origin with high salinities and low temperatures while summer water is typically of low salinity and has a relatively higher temperature (Lewis et al, 1962; Ryther et al, 1967; Parr, 1937, 1938). This seasonal change has been noted over a number of years (Lewis et al, 1962; Ryther et al, 1967; Beers et al, 1968). The zooplankton fauna may thus be expected to vary seasonally and changes in zooplankton standing crops have already been reported (Lewis et al, 1962, Calef & Grice, 1967).

The present study describes in detail the seasonal changes in the zooplankton fauna over a two year period from a station off the west coast of Barbados. All of the species collected have not been included in this study nor indeed have all of them been identified. The report is based upon the commonly occurring species, comprising a substantial portion of the standing crop, which are of interest in an assessment of the plankton production of the area. Previous recent investigations of plankton from Barbados waters have been reported by Wickstead (1956), Hall (1955), and by Fish (1960). Accounts of the pelagic copepods of nearby eastern Venezuela waters has been prepared by Legaré (1964) and Cervigon (1962) while Calef and Grice (1967) have considered zooplankton abundance of the tropical Atlantic southeast of Barbados.

METHODS AND MATERIALS

Plankton samples were collected twice monthly at night from a station off the west coast of Barbados, from September of 1958 to August of 1960. This station was situated about 5 miles offshore and was located each time by line of sight from shore markers.

* Contribution from the Bellairs Research Institute of McGill University St. James, Barbados, West Indies.

One meter diameter stramin nets were used for all collections and the nets were towed just below the surface for half hour intervals. Towing speed was estimated at 2 knots.

In order that catches would be comparable on a seasonal basis, unaffected by variations in illumination, all collections were made at the same time each night on nights with no moon or when the sky was completely overcast.

After volume determination, plankton samples were preseved in 5% buffered formalin and made up in a fixed volume. Sub-samples of 50 cc each were removed and all species here reported were sorted and counted from the sub-samples. Counts shown in the figures are means of two monthly collections.

As far as possible representative specimens were sent to specialists for identification. We are grateful to Dr. H. B. Moore for assistance with the euphausids and siphonophores, Dr. L. Pierce for the identification of chaetognaths, Dr. T. E. Bowman for the identification of amphipods and Dr. O. Tattersal for the identification of mysids.

Seasonal variation

Siphonophora

Abyla leuckartii Huxley

This species was taken regularly in small numbers throughout both years.

Abylopsis eschscholtzii Huxley

Both the eudoxid and polygastric generations of this species were collected. The seasonal variation of catches of the eudoxid generation is shown in Fig. 1 for night surface hauls. There was no clear pattern of seasonal variation and the distribution was irregular. The polygastric generation was present only in small numbers. It was a shallow living (40 meters) species in Bermuda with a winter maximum (Moore, 1949). In Florida, Moore (1953) found it occurred most commonly in spring and autumn at a mean depth of 59 meters.

Abylopsis tetragona Otto

Both generations of this species were taken in the collections. They occurred regularly in small numbers. It had a winter maximum both at Bermuda (Moore, 1949) and at Miami (Moore, 1953).

Chelophyes appendiculata (Eschscholtz)

Two generations of *C. appendiculata* were found during both years. The polygastric generation of this species was occassionally abundant in night surface hauls in the winter and spring of both years. The eudoxid generation of *C. appendiculata* showed no apparent seasonal variation in surface hauls. It was reported by Moore (1953) to be rare in Florida but fairly common in Bermuda (Moore, 1940).

Eudoxides mitra (Huxley)

This species was commonest in surface night hauls in the winter and spring of both years. Its occurrence at both Bermuda and Florida was sporadic (Moore, 1949, 1953). It was most abundant in Bermuda at a depth of 125 meters and in Florida at 134 meters.

Eudoxides spiralis (Bigelow)

The superior nectophore only has been identified from the collections. It occurred in only small numbers and was most abundant in February 1959

Diphyes bojani (Eschscholtz)

The polygastric generation of this species was well represented throughout the year. Large numbers of this species were taken at the surface in September of 1958, during the summer months of 1959, and again during May to July of 1960. It was a shallow living (40 meters) species in Bermuda and was most abundant in the winter (Moore, 1949). In Florida Moore (1953)

reported it commonest during the autumn at a mean depth of 72 meters.

