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The correlation between meat contents of blue mussels (Mytilus edulis) and the number of parasites (Mytilicola intestinalis)

by

Volkert Dethlefsen

Institut für Küsten- und Binnenfischerei
der Bundesforschungsanstalt für Fischerei
Hamburg
Außenstelle 219 Cuxhaven, Kapitän-Alexander-Str. 54

Summary

Seasonal fluctuations of meat contents of blue mussels were recorded together with their parasitation. From these data the correlation between numbers of Mytilicola intestinalis and the meat content of the respective mussel was analysed statistically. Meat contents of mussels were lowest when spawning occurred (May). Fluctuations of meat contents of parasitized and non parasitized mussels did not reveal any marked differences. Statistical analysis of the relationship between number of parasites and meat contents of mussels gave proof of no significant correlation.

Introduction

The connection between the severe mortalities of Dutch culture mussels in the autumn of 1949 and the simultaneous high numbers of Mytilicola intestinalis in the mussels (KORRINGA, 1950) had mainly been respondible for a lot of surveys carried out in many European countries and in subsequent years it was generally accepted that Mytilicola intestinalis was the causative agent of mass-mortalities of mussels in Holland and Germany (MEYER and MANN, 1950).

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In an excellent review KORRINGA (1968) summarizes the present knowledge on the parasite and it is clear that there is a marked divergence of opinion on the effects of the parasite on the host. Thus KORRINGA (1950), MEYER and MANN 1950 and COLE and SAVAGE (1951) conclude that the meat content of the mussels was adversely affected by the number of Mytilicola intestinalis. Similar data for the effect of Mytilicola orientalis on the condition of oysters have been presented by ODLAUG (1946) for Ostrea lurida and CHEW et al (1955) for Crassostrea gigas.

On the other hand there are several authors who were not able to detect any harmful effects of the parasite on their hosts (GENOVESE 1959, HRS-BRENKO 1964, CASPERS 1939, ANDREU 1963, MONTEIRO and FIGUEIREDO 1961 and WILSON 1938 (Mytilicola orientalis on Crassostrea gigas).

A third group of authors holds an opinion between these two and assumes without giving data, that there must be a harmful effect even though relatively highly infected mussels were found to be in excellent condition and obviously not harmed by the parasites (HEPPER 1955, MEYER-WAARDEN 1956, 1960, 1963, CAMPBELL 1970, THEISEN 1966).

In connection with the monitoring of seasonal and annual fluctuations in parasite numbers the meat content of individual mussels was measured in order to obtain sufficient data for a statistical analysis of the correlation between meat content and parasites.

2. Material and Methods

2.1. Sampling sites

Sampling was carried out from June 1971 to August 1973.
Basic consideration for the selection of sampling sites was that apart from localities with traditional high infestation also mussels without any parasites should be sampled. This would allow comparison of seasonal changes in meat content in parasitized and non parasitized mussel populations.

Further it was important that a continuous sampling from the same place of a mussel bank throughout the whole period of investigation should be guaranteed. From these considerations the following sampling sites were chosen.

An area with a traditional high infestation in Ostfriesland (Lower Saxony) was the Wattensea near Norddeich (Fig 1) with three sampling sites.

I. Norddeich harbour

mussels exposed to the air during low tide, average time of exposal to the air being 30%

Position 53° 37' 33'' N
7° 9' 24'' E

II. Buse Riede

mussels not exposed to the air, average depth of water 2.5 m

Position 53° 39' 30'' N
7° 10' 5'' E

III. Oster Riede

mussels not exposed to the air, average depth of water 2.1 m

Position 53° 40' 45'' N
7° 9' 50' E

At these three sites sampling was carried out regularly in monthly intervals.

The last survey on the distribution of Mytilicola intestinalis in mussels from the German coast (DETHLEFSEN 1972) had confirmed the pattern of distribution found in 1950 and the following years (MEYER and MANN 1950).

Mussels from the northern parts of the Schleswig-Holstein coast were not parasitized, so a 4th sampling site was chosen near Husum:

IV. Husum Watt

mussels not exposed to the air, average depth of water 1.5 m

Position 54° 27' 23'' N
8° 40' 59'' E

Mussels were sampled by ship with dredges. They were transported without water, and they were stored in a normal refrigerator before being investigated. Preceding work (DETHLAFSEN 1970, 1972) revealed that a storage without water for a period of up to 9 days did not influence the numbers of parasites.

2.2. Methods

The sample size was uniformly 50 mussels per station per month. After cleansing the mussels from adhering barnacles etc. the posterior adductor muscle was cut, the introduction of the scalpel into the mussel being facilitated by shifting the right valve against the left valve. After the left valve had been removed the length of the shell was measured (to the nearest mm).

