parasitologia

MDPI

Review

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

Francisco Alfaia [1,2,†], Catarina Jota Baptista [3,4,5,6,*,†], Viktória Sós-Koroknai [7,8], Márton Hoitsy [7,8], Endre Sós [7,8,‡] and Luís M. Madeira de Carvalho [1,2,*,‡]

1 Faculty of Veterinary Medicine, University of Lisbon, 1300-477 Lisbon, Portugal; franciscoalfaia@gmail.com
2 Centre for Interdisciplinary Research in Animal Health, Associated Laboratory for Animal and Veterinary Sciences (CIISA-Al4Animals), 1300-477 Lisbon, Portugal
3 Department of Veterinary Sciences, School of Agrarian and Veterinary Sciences (ECAV), University of Trás-os-Montes and Alto Douro (UTAD), 5000-801 Vila Real, Portugal
4 Centre for the Research and Technology of Agro-Environmental and Biological Sciences (CITAB-Inov4Agro), UTAD, 5000-801 Vila Real, Portugal
5 Institute of Biomedicine (IBIOMED), Universidad de León, 24071 Leon, Spain
6 Egas Moniz Center for Interdisciplinary Research (CiiEM), Egas Moniz School of Health & Science, 2829-511 Caparica, Portugal
7 Budapest Zoo and Botanical Garden, 1146 Budapest, Hungary; koroknai.viktoria@zoobudapest.com (V.S.-K.); hoitsym@gmail.com (M.H.); drsos.endre@zoobudapest.com (E.S.)
8 Department of Exotic Animal and Wildlife Medicine, University of Veterinary Medicine Budapest, 1078 Budapest, Hungary
* Correspondence: catabap@hotmail.com (C.J.B.); madeiradecarvalho@fmv.ulisboa.pt (L.M.M.d.C.)
† These authors contributed equally to this work.
‡ These authors coordinated this research equally.

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

Citation: Alfaia, F.; Jota Baptista, C.; Sós-Koroknai, V.; Hoitsy, M.; Sós, E.; Madeira de Carvalho, L.M. Hedgehogs' Parasitology: An Updated Review on Diagnostic Methods and Treatment. *Parasitologia* **2024**, *4*, 82–90. https://doi.org/10.3390/parasitologia4010007

Academic Editor: Geoff Hide

Received: 20 February 2024
Revised: 12 March 2024
Accepted: 15 March 2024
Published: 17 March 2024

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 rastegaievae*, *I. schmaltzi*, *I. erinacei*, *Eimeria perardi*, and *E. ostertagi*. Although they are normally asymptomatic, high levels of parasitism by *I. erinacei* and *I. rastegaievae* 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 *Porrocaecum* spp. larvae, *Pterygodermatites plagiostoma*, *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].

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

* MIF—merthiolate-iodine-formalin.

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

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

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.

