RICHARD J. NEVES

Dartnall
Walkey
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The distribution of glochidia of the Swan mussel, *Anodonta cygnea* (Mollusca) on the Three-spined stickleback *Gasterosteus aculeatus* (Pisces)

H. J. G. DARTNALL* AND M. WALKEY

Department of Zoology and Comparative Physiology, Queen Mary College, Mile End Road, London

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(With 3 figures in the text)

The pattern of infestation by glochidia of the Swan mussel, *Anodonta cygnea*, on a population of the Three-spined stickleback, *Gasterosteus aculeatus* was studied over a period of 12 months. The results obtained are considered under the four headings of incidence, intensity, the effect of fish size and the topographical distribution of parasites on the host.

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Introduction

The larvae of certain species of freshwater mollusc have a short, obligate parasitic stage in their life cycle. The larvae, called glochidia, are ectoparasites on the fins, gills and body surface of fishes. Although the general nature of the parasitic phase has been known for many years, there are relatively few critical observations on the extent of the interrelationship between glochidia and their various species of fish host. The present study represents an analysis of the pattern of infestation by glochidia of the Swan mussel *Anodonta cygnea* on a population of Three-spined sticklebacks, *Gasterosteus aculeatus*.

Materials and methods

Sticklebacks were taken from the Shoulder of Mutton Pond in Epping Forest, Essex (Ordnance Survey 1:50000, 2nd series, sheet 177, grid reference TQ 408873). The fish were caught with a 1·5 m beam trawl which was pulled some 30 m, through pond weed, round the pond periphery. At least 30 fish were collected each month. The fish were taken to the laboratory where they were examined within three days. They were killed, by pithing, after which the position of each glochidium on its host was recorded. The length (from nose to caudal peduncle) and sex of the host was noted.

Results

The data are considered in four sections, namely the incidence, the intensity, the effect of fish size, and the topographical distribution of the parasite on the host.

* Present address: British Antarctic Survey, Madingley Road, Cambridge.

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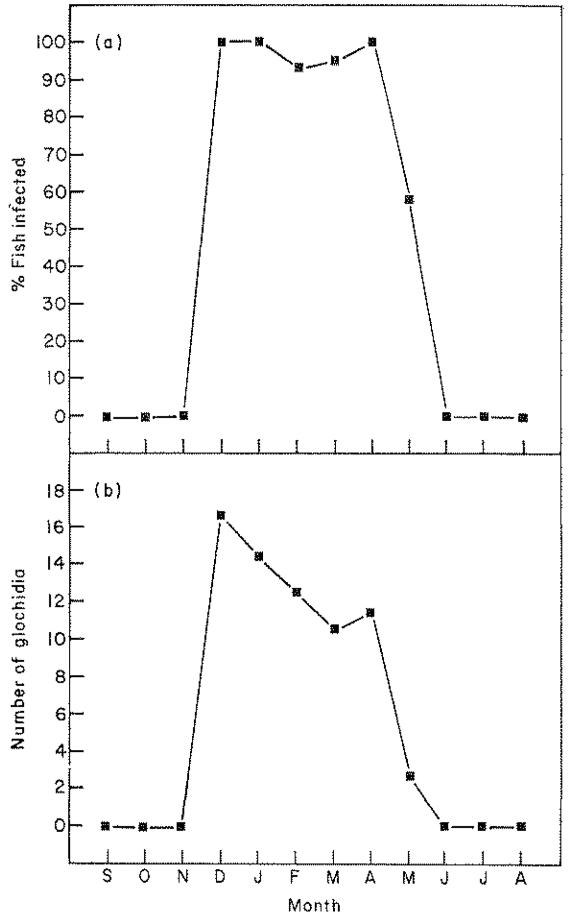

FIG. 1. (a) The monthly variation of incidence of infestation. (b) The monthly variation of intensity of infestation.

Incidence is defined as the percentage of fish parasitized. The monthly variation in incidence is shown in Fig. 1(a), and a marked seasonal cycle is evident. No glochidia were recovered during the six-month period June to November. Between December and April, however, nearly every fish was infected. In May just over half were infected.

The intensity of infection is defined as the mean number of parasites per infected fish. Monthly values for intensity of infection are shown in Fig. 1(b). As recorded here, intensity of infection takes no account of variation in the sizes of fish sampled. Dividing the fish into six arbitrary size classes (Fig. 2), it is at once evident that the size composition of each sample was not constant. Comparison of the histograms shows that, despite variations in the length frequency distributions, the larger fish were always the more heavily infected. However, the variations in size of sampled fish may bias the results, and indicate an artificial decrease in parasite population density throughout January, February and March. Undoubtedly by May, the population of attached glochidia is declining rapidly.