For the following investigation the method proposed by BOLSTER (1954) was used with slight changes, to count Modiolicola insignis.

I. Measurement of meat content.

The body tissues of the mussels were removed from the right shell and after being dried on filter paper were exposed to the stream of hot air of a ventilator for 15 min. After this time meat and shell were weighed individually on a microbalance.

Another method was applied to estimate the dry weight of meat. Meat and valves were dried for 16 hours (14 h at 60° and 2 h at 80°C) and weighed afterwards. Data on time of sampling, percentage of meat, number of samples length of mussels and on temperature salinity and pH at the sampling sites will be published in a seperate paper (Dethlefsen, in press).

3. Results

The seasonal fluctuations of the meat content (estimated on wet weight basis) of mussels from different stations are given in Fig. 1, 2 and 3. The values for Fig. 1 and 2 were obtained from parasitized, and those for Fig. 3 from non parasitized mussels (Station 4). Meat contents were lowest in mussels exposed to the air (Station I, Fig. 1). At the beginning of the investigation meat content was about 35% decreasing steadily and reaching minimum values in May 1972. After June 1972 meat content of the mussel increased rapidly reaching maximum values in October 1972 (44.5%).

In the following months the meat content decreased again but minimum values (37%) were markedly higher than in the season before. Meat contents were again lowest in May. Very similar was the pattern of seasonal fluctuations of meat contents of mussel not exposed to the air at low tide although the average values of meat content were higher than at station I. Lowest meat contents from mussels of station 3 (Fig. 2) were found in May 1972 and May 1973. The meat contents of non parasitized mussels (station 4) are given in Fig 3. The seasonal course is similar to those shown above, the fluctuations were within a range of 34 and 42%. In the second period meat contents were higher than in the first. However maximum values of meat content were reached much earlier occurring in July in both seasons compared with September-October for stations 1 and 3. From Fig. 1 and 2 it can be seen that the average numbers of parasites follow an annual course opposite to that of the meat contents. However in the winter a more or less parallel decrease was noted with a minimum of meat content reached in May the minimum of average number of parasites is reached 1-2 months later. Altogether one can have the impression that meat contents of the mussels decrease when average numbers of parasites are higher than 7 - 8 Mytilicola per mussel.

As soon as number of parasites decrease markedly below this value an increase of the meat contents follows. This finding may lead to the conclusion that the numbers of parasites are the causative agent of changes in meat content. But it might also be possible that both factors are dependent for instance on temperature. The correlations between meat content and numbers of parasites were computed for 12 months and the correlation coefficients are given in table 1. The data for 50 mussels per month and per station were tested to see if there was a linear correlation between meat contents and numbers of parasites. For such a correlation to be significant correlation-coefficients should be higher than 0.6 - 0.7. Such values were found only twice out of 39 correlations tested (table1) 1. 16.9.71 stations I (Norddeich harbour), the average number of parasites was 9.6 Mytilicola per investigated mussel. 2. 4.8.71 station 3 (Buse Riede), average number of parasites was 3.3 Mytilicola per investigated mussel. The remaining 37 correlation-coefficients show, that there is no significant linear correlation

between parasite numbers and meat content. This finding is supported by Fig. 10, 11 and 12, where the correlation of meat content and numbers of parasites is shown graphically (only 260 points out of 600 are shown for the sake of clarity). The distribution of these points makes it evident that a simple linear correlation cannot exist. The calculations mentioned above were based on mussels of different sizes and since it can be seen from literature that meat contents of mussels may depend on their size (KORRINGA 1955, BAIRD 1958) the mussels were sorted into different size groups. For these different size groups correlation-coefficients were calculated and results are given in table 2. In a single case (station 3, Osterriede, size group 56 - 60 mm) a coefficient was obtained that shows a nearly significant correlation. In the rest no significant correlation could be found.

Since the estimation of meat content of mussels based on wet weight is a very rough method that includes possible mistakes caused by varying water contents of the tissues of mussels (KORRINGA 1955) it was decided to carry out an additional test based on dry weight.

600 mussels used in this test were dredged in November 1973. At station 1 1543, station 2 1882 and station 3 1955 Mytilicola intestinalis of different developmental stages were found in 200 mussels each, the mussels were selected length of 45-55 mm at station1 and 55-65 mm at Station 2 and 3.