The free eudoxid stage has also been identified from the collections. The seasonal variation in catches is illustrated in Fig. 2. It was abundant in the night surface hauls of September 1958 and 1959 and during June and July of 1959 and 1960.

Sulculeolaria quadrivalvis Blainville

Only the polygastric generation of this species has been identified. It occurred in small numbers throughout the year without any evident seasonal peaks.

Hippopodius hippopus Forskol

Nectophores of this species occurred occasionally in the Barbados area in small numbers.

Agalma okeni Eschscholtz

This species occurred regularly throughout both years but was always taken in small numbers.

CHAETOGNATHA

Sagitta enflata Grassi

This species was the most frequently occurring chaetognath from the Barbados area. Fig. 3 illustrates the seasonal variation. Although the smallest numbers were taken in December of both years, the annual variation was irregular and there was no striking seasonal pattern. This species has a cosmopolitan distribution in warmer waters. Ritter-Zahony (1911) reported its range to be between 40°N and 40°S latitude. It has been taken from the west coast of Florida by Pierce (1951), and from Bermuda by Moore (1949). The species is a typical offshore form and has little tolerance for low salinities or high temperatures (Pierce, 1951). Moore stated the mean day-level in Bermuda was 115 meters. Owre (1960) found it was most abundant at a depth of 88 meters in Florida where it had a summer maximum.

Sagitta seratodentata Krohn

This species occurred continuously throughout the years studied. It was not as numerically abundant as *S. enflata*. The largest numbers occurred in February of 1959 in surface hauls. Small numbers only were collected throughout the remainder of the years studied. Moore (1949) reported it as a shallow living species (75 meters) in Bermuda. Owre (1960) stated it was abundant at about 100 meters in Florida and that it had summer and autumn maxima.

Sagitta hispida Conant

This species occurred throughout the years studied in very small numbers. No marked variation in numbers was therefore evident. Specimens were collected by Pierce (1951) from the western coast of Florida. It was reported by Owre (1960) to be a shallow living species (89 meters) in Florida with spring and autumn maxima.

Sagitta hexaptera D'Orbigny

This species was collected in small numbers in surface tows. It was common throughout the year, with a maximum in summer and autumn. Owre (1960) found it was a shallow living species (109 meters) with summer and autumn maxima in Florida. Moore (1949) reported it was most common in summer and autumn in Bermuda and had a day level of abundance at 95 meters.

Pterosagitta draco (Krohn)

This species was present in small numbers throughout the year. A small peak of abundance was evident from September to December 1959. This agrees with the autumn maximum found for the species by Moore (1949) at Bermuda and Owre (1960) in Florida.

Krohnitta subtilis (Grassi)

This species was taken only on a few occasions in the Barbados area. It had

numbers in night surface hauls in January, March and April of 1959 and July of 1960.

Paraphronima gracilis Claus

A few specimens of this species were taken near the surface in May and November of 1959 and January of 1960.

Hyperia fabrei (Milne-Edwards)

This species was taken in small numbers in night surface hauls in the winter and spring of each year from December to May.

Hyperia macrophthalma Vosseler

This species was taken in small numbers in night surface hauls from December to May of both years.

Hyperia thoracica Bovellius

This species was taken in small numbers in night surface hauls from December to May of both years.

Hyperioides longipes Chevreux

A few specimens were taken in night surface hauls from December to May of both years.

Anchylomera blosscvillcii Milne-Edwards

This species occurred in night surface hauls throughout both years but was most abundant in January and February.

Phrosina semilunata Risso

This species was taken in only four occasions in March and May of 1959 and January and March of 1960.

Phronima atlantica Guerin

A small number of specimens were taken from night surface hauls during the winter and spring of both years.

Sympronoe parva (Claus)

This species was taken in very small numbers only on a few occasions in January and February of both years.

Simorhynchotus antennarius (Claus)

Only a small number of specimens of this species were taken in night surface hauls from January to June of 1960.

Streetsia steenstrupii Bovallius

Only a small number of specimens were taken in night surface hauls in the winter months of both years.

