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Lernaeocera branchialis (*Copepoda parasitica*) and its damaging effect upon some gadids

By Hans Mann

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(Director: Dozent Dr. phil. habil. P.F. MEYER)

LERNAEOCERA BRANCHIALIS (Copepoda parasitica) AND ITS DAMAGING EFFECT UPON SOME GADIDS

by Hans MANN

with 10 Tables

(A) INTRODUCTION

The copepods which are parasites on marine fishes have been studied so far almost exclusively from the zoological point of view, and have been given hardly any consideration in fishery studies. In general, only a slight damaging effect, if any, was ascribed to them. However, in freshwater fisheries, the destructive effects caused by the copepods parasitic on the gills of food fish are very well known. For example, strong infection with Ergasilus sieboldi on tench may lead to the extermination of the entire tench population in a body of water, necessitating the use of another type of table fish in the infected body of water (10). Recently, increased attention has been given also to the well-known skin parasite Argulus foliaceus, since it became known that it is capable of transmitting the pathogen of infectious abdominal dropsy (4).

(B) BIOLOGY OF LERNAEOCERA

Among the parasitic copepods living on food fish in the sea, the specific form Lernaeocera branchialis has special parasitic habits which would seem to indicate damage to its host.

This parasite lives in the gill chamber of cod and similar fishes. In order to understand its destructive effect, it is necessary to make some brief statements concerning the biology of this parasite.

Lernaeocera does not live on the gills - as the better-known ergasilids do - but, rather, on the inner wall of the gill chamber. The mature parasite can be recognized very well with the naked eye by lifting up the gill cover of the infected fish. The S-shaped, curled up body and the ramification of the head section in the form of antlers are particularly conspicuous.

The nauplius larva, which is characteristic of copepods, leaves the egg and develops to the copepodid stage after a number of moults. Up to that point, both sexes develop in the same manner. In the copepodid stage the parasites settle on the gill arches of flatfishes, clinging to them by means of a frontal thread. The copepodid stages become capable of reproduction and copulate already on the flatfishes. The fertilized females leave the fish and swim around freely for a short time until they have found a suitable host, e.g. codfish or other gadids. The males die since they have fulfilled their task.

The impregnated female settles on the wall of the gill cavity of fish of the Gadus species and undergoes a peculiar transformation. While its head pierces through the wall of the gill cavity in the direction of the heart of the host fish, the segmentation of the body gradually disappears. When the head has reached the tissue of the heart bulb, the anchorage is achieved by folding forward three processes which are at an angular position in relation to each other, laterally at the end of the head - and these processes later develop ramifications at their terminal sections. The trunk gradually assumes a saccular shape but /134 bulges somewhat at the place where later the sex segment will form. When the individual is finally anchored, its body is curved in the shape of an S and distorted towards the longitudinal axis. In the meantime, it has grown to at least 20 mm. and has developed its egg sac, appearing as attached to entangled strings. Neither antennae nor limbs have developed, and are still only minute appendages in the same state as they were in the copepodid stage.

The name "branchialis" is actually wrong because the parasite does not live on the gills but penetrates into the tissue of the Bulbus. That tissue is capable of compensatory thickening and has a significant reserve material of embryonic cells in this organ (14). As investigations have shown (14), (16), (2), the parasite does not take blood for its food from the aorta proper, but rather from the smaller vessels of the walls. In addition to the blood from the host, which represents the main food, real tissue was occasionally observed in the alimentary canal of the parasite.

