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Rearing of whitefish (Coregonus lavaretus L. f. baltica) using two different start dry diets and a zooplankton diet in a brackishwater environment

by

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Abstract

The effect of two artificial and one natural start food on growth and survival of whitefish larvae (Coregonus lavaretus L., f. baltica) 3 days after hatching was investigated in a tank experiment over a period of 60 days. Whitefish larvae were reared on diets consisting of commercially available dry larval feeds from FINNEWOS (Aquastart 0) and TETRA (AZ 200 000 , AZ 200 00). The food ration was 20 % of the body weight during the first 3 weeks of the feeding experiment. After this period the food ration has been gradually reduced to about 6% BW. With both diets a final fish weight of about 200 mg, a body size of 30 mm ± 5 mm, and 71 % survival over the 60 days study period were achieved. The specific growth rate (per cent growth per day) was 5.9 for Aquastart and 5.7 for AZ 200 , respectively. Larvae fed with artificial dry feed grew better than those reared on a diet combining live zooplankton (mostly *Eurytemora affinis* nauplii), live *Artemia* spp. nauplii, and decapsulated *Artemia* cysts. The initial food ration decreased from about 40 % BW at the beginning to about 10 % BW after 3 weeks and later. However the growth rate was only 3.8 und the natural mortality about 72 % using this combined live feed.

Introduction

Devoted to the rehabilitation of the depleted whitefish population in the Southern Baltic and Achterwasser/Kleines Haff region (Mecklenburg-Vorpommern/Germany), this programme was initiated in 1992 as combined laboratory-scale and large-scale field studies at the fish culture station Born/Darß of the "Verein Fisch-Umwelt" in association with the "Institut für Fischerei" of the country Mecklenburg-Vorpommern. The stock size of the so-called Ostseeschnäpel (Baltic whitefish) (*Coregonus lavaretus L. ,f. baltica*)has been reduced to a critical point by overfishing and unfavourable environmental conditions, like increased nutrient supply and oxygen conditions. Therefore a fully-intensive, large- scale culture and stocking programme for Ostseeschnäpel (Baltic whitefish) is needed. As starting point this feeding experiment has been carried out in a brackishwater environment. Comparable rearing experiments by use of commercially available artificial starter feeds were carried out by RÖSCH (1988/1989), SEGNER et al. (1989), HARRIS and HUISMAN (1991), and BELTRAN and CHAMPIGNEULLE (1992). An alternative method, described by JÄGER and NELLEN (1980/1984) is the rearing of whitefish under natural conditions in illuminated net cages using attracted live zooplankton as food source. Both methods have been used in our rearing experiment, but only results from the indoor experiment will be described in this presentation.

Material and Method

Whitefish eggs were collected from the spawning population in Peenestrom/Kleines Haff region, Eastern Germany, generally in November. Adult fish were taken in gil-nets, eggs were dry-fertilized and transported in approximately 2 h to the hatchery and hatched until the end of march next year. The egg quality was poor and the fertilization rate difficult to estimate but certainly lower compared to other publications. *Coregonus lavaretus f. baltica* larvae hatched on 23 march were adapted to 5°C cold brackishwater tanks with a salinity of 4.5‰ .

The water source for all larval diet studies was the Koppelstrom of the Darß-Zingst Bodden chain, a highly eutrophicated water body. The water parameter during the experiment are shown in the following Table.

Table 1. Water parameter from the tank water in 1992

Parameter	Month	March	April	May
Temp.[°C]		4.90	10.50	16.40
O^2 [mg/l]		15.20	11.60	8.00
pH		6.61	8.68	9.23
Sal.[S‰.]		5.00	4.20	4.30
NO^2[mg/l]		0.08	0.04	0.07
NO^3[mg/l]		3.00	6.03	1.00
NH4[mg/l]		0.15	0.18	0.24
PO4[mg/l]		0.55	0.50	1.32
CSB[mg/l]		15.00	15.00	15.00
BSB5[mg/l]		12.10	13.70	11.80

Figure 1 shows the development of water temperature and dissolved oxygen in the course of the experiment.