Author Contributions: Conceptualisation: F.A., C.J.B., E.S., V.S.-K., M.H. and L.M.M.d.C. Supervision: E.S. and L.M.M.d.C. Writing—draft preparation: C.J.B. Writing—revision: F.A., L.M.M.d.C., V.S.-K. and M.H. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by National Funds by the Fundação para a Ciência e a Tecnologia (FCT) e and Ministério da Ciência e Tecnologia (MCT). C.J.B. received funding from FCT—reference of the projects: UIDB/04033/2020 and 2021.04520.BD (PhD scholarship). C.J.B. also thanks FCT/MCTES for the financial support to CiiEM (10.54499/UIDB/04585/2020). Authors from CIISA/FMV (AL4Animals) (F.A., J.L. and L.M.M.d.C.) also received funding from FCT–reference of the projects: UIDB/00276/2020, and LA/P/0059/2020.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Wilson, D.E.; Reeder, D.M. *Mammal Species of the World: A Taxonomic and Geographic Reference*, 3rd ed.; Johns Hopkins Press: Baltimore, MD, USA, 2005; Volume 2.
2. Mitchell-Jones, A.J.; Amori, G.; Bogdanowicz, W.; Krystufek, B.; Reijnders, P.J.H.; Spitzenberger, F.; Stubbe, M.; Thissen, J.B.M.; Vohralik, V.; Zima, J. *The Atlas of European Mammals*; Poyser: London, UK, 1999; ISBN 9780856611308.
3. Bexton, S. Hedgehogs. In *BSAVA Manual of Wildlife Casualties*; Mullineaux, E., Keeble, E., Eds.; British Small Animal Veterinary Association: London, UK, 2016; pp. 117–136.
4. Pfäffle, M. Influence of Parasites on Fitness Parameters of the European Hedgehog (Erinaceus europaeus). Ph.D. Dissertation, Fakultät für Chemie und BiowissenschaftenKarlsruher Institut für Technologie (KIT)—Universitätsbereichvorgelegte, Karlsruhe, Germany, 2010.
5. Moore, L.J.; Petrovan, S.O.; Baker, P.J.; Bates, A.J.; Hicks, H.L.; Perkins, S.E.; Yarnell, R.W. Impacts and Potential Mitigation of Road Mortality for Hedgehogs in Europe. *Animals* **2020**, *10*, 1523. [CrossRef] [PubMed]
6. Yarnell, R.W.; Pettett, C.E. Beneficial Land Management for Hedgehogs (Erinaceus europaeus) in the United Kingdom. *Animals* **2020**, *10*, 1566. [CrossRef] [PubMed]
7. Haigh, A.; Butler, F.; Ramsay, R. An Investigation into the Techniques for Detecting Hedgehogs in a Rural Landscape. *J. Negat. Results* **2012**, *9*, 15–26.