(C) INVESTIGATIONS CARRIED OUT SO FAR CONCERNING THE RELATIONSHIPS BETWEEN PARASITISM AND FISH SIZE

Opinions differ widely on damaging effects upon the host by the parasite Lernaeocera branchialis. CAPART (2) does not ascribe great economic significance to the parasite. Although fish may be injured by the parasitization, as a consequence of which loss of blood or an infection may occur, the presence of the parasite is not regarded as having an essential influence upon the mature fish. In contrast with that opinion, however, T. SCOTT (12) reported the observation that whiting and other gadids had become emaciated in cases of infection with Lernaeocera that had sucked out their blood. A. SCOTT (13) also distinctly noted an effect of the parasite on the host fish at the time of the great infestation of whitings in 1928. VON OORDE DE LINT and J. H. SHURMANS STEKHOVEN (9) report that Lernaeocera branchialis would seem to cause breathing difficulties and heart trouble in young Gadus morrhua. In order to shed light on the question of the destructive effect of the parasite upon the host, intensive investigations have been carried out on various gadids in the North Sea.

(D) METHOD

According to the observations made by SHURMANS STEKHOVEN and PUNT (15), the major infection of gadids with parasites is supposed to occur in midsummer or at the beginning of fall. Most of the fresh stages of infection are found in September. Consequently, we started our investigations in the late summer months of 1949.

On the fish market of Cuxhaven, freshly caught cod, haddock and whiting specimens, which had just been brought to shore, were examined to determine Lernaeocera infection. Also examined were large numbers of fishes which had been brought to shore in Cuxhaven from cutters. Frequently, fishes from secondary catches on crab cutters were also checked for infection. On research voyages with the research cutter "Uthörn" some fish were caught off Helgoland with a special net (Knüppelnetz) and the fish were examined for their parasitization.

For all fishes the total length and body weight were determined, and the length-weight-coefficients were calculated from these figures, on the basis of Larsens' formula $g = \frac{k \times l^3}{100}$. A number of data are already available about the coefficients for the most important Gadus species (8). In comparing our figures with those of LUNDBECK, it must be pointed out that our figures were determined partly on ~~killed~~ dead fish and partly on fish that had not been killed as yet, whereas LUNDBECK /135
worked mostly on fish that had been killed for marketing. In order to eliminate in our investigations the various influences upon the length-weight ratio, such as age and season (8), the length-weight coefficients were calculated separately for the individual catches examined and the data obtained initially compared in relation to each other.

(E) INVESTIGATIONS ON WHITING (Gadus merlangus L.)

Uniform material, where the influence of the parasitization upon growth becomes clearly apparent, was obtained on 30 October 1950 between Helgoland and the floating light vessel Feuerschiff Elbe I. A total of 75 whitings were caught; 21, i.e. 28%, were infected with Lernaeocera. The length-weight coefficient of these fish was calculated at 5 cm. intervals, using, however, only the healthy, noninfected individuals.

TABLE 1

Length-Weight Coefficient of Healthy Whiting

(Caught on 30 October 1950 off Helgoland)

Length in cm	C
15--19,9	0,766
20--24,9	0,809
25--29,9	0,830
30--35,0	0,786

For the sake of comparison with this table (No. 1) with the length-weight coefficient of healthy fish, the data for infected fish are given in Table 2.

TABLE 2

Length-Weight Coefficient and Underweight of Parasitized Whiting

(Caught on 30 October 1950 off Helgoland)

No.	Length in cm	Weight in g	C	Infection	Underweight in %
1	12,7	13	0.635	1	—
2	14,3	20	0.684	1	—
3	14,7	23	0,724	1	—
4	16,7	29	0,623	2	19
5	17,0	34	0,692	1	10
6	17,5	38	0,709	1 +	8
7	18,0	42	0,721	1	6
8	20,2	54	0.655	1	20
9	22,5	97	0,851	1	0
10	22,8	92	0,777	1 +	4
11	23,0	92	0,756	1 +	7
12	23,0	92	0,756	1 +	7
13	23,0	95	0,781	R	4
14	23,1	109	0,884	1 R	0
15	24,0	125	0,904	1	0
16	24,1	95	0,679	1	6
17	24,8	119	0.781	R	4
18	25,7	109	0.642	2 +	23
19	28,2	109	0,486	2 R	42
20	29,5	200	0,779	R	6
21	29,6	220	0.848	R	0