Amphithyrus bispinosus Claus

This species was present in small numbers throughout both years in night surface hauls. It was most abundant in the spring and summer.

Hemityphis crustulatus Claus

This species was found on only a few occasions in night surface hauls.

Parascelus edwardsii Claus

This was the most abundantly occurring amphipod taken in Barbados. Fig. 22 shows the seasonal distribution in night surface hauls. It was least abundant during November and December of each year.

FISH LARVAE

The distribution of all the fish larvae taken in night surface hauls is shown in Fig. 23. There was no apparent pattern of seasonal variation and the distribution was irregular.

DISCUSSION

The seasonal variation in zooplankton previously reported from Barbados (Lewis et al, 1962) has indicated a marked increase in zooplankton biomass during the summer periods of both 1959 and 1960. Calef and Grice (1967) have also described increases in the zooplankton population in the wes-

tern tropical Atlantic region in May and June.

It is evident, however, that the same pattern of seasonal variation is not found in all of the component species of the population. Fish (1962) for example, found that copepods were more abundant during January than in the other months of the year in the Barbados area in 1957 and 1958.

In the present study, peaks of abundance of various species of copepods occurred during all seasons of the year. However, the largest numbers of copepods were taken during the winter and summer of 1959 and during the summer of 1960.

Analysis of the seasonal variation of the Euphausiacea also indicated specific differences in seasonal occurrence. *Euphausia tenera* had peaks of abundance in both winter and summer months as did *E. mutica* and *E. americana*. A regular feature of the distribution of the euphausids was however the small number present during the late autumn of both years, from November to January.

The two most abundant species of siphonophores, *Abylopsis eschscholtzii* and *Diphyes bojani* showed peaks of abundance in both winter and summer but were irregular in seasonal variation. *Abylopsis* markedly increased in numbers in March of both 1959 and 1960 and was abundant during the summers of both years as well. *Diphyes* was most abundant during the summer months of both years but also showed an increase in population in the winter of 1959.

Two species of common pteropods, *Hyalocylis striata, Cavolinia longirostris* and *Diacria trispinosa* were most abundant during the winter months while others including *Creseis virgula* had peaks of abundance during the summer.

The most common amphipod, *Parascelus edwardsii* showed no marked variation in seasonal distribution.

The decapod *Lucifer* was most abundant during the late autumn and winter of 1959 and during the autumn of 1960. A single peak of abundance of *Lucifer* also occurred during the summer of 1960. The distribution of larval brachyurans on the other hand was quite regular with two yearly peaks in the spring and autumn. These were likely associated with breeding cycles for Lewis (1960) has recorded spring spawning seasons for a number of brachyuran species.

Possibly the most irregular of the seasonal distributions was that of the larval fish. Marked fluctuations in numbers occurred throughout both years.

Several other features of the seasonal variation in the zooplankton population may be noted. Although a few species such as the euphausids *Thysanopoda aequalis* and *Euphausia pseudogibba* or the copepods *Miracia efferata* and *Pontellina plumata* occurred on only a few occasions during each year, most of the common forms were taken nearly every month. The number of species of each taxon remained nearly constant throughout the year and there was, therefore, no great seasonal variation in diversity of species.

In terms of total numbers of animals captured each month, three groups were consistently dominant in the tows. The data presented in Table 1 illustrates the seasonal variation of various taxa expressed as percentages of the total catch. The copepods, euphausids and siphonphores were most abundant nearly every month.

Annual variations in the size of the total zooplankton biomass were also observed. Zooplankton measured volumes were much higher in the summer of 1959 than in 1960 (Lewis et al, 1962). Total biomass in terms of dry weight was found to be twice as high in the winter of 1962 as in 1963 (Beers et al, 1965). The same authors found winter peaks of zooplankton abundance over a three year period from 1961 to 1963 as well as an increase in the summer of 1962. On the other hand, gross primary production was greater during the summer than during the winter from 1961 to 1963 (Beers et al, 1968).

