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Title: **Observations on the distribution, daily migration and food intake rates of Chaoborus flavicans (Meigen) in the Goggausee.**

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Observations on the distribution, daily migration and food intake rates of Chaoborus flavicans (Meigen) in the Goggausee.

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Translated by: P.L. Mock.

Introduction

Findenegg (1963) was able to show that the Goggausee, in spite of its modest depth (Z_{max} = 12 metres), shows meromictic properties: autumn and spring circulation extend only to a depth of 8 metres. The water layers below about 10 metres are constantly oxygen-free, the critical zone with at least intermittent oxygen loss lies at a depth of between 6 and 10 metres. The bottom of the deep zone consists of a coarse, flaky, very water-rich black sediment.

As in the Klopeiner See and the Längsee, the distribution frontier of the metazoic bottom fauna lies somewhat above the actual oxygen zero point (Danielopol & Juggwirth, unpubl.). Chaoborus flavicans forms an exception, as during the day it inhabits the oxygen-free depths.

Chaoborus flavicans is ecologically a thoroughly researched species (Parma, 1971; reviewed by Roth & Parma, 1970). Regarding the biology of its feeding and the role of the predatory species in the "food chain" of the pelagic population there are however still many question to be asked. The limnological excursion (20th to 26th May, 1974) offered an opportunity to investigate the daily vertical migration of the species with reference to its food supply of zooplankton (Herzig & Moog, in preparation) as well as the chance to carry out some preliminary experiments on its rate of food intake.

Method

The planktonic distribution of the species was investigated with c[illegible] nets (aperture 100 sq.cm., metre draught), the benthic by means of an Ekman-Birge grab (likewise 100 sq.cm. aperture).

Determination of the feed rate was carried out in an improvised laboratory. The feeding material was pumped continuously during the evenings by means of a hand pump from about one metre depth of the lake and filtrated through a 200-µm net. The natural density of the zooplankton of this size of class (predominantly Copepoda of the Cyclops species) was counted (by three random tests at 10 litres before and after the experiments). One litre of filtered lake water was added to the zooplankton filtrate of 5, 10, 50 or 100 litres, and in this way a series of food concentrations of between 10 and 250 individuals per litre was attained. The experimental vessels, with the exception of the control equipment, were each furnished with 10 Chaoborus larvae, which had been taken out of the lake shortly after the anaerobic phase, at about 20.00 hours (see daily migrations). The larvae concentrations of 10 individuals per litre lies somewhat above the highest naturally-occurring values and plainly (four to five times) above the average concentrations of the larvae in the epilimnion during the night (see Tabl. 1).

The experiments took place at 15 ± 0.5°C and in darkness. The start of the experiments was always between 21.00 and 22.00 hours. After three hours of exposure the samples were filtrated through a 50-µm net, fixed with formol and the remaining zooplankton was counted. According to food concentration, in each case three parallel experiments were carried out.

Results

The population density of the species in the Goggausee is very large. A population density of 110 individuals per 100 sq.cm is obtained in the clasp net catches. This is valid for the area within the seven-metre isopleth. The uniform condition of development of the population (all animals in the last, fourth larval stage, body length 9 to 11 mm.) indicates a univoltine development with a flight period in the summer, similar to what is known in other waters.

The benthic distribution corresponds to that found in other meromictic lakes (eg. the Langsee, Schiemer 1973): the animals prefer to colonise the bottom layers of the oxygen-free zone. Certainly a clear depth zoning is shown here: during the day larger numbers of individuals could be established in the sediment in 6-7 metres, so the number of benthically-occurring animals at the 12 metre depth was extraordinarily low.

Almost the entire population is spread here during the day in the water column between 7 and 12 metres. The distribution picture - occurrence of plankton in deeper zones, and benthic in shallower ones - appears to be dependent on the light intensity. Laboratory findings on the penetration depth of the larvae in the sediment depending on light intensity are available from Larow (1969).

The established daily movement of the planktonic depth distribution (Fig. 1, Tabl. 1) corresponds to findings in the records which have been ascertained several times (eg. Teraguchi & Northcote, 1966, Goldspink & Scott, 1971; review of the literature: Roth & Parma, 1970).

