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FEEDING OF BALTIC HERRING LARVAE IN THE GULF OF FINLAND

by

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Abstract

Baltic herring larvae in the Gulf of Finland have absorbed all the yolk in the yolk sac by the time they reach a length of 9 mm. Intake of external food does not usually begin before the yolk has been absorbed. Absorption is faster later in the summer, when the water is warmer. The feeding habits of the larvae show a clear dial rhythm. Larvae of all sizes eat during the light period and in the illuminated upper water layers, appearing to be unaffected by the dial vertical migration of their food organisms. The most important food is copepods of different stages, but in spring when the water is colder the larvae eat less motile organisms, such as rotifers and planktonic eggs. The size of the food organisms increases with the size of the larvae, but bigger larvae also eat smaller organisms, such as nauplii. At a rough estimate, larvae up to 16 mm eat about 5 mg a day.

Résumé

Après avoir dépassé la longueur de 9 mm les larves de hareng de la Baltique dans le Golfe de Finlande ont absorbé tout le jaune du sac au jaune d'oeuf. Prendre de la nourriture extérieur ne commence pas, habituellement, qu'après le jaune a été absorbé. L'absorption se passe plus vite vers la fin de l'été à cause de l'eau plus chaud. Les larves, en se nourrissant, se montrent des habitudes caracterisées par un rythme clairement horaire. Les larves de toutes les grandeurs se nourrissent pendant la periode lumineuse et dans l'eau luminé et le plus proche de la surface, évidemment sans réagir à la migration horaire verticale des organismes de leure nourriture. La plus importante nourriture est constituée de copepods de differents stades, mais au printemps, quand l'eau est plus froid, les larves prennent d'organismes moins mobiles tels que les rotifères et les oeufs de plancton. La taille des organismes de nourriture s'augmente à mesure de la taille des larves, mais les larves plus grandes aussi prennent d'organismes plus petits tels que les nauplii. D'après une grosse estime, les larves de taille vers de 16 mm mangent environ 5 mg par jour.

Introduction

In summer 1974 the Finnish Game and Fisheries Research Institute investigated the vertical distribution of Baltic herring larvae in the Gulf of Finland. This work included a study of the feeding habits, since these may be one of the reasons for a certain vertical distribution pattern. Moreover, knowledge of the larval feeding habits may serve to explain differences in the year-class strengths.

Material and methods

The field sampling was done during May, June, July and August with a modified Gulf-V sampler (SJÖBLOM & PARMANNE 1978). The sampler was combined with a zooplankton sampler. The samples were taken six times during 24 hours, at depths of 0.2,1,2, 4,8, and 16 m, and were preserved in 4 % formalin.

The feeding habits were studied on the samples from May 29/30, June 26/27 and July 24/25. These samples were chosen because they were sufficiently large and the larval length distribution had changed between these dates. When possible, 10 larvae were taken at random from each sample. Their length was measured to the nearest 0.5 mm. The intestine was opened with needles, and the presence or absence of the yolk-sac yolk was recorded. In the samples from June and July the food organisms were measured to the nearest 0.1 mm and identified. Notes were made on the position of the food in the intestine. Tables (MELVASALO et al. 1973) were used to make a rough estimate of the live weight of the food. In all, the intestines were opened in 658 larvae, which represented 16.9 % of the total catch (3901) of these three days.

To obtain a measure of the extent to which the food was digested i.e. how recently it had been taken, each food organism was given a "digestion grade", according to a scale from 0 to 3:

0. The food organism was nearly unrecognizable e.g. a copepod integumet which was totally empty and wrinkled, located far back in the intestine, close to the anus, the carapace being transparent when held up to the light.

1. The food organism was recognizable, e.g. a copepod integument which was not yet completely transparent and still showed some contents.

2. The food organism had been in the intestine for a while and digestion had begun. It was not as "firm" as a fresh organism, but the carapace was still coloured.

3. The food organism was fresh and largely unaffected.

The following water temperatures were measured in the 10-0 m layer (SJÖBLOM & PARMANNE 1978):

May 29/30 6-8 °C
June 26/27 9-16 °C
July 24/25 9-17 °C

The digestion times at these temperatures were estimated with the aid of BLAXTER (1962) and RANNAK & SIMM (1975), among others:

Digestion grade	May 29/30 6-8 °C	June 26/27 9-16 °C	July 24/25 9-17 °C
0	more than 6(-8) hr.	more than 4 hr.	more than 4 hr.
1	less than 6(-8) hr.	about 4 hr.	about 4 hr.
2	"	"	"
3	less than 6 hr.	less than 4 hr.	less than 4 hr.

