Hedgehogs’ Parasitology: An Updated Review on Diagnostic Methods and Treatment

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Abstract: The genus Erinaceus is commonly found in rescue centres across the European continent despite the reported decline in some countries. Parasite infections are frequently detected in rescued hedgehogs, leading to increased morbidity and mortality and consequently conditioning their recovery. Some of the most frequent parasites include respiratory nematodes, such as Crenosoma striatum and Capillaria spp., which may lead to important pneumonia. Moreover, some of these agents have zoonotic potential, such as Cryptosporidium spp., Sarcoptes spp., and several species of ticks and fleas, which may transmit different vector-borne pathogens. This review provides a brief guide on hedgehogs’ internal and external parasitology, as well as some suggestions for diagnosis and treatment that are relevant for wildlife veterinarians, biologists and other researchers.

Keywords: Erinaceus; hedgehog; parasite; wildlife medicine

1. Introduction

Hedgehogs are small mammals, members of the family Erinaceidae, subfamily Erinaceinae comprising five genera: Atelerix, Erinaceus, Hemiechinus, Mesechinus and Paraechinus. The genus Erinaceus includes four species naturally distributed among the Eurasian continent: E. amurensis, E. concolor, E. europaeus and E. roumanicus [1]. Particularly in Europe, E. europaeus is dispersed throughout Western Europe, southern Scandinavia and Russia, E. roumanicus and E. concolor are distributed throughout Eastern Europe. Moreover, A. albiventris is also popularly recognised by Europeans since it is the most common hedgehog species used as a pet [2–4].

The food regimen classification of hedgehogs is controversial, and different sources suggest distinct classification. Hedgehogs are primarily insectivores but are also opportunistic omnivores, feeding on insects, berries, earthworms, snails, seeds, small reptiles and also some vegetables and plant material [3,5,6]. They are mostly active during night and usually hibernate during Winter, especially in the coldest environments [3,6].
Although resilient and considered stable (“Least Concern” Red List status), recent national reports have been presenting a decline in the European species in several countries, suggesting vulnerability, which may change their conservation status. The main threats vary according to the geographic location but include car collisions, predation by wild or domestic carnivores, poisoning and traumatic injuries induced by agricultural machines [7–10]. Considering this, veterinarians should be aware of the infectious agents (parasites) that may increase mortality or morbidity in hedgehogs’ populations or conditionate their recovery in rescue centres. Moreover, particularly for A. albiventris, exotic pets’ veterinarians should also recognise their pathogens and their importance in the health of these animals and their owners.

Although there have been other reviews on the subject [11], the authors believe there is not enough information to provide a consistent, systematic review or a book chapter on hedgehog parasitology. However, there are a considerable number of cases of parasitic infections and there is a need to summarise the available information to make it easier to read for wildlife veterinarians and researchers. Therefore, this literature review intends to provide a consolidated guide on the internal and external parasitology of hedgehogs.

2. Internal Parasites

2.1. Coccidia

According to the literature, there is a high number of coccidian species capable of parasitizing hedgehogs, namely *Isospora rastegaevae*, *I. schmaltzi*, *I. erinacei*, *Eimeria perardi*, and *E. ostertagi*. Although they are normally asymptomatic, high levels of parasitism by *I. erinacei* and *I. rastegaevae* have been causing severe lesions in young hedgehogs, with the presence haemorrhagic faeces and diarrhoea [12–15].

2.2. Cryptosporidium spp.

*Cryptosporidium* spp. can infect mammals, birds, fish, and reptiles, and cases of infection by *Cryptosporidium parvum* and *C. erinacei* have been detected in hedgehogs [16,17]. Their zoonotic potential should be considered from a public health perspective, especially for *C. parvum*. Therefore, people in contact with infected hedgehogs should be careful and wear protective equipment [18]. Cases of *Cryptosporidium* spp. dissemination in hedgehogs has been documented for periods of up to 70 days. Therefore, recovered hedgehogs may have the capacity to act as vectors of infection after their release into the wild, and that is why some authors have recommended faecal examinations upon entry and exit from recovery centres [16].

The infection may occur through the ingestion or inhalation of oocysts. Subsequently, the sporozoites are released and colonise the cells of the intestine. Then, sporulated oocysts leave the intestinal cells and can either reinfect the host or be expelled into the environment (depending on the oocyst’s wall thickness), where they exhibit considerable resistance [16,19,20].

Clinical signs associated with infection by *Cryptosporidium* spp. may include anorexia, depression, dehydration, and diarrhoea [16,19].

2.3. *Giardia* spp.

It was possible to find a single reference to *Giardia* spp. infection in *E. europaeus* in New Zealand, on a farm with a history of human giardiasis. Considering the zoonotic potential and the diversity of hosts of this parasite, this finding should be referred [21,22].

