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The Role of *Artemia* spp (Branchiopoda: Artemiidae) as Intermediate Hosts for Avian Cestodes

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Abstract

Brine shrimps of the genus *Artemia* can tolerate hyper saline aquatic environments and thus, are able to occupy ecological niches. These brachiopod crustaceans play an important role as food source for flamingos and other waders and act as intermediate hosts for a variety of cestodes. Comparison of scolex structures of adult tapeworms with those of the cysticercoids in *Artemia* spp gave evidence that brine shrimps act as intermediate hosts for *Aploparaksis parafilum, Brachiopodataenia gvozdev, Confluaria podicipina, Fimbriaroides tadornae, Flamingolepis caroli, F. flamingo, F. liguloides, F. tengizi, Hymenolepis californicus, Wardium fusca* and *W. stellorae* of the Hymenolepididae family, *Anomolepis averini*, *Anomotaenia tringae* and *A. microphallus* of the Dilepididae family and *Gynandotaenia stammeri* and *Gynandrotaenia* spp. a so far undetermined further species of this genus of the Progynotaeniidae family.

Keywords: Artemia; Brachiopoda; Cysticercoids; Hymenolepididae; Dilepididae; Progyotaeniidae

Introduction

Brine shrimps or *Artemia* is a phylogenetically old genus of aquatic crustaceans contains of sibling species and super species defined by the criterion of reproductive isolation. The species inventory of the genus is disputed but according to Asem et al. [1] it consists of *Artemia salina, A. monica, A. urmiana, A. franciscana, A. sinica, A. tibetiana* and parthenogenetic populations called *A. parthenogenetica*. Brine shrimps can tolerate saline (2.5%) to hyper-saline (25%) waters with an optimum range of 6 -10% salinity and occur world-wide in inland salt waters and thus, occupy ecological niches that protect them from predators such as fish. Under normal conditions female brine shrimps are ovo-viviparous and naupilus larvae usually hatch immediately after placement of eggs while unfavorable conditions (low oxygen, rising temperatures, desiccation of pools) led to the production of floating, thick shelled, metabolically inactive brown cysts that can survive for up to two years in dry conditions and hatch when hydrated under optimal conditions [2]. Naupuli of brine shrimps are among the most widely used live diet in the larviculture of fish and shellfish and over 2000 metric tons of dry *Artemia* cysts are marked world-wide [3]. Brine shrimps are also a major compound in the diet of flamingos and a number of waders occurring in subsequent habitats and during evolution a relationship between these birds, their cestodes and brine shrimps acting as intermediate hosts has been established.

Cestodes using brine shrimps as intermediate hosts

Hymenolepis californicus was the first species that was detected in its larval stage in brine shrimps of Mono lake and salt pools near Chula Vista in California. To establish the relationship of this cestode larvae with the adult tapeworm Young [4] fed laboratory hatched California gulls and proved the identity of cysticercoids and adult cestodes grown in the gulls. Starting in the 1970th, scientists of the Zoological Institute in Almaty started ecological studies in the in the lake Tengiz in the Tselinograd district of northern Kazakhstan. This undrained lake is fed by the river Nura and occupies a territory of 1,950km^2. Tengiz is the largest saline lake in Kazakhstan and its shore and surroundings of the Korgalzhin National Park is home to the most northern population of greater flamingos and more than 300 other birds. The occurrence of *A. salina* on a massive scale in the Tengiz Lake gave reason to investigate its role as possible intermediate hosts for avian cestodes since eight different species of tapeworms were found in greater flamingos originating from that place [5]. Out of 36.500 brine shrimps collected between July and October 1971 2.235 (=6.1%) specimens were infected with 10 different cysticercoids. Amongst them were three representatives of the family Hymenolepididae: *Flamingolepis dolgushini, F. tengizi* and *Aploparaksis parafilum* in prevalence of 3.0%, 0.13%, and 0.033% respectively [6].