Results

1. The absorbtion of the yolk-sac yolk and the first intake of external food

None of the larvae bigger than 9.5 mm had yolk in the yolk sac (Tab. 1). The proportion of smaller larvae without yolk was lower later in the summer (Table 1), and the size of the larvae at the first intake of external food also decreased during the summer (Table 2). There were two larvae with both yolk-sac yolk and food in their intestines. In view of the above results, larvae smaller than 8 mm were excluded from the following investigations.

Table 1. Occurrence of yolk-sac yolk in larvae of different sizes.

Date	Size mm	No. with yolk 7.5	8	9	% with yolk 7.5	8	9
May 29/30		24	81	23	88.9	52.9	29.5
June 26/27		50	15	0	82	31.3	0
July 24/25		7	0	0	63.6	0	0

Table 2. Occurrence of larvae smaller than 10 mm with food in their intestines.

	Size mm	No. with food 7.5	8	9	% of total larvae 7.5	8	9	% of larvae with-out yolk-sac yolk 7.5	8	9
May 29/30		0	5	11	0	3.2	14.1	0	6.9	20
June 26/27		3	9	17	4.9	18.8	26.8	27.3	27.3	(26.8)
July 24/25		1	0	1	9.1	0	100	25	(0)	(100)

2. The diel rhythm in the larval feeding habits

As seen in Fig. 1, the majority of larvae with food in their intestines were taken in the upper water layers. In June, the lightest time of the year, there were a number of larvae with food in their intestines also in the deeper water layers.

Fig. 2 shows that the majority of the larvae with food in their intestines were caught during the lightest time of the day. The digestion grade was used to estimate the time when the food was taken (Fig. 3). Quite undigested food (grade 3) may probably be assumed to originate from the sampling depth. Fig. 4 shows the vertical distribution of larvae with undigesteed food in the their intestines. It seems that few larvae feed at the surface, or perhaps the larvae become inactive and sink directly after eating. This may explain why a number of larvae with undigested food were taken in the deeper water layers on June 26/27. It seems reasonable to assume that undigested food was taken at the time of sampling. Fig. 5. shows the diel distribution of larvae with undigested food in their intestines. As in Fig. 3. a clear diel rhythm is apparent, the larvae eating during the lightest time of the day. The feeding habits do not differ between larvae of different sizes (Fig. 6 and 7).

3. The composition of the food

The composition of the food of larvae of different sizes on the three different sampling dates is shown in Fig 8. It seems that when the water is colder in May, the smaller larvae have to eat less motile organisms than larvae of the same size later in the summer.

The food consisted of the following organisms (young copepodites and nauplii not determined):

	May 29/30	June 26/27	July 24/25
Tintinopsis brandtii	x		
Syncheta sp.	x		
S.monopus	x		
Macoma baltica l.	x	x	
Bosmina coregoni juv.			x
Cladocera sp. juv.		x	
Podon polyphemoides (in 25-mm larva)			x
calanoid cop.sp.ad.			x
sp.juv.		x	
sp.naup.	x	x	x
Acartia sp.		x	x
A.bifilosa		x	x
A.longiremis	x		x
A.tonsa		x	x
Eurythemora sp.		x	x
E. hirundoides			x
Balanus improvisus naup.		x	
Balanus (?) eggs	x		

No phytoplankton was found in the intestines of the larvae.

4. The size of the food organisms

As the larvae grow, their ability to catch bigger organisms increases, and the size range of their prey also becomes wider. It appears that the bigger larvae continue to eat small food organisms as well (Fig. 9).

5. The live weight of the food

The minimum live weight of the food in larvae up to 16 mm was estimated at about 1 mg per individual. In the biggest larvae the weight varies between 10 and 80 mg.

If sampling is sufficiently frequent to cover the larval feeding periods, it is possible to estimate the daily intake of food. If the larvae do not eat more than once a day, the minimum intake will be about 1 mg, or, for instance, 1 nauplius a day. However, since some of the larvae had both undigested and partly digested food in their intestines, they can be assumed to eat more than once every day. On the basis of the diel feeding pattern described above and assuming that sampling was sufficiently frequent, the mean minimum daily food intake of larvae up to 16 mm may be roughly estimated at 5 mg.