The frequency (in percent) in which Mytilisola occurred in the mussels in definite numbers made it evident that low or non parasitized mussels as well as very highly parasitized mussels were sampled in sufficient numbers. The points showing the correlation of meat contents and numbers of parasites are given in Fig. 7, 8 and 9. From these figures it is clear that the points are not distributed linearly. The results of the statistical analysis of these data are given below:

station 1	station 2	station 3
n = 200	n = 200	n = 200
r = 0.0183476	r = 0.0079698	r =+0.1569240, no correlation

In addition the data were tested to see if there was a linear corre-

lation between number of parasites and water contents of mussels.

n = 200 (station 2)
r = 0.079334611 no correlation

The correlation between meat (weight wet) and meat dry weight was highly significant

n = 200 (Station 2)
r = 0.0950061260

Since it was obvious that no linear regressions existed it was abated to test whether the correlation between numbers of parasites and meat content though not linear following the equation $y = a.x^b$. For this purpose the sample of 200 mussels from station 2 was divided in subsamples of 50 mussels each and the correlation-coefficients were calculated. Results are given below. In all four cases tested no significant non linear correlation existed.

1.)	2.)	3.)	4.)
n = 50	n = 50	n = 50	n = 50
r = -0.031439	r = -0.114324	r = o.175656	r = 0.005815

Table 1 Correlation between numbers of Mytilicola intestinalis and meat contents (based on wet weight) of Mytilus edulis. Coefficients of regr. are based on 50 values each, exceptions are indicated. (y = a + bx, Y = number of parasites, x = meat contents in %).

date	station 1 r	station 2 r	station 3 r
4 aug 71	0.05509	0.6438	0.3363
16 sep	-0.6150	-0.1203	0.2206
4 oct	0.03713	0.01295	0.05757
10 nov	0.1787	0.2247	0.1854
2 dec	-0.3903	0.1161*	-0.2272**
5 jan 72	-0.1360	0.1791	-0.4104
7 feb	-0.01316	-0.3129	0.3706
1 mar	0.2894	-0.2414	-0.2216
4 apr	0.1686	0.1210	0.3479
8 may	-0.1359	0.0011	0.2769
5 jun	-0.3181	0.1560	0.3235
5 jul	o.2841	-0.4379	-0.0454
1 aug	0.3157	0.1826	0.0838

* 25 mussels, ** 20 mussels

Table 2 Correlations between numbers of Mytilicola intestinalis and meat content of Mytilus edulis. The material from table 1 has been devided into groups of the same size.

	length group 41 - 45 mm	length group 46 - 50 mm	length group 51 - 55 mm	length group 56 - 60 mm	length group 61 - 65 mm
station 1					
n	154	198	166	60	22
r	-0.124974	-0.049886	-0.128647	0.195595	-0.099795
station 2					
n	73	180	162	83	54
r	-0.240191	-0.154463	-0.043502	-0.174472	+0.172927
station 3					
n		161	184	137	81
r		+0.110419	+0.079209	+0.492384	-0.179073

4. Discussion

The seasonal changes of gonad index (breeding cycle), condition index and the organic dryweight reported by SEED (1969a) BAIRD(1966) DE ZWAAN and ZANDEE (1972) and DARE (1973) give good agreement with our results on changes in meat content. Most striking were the marked decreases of condition indices and meat contents at the beginning of reproduction of the mussels. Minimum values were found in May when spawning occurs. Similar declines in dry fishes weight occurred in Cardium edule (HANCOCK and FRANKLIN 1972) Venus mercenaria (ANSELL et. al. 1964), Tellina tenuis (ANSELL and TREVALLION 1967) and Donax vittatus (ANSELL 1972). As far as I know the populations of Mytilus mentioned by SEED, BAIRD and DARE were not parasitized by Mytilicola. Comparing the annual changes of meat contents of parasitized and non parasitized mussels one can state that no principal differences existed either in the appearence of peaks or in the range of fluctuations. The partly inverse relationship of the course of meat contents and infestation should not lead to the misinterpretation that the course of infestation causes the

course of meat contents, i.e. there is not necessarily a cause: effect relationship.

Another misinterpretation, due to wrong sampling time, should be avoided. Sampling for routine investigation of Mytilicola intestinalis should not be carried out in summer because the numbers of parasites found at that time do not represent a true level of infestation. The low quality of mussels during summer (low meat contents during spawning) and the simultaneously low numbers of parasites could lead to the erroneous conclusion that when numbers of parasites are very low the mussels are of poor quality.

As already mentioned in the introduction there is a strange discord in respect of judging the influence of Mytilicola intestinalis upon the mussels. The very few papers presenting data on this question state more or less heavy damages. The most severe losses in condition were detected by KORRINGA (1952).

