

Flødevigen rapportser. 1, 1988 ISSN 0333-2594

FEEDING BEHAVIOUR OF *DIAPHUS DUMERILII* IN NW AFRICA WITH NOTES ON ITS RELATION TO OTHER MYCTOPHIDS IN THE AREA

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ABSTRACT

Alwis, A. de and Gjørseter, J. 1988. Feeding behaviour of *Diaphus dumerilii* in NW Africa with notes on its relation to other myctophids in the area. Flødevigen rapportser. 1, 1988: 55-71.

The feeding pattern of *D. dumerilii* was studied based on material collected by R/V "Dr. Fridtjof Nansen" from west Africa (from Mauritania to Nigeria-Congo area and the Cape Verde Islands) in 1981. The other species, *Diaphus dumerilii*, *D. taaningi*, *Myctophum affine* and *M. nitidulum* from the same area were studied for comparison.

In *D. dumerilii*, copepods were the main forage item while crustacean larvae ranked second in abundance. Euphausiids, larvaceans and salps were also important in the diet. Molluscs, fish, fish larvae and amphipods were less frequently observed. Polychaetes and chaetognaths were rarely found. It is suggested that this species generally is an opportunistic feeder, although it may show a preference for prey species having conspicuous eye pigmentation (i.e. euphausiids), body colour (i.e. crustacean larvae) or other conspicuous features (i.e. pigmented spot on the side of cephalothorax in the copepod *Pleuromamma*). They also seem to select prey taxa with sizes of 1.5-3.5 mm. *D. dumerilii* also showed a tendency for the larger fish to take larger prey items than the smaller fish.

Comparison of the diet of *D. dumerilii* with that of *D. taaningi* and *Myctophum nitidulum* and *M. affine* showed that these species had different feeding patterns.

INTRODUCTION

The mesopelagic fish have been recognized as an important component of oceanic ecosystems and also as a potential fishery resource. This

has encouraged many studies on various aspects of their ecology. The literature on the food and feeding behaviour of mesopelagic fish is growing (Clarke 1978, 1980, Hopkins and Baird 1977, 1985, Kinzer and Schulz 1985), but still the trophic ecology of most species is not sufficiently known.

Diaphus dumerilii is a common tropical myctophid. It is the most abundant representative of this family in the Caribbean Sea and is also abundant in the Mauritanian upwelling (Nafpaktitis et al. 1977). In the eastern central Atlantic it has been caught abundantly in larger pelagic trawls and large catches are also reported off Uruguay (Gjøsæter and Kawaguchi 1980, Gjøsæter and Blindheim 1982).

Some observations on feeding and other aspects of the biology of this species were made by Samyshev and Schetinkin (1973), Gjøsæter and Blindheim (1982) and Kinzer and Schulz (1985).

This paper deals with the feeding behaviour of *D. dumerilii* collected off north western Africa. The main objectives were to study the food composition and its variation between areas and between size groups. The food was also compared to that of some other myctophids caught in the same area.

MATERIALS AND METHODS

Fish for this study were collected by R/V "Dr. Fridtjof Nansen" operating in the west African waters from Mauritania to Nigeria-Congo and off the Cape Verde Islands during August and November-December 1981. Sampling stations are given in Appendices 1 and 2.

The fish were collected using large trawls. The bottom trawl used in this survey was a 134 foot head-line shrimp trawl adapted for demersal fish trawling. The effective vertical opening of the net was about 6 m. The pelagic trawl used was about 120 m in circumference and the vertical opening was about 13 m. The cod end of these trawls was lined with a 10 mm meshed fine net. Pelagic trawl operations were monitored by a 50 KHz acoustic net sonde. Neither the bottom nor the pelagic trawl had opening-closing devices. For more details about the ship and the equipment see Strømme et al. (1983).

A total of about 350 myctophid fish were collected and preserved in 4% formaldehyde immediately after capture. Further identification and bio-

logical studies were carried out in the Department of Fisheries Biology, University of Bergen, Norway. The majority of the fish belonged to the species *Diaphus dumerilii* (>85%). Other species analysed were *Myctophum nitidulum*, *Myctophum affine* and *Diaphus taaningi*.

