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THE INCIDENCE OF *CARCINONEMERTES CARCINOPHILA* (KOLLIKER) ON SOME DECAPOD CRUSTACEANS FROM THE SCOTTISH WEST COAST

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ABSTRACT

From May 1985 until June 1987, decapod crustaceans in the Firth of Lorne were caught monthly by creeling. Ovigerous animals were preserved, and the gills and egg masses examined for evidence of infestation by the nemertean parasite *Carcinonemertes carcinophila*. Samples of the gills from male and non-ovigerous female crabs were also retained, and examined for the encysted juvenile stage. In the early months of 1989, a few ovigerous *Carcinus maenas* obtained by diving were examined.

Ovigerous *Liocarcinus puber* and *L. depurator* were caught in small numbers, and both were infested with the parasite. In *L. depurator* the gills were heavily infested with the encysted juveniles, but few worms were found in the egg mass, 7 being the highest number in a single crab. In *L. puber* up to 25 worms were found in an individual crab, but the number of cysts in the gills was low. Only one ovigerous *C. maenas* was obtained by creeling; the egg mass contained only a few nemertines, and very few cysts were found on the gills. However, of the few shore crabs obtained by diving, one had the highest number of free-living worms found on an egg mass (42), but again very few cysts were found on the gills. Examination of the gills from male and non-ovigerous female crabs confirmed that *C. maenas* and *L. puber* had few identifiable encysted juveniles, whereas *L. depurator* had a very high number. No evidence of infestation was found in either the squat lobster *Munida rugosa* or the spider crab *Hyas araneus*, both of which were caught in considerable numbers.

The egg strings of the parasite were found from May to October, associated with worms at least 13.6 mm long, although larger worms were found during the winter months.

INTRODUCTION

The nemertine *Carcinonemertes carcinophila* was first described by Kolliker in 1845 from specimens obtained from the European shore crab *Carcinus maenas* (L), and has been recorded from British *C. maenas* many times since (Humes 1942, Gibson 1983). The only other host crab recorded from British and European waters is the swimming crab *Liocarcinus depurator* (L) (Wynhoff 1912, Vivares 1971). Dieck (1874) found the nemertine in the Mediterranean on *Galathea strigosa* L., but there are no records of it being found on this host in British waters.

Wickham & Kuris (1985) gave a brief historical background to the nomenclature, and, like Humes (1942), tabulated the then known hosts, both European and

American. Wickham (1986) reviewed the literature, and summarised the records of rates and intensities of infestation on decapod crustacean hosts, whilst Kuris & Wickham (1987) give a comprehensive review of the literature relating to nemerteans predating crustacean eggs, and discuss the relationships between the nemerteans and their crustacean hosts. Cambell et al. (1989) also give an updated review of the known hosts, and describe a new species from an Australian palinurid.

The species *C. carcinophila* has been divided into two varieties (Humes 1942). *C. c. carcinophila,* the original European form as described by Kolliker (1845), also occurs on *Callinectes sapidus* Rathbun from the north Atlantic seaboard of America. The variety *C. c. imminuta* described by Humes (1942) infests a number of *Callinectes* species and other genera southwards from North Carolina. Humes (1942) investigated the structure and biology of the variety *C. c. imminuta*, but had to rely upon deduction rather than observation in his account of egg and larval development.

Juvenile *C. carcinophila* are found encysted on the gill lamellae of host species, migrating to the egg mass once this has been laid. The nemertine secretes a characteristically ornamented mucous tube, reputedly feeds on the host eggs, grows, and lays its own eggs in mucous strings over and amongst the host egg mass. The parasite eggs hatch in approximately ten days, but the method of dispersal of the parasite to other hosts has not been observed. In the European *C. c. carcinophila* the indication is of a very short larval existence, van Beneden (1861) stating that the larvae lose their cilia and adopt the crawling habit within three days of hatching. Larvae were believed to pass their entire development period within the host egg mass. Whether the juvenile nemertines feed whilst encysted is a matter for conjecture (Wickham & Kuris 1985), and whether the juveniles on male hosts are lost to the population as is generally assumed, or have a mechanism for migrating to a female host as in some other species (Wickham et al. 1984, Kuris & Wickham 1987) is not known.

