ON THE FOOD OF CAPELIN IN THE SUBARCTIC WATERS NORTH OF ICELAND

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The food of capelin, *Mallotus villosus* (MÜLLER), caught in July and November 1993 and in June-July 1994 in the waters north of Iceland was investigated. A total of 716 stomachs of capelin ranging in length from 2.1 to 20.0 cm were examined. Of these 575 or 80 % were found to contain food. Empty stomachs were most frequent amongst the smaller length classes and more so in winter than summer. On average the stomach content was only ca 2 mg dry weight in November, while in June-July it was ca 78 mg dry weight. Copepods were numerically the most important identifiable food component in all length classes, constituting ca 92-99 % in July and ca 65-93 % in November. *Calanus finmarchicus* (GUNNERUS) was the most abundant copepod species, ranging in July from ca 14 to 65 % of identifiable copepods and in November from ca 19 to 85 % of the copepods. *C. hyperboreus* (KRØYER) was the second most numerous copepod in the stomachs. When the food was considered in terms of weight copepods constituted 71-100% of the weight of the food in July while euphausiids made up 0-23 %. In November the dry weight composition of the food was generally similar to that observed in July. In terms of dry weight the importance of copepods in the diet decreased with the size of the capelin while the opposite was true for euphausiids. The food of capelin was found to be largely similar to the composition of zooplankton in the sea indicating that limited food selection was taking place.

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INTRODUCTION

Capelin is by far the most important pelagic fish stock in Icelandic waters (VILHJÁLMSSON 1983, 1994). Further, capelin is the most important prey of cod in Icelandic waters (MAGNÚSSON & PÁLSSON 1989), which is in turn the most important demersal fish stock in the area (SCHOPKA & MARTEINSDÓTTIR 1994). Changes in the stock size of the capelin have been reflected in the growth of the cod stock (MAGNÚSSON & PÁLSSON 1989) thus demonstrating its key role in the trophic relations in the waters around Iceland.

Commercial exploitation of the Icelandic capelin stock began in the late sixties and during the period of its exploitation the capelin stock has undergone major changes in stock size. The changes in adult stock size have been attributed to heavy fishing, but environmental factors also seem to play an important role in the annual recruitment (VILHJÁLMSSON 1983, 1994).

Limited information is available on the food and feeding of capelin in the waters around Iceland. SÆMUNDSSON (1926) mentioned some important food components but provided no quantitative data. JÓNSSON & FRIÐGEIRSSON (1986) and PÁLSSON (1973, 1974, 1977), respectively, reported on the food of the larvae and the 0-group. The only quantitative information available on the food of the older age classes of the Icelandic capelin is based on material sampled during the autumn and early winter months (SIGURÐSSON & ASTTHORSSON 1991).

The information available on the food and feeding of capelin from other boreal and arctic ecosystems is also rather limited. Thus the food of the capelin in the Barents Sea was investigated by PANASENKO (1981, 1984), PANASENKO & NESTEROVA (1983), ELLERTSEN & al. (1982), AJIAD & PUSHAEVA (1991) and HUSE & TORESEN (1996), while VESIN & al. (1981) reported on the food of the capelin in Canadian waters. Further, HASSEL & al. (1991) recently reported on the impact of grazing from capelin in the northern Barents Sea.

The present paper presents the first quantitative information on the food and feeding of the Icelandic capelin stock as observed during its main feeding period in summer. Such information is an important prerequisite for understanding its dynamics and role in the marine ecosystem around Iceland.

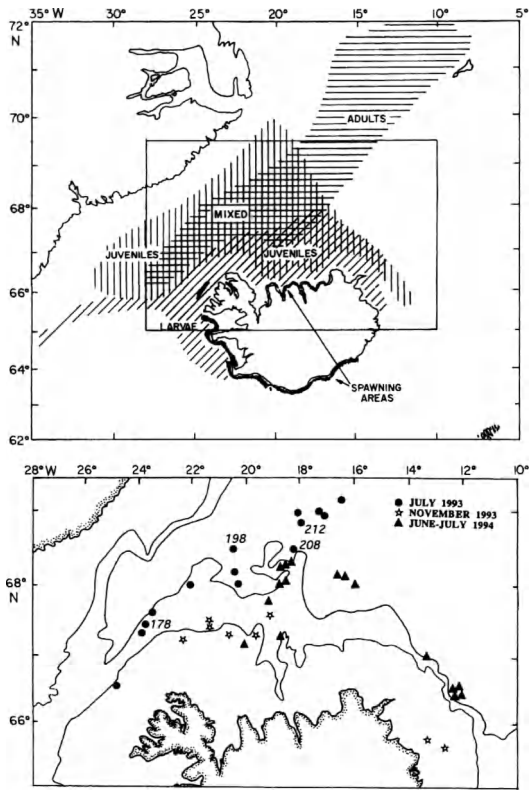

Fig. 1. Spawning grounds and general distribution of larvae, juvenile and adult stock of Icelandic capelin (adapted from VILHJÁLMSSON 1983, 1994) and the location of trawling stations for stomach samples north of Iceland in July and November 1993. The encircled stations further indicate those from which zooplankton was also sampled in July 1993.

