Research Note

Nucella lapillus as a paratenic host for *Maritrema arenaria*

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Abstract

Metacercariae of the microphallid trematode *Maritrema arenaria* are found in the shore barnacle *Semibalanoides balanoides* which is heavily predated by the dog whelk, *Nucella lapillus*. This study demonstrated that, under experimental and natural conditions, *M. arenaria* metacercarial cysts were ingested by *N. lapillus* and the metacercariae retained their viability while passing through the molluscs' digestive systems. Dog whelks are a known food source for numerous bird species, leading to the conclusion that they may act as paratenic hosts of *M. arenaria*. The strategic importance of the adoption by *M. arenaria* of *N. lapillus* as a paratenic host is discussed.

Hadley & Castle (1940) described part of the life cycle of *Maritrema arenaria*, identifying the ruddy turnstone (*Arenaria interpres*) as the definitive host and the barnacle (*Semibalanus balanoides*) as the intermediate host. The primary host was identified by Irwin *et al*. (1990) who established that a microphallid cercaria previously known as *Cercaria littorina saxatilis V* (Popeil, 1976) found in the rough periwinkle (*Littorina saxatilis*) developed into the metacercaria of *M. arenaria*. The research by Irwin *et al*. (1990) and subsequent collection of barnacles from Jordanstown shore on Belfast Lough, N. Ireland has shown that there is a high prevalence of *M. arenaria* metacercarial cysts in the *S. balanoides* at that site. It is also apparent that the carnivorous gastropod mollusc, *Nucella lapillus*, heavily predates the infected barnacles. That being the case, the possibility that *N. lapillus* inadvertently ingests *M. arenaria* metacercarial cysts along with barnacle soft tissues appears likely. As *N. lapillus* is subject to predation by birds, any metacercariae which they have consumed and retained in their digestive tracts will be passed on to potential final hosts. If the metacercarial cysts should retain their viability under these circumstances, birds, which predate *N. lapillus*, are likely to become infected by *M. arenaria*.

In order to establish if *N. lapillus* ingests *M. arenaria* metacercarial cysts when preying on infected *S. balanoides*, and to ascertain if ingested cysts retain their viability, three replicates of the following experiment were carried out in late May/early June 1998. Uninfected *N. lapillus* were sampled from a distant site where *M. arenaria* cysts had never been observed in specimens of *S. balanoides*. Small rocks covered with *S. balanoides* were collected from Jordanstown shore where the prevalence and mean intensity (Bush *et al*., 1997) of *M. arenaria* metacercarial cysts in the barnacles are high. The uninfected *N. lapillus* were maintained in clean sea water in an incubator at 10°C for 24 h prior to experimentation. They were then introduced into a tank of sea water containing the rocks covered with infected barnacles, *S. balanoides*. The tank was covered with transparent glass and left outdoors under ambient conditions. After 24 h, during which the *N. lapillus* could feed *ad libitum* on the infected barnacles, the gastropods were removed and immediately dissected. *Maritrema arenaria* metacercarial cysts found in the *N. lapillus* were accumulated and, in order to ascertain if they had maintained their viability, the cysts were subjected to an *in vitro* excystment regime devised by Irwin *et al*. (1984). Viability was assessed as the

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percentage of the metacercariae which successfully excysted to give rise to active juvenile worms. Results of the three replicates of this experiment were combined as follows: After 24 h exposure to barnacles known to contain *M. arenaria* metacercarial cysts, 11 from a total of 24 *N. lapillus* had *M. arenaria* cysts in their digestive tracts. This represented a parasite prevalence of 45.8% with a mean intensity of 3.54 parasites per host. Of 39 cysts recovered, 31 (79.49%) were viable. In all cases the excysted metacercariae were identified as *M. arenaria*.

To assertain if *N. lapillus* in a natural environment might possess viable *M. arenaria* metacercarial cysts in their tissues, 26 of these gastropods were collected from the Jordanstown shore where *M. arenaria* metacercarial cysts are prevalent in the barnacles. Immediate dissection of these *N. lapillus* demonstrated that 12 had *M. arenaria* metacercarial cysts in their digestive tracts. This represented a prevalence of 46.15% with a mean intensity of 4.83 parasites per host. Again the Irwin *et al*. (1984) excystment regime was used to assess the viability of the cysts and, in this case, it was also applied to a similar number of *M. arenaria* cysts taken from their usual second intermediate host, *S. balanoides*. Three replicates of the experiment were carried out and the combined results were as follows: 44 (75.86%) of a total of 58 *M. arenaria* metacercarial cysts found in the digestive tracts of naturally infected *N. lapillus* were viable. That compared with 52 (89%) from a total of 58 taken directly from their usual intermediate host, the barnacle *S. balanoides*.

In an attempt to establish if *M. arenaria* metacercarial cysts found in *N. lapillus* are merely transient in the gut, the following experiment was performed. Six *N. lapillus* were maintained in an aquarium which was placed outdoors at ambient temperature. The molluscs were allowed to feed freely on barnacles known to contain large accumulations of *M. arenaria* metacercarial cysts. *Nucella lapillus* faecal pellets were collected at intervals and examined under a low power binocular microscope for the presence of metacercarial cysts. After 24 h, five cysts were found in the faecal material. In a further 2 days, 12 more cysts were located and after a period of one week a further 20 cysts were identified in the *N. lapillus* faeces.

The experiments carried out in this study clearly establish that *N. lapillus*, in natural and experimental environments, can ingest and temporarily retain *M. arenaria* metacercarial cysts, and the viability of the cysts is maintained at a level similar to that of cysts taken from the recognized intermediate host, *S. balanoides*. According to Mehlhorn (1988) the term 'paratenic' is applied to a host inside which no development occurs but only an accumulation of infectious stages. This leads us to the conclusion that *N. lapillus* acts as a paratenic host for the digenetic trematode *M. arenaria*.

Nucella lapillus is known to be a food source for a number of species of birds including the rock pipit (*Anthus spinoletta*) (Gibb, 1956), the oystercatcher (*Haematopus ostralegus*), purple sandpiper (*Calidris maritrema*) and the whimbrel (*Numenius phaeopus*) (Cramp & Simmons, 1983). It is very likely that these birds will be infected by *M. arenaria* by way of the paratenic host route. Adoption of *N. lapillus* as a paratenic host could well be of benefit to the trematode as it would increase the diversity, and therefore the availability, of its definitive hosts. Few birds other than the turnstone (*Arenaria interpres*, after which the worm was named) are known to selectively feed on barnacles. Turnstones are winter visitors to most palaeoarctic shores such as Belfast Lough, and this must limit the transmission of *M. arenaria* eggs to the winter months. Adoption of other bird hosts, some of which feed on *N. lapillus* throughout the year, would not only provide additional host numbers but it could allow for distribution of the parasite's eggs in the summer when climatic conditions might well be more conducive for infection of the primary host, *L. saxatilis*. Inclusion of *N. lapillus* as a paratenic host in its life cycle may represent an important survival strategy for *M. arenaria*.

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