2.4. *Hymenolepis erinacei*

Compared to other parasites, cestodes (such as *H. erinacei*) normally present low prevalence in hedgehogs [23]. *H. erinacei* measures up to 16 centimetres in length and is characterised by having proglottids with their own movement, which may appear in faeces [3,15]. Different species of insects may work as intermediated hosts. However, it is also possible for the cysticercoid larvae to develop directly in the rectum of hedgehogs [3,12,15].
Clinical signs include an alternation between diarrhoea and constipation, loss of body condition, and debilitation [12,15].

2.5. Brachylaemus erinacei

*Brachylaemus erinacei* is the most prevalent trematode in hedgehogs [19]. These parasites are found in the small intestine and bile ducts of their hosts. The expelled eggs are ingested by gastropod molluscs (such as *Succinea* spp., *Helix* spp., and *Arion* spp.), and those may integrate with the diet of hedgehogs [24].

Clinical signs associated with infection by this parasite include weight loss, restlessness, inflammation of bile ducts, haemorrhagic enteritis, anaemia, and, in more extreme cases, death [24].

2.6. Crenosoma striatum

*Crenosoma striatum* is certainly one of the most common nematodes that infect hedgehogs. These parasites inhabit the bronchi and trachea and may be present in large numbers [12,25–27]. Females lay numerous eggs, and larvae hatch usually in the trachea, being aspirated and swallowed, progressing to the digestive system; the reason why they can also be found in faeces, although this elimination is intermittent. Snail gastropods with and without shells (as *Succinea* spp. or *Agrolimax* spp.) are the intermediated hosts that may have L3 infective larvae that (if ingested) penetrate the intestine and move to the lungs (via bloodstream or haemolymphatic route [15,25,27].

Clinical signs include dry cough, crackling respiration, choking fits, pneumonia, anaemia, or even death due to the presence of large quantities of parasitic forms [12,26]. Parasitic bronchopneumonias are very common in hedgehogs, especially in first-year hedgehogs. *C. striatum* and *Eucoleus aerophilus* (see the next section) are the most common agents and are frequently found together in necropsies. Lungworms can be collected by performing some incisions in the lung and doing smooth finger pressure on its portions. These parasites usually come out from the bronchi and then should be preserved under alcohol 70% until examination.

Diagnosis is made by microscopic identification of L1 larvae in fresh faeces, using methods such as the Baermann technique or by tracheobronchial washing [3,12,28].

2.7. Capillaria spp.

Different species of *Capillaria* can be found in hedgehogs, either in the intestinal or pulmonary tract. The two species that parasitise the intestinal tract of hedgehogs are *C. erinacei* and *C. ovoreticulata* [4], while the lung is usually parasitised by *Eucoleus aerophilus* (syn. *C. aerophila*) [12,25].

Considering the intestinal *Capillaria* spp., the infective larvae can be found in large quantities in earthworms, so hedgehogs can be infected by their ingestion or directly through the environment. Infection by these can cause intestinal disorders, diarrhoea, enteritis, and, in cases of massive infections, lead to the death of animals [4,12,25]. Diagnosis can be made through microscopic observation of eggs in faeces using flotation methods [3].

Regarding *E. aerophilus*, adult forms parasitise the bronchi, bronchioles, and trachea of hedgehogs, and they are also eliminated intermittently [4,13,15]. Similarly to *C. striatum*, the clinical signs include cough, crackling respiration, increased respiratory rate, pneumonia, secondary bacterial infections, choking fits, and death [4,25]; and the diagnosis is made by microscopic identification of eggs in faeces or tracheobronchial washings [3,12].

2.8. Physaloptera clausa

*Physaloptera clausa* is a nematode commonly found in hedgehogs’ gastrointestinal tract, particularly in *E. europaeus* and *E. amurensis* [29]. Some insects, such as crickets or beetles, serve as intermediate hosts, and reptiles may serve as paratenic hosts [30,31].
Although these infections are normally asymptomatic, when these parasites change their site of attachment in the intestine wall, they may induce ulcers, inflammation, haemorrhages, and, in some more extreme cases, cachexia and diarrhoea [15,30].