The mean number of food organisms does not increase with the size of the larvae (Fig. 10).

6. The vertical distribution of zooplankton compared with the distribution of undigested food.

If food of digestion grade 3 originates from the depth at which the larva was caught, and if the larvae migrate vertically during the day to obtain food, then the grade 3 food should show the same vertical distribution as the food organisms. However, the vertical distribution of the undigested food on 26/27 June (Fig. 11) is not the same as that of planktonic copepods sampled on the same day (SJÖBLOM & PARMANNE 1978). This suggests that the larvae do not migrate vertically in search of food.

Discussion

The proportion of larvae with empty intestines was remarkably large (52.1 %). This can partly be caused by the stress the larvae were exposed to during sampling and preservation. There are reports (e.g. BLAXTER 1965) that larvae put in formalin may empty their intestine. In addition, the mortality among larvae is very high and some of the larvae may already have been too weak to catch any food.

The size at which the larvae had absorbed the yolk-sac yolk was nearly the same in this study as in, for instance, that of RANNAK (1959). The more rapid absorption later in the summer is probably due to the temperature conditions (see also BLAXTER & HEMPEL 1966). The absorption of the yolk and the transition to external food is of the greatest importance for the survival of the larvae (e.g. MARR 1955 and BLAXTER 1962).

According to BLAXTER & HOLLIDAY (1963), the large eyes of the larvae play an important role in the uptake of food. Until the metamorphosis of the larvae, the retina consists only of cones (BLAXTER 1965), and as is seen here, the larvae eat only during the light time of day and in the illuminated upper water layers.

The composition of the food is probably influenced by both the structure of the local zooplankton and the temperature. The composition can be seen to vary slightly during the summer and it probably also varies from year to year.

In this study the live weight of the food was estimated from tables, and this is probably the reason why my results deviate rather greatly from those, for example, RANNAK & SIMM (1975).

HENTSCHEL (1959), among others, has estimated the numbers of food organisms that larvae of different sizes need to eat per day. The numbers correspond fairly well with the mean number of food organisms eaten by the larvae from the Gulf of Finland in the period preceding the sampling time, but the larvae presumably eat more than once or twice a day and they probably do not eat in the dark period.

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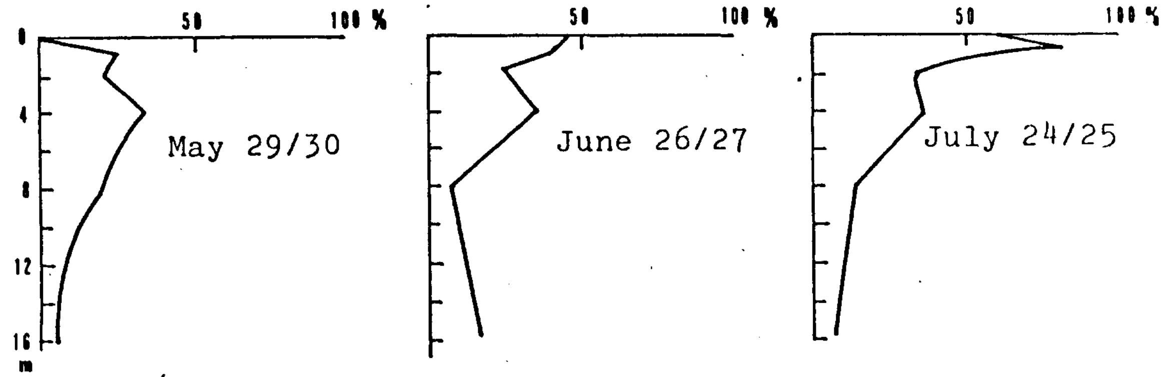

Fig. 1. The vertical distribution of larvae with food in their intestines.