8. Pettett, C.E.; Johnson, P.J.; Moorhouse, T.P.; Macdonald, D.W. National Predictors of Hedgehog Erinaceus europaeus Distribution and Decline in Britain. *Mammal Rev.* **2018**, *48*, 1–6. [CrossRef]
9. Taucher, A.L.; Gloor, S.; Dietrich, A.; Geiger, M.; Hegglin, D.; Bontadina, F. Decline in Distribution and Abundance: Urban Hedgehogs under Pressure. *Animals* **2020**, *10*, 1606. [CrossRef] [PubMed]
10. Williams, B.M.; Baker, P.J.; Thomas, E.; Wilson, G.; Judge, J.; Yarnell, R.W. Reduced Occupancy of Hedgehogs (Erinaceus europaeus) in Rural England and Wales: The Influence of Habitat and an Asymmetric Intra-Guild Predator. *Sci. Rep.* **2018**, *8*, 12156. [CrossRef] [PubMed]
11. Rasmussen, S.L.; Hallig, J.; van Wijk, R.E.; Petersen, H.H. An Investigation of Endoparasites and the Determinants of Parasite Infection in European Hedgehogs (Erinaceus europaeus) from Denmark. *Int. J. Parasitol. Parasites Wildl.* **2021**, *16*, 217–227. [CrossRef]
12. Mehlhorn, H. *Encyclopedic Reference of Parasitology*, 2nd ed.; Mehlhorn, H., Ed.; Springer: Berlin/Heidelberg, Germany, 2001.
13. Mehlhorn, H. *Animal Parasites*; Springer International Publishing: Cham, Switzerland, 2016; ISBN 978-3-319-46402-2.
14. Pyziel, A.M.; Jeżewski, W. Coprology of a Single Northern White-Breasted Hedgehog (Erinaceus roumanicus): First Report of Isospora Rastegaievae in Poland. *Acta Parasitol.* **2016**, *61*, 636–638. [CrossRef]
15. Beck, W. Endoparasiten Beim Igel. *Wien. Klin. Wochenschr.* **2007**, *119*, 40–44. [CrossRef]
16. Hofmannová, L.; Hauptman, K.; Huclová, K.; Květoňová, D.; Sak, B.; Kváč, M. Cryptosporidium erinacei and C. parvum in a Group of Overwintering Hedgehogs. *Eur. J. Protistol.* **2016**, *56*, 15–20. [CrossRef]
17. Kváč, M.; Hofmannová, L.; Hlásková, L.; Květoňová, D.; Vítovec, J.; McEvoy, J.; Sak, B. Cryptosporidium erinacei n. sp. (Apicomplexa: Cryptosporidiidae) in Hedgehogs. *Vet. Parasitol.* **2014**, *201*, 9–17. [CrossRef]
18. Hunter, P.R.; Thompson, R.C.A. The Zoonotic Transmission of Giardia and Cryptosporidium. *Int. J. Parasitol.* **2005**, *35*, 1181–1190. [CrossRef] [PubMed]
19. Taylor, M.; Coop, R.; Wall, R. *Veterinary Helminthology*; Wiley Blackwell: Hoboken, NJ, USA, 2016.
20. Khan, A.; Shaik, J.S.; Grigg, M.E. Genomics and Molecular Epidemiology of Cryptosporidium Species. *Acta Trop.* **2018**, *184*, 1–14. [CrossRef]
21. Chilvers, B.L.; Cowan, P.E.; Waddington, D.C.; Kelly, P.J.; Brown, T.J. The Prevalence of Infection of Giardia spp. and Cryptosporidium spp. in Wild Animals on Farmland, Southeastern North Island, New Zealand. *Int. J. Environ. Health Res.* **1998**, *8*, 59–64. [CrossRef]
22. Skuballa, J.; Taraschewski, H.; Petney, T.N.; Pfäffle, M.; Smales, L.R. The Avian Acanthocephalan Plagiorhynchus Cylindraceus (Palaeacanthocephala) Parasitizing the European Hedgehog (Erinaceus europaeus) in Europe and New Zealand. *Parasitol. Res.* **2010**, *106*, 431–437. [CrossRef] [PubMed]
