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The Sea Stars (Echinodermata: Asteroidea): Their Biology, Ecology, Evolution and Utilization

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Abstract

The Sea stars (Asteroidea: Echinodermata) are comprising of a large and diverse groups of sessile marine invertebrates having seven extant orders such as Brisingida, Forcipulatida, Notomyotida, Paxillosida, Spinulosida, Valvatida and Velatida and two extinct one such as Calliasterellidae and Trichasteropsida. Around 1,500 living species of starfish occur on the seabed in all the world's oceans, from the tropics to subzero polar waters. They are found from the intertidal zone down to abyssal depths, 6,000m below the surface. Starfish typically have a central disc and five arms, though some species have a larger number of arms. The aboral or upper surface may be smooth, granular or spiny, and is covered with overlapping plates. Many species are brightly colored in various shades of red or orange, while others are blue, grey or brown. Starfish have tube feet operated by a hydraulic system and a mouth at the center of the oral or lower surface. They are opportunistic feeders and are mostly predators on benthic invertebrates. They have complex life cycles and can reproduce both sexually and asexually. Most can regenerate damaged parts or lost arms and they can shed arms as a means of defense. The Asteroidea occupy several significant ecological roles. Starfish, such as the ochre sea star (*Pisaster ochraceus*) and the reef sea star (*Stichaster australis*), have become widely known as examples of the keystone species concept in ecology. They are sometimes collected as curios, used in design or as logos, and in some cultures, despite possible toxicity, they are eaten. Starfish have been the recent research topic due to their diverse bioactivities, excellent pharmacological properties and complex secondary metabolites including steroids, steroidal glycosides, anthraquinones, alkaloids, phospholipids, peptides, and fatty acids. These chemical constituents exhibit cytotoxic, hemolytic, antiviral, antifungal, and antimicrobial activities and thus have important implications for human health benefits.

Keywords: Starfish; Biology; Ecology; Evolution; Bioactive compounds

Introduction

Echinoderms are an entirely marine phylum whose populations are prevalent in benthic ecosystems throughout the world's oceans. Starfish or sea stars are echinoderms belonging to the class Asteroidea. They are a large and diverse class having seven extant orders viz. Brisingida, Forcipulatida, Notomyotida, Paxillosida, Spinulosida, Valvatida and Velatida and two extint one such as Calliasterellidae and Trichasteropsida [1,2]. Approximately 1,500 living species of starfish occur on the seabed in all the world's oceans, from the tropics to subzero polar waters. The scientific name Asteroidea was given to starfish by the French zoologist de Blainville in 1830. It is derived from a star and form, likeness, appearance [3]. The class Asteroidea belongs to the phylum Echinodermata. As well as the starfish, the echinoderms include sea urchins, sand dollars, brittle and basket stars, sea cucumbers and crinoids.

The larvae of echinoderms have bilateral symmetry, but during metamorphosis, this is replaced with radial symmetry, typically pentameric [4]. Adult echinoderms are characterized by having a water vascular system with external tube feet and a calcareous endoskeleton consisting of ossicles connected by a mesh of collagen fibres [5]. Starfish are included in the subphylum Asterozoa, the characteristics of which include a flattened, star-shaped body as adults consisting of a central disc and multiple radiating arms. The subphylum includes the two classes of Asteroidea, the starfish, and Ophiuroidea, the brittle stars and basket stars. Asteroids have broad-based arms with skeletal support provided by calcareous plates in the body wall, while ophiuroids have clearly demarcated slender arms strengthened by paired fused ossicles forming jointed vertebrate [6].

Most starfish have five arms that radiate from a central disc, but the number varies with the

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group. It is not unusual in species that typically have five arms for some individuals to possess six or more through abnormal development [7].

Starfish Biology

The body wall consists of a thin cuticle, an epidermis consisting of a single layer of cells, a thick dermis formed of connective tissue and a thin coelomic myoepithelial layer, which provides the longitudinal and circular musculature. The dermis contains an endoskeleton of calcium carbonate components known as ossicles. These are honeycombed structures composed of calcite microcrystals arranged in a lattice [8]. They vary in form, with some bearing external granules, tubercles and spines, but most are tabular plates that fit neatly together in a tessellated manner and form the main covering of the aboral surface [9]. Some are specialized structures such as the madreporite (the entrance to the water vascular system), pedicellariae and paxillae [10]. Pedicellariae are compound ossicles with forceps-like jaws. They remove debris from the body surface and wave around on flexible stalks in response to physical or chemical stimuli while continually making biting movements. They often form clusters surrounding spines [9,10]. Several groups of starfish, including Valvatida and Forcipulatida, possess pedicellariae [11]. In Forcipulatida, such as *Asterias* and *Pisaster*, they occur in pompom-like tufts at the base of each spine, whereas in the Goniasteridae, such as *Hippasteria phrygiana*, the pedicellariae are scattered over the body surface. Some are thought to assist in defence, while others aid in feeding or in the removal of organisms attempting to settle on the starfish's surface [12]. Some species like *Novodinia antillensis* and *Labidiaster annulatus* use their large pedicellariae to capture small fish and crustaceans [13].