In recent years nemerteans of this genus have been recognised as very serious egg predators on American crab species, destroying up to 100% of the crab egg mass, and consequently being responsible for seriously depleting the recruitment of young crabs to commercially important fisheries (Wickham 1986). The recent increase in the commercial interest in, and exploitation of, the smaller crab species in Great Britain, in particular the velvet crab *Liocarcinus puber* (L.) and to a lesser extent the shore crab *Carcinus maenas,* highlights the need for a more detailed knowledge of hitherto neglected aspects of European crab associates.

This paper presents new information on the occurrence of *Carcinonemertes* in crabs from the west coast of Scotland, based on material collected in the course of other investigations. The crustacean egg masses examined derived from a study of the occurrence and distribution of the decapod crustaceans within the area of the Firth of Lorne, and the crab gills from a study of the polychaete associ-

ate *Iphitime cuenoti* Fauvel (Comely & Ansell in preparation). The occurrence of *Carcinonemertes* was appreciated too late to allow these various interests to be co-ordinated, and the results presented here are therefore derived from somewhat disparate sources.

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METHODS

From May to November 1985 commercial crab creels with an aperture of 80 mm were laid in two groups, or 'strings', each of 12 creels, for 24 hour periods at 47 locations around the Firth of Lorne, from the south end of Lismore to the northern end of the Lynn of Lorne, at depths ranging from 5-25 m. From December 1985 until June 1987 four strings of 6 creels were laid monthly at two sites only; the south end of Lismore, and at Eriska, immediately south of the entrance to Loch Creran. A string of creels was laid at 5, 10, 15 and 25 m at each site. All crustacean decapods caught were examined for the eunicid polychaete *Iphitime cuenoti,* and samples consisting of 2-3 gills from each crab infested with the polychaete were retained for further examination. These gills, together with gills from ovigerous crustacea retained entire in 1985 were examined microscopically for juvenile nemertines in this study. Preserved egg masses which had been retained from some of the ovigerous crabs in the same collections, were examined for adult nemertines and their egg strings. Wherever possible the nemertines were counted and measured.

In addition to the above collections, a small number of ovigerous *Carcinus maenas* were obtained amongst the boulder scree within the lower *Laminaria* zone at a site close to the laboratory during the first few months of 1989, and these animals were examined fresh. The nemertines from these crabs were measured alive and again after fixation in 70% alcohol. The linear regression of live length (y) on preserved length (x) is given by the equation

$$y = 1.32x + 0.38 \text{ mm. } r = 0.96; N = 61.$$

RESULTS

Ovigerous crabs

The percentage of the total catch of female crabs of each species which were ovigerous varied considerably (Table 1). Of almost 1000 female *Carcinus maenas* caught by creeling, only one ovigerous individual was found (June 1986), whilst 76.2% of all female *Hyas araneus* (L.) caught were carrying eggs. The seasonal oc-

Table 1. The numbers of various ovigerous decapods caught in the Firth of Lorne area of the west coast of Scotland during experimental fishing from 1985 to 1987.

Species	Number		%
	Females	Ovigerous	Ovigerous
Munida rugosa	411	110	26.8
Liocarcinus puber	299	22	7.4
Liocarcinus depurator	1108	152	13.7
Carcinus maenas	957*	1	0.1
Hyas araneus	210	160	76.2

* Does not include female crabs showing evidence of parasitisation by *Sacculina*.

currence of ovigerous females in those species which were caught regularly in sufficient numbers is shown in Fig. 1. The majority of the two *Liocarcinus* species carry eggs for only a relatively restricted period from March until May, although small numbers of ovigerous individuals may be found throughout the year, and observations by diving have shown that individual *Liocarcinus puber* spawn as early as late January. This is in marked contrast to *Hyas araneus* in which significant numbers of egg bearing females occur throughout the year, but with the proportion rising during the winter months. The squat lobster *Munida rugosa* (Fabricius) also carries its eggs during the winter. The ovigerous *C. maenas* caught in January 1989 bore eyed larvae, indicating that this species also carries its eggs during the winter months.