+ = Lernaeocera with egg sacs
R = Remainder of head

In almost all cases, the length-weight coefficient is lower than that of the healthy fish, i.e. the fish weighed less than they ought to, considering their length. This becomes particularly obvious in cases of fish No. 4, 18, 19. Those individuals had two or three parasites on their gill arches. In some parasitized fish (No. 14, 15, 21), however, the coefficient is as high as the normal value. When these fish with normal length-weight coefficients were investigated in greater detail, it became apparent that they had been infected with either very young parasites which had just settled, or still showed the so-called "Penella" stage; or only remains of earlier older parasites which had already died were found between the gills. Frequently, the chitinous skins of the heads of dead Lernaeocera are found between the gill lamellae or on the wall of the gill cavity. Whereas the soft body had already decayed, the head with the hook-shaped processes was preserved. Whenever only the remainder of the dead head was found in such cases, it can be assumed that the host fish survived the damage to its health and has already compensated the weight difference. In cases of recent infection as in some individuals (e.g. fish No. 15) in which the fish is in a very good state of nutrition, the parasitization is not yet reflected in the length-weight coefficient.

The effects of infection with several parasites become apparent particularly in two fish which were caught on

4 August 1950 off Cuxhaven. Both fish had been infected with two living and two dead Lernaeocera; the coefficients amounted to 0.497, and 0.437 respectively, whereas the normal values of the healthy individuals caught at the same time amounted to 0.809, and 0.830 respectively. The lowest length-weight coefficient recorded in our investigations on whiting specimens amounted to 0.346. In the latter case, the individual originated from a larger catch, from a crab cutter, off Kugelbake near Cuxhaven, on 26 September 1950. The individual had a length of 27 cm. and a weight of 68 g. An exceedingly large parasite with mature eggs was found on the gills. The fish was emaciated to such an extent that it showed the typical "knife-edged" back which had been observed in freshwater fisheries on bream (Abramis brama L.) which have been infected with Ligula. T. SCOTT (12) must have found similarly emaciated gadids, and consequently such destructive effects are no exception. Accordingly, it would seem to appear that not only the number of the parasites, but also the age of development of the parasite and the degree of development of the sex products has some importance for the extent of the destructive effect upon the fish.

Our further investigations have confirmed this presumption, and we were able to notice again and again that parasitization with small, i.e. young parasites in the "Penella" stage, affected only slightly or not at all the health of the host fish. The larger the parasite becomes,

the more the extent of the damage to the fish increases. The number of whiting individuals infected with Lernaeocera in one catch can vary greatly. In the above-described material, 28% were infected. The largest infestation we were able to notice in our investigations was such that 75% of the whiting individuals caught had Lernaeocera on their gills. In a catch on 26 September 1950, 136 fish were examined, 35 individuals of which had parasites, i.e. approximately 25% of the total catch. Of the 35 infected individuals, 25 were infected with one parasite (71%), 7 were infected with two parasites (20%), and three individuals with three parasites (9%). A similar distribution with regard to the number of parasites on the gills of individual fish was noted repeatedly in later control investigations. The largest number of parasites we have observed were 10 young forms simultaneously on one fish of a length of about 25 cm. In order to ascertain /13
the damaging effect of the parasites upon the weight of the infected fish, the "standard weight" of a number of fish examined was determined with the aid of the length-weight coefficient, and the percentage of the "underweight" was then calculated (Table 2). It is obvious that as a rule the infected fish are 5-10 per cent lighter than the individuals without parasites. More than 10% underweight was observed on fish with more than one parasite on their gills (No. 4, 18, 19). With an increase in the number of parasites, the weight loss increases (No. 19). The largest underweight was observed,

of course, on the fish already mentioned which had reached a weight of only 68 g. with a length of 27 cm.; this individual had only 42% of the weight it should have had under normal conditions considering its length. These figures show clearly that a destructive effect is noticeable in cases of infection with Lernaeocera.

(F) INVESTIGATIONS ON COD (Gadus morrhua L.)