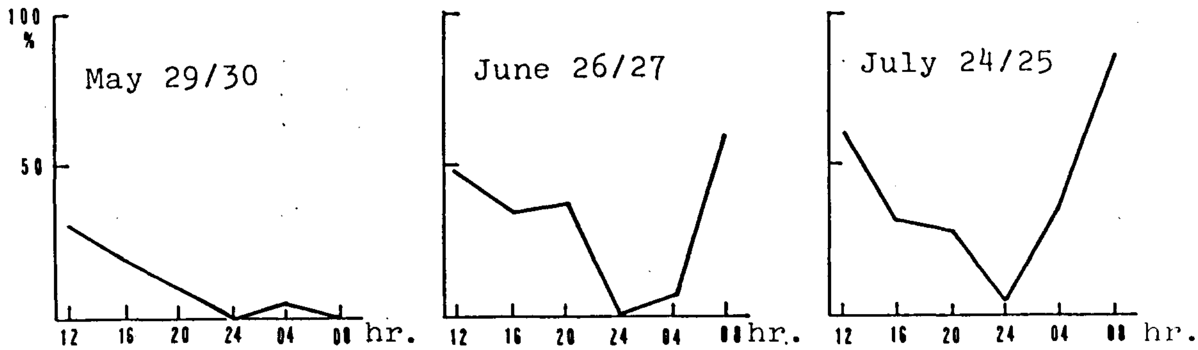

Fig. 2. The distribution of larvae with food in their intestines by the time of day.

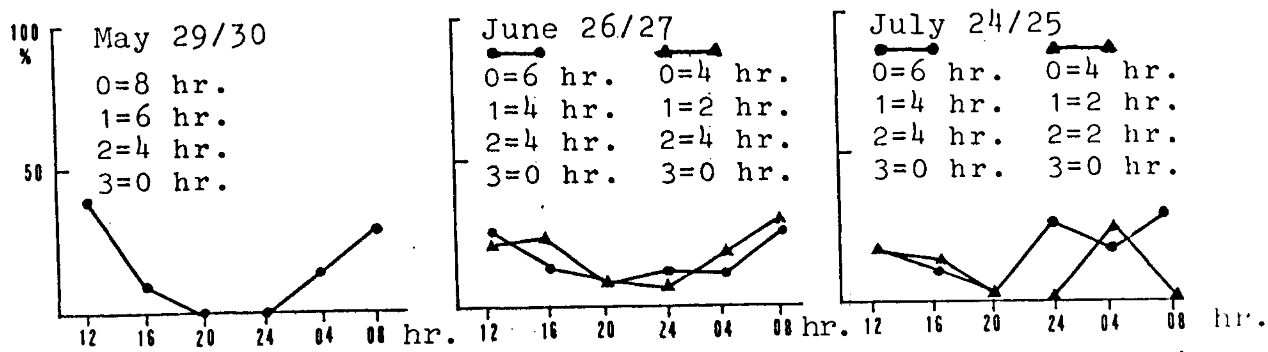

Fig. 3. The estimated time at which the food organisms were taken. (The curve shows their proportions of the total number of food organisms).

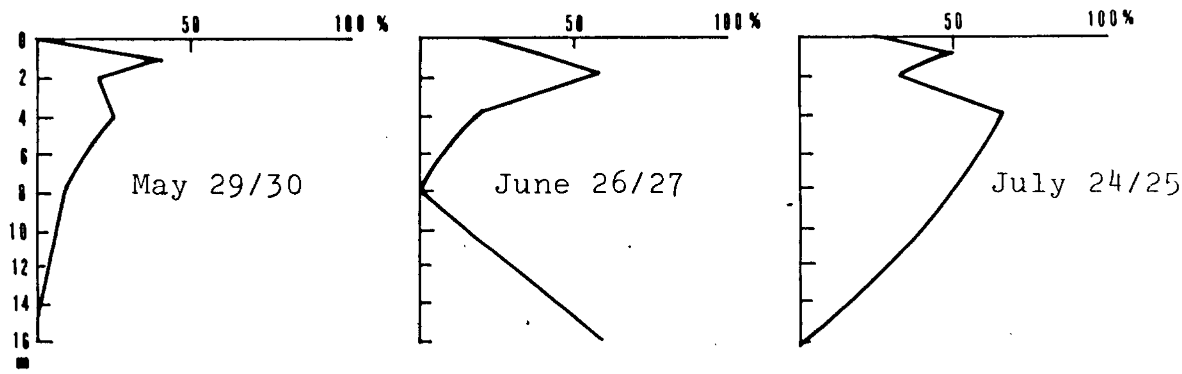

Fig. 4. The vertical distribution of larvae with undigested food in their intestines. (Shown as their proportions of the total number of larvae with food in their intestines at the same depth).