The condition index (condition index in his paper of 1952 was given as 1000 x dry weight of mussel in gr. divided by volume of valves in ccm) of highly (10 - 15 Mytilicola per mussel) parasitized mussels was 26 - 44% lower or non parasitized mussels. These results were repeated again in 1955 (KORRINGA, 1955). COLE and SAVAGE (1950) measured the wet meat of 50 mussels of the same size and found weight of meat was lowest when parasite numbers were high. However this finding must not be overestimated because it is based on too low a number of mussels.

MEYER and MANN (1950) found the meat contents of mussels (percentage of wet meat to total weight of mussel) was reduced in the order of 5% when parasitized. The water contents of the mussels (presumably the water in the mantle cavity) is reduced by 9.3% when mussels are parasitized. The last finding is not quite understandable because if parasitized mussels have a lowered meat content then the volume of meat in the valves is reduced, and a lowered meat content and a lowered meat volume should be compensated by a higher proportion of water in the mantle cavity. If the estimation of meat contents is based on measurements of total weight of mussel including the water in the mantle cavity, extreme care should be taken to avoid incorrect measurements. It is not possible to prevent the mussels partly loosing the mantle cavity water before being processed. As far as I am aware the above Literature are the only papers in which data on

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the influence of Mytilicola intestinalis on their host are presented. However ODLAUG (1946) investigated the influence of a related species, Mytilicola orientalis, on Olympia oysters Ostrea lurida. Altogether he found 62 out of 1138 oysters parasitized and he compared the condition indices of parasitized and non parasitized oysters in subgroups of ca 100 oysters each. The bases for condition indices of not parasitized oysters were 1-8 individuals, so his values are not directly comparable. Besides that 8 out of 69 parasitized oysters (12.9%) showed condition indices higher than the average. ODLAUG states that fatness of oysters was reduced during spawning, and this reduction was higher than in the case of infestation. CHEW et al (1965) found the condition indices (calculated on wet weight basis) of pacific oysters Crassostrea gigas to be lowered by Mytilicola orientalis but they were not able to find a correlation between numbers of parasites and mortalities of the oysters that occurrred in the duration of their survey.

There is a considerable number of authors who agree with the results on damaging effects but point out that even highly parasitized mussels were found in an excellent condition: HEPPER (1955), MEYER-WAARDEN (1956, 1960, 1963), ANDREU (1963), MONTEIRO and FIGUEIREDO (1961), THEISEN (1966) and CAMPBELL (1970). Most of these authors attribute this finding (high parasitation connected with high quality of the mussel) to environmental conditions which are so good that effects of parasitation are compensated and not measurable.

In our investigation three sites of sampling were selected which did not represent optimum condition, that holds true espesially for station 1 which was exposed to the air at low tide.

A very interesting result obtained by CAMPBELL (1970) was that mussels were effected more by starvation or lack of food than by infestation. In his starvation experiments the colour of starving mussels turned to yellow brown instead of green, a symptom which KORRINGA (1951) ascribed to be caused by Matilicola. Investigations of authors, who were not able to detect any harmful influence of the parasites on their hosts (GENOVESE 1959, BRENKO 1964) turned out to be rather unimportant because the material investigated were not large enough samples. However it may well be that results have been disregarded through psychocogical reasons. WILSON (1938)

speaking about copepods of the genus Mytilicola remarks: "it is misleading to designate these copepods as parasites without qualification since that word implies that they feed upon thefluids or the tissues of their host. They should be designated as commensals or at the worst as semiparasites. As can be seen from the mouthparts they are not suited for sucking blood or biting the body tissues of the host. In all probability these copepods subsist by appropriating a portion of the food. They are not, therefore, definitely harmful." In the light of these contradictary and nonuniform findings it is not surprising that it has not been possible to find any statistically significant correlation between meat content and infestation. But what are the reasons for these abvious discords?

When in 1949 the causative agent of mass-mortalities of Dutch mussels was looked for the problem was thought to be solved when Mytilicola intestinalis was detected living in the mussels. The number of parasites was considered to be extremely high and the invasion of Mytilicola into the area concerned was supposed to have taken place very recently. Soon it was generally accepted that a sudden mass occurrence of Mytilicola had causedthe extensive mortalities of mussels. (KORRINGA, 1950, 1952, 1956, 1957. KORRINGA and LAMBERT 1951). Proof for this assumption has not been given. When DOLLFUS (1951) remarked that Mytilicola alone could not have been the reason for mass mortalities he was answered by KORRINGA (1968): "Dollfus was really the only scientist who pleaded not guilty for Mytilicola intestinalis. But we can hardly blame him: he was so fond of parasitic copepods that he simply could not hear the thought of their doing serious harm to, or even kill, other creatures".