In order to examine the influence of the parasite upon cod, a larger series of measurements was carried out on the Cuxhaven market, summarized in Table 4. We were able to examine, at the same time, living fish which had not yet been cut up from the secondary catch from the cutters. As in the case of whiting, the length-weight coefficient and the percentage of underweight were calculated. Also in this case, interference with the growth of the cod specimen was observed in cases of infection with Lernaeocera. The underweight was particularly pronounced when several parasites or mature parasites with egg sacs were present in the gill chamber. The largest number of parasites observed amounted to 10 on one fish. If the severity of infection in younger individuals (Table 4) is compared with market fish (Table 6), it is apparent that the younger individuals were infected to a greater extent. In our investigations on cod individuals up to about 30 cm., originating from the vicinity of Cuxhaven up to Helgoland, we noted an average 80% infection. Fifty per cent of the individuals had only one parasite. Fifteen to twenty per cent of the infected individuals had two parasites in the gill chamber, whereas the remaining distribution was as follows: 3 parasites 10%, 4 parasites 5-10%, more than 4 parasites up to 5%. The older fish ready for marketing had only one parasite in most cases, rarely two, and the maximum observed in one case was six small parasites at the same time on a cod specimen of 1320 g., 52 cm. in length. These figures show clearly that a multiple infection on the same individual is possible, and has also been noted by SHURMANS-STEKHOVEN (14, 15). Young individuals are not immune, as had been formerly assumed. We would even assume that several infections may occur at the same time or in rapid succession in short intervals since we frequently found parasites in the same stage of development on one and the same fish.

TABLE 3

round (ungutted)

Length-Weight Coefficients for Healthy Cod

~~Which has not yet been Cut Up~~

Length	C
up to 10 cm	0,952
10,1—14,9	0,828
15 —19,1	0.913
20 —24,9	0,918
25 —29,9	0,782

TABLE 4

Parasites on round Cod ~~not yet Cut Up~~

Secondary Catch from Fishing Cutters from Cuxhaven

Caught in September and October 1949

No.	Length cm	Weight g	C	Infection	Underweight %
1	9,9	7,0	0,722	1	24
2	9,9	7,5	0,773	1	19
3	10,3	8,5	0,778	1	7
4	11,0	9,8	0,736	2	2
5	11,0	9,8	0,736	2	12
6	11,2	11,0	0,738	1	16
7	11,2	10,0	0,712	2	14
8	11,4	11,1	0,749	4	11
9	11,4	11,1	0,749	4	10
10	14,5	23,0	0,754	1	8
11	15,0	24,5	0,728	1	20
12	20,9	55,0	0,603	2 R	34
13	21,2	75,0	0,787	2	0
14	21,5	63,0	0,634	1	31
15	21,6	68,5	0,679	2 R	26
16	21,9	72,0	0,686	1	26
17	22,5	60,0	0,527	2	33
18	22,5	95,0	0,834	1 R	0
19	23,0	77,5	0,637	3	31
20	24,5	70,0	0,476	2	35
21	24,5	95,0	0,646	2 R	30
22	25,5	122,0	0,736	1	6
23	25,5	122,0	0,719	2	8
24	27,5	156,0	0,750	1	4
25	37,3	371,0	0,715	10	—

TABLE 5

Length-Weight Coefficient for Cod Individuals Without Infection –

Calculations based on ~~round~~ gutted Individuals ~~which had been Cut Up~~,

Brought to the Shore at the Cuxhaven Fish Market,

in August and September 1949

Length in cm		C
45	49	1,16
50	54	1,032
55	59	1,07
60	64	1,05
80	84	0,909
85	89	0,908
90	94	0,906
95	99	0,857
100	104	0,843

TABLE 6

~~Gut-Up~~ Gutted Cod Infected with Parasites -

Catches: Fladengrund and Gat in August and September 1949

(Cuxhaven Fish Market)