Stomachs were removed (anterior end of the esophagus to the pyloric constriction) and opened under a binocular dissecting microscope and the contents were placed in a petri dish with few drops of water. The opened stomach was flushed with fresh water to ensure all the adhering materials go into the petri dish. Presence or absence of prey items in the mouth and forepart of the oesophagus was recorded, but not included in the data. The contents of the petri dish were separated carefully, examined under a binocular microscope and measured to the nearest 0.1 mm with an ocular meter. Prey items were identified only to major taxa (usually order). For most abundant prey items the following measurements were made:

Copepods - prosome length

Ostracods, amphipods - maximum carapace length

Other organisms - total length

Number and sizes of prey items observed in the stomachs of each species were recorded. From these data composition of diet, ontogenetical variation etc. were investigated. Standard lengths of all fish were also recorded. For studies of ontogenetical variation, fish were grouped into 10 mm size groups.

RESULTS

1. Prey species composition in *D. dumerilii*

a) Frequency of occurrence

6-56% of the fish taken from the Nigeria-Congo area and Cape Verde Islands had eaten copepods only (Fig. 1). At the single station of Mauritania (station 389) no stomachs were found with copepods alone. Occurrence of stomachs with copepods and other items together ranged from 6-92% in all but station 379 of the Cape Verde Islands.

The crustacean larvae alone or in combination with other prey items ranked second in frequency of occurrence (Fig. 1). Crustacean larvae alone

were found in 2.40% of stomachs of fish from four sampling stations (stations 214 and 234 of the Nigeria-Congo area and stations 354 and 379 of the Cape Verde Islands). 4.28% of stomachs at all stations, except stations 365 and 379 of Cape Verde Islands, had copepods and crustacean larvae together. Only two stations in the Nigeria-Congo area (stations 214 and 234) had stomachs with crustacean larvae together with other prey items (20% and 1% respectively).

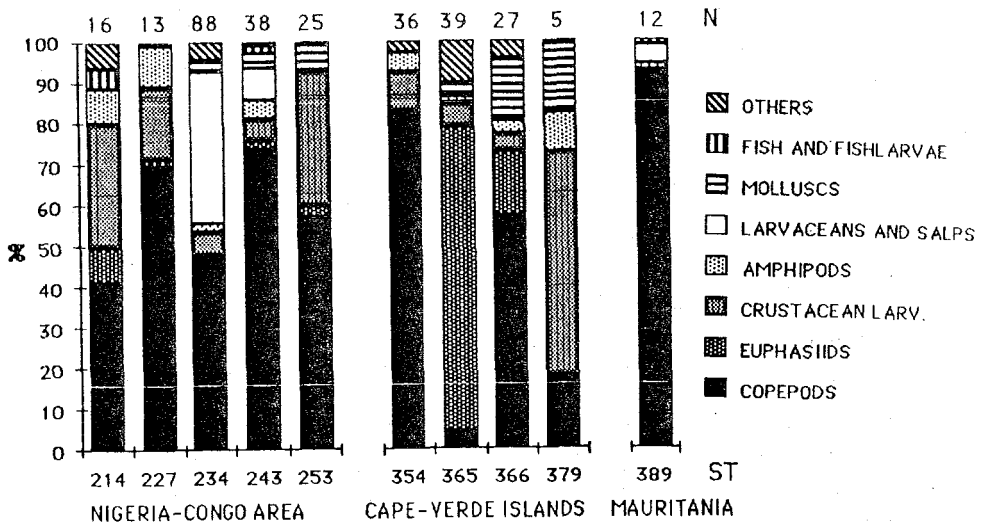


Fig. 1. Frequency of occurrence of prey items in *Diaphus dumerilii*. Station numbers and sampling area are indicated below the bars, and number of fishes studied at each station are shown above the bars.

Fish stomachs from stations 243 and 253 of the Nigeria-Congo area, and stations 365 and 366 of the Cape Verde Islands had euphausiids in their diet and the highest frequency of occurrence (67% of the stomachs) was observed at station 365 (Fig. 1).

