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ZOO-CHEMICAL PROFILE, ZOO-SYNTHESIS OF METALLIC NANOPARTICLES AND THEIR APPLICATIONS: A SHORT REVIEW

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ABSTRACT

Zoochemicals refer to animal chemical composition, including secondary metabolites, that is similar to plant and microbial secondary metabolites. Zoochemicals are naturally reducing and capping agents that respond to the zoosynthesis of metallic nanoparticles and promising nano-based drugs. The term "zoosynthesis of metallic nanoparticles" refers to zoo-extracts from animal sources that contain secondary metabolites that are involved in metal ion reducing and capping agents that form metal atoms. These are called zoo-synthesized metallic nanoparticles. Animal secondary metabolites like alkaloids, terpenoids, saponins, etc. are produced by marine invertebrates, which are equivalent to plant secondary metabolites and have been used in environmental and biomedical applications. In the present review, we focused on and discussed zoochemicals of invertebrate origin and their applications. Alkaloids, terpenoids, and saponins were major secondary metabolic zoo-compounds observed in most of the marine invertebrate phylum, such as Porifera, Mollusca, and Echinodermata, with a suitable solvent extracted, and zoo-extract was used as a potential biological activity, such as antioxidant, anti-inflammatory, cytotoxic, insecticide, and antimicrobial, while also metallic nanoparticle synthesis, such as CuO, ZnO, Ag, and Au nanoparticles. In the present review, a succession of zoochemicals from marine invertebrates are effective, eco-friendly drugs and have biological activity in the search for new drugs, while zoochemicals are evidence of metal-reducing agents that use animal-mediated nanoparticle synthesis, which results in effective, eco-friendly nano-drugs.

Keywords: Zoochemicals, Nanoparticles synthesis, Biological activity, Marine invertebrate.

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INTRODUCTION

Zoochemicals refer to animal chemical composition, including secondary metabolites, that is similar to plant and microbial secondary metabolites [1,2,3]. The present short review focuses on zoochemicals accruing from animal sources, including marine invertebrates that provide valuable secondary metabolites and metal-reducing agents in response to the zoosynthesis of metallic nanoparticles. We observed zoochemicals from most of the invertebrate

phylum, including some notable phylum such as Porifera, Mollusca, and Echinodermata. Tables 1 and 2 show the biological and nanoparticle synthesis of animal sources.

Phylum Porifera zoochemicals

Hyattella intestinalis marine sponge 70% ethanolic zoo-extract contained 60 zoochemicals were identified using GC-MS techniques [2], and tryptamine alkaloids were confirmed using HPLC techniques [4].

Luffariella herdmani marine sponge with extraction of dichloromethane and methanol with zoochemicals contained alkaloids, terpenoids, sterols, saponins, and anthraquinones, by Kuruppuarachchi and Gunathilake [5].

Hyrtios erectus, Pseudoceratina purpurea, Carteriospongia foliascens, Stylissa carteri, and *Axinella acanthelloides* marine sponges extracted with ethanol, methanol, acetone, hexane, and chloroform were screened for zoo-chemical profiles, while the presence of alkaloids and terpenoids in most of the extract and sponges was observed by Muthiyan *et al.* [6].

GC-MS analysis of marine sponges *Haliclona* (Gellius) sp., *Lamellodysidea herbacea,* and *Spheciospongia inconstans* identified mainly sterols and fatty acids. *Haliclona* (Gellius) sp. showed 23 compounds were identified, *Lamellodysidea herbacea* had 21 compounds identified, and *Spheciospongia inconstans* had 19 compounds identified using GC-MS, while the zoochemicals of alkaloids, saponins, and terpenoids were qualified in all three marine sponges [7].

Tetilla dactyloidea marine sponge extract with methanol, and six compounds were identified using GC-MS, including 9-Octadecenoic acid (Z)-, 2-hydroxy-1-(hydroxymethyl) ethyl ester, by Krishnan *et al.* [8].

Haliclona sp., Dactylospongia elegans, Aaptos suberitoides, and *Stylissa massa* zoochemicals of alkaloids, saponins, flavonoids, and tannins were present, according to Rivera and Uy, [9].

Phylum Mollusca zoochemicals

Sea hare *Dolabella auricularia* revealed the zoochemicals contained in alkaloids, saponins, steroids, tannins, and terpeneoids, by Tayone *et al.* [10].

Phylum Echinodermata zoochemicals

Sea urchin *Salmacis virgulata* test zoochemicals contained 59 identified zoochemicals, including hexadecanoic acid and stigmasterol, while one unknown zoochemicals contained 60 zoochemicals, using GC-MS techniques by Karnan *et al.* [11].

Sea urchin *Diadema setosum* gonad with an extract of methanol, ethyl acetate, and n-hexane fraction was determined to be zoochemically alkaloid, saponin, and phenolic by Rompas *et al.* [12].

Sea cucumber *Bohadschia vitiensis* zoochemicals, which contained saponins, terpenoids, and sterols, by Jayathilake and Gunathilake, [13].