Fluctuations in abundance were both large and frequent in many species. Such seasonal fluctuations are characteristic of temperate and cold water plankton (Raymont, 1963) and are usually associated with breeding cycles. The work of Moore (1949) in Bermuda and of Bsharah (1957) in the Florida current suggests that small

TABLE 1

COMPARISON OF RELATIVE NUMBERS OF ZOOPLANKTON FROM NIGHT SURFACE HAULS (SEPTEMBER 1958 - AUGUST 1960) EXPRESSED AS PERCENTAGES OF TOTAL ANIMALS PER 50 CC SAMPLE

Month	Amphipods	Copepods	Chaetognaths	Decapods	Euphausiids	Pteropods	Salps	Siphonophores	Others
Sept. ...	0.3	7.2	4.9	9.4	15.8	0.2	1.2	58.5	2.2
Oct.	2.3	17.6	13.6	30.3	13.0	0.4	0.2	20.2	1.7
Nov. ...	0.4	27.5	12.4	5.1	6.2	0.3	0.6	44.8	3.7
Dec. ...	1.1	28.8	11.4	16.3	12.1		0.7	26.6	2.6
Jan. ...	2.1	39.1	14.8	13.0	11.4	0.1	3.7	13.4	1.9
Feb. ...	1.7	47.7	15.4	8.8	8.1	2.5	1.4	10.6	3.4
March .	3.0	31.2	7.3	11.3	28.2	1.0	2.5	11.2	4.1
April ...	7.9	11.5	6.9	10.7	27.3	1.1	0.6	27.5	6.2
May ...	2.5	3.4	8.0	11.4	65.0	0.5	0.3	8.0	6.0
June ...	3.6	14.9	17.2	1.0	27.7	0.9	10.2	28.5	0.8
July ...	3.1	10.7	10.7	1.1	30.1	1.0	11.1	30.9	0.9
Aug. ...	12.2	5.8	6.4	2.4	33.3	2.7	5.3	30.4	1.1
Sept. ...	1.4	29.6	10.0	12.2	10.4	0.5	5.3	26.5	3.6
Oct.	3.2	35.0	8.0	13.6	21.2	0.8	3.4	13.7	1.8
Nov. ...	7.8	30.8	21.2	10.0	9.1	0.5	5.7	10.2	4.0
Dec. ...	17.7	19.5	33.7	1.7	4.1	0.5	4.7	17.7	0.4
Jan. ...	9.1	41.7	5.8	3.9	18.9	0.9	1.8	15.7	1.7
Feb. ...	9.8	7.0	7.0	6.0	54.1	0.1	0.5	10.7	4.4
March .	7.6	41.7	19.7	5.5	13.3	0.4	0.8	6.5	4.5
April ...	15.4	12.4	4.6	7.6	22.6	4.5	4.4	26.0	2.2
May ...	2.1	19.7	2.7	55.5	6.3	1.3	2.5	7.9	1.3
June ...	3.9	8.6	8.1	8.6	47.2	1.3	1.3	19.1	1.8
July ...	8.7	4.8	2.5	6.7	28.4	0.7	0.5	46.7	0.6

seasonal fluctuations in abundance are a feature of the zooplankton of tropical oceanic waters. Wickstead (1958), has, however, demonstrated marked fluctuations in tropical zooplankton in the Singapore Straits which he attributed to hydrographic changes related to the monsoon climate.

The frequent and marked fluctuations in numbers of the Barbados zooplankton suggest an irregularity of distribution which may be associated with variable local hydrographic conditions rather than with seasonal changes in production. Ryther et al (1967) have reported that low salinity surface water occurs in patches east of Barbados during the summer. These patches drift westward and gradually loose their identity in the Caribbean. The surface water flowing past Barbados in the summer may thus be expected to be variable in salinity and other characteristics over rather short periods of time.

The vertical distribution of some of the most abundant species is then of importance because the surface living forms will be most affected by the seasonal surface water changes. The siphonophore *Abylopsis eschscholtzii* for example, is a shallow water form (Moore, 1949) and showed frequent fluctuations in population numbers throughout both years. *Sagitta enflata* is a shallow living form (Owre, 1960) and also showed frequent and large fluctuations in numbers during the spring and summer seasons. On the other hand the numbers of the amphipod *Parascelus edwardsii* were relatively constant during the year and this species in a very deep living form (Reid, 1955; Stephensen, 1926).