Larvaceans and salps alone or together with other prey were found in fish taken from three stations (stations 234 and 243 of the Nigeria-Congo area and station 389 of Mauritania). Fish from station 389 had the highest frequency of occurrence (42% had copepods with larvaceans and salps and 8% had larvaceans and salps only) (Fig. 1).

Other organisms recorded frequently were amphipods and molluscs (Fig. 1). Fish and fish larvae were also observed but less frequently.

b) Number of prey items

Fig. 2 shows the prey composition given as number of food items in each category as a percentage of all food eaten by fish from the three areas considered. The general pattern is fairly similar. Copepods played a main role in the diet in all three areas. Crustacean larvae and larvaceans and salps were also important in the Nigeria-Congo area, and euphausiids

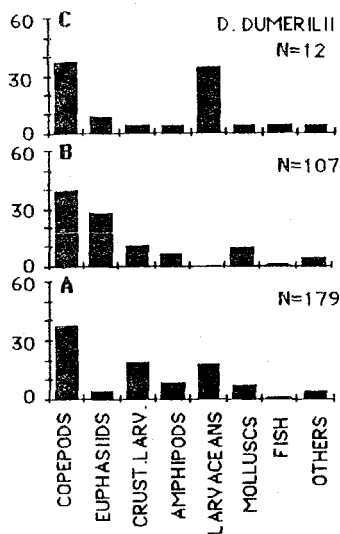


Fig. 2. Prey composition of *Diaphus dumerilii* caught in A: the Nigeria-Congo area, B: around the Cape Verde Islands and C: off Mauritania. The number of items of each food category is given as percentage of all identified food items.

were more important in the Cape Verde Islands. The most striking difference was the frequency of larvaceans and salps which was zero off the Cape Verde Islands, more than 18% in the southern area and 34% at the single station taken off Mauritania.

2) Ontogenetical variations in feeding

Ontogenetical variations in feeding could be related to type and size of food items and to the number of food items per stomach.

The data do not suggest any clear variation in preference of prey items with fish size, although copepods were taken more frequently by young fish in the Cape Verde Islands area (Fig. 3). The material is, however, not suited to a detailed statistical analysis.

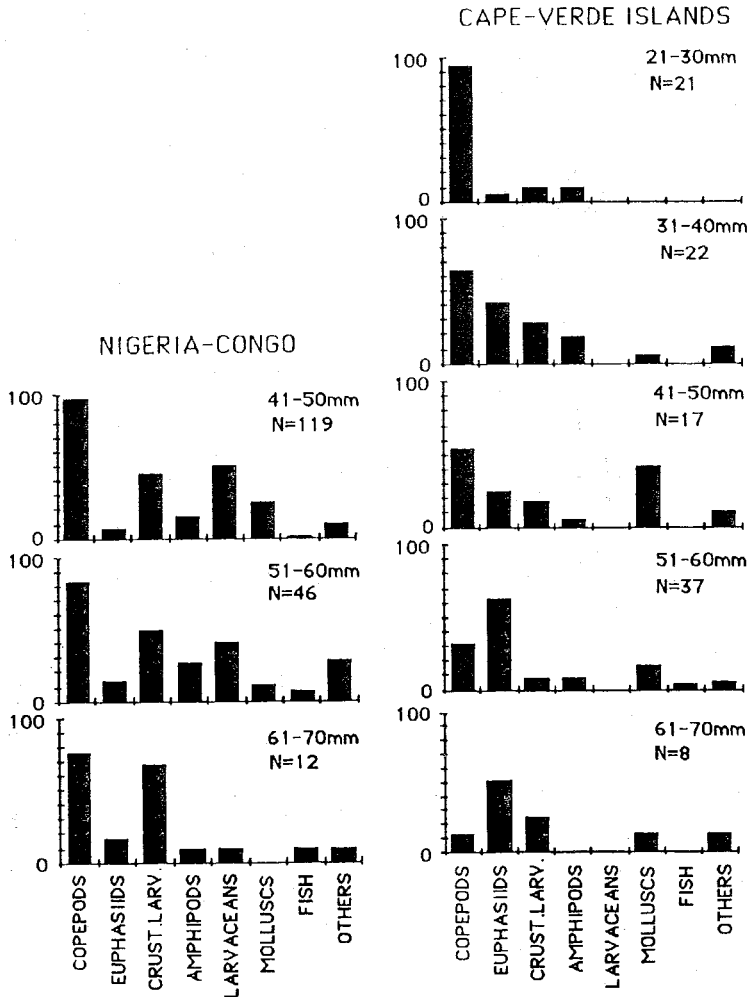


Fig. 3. Variation in prey with fish size. Number of prey in various taxa as percentage of total number of prey taken. The figures give fish size and number of fish studied in each category (N).