MATERIAL AND METHODS

The capelin was sampled with a pelagic Harstad trawl on the feeding grounds in the subarctic waters north and northeast of Iceland (ca 66-69°N, ca 12-26°W) in July and November 1993 and June-July 1994 (Fig. 1). The trawl had an opening of approximately 20 m by 20 m and a mesh size of 10 mm in the cod end. The trawling time and depth varied from several minutes to one hour and from the near surface to approximately 200 m depth.

From each station an attempt was made to collect a random subsample of 5 fish of 2 cm length classes 2.1-20.0 cm (2.1-4.0, 4.1-6.0, 6.1-8.0 etc.). However, due to the different geographical distribution of the different length/age classes this was seldom possible and usually only a limited part of the size range could be sampled at a given station. After sampling the stomachs were dissected from the fish and preserved in 4 % formaldehyde-seawater solution until later analysis.

The laboratory analysis of the stomachs was somewhat different for the material sampled in the two years. For the material from 1993 the content of individual stomachs was emptied into a petri dish for identification to the lowest taxonomic level possible and counting. Finally, the wet weight of the stomach content as belonging to the following five main food categories: copepods, euphausiids, amphipods, other food groups and unidentifiable remains, was also measured. On the other hand, for the material from 1994, only the total dry weight of the stomach content was measured after drying for 20 hours at 70 °C. In order to make the weightings from the two years comparable, wet weights for the material from 1993 were converted to dry weights using information from MATTHEWS & HEIMDAL (1980).

The zooplankton material (Fig. 1) was obtained with a BIONESS multiple opening-closing net (SAMEOTO & al. 1980) having 0.25 m^2 mouth opening and with 200 mm nets. The samples were taken in 6 depth intervals from 0 to 150 m depth and preserved in 4 % formaldehyde-seawater solution until analysed. In the laboratory the zooplankton was identified to the highest taxonomic level possible and counted. For the present analysis the samples from the different depth strata at each station have been combined into one sample and further grouped into the following four categories: copepods, euphausiids, amphipods and other zooplankton.

RESULTS

The material sampled in each of the length classes during the different cruises is summarised in Table 1. A total of 716 stomachs were examined and of those 575 or 80 % were found to contain food. A marked difference was observed between seasons in the amount of food in the stomachs. Thus in July 1993 and June 1994, respectively, 91 and 90 % of the capelin examined had food of some kind, while in November 1993 only 39 % were found to contain food. During November empty stomachs were particularly evident amongst the smallest length classes (2.1-10.0 cm).

On average during one calendar day the dry weight per stomach in November 1993 was only 2.1 mg, while in July 1993 and in June-July 1994 it was 83.8 and 72.0 mg. Thus the food in the stomachs was 35-40 times greater in summer than winter. Even though we are not comparing stomachs from exactly the same length classes (Table 1) this clearly demonstrates the marked difference in the intensity of feeding between summer and early winter.

The percentage composition of the food of capelin in terms of numbers in July and November 1993 when grouped into four major food categories: copepods, euphausiids, amphipods and 'other groups' is shown in Fig. 2. In terms of numbers the food of all length classes was dominated by copepods, 92-99 % in July (Fig. 2A) and 65-93 % in November (Fig. 2B). The percentage of the 'other groups' in the stomachs was similar and usually around 2 % in July. In November 7-17 % of the stomach content consisted of euphausiids in all but the largest length class where no euphausiids were present. Other food groups constituted ca 20 % of the stomach content

of the two largest size classes in November. However, as the number of stomachs with identifiable food was extremely small (5-8 in length classes 14.1-18.0 cm, Table 1) and further as only a few food items were found in each stomach the result should be interpreted with care.