No.	Length cm	Weight g	C	Infection	Underweight %
1	34	350	0,890	1	—
2	35	380	0,886	1	—
3	43	765	0,962	1	—
4	45	765	0,810	1	28
5	52	1320	0,939	6	9
6	55	1240	0,745	2	30
7	62	1915	0,803	1	24
8	82	4800	0,891	1	2
9	87	6900	1,05	1	0
10	90	5480	0,752	1	17
11	91	5770	0,766	1	16
12	97	7900	0,865	1	0
13	97	8530	0,978	1	0
14	100	6900	0,890	1	20
15	103	9340	0,855	1	0
16	104	7400	0,658	1	22

The infection is not absolutely restricted to early development, because we also found young specimens without any developed egg sacs on fish ready for marketing (e.g. on an individual of 100 cm. and 6.9 kg.). However, on larger fish, old parasites with developed egg strings are predominant.

The smallest infected cod individual we were able to examine was 9.9 cm. long and weighed 7 g.; fish less than 9 cm. in length were always free from Lernaeocera. It may be assumed that in the case of cod, similar relationships between the fish migrations and infection with Lernaeocera branchialis exist, as have been presumed by SPROSTON and HARTLEY (16) concerning whiting (*Gadus merlangus*) and pollack

(Gadus pollachius). The youngest forms are free from any kind of infection. Infection occurs only at the moment /139 when the young fish migrate from the open sea into the estuary. This is quite understandable because flatfishes live there which act as intermediate hosts for the parasite Lernaeocera. SPROSTON and HARTLEY still presume that the infected fish act abnormally and do not return to the open sea since infected fish have never been found in deep water in the case of whiting and pollack. We were unable to confirm this observation in our investigations, because we found Lernaeocera infections also on cod, haddock and whiting caught at sea (Table 6). The fact that the infection appears to be slighter in large fish may be explained by the fact that the more heavily infected young stages are also more heavily damaged in accordance with the infection. Consequently they are more likely to fall victims to predatory fish ~~of prey~~ or to perish as a consequence of the parasite infection proper, thus leading to a natural selection in this manner. Evidence would still be required concerning the existence of a further selection presumed by SPROSTON and HARTLEY, namely that the infected individuals do not migrate to the open sea. Quite frequently, the remain~~ders~~s of dead Lernaeocera are found in older fish next to fresh parasite infections. This proves that new infections or secondary infections may occur at any time also in more mature stages of the host fish.

A difference in the degree of damage in older fish as against younger fish was noted only under certain conditions. In smaller fish, weight is always clearly influenced by the parasitization. The growth of larger fish is also affected by the parasite, however in most cases the larger fish are better able to compensate the weight difference that exists in relation to healthy fish. This will apply particularly if the parasite is dead and if no new infection occurred. The difference between younger and older fish becomes better /140 apparent if the degree of infection is examined. Almost 80% of the young fish were in most cases infested with Lernaeocera, whereas only 3-6 per cent of the large market fish exceeding 35 cm. showed the parasite, according to our observations from 1949 to 1951.

(G) INVESTIGATIONS ON HADDOCK (*Gadus aeglefinus*)

In the same manner as in the case of whiting and cod, Lernaeocera infection was also examined in haddock. Material was available to us, partly fish ready for marketing at the auction, and also smaller fish from the secondary catches from fishing cutters. Again, the infection was particularly heavy on the smaller fish which had been caught in the area of the estuary. In general, according to our investigations from 1949 to 1951, about 75% of haddock individuals up to 25 cm. in size were infected with Lernaeocera. In cases of fish ready for marketing, infection ranged from 20 to 30 per cent.

From the point of weight, infection was also more noticeable on the smaller fish, as compared with the larger individuals above 30 cm. In the majority of cases, the smaller infected fish had an underweight of 30% and more, whereas this degree of underweight was rarely reached in cases of larger fish. The number of parasites was also higher in the case of small fish. Whereas only 10-20 per cent of the fish ready for marketing had more than one parasite, the smaller fish had /1
multiple infections in 50-75 per cent of the cases. Occasionally the question was raised as to whether one side of the gills was particularly favoured by the parasite. Investigations in this respect on our material showed that both sides are evenly infected by the parasites. It does not seem to matter in cases of secondary infections, whether one or the other side of the gill chamber has already been infected.

