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A Review of Studies on Yellow-Spotted Millipede Harpaphe Haydeniana

Vijaydharssani. K
Research Scholar, Department of Zoology
Holy Cross College (Autonomous), Tiruchirappalli – 620019
Tamil Nadu, South India.

Horne Iona Averal
Associate Professor, IQAC Coordinator, Department of Zoology
Holy Cross College (Autonomous), Tiruchirappalli – 620019
Tamil Nadu, South India.

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Correspondence to
Horne Iona Averal
profionahorne@gmail.com

ORCID: Horne Iona Averal
https://orcid.org/xxxx-xxxx-xxxx-xxxx

ABSTRACT

A range of studies have explored the diversity and distribution of millipedes, including the yellow-spotted millipede. Chen (2023) and Patil (2018) both identified new species in their respective studies in China and India, while Boccardo (2001) and Bogyó (2015) focused on the habitat and seasonal variations in millipede populations in Brazil and Hungary. These studies collectively contribute to our understanding of the yellow spotted millipede's ecological role and its potential as a bioindicator of environmental health. In India, particularly in the Western and Eastern Ghats, Patil (2018 and Ramanathan (2023 have revealed a rich diversity of species. Hence, the present study focuses on the importance and application of the yellow millipede, collected from various literature available in Google Scholar.

Key terms: Yellow-Spotted Millipedes, Harpaphe Haydeniana, Millepedes Taxonomy, Millepedes Classification, Millepedes study scope

1. Introduction

Millipedes, while generally harmless, can become a nuisance when they invade homes in large numbers, potentially contaminating food and causing respiratory problems for those with allergies (Cranshaw, 2019). They are particularly attracted to damp areas, and their presence can be a sign of excess moisture in the home (Cranshaw, 2019). To address infestations, it is recommended to wait for a few days for the problem to subside and then vacuum the remaining bodies, while also removing debris and sealing openings around the foundation (Cranshaw, 2019). If problems persist, insecticides may be used (Cranshaw, 2019). Insight Pest Solutions offers millipede extermination services to address these issues.

The yellow spotted millipede, a non-native species, has been introduced to various locations, including Arkansas, Louisiana, Oklahoma, Texas, India, and Singapore

(McAllister 2019; Decker, 2012). These millipedes are known to have arrived in non-native sites via potted plants and compost from greenhouses (McAllister, 2019). They are most commonly found in the order Polydesmida, which produces the brightest fluorescence under ultraviolet light (Marek, 2017). Despite being a pest of potatoes in some areas, no pathogenic microorganisms have been found in these millipedes (Brito, 1994).

Research on millipede applications reveals several promising uses for these arthropods. Millipedes serve as an alternative source for chitin extraction, with studies showing a 35.7% yield from Spirobolida species, comparable to conventional crustacean sources (R. S et al., 2018). The extracted chitin can be used to prepare chitosan-linked nanoparticles for various applications (R. S et al., 2018). Millipedes also demonstrate significant potential in organic waste management, with Xenobolus carnifex effectively composting leaf litter, sugarcane trash, rice husk, and sawdust to produce nutrient-rich fertilizer that enhances plant growth (M. Alagesan, 2011). Additionally, millipede secretions show promise as natural antibiotics, with compounds from species like Ophistreptus guineensis and Pachybolus ligulatus exhibiting antibacterial and antifungal properties that could help combat antibiotic resistance (Yunusa B. Idris et al., 2025). Furthermore, millipedes play important roles in biodiversity conservation, particularly as indicators of soil ecosystem health (M. Hamer & R. Slotow, 2002).

2. Background of the research on Milliepedes

Millipedes, often overlooked as mere detritivores, are emerging as a remarkably valuable resource with diverse ecological and biotechnological applications. Beyond their role in soil aeration and organic matter decomposition, recent research reveals that millipedes offer far more than simple nutrient cycling services. A significant area of interest lies in their defensive secretions, which contain a complex cocktail of bioactive compounds exhibiting potent antibacterial, antifungal, and even antimalarial properties. Studies by Yunusa B. Idris and B. Illic have documented the antimicrobial activity of these secretions against a range of human and plant pathogens, suggesting they could be a crucial, untapped reservoir for discovering novel antibiotics to combat the growing threat of multidrug-resistant infections. The chemical diversity within these secretions, particularly from species like Apheloria and Eurydesmus, presents a promising avenue for pharmaceutical development.