The numbers of Mytilicola found on the Dutch coast were detected to be within the same range in the following years, and they have not changed up to the present. The numbers are still considered to be high. It is hard to understand why a sudden occurrence and a sudden dangerous increase should have taken place on the Dutsch coast when in 1939 (CASPERS, 1939) on the German coast and in 1937 (ELLENBY 1937) on the British coast, numbers of Mytilicola were as high as they are today. The assumption that Mytilicola invaded the Dutch coast at some time before 1949 (HAVINGA, 1951) is not provable.

This question cannot be answered in the future, but it is possible

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to recheck if Mytilicola intestinalis does influence the meat contents or the condition indices of their hosts. Scientists in neighbouring countries, where Mytilicola occurs are therefore recommended to carry out similar investigations with the same or improved methods. If the results obtained in the course of these investigations correspond to those described in the present paper it would be necessary to rethink out present knowledge on the relation Mytilicola-Mytilus.

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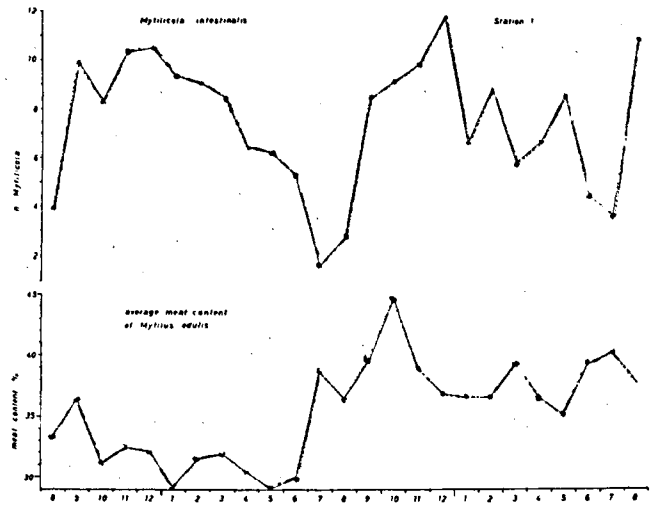

Fig. 1: above: Monthly variations of average number of Mytilicola intestinalis per investigated mussel at station 1
below: Monthly variations of average meat contents of Mytilus edulis at station 1. (estimated on wet weight basis).

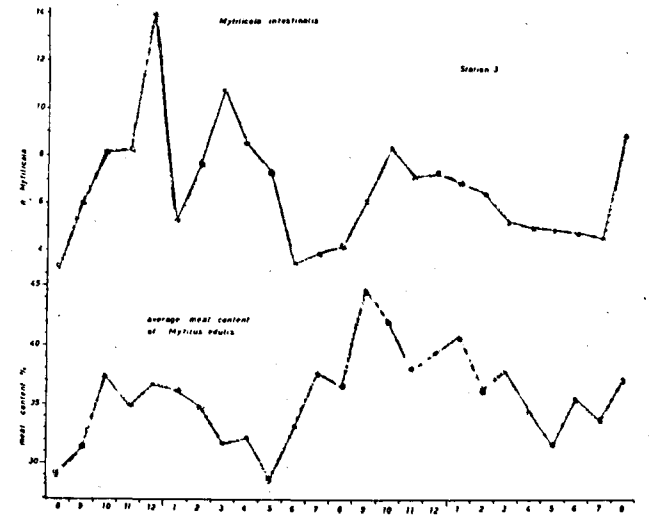

Fig. 2: above: Monthly variations of average number of Mytilicola intestinalis per investigated mussel at station 3
below: Monthly variations of average meat contents of Mytilus edulis at station 3 (estimated on wet weight basis).

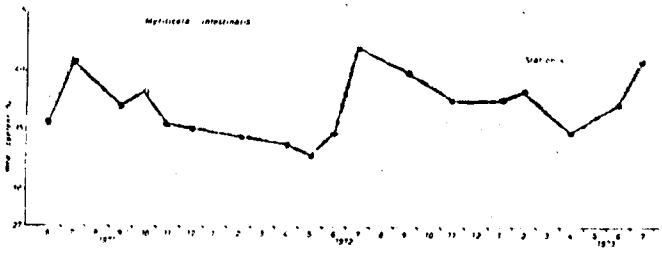

Fig. 3: Monthly variations of average meat contents of Mytilus edulis at station 4 (estimated on wet weight basis).