It may be concluded, then, that there was considerable individual variation in the seasonal occurrence of the zooplankton species. While copepods were generally most abundant in winter, other species were more abundant in summer water. Thus, frequency of occurrence rather than difference in species composition, distinguished winter from summer water

or winter and summer populations. The zooplankton biomass was variable from year to year and there were marked seasonal fluctuations in numbers. This variability is probably related to the instability of the local hydrographic system.

LITERATURE CITED

BEERS, J. B., D. M. STEVEN, J. B. LEWIS AND D. W. MENZEL 1965. Primary productivity in the tropical north Atlantic off Barbados and the Caribbean Sea off Jamaica. Mim. Rept. Biol. Branch Off. Naval Res Contract NONR *1135* (05): 1-129.

BEERS, J. B., D. M. STEVEN AND JOHN B. LEWIS 1968. Primary productivity in the Caribbean Sea off Jamaica and the tropical north Atlantic off Barbados. Bull. Mar. Sci., *18* (1): 86-104.

BONNEVIE, K. 1933. Pteropoda. Rept. Sar. N. Atlantic deep sea expedition., *3* (1): 1-69.

BSHARAH, L. 1957. Plankton of the Florida Current V. Environmental conditions, standing crop, seasonal and diurnal changes at a station forty miles east of Miami. Bull. Mar. Sci. Gulf and Carib., *7* (3): 210-251.

CALEF, G. W. AND G. D. GRICE 1967. Influence of the Amazon River outflow on the ecology of the western tropical Atlantic II. Zooplankton abundance, copepod distribution, with remarks on the fauna of low-salinity areas. J. Mar. Res. *25* (1): 84-94.

CERVIGON, F. 1962. Contribución al conocimiento de los copépodos pelágicos de las costas de Venezuela. Mem. Soc. Cienc. Nat. La Salle, *22* (63): 181-188.

CHEN, C. AND A. W. H. BÉ 1964. Seasonal distributions of euthecosomatous pteropods in the surface waters of five stations in the western North Atlantic. Bull. Mar. Sci. Gulf and Carib., *14* (2): 185-220.

FARRAN, G. P. 1936. Copepoda. Sci. Rept. Gt. Barrier Reef. Exped., *5* (3): 73-142.

FISH, A. G. 1962. Pelagic copepods from Barbados. Bull. Mar. Sci. Gulf and Carib., *12* (1): 1-38.

HALL, D. N. F. 1955. Recent developments in the Barbadian flying-fish fishery and contributions to the biology of the flying-fish *Hirundichthys affinis* (Günther) Colonial Office, Fishery Publications, *7*: 1-41.

LEGARE, J. E. H. 1964. The pelagic copepoda of eastern Venezuela. 1. The Cariaco Trench. Bol. Inst. Oceanog. Univ. Oriente, *3* (1): 15-81.

LEWIS, J. B. 1954. The occurrence and vertical distribution of the Euphausiacea of the Florida Current. Bull. of Mar. Sci. Gulf and Carib., *4* (4): 265-301.

LEWIS, JOHN B. 1960. The fauna of rocky shores of Barbados, West Indies, Can. J. Zool., *38*, 391-435.

LEWIS, J. B., J. K. BRUNDRITT AND A. G. FISH 1962. The biology of the flying fish *Hirundichthys affinis* (Gunther), Bull. Mar. Sci. Gulf and Carib., *12* (1): 73-94.

MOORE, H. B. 1949. The zooplankton of the upper waters of the Bermuda area of the North Atlantic. Bull. Bing. Ocean. Coll., *12* (2): 1-97.

MOORE, H. B. 1953. Plankton of the Florida Current. II Siphonophora. Bull. Mar. Sci. Gulf and Carib., *2* (4): 559-573.

OWRE, H. B. 1960. Plankton of the Florida Current VI. The Chaetognatha. Bull. Mar. Sci. Gulf and Carib., *10* (3): 255-322.

PARR, A. E. 1937. A contribution to the hydrography of the Caribbean and Cayman Seas. Bull. Bingham Oceanogr. Coll., *5* (4): 1-110.

PARR, A. E. 1938. Further observations on the hydrography of the Eastern Caribbean and adjacent Atlantic waters. Bull. Bingham Oceanogr. Coll., *6* (4): 1-29.

