The European Zoological Journal

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/tizo21

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To cite this article: A. Alvaro, L. Sanchez-Ruiz, I. Varotto-Boccazzi, G. Naro & P. Gabrieli (2025) Uninvited guests: flesh fly maggots as accidental parasites in the intestines of a common wall lizard, The European Zoological Journal, 92:1, 443-448, DOI: 10.1080/24750263.2025.2468803

To link to this article: https://doi.org/10.1080/24750263.2025.2468803

Published online: 03 Mar 2025.

The European Zoological Journal, 2025, 443–448
Vol. 92, No. 1, https://doi.org/10.1080/24750263.2025.2468803

Uninvited guests: flesh fly maggots as accidental parasites in the intestines of a common wall lizard

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(Received 25 October 2024; accepted 26 December 2024)

Abstract
Myiasis refers to the infestation of vertebrates, including humans, by the larvae of Diptera. This condition can affect various parts of the host's body, where the larvae feed, including the gastrointestinal tract. In cases of intestinal myiasis, obligate parasitic fly larvae complete the development up to the pupal stage within the host's gastrointestinal system. Other fly species, typically free-living, can cause opportunistic infestations in the gastrointestinal tract, leading to a condition known as pseudomyiasis or accidental intestinal myiasis. Here, we present a potential case of gastrointestinal infestation in a male of *Podarcis muralis*, the common wall lizard, by larvae of *Sarcophaga carnaria*. The lizard was found dead with a swollen abdomen, and upon dissection, 28 maggots were recovered from its intestines. The larvae were intact and arranged longitudinally, with one found near the cloacal opening. To the best of our knowledge, this is the first reported case of intestinal myiasis in a reptile.

Keywords: *Myiasis*, *reptile*, Podarcis muralis, *Sarcophagidae*, Sarcophaga carnaria

Introduction

Myiasis is the infestation of vertebrate animals, including humans, by obligatory or facultative parasitic larvae of Diptera. These larvae feed on the host's tissues, bodily fluids, or ingested food (Zumpt 1963, 1965). Myiases presents in various forms, depending on the location and feeding behavior of the maggots within their host, and are classified into five types: 1) sanguinivorous, 2) dermal/subdermal, 3) nasopharyngeal, 4) urogenital, and 5) intestinal (Zumpt 1965). In cases of intestinal myiasis, fly larvae reside and develop in the host's alimentary tract. A well-known example involves the obligate parasitic larvae of the Gasterophilinae subfamily (Zumpt 1965).

Some maggots, however, can be ingested by a vertebrate host and pass through its gastrointestinal tract, eventually appearing in the feces. This can cause symptoms such as abdominal pain and diarrhea. This condition, where the larvae do not mature within the host's digestive tract, has been termed "pseudomyiasis" (Zumpt 1963, 1965). However, other authors have critiqued the term and suggested "accidental intestinal myiasis" (Snyman et al. 2022), noting that the maggots are often ingested as eggs or first instar larvae and are expelled as last instar larvae or pupae, suggesting they likely feed on the host's digestive content to complete their life cycle.

The insects implicated in this condition typically belong to the dipteran families Muscidae, Sarcophagidae, Stratiomyidae, and Calliphoridae, whose larvae usually develop on feces and carcasses (Zumpt 1965). In cases of accidental intestinal myiasis, they act as facultative parasites. Accidental intestinal myiasis has been reported in humans (Udgaonkar et al. 2012; Ly et al. 2018; Mizumoto & Yamamoto 2019; Amir 2021) and a few cases have also been documented in other species, such as domestic dogs, cattle, and chickens (Manchón et al. 1998; Manrique-

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Saide et al. 1999; Salem & Attia 2021; Snyman et al. 2022).

To date, little is known about gastrointestinal myiasis in reptiles. However, this lack of knowledge could derive from underreporting, as many reptiles (e.g., small lizards) are generalist feeders and may consume food infested with maggots. Anecdotal evidence exists from reptile owners who have found live larvae in their pets' feces, as maggots are sometimes sold as live food for pet reptiles (Beardeddragon.org. 2019; Ball-pythons.net. 2020; Community.morphmarket.com. 2024).

