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Review Article

Human-Associated Helminths in Sea Turtles (Testudines: Cheloniidae) from Brazil: Ecological Implications and the Bioindicator Potential for Environmental Health

Ricardo Andrade Barata[1]* and Fábio de Souza Kirchpfennig[1,2]

[1]*Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brazil*

[2]*Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis, Brazil*

***Corresponding author**

Ricardo Andrade Barata, Universidade Federal dos Vales do Jequitinhonha e Mucuri, Brazil, Tel: 38988310805

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Abstract

Sea turtles are exposed to a range of anthropogenic stressors, including habitat degradation and pollution. Along the Brazilian coast, the discharge of untreated sewage into marine environments introduces fecal pathogens and contributes to habitat contamination. Owing to their longevity, migratory behavior, and ecological sensitivity, sea turtles are recognized as effective sentinels of environmental change. Rather than focusing on isolated records, this review advances a conceptual framework that interprets detections of *Strongyloides* sp., *Hymenolepis* sp., and *Ascaris* sp. in Cheloniidae as indicators of cross-ecosystem disturbance. We critically examine possible exposure pathways, including sewage-driven contamination, sediment persistence, and altered trophic interactions, and discuss how these helminths may function as sentinels of fecal pollution and ecosystem health. Finally, we highlight knowledge gaps and research priorities necessary to validate these taxa as bioindicators.

INTRODUCTION

Sea turtles are key components of marine ecosystems, contributing to nutrient cycling, habitat maintenance, and food web dynamics [1-3]. However, their survival is threatened by a range of anthropogenic pressures, including coastal development, marine debris, incidental capture in fisheries, and, notably, pollution from untreated sewage and industrial waste [4,5].

On the Brazilian coastline, rapid urban expansion and deficient sanitation infrastructure have led to the discharge of significant volumes of untreated domestic effluents into marine environments [6-8]. This contamination introduces a wide array of pathogenic microorganisms and organic pollutants into aquatic systems, many of which can persist in sediments or bioaccumulate in marine organisms [9-11]. Sea turtles, due to their long lifespans, broad migratory ranges, and ecological plasticity, are particularly vulnerable to such disturbances and have been proposed as effective sentinels for marine environmental health [12,13].

Environmental parasitology has increasingly recognized the utility of parasites as bioindicators of ecological integrity and pollution. Parasites can reflect changes in host health, trophic interactions, and contaminant exposure, offering a sensitive and integrative means to assess anthropogenic impacts on ecosystems [14-16]. Among such indicators, helminths with life cycles dependent on environmental conditions and intermediate hosts may be particularly informative.

While previous studies have documented the occurrence of terrestrial-origin helminths in sea turtles, their broader ecological implications remain largely unexplored. This article does not present new field data but instead develops an interpretive synthesis that reframes such findings as signals of terrestrial-marine connectivity.

HUMAN-ASSOCIATED HELMINTHS IN SEA TURTLES: UNUSUAL BUT ECOLOGICALLY MEANINGFUL RECORDS

Reports from the Brazilian coast described *Strongyloides*

sp. eggs in *Eretmochelys imbricata*, *Hymenolepis* sp. eggs in both E. *imbricata* and *Chelonia mydas,* and *Ascaris* sp. eggs in C. *mydas* [17]. These helminths are classically associated with terrestrial hosts and sanitation failures [18,19]. which makes their detection in marine turtles particularly striking. Rather than treating these occurrences as anomalies or artifacts, we interpret them as potential ecological indicators of fecal pollution and ecosystem disturbance [14-16].

ECO-EPIDEMIOLOGICAL PATHWAYS OF EXPOSURE

The occurrence of terrestrial-origin helminths in sea turtles, as reported by [17], can be explained by multiple non-exclusive mechanisms. One possible route is the direct input of untreated sewage, which introduces eggs and larvae into marine environments, consistent with studies highlighting sewage as a source of aquatic contamination [9-19].

Another pathway involves the persistence of resistant eggs in sediments and their trophic transfer, reflecting the high environmental resilience of these parasites [20]. Furthermore, chemical contaminants are known to compromise immune responses in reptiles and marine mammals, which may facilitate atypical infections that would otherwise remain transient [21,22]. Together, these mechanisms underscore the complex interface between deficiencies in human sanitation, coastal ecosystem integrity, and marine wildlife health.

PARASITES AS BIOINDICATORS OF SEWAGE POLLUTION: A CONCEPTUAL FRAMEWORK

From an environmental parasitology perspective, the detection of terrestrial-origin helminths in sea turtles [17], should be interpreted as a signal of sewage-driven contamination. The use of parasites as bioindicators is well established in aquatic ecosystems [13-23]. Helminths such as *Ascaris* spp., due to the remarkable resistance of their eggs, and *Strongyloides* spp., directly associated with fecal pollution [18-24]. reinforce the applicability of this approach. Moreover, studies have shown that pollutants can interfere with parasite development and transmission, altering host–parasite interactions and further strengthening their role as indicators [25,26].

RESEARCH PRIORITIES AND KNOWLEDGE GAPS

To consolidate the use of human-associated helminths as bioindicators in sea turtles, several research priorities must be addressed. First, studies should quantify prevalence and infection intensity across different regions and turtle species, generating robust epidemiological baselines [2,3]. Second, efforts are required to differentiate true infections from mere contamination, through histopathology and molecular diagnostics, which have proven effective in distinguishing parasite–host interactions in wildlife studies [24]. Third, parasitological data must be correlated with environmental parameters such as water quality, sewage discharges, and land-use patterns, strengthening causal inferences between contamination and parasite occurrence [6-8].

Another essential priority is to evaluate the health impacts of these parasites on turtles themselves, especially regarding immune function under contaminant exposure, since pollutants are known to impair immunity in marine vertebrates [21,22]. Finally, parasitological surveillance should be integrated into long-term conservation programs, allowing these organisms to contribute effectively to interdisciplinary assessments of marine ecosystem health [12-16]. Addressing these gaps will provide the empirical foundation necessary to validate the bioindicator potential of *Strongyloides*, *Hymenolepis*, and *Ascaris* in sea turtles.

CONCLUSIONS

The occurrence of *Strongyloides*, *Hymenolepis,* and *Ascaris* in sea turtles should not be dismissed as accidental. Instead, these findings provide a unique window into the eco-epidemiological effects of sewage on marine ecosystems. By reframing terrestrial-origin helminths as potential bioindicators, we highlight their value for conservation monitoring and propose their integration into interdisciplinary assessments of marine ecosystem health.

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AUTHORS' CONTRIBUTIONS

Ricardo Andrade Barata: Conceptualization, Formal analysis, Writing - original draft.

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