PIERCE, E. L. 1951. The Chaetognatha of the west coast of Florida. Biol. Bull., *100* (3): 206-228.

RAYMONT, J. E. G. 1963. Plankton and Productivity in the Oceans. Pergamon Press, Oxford, London, New York, Paris, viii + 660 pp.

REID, D. M. 1955. Amphipoda (Hyperiidae) of the coast of tropical West Africa. Atlant. Rept., *3*, 7-40.

RITTER-ZAHONY, R. VON 1911. Revision der Chaetognathen. Dtsch. Sudpol. Exped., *13* (5): 1-71.

ROELH, M. G. AND H. B. MOORE 1965. The vertical distribution of some common copepods in the Straits of Florida. Bull. Mar. Sci., *15* (3): 565-570.

ROSE, N. 1929. Copepodes pelagiques particulariérement de surface provenant des campagnes scientifique due Prince Albert 1er de Monaca. Result Camp. Sci. Monaco., *78*: 1-123.

RYTHER, J. H. D. W. MENZEL AND N. CORWIN 1967. Influence of the Amazon River outflow on the ecology of the western tropical Atlantic. I. Hydrography and nutrient chemistry. J. Mar. Res., *25* (1): 69-83.

STEPHENSEN, K. 1926. Hyperiidae-Amphipoda (part 3). Rept. Danish Oceanog. Expd. to the Mediterranean and adjacent seas., 2. D. *4*, 73-149.

STUBBINGS, H. G. 1938. Pteropoda. Sci. Rep. John Murray Exped., *5* (2): 15-33.

TATTERSALL, W. M. 1926. Crustaceans of the

orders Euphausiacea and Mysidacea from the western Atlantic Proc. U.S. Nat. Mus., *69*: 1-31.

WICKSTEAD, J. H. 1956. A note on some pelagic copepods from the West Indies. Barbados Mus. Hist. Soc., *24* (1): 3-28.

WICKSTEAD, J. H. 1958. A survey of the larger zooplankton of the Singapore Straits. J. Cons. Int. Expl. Mar., *23*: 314-353.

WORMELLE, R. 1962. A survey of the standing crop of the Florida current VI. A study of the distribution of the pteropods of the Florida Current. Bull. Mar. Sci. Gulf and Carib., *12* (1): 95-136.

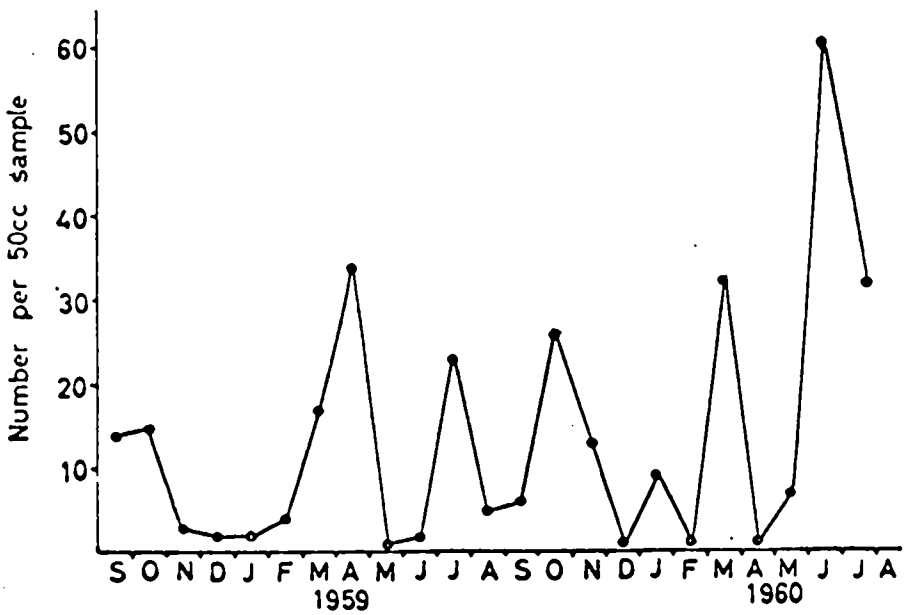

FIG. 1. Seasonal variation in abundance of eudoxid generation of *Abylopsis eschscholtzii*, night surface tows