Gills

Of 27 ovigerous *L. depurator* for which all of the gills were available, 9 had necrotic gill disease (Comely & Ansell 1989), and 25 had nemertean cysts on the gill lamellae. Of these latter, 56% had < 4 cysts / gill, 36% had 5-10 / gill and 8% had > 10/gill. Of the 7 ovigerous *L. puber* for which gills were available, all had small necrotic lesions and all had <4 nemertean cysts in each gill. There is no comparable information for *H. araneus,* but in *M. rugosa,* of gills from 19 ovigerous females which were examined, no nemertine cysts were found, and there was no evidence of necrotic lesions. Small, round brown spots were common, but they appeared to be superficial and possibly represented unsuccessful parasitic attacks rather than loci for necrotic disease.

Of the 2-3 gills retained from each crab infested with *Iphitime cuenoti*, which included males and non-ovigerous females, nemertine cysts were found in 140 of the 155 *L. depurator* examined, but only 7 from 124 *L. puber,* and 2 from 99 *L. corrugatus*. None were found in the gills of 20 *Carcinus maenas* or 14 *H. araneus* examined. In the *C. maenas* caught in 1989 only a single cyst was found in the gills of each of two crabs, and two on a third crab examined, despite the occurrence of large numbers of nemertines on the egg masses.

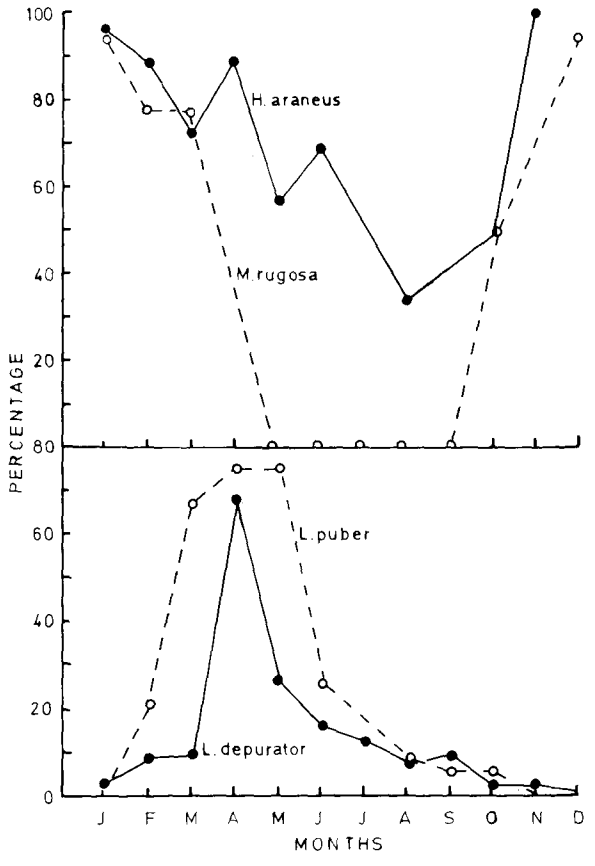

Fig. 1. The seasonal occurrence of ovigerous females in different decapod crustacean species as a percentage of the total number of females of each species caught. The monthly figures from 1985-1987 have been combined.

Egg mass

Free-living nemertines were found on the host eggs from January to October, and although encysted nemertines were most numerous on *L. depurator,* larger and more abundant adults were found on *L. puber.* There are insufficient data on *C. maenas* to enable conclusions to be drawn; the only ovigerous crab caught by creeling had eggs close to hatching, and the egg mass had a copious felting of nemertine egg strings. However, of the crabs caught in 1989, the two captured in January were both infested, one with the highest number of nemertines found on any crab species during this investigation. No nemertines, or indication of their presence, were found on *H. araneus* or *M. rugosa.*

Nemertine egg strings were found from May to October associated with worms of at least 13.6 mm in length. On one *L. depurator,* egg strings were found, but no worms, and on three host crabs empty worm tubes but no worms or their eggs were found; these records have not been included in Table 2. Nemertines were only found on host eggs which were at least embryonate, but it is possible that very

small worms migrating into the host egg mass when the latter was at an earlier stage of development, were overlooked. This is confirmed by observations on a *L. puber* severely affected with Black Necrosis which, after being maintained in a tank in the laboratory for several months, in late February spawned and died. The numbers of eggs produced were insufficient to occupy all the pleopods, but nevertheless 25 nemertines were found attached to the rachi, ranging in size from 0.56 mm - 4.80 mm after preservation in alcohol.

