# CASES OF LUNGWORM INFECTIONS IN HEDGEHOGS (*ERINACEUS EUROPEUS*) IN GREECE AND THEIR THERAPEUTIC APPROACH

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# Introduction

The European hedgehog (*Erinaceus europaeus*) is one of the most common European wild mammalian species and it is widespread in Greece. Human related causes as well as infectious conditions have resulted in a declining tendency of their populations (Lehmann et al., 2024). Lungworm infections are the most common cause of respiratory disease in European hedgehogs (Van de Weyer et al., 2023). The nematodes *Crenosoma striatum* and *Capillaria aerophila* are the hedgehog's pulmonary parasites (Lehmann et al., 2024). Lungworms are transmitted both through gastropods, which hedgehogs feed on, and also directly (Majeed et al., 1989; Barradas et al., 2020). They can cause severe pneumonia, which is usually complicated by bacteria and if left untreated, it can be life threatening (Van de Weyer et al., 2023). The treatment attempts of lungworm infections in hedgehogs present limited success, as they are empirical and not based in sufficient scientific data (Lehmann et al., 2024).

In the present study, cases of lungworm infections in European hedgehogs in Greece are described, along with a novel and successful therapeutic approach.



Figure 1: Crenosoma spp. larvae detected in

Figure 2: Capillaria spp. eggs detected in

#### 87.5% of the hedgehogs' faecal samples.

#### 50% of the hedgehogs' faecal samples.

# Methodology

Seventeen (17) hedgehogs that were found wandering in urban areas were admitted to ANIMA – The Hellenic Wildlife Care Association (Athens). One of them, which was presented with nasal discharge, passed away a few hours after its admission. Necropsy and lung histopathology were performed. From the rest of the animals faecal samples were collected and examined with a flotation method using ZnSO4 (33.2%) in combination with the Baermann method in order to assess the presence of lungworm larvae.

Thereafter, infected animals were treated using the combination of esafoxolaner, eprinomectin and praziquantel (NexGard® Combo, Boehringer Ingelheim) *per os* at a dose rate of 0.2 ml/Kg BW. The oral route was chosen as the absorption from the thickened hedgehogs' skin was questioned. On 7, 10 and 14 days post treatment, faeces were collected and re-examined individually with a flotation method using ZnSO4 (33.2%) combined with the Baermann method.

Furthermore, on days 0 (the day when the treatment was given but before the administration) and 15 (one day after the last faecal collection) 0.5 ml of blood was collected from the medial saphenous vein of each hedgehog, under anaesthesia (mask induction of 5% isoflurane in an oxygen flow rate of 2 L/min and then maintenance in 2% isoflurane). The blood was sent to a specialized laboratory for testing some biochemical parameters so as to assess the renal and hepatic function of the hedgehogs, pre- and post treatment. More specifically, blood urea nitrogen (BUN), creatinine (Crea), alanine transaminase (ALT), and glutamate dehydrogenase (GLDH) were measured in the blood serum of the hedgehogs. Moreover, the weight of each animal was recorded on the same days.

During the survey, all the hedgehogs were hospitalized individually in pet carriers, under the same and controlled environmental conditions (25°C, humidity 40%), and they were fed with a mixture of cat food and commercial insects.





Figure 3: Gross pathology of the lung of a European hedgehog infected with *Crenosom*a spp.



**Figure 4**: Cross section of the lung's parenchyma of a European hedgehog infected with *Crenosoma* spp. Multiple sectioned nematodes (arrows) are present in the bronchiolar lumens.

## Discussion - Conclusion

The present study assessed the prevalence of common lungworm infections in European hedgehogs in Greece. As regards *Crenosoma* spp., several studies conducted in Europe have detected lower prevalence rates (40-46%) (Mariacher et al., 2021; Barradas et al., 2020; Liatis et al., 2017; Majeed et al., 1989). For *Capillaria* spp., some surveys have recorded lower rates of infection (36.8%-42.5%) (Mariacher et al., 2021; Liatis et al., 2017; Majeed et al., 1989), while one study demonstrated significantly higher prevalence rate (81%) (Van de Weyer et al., 2023).

Moreover, the current study presented for the first time a successful treatment protocol for the parasitism by *Crenosoma* spp. and *Capillaria* spp. in the European hedgehogs. It supported the efficacy and safety of a single oral administration of the combination of esafoxolaner, eprinomectin and praziquantel against lungworm infections in hedgehogs and this offers an easy to apply treatment option. Previous attempts of treating lungworms in this animal species using only moxidectin had poor efficacy and this is not recommended (Van de Weyer et al., 2023). Oral levamisole for two consecutive days has been found to be more effective than a single subcutaneous injection of ivermectin, however an additional dose of levamisole on days 10-12 post treatment may be indicated (Van de Weyer et al., 2023). The aforementioned data highlight the need for further studies regarding the treatment of these parasites.

## Results

On day 0, *Crenosoma* spp. larvae were detected in the faeces of 14 hedgehogs (14/16, 87.5%) (Figure 1) and, also, 8 of them (50%) excreted additionally *Capillaria* spp. eggs (Figure 2). The necropsy of the hedgehog that died shortly after its admission revealed lungs with lesions consistent with bronchopneumonia (Figure 3). The cross-section of its parenchyma uncovered nematodes that resembled *Crenosoma* spp. (Figure 4). The histological examination (hematoxylin and eosin staining) confirmed the diagnosis of mixed cellular, extensive, and moderate bronchopneumonia, with intralesional *Crenosoma* spp. nematodes. The bronchiolar epithelium was mildly hyperplastic and infiltration of mixed leucocytes and rare eosinophils was detected. There were foci of atelectasis and also some of mild alveolar hyperinflation.

The nematodes in the bronchiolar lumens were approximately 300  $\mu$ m in diameter. They had eosinophilic cuticles, polymyarian coelomyarian musculature, a pseudocoelom and a digestive tract lined by few multinucleate cells with a short brush border. Occasionally brown pigment was present in their digestive epithelium. Some of the nematodes showed a uterus distended by ova and larvae.

On days 7, 10 and 14 post treatment, no parasitic elements were detected in the faeces of the 13 out of the 14 infected hedgehogs. In the faecal sample of one hedgehog, which was infected both by *Crenosoma* spp. and *Capillaria* spp., *Crenosoma* spp. larvae were detected on day 7 post treatment. The faecal examination of this individual was negative at days 10 and 14 post treatment.

Regarding the tested biochemical parameters (BUN, Crea, ALT, GLDH), all were assessed as normal in all hedgehogs, both before and after the treatment, according to the blood reference intervals for *Erinaceus europaeus*, as they were published by Rosa et al. in 2024. All the hedgehogs gained weight during the 15 days of the study and the mean gain weight was 25%.

Given the high incidence of parasitic pneumonias in wild hedgehogs presented in wildlife hospitals worldwide (Van de Weyer et al., 2023), the reduction of lungworm burden plays a significant role in the conservation of this animal species.

Moreover, it is noteworthy, that, although the hedgehog is the only known final host for *Crenosoma striatum*, *Capillaria aerophila* also parasitizes in dogs and cats, as well as in other wild animal species (Lehmann et al., 2024). Consequently, studying the parasites of wildlife is of importance in the framework of One Health, as wild animals pose a reservoir for many parasites concerning domestic animals as well as humans (Thompson R.C., 2009).

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