23. Binkiene, R.; Miliute, A.; Stunženas, V. Molecular Data Confirm the Taxonomic Position of Hymenolepis erinacei (Cyclophyllidea: Hymenolepididae) and Host Switching, with Notes on Cestodes of Palaearctic Hedgehogs (Erinaceidae). *J. Helminthol.* **2019**, *93*, 195–202. [CrossRef] [PubMed]
24. Döpke, C. *Kasuistische Auswertung Der Untersuchungen von Igeln (Erinaceus Europaeus) Im Einsendungsmaterial Des Instituts Für Pathologie von 1980 Bis 2001*; Tierärztliche Hochschule: Hannover, Germay, 2002.
25. Majeed, S.K.; Morris, P.A.; Cooper, J.E. Occurrence of the Lungworms Capillaria and Crenosoma spp. in British Hedgehogs (Erinaceus Europaeus). *J. Comp. Pathol.* **1989**, *100*, 27–36. [CrossRef]
26. Hoseini, S.M.; Youssefi, M.R.; Mousapour, A.; Dozouri, R.; Eshkevari, S.R.; Nikzad, M.; Nikzad, R.; Omidzahir, S. Histopathologic Study of Eosinophilic Bronchointerstitial Pneumonia Caused by Crenosoma striatum in the Hedgehog. *J. Zoo Wildl. Med.* **2014**, *45*, 335–338. [CrossRef]
27. Barradas, P.F.; Flores, A.R.; Mateus, T.L.; Carvalho, F.; Gärtner, F.; Amorim, I.; Mesquita, J.R. Crenosoma striatum in Lungs of European Hedgehogs (Erinaceus europaeus) from Portugal. *Helminthologia* **2020**, *57*, 179–184. [CrossRef]
28. Allen, S.; Greig, C.; Rowson, B.; Gasser, R.B.; Jabbar, A.; Morelli, S.; Morgan, E.R.; Wood, M.; Forman, D. Dna Footprints: Using Parasites to Detect Elusive Animals, Proof of Principle in Hedgehogs. *Animals* **2020**, *10*, 1420. [CrossRef]
29. Chen, H.-X.; Ju, H.-D.; Li, Y.; Li, L. Further Study on Physaloptera Clausa Rudolphi, 1819 (Spirurida: Physalopteridae) from the Amur Hedgehog Erinaceus amurensis schrenk (Eulipotyphla: Erinaceidae). *Acta Parasitol.* **2017**, *62*, 846. [CrossRef]
30. Gorgani-Firouzjaee, T.; Farshid, A.A.; Naem, S. First Ultrastructural Observations on Gastritis Caused by Physaloptera Clausa (Spirurida: Physalopteridae) in Hedgehogs (Erinaceus europeaus). *Parasitol. Res.* **2015**, *114*, 3693–3698. [CrossRef]
31. Gorgani, T.; Naem, S.; Farshid, A.A.; Otranto, D. Scanning Electron Microscopy Observations of the Hedgehog Stomach Worm, Physaloptera Clausa (Spirurida: Physalopteridae). *Parasit. Vectors* **2013**, *6*, 87. [CrossRef] [PubMed]
32. Pfäffle, M.; Černá Bolfíková, B.; Hulva, P.; Petney, T. Different Parasite Faunas in Sympatric Populations of Sister Hedgehog Species in a Secondary Contact Zone. *PLoS ONE* **2014**, *9*, e114030. [CrossRef]
33. Filu, C.; Blasco, S.J.; Torres, J.; Miquel, J.; Casanova, J.C. On the Helminthfauna of Erinaceus Europaeus Linnaeus, 1758 (Insectivora, Erinaceidae) in the Iberian Peninsula. *Rev. Ibérica Parasitol.* **2001**, *61*, 31–37.
34. Hildebrand, J.; Adamczyk, M.; Laskowski, Z.; Zaleśny, G. Host-Dependent Morphology of Isthmiophora Melis (Schrank, 1788) Luhe, 1909 (Digenea, Echinostomatinae)—Morphological Variation vs. Molecular Stability. *Parasit. Vectors* **2015**, *8*, 481. [CrossRef]
35. Löwenstein, M.; Prosl, H.; Loupal, G. Parasitoses of the Hedgehog and Their Control. *Wien. Tierarztl. Monatsschrift* **1991**, *78*, 127–135.