TABLE 7

Length-Weight Coefficient of ~~Cut-Up~~ gutted Healthy Haddock (Cuxhaven Fish Market), Caught in October 1950 on Fladengrund

Length in cm	C
35--39	1,12
40--44	0,951
45--49	0,905

TABLE 8

~~Cut-Up~~ Gutted Haddock with Parasites (Cuxhaven Fish Market)

Caught in October 1950 on Fladengrund and Gat

No.	Length cm	Weight g	C	Infection	Underweight %
1	32	330	1,00	1	11
2	34	330	0.839	1	25
3	34	350	0.89	1	20
4	34	420	1,07	R	5
5	35	475	1.11	R	0
6	36	430	0.922	R	18
7	36	480	1.103	2 R	2
8	36	540	1.16	R	0
9	37	600	1,16	1	0
10	38	500	0.911	1	19
11	41	690	1,0	1	0
12	42	700	0,946	2	0
13	42	800	1,08	1	0
14	48	625	0,561	1	38
15	55	795	0,478	1	47

TABLE 9

Length-Weight Coefficient of Healthy round Haddock ~~not yet Cut Up~~

(Caught in March 1950 off Cuxhaven)

Length in cm	C
14—19,9	0,987
20—24,9	0,951

TABLE 10

Round Haddock ~~not Cut-Up~~, Caught off Neuwerk on 24 March 1950

No.	Length cm	Weight g	C	Infection	Underweight
1	14,2	17	0,594	1	40
2	14,8	17	0,524	1 R	47
3	14,8	18	0,555	1 R	34
4	14,8	20	0,617	3 R	38
5	15,4	26	0,712	2	28
6	15,6	24	0,632	1	36
7	15,8	17	0.431	2 R	56
8	16,0	26	0,635	3	36
9	16,5	28	0.623	2 R	36
10	16,5	29	0,645	1	35
11	16,7	33	0.710	2 R	28
12	19,2	47	0,664	2	23
13	20,5	82	0,951	1	0
14	22,9	80	0,666	1	30
15	23,5	85	0,655	3	31
16	23,7	71	0,534	2 R	44

(H) THE DESTRUCTIVE EFFECT OF THE PARASITIZATION

Through measurements of three Gadus species, whiting, cod and haddock, we were able to prove that the fish infected with Lernaeocera had actually suffered damage. The majority of the parasitized fish weighed less than they would have had to weigh normally in accordance with their length. The damaging effect increases with the number of parasites in the gill chamber. Similar observations have been made in the freshwater fisheries establishments (10) on bream (<u>Abramis brama</u>) and on tench (<u>Tinca vulgaris</u>) which had been infected with the copepod Ergasilus. In cases of slight infection, the fish were of normal weight, but as soon as the number of parasites on the gills had exceeded a certain limit, the fish became visibly emaciated. The same observation had been made on fish in Lake Mondsee (6), i.e. the growth decline increased purely and proportionately with increasing age. Such rising growth inhibition with increasing age is understandable since the effect of the parasite (Ergasilus) upon growth increases with time, i.e. the longer the infection lasts, the greater it will be. This observation would not seem to apply to infection with Lernaeocera, because in the case of older fish, a slighter /142 destructive effect was noted almost in all cases - expressed in relative underweight - than this was the case for young fish. This may be explained in the following manner: the really heavily damaged fish will never be brought to the market because they disappear and cannot be found later. Or one must assume that the infected fish overcomes the destructive effect when the parasite dies after the formation of the egg strings. This would seem to be confirmed by the data concerning fish on which the dead parasite heads had been found. Finally, the type of the parasitization would also seem to exercise an influence upon the degree of damage. We frequently noted in older fish that the parasites had not penetrated into the Bulbus - as was mostly the case in young fish - but had become anchored in the Aorta ventralis. Moreover, the reaction of the host to the parasite differed - as we noticed on infected cod. In cases of young fish, the parasite was frequently only very weakly anchored in the host, i.e. it was extracted without great difficulty. In the case of larger fish, this was quite difficult in most cases. It became apparent in more detailed investigations that in the case of large fish, the head of the parasite was surrounded by growth of compensatory tissue of the host, and that the parasite was more or less incapsulated. We would therefore assume that older fish are capable of an increased defensive reaction than the younger specimens.