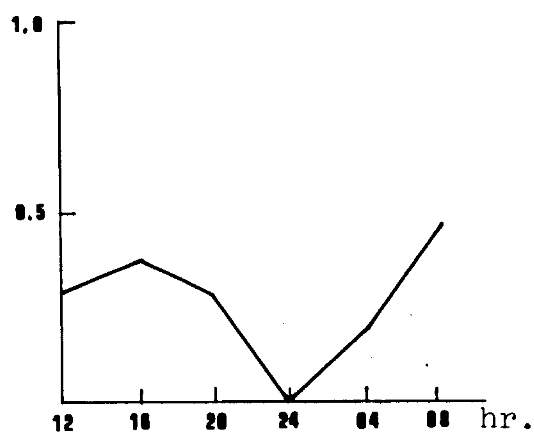

Fig. 5. The distribution of larvae with undigested food in their intestines by the time of day. (Shown as their proportions of the total number of larvae with food in their intestines).

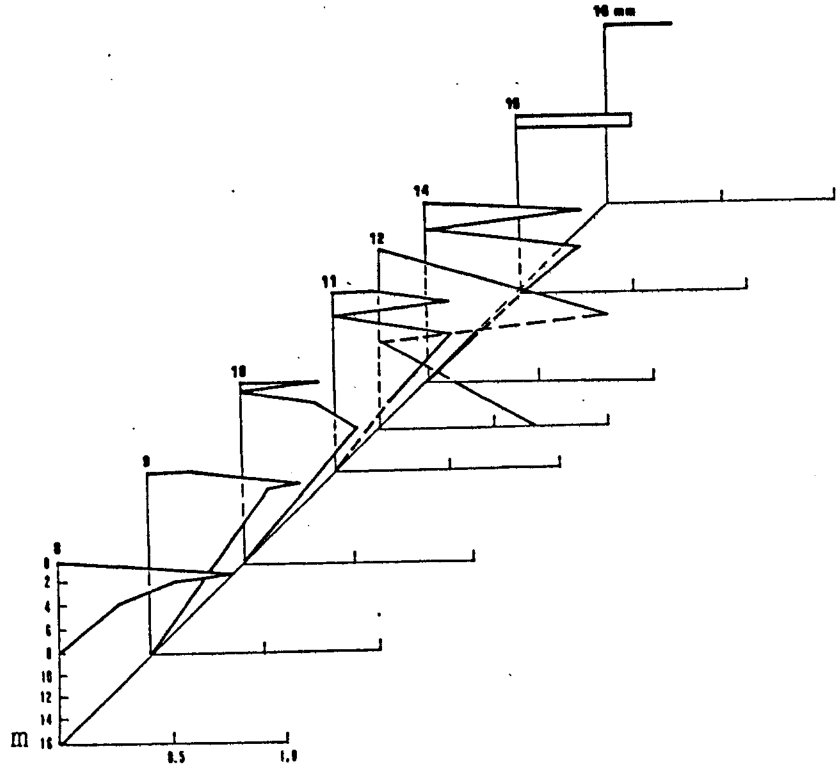

Fig. 6. The distribution of larvae with undigested food in their intestines by size and depth. (Shown as their proportions of the total number of larvae with food in their intestines).

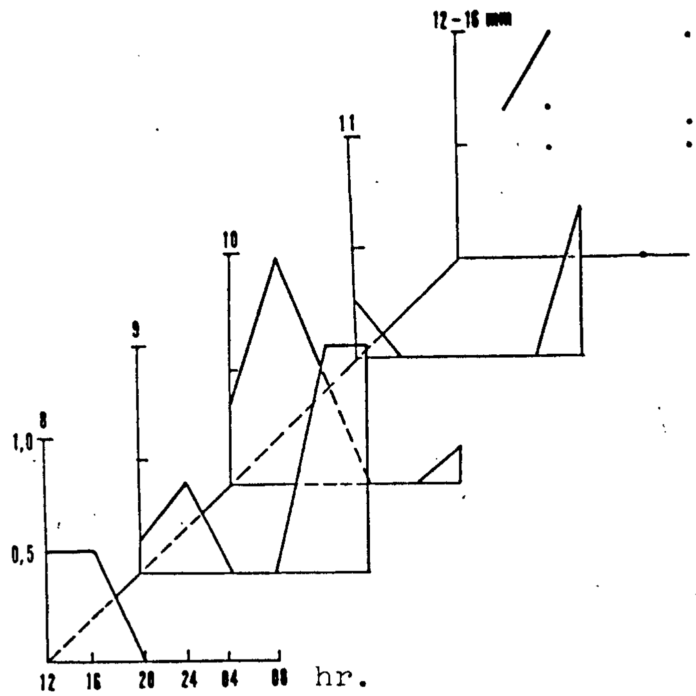

Fig. 7. The distribution of larvae with undigested food in their intestines by size and time of day. (Shown as their proportions of the total number of larvae with food in their intestines).