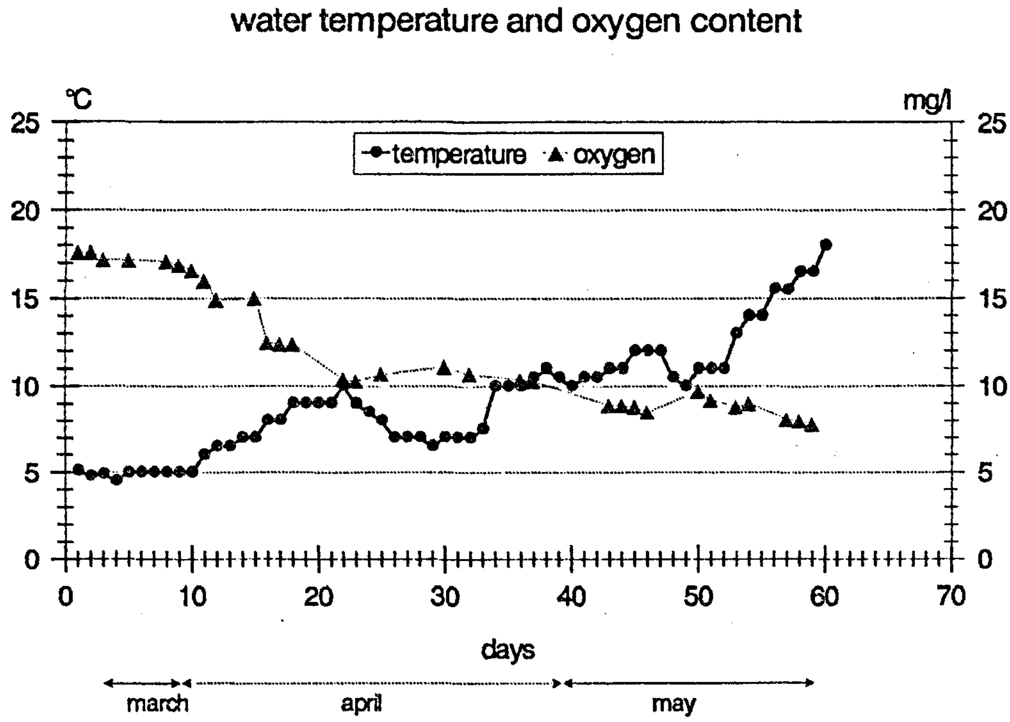

Figure 1. Water temperature and dissolved oxygen March-May 1992.

A total amount of 150.000 larvae were distributed to 3 tanks with 780 l content each (e.g. 64 larvae per liter). The replacement time for the tank water was 30 minutes (26 l/min). The larvae were kept unter natural water temperature and oxygen conditions, affected by the ambient inlet temperatures, but with 24-h permanent lighting regime (concealed fluorescent light of about 160 lx).
Larvea held in tank 1 were fed with a combined diet of zooplankton, caught by a plankton pump, newly hatched brine shrimps *Artemia salina* nauplii, and decapsulated *Artemia* cysts (Sorgeloos et al. 1977). Startfeeding in tank 2 was with artificial feed from FINNEWOS (Aquastart 0). Starter feeds of larval coregonids in tank 3 was TETRA AZ 200 000. All dry feeds were delivered by hand and the frequency was 15 times a day from 7.00 a.m. to 9.00 p.m.. The startfeeding rate using dry feed was 20 % of body weight at the beginning of the experiment and 6 % after 3 weeks of feeding. Zooplankton in tank 1 was fed two times a day . For this trial a daily ration of 40 % BW at the beginning and 10 % BW after 3 weeks and later was given.

Tank hygiene was maintained, with tanks being siphoned three times a week in addition to a rapid draw down of the tank to half-height in order flush settled solids every day.
Body weight and length data were collected by lethal sampling every week. The larvae were measured to 0.5 mm below and weighed to 0.01 g, and the sample size was 30 individuals per tank. The dry weight was determined after 24 h drying with 60 °C to a exactness of 0.001 g.
For the determination of the natural zooplankton community density, 10 l water were sampled and analyzed every week.
Growth data for the three experiments were compared through ANOVA and the specific growth rate (SGR) was determined using the formula given by BELTRAN and CHAMPIGNEULLE, 1992 (ln final WW minus ln initial WW/t x 100 in %).
In order to avoid infections caused by Trichodina sp. and Apiosoma sp. whitefish larvae were treated with formaldehyd and malachitgreen, respectively (Schäperclaus, 1979).