Furthermore, the potential extends beyond direct medicinal use. Research by Maxwell Kelvin Billah has demonstrated that specific mixtures of millipede extracts exhibit potent antibacterial activity, highlighting the synergistic effects possible when combining compounds from different species. This complexity makes millipedes a unique natural library for drug discovery. Compounds derived from these secretions may also find applications in agriculture as eco-friendly biopesticides or fungicides, reducing reliance on synthetic chemicals.

Another compelling application is in waste management. Sridhar (2013) pioneered the concept of using pill millipedes (Arthrosphaera spp.) to efficiently transform urban organic solid waste into high-quality compost, termed "Milli-compost." This process offers a sustainable alternative to traditional composting methods. Notably, Thakur's comparative analysis revealed that Milli-compost possesses superior nutrient content—notably higher levels of nitrogen, phosphorus, and potassium—and improved physical properties, such as better water retention and porosity, compared to earthworm-produced vermicompost. This makes it an exceptionally valuable organic fertilizer for horticulture and sustainable agriculture, effectively closing the urban nutrient loop.

Beyond their biochemical and agricultural utility, millipedes hold cultural and nutritional significance. Enghoff's work highlights that in certain cultures around the world, millipedes are consumed as food. While their defensive secretions require careful processing, they are believed to possess inherent nutritional value. They may even confer antimalarial benefits, presenting a potential source of protein and bioactive compounds in regions where other protein sources are scarce. This dual role—as both a food source and a source of medicine—underscores their multifaceted importance.

The most groundbreaking application, however, involves the extraction of chitin. As Raghu H. S. points out, millipedes, due to their vast numbers and high chitin content in their exoskeletons, represent a colossal, underutilized biomass for large-scale chitin production. Chitin is a vital biopolymer used in numerous industries: as a wound dressing in medicine, a biodegradable packaging material, a flocculant in water purification, and a feed additive in aquaculture. Leveraging millipedes as a primary source could provide a more sustainable and scalable alternative to the current industry standard, which relies heavily on crustacean shells (shrimp, crab), a resource subject to seasonal fluctuations and ethical concerns related to marine fisheries. The abundance of millipedes in terrestrial ecosystems makes them a viable, renewable source for this critical

biomaterial.

In conclusion, millipedes are far more than garden curiosities. Their defensive secretions offer a treasure trove for new medicines, their waste-processing capabilities enable innovative composting solutions, their potential as a food source addresses nutritional needs, and their abundant chitin provides a sustainable raw material for advanced biotechnology. Recognizing and harnessing these multifaceted contributions can lead to significant advancements in medicine, sustainable agriculture, environmental remediation, and industrial materials science, transforming a humble invertebrate into a cornerstone of a circular bioeconomy.

3. Yellow-Milliepedes in India

The yellow spotted millipede, a member of the Chelodesmidae and Paradoxosomatidae families, has been found in canola cultivation in Brazil (Bouzan, 2023). In Australia, the 'Ommatoiulus moreleti' millipede is a nuisance pest, with activity patterns influenced by climatic conditions (Baker, 1988). Fossil evidence of millipedes, including the Sinosoma luopingense, has been found in the Middle Triassic Luoping biota of China (Huang, 2018). In the Kalahari, millipedes exhibit unique behaviors and ecological adaptations, such as burrowing and surface activity after rainfall (Dangerfield, 1998).

Research on the yellow spotted millipede in India is limited, with most studies focusing on other millipede species. Verma (1980) identified various pests of pearl millet in India, but did not specifically mention the yellow spotted millipede. Ramanathan (2023) and Alagesan (2013) both conducted studies on millipede diversity and distribution in different regions of Tamil Nadu, but did not specifically mention the yellow-spotted millipede. Gour (2020) studied the diversity of millipedes in the Amravati region of Maharashtra, but also did not specifically mention the yellow-spotted millipede. Therefore, there is a gap in the literature regarding the overall view of the yellow spotted millipede in India.

4. Classification of Millipede

The higher classification of millipedes is problematic, with ordinal taxa not uniform in underlying diversity, and species diversity estimates unreliable due to inconsistent taxonomic effort.