The size of food items in different size groups of fish is shown in Fig. 4. For copepods, the smallest prey item, there was a weak increasing trend in size with increasing fish size. For euphausiids, the largest prey items, there was a clear tendency for larger fish to take larger prey sizes. In the other two groups studied (amphipods and crustacean larvae), no obvious trend was observed. Larger fish could obviously eat a larger

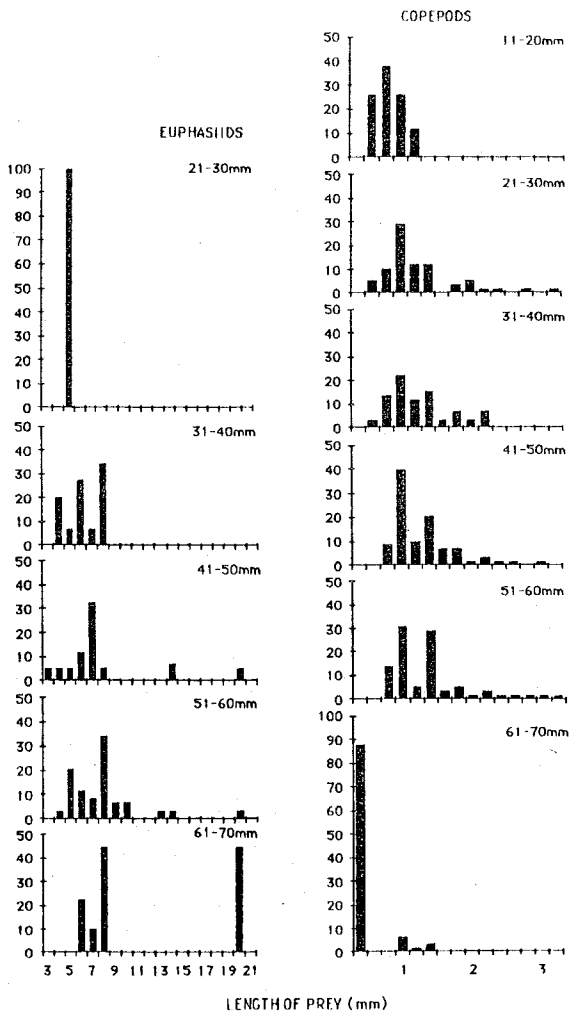


Fig. 4. Relation between length of *D. dumertli* and size of prey.

number of food items than smaller fish, as exemplified by copepods (Fig. 5). The median number of copepods in a fish stomach did not, however, change much with fish size.

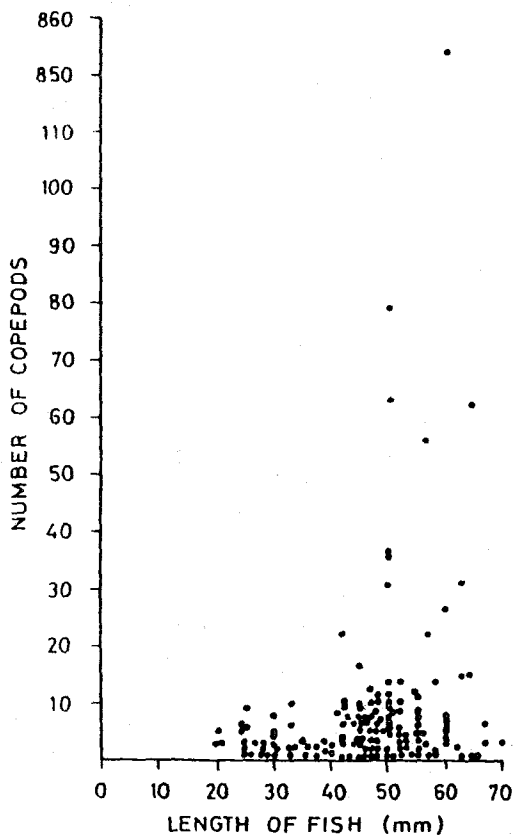


Fig. 5. Relation between length of *D. dumerilii* and number of copepods eaten.