Results

The acceptance of the three feeds were significantly different at initial feeding. In general the food consumption starts immediately after startfeeding. Food acceptance was obviously with TETRA AZ 200 000 due to the red coloured bellys. After 5 days more than 80 % of this trial starts continously feeding. RÖSCH (1988) described in detail the feeding behaviour of two different taxa of whitefish species in the first two days after startfeeding. The food consumption behaviour of Baltic whitefish larvae is comparable with the so-called near-shore-spawning gangfish larvae of the Lake Constance. The coarse-grained FINNEWOS Aquastart 0 feed was also well accepted but a bit delayed. After 5 days only 50 % of larvae had particle of dry feed in their stomachs.
Growth data for the three diet regimes are presented in Tables 2 to 4.

Table 2. Body size of Baltic whitefish larvae — TETRA AZ 200 000

Totallength (mm) March-May 1992

	2.day	5.day	10.day	16.day	23.day	30.day	37.day	44.day	51.day	60.day
Mean (mm)	12,30	12,32	12,55	14,12	16,02	16,40	18,28	20,75	24,85	29,85
Variance	0,16	0,20	0,22	0,78	1,29	4,33	6,14	4,86	7,61	28,90
Standarddevi.	0,40	0,45	0,47	0,88	1,14	2,08	2,48	2,21	2,76	5,38
Coefficient of variat. (CV%)	3,26	3,65	3,71	6,24	7,09	12,69	13,55	10,63	11,10	18,10

Table 3. Body size of Baltic whitefish larvae	FINNEWOS Aquastart 0									
	Totallength (mm) March-May 1992									
	2.day	5.day	10.day	16.day	23.day	30.day	37.day	44.day	51.day	60.day
Mean (mm)	12,47	12,20	13,58	12,97	16,47	18,05	19,93	21,47	25,55	32,13
Variance	0,22	0,39	0,28	0,56	0,98	3,17	4,84	3,43	7,70	14,17
Standarddev.	0,47	0,62	0,53	0,75	0,99	1,78	2,20	1,85	2,78	3,76
Coefficient of variat.(CV%)	3,75	5,09	3,91	5,79	6,00	9,86	11,03	8,62	10,86	11,71

Table 4. Body size of Baltic whitefish larvae	LIVE FEED									
	Totallength (mm) March-May 1992									
	2.day	5.day	10.day	16.day	23.day	30.day	37.day	44.day	51.day	60.day
Mean (mm)	12,46	12,62	13,27	13,47	16,23	16,33	16,10	20,05	19,87	24,18
Variance	0,06	0,24	0,30	0,79	0,80	1,67	1,71	10,75	9,08	7,01
Standarddevi.	0,25	0,49	0,55	0,89	0,90	1,29	1,31	3,28	3,01	2,65
Coefficient of variat. (CV%)	2,01	3,88	4,14	6,59	5,51	7,92	8,12	16,35	15,17	10,95

There is obviously no significant difference in growth parameter between TETRA and FINNEWOS starter diets, but a strong difference to natural zooplankton diet. The reason must be the decrease in plankton biomass at the end of April.
The growth curve for all diets is presented in Figure 2. The plankton diet displayed significantly smaller fish than the other two diets.