2.9. Other Endoparasites Occasionally Found

*Plagiorhynchus cylindraceus* is a palaeacanthocephalan parasite. *P. cylindraceus* is a common intestinal parasite of passerine birds that can also occur in mammalian species in the intestinal tract or parenterally. According to the authors, it can be considered a “modern parasite” taking advantage of transcontinental spread of infection and anthropogenic promoted transmission. In Europe and New Zealand, immature worms have been found in hedgehog peritoneal cavity [22,32]. Other endoparasite forms have also been occasionally or locally identified in a few hedgehogs’ assessments [11], such as *Porroacum* spp. larvae, *Pterygodermatites plagistoma*, *Nephridiorhynchus major*, and *Prosthoryhnchus* spp. in the Iberian peninsula [33], *Isthmiophora melis* in Czech Republic [34] *Nephrotrema truncatum* in Austria [35], *Dicrocoelium dendriticum*, *Brachylecitum aetechini*, *Mesocestoides* spp. and *Brachylecitum mackoi* in Italy [36,37], and *Oliganthorhynchus erinacei* syn. *Echinorhynchus erinaceid* in the UK [38].

3. External Parasites

Mites belonging to the genera *Notoedres*, *Psoroptes*, and *Sarcoptes* can be found in hedgehogs [12]. *Notoedres cati* and *Otodectes cynotis* have often been identified in hedgehogs and authors have suggested the contact with domestic cats as source of infection [3,39–42]. *Sarcoptes* spp. usually cause intense itching, skin scaling, spine shedding, and loss of body condition [41,43,44]. While cases of demodicosis (caused by *Demodex erinacei*) can occur in hedgehogs, they are rare and often underdiagnosed. The clinical signs include papules and thick crusts on the skin [3,45].

3.1. Fleas

In addition to hedgehog-specific flea species, such as *Archaeopsylla erinacei* and *Hystrichopsylla talpae*, other flea species that typically parasitise other animals, such as dogs, cats, and birds, can also be found in these mammals [19,46,47]. Infected hedgehogs may show signs of weakness, itching, and, in severe cases, anaemia [46]. Despite their direct impact on hedgehogs, *A. erinacei* is particularly relevant due to the potential transmission of pathogenic agents [47–50]. Hornok et al. (2014) have identified *Rickettsia helvetica* and *Bartonella henselae* in fleas of the species *A. erinacei* parasitising hedgehogs [50].

3.2. Ticks

*Rhipicephalus* spp. and *Ixodes* spp. seem to be the two most prevalent ticks genera found in hedgehogs [19,51]. In large quantities, ticks can cause significant blood loss and, therefore, severe anaemia. *Rhipicephalus sanguineus* has been showing a high prevalence of infection in hedgehogs [51,52]. Hedgehogs can be parasitised throughout their bodies, but especially around the eyes, ears, and anus. This species is also associated with the transmission of other pathogenic agents such as *Rickettsia massiliae*, *R. conorii*, and even *Coxiella burnetti* (the zoonotic agent responsible for Q fever) [53–55]. Among the species of the genus *Ixodes* spp., *I. ricinus* and *Pholeoixodes hexagonus* (previously known as *Ixodes hexagonus*) are two of the most prevalent species. *Ixodes* spp. are relevant from a public health perspective, since they have the capability to transmit several pathogens with zoonotic potential, such as *Anaplasma phagocytophilum*, *Borrelia burgdorferi*, *B. afzelii*, *B. bavariensis*, *Rickettsia helvetica*, *Babesia divergens*, *B. venatorum*, and *B. microti* [56–61]. Dumitrache et al. [51] conducted a study on the prevalence of ticks infected with *B. burgdorferi* and *A. phagocytophilum* in *E. roumanicus*. A total number of 959 ticks were found in 24 hedgehogs, with 957 of them belonging to the species *I. ricinus*. The prevalence of *B. burgdorferi* was 0.4%, and the prevalence of *A. phagocytophilum* was 12%.
Tables 1 and 2 summarise the diagnostic methods and treatment options available for parasitic diseases in hedgehogs.

**Table 1. Summary of hedgehog parasites and diagnostic methods [62,63].**

<table>
<thead>
<tr>
<th>Parasites</th>
<th>Diagnostic Methods (Examples)</th>
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</thead>
<tbody>
<tr>
<td>Coccidia</td>
<td>MIF */Flotation</td>
</tr>
<tr>
<td><em>Cryptosporidium</em> spp.</td>
<td>Microscopic observation of faecal smears with Ziehl Neelsen stain</td>
</tr>
<tr>
<td><em>Giardia</em> spp.</td>
<td>Microscopic observation of faecal smears, ELISA (for coproantigens) or PCR techniques</td>
</tr>
<tr>
<td><em>Hymenolepis erinacei</em></td>
<td>Direct observation of eggs in faecal samples, with or without flotation method</td>
</tr>
<tr>
<td><em>Brachylaemus erinacei</em></td>
<td>Direct observation of eggs in faecal samples, with or without flotation method</td>
</tr>
<tr>
<td><em>Crenosoma striatum</em></td>
<td>Identification of L1 larvae present in fresh faeces, after performing the Baermann method</td>
</tr>
<tr>
<td><em>Capillaria</em> spp.</td>
<td>Microscopic observation of eggs from faecal samples, after performing the flotation method</td>
</tr>
<tr>
<td><em>Physaloptera clausa</em></td>
<td>Direct observation of eggs in faecal samples, with or without flotation method</td>
</tr>
<tr>
<td>Mites</td>
<td>Microscopic observation of mites from skin scrapings</td>
</tr>
<tr>
<td>Fleas</td>
<td>Observation of fleas (during the clinical exam, for example)</td>
</tr>
<tr>
<td>Ticks</td>
<td>Observation of fleas (during the clinical exam, for example)</td>
</tr>
</tbody>
</table>