3) Co-variation between copepods and larvaceans/salps in *D. dumerilii*

At one station where copepods, larvaceans and salps frequently occurred in the same stomach, graphs were plotted to study the relationship of prey preference (Fig. 6). It could be expected that some fish would specialize in copepods and others on larvaceans and salps.

No statistical tests were performed as the samples in these two stations were few and the distribution of these prey items in the area was not known.

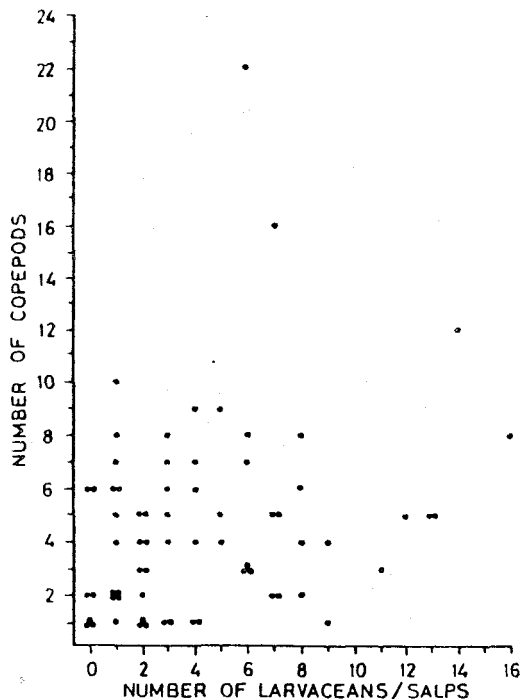


Fig. 6. Relation between numbers of larvaceans or salps eaten by a *D. dumerilii* and the number of copepods eaten by the same fish.

4) Variation of feeding in *D. dumerilii*

Often different fish specimens taken at one station showed a great difference in composition of the stomach contents.

For some important taxa of food items, analysis of variance was conducted to compare the variation in number of items eaten by fish caught within a station with the variation between stations (Zar, 1974). Table 1 summarizes the analysis. In all cases the variation between stations was significantly higher than the variation within a station.

4) Food of other species in the area and a comparison with that of *D. Dumerilii*

At station 232 three fish species were caught. They were *Myctophum nitidulum*, *M. affine* and *Diaphus taaningi*. Frequency of occurrence of stomachs with copepods alone or together with other items were very

Table 1

Analysis of variance to compare the variation in number of items eaten by fish caught within a station with that between stations.

Prey item	Number of stations	Number of fish	Number of prey items	SS tot DF	F
copepods	10	295	2202	134.2	31.9
crustacean larvae	10	295	281	10.0	134.0
larvaceans/salps	3	137	301	14.1	26.1
amphipods	9	270	111	8.5	46.8
euphausiids	8	254	107	1.5	50.2

high in both *M. affine* (81%) and *D. taaningi* (86%). In contrast, stomachs of *M. nitidulum* had a high percentage of crustacean larvae alone or together with other food items (Fig. 7). In *D. taaningi*, no crustacean larvae were found but 57% of the fish had eaten larvaceans and salps (either alone or together with copepods). Two *Myctophum* species, on