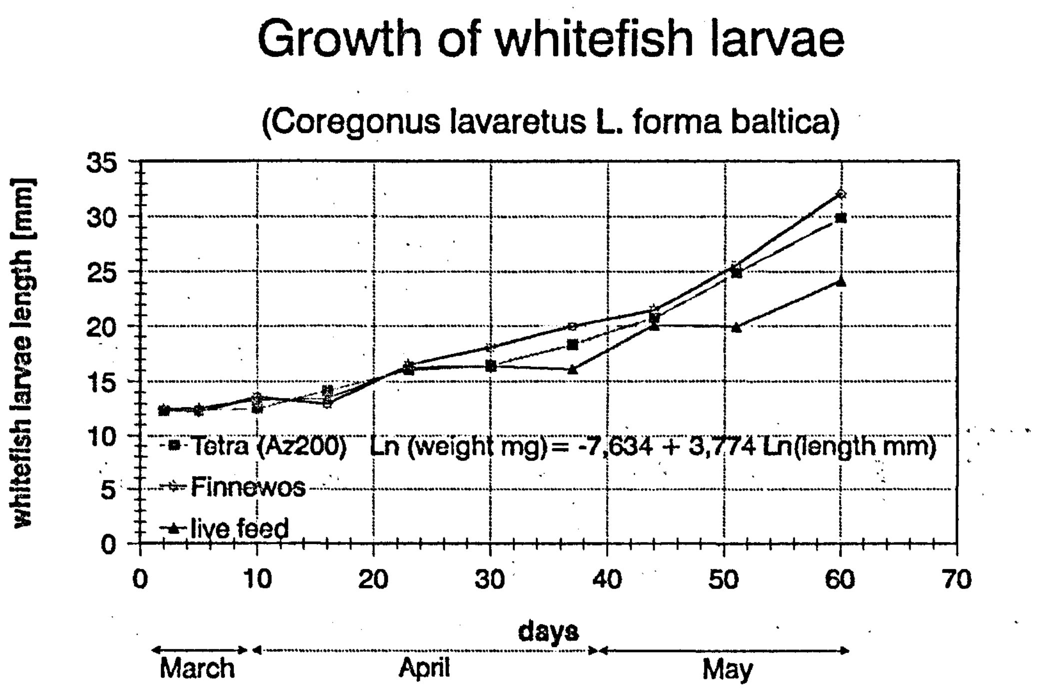

Figure 2. Body length of whitefish larvae, March-May 1992

The comparison between TETRA and FINNEWOS based growth on day 60 show a significant left skewed distribution for the FINNEWOS group. Smaller fish are less abundant than larger ones. This distribution pattern occurs already since day 5. The TETRA group has a higher variability, smaller fish are more abundant compared to the FINNEWOS group (see Figures 3 an 4). The reason might be the the fine grained nature of the TETRA feed.