In this report, we present the first scientifically documented case of accidental myiasis in the gastrointestinal tract of a reptile: a male specimen of *Podarcis muralis* (Laurenti, 1768), the common wall lizard, in which 28 intact first instar larvae of the flesh fly *Sarcophaga carnaria* (Linnaeus, 1758) were discovered.

Material and methods

During a parasitological survey of synanthropic reptiles on July 7th, 2023, an individual *P. muralis* exhibiting lethargic behavior was found in the Salvano locality (municipality of Palazzago, Bergamo Province, Italy) at coordinates 45.740889, 9.553105. After capture, the lizard was placed in a fauna box. Its poor health was evident, so we delayed sample collection. After nearly an hour of observation, the lizard died. The specimen was then transported to the EntoPar laboratory at the University of Milan and stored at −20°C. The lizard was then dissected to search for endoparasites. The lizard was collected under the authorization of the Italian Ministry of Environment (Protocol number: 77772–21/06/2022), issued after approval from ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale).

Upon opening the gastrointestinal tract, 28 dead intact larvae were observed (Figure 1). These larvae were removed and examined under a Leica M50 microscope (Leica Microsystems, Germany) and were identified as belonging to the order Diptera based on their morphology. All the larvae were determined to belong to the same species due to the high degree of similarity in their general morphology and cephaloskeleton architecture. Some larvae were dissected to isolate the cephaloskeleton and posterior spiracles, which were subsequently observed and photographed under a Leica DM1000 microscope (Leica Microsystems, Germany). Species identification was performed using morphological keys and systematic catalogs (Povolný & Verves 1987; Pape 1996). Photographs of a representative larva were taken using a Keyence VHX-7000 digital microscope (Keyence Corporation, Osaka, Japan).

Genomic DNA was extracted from a pool of 10 larvae using the DNeasy Blood and Tissue Kit (Qiagen, Hilden, Germany). A fragment of the Cytochrome C oxidase subunit one (COI) gene was amplified using the universal DNA primers LCO1490 and HCO2198 (Folmer et al. 1994), following the PCR protocol described by Otim et al. (2021). PCR product was then sequenced on both strands

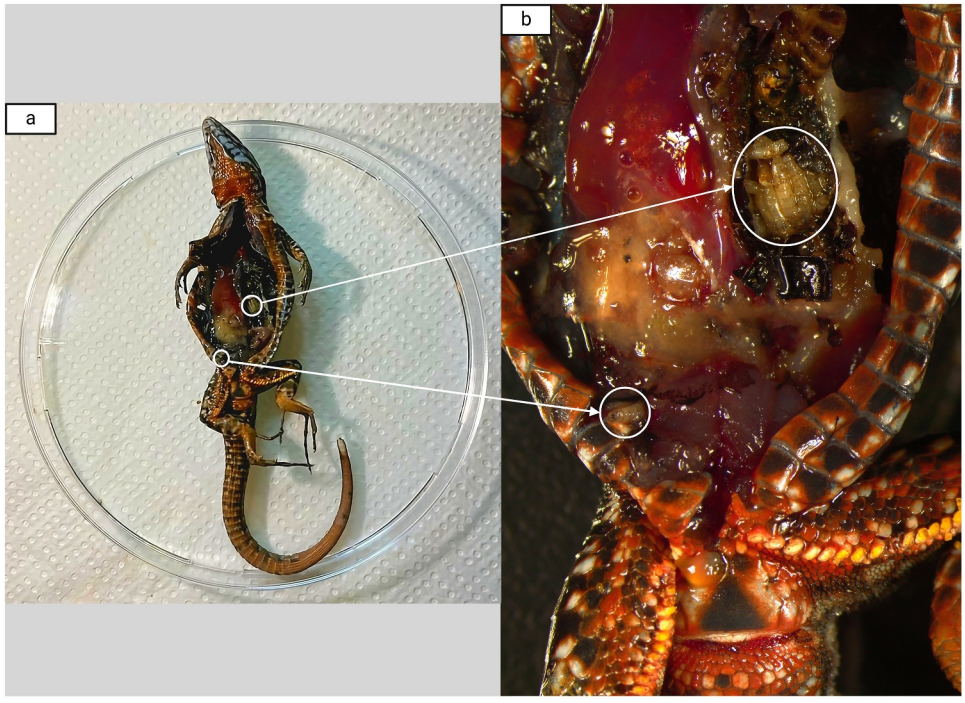

Figure 1. (a) The dissected *P. muralis* specimen with (b) highlighted the *S. carnaria* larvae in its gastrointestinal tract.