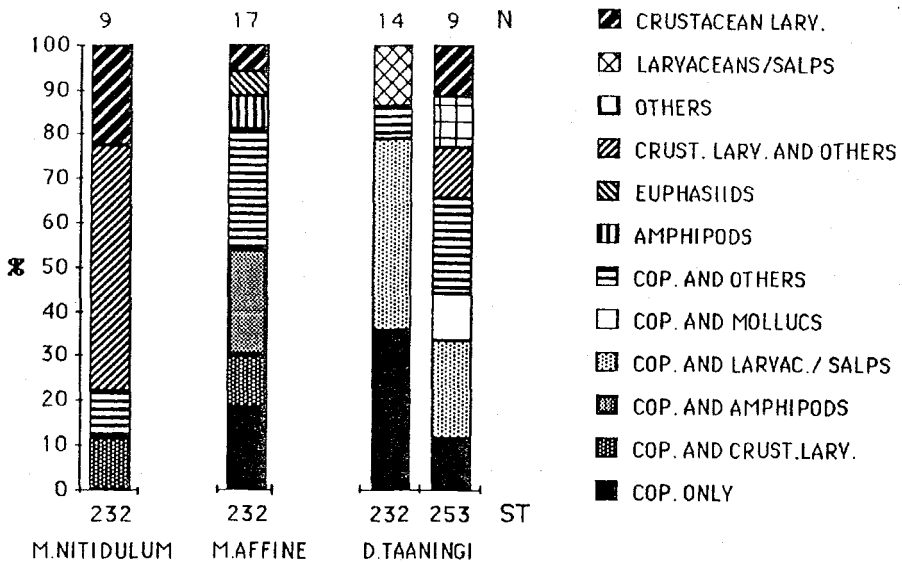


Fig. 7. Frequency of occurrence of prey items in *Myctophum nitidulum*, *M. affine* and *Diaphus daaningi*. Station numbers are indicated below the bars and number of fish studied at each station above the bars.

the other hand had no larvaceans and salps. *M. affine* also had taken a different diet than the other two species (Fig. 8)

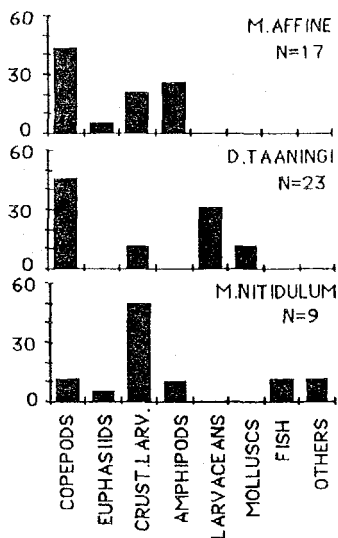


Fig. 8. Prey composition of *Myctophum nitidulum*, *M. affine* and *Diaphus taaningi* from the Nigeria-Congo area. The number of items of each food category is given as percentage of all identified food items.

No *D. dumerilii* were caught from station 232. But this species taken from a close station (station 234) had eaten copepods (more than 90% of fish had eaten copepods alone or together with other prey items). Larvaceans and salps were also fairly important in their diet.

D. taaningi was also caught at station 253. The main difference between this species and *D. dumerilii* at this station was that *D. taaningi* had eaten larvaceans and salps. Copepods showed a lower dominance in this species than in *D. dumerilii*. However, the material of other species considered here is too small for a detailed analysis.

DISCUSSION

A number of investigators have pointed out that feeding in the cod-end of the net is one of the main sources of error encountered in food studies. However, in the present study net feeding was quite unlikely to occur since the mesh size used in the cod-end (1 cm) was too coarse to hold

the small items like copepods which were very dominant in their diet. On the other hand, if they had eaten more larger items like euphausiids and fish larvae which could have been retained in the cod-end, occurrence of fresh specimens of prey in their mouths or foreparts of the oesophagus could be expected. But no such observations were made. There were no newly ingested fish scales in the stomachs or in the mouths of fish which could also be an indication of net feeding. Thus it can be assumed that the food composition observed in fish reflect their true food consumption in the natural environment. Various studies on the diet of *D. dumerilii* have given highly variable results.

Copepods were the dominant prey item of *D. dumerilii* in the present study (Fig. 1, 2).

Crustacean larvae were second highest in the diet. Euphausiids, larvaecans and salps also played an important role. Molluscs, fish, fish larvae and amphipods were observed less frequently. Polychaetes and chaetognaths were very rarely observed (which are included in the "other prey" category in the analysis). The contribution by larvaceans and salps (34%) in the single station taken of Mauritania (Fig. 3) was another interesting observation in this study.