The zoochemical composition of selected sea stars *Linckia laevigata, Protoreaster nodosus,* and *Acanthaster planci* showed the presence of alkaloids, flavonoids, saponins, triterpenoids, and cardiac glycosides while being rich in saponins and steroids [14].

The isolated compounds are holothurin A (1) and echinoside A (2) triterpene saponins from sea cucumber *Pearsonothuria graeffei*, which were separated by HPLC [15].

Twenty one lanostane-type non-sulphated triterpene glycosides were isolated from *Bohadschia cousteaui* (sea cucumber) body walls. 10 new saponins, including 2 pentasaccharide, 8 hexasaccharide saponins and 11 known triterpene glycosides, were isolated by HPLC and their structures determined by NMR techniques [16].

Table 1: Invertebrate animal with Biological activity

Invertebrate animal		Activity	References
Phylum	**Study animals**		
Echinodermata	Sea urchin *Salmacis virgulata* test	*In silico* antifungal	Karnan *et al.* [11]
Porifera	Marine sponge *Hyattella intestinalis*	Insecticidal	Karnan *et al.* [17]
Porifera	Marine sponge *Luffariella herdmani*	*In vivo* toxicity, *in vitro* anti-inflammatory	Kuruppuarachchi and Gunathilake, [5].
Cnidaria	Jellyfish *Aurelia aurita*	Antioxidant	Khalil *et al.* [18].
Mollusca	Marine snail *Hemifusus colosseus*	Antimicrobial and antioxidant	Nguyen *et al.* [19].
Echinodermata	Sea urchin *Diadema setosum*	Antibacterial	Rompas *et al.* [12].
Porifera	Marine sponge *Hyrtios erectus*	Cytotoxic	Muthiyan *et al.* [6].
Echinodermata	Sea cucumber *Bohadschia vitiensis*	Anti-inflammatory, Antioxidant and Toxicity	Jayathilake and Gunathilake, [13].
Mollusca	Egg strings from sea hare *Dolabella auricularia*	Antioxidant	Tayone *et al.* [10].
Arthropods	Ground beetle	Antibacterial	Yahaya *et al.* [20].
Porifera	Marine sponges *Haliclona* sp., *Lamellodysidea herbacea*, and *Spheciospongia inconstans*,	Antimicrobial and cytotoxicity	Putra and Hadi, [7].
Porifera	Marine sponge *Tetilla dactyloidea*	Anticancer	Krishnan *et al.* [8].
Arthropods	Marine blue swimmer crab (*Portunus pelagicus)* and mud crab (*Scylla tranquebarica)*	Antibacterial	Laith *et al.* [21].
Cnidaria	Jellyfish *Porpita porpita*	Antimicrobial	Umamageswari *et al.* [22]
Arthropods	Soft-shelled and hard-shell crab *Charybdis lucifera*	Antioxidant activity	Soundarapandian *et al.* [23]
Echinodermata	Sea cucumber *Bohadschia cousteaui*	Antimicrobial	Elbandy *et al.* [16]
Porifera	Marine sponges *Haliclona sp., Dactylospongia elegans, Aaptos suberitoides* and *Stylissa massa*	Antioxidant and cytotoxic	Rivera and Uy, [9]

Zoo-synthesis of metallic nanoparticles using Invertebrate animals

The term "zoosynthesis of metallic nanoparticles" refers to zoo-extracts from animal sources that are involved in metal ion (M^+) reducing and capping agents, which form metal atom (M^0). These are called zoo-synthesized metallic nanoparticles with zoo-extracts that contain animal secondary metabolites. Table 2 shows the metallic nanoparticle synthesis of animal sources, called zoo-synthesized NPs.

Table 2: Invertebrate animal with metallic nanoparticle synthesis

Invertebrate	Metallic NPs	Application	References
Sea urchin *Salmacis virgulata* test	CuONPs	-	Karnan *et al.* [11]
Marine sponge *Hyattella intestinalis*	ZnONPs	Insecticidal activity	Karnan *et al.* [1]
Marine sponge *Hyattella intestinalis*	CuONPs	Insecticidal activity	Karnan *et al.* [17,4]
Brittle star *Ophiocoma scolopendrina*	AgNPs	Antibacterial, antioxidant, anti-diabetic and catalytic degradation of organic dyes	George *et al.* [24]
Marine sponge *Spongia officinalis*	ZnONPs	Antimicrobial and insecticidal activity	Hasaballah *et al.* [25]
Marine Bivalvia shell	AgNPs	Larvicidal activity	Sivanandham Velavan et al. [26]
Marine sponge *Haliclona*	AgNPs	-	Hamed *et al.* [27]
Marine sponge *Acanthella elongata*	AgNPs	-	Inbakandan *et al.* [28]
Marine sponge *Acanthella elongata*	AuNPs	-	Inbakandan *et al.* [29]

CONCLUSION

Alkaloids, terpenoids, and saponins are major secondary metabolic zoo-compounds observed in most invertebrate animals and used for potential biological activity and zoo-mediated metallic nanoparticle synthesis. In the present review, a succession of zoochemicals are effective, eco-friendly drugs, and there is evidence of metal-reducing agents that use animal-mediated nanoparticle synthesis, which results in effective nanobased, eco-friendly drugs.

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