The characteristic location adopted by the nemertines, at least initially, was along the lower third of the pleopodal endopod rachis, from which they reached out into the main egg mass of the host. Larger worms were commonly found insinuated amongst the main body of the egg mass, and the eggs of the parasite were characteristically laid on, or close to, the outer periphery of the host egg mass. No evidence of host egg predation was found, even when several mature parasites were present. When empty crab egg shells were found they could invariably be related to natural hatching of the larval crabs.

DISCUSSION

Of the three portunid crabs known to harbour *Carcinonemertes carcinophila,* two carry their eggs during the early summer, with a few individuals extending into the autumn, whilst the third, *Carcinus maenas,* carries eggs during the winter. In these crabs the eggs are only partially covered by the reflexed abdomen, and are therefore largely exposed to the surrounding water currents. Similarly the squat lobsters protect their eggs by reflexing the abdomen and telson, the effect being rather similar to that achieved by the crabs, and it is possible, therefore, that the nemertine might successfully parasitise them, as indicated by the record for *Galathea strigosa* in the Mediterranean (Dieck 1874), although no parasites were found in this study on *Munida rugosa.* In *Hyas araneus* the abdominal cavity is almost completely closed by the strongly concave inner surface of the reflexed abdomen, which must create a very different microhabitat to that found in portunids and squat lobsters. This may be a factor in precluding the successful parasitisation of this crab. The relationship between host behaviour and the success of the parasite is discussed by Kuris & Wickham (1987) for American crustacea.

Neither the European or American variety of *Carcinonemertes carcinophila* appears to be implicated in serious epizootic infestations such as recorded for other *Carcinonemertes* species infesting American crab species. *C. epialti* Coe on *Cancer magister* Dana may occur in numbers up to 100 000 worms/crab (39.6 worms/1000 crab eggs), resulting in total destruction of the host egg mass, those eggs not destroyed by the parasite being affected by secondary invaders such as fungi (Wickham 1986). During the present investigation the damage to the host egg mass appeared to be negligible, no damaged eggs being found in the preserved or fresh

Table 2. The infestation rate and numbers of the nemertine *Carcinonemertes carcinophila carcinophila* found on the egg masses of the three crab species harbouring this parasite. Results are the combined figures for the years 1985-1987. Crabs from 1989 are marked with an asterisk. Note that not all of the crab egg masses included in Table 1 were retained for examination.

Month	CRABS		NEMERTINES (Nem)				
	total nos.	with Nem.	highest N/Crab	total Nem.	length (mm) min.	max.	mean
			Liocarcinus depurator				
Apr.	16	4	1	4	1.7	13.6	6.3
May	54	16	7	29	0.8	15.7	5.4
June	5	1	6	6	-	-	-
July	1	1	1	1	2.8		
Sept.	1	0					
Oct.	1	1	1	1	1.0		
			Liocarcinus puber				
Feb.*	1	1	25	25	0.6	4.8	1.5
Apr.	6	1	1	1	-	-	-
May	3	2	10	13	0.7	22.4	8.0
Sept.	1	1	2	2	2.2	6.8	4.5
Oct.	6	3	16	24	3.6	20.8	12.4
			Carcinus maenas				
Jan.*	2	2	42	43	0.9	15.0	4.7
Feb.*	1	1	1	1	7.0		
June	1	1	6	6	-	-	-

material examined which could be conclusively related to nemertine predation. As *L. depurator* can carry 25-140 thousand eggs, depending on size (Mori & Zunino 1987), the maximum infestation rate of 7 worms recorded for an individual of this species gives a very low parasite/host egg ratio. For *C. maenas,* which carries approximately 185 000 eggs (Broekhuysen 1936), the maximum number of 42 parasites found on an individual still gives a relatively low ratio.

As at least one of the known portunid hosts is ovigerous at any one time of the year, the parasite is potentially able to develop throughout the year, although there is no positive verification for November or, possibly, December from these data, nor is there any evidence that egg production can occur throughout the winter. *Hyas araneus* bears eggs throughout the year, and as the parasite was not found on this species it can be concluded that this is a physically unsuitable host. *Munida rugosa* carries its eggs throughout the winter, as does *Galathea strigosa* (Marine Biological Association 1957, Bruce et al. 1963) in British waters, and as there are no apparent seasonal barriers to the development of the nemertine, these species must also be regarded as unsuitable hosts. Although it is recorded from the Mediterranean on *G. strigosa* (Dieck 1874), it is possibly significant that no further records of its occurrence on this species are known, nor has it been recorded on any other European macruran.