The composition of the identifiable copepods found in the stomachs is shown in more detail in Fig. 3. Of all copepods identified to species *Calanus finmarchicus* (GUNNERUS) was the most abundant one. In July it constituted ca 14-65 % of identifiable copepods (Fig. 3A). In November *C. finmarchicus* was not identified from the largest length class while in the others it constituted ca 17-92 % of the copepods (Fig. 3B). In July *C. hyperboreus* (KRØYER) was the second most numerous copepod in the stomachs. However, it was not identified from the smallest size class, while in other length groups it constituted ca 14-28 % of the identified copepods. *C. hyperboreus* was generally less abundant in the stomachs from November, except for the largest length class where it was the only copepod species identified. *Metridia longa* (LUBBOCK) constituted a small fraction (ca 2-6 %) of the identifiable copepods in the stomachs of 12.1-18 cm capelin in July, while it was not present in neither the smallest nor the largest length classes. In November the abundance of *M. longa* ranged from 0 to 66 %, being highest in the 14.1-16.0 cm size class and lowest in the 16.1-18.0 cm size class. *Pseudocalanus* spp. constituted ca 74 % of the copepods from the smallest length class in July while it was much less abundant in the larger length classes, no *Pseudocalanus* spp. were identified from the stomachs sampled in November. *Pseudocalanus* spp. is the smallest of the most numerous copepods in the stomachs of capelin during summer and Fig. 3A may suggest that this species is possibly an important food constituent for capelin smaller than the ones analysed from July 1993. Future studies ought to attempt to get more in-

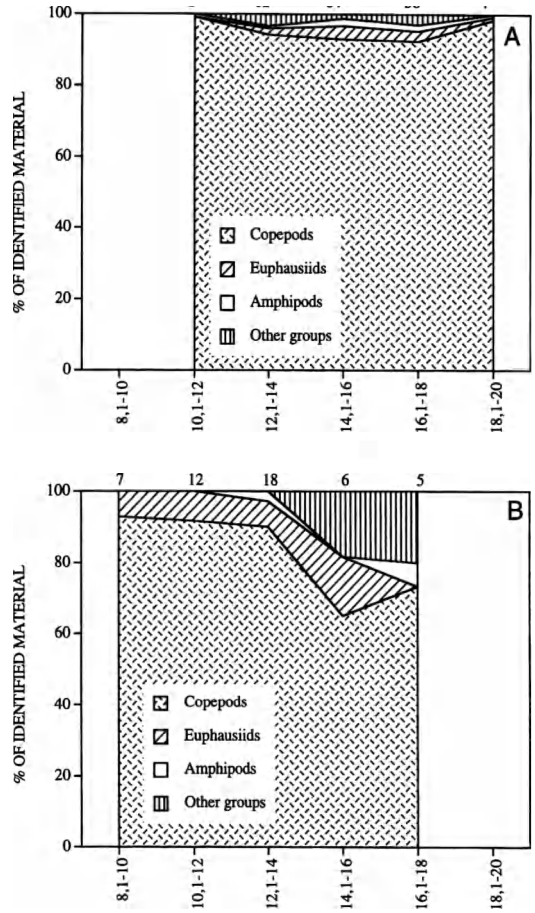

Fig. 2. Food composition (percentage number) of Icelandic capelin in July (A) and November (B) 1993. The numbers at the top of the figures show the number of fish with identifiable food.

Table 1. Summary according to length classes (cm) of material used for analysis of the food of Icelandic capelin in July 1993, November 1993 and June-July 1994. The number and percentage of stomachs with some kind of food is also shown.

		Length classes								
	Sampling time	2.1-4	4.1-6	6.1-8	8.1-10	10.1-12	12.1-14	14.1-16	16.1-18	18.1-20
Number analysed	Jul. 1993					5	70	70	65	4
Number with food						2	64	65	60	4
%						40	91.4	92.9	92.3	100
Number analysed	Nov. 93	4	5	10	33	22	31	23	15	
Number with food		0	0	0	13	12	18	8	5	
%		0	0	0	39.4	54.5	58.1	34.8	33.3	
Number analysed	Jun.-Jul. 94		2	90	17	20	70	70	70	20
Number with food			1	57	16	20	70	70	70	20
%			50	63.3	94.1	100	100	100	100	100