The distribution of glochidial burdens within the fish population was positively skewed (Fig. 3). It can be seen that 86% of the fish were parasitized with 20 or fewer glochidia.

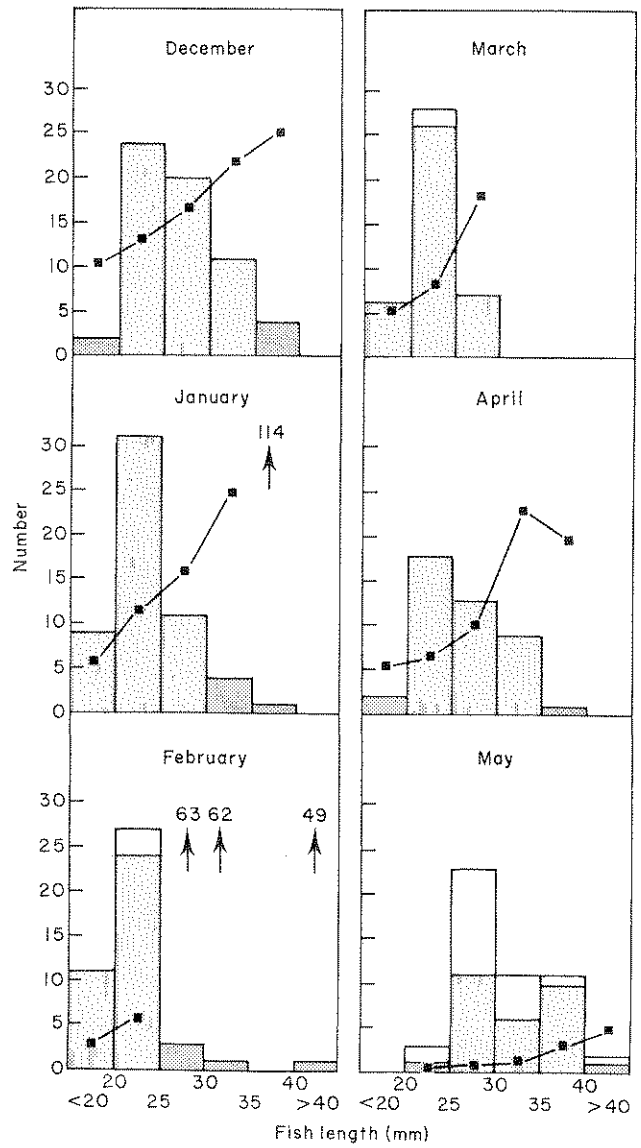

FIG. 2. The monthly relationship between size and infestation. Histograms show the total number of fish in each size class, the number of infected fish being shaded. Frequency polygons indicate the mean number of glochidia per infected fish for each size class.

However, whilst most fish were relatively lightly parasitized, a few sticklebacks carried massive infestations. These heavily infected fish were not necessarily the largest in any one sample. No difference was observed in the infection of male and female fish.

As recorded in Table I, glochidia were found on all exposed surfaces. The principal infected regions of the body were the fins (47·6%). The external surfaces of the head, including mouth, throat, opercula and eyes supported 24·7% of the total glochidial population, whilst the gills and buccal cavity carried 18·7% of the parasites recovered. No

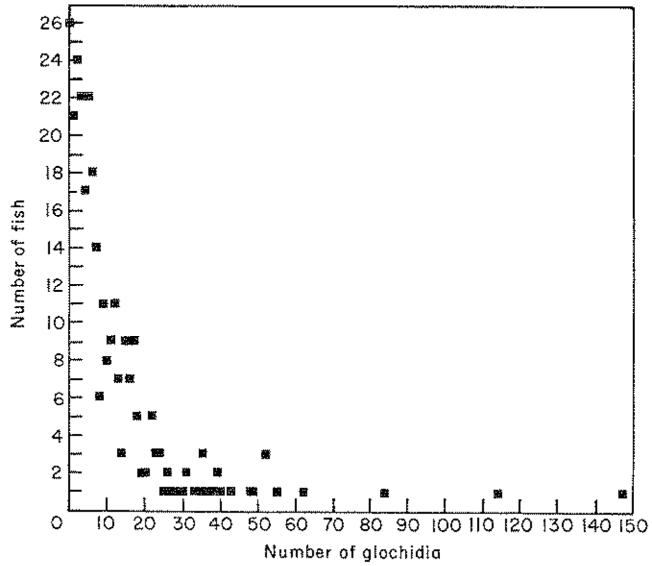

FIG. 3. Frequency distribution showing the burdens of glochidia in the fish samples.

significant variation in topographical distribution was observed during the sampling period.

