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The fauna of lanternfishes (Myctophidae, Pisces) in the sound-scattering layers of the epipelagic region in the northwestern part of the Indian Ocean

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The fauna of lanternfishes (Myctophidae, Pisces) in the sound-scattering layers of the epipelagic region in the northwestern part of the Indian Ocean

by S.A. Tsarin

The sound-scattering layers play an important role in the trophic structure of the ocean and the vertical transfer of energy. The direct commercial utilization of the population of the sound-scattering layers also offers certain prospects.

The Myctophidae, which include prolific oceanic forms, are one of the main components, and in many cases the basic one of the fauna of the sound-scattering layers. This paper looks at some of the characteristics of the formation of the myctophid complex in the sound-scattering layers and the natural interrelations of its components.

Material and method. The material for these investigations consisted of the trawl catches carried out during the 8th trip of the "Professor Vodyanitsky" research vessel to the northwestern part of the Indian Ocean (in the area extending from the equator

*The numbers in the right-hand margin are the pages of the Russian text - translator

to 9° N lat and from 54° E long to 60° E long) in March-April 1980 (during the period of the winter monsoon). The sound-scattering layers were recorded on a frequency of 20 kHz with the help of an "Elac-Superladar"* hydroacoustic station. By the fauna of the sound-scattering layers we mean all the animal organisms (regard-
(12)
less of their ability to reflect sound at the given working frequency of the echo sounder) caught from the depth of the sound-scattering layer at the time it was being recorded. The fishing gear consisted of a 20-metre midwater trawl in which the codend was replaced with a 29-metre Isaacs-Kidd trawl in Samyshev's and Aseyev's modification (with a conical insert of No. 10 gauze in the codend portion). All the trawling was carried out within the epipelagic region at depths of the main sound-scattering layer and directly above its upper edge. Each trawling operation lasted one hour; they were carried out during the dark hours, when the sound-scattering layers could be traced clearly.

Systematic composition and dominant species. A total of 44 species of young and adult myctophids from 14 genera has been noted in the study area (Table 1). The adult specimens of the genera Symbolophorus, Centrobranchus and Myctophum (except for M. selenops, M. lunatum, and in the given area possibly M. asperum) are near-surface species and were probably caught at higher levels as the trawls were being hauled out.

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The most abundant genus among the Myctophidae of the sound-scattering layers is the systematically complex Diaphus group. Eighteen species of this genus comprise more than one-third of

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*conjectural spelling - translator

the total numbers and biomass of lanternfishes. The genus Lampanyctus also constitutes a significant part of the catches.

Table 1. Species composition of young and adult lanternfishes in the northwestern part of the Indian Ocean

Genus, species	Study area	
	0–5° c.w.	5–9° c.w.
Hygophum proximum Becker, 1965	+	+
Benthosema fibulata (Gilber et Gramer, 1897)	+	+
B. pterota (Alcock, 1891)	+	+
Diogenichthys panurgus, Bolin, 1946	+	+
Symbolophorus evermanni (Gilbert, 1905)	+	+
S. rufinis Tåning, 1928	+	+
Myctophum aurolaternatum Garman, 1899	+	+
M. apserum (Richadson, 1844)	+	+
M. lychnobium Bolin, 1946	+	+
M. lunatum Becker et Borodulina, 1978	+	+
M. nitidulum Garman, 1899	+	–
M. obtusirostrum Tåning, 1928	+	+
M. selenops Tåning, 1928	+	–
M. spinosum (Steindachner, 1867)	+	+
Centrobranchus andreae (Lütken, 1892)	+	–
Diaphus arabicus Nafpactitis, 1978	+	+
D. fulgens Brauer, 1904	+	+
D. sp. группы Theta (sp. nova)	+	–
D. brachycephalus Tåning, 1928	+	–
D. richardsoni Tåning, 1932	+	–
D. fragilis Tåning, 1928	+	+
D. jenseni Tåning, 1932	+	+
D. malayanus Weber, 1913	+	+
D. lucidus Good and Bean, 1896	+	+
D. lütkeni Brauer, 1904	+	–
D. nielseni Nafpaktitis, 1978	+	+
D. perspicillatus Ogilby, 1898	+	+
D. problematicus Parr, 1928	+	–
D. signatus Gilbert, 1908	+	+
D. splendidus Brauer, 1904	+	–
D. suborbitalis Weber, 1913	+	–
Notolychnus valdiviae (Brauer, 1904)	+	+
Lampadena luminosa (Garman, 1899)	+	–
Triphoturus sp.	+	+
Lampanyctus alatus Good and Bean, 1896	+	+
L. lineatus Tåning, 1928	+	–
L. macropterus (Brauer, 1904)	+	+
L. nobilis Tåning, 1928	+	+
L. intricarius Tåning, 1928	+	–
L. turneri Fowler, 1933	+	–
Bolinichthys longipes Brauer, 1906	+	+
Ceratoscopelus warmingi (Lütken, 1892)	+	+
Notoscopelus candispinosus Johnson, 1863	+	+