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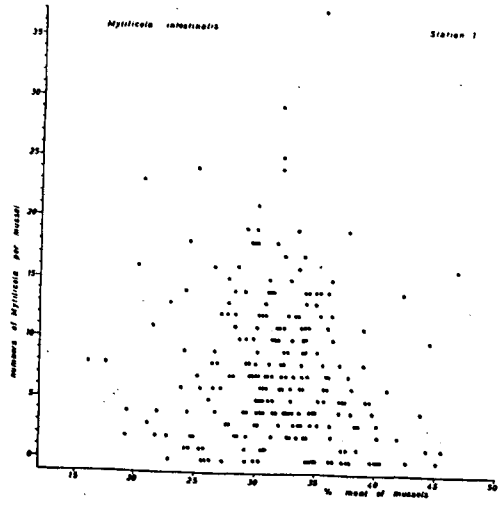

Fig. 4: Total number of Mytilicola intestinalis per individual mussel plotted against the meat content (wet weight) of the respective mussel at station 1.

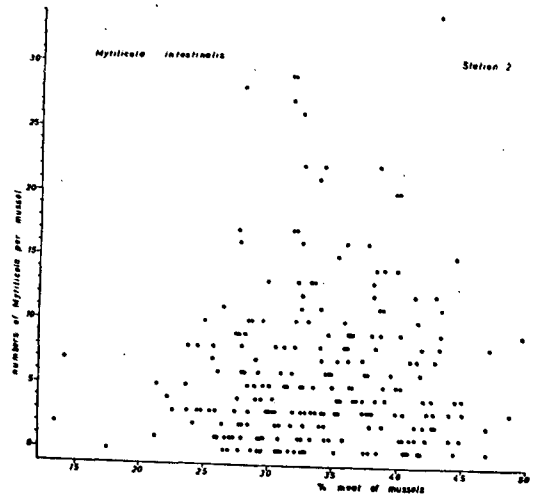

Fig 5: Total number of Mytilicola intestinalis per individual mussel plotted against the meat content (wet weight) of the respective mussel at station 2.

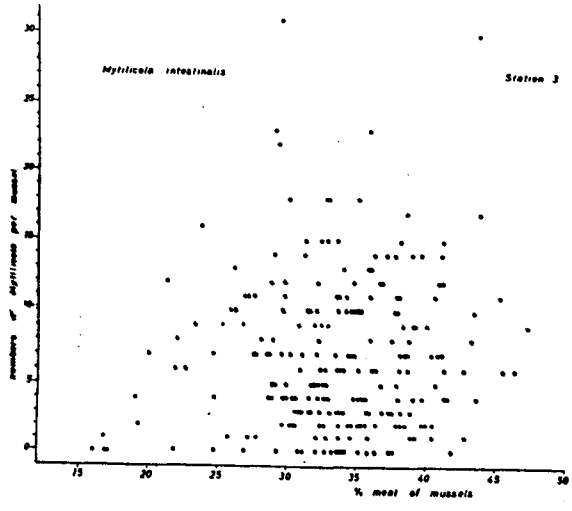

Fig. 6: Total number of Mytilicola intestinalis per individual mussel plotted against the meat content (wet weight) of the respective mussel at station 3.

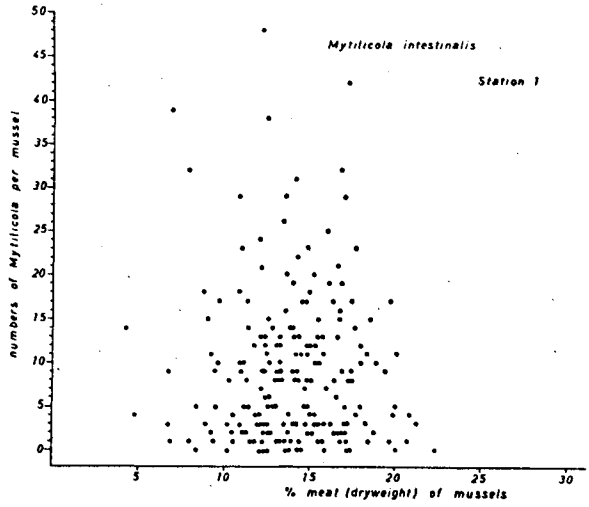

Fig. 7: Total number of Mytilicola intestinalis per individual mussel plotted against the meat content (dry weight) of the respective mussel at station 1.

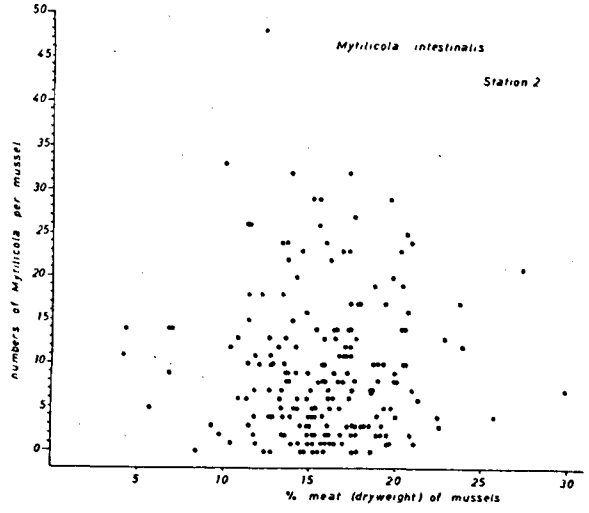

Fig. 8: Total number of Mytilicola intestinalis per individual mussel plotted against the meat content (dry weight) of the respective mussel at station 2.