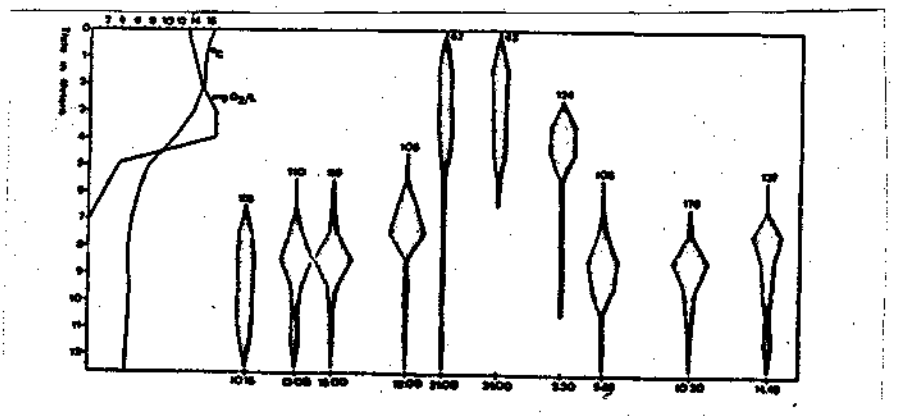

Fig. 1: Vertical migration of Chaoborus falvicans on 23rd and 24th May, 1974, shown in percentages. The numbers above the diagrams give the total catch per water column and 100 sq.cm. surface. For comparison temperature and oxygen layering are shown.

Tiefe	10.15	13.00	15.00	19.00	21.00	24.00	3.30	5.45	10.30	14.45
0— 1	—	—	—	—	6	7	—	—	—	—
1— 2	—	—	—	—	13	15	—	—	—	—
2— 3	—	—	—	—	12	13	—	—	—	—
3— 4	—	—	—	—	13	12	42	—	—	—
4— 5	—	—	—	—	9	13	47	—	—	—
5— 6	—	—	—	4	1	3	8	—	—	—
6— 7	—	1	5	32	2	—	5	3	—	1
7— 8	31	21	14	53	—	—	8	16	16	57
8— 9	42	50	46	4	1	—	7	46	89	29
9—10	34	16	14	7	1	—	7	35	38	23
10—11	36	9	4	4	—	—	—	3	24	10
11—12	23	13	3	1	4	—	—	3	11	17
Σ	166	110	86	105	62	63	124	106	178	137

Tabl 1: Planktonic depth distribution of Chaoborus flavicans during the day (23rd and 24th May 1974). Numbers of individuals per water column of 1 metre height and 100 sq.cm. surface (10 l).

As specified, the population is concentrated during the daytime in the oxygen-free water region beneath 7 metres. With dusk the upward migration begins. At around 21.00 hours a distribution is reached which seems to be typical for the entire night. By early morning the downward migration begins, which reaches the original starting-point at about 6.00 hours. This pattern of the daytime vertical migration agrees with the findings on the light dependency of the distribution in the depths (eg. Malueg & Hassler, 1971).

During the daytime migrations the animals are exposed to strong variations in temperature, oxygen content and food supply. The food of Chaoborus flavicans consists mainly of zooplankton. On the question of the food preference of various members of the zooplankton, there are available rather contradictory findings. Also the significance of benthic feeding is still uncertain (discussion by Swüste et al., 1973). It can be deduced from the distribution picture of Chaoborus and its potential food organisms which are concentrated in larger amounts in the upper five metres of the water column, (Herzig & Moog, in preparation) that the food intake must follow preferably within the period of 20.00 to 4.00 hours.

The feeding of the Goggausee population should be exclusively planktonic. During the period of investigation the crustacean plankton consisted for the most part of Cyclops, especially Cyclops copepodites. Daphnia longispina O.F. Müller and Bosmina longirostris (O.F. Müller) play a subordinate role. Next to the crustaceans, several rotatorian species appear in high concentrations (Keratella cochlearis Gosse and quadrata Müller, Filinia species, Polyarthra species, etc.)

The results of the food experiment (Fig. 2, Tabl. 2) are confirmed on methodical grounds to the crustacean plankton.

