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The relations between mites of the genus *Unionicola* and the mussels *Anodonta* and *Unio*.

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ABSTRACT

The locations in mussels of four species of watermites, *Unionicola aculeata*, *U. bonzi*, *U. intermedia* and *U. ypsilophora* and their degrees of parasitism have been compared. *Unionicola aculeata* and *U. bonzi* do not live parasitic and need *Anodonta anatina* and *Unio pictorum* respectively as a shelter for their transformation stages. *Unionicola intermedia* and *U. ypsilophora* live parasitic on the gills of *Anodonta anatina* and *A. cygnea* respectively. Every female of *Unionicola ypsilophora* has a territory in the mussel, as contrasted with *U. intermedia*, many females of which are found together. The consequences for the population density are discussed.

INTRODUCTION

The relations between watermites and freshwater mussels have been studied in relatively few cases. Host specificity is indicated for a number of European species, such as *Unionicola bonzi* by CLAPARÈDE (1869) and *U. intermedia* and *U. ypsilophora* by MITCHELL & PITCHELL (1953). MITCHELL (1955) has described the life history of *U. aculeata*.

In general, the larva of watermites parasitizes insects and the nymph (deutonymph) and the adult lives carnivorously. According to CASSAGNE-MÉJEAN (1967) the quiescent stages between larva and nymph and between nymph and adult correspond with the proto- and respectively tritonymph of the other Acari.

The question posed is to what extent are the named *Unionicola* species dependent on freshwater mussels and how is this development to be explained.

According to many authors the life span of a *Unionicola* larva is very short as it transforms, almost directly, into the subsequent quiescent stage (VIETS & PLATE, 1954; MITCHELL, 1955). However,

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JONES (1965) claims to have found *U. intermedia* and, presumably, *U. aculeata* larvae on *Chironomus plumosus*.

Through field research, infection tests and the measuring of various stages we hope to find a solution for these questions.

MATERIAL

The mussels were captured in "het Gein", a very slowly running stream 10 Km. S.E. of Amsterdam. Quiescent stages were identified by removing them from the mussel and letting them hatch in petridishes.

The following species were found in the research area: the mites *Unionicola aculeata*, *U. bonzi*, *U. intermedia*, *U. psilophora* and the mussels *Anodonta anatina*, *A. cygnea* and *Unio pictorum*.

RESULTS

Unionicola aculeata (KOENIKE, 1890).

KOENIKE (1915) has studied its life history in Europe, and found a relation with mussel species and MITCHELL (1955), in America has found its quiescent stages in the mussel *Lampsilis siliquoidea*.



Fig. 1. *Unionicola aculeata*. Tritonymphs on the inhalant siphon and some of them on the gills of *Anodonta anatina*. The grey spots are empty skins of hatched mites. On the background eggs in the mantle tissue.

In July we found dozens of tritonymphs near and on the inhalant siphon and the hind part of the gills of *Anodonta anatina*. A few were also found in *A. cygnea*. MITCHELL found tritonymphs deeply imbedded in the tissue near the exhalant siphon of *Lampsilis siliquoidea*, whereas we found them attached to the tissue with their cheliceres. Many protonymphs were found in the gill tissue of this same *A. anatina*.

It was already known that *U. aculeata* only needs the mussel to deposit its eggs in and uses it as a shelter during the transformation stages. BÖRTGER (1970) found that the adult animals fed on cladocera.

Unionicola bonzi (CLAPARÈDE, 1869).

According to CLAPARÈDE this species always remains in the mussel (*Unio pictorum*), although others have suggested that its manner of living is similar to that of *Unionicola aculeata*, since adults have been captured out of the mussel. We have also found *U. bonzi* in the open water and our infected mussels (Tab. 1) illustrate that especially the nymph and the adult of this species live out of the mussel.