The most abundant in the trawl catches were Triphoturus sp. (13.4%), H. proximum (10.2%), D. panurgus (9.8%), D. malayanus (8.7%) and L. macropterus (7.9%) which together constitute one-half of the numbers of all the myctophids.

In biomass, the bulk of the fauna of the sound-scattering layers (39.1%) is made up of H. proximum (14.7%), C. warmingi (12.3%) and D. fragilis (12.1%) (the latter makes up only 1.3% of the numbers of lanternfishes).

Some species have been encountered singly (D. splendidus, D. regani, D. lucidus, Diaphus theta, N. candispinosus, L. lineatus, L. intricarius, M. selenops), some are "near-surface" species (M. aurolaternatus, M. lychnobium, M. nitidulum, M. obtusirostrum, C. andreae), and some are apparently deep-sea species (L. luminosa).

On the whole, the sound-scattering layers of the tropical zone of the Indian Ocean are characterized by a relatively low degree of dominance by individual species because of the abundance of specific forms.

Geographic distribution. According to the zoogeographic zoning of epi- and mesopelagic planktonic organisms, the lanternfishes are confined to certain water masses [2, 4, 6].

Of the "layer" species of myctophids noted in the study area, three have a widely tropical range, i.e. they are found throughout the tropical zone of the ocean. These are L. alatus, N. valdiviae and N. candispinosus. Three species have a distant-neritic tropical type of range (B. fibulata, B. pterota and D. regani). The rest of the "layer" myctophid species studied by us are confined to the central and equatorial water masses, they being central, equatorial and equatorial-central species. At the same time, N. valdiviae, L. nobilis and L. luminosa are circumtropical species.

A study of the species composition of trawl catches and the degree of dominance of the prolific species has shown us that two complexes of "layer" myctophids exist in the given area of the Indian Ocean during the winter monsoon period.

One complex is noted for the region of 9-4° N lat, and is confined to the Arabian water masses; the other is observed from the equator up to approximately 4° N lat, and is confined to the water masses in the equatorial region. When we compare the data of faunistic research with the hydrologic conditions of the given area of the Indian Ocean, we distinguish two sub-regions in this region, "central" (north of 4° N lat) and "subequatorial" (south of 4° N lat).

On the whole, it is impossible to draw a distinct boundary between the geographic subregions in this area, which is obviously due to the absence of a clear dividing line between the water masses, i.e. one water mass gradually passes into the other one.

Twenty-nine species of myctophids from 14 genera are encountered in the central subregion. The basic species of the complex are L. macropterus, Triphoturus sp., H. proximum and D. nielseni, which together constitute 52.9% of the myctophid numbers. L. macropterus is the most abundant species (18.1%). In biomass, the dominant ones are H. proximum and D. signatus, which together constitute 35.1% of it. H. proximum is the predominant one of the two (17.9%). This species may be a miscellaneous group. In the area studied, we observed individuals of both the typical form of Hygophum proximum [1], as well as forms differing from the typical one in colour, relative body height, the position of the Pol_1

photophore and the position of the straight line through Pol_1-Pol_2.

All the 44 species of myctophids recorded in the study area are observed in the subequatorial subregion. The basic species of this community are Triphoturus sp., D. jenseni and D. malayanus (35.2% of all the lanternfishes). The predominant ones in biomass (14) are C. warmingi, D. fragilis and D. perspicillatus, which together make up 40.3% of the total biomass of myctophids. Triphoturus sp. is the most abundant (12.8%), C. warmingi ranks first in biomass (15.8%), and D. fragilis makes up 14.8% of the total biomass of myctophids and only 1.9% of their numbers.