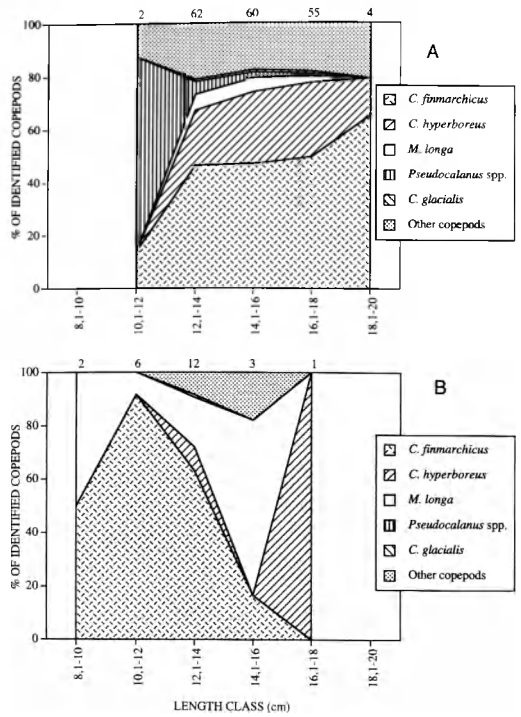

Fig. 3. Copepods (percentage number) occurring in the stomachs of Icelandic capelin in July (A) and November (B) 1993. The numbers at the top of the figures show the number of fish with identifiable copepods.

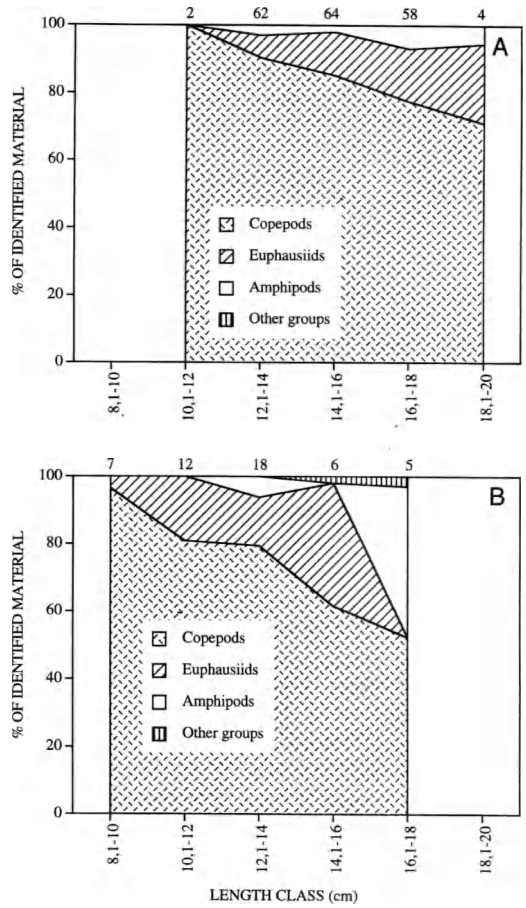

Fig. 4. Food composition (percentage dry weight) of Icelandic capelin in July (A) and November (B) 1993. The numbers at the top of the figures show the number of fish with identifiable food.

formation on the food of the smallest capelin during the summer months. 'Other copepods' usually constituted about 20 % of the total number of copepods in July while in November they were less abundant. In July the 'other copepods' consisted of *Euchaeta norvegica* Boeck, *E. glacialis* Hansen and *Temora longicornis* (Müller), while in November they were mainly *Euchaeta* spp.

Thysanoessa inermis (Krøyer) and *T. longicaudata* (Krøyer) were the only euphausiids found in the stomachs and *T. inermis* was the more numerous one (57 %). Two species of amphipods (*Themisto libellula* Mandt and *T. compressa* (Goës) were found in the stomachs, the former was much more abundant (78 %) than the latter.

Due to the different size of the different prey groups Figs 2 and 3 may give a somewhat misleading picture of their actual importance as food for capelin. In order to get a further idea of the relative importance of the different planktonic groups as food, Fig. 4 shows its constitution for four categories (copepods, euphausiids, amphipods, and 'other groups') in terms of dry weight.

The copepods were the most important food constituent also in terms of weight, but were not as dominating as numerically. In July the dry weight of copepods was relatively greatest in the smallest length class (ca 100 %) decreasing gradually to ca 71 % in the largest one (Fig. 4A). The percentage dry weight of euphausiids, however, increased with increasing length from ca 0 % in the smallest length class to ca 23 % in the largest one. Amphipods constituted similarly an insignificant part of the dry weight of the smallest capelin while in the largest size classes they constituted ca 6 % of the food. The food group 'other groups' contributed insignificantly when the food was considered in terms of weight. In November the dry weight composition of the food was similar to that observed in July except that amphipods replaced euphausiids as the second most important group in the largest size class (Fig. 4B), however, we again stress

the limitations mentioned above regarding the material on the largest length classes in November.