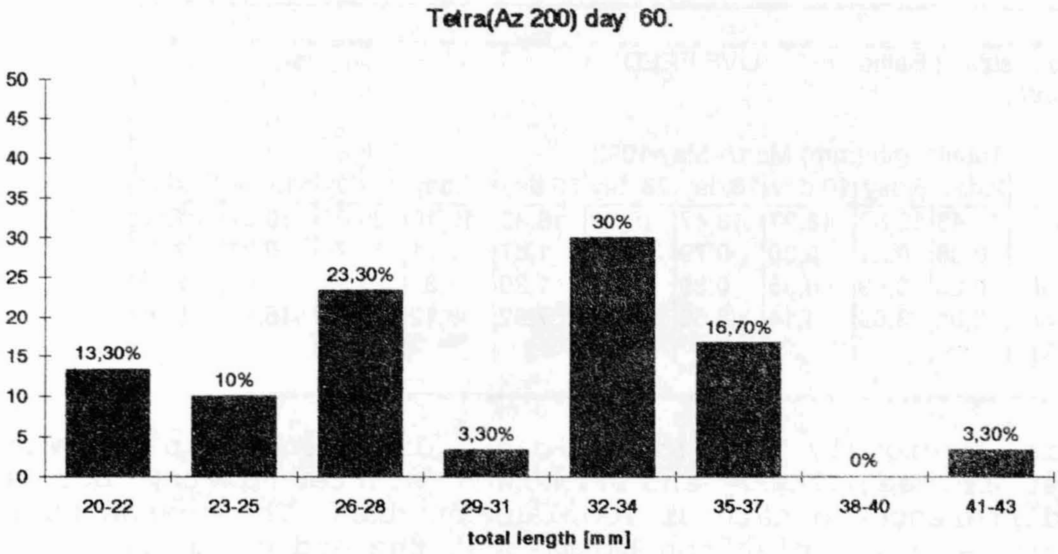

Figure 3. Size distribution of coregonid larvae, TETRA feed

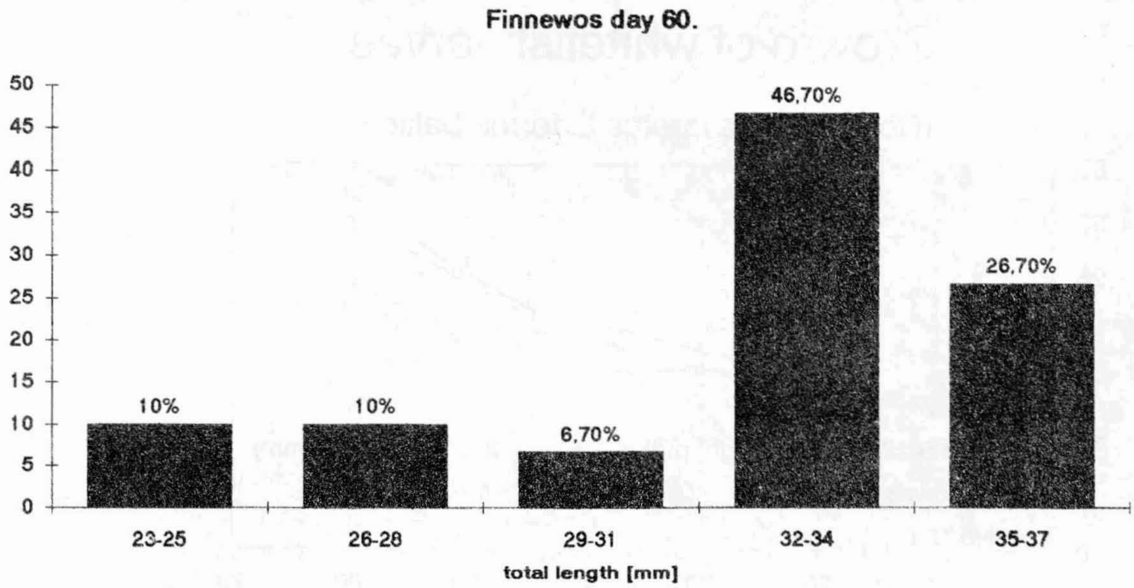

Figure 4. Size distribution of coregonid larvae, FINNEWOS feed

After 18 days the occurence of air bubbles in whitefish larvae gut was observed. According to DABROWSKY (1988) this influenced the natural mortality to a certain extend. The establishing of the swimm bladder starts according to BELTRAN and CHAMPIGNEULLE (1992) after 15 days. This corresponds to larval development stage 5, LUCZYNSKI et al.(1988).
TETRA AZ 200 000 was given until day 37 (later on AZ 200 00). The specific growth rate was 5.7% per day. This resulted in a food coefficient rate of 4.27 (food coefficient means amount of food given, devided by the weight increment). With a protein content of 52 % and a weight increment of 515 g for the whole population this value corresponds to a PER (protein efficiency ratio) value of 0.45. The growth data for the three diet regimes testet are presented in Table 5 and Figure 5.

Table 5. Growth data (wet- and dry weight) for coregonid larvae

TETRA	2 day	5 day	10 day	16 day	23 day	30 day	37 day	44 day	51 day	60 day
wet weight (mg)	5,90	5,97	6,38	10,63	18,17	16,20	25,07	40,83	88,40	182,60
dry weight (mg)	-	-	1,03	1,57	-	2,90	4,93	7,87	18,57	33,10
moisture (%)	-	-	83,24	85,27	-	82,10	80,32	80,74	79,00	81,87
FINNEWOS	2 day	5 day	10 day	16 day	23 day	30 day	37 day	44 day	51 day	60 day
wet weight (mg)	6,20	5,73	8,43	7,93	14,33	19,60	36,97	52,67	88,33	214,70
dry weight (mg)	-	-	0,70	0,97	-	3,93	6,57	9,63	18,57	36,90
moisture (%)	-	-	91,70	87,82	-	79,93	82,24	81,71	78,98	82,82
Plankton/*Artemia*	2 day	5 day	10 day	16 day	23 day	30 day	37 day	44 day	51 day	60 day
wet weight (mg)	6,17	6,50	7,77	10,63	20,70	13,83	16,13	43,07	32,87	62,37
dry weight (mg)	-	-	0,30	1,93	-	2,10	1,93	7,67	6,47	8,63
moisture (%)	-	-	96,14	81,82	-	84,82	88,02	82,20	80,32	86,16