In the northern part of the subequatorial subregion ($4^{\circ}13'$ N lat, $59^{\circ}59'$ E long), we have encountered a species of the genus Diaphus, which belongs to the D. fulgens—D. theta complex; this is probably a new species which has not yet been described. Morphologically, it resembles the D. theta group most of all (in the position of the first AO_a photophore, the position of the straight line through the first and second AO_a photophores, and in the number of AO_p photophores). However, according to the observations of some other authors [8], the species of this group belong to the moderately psychrophilic complex of myctophids, and so the discovery of this species at tropical latitudes is quite unexpected and interesting.

D. lutkeni, D. problematicus, D. richardsoni, D. suborbitalis, D. splendidus, L. turneri, L. nobilis, L. lineatus, L. intricarius and M. selenops of the genera Centrobranchus and Lampanyctus were encountered only in the subequatorial subregion. Only the typical

forms of Hygophum proximum are encountered in this subregion.

In the course of our investigations, we obtained more accurate information about the ranges of some of the species of "layer" myctophids. Specimens of D. brachicephalus were recorded in the northwestern part of the ocean for the first time (0-4° N). It had been thought that they inhabited more southern areas [8]; in fact, this species constituted a significant fraction (13%) of the numbers of myctophids in the sound-scattering layers; these were young fish 0.95-1.4 cm long and weighing 0.02 g on the average.

The species Myctophum lunatum was encountered in the Indian Ocean for the first time (322 specimens, 0-5° N lat, 54-60 E long). This species has been described by V.E. Becker and O.D. Borodulina [3] as part of the species group "M. asperum". It was considered to be endemic in the seas of the Indo-Malayan achipelago.

Most of the specimens of M. lunatum were caught in the subequatorical subregion. It is practically totally replaced by M. asperum north of 4-5° N lat. This type of range was first indicated for the Myctophidae by V.E. Becker and O.D. Borodulina [3] when they described the species M. lunatum in the seas of the Indo-Malayan archipelago where it replaced M. asperum. We observed similar tendencies in regard to a number of other species which are very similar morphologically (e.g. individual species of the genus Benthosema and Diaphus). B. fibulata predominates in the central subregion, and it is replaced by B. pterota in the subequatorial subregion. Most of the D. jenseni are found in the subequatorial part of the ocean, and it is substantially replaced by D. malayanus north of 4° N lat. This is consistent with

published data [7, 8] that the range of D. malayanus extends slightly farther north than that of D. jenseni.

Vertical distribution. Along with the absolute depth of the region inhabited by the species, it is very interesting to study their vertical structure within the sound-scattering layers. When trawling was carried out above the upper edge of the main sound-scattering layer and at its uppermost levels, the catches were found to contain a particular complex of myctophid species, characterized by impoverishment of the species composition and a smaller number of lanternfishes (as compared with the sound-scattering layers), which indicates that most of the interzonal myctophids are concentrated in the sound-scattering layers.

The data from a series of catches carried out in the central subregion give us the most complete picture of the myctophid fauna at the uppermost levels of the sound-scattering layer and above its upper boundary. These samples were found to contain a total of 15 species of myctophids (the number of species varied from 4 to 9 in the individual samples); five of the species are nyctepipelagic. The basic species of the complex directly above the sound-scattering layers were H. proximum and D. panurgus, which together constituted 81.6% of the numbers and 90.1% of the biomass. A 100% occurrence rate is indirect proof that some of the individuals of these species rise to the uppermost levels of the sound-scattering layer and beyond its upper edge (no other species of myctophids is encountered this frequently in the area under study). D. panurgus is probably distributed uniformly within the sound-scattering layer and directly above it, while the concentration

of H. proximum is the highest above the sound-scattering layer and decreases with depth. Most likely, these species are not among the main sound reflectors on the working frequencies used during the given trip.

In one of the samples (6° N lat, 60° E long), we found 39 specimens of "near-surface" S. rufinus which constituted 69.1% of the biomass of myctophids in the given case. This was due to the fact that trawling was carried out above the upper edge of the main sound-scattering layer. D. signatus, D. perspicillatus, M. asperum, as well as the nyctepipelagic species M. lychnobium, M. obtusirostrum and M. spinosum were encountered singly. These catches did not contain any B. longipes, C. warmingi, D. malayanus, N. valdiviae, or species of the genus Lampanyctus which were comparatively numerous in the catches from other depths of the sound-scattering layer.