(Eurofins Genomics GmbH, Konstanz, Germany), and the resulting consensus sequence was deposited in GenBank under accession number PP442029.1.

Results and discussion

The larvae were morphologically identified as first instars of *S. carnaria* based on the distinctive features of their posterior spiracles and cephaloskeleton (Figure 2). This identification was confirmed through COI barcoding: the top BLASTn match for the obtained sequence was *S. carnaria* sequence MH118260.1, with no gaps and a 99.70% sequence identity (656/658 identical bases).

Like other flesh flies, *S. carnaria* is ovoviviparous, meaning it gives birth to live larvae, typically depositing them on decaying organic matter or rotting meat, which serve as food sources for the larvae. The species has also been observed depositing larvae

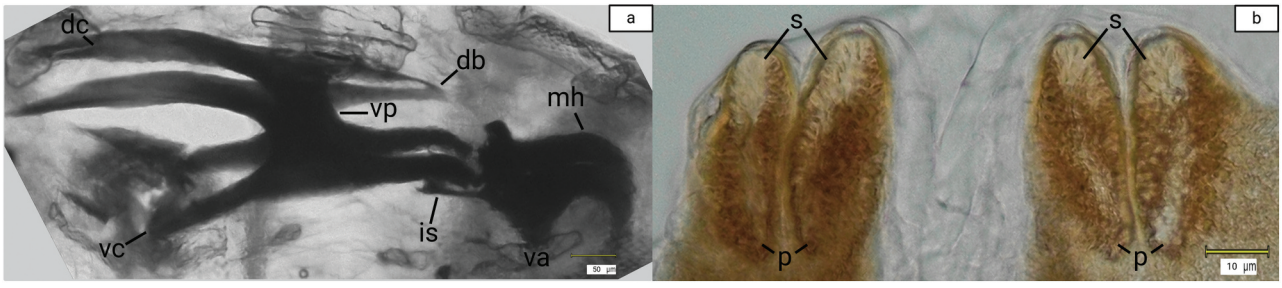

Figure 2. Dissected (a) cephaloskeleton (Magnification: 300X) and (b) posterior spiracles (Magnification: 1000X) used for morphological species determination. (a) *dc: dorsal cornua; db: dorsal bridge; vp: vertical plate; mh: mouth hook; vc: ventral cornua; is: intermediate sclerite; va: ventral apodeme*. (b) *s: slits; p: peritreme.*