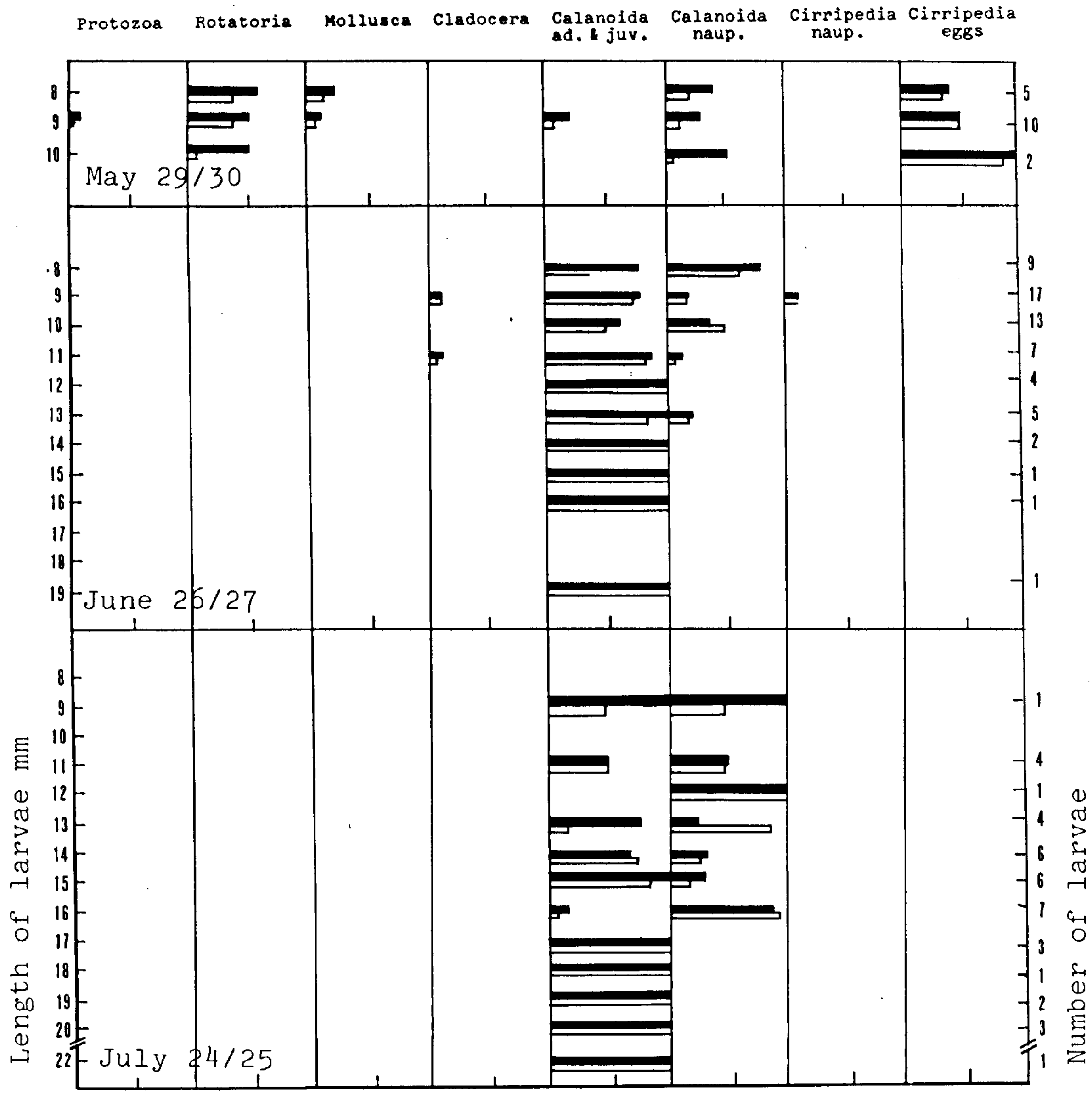

Fig. 8. The composition of food in larvae of different sizes on the three sampling dates. Filled bars show the relative frequency of the food organisms among the larvae with food in their intestines. Empty bars show their proportions of the total food organisms.