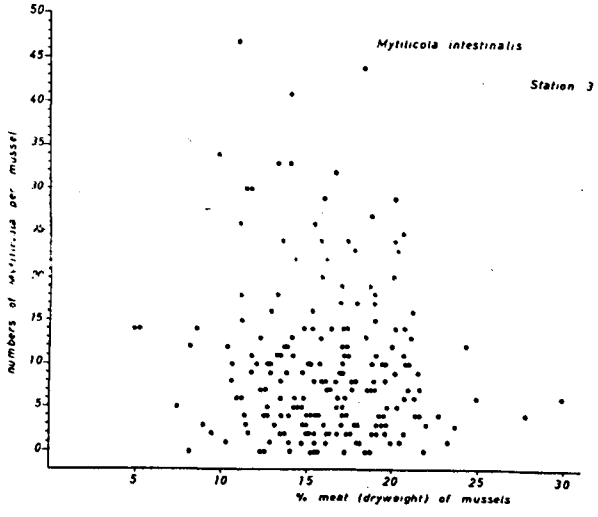

Fig. 9: Total number of Mytilicola intestinalis per individual mussel plotted against the meat content (dry weight) of the respective mussel at station 3.

Literature

ANDREU, B., 1963: Propagación del copepodo parásito Mytilicola intestinalis en el mejillón cultivado de las rias gallegas (NW de España). Inv. Pesq. 24, 3.20.

ANSELL, A.D., 1972: Distribution, growth and seasonal changes in biochemical composition for the bivalve Donax vittatus (da Costa) from Kames Bay, Millport. J. Exp. mar. Biol. Ecol, 10: 137-150

ANSELL, A.D. LOOSMORE, F.A. and LANDER, K.F. 1964: Studies on the hard-shell clam, Venus mercenaria, in British waters. II Seasonal cycle in condition and biochemical composition. J. appl. Ecol., 1, 83-95

ANSELL, A.D. and TREVALLION, 1967: Studies on Tellina tenuis (da Costa). I. Seasonal growth and biochemical cycle. J. exp. mar. Biol. Ecol., 1, 220-235

BAIRD, R.H., 1958: Measurement of condition in mussels and oysters. J. Cons. int. Explor. Mer. 23, 249-57

BAIRD, R.H., 1966: Factors affecting the growth and condition of mussels (Mytilus edulis L.). Fish.Invest.,Lond (2), 25, 1-33.

BRENKO, M., 1964 Mytilicola intestinalis as a parasite of mussels in natural beds and artificial rearing places of the eastern Adriatic. Acta Adriatica, 2, 161-165.

CAMPBELL, S.A., 1970: The occurrence and effects of Mytilicola intestinalis in Mytilus edulis. Mar. Biol., 5, 89-95

CASPERS, H., 1939: Über Vorkommen und Metamorphose von Mytilicola intestinalis Steuer (Copepoda paras.) in der südlichen Nordsee. Zool. Anz. 126, 161-171

CHEW, K.K., SPARKS, A.K. and KATKANSKY, S.C. 1965: Preliminary results on the seasonal size distribution of Mytilicola orientalis and the effect of this parasite on the condition of the Pacific oyster, Crassostrea gigas. J. Fish Res. Bd. Canada 22, 1099-1101.

COLE, H.A. and SAVAGE, R.E., 1951: The effect of the parasitic copepod Mytilicola intestinalis Steuer upon the condition of mussels. Parasitolofy 41, 156-161

DARE, P.J., 1973: Seasolan changes in meat condition of sublitoral mussels (Mytilus edulis L.) in the Conwy fishery, North Wales. I.C.E.S. Council Meeting 1973, Shellfish Benthos, K: 31, 10 pp (mimeo).

DETHLEFSEN, V., 1970: On the Parasitology of Mytilus edulis(L.1758). I.C.E.S. Council Meeting 1970, Shellfish Benthos, K: 16, 13 pp. (mimeo).