We could establish some of the tendencies of myctophid distribution within the sound-scattering layers by studying the trawl catches from the same place (0° N lat, 56° E long), but from various depths of the sound-scattering layer, carried out at 24-hr intervals. The species composition and dominance in numbers varied insignificantly, which was apparently due to the insignificant differences in fishing depths. On the other hand, a study of the relative biomass of myctophid species reveals a more distinct picture of the vertical structure of the sound-scattering layer. Large D. problematicus and D. richardsoni predominate at the lower levels of the sound-scattering layer, and large N.

candispinosus make up a significant part of the biomass. The concentration of myctophids was significantly higher at the upper levels.

Only a general picture of the vertical distribution of lanternfishes in the sound-scattering layers can be put together on the basis of these data.

The foremost position at the upper levels of the sound-scattering layers is occupied by D. nielseni which probably rise closer to the surface than any of the other species of this genus [C. warmingi, Triphoturus sp., D. perspicillatus, D. fragilis, B. longipes and N. valdiviae (the last three keep to somewhat greater depths)]. D. problematicus, D. richardsoni, D. signatus, the majority of Lampanyctus species, the fairly common and large D. fragilis and C. warmingi predominate at medium depths of the sound-scattering layers, and the species of Diaphus and Lampanyctus predominated at the lower depths.

In many of the myctophid species, the larger individuals keep to the deeper levels of the sound-scattering layers (Table 2).

Table 2. Size variation of some prolific myctophids depending on the levels of the sound-scattering layers

Species	Average length of myctophids (cm) at different levels of the sound-scattering layers	
	upper	middle
D. fragilis	2.7	6.8
D. perspicillatus	3.6	4.3
D. signatus	2.6	4.0
C. warmingi	2.2	5.0

This indicates that the different species of myctophids in the sound-scattering layers are confined to certain depths. At the same time, some species have a wide vertical range, sometimes extending beyond the sound-scattering layers, while others stay within a comparatively narrow range inside the sound-scattering layers (within the epipelagic region at the time of its existence). Some species at one and the same level of the sound-scattering layers are represented by individuals at all the stages of development; in other species, the larvae, the young and the adults keep to separate levels. Therefore, it often makes sense to speak of the vertical distribution of only individuals of the same age (same size) of a particular species.

Size, body mass, sex ratio. H. proximum. Specimens measuring 1.0-5.2 cm in length and weighing 0.01-1.90 g were found in the catches. The average size varied from 2.0 to 3.8 cm in individual trawl catches, and on the whole amounted to 2.7 cm; the average weight was 0.46 g. This species is represented by two modal groups, 1.0-1.5 cm and 3.5-4.0 cm (Fig. 1); the length of the fish increases slightly toward the equator (Fig. 2). Usually, there were hardly any 2.0-2.5 cm fish in the catches, except in trawl catch No. 8 (Fig. 1). It is interesting to note that this size group is represented by individuals passing from the juvenile stage to the adult stage. Sexual dimorphism is clearly defined in large fish; smaller ones do not usually have their caudal glands yet.

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The sex ratio is approximately 1:1; the number of males in the trawls varied from 40 to 72%. Three specimens of this species

had supra- and infracaudal glands. The gonads of large dissected females were at the fifth stage of maturity. The representatives of both sexes belong to the same modal class, but the average length of the females is slightly greater (3.6 cm compared with 3.4 cm in the males).

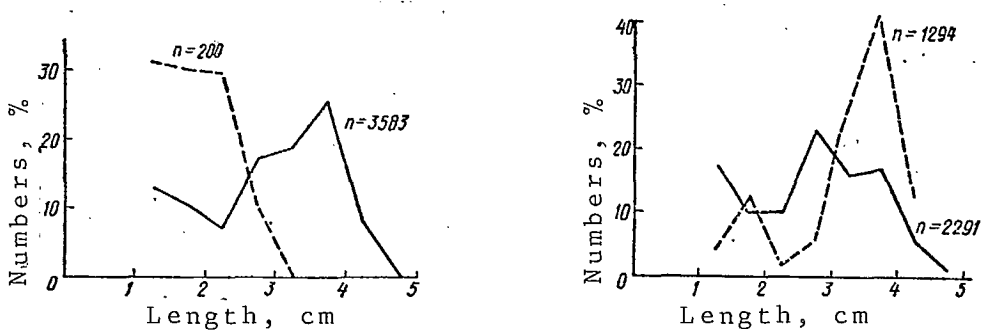

Fig. 1. Size structure of the species H. proximum (continuous line) and its individuals (broken line) from trawl catch No. 8