	Number of mussels	Infected with eggs	Infected with protonymphs	Infected with nymphs	Infected with tritonymphs	Infected with adults
October 1966	51	34(67)				1(2)
January 1967	58	51(86)				2(4)
April "	35	31(89)	+	3(9)	1(3)	1(3)
May "	23	18(78)	13(56)		11(48)	4(17)
June "	27	25(92)	9(33)	1(4)	2(7)	16(59)
August 1970	53	49(92)	40(76)	20(38)	7(13)	10(19)

Table 1. *Unio pictorum* infected with various stages of *Unionicola bonzi*. The numbers in parentheses give the percentages.

At first we did not see that the protonymphs of *U. bonzi* are imbedded in the division of the gill plates, thus it is possible that this stage hibernates with the adults and the eggs.

The average number of adult mites per infected mussel was 2.5 (1—8) and the average number of nymphs was 2 (1—5). Many more mussels were infected with eggs and protonymphs than with free stages, and the number of eggs and protonymphs per mussel was much larger.

We may conclude, in view of such differing results in *U. intermedia* and *U. psilophora*, that the adult mites seek the mussels prior to reproduction, while the nymphs seek the mussels in order to transform into the adult stage.

Larvae and nymphs can be captured by isolating the mussels and

periodically sieving the water. In this way, in the first half of August (30/7—13/8/1970), 55 larvae and 5 nymphs were collected from 8 mussels which had been investigated 5 times. It appears that all free stages provide for the dispersion.

Contrary to *U. aculeata*, the quiescent stages of *U. bonzi* appear more within the mussel: that is, most of the eggs were observed in the gills in groups of 5—10, the protonymphs were encountered in the tissue at the division of the inner and outer gill plates and the tritonymphs are found to be attached with their cheliceres to the mantle near the labial palps of the mussel. Adult mites are also found, although very seldom, in *Anodonta cygnea* and *A. anatina*.

Unionicola intermedia (Koenike, 1882).

MITCHELL & PITCHFORD, in their experiments in England, found *U. intermedia*, of which large populations can appear in the mussel, almost exclusively in *Anodonta anatina*. Our data agree; we found adults, nymphs and eggs as hibernating stages. No males were captured after the winter months. In contrast with *U. bonzi*, in mussels which were not infected with adult mites, there was most often an absence of eggs.

In addition to adult mites, we also found large numbers of nymphs. According to literature and our own data, it is clear that nymphs and adults live in the mussel. Infection tests have shown that adults, once they are removed from the mussel are capable of penetrating it again.

In the case of a parasitic relation it is not only important to know how many parasites there are, but also the place where they prefer to stay. After the mussels were captured, they were immediately opened, thus the mites scarcely had time to move. Five areas were distinguished within the mussel: between the mantle and the left gill (I), between the left gill plates (II), between the gills and the foot (III), between the right gill plates (IV), and between the mantle and the right gill (V). It was not possible to distinguish smaller areas, especially in the still to be discussed *U. ypsilophora*, due to its movability.

On 16 April, 1970, 25 *A. anatina* were examined, 22 of which were infected with *U. intermedia* (the results are given in Tab. II), 2 with *U. ypsilophora* and only one was not infected.

From Tab. II it appears that they are found mainly between the gill plates, and, in our opinion, nearer to the mouth than to the inhalant siphon. Differences between the left side and the right side are not significant.

In areas II and IV, 1—12 females and 1—24 nymphs were found per mussel. 12 females and 15 nymphs, close together on the gills, were the largest amount per area.

Area in the mussel	Number of <i>U. intermedia</i> in 22 <i>A. anatina</i>		Number of <i>U. ypsilophora</i> in 24 <i>A. cygnea</i>		
	♀♀	nymphs	♂♂	♀♀	nymphs
I	6	4	2	4	-
II	50	185	3	10	2
III	2	14	2	4	-
IV	35	139	3	10	2
V	-	2	4	7	1

Table 2. Distribution of *U. intermedia* and *U. ypsilophora* in infected *A. anatina* and *A. cygnea* on 16 April, 1970.

Unionicola ypsilophora (BONZ, 1783).