DETHLEFSEN, V., 1972: Zur Parasitologie der Miesmuschel (Mytilus edulis L., 1758). Ber.dt.wiss.Kommn.Meeresforsch. 22, 3,344-371

DOLLFUS, R.P., 1951: Le Copépode Mytilicola intestinalis. A.Steuer peut-il être la cause d'une maladie épidémique des moules? Rev. Inst. scien. Pêch.marit., 17, 81-83

ELLENBY, C., 1947: A copepode parasite of the mussel new to the British fauna, Nature, Lon., 159, 645-646

GENOVESE, S., 1959: Sulla presenza di Mytilicola intestinalis Steuer (Copepoda parasitica) nel Lago di Ganzirri. Atti Soc. pelorit.Sci.Fis.mat.nat.,5,47-53

HANCOCK, D.A. and FRANKLIN 1972: Seasonal changes in the condition of the edible cockle (Cardium edule L.) J. appl.Ecol, 9, 567-579

HAVINGA, B. 1951: Mytilicola intestinalis in relation to other invasions of aquatic animals. Rev. Trav. Inst. scient. Pêch.marit. 17,77-80

HEPPER, B.T., 1955: Environmental factors governing the infection of mussels, Matilus edulis, by Mytilicola intestinalis. Fish.Invest.Lond. (2), 20, (3), 1-21

KORRINGA, P., 1950: De aanval van de parasiet Mytilicola intestinalis op de Zeeuwose mosselcultuur. Visserij-Nieuws 3 (7) suppl. 7 pp.

KORRINGA, P., 1952: Epidemiological observations on the mussel parasite Matilicola intestinalis-Steuer, carried out in the Netherlands 1951 Annales Biol. 8, 182-185

KORRINGA, P., 1955: Qualitätsbestimmungen an Miesmuscheln und Austern. Arch. FischWiss. 6, 189-193

KORRINGA, P., 1956: Epidemiological observations on the mussel parasite Mytilicola intestinalis Steuer, carried out in the Netherlands 1954. Annales Biol. 11, 184-186

KORRINGA, P., 1957: Epidomiological observations on the mussel parasite Mytilicola intestinalis Steuer, undertaken in the Netherlands, 1955 Annales Biol. 12, 230-231

KORRINGA, P., 1968: On the ecology and distrivution of the parasitic copepod Mytilicola intestinalis (Steuer). Bijdr. Dierk 38, 47-57

KORRINGA, P., and LAMBERT, L. 1951: Quelques observations sur la fréquence de Mytilicola intestinalis Steuer (Copepoda parasitica) dans les moules du littoral méditerranéen francais. Rev. Trav.Inst.scient.Pêch.marit.,17, 15-29

MEYER, P.F. and MANN, H. 1950: Beiträge zur Epidemiologie und Physiologie des parsitischen Copepoden Mytilicola instestinalis. Arch.FischWiss., 2, 120-134

MEYER-WAARDEN, P.F, 1956: Sind in Deutschland die Voraussetzungen für eine Muschelwirtschaft vorhanden. Fischwirtschaft, 3, 3-12

MEYER-WAARDEN,PF.,1960: Gibt es eine deutsche Qualitätsmuschel? Fette, Seifen, Anstrichmittel 62, (6),525-530

MEYER-WAARDEN,PF.,1963: The infection of Mytilus edulis with Mytilicola intestinalis in the German Wodden-Sea from 1958-1963. I.C.E.S. C.M. 1963. Shellfish Committee Doc 103, 5 pp (mimeo)

MONTEIRO, M.C. and FIGUEIREDO 1961: Note sur la repation de Mytilicola intestinalis Steuer dans l'estuaire du Tage. Notas Estud.Inst.Biol.mar.Lisb. 22, 1-173

ODLAUG, T.O., 1946: The effect of the Copepod Mytilicola orientalis upon the olympia oyster Ostrea lurida. Trans.Am.Microsc.Soc. 55, 311-317

SEED, 1969a:The Ecology of Mytilus edulis L. (Lamellibranchiata) on exposed rocky shores. I. Breeding and Settlement. Oecologia 3, 277-316.

SEED, 1969b: The Ecology of Mytilus edulis L. (Lamellibranchiata) on exposed rocky shores. II Growth and Mortality. Oecologia 3, 317-350

19/-

THEISEN, B.F., 1966: Mytilicola intestinalis Steuer in Danish Waters 1964-65. Medd.Danm.Fisheri-Havunders.,N.S.,4,327-337

WILSON, C.B., 1938: A new copepod from Japanese oysters transplanted to the Pacific Coast of the United States. J. Wash.Acad.Sci. 28, 284-288

ZWAAN,A. DE and ZANDEE, D.I., 1972: Body distribution and seasonal changes in the glycogen content of the common sea mussel Mytilus edulis. Comp. Biochem.Physiol. 43 A, 53-58