Fig. 2. Variation of size structure of H. proximum depending on the latitude of the area (north of 4° N - broken line, south of 4° N - continuous line)

D. panurgus. The specimens caught were 1.0-2.3 cm long (average 1.7 cm) and weighed 0.01-0.16 g (average 0.06 g). The modal class was made up of 1.0-1.5 cm individuals (Fig. 3). In male fish, the supracaudal glands can already be seen at a body length of 1.1-1.3 cm, whereas in female fish, sex can be determined by external characters only when they are larger. Both the infra- and supracaudal glands were present in two of the specimens. The sex ratio was 1:1. We observed no sex differences in the size-weight structure of the species.

C. warmingi. This species measures 1.3-7.4 cm (average 3.3 cm) in length. The specimens in the catches weighed from 0.03 to 5.00 g (average 0.87 g). They fell into two modal classes, 1.5-2.0 and 5.5-6.0 cm (Fig. 3), and weighed 0.17-1.20 g (average

0.42 g).

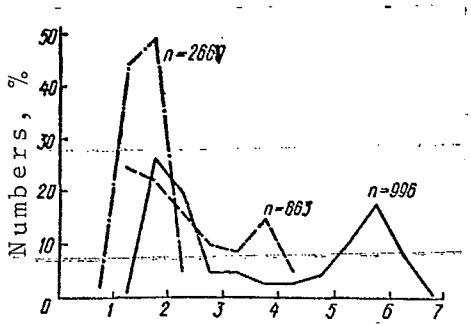

Fig. 3. Size series of C. warmingi (continuous line), B. longipes (broken line) and D. panurgus (dot-and-dash line)

Conclusions. 1. Forty-four species of lanternfishes from 14 genera have been recorded in the ichthyofauna of the sound-scattering layers in the epipelagic region of the northwestern part of the Indian Ocean. One species of the genus Diaphus from the D. fulgens—D. theta complex is probably a new one. M. lunatum was indicated for the Indian Ocean for the first time, and D. brachycephalus for the given latitudes for the first time. 2. In the area of our investigations, Triphoturus sp., H. proximum, D. panurgus, D. malayanus and L. macropterus are the dominant species as to their numbers, together constituting one-half of all the myctophids. H. proximum, D. fragilis and C. warmingi predominate in biomass (39.1% of all the lanternfishes). Of all the myctophid species, Triphoturus sp. ranks first in numbers (13.4%), and H. proximum in biomass (14.7%). 3. Small myctophids (2.0-5.0 cm in length) predominated in the catches. The largest specimens were noted in N. candispinosus (10.0 cm) and D. fragilis (9.6 cm). 4. On the basis of our investigations, two subregions can be singled out in the study area, the "central" subregion (north of 4° N

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lat) where L. macropterus dominates in numbers (18.1%) and H. proximum in biomass (17.9%), and the "subequatorial" subregion (south of 4° N lat) in which Triphoturus sp. ranks first in numbers (12.8%) and C. warmingi in biomass (15.8%). 5. Each of the species of "layer" myctophids has a tendency to be confined to certain depths of the sound-scattering layer.

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S. A. TSARIN

MYCTOPHIDAE (PISCES) FAUNA IN SOUND-SCATTERING LAYERS OF THE INDIAN OCEAN NORTH-WESTERN EPIPELAGIAL

Summary

The sound-scattering layer ichthyofauna of the Indian Ocean epipelagial (northwestern part) is found to contain 44 species from 14 genera. As species forms in zoocoenosis of the region under study are very diverse the dominance degree of particular species is relatively low. Myctophids of small size (2—5 cm) were predominant in the catch. Northwards and southwards of 4°N. L. there occurred a change in species composition and dominance character of abundant species. Each of "layer" myctophid species is confined to certain horizons of sound-scattering layers.

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