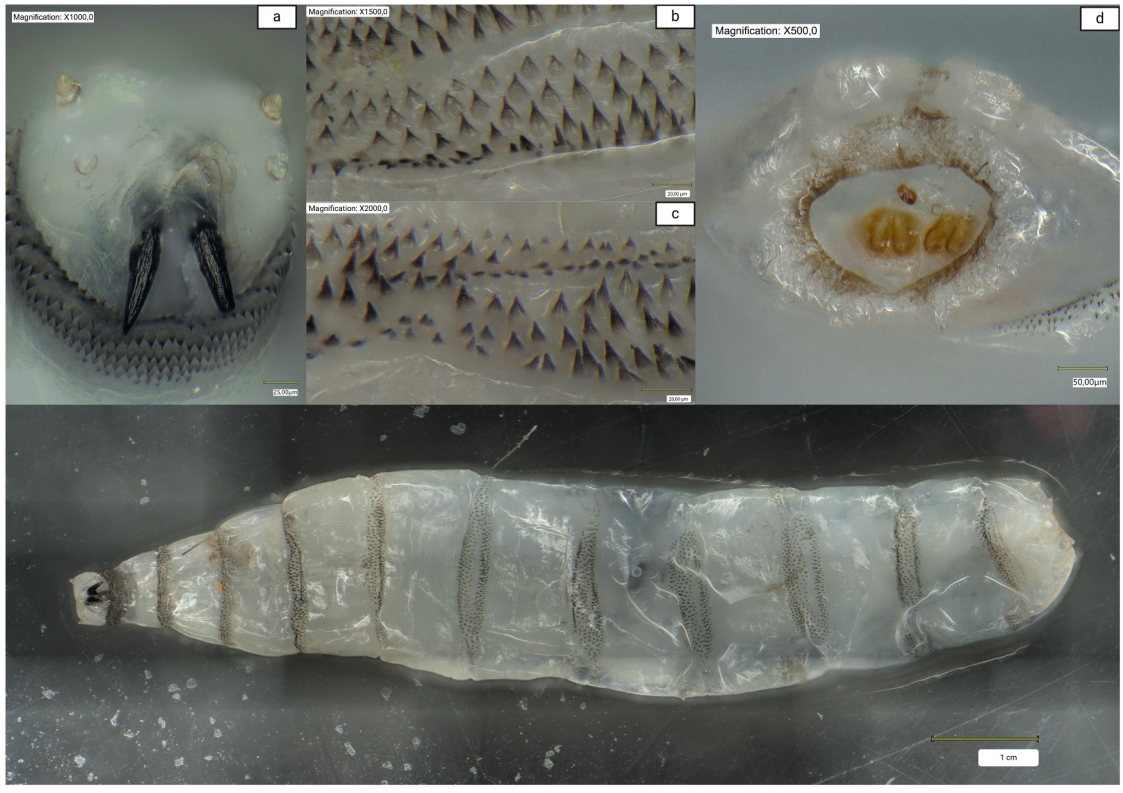

Figure 3. General view of a representative larva specimen plus some details at different magnifications that highlight its physical integrity. (a) cephalic region, magnification: 1000X; (b), (c) spines, magnification: 1500X and 2000X; (d) caudal region, magnification: 500X.

near earthworm burrows, where the larvae prey on earthworms (Kirchberg 1954; Eberhardt 1955).

In the case presented here, we would suggest that the lizard ingested the larvae: i) either by preying directly on them or on a gravid fly female; ii) by consuming an earthworm; iii) or by scavenging on decaying infested organic material. Once ingested, the larvae may have continued their development within the lizard's gastrointestinal tract, leading to an intestinal myiasis. Supporting evidence includes the fact that the larvae were found completely intact and showed no signs of physical damage, even when examined at 2000× magnification (Figures 3–5). Even considering that lizards can swallow their food without chewing, it is unlikely that the chemical process of digestion did not produce any noticeable physical alteration on the larvae, considering also that they were at the first instar, which is the smallest and most fragile stage.

First instar larvae of *S. carnaria* measure around 2.5 mm upon release from the female and molt to

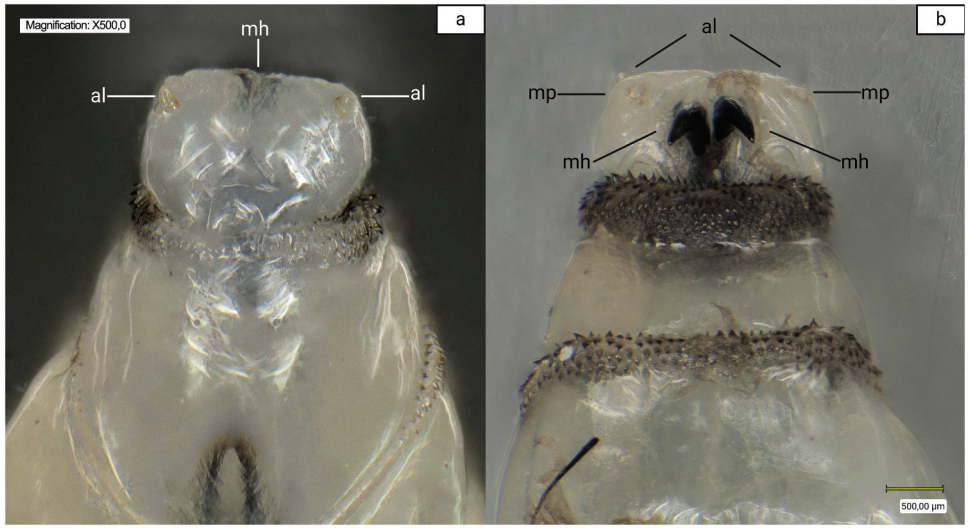

Figure 4. Detail of the cephalic region of the *S. carnaria* larva, in dorsal (a) and ventral (b), view. Magnification: 500X. *al: antennal lobes; mh: mouth hook of the cephaloskeleton; mp: maxillary palps..*