36. Casanova, J.C.; Ribas, A. Description of Brachylecithum Mackoi n. Sp. (Digenea: Dicrocoeliidae) from the European Hedgehog, Erinaceus europaeus (Insectivora: Erinaceidae). *J. Parasitol.* **2004**, *90*, 793–796. [CrossRef] [PubMed]
37. Giannetto, S.; Niutta, P.; Giudice, E. Parasitological Research on the Hedgehog (Erinaceus Europaeus) in Sicily. *ATTI Soc. Ital. Sci. Vet.* **1993**, *47*, 1433–1436.
38. Gaglio, G.; Allen, S.; Bowden, L.; Bryant, M.; Morgan, E.R. Parasites of European Hedgehogs (Erinaceus Europaeus) in Britain: Epidemiological Study and Coprological Test Evaluation. *Eur. J. Wildl. Res.* **2010**, *56*, 839–844. [CrossRef]
39. Foley, J.; Serieys, L.E.K.; Stephenson, N.; Riley, S.; Foley, C.; Jennings, M.; Wengert, G.; Vickers, W.; Boydston, E.; Lyren, L.; et al. A Synthetic Review of Notoedres Species Mites and Mange. *Parasitology* **2016**, *143*, 1847–1861. [CrossRef] [PubMed]
40. Stevanović, O.; Vujanić, D.; Dobrijević, M.; Nedić, D.; Trbojević, I. Notoedrosis In a Household Cat—Case Report. *Arch. Vet. Med.* **2019**, *12*, 39–47. [CrossRef]
41. Wright, I. Management of Parasites of Mammalian Wildlife in European Hedgehogs (Erinaceus europaeus). *Vet. Nurse* **2022**, *13*, 298–302. [CrossRef]
42. Patel, U.; Mukherjee, S. Successful Treatment of Otodectes Cynotis Infestation in Domestic African Pygmy Hedgehogs (Atelerix Albiventris): A Case Report. *Int. J. Vet. Sci. Anim. Husb.* **2023**, *8*, 103–105. [CrossRef]
43. Escobar, L.E.; Carver, S.; Cross, P.C.; Rossi, L.; Almberg, E.S.; Yabsley, M.J.; Niedringhaus, K.D.; Van Wick, P.; Dominguez-Villegas, E.; Gakuya, F.; et al. Sarcoptic Mange: An Emerging Panzootic in Wildlife. *Transbound. Emerg. Dis.* **2022**, *69*, 927–942. [CrossRef] [PubMed]
44. Arlian, L.G.; Morgan, M.S. A Review of Sarcoptes Scabiei: Past, Present and Future. *Parasit. Vectors* **2017**, *10*, 297. [CrossRef]
45. Izdebska, J.N.; Rolbiecki, L. The Biodiversity of Demodecid Mites (Acariformes: Prostigmata), Specific Parasites of Mammals with a Global Checklist and a New Finding for Demodex Sciurinus. *Diversity* **2020**, *12*, 261. [CrossRef]
46. Visser, M.; Rehbein, S.; Wiedemann, C. Species of Flea (Siphonaptera) Infesting Pets and Hedgehogs in Germany. *J. Vet. Med. Ser. B* **2001**, *48*, 197–202. [CrossRef]
47. Dudek, K.; Foldvari, G.; Majlathova, V.; Majlath, I.; Rigo, K.; Molnar, V.; Toth, M.; Jankowiak, L.; Tryjanowski, P. Patterns in the Distribution and Directional Asymmetry of Fleas Living on the Northern White-Breasted Hedgehog Erinaceus Roumanicus. *Folia Parasitol.* **2017**, *64*, 2026. [CrossRef]
48. Zurita, A.; Callejón, R.; de Rojas, M.; Cutillas, C. Morphological, Biometrical and Molecular Characterization of Archaeopsylla Erinacei (Bouché, 1835). *Bull. Entomol. Res.* **2018**, *108*, 726–738. [CrossRef]
49. Greigert, V.; Brunet, J.; Ouarti, B.; Laroche, M.; Pfaff, A.W.; Henon, N.; Lemoine, J.-P.; Mathieu, B.; Parola, P.; Candolfi, E.; et al. The Trick of the Hedgehog: Case Report and Short Review About Archaeopsylla Erinacei (Siphonaptera: Pulicidae) in Human Health. *J. Med. Entomol.* **2020**, *57*, 318–323. [CrossRef]
50. Hornok, S.; Földvári, G.; Rigó, K.; Meli, M.L.; Tóth, M.; Molnár, V.; Gönczi, E.; Farkas, R.; Hofmann-Lehmann, R. Vector-Borne Agents Detected in Fleas of the Northern White-Breasted Hedgehog. *Vector-Borne Zoonotic Dis.* **2014**, *14*, 74–76. [CrossRef]
51. Arnaudov, A.; Mikov, A.; Georgiev, D. Infestation of the Road-Killed Eastern European Hedgehogs (Erinaceus Roumanicus) with Ixodidae Ticks in Some Parts of Upper Thracian Plain (Bulgaria). *ZooNotes* **2022**, *192*, 1–4.
52. Dantas-Torres, F. Biology and Ecology of the Brown Dog Tick, Rhipicephalus Sanguineus. *Parasit. Vectors* **2010**, *3*, 26. [CrossRef] [PubMed]
53. Duarte, M. *Riquetsioses Do Grupo Das Febres Exantemáticas Em Canídeos Domésticos Em Portugal: Revisão Bibliográfica e Estudo Retrospectivo*; Faculdade de Medicina Veterinária da Universidade de Lisboa: Lisboa, Portugal, 2008.
54. Barradas, P.F.; Mesquita, J.R.; Mateus, T.L.; Ferreira, P.; Amorim, I.; Gärtner, F.; de Sousa, R. Molecular Detection of Rickettsia Spp. in Ticks and Fleas Collected from Rescued Hedgehogs (Erinaceus europaeus) in Portugal. *Exp. Appl. Acarol.* **2021**, *83*, 449–460. [CrossRef]
55. Mumcuoglu, K.Y.; Arslan-Akveran, G.; Aydogdu, S.; Karasartova, D.; Koşar, A.; Savci, U.; Keskin, A.; Taylan-Ozkan, A. Pathogens in Ticks Collected in Israel: II. Bacteria and Protozoa Found in Rhipicephalus sanguineus Sensu Lato and Rhipicephalus turanicus. *Ticks Tick-Borne Dis.* **2022**, *13*, 101986. [CrossRef]
56. Silaghi, C.; Skuballa, J.; Thiel, C.; Pfister, K.; Petney, T.; Pfäffle, M.; Taraschewski, H.; Passos, L.M.F. The European Hedgehog (Erinaceus Europaeus)—A Suitable Reservoir for Variants of Anaplasma phagocytophilum? *Ticks Tick-Borne Dis.* **2012**, *3*, 49–54. [CrossRef] [PubMed]
57. Szekeres, S.; Docters van Leeuwen, A.; Tóth, E.; Majoros, G.; Sprong, H.; Földvári, G. Road-killed Mammals Provide Insight into Tick-borne Bacterial Pathogen Communities within Urban Habitats. *Transbound. Emerg. Dis.* **2019**, *66*, 277–286. [CrossRef]
58. Oana, D. *Researches Regarding Ecobiology and Epidemiology of Hard Ticks Ixodidae Attack—Vectors of Lyme Disease in Romania*; University of Agricultural Sciences and Veterinary Medicine of Cluj-napoca: Cluj-Napoca, Romania, 2012.
59. Jahfari, S.; Ruyts, S.C.; Frazer-Mendelewska, E.; Jaarsma, R.; Verheyen, K.; Sprong, H. Melting Pot of Tick-Borne Zoonoses: The European Hedgehog Contributes to the Maintenance of Various Tick-Borne Diseases in Natural Cycles Urban and Suburban Areas. *Parasit. Vectors* **2017**, *10*, 134. [CrossRef]
60. Rizzoli, A.; Silaghi, C.; Obiegala, A.; Földvári, G.; Plantard, O.; Vayssier-Taussat, M.; Bonnet, S.; Špitalská, E. Ixodes ricinus and Its Transmitted Pathogens in Urban and Peri-Urban Areas in Europe: New Hazards and Relevance for Public Health. *Front. Public Health* **2014**, *2*, 113139. [CrossRef]