* MIF—merthiolate-iodine-formalin.

**Table 2. Summary of drugs used for treatment of parasite infections in hedgehogs [3].**

<table>
<thead>
<tr>
<th>Antiparasitic Drugs</th>
<th>Dosage</th>
<th>Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amitraz</td>
<td>Dilution of 1:400 and application in baths for 7 days</td>
<td>Treatment of demodicosis and sarcoptic mange</td>
</tr>
<tr>
<td>Cipermethrin</td>
<td>Topical spray applied on the affected area</td>
<td>Myiasis treatment</td>
</tr>
<tr>
<td>Cyromazine</td>
<td>Topical spray applied on the affected area</td>
<td>Myiasis treatment</td>
</tr>
<tr>
<td>Febendazole</td>
<td>110 mg/kg orally every 24 h for a period of 5 days</td>
<td>Effective against nematodes and cestodes</td>
</tr>
<tr>
<td>Fipronil</td>
<td>7.5–15 mg/kg</td>
<td>Effective against fleas and ticks</td>
</tr>
<tr>
<td>Ivermectin (injectable)</td>
<td>0.5–3 mg/kg subcutaneous</td>
<td>Effective against the vast majority of hedgehog parasites</td>
</tr>
<tr>
<td>Ivermectin (topical)</td>
<td>0.2–0.5 mg/kg</td>
<td>Effective against fleas, ticks and mites</td>
</tr>
<tr>
<td>Levamisole</td>
<td>27 mg/kg subcutaneous in 48 h periods</td>
<td>Drug of choice in the treatment of pulmonary nematodes</td>
</tr>
<tr>
<td>Mebendazole</td>
<td>50–100 mg/kg orally every 24 h for a period of 5 days</td>
<td>Effective against nematodes and cestodes</td>
</tr>
<tr>
<td>Permethrins</td>
<td>250–350 mg/kg applied topically</td>
<td>Effective against fleas, ticks and mites</td>
</tr>
<tr>
<td>Praziquantel</td>
<td>10–20 mg/kg intramuscular, subcutaneous or oral</td>
<td>Effective against cestodes and trematodes</td>
</tr>
<tr>
<td>Sulfadimidine</td>
<td>200 mg/kg subcutaneous every 24 h during a period of 3 days</td>
<td>Coccidiosis treatment</td>
</tr>
<tr>
<td>Trimetropim</td>
<td>50 mg/kg intramuscular or</td>
<td>Coccidiosis treatment</td>
</tr>
<tr>
<td>Toltrazuril</td>
<td>25–50 mg/kg in a single oral administration</td>
<td></td>
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</table>
4. Implications

Rasmussen et al. [11] indicated considerable regional differences in parasitism, also variable according to age. Different biological and geographical aspects of the individual should be taken into consideration when evaluating and treating parasite infections.

Hedgehogs have been studied and discussed as possible indicators of zoonotic agents (such as parasites) in the environment, as well as other One Health concerns, such as antimicrobial resistance [64,65]. Due to their resilience and adaptability, it is unlikely that the mentioned parasites significantly conditionate the stability and conservation of these species or impair reintroductions of rescued individuals. Only in cases of lungworm infection (associated with pneumonia) does parasitism hinder reintroduction, even though only until the end of the treatment period [66]. Nevertheless, wild and pet hedgehogs represent relevant sources of zoonotic agents and precautions should be taken when manipulating and managing these species to avoid diseases in humans (as well as other species) [65]. In both cases, treatment and prevention of severe parasite infections should be based on a diagnosis to avoid unnecessary or inadequate use of antiparasitic drugs. As shown in Table 1, most diagnostic techniques involve inexpensive and easy-to-use techniques.

5. Conclusions

Several species of internal and external parasites have been identified in hedgehogs with importance for hedgehogs’ health. Furthermore, some have a zoonotic potential, or may transmit other pathogens (as ticks and fleas). Notwithstanding, wildlife veterinarians and technicians from rescue centres should be aware of the diversity of parasites that may affect hedgehogs to improve recovery and reintroduction rates.


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