MITCHELL & PITCHFORD found *U. ypsilophora* as a parasite in *Anodonta cygnea*. The number per mussel was much less than for *U. intermedia*. Others have also recorded this phenomenon without being able to explain it. Our data correspond and it appears that eggs, nymphs and adults hibernate.

52 *A. cygnea* were captured, simultaneously with the *A. anatina* on 16 April, and were directly examined for mites, 24 mussels were infected with *U. ypsilophora* (see Tab. II), 5 with *U. intermedia*, 2 with both species and 21 were not infected. The largest number of females per mussel was 5. There appeared to be always 1 female, occasionally accompanied by a male or a nymph, per area. Once 3 females were found in one area. It follows that there were 89 areas in the mussels with 0 females, 32 with 1 and 1 with 3. So a Poisson distribution was not found in this case.

Each female has a territory which approximately corresponds with the areas into which we divided the mussel. Collections at other times and in other waters confirm this. The examined mussels of Tab. II were maximally 12 cm. long. Larger specimens were not captured.

U. ypsilophora, which can not swim, once removed from the mussel, was not able to penetrate it again.

MITCHELL (1965) found an example of population regulation in *U. fosculata* which parasitizes the mussel *Lampsilis siliquoides*. Two females were the maximum per mussel.

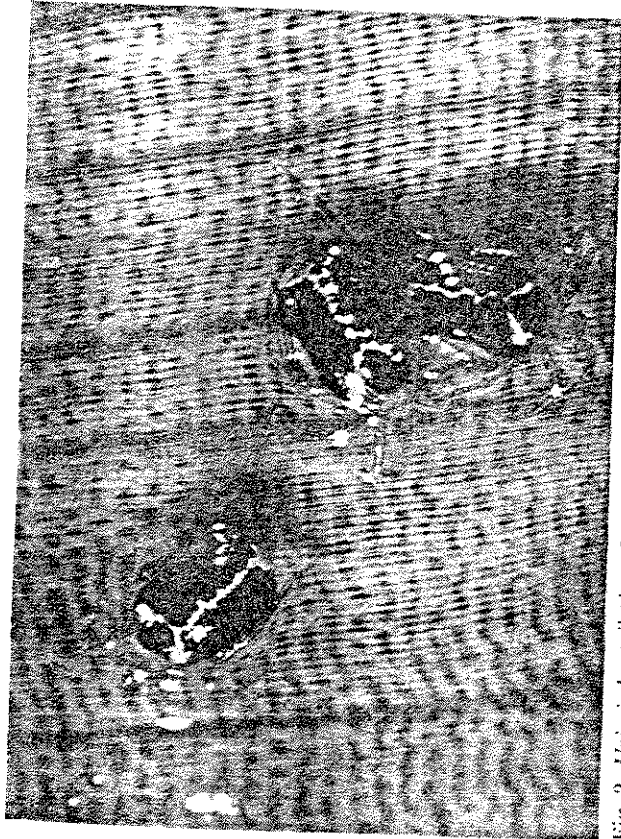


Fig. 2. *Uniomicola ypsilophora*. Three females placed on the gills of *Anodonta cygnea*.

DISCUSSION

One may conclude, that, from the four discussed species, there are two, *U. aculeata* and *U. bonzi*, which, as nymph and adult, do not parasitize. The adaptation of *U. bonzi* on the mussel is more progressed since, on the one side, the stages were more diffuse in the mussel and were found in special places, while, on the other side, *U. bonzi* is more bound to a special host than *U. aculeata*. The characteristics of this species correspond with the original qualities of this group, namely, oviposition in animal tissue, feeding on plankton during the nymph and adult stages and the host serving as a protected site for the mite during the transformation stages (MIRCHELL, 1955).

The development of "real" parasitism has possibly progressed along two paths. First, a "sedentary parasitic life" as shown by *U. intermedia*. The mites hardly move in the opened mussel and remain close together on the gill. If the mussel deteriorates under a high intensity of infection, the mites can look for a new mussel. There was nothing remarkable to be seen on the gills under a high intensity of infection. This is not possible for *U. ypsilophora* which is helpless out of the mussel. *U. ypsilophora* moves considerably and crawls away as soon as the mussel is opened. This movability permits the territory to be defended and is therefore the second development towards

parasitism. With double infections of *U. ypsilophora* and *U. intermedia* both species occupied different areas, usually the one species on the left gill plates and the other on the right gill plates. It is not improbable that *U. intermedia* could also appear in *A. cygnea*, although it would be chased away by *U. ypsilophora*, since the former appears quite regularly in *A. cygnea*.