Discussion

Glochidia are apparently non-specific and widespread parasites of freshwater fish in the United Kingdom. They have been reported on Grayling (*Thymallus thymallus*), Chub (*Leuciscus cephalus*) and Dace (*Leuciscus leuciscus*) from the River Lugg (Davies, 1967); on Bream (*Abramis brama*), Roach (*Rutilus rutilus*) and Perch (*Perca fluviatilis*) from the Shropshire Union Canal (Mishra & Chubb, 1969) on Brown trout (*Salmo trutta*), Rainbow trout (*Salmo gairdneri*), Perch, Roach, Ruffe (*Gymnocephalus cernua*) and Nine-spined sticklebacks (*Pungitius pungitius*) in an Essex reservoir (Wooten, 1973) and on Nine-spined sticklebacks, Minnows (*Phoxinus phoxinus*), Bullheads (*Cottus gobio*) and Stone-loaches (*Noemacheilus barbatulus*) from the Essex river (Dartnall, 1973 and Miss J. Landsberg, pers. comm.). They have been reported on Brown trout, Perch, Three-spined sticklebacks and Pike (*Esox lucius*), from Loch Leven (Campbell, 1974) and on Carp (*Cyprinus carpio*), Bullheads, Roach, Eels (*Anguilla anguilla*) and Perch from the Serpentine (Lee, 1977). We have also recorded them on Tench (*Tinca tinca*) from the Shoulder of Mutton Pond and there is as yet no evidence of their inability to attack any species of British freshwater fish.

In the present survey, glochidia were found on sticklebacks from December to May. This is a slightly later period than that reported by Giusti *et al.* (1975) and a slightly shorter one than that reported by Campbell (1974) for the occurrence of *Anodonta anatina* on Brown trout. Whilst the duration of glochidial attachment to fish may be influenced by the species of mussel and host concerned, it is also correlated with other factors, especially temperature.

TABLE I

Topographical distribution of glochidia

Location	Number of larvae recorded								
	Dec.	Jan.	Feb.	March	April	May	Totals	%	
Tail fin	157	159	87	66	74	7	550	16·6	
Dorsal fin	37	39	15	12	23	5	131	4·0	
Anal fin	13	15	16	3	9	3	59	1·8	
Right pectoral fin	162	112	24	44	81	9	432	13·0	25·2
Left pectoral fin	145	111	28	49	57	13	403	12·2	
1st dorsal spine	7	4	0	1	1	0	13	0·4	
2nd dorsal spine	2	4	1	4	2	0	13	0·4	
3rd dorsal spine	0	0	0	0	0	0	0	0·0	
Mouth	115	118	123	79	48	5	488	14·7	
Buccal cavity	155	54	17	65	72	11	374	11·3	
Gills	81	51	34	17	47	14	244	7·4	
Throat	36	43	23	18	17	1	138	4·2	
Head	9	5	1	4	0	2	21	0·6	
Right operculum	12	0	4	2	1	2	21	0·6	1·1
Left operculum	7	2	1	0	5	1	16	0·5	
Right eye	17	16	25	2	6	2	68	2·1	4·1
Left eye	14	17	16	13	6	0	66	2·0	
Right flank	9	7	46	8	19	3	92	2·8	4·6
Left flank	0	9	31	8	10	1	59	1·8	
Anal region	14	20	2	12	10	1	59	1·8	
Other	26	22	7	5	5	0	65	2·0	
Totals	1018	808	501	412	493	80	3312		
No. of infected fish	61	56	40	39	43	29	268		
No. of fish examined	61	56	43	41	43	50	294		

Glochidia of the river pearl mussel *Margaratifera margaratifera* are stated to remain attached to fishes for up to ten weeks, depending upon water temperature (Muus & Dahlstrom, 1971). Giusti *et al.* (1975) have shown that whilst there is a distinct seasonal reproductive cycle in *Anodonta*, gametogenesis nevertheless occurs throughout most months of the year. Glochidial attachment to fishes however is much more limited and may be closely linked to variations in water temperatures. In the Shoulder of Mutton Pond, glochidial occurrence on sticklebacks was manifest only when pond temperatures were below 12°C.

Fish examined in the present survey exhibited a general increase in infection with increasing size (Fig. 2). This may, in part, be a reflection merely of increased surface areas available for glochidial attachment. However, the distribution of parasite burdens (Fig. 3) indicates a typical pattern of over-dispersion with the majority of fish harbouring low infestations but with one or two carrying huge burdens. According to Kennedy (1975) overdispersion is typical of most natural infections and is strongly influenced by factors such as viability, dispersal and behaviour of larvae plus variations in the behaviour, susceptibility and response of hosts. Several of these factors are no doubt important in the glochidia/stickleback relationship. For example the response of fish to glochidial attack is very variable and may even, in some species, be lethal (Meyers & Millemann, 1977). In addition, glochidia are released *en masse* from the parent Swan mussel and potential fish host making contact at the time of glochidial release may easily acquire a much greater parasite burden than if contact is made at a later time. Thus although glochidial attack is theoretically a random process, several factors can be listed as contributors to an overdispersion of the larval stages upon fish hosts. Further analysis of these factors is required. Paling (1968) found that, once attached, glochidia do not move about the body of their host. He also observed that the settlement of glochidia on the gills of large (270–290 mm) Brown trout was related to the regions of maximum water flow.