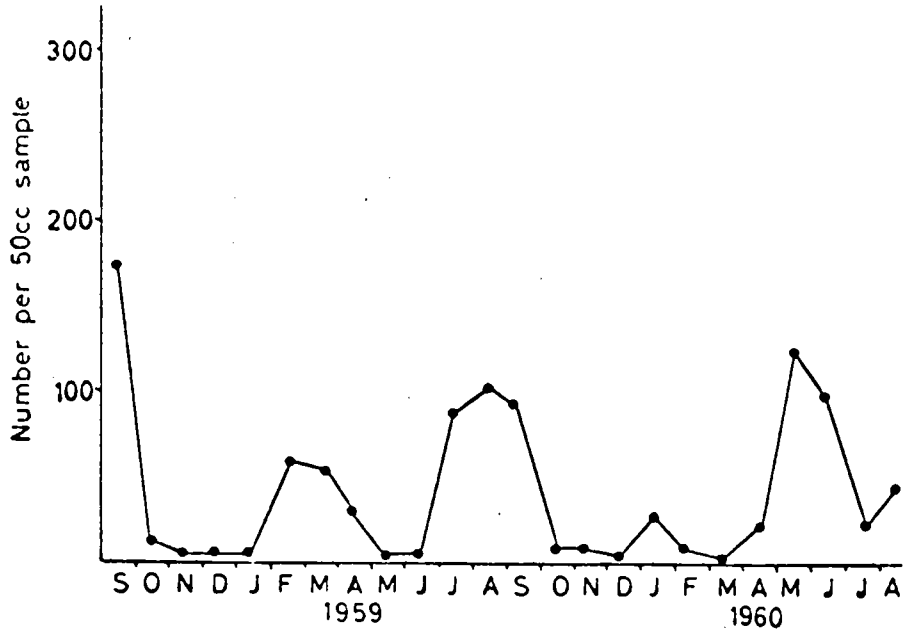

FIG. 2. Seasonal variation in abundance of eudoxid generation of *Diphyes bojani*, night surface tows

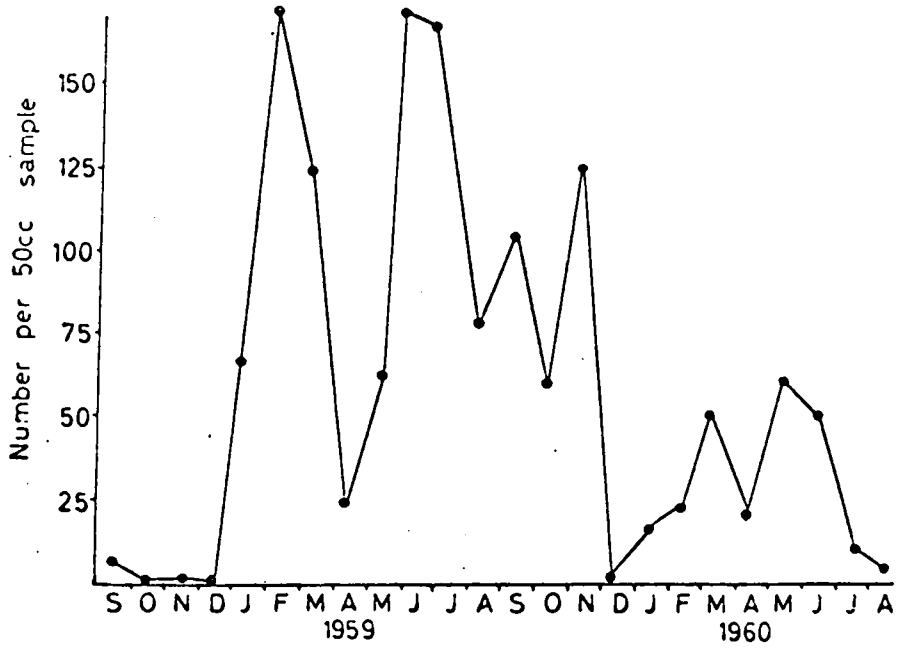

FIG. 3. Seasonal variation in abundance of *Sagitta enflata*, night surface tows.