The behaviour of *U. ypsilophora* has important consequences for the population density of the species. We are of the impression that with maximum infection the gills are less firm and covered with slimy threads. If a high mite infection proves fatal for the mussel, there is no possibility for *U. ypsilophora* to survive. Moreover, our data seem to show that this behaviour, in comparison with *U. intermedia*, leads to a much lower infection percentage.

It is known that in the *pionae*, to which *Uniomicola* belongs, the larval stage may be omitted or is not parasitic. The latter is suggested for *Uniomicola*.

According to JONES *U. intermedia* larvae live on *Chironomus*. This would appear to be a parasitic phase of the larva, which then must increase in volume. Preliminary research has indicated data in which the eggs of *U. intermedia* and those of *U. bonzi* have the same volume as the protonymph. Thus one may conclude that a parasitic larval phase did not exist. A precise description of *Uniomicola* larvae, as well as infection tests, are necessary to confirm JONES' data. For the time being it appears that the older authors are justified in stating that the larval stage is not parasitic and that it has become less important in the course of evolution. The nymph stage is probably mainly responsible for the dispersion.

SUMMARY

Some aspects of the life history of mites of the genus *Uniomicola* are discussed, together with the degree of parasitism on the freshwater mussels *Anodonta* and *Unio*.

1. *Uniomicola aculeata* needs especially *Anodonta anatina* as a shelter for the transformation stages. Tritonymphs were attached with their cheliceres on the tissue of the inhalant siphon.
2. Like *U. aculeata*, *U. bonzi* needs a mussel, in this case *Unio pictorum*, as a shelter for the eggs and the transformation stages. Tritonymphs were found in the division of the gill plates and the tritonymphs were attached on the mantle tissue near the labial palps of the mussel.
3. Large numbers of nymphs and adults of *Uniomicola intermedia* were found in *Anodonta anatina* in particular between the gill plates and only a few in *A. cygnea*. This species seems to live as a parasite

Phytoplankton Observations in the Eastern Caribbean Sea*

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ABSTRACT

A total of 88 taxa were noted in these samples, of which there were 44 diatoms, 41 pyrrophyceans, 2 cyanophyceans and 1 silicoflagellate. Totals of 37 and 38 different phytoplankters were observed during cruises E46K-67-68 and E1-C-70, respectively, with 58 species noted in the extensive samplings of E 50D-68-69. A diatomaceous flora predominated in each series of collections. The phytoplankters were well represented, but in low numbers. The overall phytoplankton concentrations were low for each of the areas studied during these three January cruises. Even the preliminary data on the coccolithophore concentration does not indicate a major development at this time of the year. Generally, phytoplankton counts were lowest at stations most distant from the island complex and especially in the shallow waters that passed between the islands, directly from the north Atlantic into the Caribbean Sea. Results from the 1969 and 1970 collections west of the Lesser Antilles correspond closely to the findings reported by HARGRAVES et al. (1970). There was considerable diversity of phytoplankton species, but they were present in low numbers. They have related this condition to the low nutrient concentrations in the oceanic waters of the Lesser Antilles region.

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during the whole life span. They are capable to penetrate mussels as adults and so they can move from one host into the other.
4. *Unionicola ypsilophora* lives as a parasite in *Anodonta egnea* and is rarely found in *A. anatina*. In general not more than five females will be found in one mussel. It appears that each has a territory. The consequences for the population density are discussed.
5. The evolution from a free living to a parasitic way of life is discussed. It is supposed that *U. intermedia* and *U. ypsilophora* have been evolved along different lines.
6. The larval stage is short and is presumably not parasitic.

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