Millipede classification within the class Diplopoda faces significant taxonomic challenges despite comprising over 12,000 described species across 16 orders (Brewer et al., 2012; Brewer & Bond, 2013). The current higher-level classification is problematic, with ordinal taxa showing non-uniform diversity patterns and lacking synapomorphic definitions (Brewer et al., 2012). Phylogenomic analyses using 221 nuclear protein-coding loci have revealed fundamental differences from existing classifications, including novel groupings like Juliformia + Merocheta + Stemmiulida and questioning traditional characteristics such as spinnerets as unifying features for Nematophora (Brewer & Bond, 2013). Order-specific studies have provided refined classifications, such as Enghoff's (2009) revised cladistic analysis of Julida using computer-assisted methods, and Oeyen & Wesener's (2018) first phylogenetic analysis of Glomerida incorporating mandible morphology. These studies collectively demonstrate that millipede systematics requires substantial revision, with molecular approaches proving essential for resolving relationships in this understudied arthropod group.

The yellow spotted millipede, a member of the class Diplopoda, is a diverse and ecologically important group of arthropods (Alagesan, 2016). It is found in various habitats, including Jamaican caves (Loomis, 1969) and the Yintiaoling National Natural Reserve in Southwest China (Chen, 2023). The species is not considered a pest in the cultivation of canola in Brazil (Bouzan, 2023).

5. Taxonomic Position

The millipede belongs to the kindom Animalia, class diplopoda, order polydesmida and family Xystodesmidae. The Genus Harpaphe and Species: Harpaphe haydeniana (Wood, 1864).

The most widely recognised "Yellow Millipede" is the yellow-spotted millipede, scientifically known as Harpaphe haydeniana, but the name can also refer to a few other similarly colored species. Here is a

taxonomic breakdown of the yellow-spotted millipede and its relatives:

5.1. Taxonomy of Yellow-Spotted Millipedes

• Kingdom: Animalia

• Phylum: Arthropoda

• Class: Diplopoda

• Order: Polydesmida

• Family: Xystodesmidae

• Genus: Harpaphe

• Species: Harpaphe haydeniana

Similar-looking millipedes in North America include Apheloria tigana and other species within the genera Boraria, Chonaphe, Paimokia, Hybaphe, and Montaphe of the family Xystodesmidae.

5.2. Notable Species and Confusion

• Harpaphe haydeniana (yellow-spotted millipede, almond-scented millipede, cyanide millipede) is predominant along the Pacific coast of North America, recognized by its black or olive-green body and distinctive yellow spots.

• Apheloria tigana (yellow and black flat millipede) occurs in the eastern United States and is also known for yellow markings and similar chemical defense, but belongs to a different lineage within the order Polydesmida. (James Baker)

• Some unrelated Asian and introduced species, such as Asiomorpha coarctata and Anoplodesmus saussurii, are also yellow-marked and can be confused with Harpaphe species.

5.3. Global Context

Millipedes with yellow markings and cyanide-based defenses are found worldwide within the order Polydesmida. These similarities are examples of convergent evolution for warning coloration and chemical defense.

6. Scope of the study of Millepedes

• The ecological study includes the role in the ecosystem: Decomposition, nutrient cycling, predator-prey dynamics, and symbiotic relationships.

• **Environmental impact:** Effects on soil quality, indicators of ecosystem health, and responses to environmental changes.

Figure 1 uses icons—a millipede for Biology and a leaf for Ecology—to visually represent each domain, with interconnected nodes detailing specific aspects of millipede biology and ecological significance.