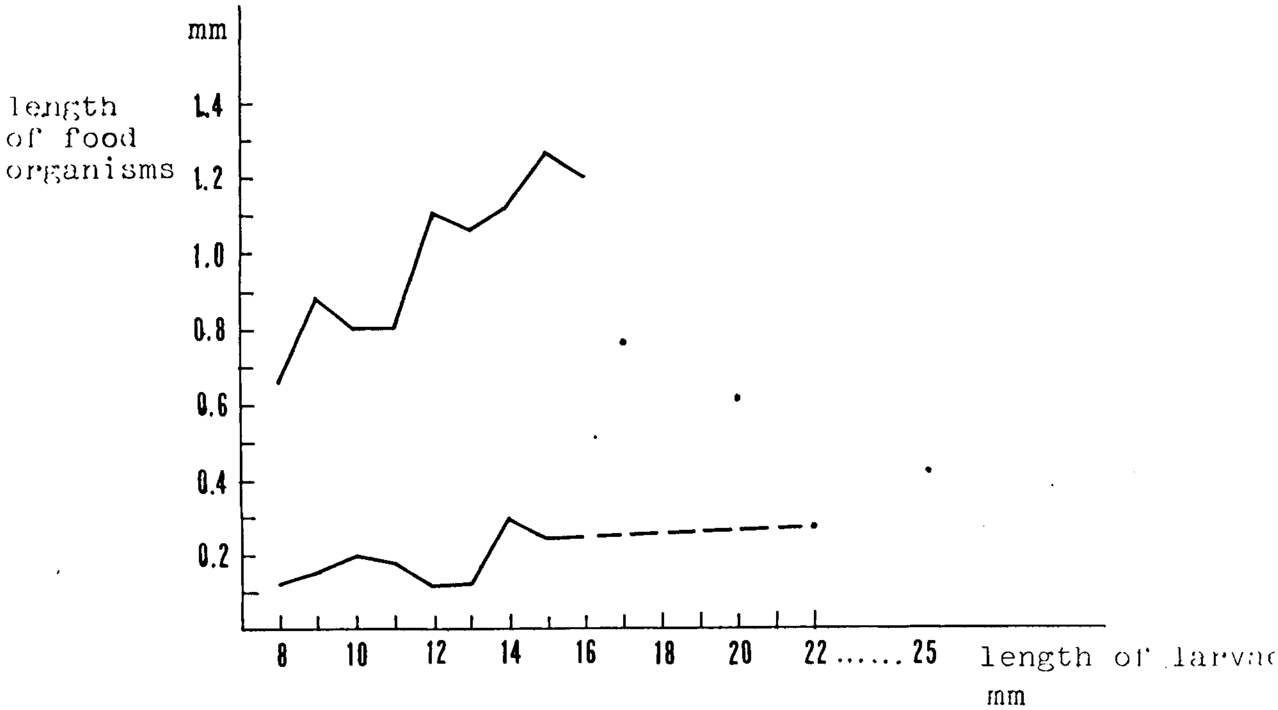

Fig. 9. Lengths of the smallest and biggest food organisms found in the larvae in June and July. (The eggs that were found in May were smaller than 0.1 mm).