Samyshev and Schitinkin (1973) studied the feeding pattern of *D. dumerilii* from the shelf slope in the northwestern African areas. They found the most significant food of this species to be Euphausiacea. Copepods were less numerous than decapod larvae. Kinzer and Schulz (1985), using samples of *D. dumerilii* from the central equatorial Atlantic, found copepods to be dominant. Appendicularians made up to 30% of the food items at one station. They also found ostracods, amphipods, euphausiids and gastropods. Hopkins and Baird (1977) indicate the dominance of copepods in the diet of *D. dumerilii* collected from the Gulf of Mexico. They have observed that copepods were nearly 50% in number of the diet of this species while decapods contributed about 30%. Larvaceans and salps (5%) and amphipods (3%) were also among their diet. The contribution from euphausiids was very small (0.6%).

High variation in number of prey items eaten by fish between stations compared with that of within stations (Table 1) support the assumption that the food composition is determined by the composition and quantitative ratio of the prey items in the sea (Cassie 1963, Collard 1970, Gorelova 1975). Vertical migratory patterns of zooplankton, like copepods and euphausiids, can also change the composition at a given time and

depth (Kinzer 1977, Clarke 1978, Scotto di Carlo et al. 1982). In the present study all the samples at different stations were taken during night hours from layers between 5 and 70 m depth (Appendix 2). Therefore it is not surprising to find the stomachs containing prey items like copepods and euphausiids predominantly, which migrate vertically in the night to the upper layers of the ocean.

The high percentage of larvaceans and salps at the station off Mauritania can be explained by the swarm behaviour of this prey species (Alldredge and Madin 1982). Differences in the species composition of the diet of *D. dumerilii* in the present study and previous studies (Samyshev and Schetinkin 1973, Hopkins and Baird 1977, Kinzer and Schulz 1985) could also be due to seasonal and regional variations.

The composition of a wide range of prey types shown by the species in this study and variations shown in different areas and seasons suggest that *D. dumerilii* would be classified as an opportunistic feeder in which a significant proportion of diet is a function of prey availability.

In this investigation most of the food items were in an advanced stage of digestion, therefore identification of prey taxa to genus was difficult. Nonetheless, more than 80% of the copepods that could be identified belonged to the genus *Pleuromamma* which was identifiable by the large pigmented spot on the side of the cephalothorax. The size range of this genus is usually between 1.5 - 3.5 mm (Wickstead 1965). The crustacean larvae observed were the larval stages of crabs which were conspicuous in colour (dark brown). Euphausiids found in the stomachs also had heavy eye pigmentation. Therefore, the selectivity pattern of *D. dumerilii* may have involved taxonomic selectivity, for species having conspicuous pigmentation, and therefore is easy to see. Preferential feeding on specific prey taxa has also been observed in several other studies (Hartmann and Weikers 1969, Merrett and Roe 1974, De Alwis 1984).

The fish we studied had mainly eaten prey smaller than 3 mm. Samyshev and Schitinkin (1973), on the other hand, point out that this species preferred relatively larger (10-20 mm and more) prey and they correlated this preference with the wide space between the gill-rakers. Clarke (1980) also suggests that the gill-raker space is one of the main factors affecting the size distribution of prey items taken by mesopelagic fish. However, the present study does not support this hypothesis as these fish had taken copepods as small as 0.2 mm whereas their gill-raker spaces were between 0.32 and 0.96 mm. This also agrees with the hypo-

thesis that these fish do not simply filter food, but catch single items. Previous studies also support this hypothesis (De Alwis 1984).

Comparison of the food of *D. dumerilii* with that of *Myctophum nitidulum*, *M. affine* and *Diaphus taaaningi* (Fig. 2, 3) suggest resource partitioning between species. A high frequency of occurrence of crustacean larvae in the stomachs of *M. nitidulum* in the Nigeria-Congo area in contrast with *M. affine*, *D. taaaningi* and *D. dumerilii*, and also the high frequency of occurrence of larvaceans and salps in the stomachs of *D. taaaningi* in contrast to *D. dumerilii* from another station of the same area, indicate different preference, but no firm conclusions can be made based on the present materials.

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