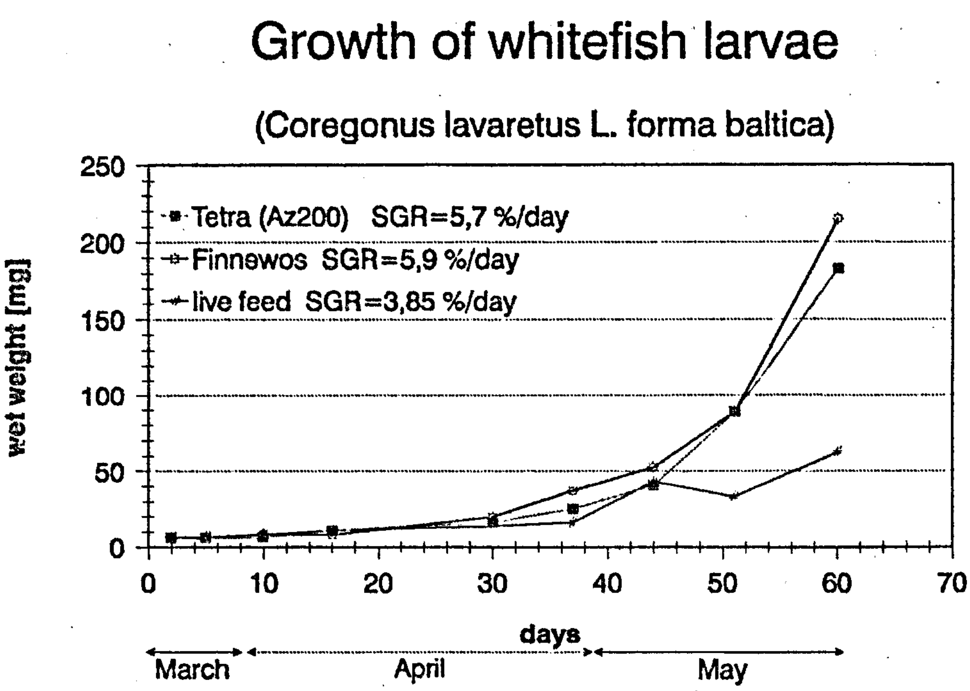

Figure 5. Body weight of Baltic whitefish larvae, 1992

Between day 37 and day 44 a short time growth occured also to the group fed with live plankton and *Artemia*. This corresponds quite well to the zooplankton biomass development in the Darß-Zingst Bodden chain(see Figure 6).