From the data available, it must be concluded that the most important impact that *Carcinonemertes carcinophila* has on its host probably relates to the effects of the cysts on the gill lamellae. In *Liocarcinus depurator* especially, almost every gill lamella had at least one cyst, and not uncommonly two, present. Whilst this crab also shows a considerable susceptibility to gill necrosis (Comely & Ansell 1989), there is no direct evidence to link the occurrence of the parasite with the disease. This does not, however, invalidate the suggestion that a high incidence of parasitic cysts may aggravate the disease (Gibson 1983) especially if they are present in large enough quantities to cause repiratory problems for the crab. The low numbers of cysts found on *L. puber,* and very low numbers on *C. maenas,* despite the success of the parasite in invading the egg masses of these species, requires further investigation.

REFERENCES

Beneden, P.-J. van, 1861. Recherches sur la faune littorale de Belgique. - Mem. Acad. r. Sci. Lett. Belg. **32**: 1-30.

Broekhuysen, G. J., 1936. On development, growth and distribution of *Carcinides maenas* (L.) - Archs neerl. Zool. **2**: 257-399.

Bruce, J. R., J. J. Colman & N. S. Jones, 1963. Marine Fauna of the Isle of Man. - Liverpool University Press. 307 pp.

Campbell, A., R. Gibson & L. Evans, 1989. A new species of *Carcinonemertes* (Nemertea: Carcinonemertidae) ecto-habitant on *Panulirus cygnus* (Crustacea: Palinuridae) from Western Australia. - Zool. J. Linn. Soc. **95**: 257-268.

Comely, C. A. & A. D. Ansell, 1989. The occurrence of Black Necrotic Disease in crab species from the west of Scotland. - Ophelia **30**: 95-112.

Dieck, G., 1874. Beitrage zur Entwicklungsgeschichte der Nemertinen. - Jena Z. Naturw. **8**: 500-520.

Gibson, R., 1983. British Nemerteans. - Synopses of the British Fauna **24**: edit. Kermack, D. M. and Barnes, R. S. K. Linn. Soc. London. 212 pp.

Humes, A. G., 1942. The morphology, taxonomy and bionomics of the nemertean genus *Carcinonemertes.* - Illinois biol. Monogr. 18 no. 4: 105 pp.

Kolliker, A. von, 1845. Ueber drei neue Gattungen von Wurmen *Lineola, Chloraima, Polycystia,* neue Wurmgattungen und neue Arten von Nemertes. - Verh. schweiz. naturf. Ges. Chur. **29**: 86-98.

Kuris, A. M. & D. E. Wickham, 1987. Effect of nemertean egg predators on crustaceans. - Bull. mar. Sci. **41**: 151-164.

Marine Biological Association, 1957. Plymouth Marine Fauna 3rd edition. - Mar. Biol. Assoc. U.K. 457 pp.

Mori, M. & P. Zunino, 1987. Aspects of the biology of *Liocarcinus depurator* (L.) in the Ligurian Sea. - Inv. pesq. **51** (suppl. 1): 135-145.

Vivares, C. P., 1971. Etudes des parasites des Crustaces Decapodes Brachyoures: Nemertes et larves Cestodes. - Ann. Parasitol. Hum. Comp. **46**: 1-9.

Wickham, D. E., 1986. Epizootic infestation of nemertean brood parasites on commercially important crustaceans. - Can. J. Fish. Aquat. Sci. **43**: 2295-2302.

Wickham, D. E. & A. M. Kuris, 1985. The comparative ecology of nemertean egg predators. - Amer. Zool. **25**: 127-134.

Wickham, D. E., P. Roe & A. M. Kuris, 1984. Transfer of nemertean egg predators during host moulting and copulation. - Biol. Bull. **167**: 331-338.

Wynhoff, G., 1912. List of nemerteans collected in the neighbourhood of Plymouth from May to September 1910. - J. mar. biol. Ass. U.K. **9**: 407-434.