Figure 5 shows the composition of the food of capelin from length classes 12.1-14.0, 14.1-16.0 and 16.1-18.0 cm (5 fish in each length class) from four stations (Fig. 1) and the composition of the zooplankton at these same stations in July 1993. It is evident that the composition of the food of the capelin is generally very similar to that in the sea with copepods dominating numerically both in the stomachs and in the plankton. At one of the stations (Stn 208) 'other groups' constituted 23 % of the prey items in the stomachs while they were only 1 % of the animals in the plankton. In this case 'other groups' were mainly larvacea and this might indicate that the capelin were selecting for them particularly. However, in this context it is worth noting that at nearby stations larvacea were abundant in the plankton and therefore their absence in the stomachs may be reflecting the patchiness of the plankton or that they were eaten in the vicinity of the station for which the comparison is made.

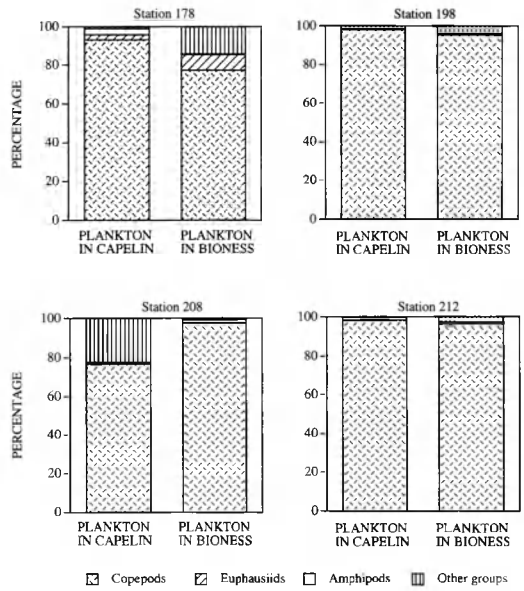

Fig. 5. Comparison between the food of capelin and the composition of zooplankton at Stations 178, 198, 208 and 212 (see Fig. 1) in July 1993.

DISCUSSION

In the waters north of Iceland, the spring increase of zooplankton begins at the end of April, reaches a peak in late May and gradually decreases to low winter levels by November (Gislason & Astthorsson 1996). This seasonal change in the zooplankton biomass is reflected in the feeding activity of the capelin as both much higher percentage of capelin had food in their stomachs in June-July than in November and much greater amount of food was observed in each stomach. Sigurdsson & Astthorsson (1991) similarly found the percentage of empty stomachs to increase from ca 25 % in August to ca 82 % in December amongst capelin caught in the waters north of Iceland, and Vesin & al. (1981) reported a lower feeding intensity of capelin in the Gulf of St. Lawrence in November and October than during the summer months. Further, in the Barents Sea capelin does not seem to feed during the period November-January (Prokhorov 1965). Several authors have also reported a cessation of feeding by spawning capelin (Vesin & al. 1981; Winters 1970).

During July copepods were the most important food component of the different length classes of capelin from the waters north of Iceland both in terms of numbers and dry weight (Figs 2; 4). Euphausiids were the second most important food group and they were more important when the food was considered as dry weight than in terms of numbers. Amphipods ranked usually third both in terms of abundance and dry weight. Gislason & Astthorsson (1996) reported copepods and euphausiids to be the most important components of the zooplankton community in the subarctic waters north of Iceland during the summer and autumn 1993 and this is reflected in the composition of the food of the capelin. Also the comparison between the food of the capelin and the composition of the zooplankton (Fig. 5) suggests that the food selection of the capelin is fairly limited and that they are probably mainly consuming the prey which is most abundant in their environment at any one time. This is in agreement with the consideration that when feeding the capelin mainly uses the gill rakers for filtering the food (Templeman 1948; Prokhorov 1965; Huse & Toresen 1996). However, as pointed out by Huse & Toresen (1996), due to large size adult krill is likely to be ingested singly by biting. Further studies on these two methods of feeding in relation to food availability and the size of the capelin are of interest.

Our findings on the food composition of capelin in the subarctic waters north of Iceland agree largely with those reported by other workers. Vesin & al. (1981) reported copepods to be numerically the most abundant prey of capelin in the Gulf of St. Lawrence, whereas euphausiids were dominant in terms of biomass. Similarly Hassel & al. (1991), Ellertsen & al. (1982) and Huse & Toresen (1996) found copepods and euphausiids to be the main prey of capelin from the Barents Sea. Further, when the food of the capelin was considered in terms of dry weight the importance of euphausiids for the larger size classes became

evident. Similar patterns of a shift from copepods to euphausiids as the capelin increase in length were reported by VESIN & al. (1981); PANASENKO (1984); SIGURÐSSON & ASTTHORSSON (1991).

In conclusion the food of capelin in the waters north of Iceland is mainly similar to that observed in other areas. There were, however, some differences but these are hard to evaluate because of lack of information on the zooplankton composition in the sea.

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