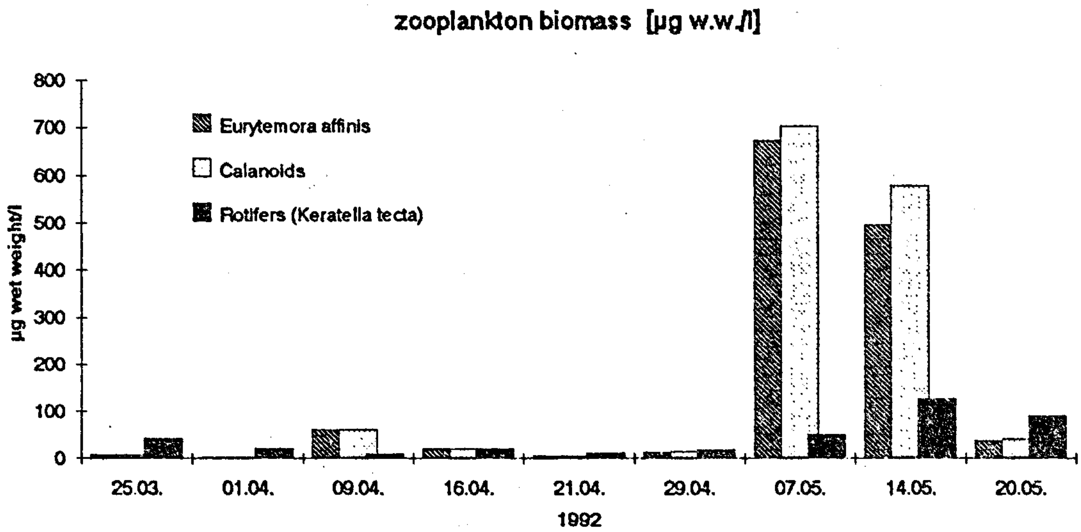

Figure 6. Zooplankton biomass March to May 1992

In order to compare this results with abundance values presented by other authors one have to notice a mean wet weight of 10 µg for adults of copepoda species and 0.1 µg for rotifers. Depending on the enormous decrease of utilizable zooplankton biomass from day 44 onwards a significant reduction in growth was observed.
After 60 days the total biomass of all three rearing trials was determined and the rearing experiments were continued in illuminated net cages just outside the culture station, in the so-called Koppelstrom, a small part of the Darß-Zingst Bodden chain.
Despite of the bad water quality in the culture station the natural mortality was comparable low. That means the individuals show a high adaptability to the environmental conditions. The mortality rate was 29 % for both groups fed with artificial feed and 72 % for the group fed with live zooplankton. There are strong indications that this high mortality rate is caused by the low zooplankton biomass at that time.

Discussion

The successful and consistent nature of this rearing experiment has demonstrated the practicability of an intensive startfeeding with dry feed TETRA AZ 200 000 and FINNEWOS Aquastart 0. Overall, the growth and survival of the Baltic whitefish larvae throughout the 60 days of experiment compare favourable with results obtained in other research studies

(DABROWSKY, 1988) The different nutritive values from AZ 200 000 and Aquastart 0 with a protein content of 53 %, and 64 %, and a fat contant of 17 %, and 13.5 %, respectively did not result in significantly different growth and survival rates. *Artemia* spp. has a protein content of about 50 % and a fat content of 21.5 % . Of course not only this two values are responsible for growth and survival. One even has to consider all the other additive substances.

However the bad survival for the group fed with live feed is caused by the delay in zooplankton development at that time. The abundance of rotifers and copepods was to low in order to get a satisfactory growth. From day 44 the food ration of zooplankton and *Artemia* was about 10% of the body weight. According to GUNKEL (1980) the food ration for 50.000 larvae at that time of development has to be at least 4 kg daily. This is 10 times higher than our ration given . We can only speculate that most of the larvae were starved. TROSCHEL and RÖSCH (1991) reported a maximum live zooplankton daily ration of 270 % of larvae wet weight. The specific growth rate was 8.7 ± 5.2 % at comparable water temperature (10-12 °C).

Dry, commercially available feeds such as TETRA AZ 200 000 and FINNEWOS Aquastart 0 containing high levels of crustacean derived components do not appear to reqiure supplementation with *Artemia* spp. in order to show high food acceptance, high growth, good survival rates and normal development. The growth and survival parameter are comparable with results reported for *Coregonus fera* fed with *Artemia* nauplii (GUNKEL, 1980). Growth is also comparable with results reported by JÄGER, NELLEN und SELL (1984) for a rearing experiment with *Coregonus lavaretus* kept in illuminated net cages. Similar results have been reached by other researcher (KLEINFELD-KRIEBITZ and RÖSCH ,1987)in case where frozen zooplankton were used in rearing experiments with *Coregonus lavaretus.*

However, questionable are the food coefficient (4.27) and the protein efficiency ratio (PER) of 0.45. But one have to consider the high food ration of 20 % BW at the beginning of the experiment. STEFFENS (1985) reported for feed with a protein content of 52 % a PER value of 2.5. This leads to the conclusion that a 4 to 5 times lower food ration would lead to the same growth rates. This needs further investigations.

To summarize, this experiment has shown that relatively high survival rates (71 %) and satisfactory growth (200 mg in 60 days) of <u>Baltic whitefish</u> larvae under brackishwater culture conditions using exclusively dry feeds are practical on a large scale. But, the rearing of whitefish seems to be more efficient using illuminated net cages situated in lakes with high biological production.

But, on a large scale commercial basis initial feeding with dry feed is only an alternative in years with cold winter and low plankton production.

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