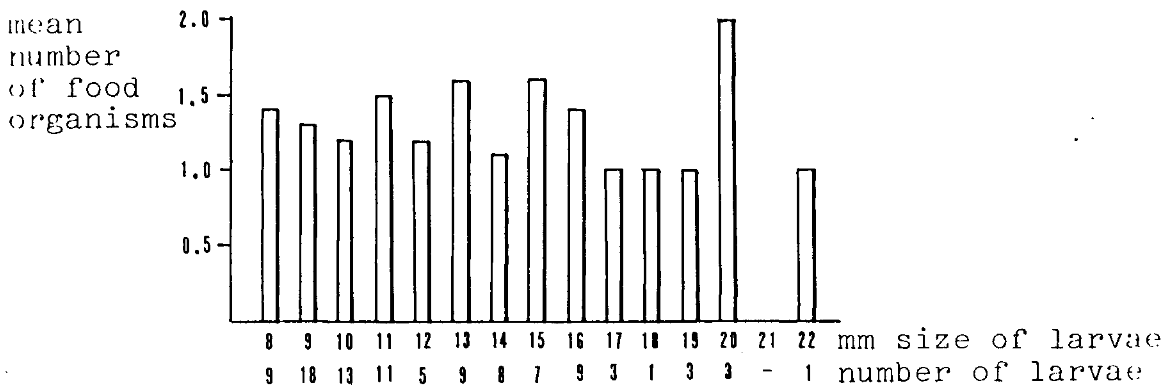

Fig. 10. The mean number of food organisms in larvae of different sizes in June and July. Size of organism disregarded.

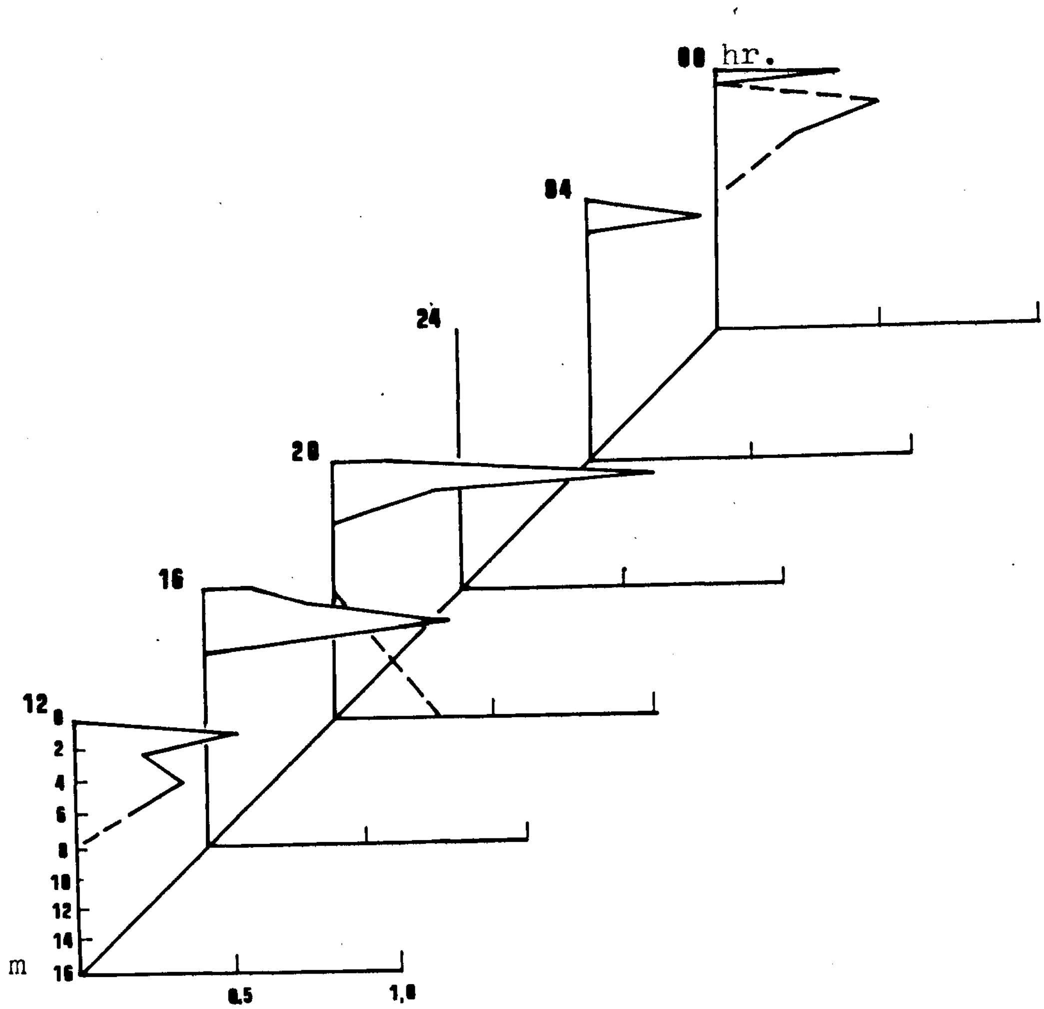

Fig. 11. The distribution of undigested food by depth and time of day on June 26/27. (Shown as proportions of the total number of food organisms).