In order get an indication of whether or not the length of fish was also affected by the parasite, in addition to the weight — we ascertained the length of the head in infected whitings as well as in noninfected whitings, and established its relation to total length. The comparison resulted in no difference between parasitized and healthy fish. This finding confirmed the observation made by LECHLER (6), i.e. parasitization always affects the weight more than the length of the fish, whereas in cases of deficient nutrition and protein shortage, forms develop through starvation which are distinguished by particularly large heads and exceedingly long tails from the normally shaped fish (18, 19).

Since earlier research workers (14) had mentioned that fish infected with Lernaeocera occasionally had breathing difficulties, we made a number of experiments on the oxygen consumption of whiting. The method was the same as the one used in earlier investigations on the oxygen consumption of fishes (3) and consisted, in principle, of a chamber where the fish could breathe while water with a known oxygen content passed through. From the difference between the oxygen content in front and behind the breathing chamber, the oxygen consumption per gram of body weight per hour was calculated on the basis of the weight and the duration of the experiment.

The experiments were carried out under a water temperature of 10° with normal sea water. The oxygen consumption per gram body substance in one hour amounted to the following - as an average of four experiments in each case:

0.12 mg. for whiting with parasites and
0.17 mg. for whiting without parasites

Unfortunately, only a small number of experiments could be carried out since whiting, especially parasitized individuals, can be kept in aquaria only with great difficulty. However, these initial investigations indicate already a reduction in oxygen consumption in the case of fish infected with parasites. Similar observations have been made by JACZO (5) in his investigations on perch (*Perca fluviatilis*), which were infected with Myxosporidia on the gills. He also noted a reduction in the oxygen consumption in the parasitized /143
fish. Consequently, we may conclude from our investigations that the breathing mechanism is affected rather significantly by the parasitization.

It also seemed indicated to carry out blood tests because it had become apparent repeatedly in earlier investigations on freshwater fishes (10) that the blood composition may be changed through diseases and parasites. Consequently, the haemoglobin content and the number of the red blood corpuscules were ascertained in some whiting individuals (investigation, October 1950). The following results were obtained:

	Haemoglobin Content	Erythrocyte Count
Parasitized whitings	20—22%	847 500
Healthy whitings	38—40%	902 500

Also in this case, only a few measurements (10 measurements) were made, and consequently the results must be evaluated with great reservations. However, the figures obtained show that parasitization can exercise an influence on the blood count, as SCHLEICHER (11) had also ascertained a reduction in the number of red blood corpuscules in perch, the gills of which had been infected with Trichodina.

On the whole, the physiological investigations have confirmed the results of weight analysis, namely indicating that Lernaeocera infection has a distinctly destructive effect upon the fish.

Summary

Whiting, cod and haddock were investigated as to the infection by Lernaeocera. The parasite has a damaging effect to the fish on which it is living. Generally speaking, infected fish have a lower weight than sound fish of an equal size. The damaging affect increases with the number of parasites. The difference in weight as compared with sound fish can be balanced, if the parasite dies and no new infection would occur. The weight of infected whiting is usually diminished by 5 to 10%. The young fish of cod and haddock are infected up to 80%. The weight is diminished by 20 to 30%. The larger fish of these species are lesser infected.
Infected fish have a smaller consumption of oxygen than sound fish. In connection with the contamination a secondary anaemia would appear.

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