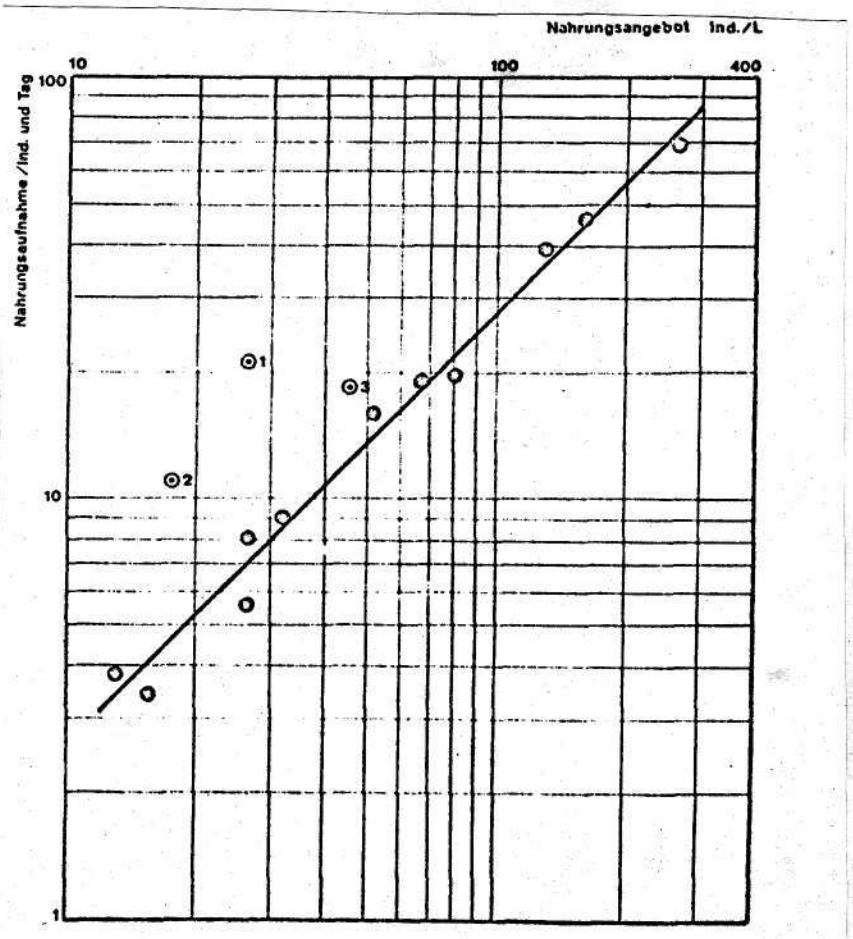

Fig. 2: Food intake of Chaoborus larvae under the described experimental conditions (15°C, 3 hrs. exposure to darkness), corresponding to 24 hrs. (black dots). For comparison the results of Kajak and Ranke-Rybicka (1970) have been inserted: 1 = predominantly copepoda, all stages; 2 = experiment 1, corresponding however only to adult copepoda and copepodita; 3 = predominantly Cladocera.

Versuchsdatum	Copepoden		Crustaceenplankton gesamt	
	angebotene Nahrungs-konzentration	Nahrungs-aufnahme von 10 Larven/3 h	angebotene Nahrungs-konzentration	Nahrungs-aufnahme von 10 Larven/3 h
22./23. Mai	24,2	9,2	25,7	9,2
	48,3	26,3	51,3	26,3
	120,8	62,1	128,3	64,6
23./24. Mai	12,5	6,2	13,2	6,4
	25,0	12,7	26,3	13,3
	62,5	31,2	65,8	31,5
	250,0	114,7	263,0	116,4
24./25. Mai	13,8	5,1	15,7	5,7
	27,6	12,6	31,4	15,0
	69,0	27,0	78,3	32,6
	138,0	68,3	156,5	78,1

Tab. 2: Food intake of Chaoborus larvae at different concentrations of prey. The copepod plankton consisted of up to 80% Cyclops copepodites, the rest of adult Cyclops animals.

The feed rates show a significant dependence on the food concentration ($I = 0.02\ D^{1.1}$; I = food intake in individual captured animals per day, D = food density). An excess supply of food with a concentration of 250 crustaceans per litre has therefore not yet been obtained. Some few experiments of a similar nature have been carried out by Kajak & Ranke-Rybicka (1970). Their values on the food intake rates lay some-what above those established by us.

From the few orientating experiments it would appear as an indication of method for future experiments, that on account of the high feed rate of Chaoborus, either the time of exposure, or the concentration of predators is chosen to be as low as possible, in order to prevent a significant dilution of food supply during the experiment. Timing of the experiment with respect to adaptation time must be followed closely according to daily rhythm of the species.

If one compares the feed rates with zooplankton conditions in the Goggausee, an overall calculation will show that the crustacean plankton does not suffice to feed the Chaoborus population. Consequently one must accept that under the conditions in the Goggausee the rotatorian plankton present the most important food source, and that the low density of crustaceans is to be attributed to the predation of Chaoborus.

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Notice

Please note that these translations were produced to assist the scientific staff of the FBA (Freshwater Biological Association) in their research. These translations were done by scientific staff with relevant language skills and not by professional translators.