61. Dumitrache, M.O.; Paştiu, A.I.; Kalmár, Z.; Mircean, V.; Sándor, A.D.; Gherman, C.M.; Peştean, C.; Mihalca, A.D.; Cozma, V. Northern White-Breasted Hedgehogs Erinaceus roumanicus as Hosts for Ticks Infected with Borrelia burgdorferi Sensu Lato and Anaplasma phagocytophilum in Romania. *Ticks Tick-Borne Dis.* **2013**, *4*, 214–217. [CrossRef] [PubMed]
62. Gomes-Gonçalves, S.; Santos-Silva, S.; Cruz, A.V.S.; Rodrigues, C.; Soeiro, V.; Barradas, P.; Mesquita, J.R. A Thorny Tale of Parasites: Screening for Enteric Protozoan Parasites in Hedgehogs from Portugal. *Animals* **2024**, *14*, 326. [CrossRef] [PubMed]
63. Marks, S.L. Rational Approach to Diagnosing and Managing Infectious Causes of Diarrhea in Kittens. In *August's Consultations in Feline Internal Medicine*; Elsevier: Amsterdam, The Netherlands, 2016; Volume 7, pp. 1–22.
64. Jota Baptista, C.; Seixas, F.; Gonzalo-Orden, J.M.; Oliveira, P.A. Can the European Hedgehog (Erinaceus europaeus) Be a Sentinel for One Health Concerns? *Biologics* **2021**, *1*, 61–69. [CrossRef]
65. Jota Baptista, C.; Oliveira, P.A.; Gonzalo-Orden, J.M.; Seixas, F. Do Urban Hedgehogs (Erinaceus europaeus) Represent a Relevant Source of Zoonotic Diseases? *Pathogens* **2023**, *12*, 268. [CrossRef]
66. Sós, E.; Sós-Koroknai, V. Veterinary Management of European Hedgehogs. In *Fowler' s Zoo and Wild Animal Medicine Current Therapy*; Elsevier: Amsterdam, The Netherlands, 2023; Volume 10, pp. 737–744.