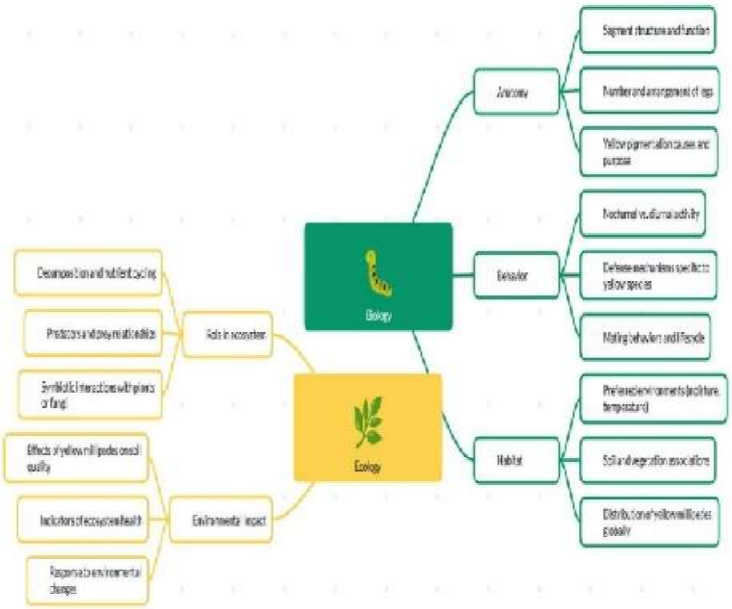

Figure 1. Ecological Aspects

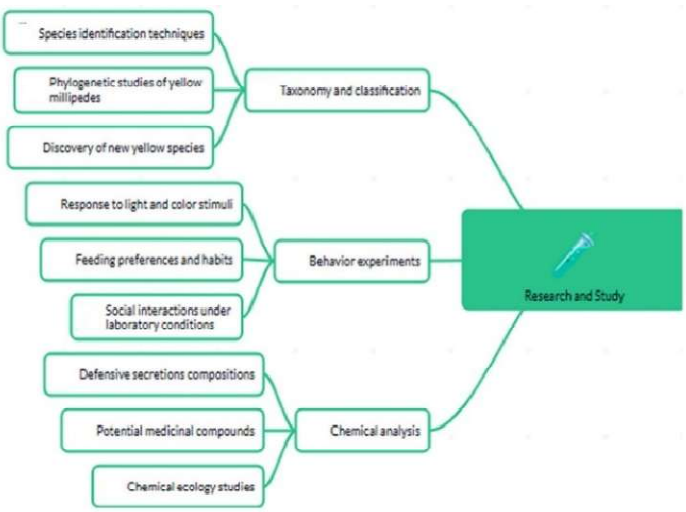

Figure 2. The scope of the research studies on millepeds

The research studies can address the issues such as

1. Taxonomy and Classification: Includes species identification techniques, phylogenetic studies, and the discovery of new yellow millipede species.

2. Behavior Experiments: Focuses on how yellow millipedes respond to light and color, their feeding preferences, and social interactions under laboratory conditions.

3. Chemical Analysis: Covers the composition of defensive secretions, potential medicinal compounds, and chemical ecology studies.

Figure 2 uses a clean, green-themed layout to organize scientific research areas related to yellow millipedes, highlighting both biological classification and experimental investigations.

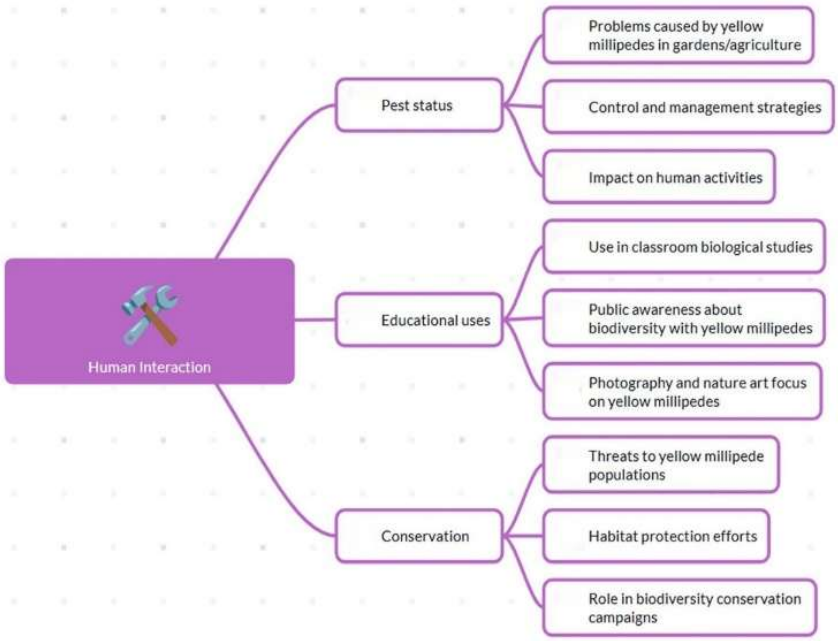

Figure 3. Human intervention of Millepedes

Figure 3 is map titled "Human Interaction", illustrated with a hammer and wrench icon, highlighting the relationship between humans and yellow millipedes. It branches into three main categories:

1. **Pest Status:** Discusses issues such as problems caused by yellow millipedes in gardens and agriculture, control and management strategies, and their impact on human activities.

2. **Educational Uses:** Covers applications like using yellow millipedes in classroom biology studies, raising public awareness about biodiversity, and their role in photography and nature art.

3. **Conservation:** Addresses threats to yellow millipede populations, efforts for habitat protection, and their role in biodiversity conservation campaigns.

It uses a purple color scheme to visually organize how humans interact with yellow millipedes in practical, educational, and environmental contexts.