The principal areas for glochidial attachment on sticklebacks from the Shoulder of Mutton Pond were in order of importance, the fins, the head region and lastly, the gills and buccal cavity. It is of considerable corroborative interest that the patterns of glochidial distribution observed in samples of sticklebacks collected from the field are almost identical with those observed during experimental infections of glochidia onto sticklebacks under laboratory conditions (Miss J. Landsberg, pers. comm.).

The relative paucity of glochidia on the gills of sticklebacks is surprising, although not unique. Giusti *et al.* (1975) showed that whilst in Tench, Pumpkinseed (*Lepomis gibbosus*) and Sand-smelt (*Atherina boyeri*), the gills harboured more glochidia than did individual fins or pairs of fins, in Perch and Pike, the numbers of glochidia on the gills were less than those on the fins. It is tempting to suggest that the active predatory habits of sticklebacks, Perch and Pike in some way contribute to a different glochidial distribution from that observed on less active omnivorous feeders such as Tench, Pumpkinseed and Sand-smelt. It seems, however, doubtful that large predators such as Pike and Perch feed on glochidia. Sticklebacks, by comparison do actively prey upon glochidia in experimental situations and their stomach contents may contain appreciable numbers of glochidia under natural feeding regimes.

Giusti *et al.* (1975) suggest that the "lurking" predation strategy of pike presents the fish with many more opportunities for glochidial attack than are presented to other species of fish. Certainly, the feeding, foraging and selection behaviour of potential predators and hosts must be considered in any analysis of glochidial attack upon freshwater fish.

An alternative hypothesis to account for glochidial distribution patterns is that they may partly be a reflection of host size. The relatively large size of a glochidium compared with the diameter of a stickleback oesophagus renders it unlikely that the parasite will be passively (and unconsciously?) swept into the branchial clefts and much more likely that it will be either swallowed or rejected. Each action may account for a lower glochidial concentration on the gills in *G. aculeatus* than have been recorded in other species of fish (Paling, 1968; Giusti *et al.*, 1975).

Thus whilst the exact factors controlling site selection by glochidia require further analysis, the availability of the larvae, size of fish, type of food selection and feeding behaviour all appear to interact to determine the distribution of the parasitic phase on fish hosts.

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REFERENCES

Campbell, A. D. (1974). The parasites of fish in Loch Leven. *Proc. R. Soc. Edinb.* (B) **74**: 347–364.

Dartnall, H. J. G. (1973). Parasites of the nine-spined stickleback *Pungitius pungitius* (L.) *J. Fish Biol.* **5**: 505–509.

Davies, E. H. (1967). Thesis, University of Liverpool, cited by Chubb, J. C. (1970) in *Aspects of fish parasitology:* 134. Taylor, A. E. R. and Muller, R. (Eds). Oxford and Edinburgh: Blackwell Scientific Publications.

Giusti, F., Castagnolo, L. M. F. & Renzoni, A. (1975). The reproductive cycle and the glochidium of *Anodonta cygnea* L. from Lago Trasimeno (Central Italy). *Monitore zool. Ital.* (N.S.) **9**: 99–118.

Kennedy, C. R. (1975). *Ecological animal parasitology.* Oxford: Blackwell Scientific Publications.

Lee, R. (1977). The Serpentine fish and their parasites. *Lond. Nat.* **56**: 57–70.

Meyers, T. R. & Millemann, R. E. (1977). Glochidiosis of salmonid fishes. 1. Comparative susceptibility to experimental infection with *Margaritifera margaritifera* (L.) (Pelecypoda: Margaritanidae). *J. Parasit.* **63**: 728–733.

Mishra, N. T. & Chubb, J. C. (1969). The parasite fauna of the fish of the Shropshire Union Canal, Cheshire. *J. Zool., Lond.* **157**: 213–224.

Muus, B. J. & Dahlstrom, P. (1971). *Freshwater fish of Britain and Europe* (edit. by Wheeler, A.) London: Collins. [English translation. First published in Denmark, 1967.]

Paling, J. E. (1968). A method of estimating the relative volume of water flowing over the different gills of a freshwater fish. *J. exp. Biol.* **48**: 533–544.

Wootten, R. (1973). The metazoan parasite fauna of fish from Hanningfield Reservoir, Essex, in relation to features of the habitat and host populations. *J. Zool., Lond.* **171**: 323–333.

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