The examination of the helminthofauna of the shelduck led to the description of a new hymenolepidid cestode, *Fimbriaroides tadornae*. Eggs of this tapeworm were fed to *A. salina* and the development of the cysticercoid was monitored. Under conditions of 6.5% salinity and a constant temperature of 22 °C the development Were completed at day 12 to13 after infection. Out of 140 brine shrimps used 76 (=54.3%) became infected and harbored up to13 cysticercoids. No information on the natural infection of *A. salina* in the lake Tegiz was given [7]. Cysticercoids of *Anomolepis averini was* found in *A. salina* in high prevalence of 5.3-9.1% in the bays of the Tengiz lake while in collecting places that were located at a far distance from the shore prevalence was much lower and reached only 0.4-0.86%. *Branchinella spinosa*, another brachipod harbored also *Anopolepis* cysticercoids but in low prevalence of 0.22% [8]. The adult tapeworm of this dilepidid cestode was found in numbers of 1-15 in intestines of the red necked phalaropes in a prevalence of 13.7%. *Gynandotaenia stammeri* of the Progynotaeniidae family was present in 0.04% of examined shrimps [9]. The presence of *G. stammeri* in brine shrimps in the French Carmague was also mentioned by Gabrion & Mac Donald [10]. *Confluaria podicipina*, a hymenolepidid cestode originally described from grebes northern America was also detected in black necked, great crested and in red-necked grebes in Kazakhstan [11-13].

Larval stages with eight aploparaksoid hooks on the scolex matching in size and shape with those found of *C. podicipina* in grebes were present in *A. salina* from Lake Tengiz in a prevalence of 0.05-0.35% [14]. Further research was dedicated to hymenolepidid cestodes of the genus *Wardium* that parasites the intestines of gulls and subsequent cysticercoids that were seen in *A. salina* originating from Tengiz lake. These were *Wardium stellorae* [15] and *W. fusca* [16]. Among the *Wardium* species from gulls of the lake Tengiz was a so far undescribed new species, *W. gvozdevi* that occurred in a high prevalence in slender billed gulls. Experimental infections of *A. salina* carried out at 22-24 °C showed that the development of cysticercoids of *W. gvozdevi* is completed within 12-15 days [17]. A cysticercoid scolex structures of which matched with those of the cestode *Wardium manubriatum* of the slender billed gull was detected in a single fairy shrimp (*Branchinella spinosa*) collected in the lake Tegiz [18]. The cysticercoid of *Eurycestus avoceti*, a dilepidid cestode of the avocet was originally described from *Artemia sp*. from Camargue, a wetland in southern France in a paper by Gabrion & MacDonald [10]. This cysticercoid was also found in low prevalence of 0.03-0.5% in *A. salina* from Tegiz lake [19]. The author mentioned also findings of the adult tapeworm in avocets but saw scolices and strobila fragments of *E. avoceti in* juvenile flamingos as well.

The larval stage of two further members of the *Flamingolepis* genus was described in *Artemia sp*. from Camargue wetlands. Cysticercoids of both *F. caroli* and *F. flamingo* were detected in a very low prevalence of 0.074% and only single cysticercoids were found in infected shrimps [20]. A survey on cysticercoids in *Artemia parthenogenetica* originating from the Odiel Marshes in Andalusia in Spain revealed the presence of 8 different species, amongst them *Anomotaenia tringae* and an *Anomotaenia* species with 26-30 rostellar hooks. Scolex structures of the latter species showed some similarities with *A. microphallus* an euryxenous cestode of waders. However, none of the descriptions of *A. microphallus* reported more than 24 rostellar hooks. Other species found in this study were *F. liguloides*, *F. flamingo, C. podicipina, W. stellorae, E. avoceti and G. stammeri* [21].

Further research on the role of brine shrimps as intermediate hosts of avian cestodes was done in saline lakes in Algeria [22], in the Western Mediterranean costs of Spain and France [23]. Extension of research work on A. *salina* and *A. parthenogenetica* in the Odiel Marshes in Spain showed the presence of 9 already known cestode larval stages and revealed a so far undescribed cysticercoid that was allocated to the genus *Gynandrotaenia* [24]. A further *Artemia* species occurring in the Odiel Marshes is the neozoon *A. franciscana.* This species originates from San Francisco Bay and Great Salt Lakes in North America and was introduced to Spain in the 1980th. Apart from cysticercoids of *F. liguloides, F. flamingo, E. avoceti* and *G. stammeri A. franciscana* was also infected with nematode larvae of the Acuariidae family. Redon et al. [25] studied parasite development stages of *A. franciscana* in the Great Salt Lake in Utah and found infections with four different cestodes (*C. podicipina, H. californicus, Wardiumsp. and Fuhrmannolepis averini*) along with larval stages of a nematode belonging to the Acuariidae family [26-30].

Conclusion

Artemia spp. in their inland saltwater habitats play an important role as food source for wader birds. Feeding on plankton, brine shrimps ingest also helminth eggs and had become intermediate hosts for avian cestodes. So far, cysticercoids of 16 different species of the Hymenolepididae, Dilepididae and Progynotaeniidae were found in *Artemia* spp.

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