7. Research in India

Research on millipedes in India, particularly in the Western and Eastern Ghats, has revealed a rich diversity of species (Patil, 2018; Ramanathan, 2023). The presence of Trigoniulus corallines in both regions suggests a potential overlap in their habitats (Patil, 2018; Ramanathan, 2023). Similarly, the Alagar Hills Reserve Forest in Tamil Nadu has been found to host a variety of millipede species, with mid-elevations being particularly rich in diversity (Alagesan, 2013). However, specific information about the yellow spotted millipede in India is not provided in these studies, indicating a need for further research (Chakraborty, 2018; Alagesan, 2013; Abdar, 2022; Patil, 2018) Fig . 4.

Figure 4. Yellow-spotted millipede, Harpaphe Haydeniana

The yellow-spotted millipede, Harpaphe Haydeniana, is a common bug found in the moist forests along the Pacific coast (Looney, 2012). These millipedes have long dark brown or black bodies with contrasting yellow spots down their sides and are known for having multiple body segments, each containing two pairs of legs (Foster, 2011). Females usually consist of 31 pairs of legs while males have 30 (Foster, 2011). The activity of these millipedes is influenced by environmental conditions, with a change in activity rhythm observed in late summer and autumn (Baker, 1988). They play an essential role as detritivores in the ecosystem (Foster, 2011).

8. Diversity of Millipede In India

Research on millipede diversity in India has revealed a variety of species in different regions. In the Yelagiri hills of Tamil Nadu, 10 species were identified, with the genus Arthrosphaera being dominant

(Chezhian, 2016). Similarly, the Sirumalai Hills in Tamil Nadu were found to host 8 species, with differences in species composition across elevations (Ramanathan, 2023). The Alagar Hills Reserve Forest, also in Tamil Nadu, showed a peak in millipede diversity at mid-elevations, with specific species being more abundant at 450m (Alagesan, 2013). In the Chandoli National Park in Western Maharashtra, a higher diversity of millipedes was found, influenced by less habitat disturbance and food availability (Abdar, 2022). These studies collectively highlight the rich and varied millipede diversity in India, with specific species being more prevalent in certain regions and elevations.

8.1. Millipede Habitat and the Prevention Strategies

Yellow-spotted millipedes, which are harmless to humans, prefer damp and cooler environments and feed on organic debris (Cranshaw, 2019). They can become an annoyance, especially if there is an invasion near your home. To prevent this, it is recommended to reduce moisture and seal potential entry points (Cranshaw, 2019). Removing attractants, such as decaying plants and keeping the home clean can also help (Cranshaw, 2019). In severe infestations, professional pest control services may be necessary (Cranshaw, 2019).

8.2. Environmental uses in India

A significant part of the forest ecosystem in India plays a crucial role in the turnover of organic matter and the availability of minerals in its habitat (Bano, 1992). However, its specific environmental uses in India, particularly in relation to pearl millet, are not explicitly discussed in the available literature. Further research is needed to explore the potential applications of the yellow spotted millipede in the context of pearl millet and other agricultural practices in India.

8.3. Impact of Pollutant in this Species

The studies by Surber (1959) and Farfan (2008) both highlight the ability of certain invertebrates, such as the midgefly and specific millipede species, to survive in polluted environments. This suggests that the yellow spotted millipede may also have a high tolerance for pollutants. However, the particular impact of contaminants on this species is not directly addressed in the available literature. Further research is needed to understand the potential effects of contaminants on the yellow spotted millipede.

8.4. Millipedes as a Food for Tribals in India

The use of the yellow spotted millipede by tribals in India is not directly addressed in the provided research papers. However, Enghoff (2014) and Patil (2018) provide valuable information on the nutritional value and diversity of millipedes, respectively. Lever (1939) discussed that the irritant exudation from a centipede has an anti-parasitic effect, which may be relevant to the use of millipedes by tribals. Patil (2003) highlights the use of wild animal parts, including millipedes, by tribals in Nandurbar district, Maharashtra, for medicinal purposes. This suggests that the yellow spotted millipede may have traditional medicinal uses among tribals in India.

9. Conclusion

The present study focuses on the review of the yellow spotted millipede, Harpaphe Haydeniana. The diversity and the economic importance were discussed. In India, different species were identified, which showed a good diversity in the Western and Eastern Ghats. From various literature, it has been proven that tribes living in India used the yellow spotted millipede as food as well as medicine. However, research is needed on this site to understand the medicinal properties of these organisms fully. Hence, it was concluded that further research needs to be conducted on the yellow spotted millipede.

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