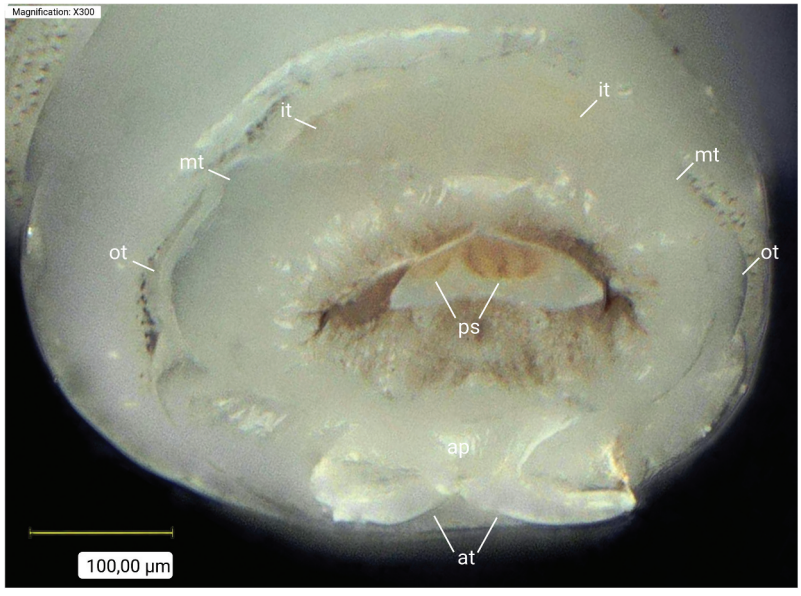

Figure 5. Detail of the caudal region of the *S. carnaria* larva, in frontal view. Magnification: 300X. *it: inner tubercles; mt: medium tubercles; ot: outer tubercles; ps: posterior spiracles; ap: anal plate; at: anal tubercles.*

the second instar at approximately 3.8 mm of length (Povolný & Verves 1987). The larvae recovered from the lizard measured 3.25 mm, indicating they were approaching the molt to the second instar, while inside the lizard's intestines. Furthermore, all larvae were positioned longitudinally within the lizard's intestines, with one specimen found in the distal portion near the cloacal opening. Other sclerotized, digested remains, likely from different insects, were also present in the intestines, suggesting that the lizard's digestive processes were functioning normally.

Taken together, this evidence suggests that the larvae were alive inside the lizard, prior to the lizard death, and may have undergone some development within its gastrointestinal tract, resulting in an accidental intestinal myiasis.

Conclusion

Our study presents the first documented case of accidental intestinal myiasis in a reptile, specifically in a specimen of the common wall lizard. The pristine condition of the larvae, their size, their arrangement within the lizard's intestines, and the presence of other digested insect remains all support the likelihood of myiasis. To gain a deeper understanding of the epidemiology of reptile gastrointestinal myiasis, further collection and monitoring of wild and pet reptiles are needed. This condition may be underreported, as lizards are known to consume maggots or food contaminated with larvae. This report raises new questions about the use of maggots of certain species of flies as live food for pet reptiles, warranting further investigation into the potential risks associated with this practice.

Acknowledgments

The authors would like to acknowledge Prof. Claudio Bandi and Prof. Sara Epis for their supervision during the realization of the present work.

Reptiles were captured, manipulated and handled under the authorization of the Italian Ministry of Environment (Protocol number: 77772 - 21/06/2022), issued after approval from ISPRA (Istituto Superiore per la Protezione e la Ricerca Ambientale).

All the figures were created with BioRender.com.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Data availability statement

All data supporting the findings of this study are provided in the paper and accessible through the GenBank database.

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