There may also be papulae, thin-walled protrusions of the body cavity that reach through the body wall and extend into the surrounding water. The structures are supported by collagen fibres set at right angles to each other and arranged in a three-dimensional web with the ossicles and papulae in the interstices. This arrangement enables both easy flexion of the arms by the starfish and the rapid onset of stiffness and rigidity required for actions performed under stress [14].

Water vascular system

The water vascular system of the starfish is a hydraulic system made up of a network of fluid-filled canals and is concerned with locomotion, adhesion, food manipulation and gas exchange. Water enters the system through the madreporite, a porous, often conspicuous, sieve-like ossicle on the aboral surface. It is linked through a stone canal, often lined with calcareous material, to a ring canal around the mouth opening. There are usually two rows of tube feet but in some species, the lateral canals are alternately long and short and there appearing to be four rows. The interior of the whole canal system is lined with cilia [15].

When longitudinal muscles in the ampullae contract, valves in the lateral canals close and water is forced into the tube feet. These extend to contact the substrate. Although the tube feet resemble suction cups in appearance, the gripping action is a function of adhesive chemicals rather than suction [16]. Other chemicals and relaxation of the ampullae allow for release from the substrate. Most starfish cannot move quickly, a typical speed being that of the leather star (*Dermasterias imbricata*), which can manage just 15 cm in a minute [17]. Some burrowing species from the genera *Astropecten* and *Luidia* have points rather than suckers on their long tube feet and are capable of much more rapid motion, "gliding" across the ocean floor. The sand star (*Luidia foliolata*) can travel at a speed of 2.8 m per minute [18].

Gas exchange also takes place through other gills known as papulae, which are thin-walled bulges on the aboral surface of the disc and arms. Oxygen is transferred from these to the coelomic fluid, which acts as the transport medium for gasses. Oxygen dissolved in the water is distributed through the body mainly by the fluid in the main body cavity; the circulatory system may also play a minor role [19].

Digestive system and excretion

The gut of a starfish occupies most of the disc and extends into the arms. The cardiac stomach is glandular and pouched and is supported by ligaments attached to ossicles in the arms so it can be pulled back into position after it has been everted. The pyloric stomach has two extensions into each arm: the pyloric caeca. These are elongated, branched hollow tubes that are lined by a series of glands, which secrete digestive enzymes and absorb nutrients from the food. A short intestine and rectum run from the pyloric stomach to open at a small anus at the apex of the aboral surface of the disc [20]. The semi-digested fluid is passed into their pyloric stomachs and caeca where digestion continues and absorption ensues [21]. In more advanced species of starfish, the cardiac stomach can be everted from the organism's body to engulf and digest food. When the prey is a clam or other bivalve, the starfish pulls with its tube feet to separate the two valves slightly, and inserts a small section of its stomach, which releases enzymes to digest the prey. The stomach and the partially digested prey are later retracted into the disc. Here the food is passed on to the pyloric stomach, which always remains inside the disc [22]. The retraction and contraction of the cardiac stomach is activated by a neuropeptide known as NGFFYamide [22]. Some starfish are not pure carnivores, supplementing their diets with algae or organic detritus. Some of these species are grazers, but others trap food particles from the water in sticky mucus strands that are swept towards the mouth along ciliated grooves [21]. These cells engulf waste material, and eventually migrate to the tips of the papulae, where a portion of body wall is nipped off and ejected into the surrounding water. Some waste may also be excreted by the pyloric glands and voided with the faces [20]. Starfish do not appear to have any mechanisms for osmoregulation, and keep their body fluids at the same salt concentration as the surrounding water. Although some species can tolerate relatively low salinity, the lack of an osmoregulation system probably explains why starfish are not found in fresh water or even in many estuarine environments [20].

Sensory and nervous systems

Although starfish do not have many well-defined sense organs, they are sensitive to touch, light, temperature, orientation and the status of the water around them. The tube feet, spines and pedicellariae are sensitive to touch. The tube feet, especially those at the tips of the rays, are also sensitive to chemicals, enabling the starfish to detect odour sources such as food [21]. Many starfish also possess individual photoreceptor cells in other parts of their bodies and respond to light even when their eyespots are covered. Whether they advance or retreat depends on the species [23]. While a starfish lacks a centralized brain, it has a complex nervous system with a nerve ring around the mouth and a radial nerve running along the ambulacral region of each arm parallel to the radial canal. The peripheral nerve system consists of two nerve nets: a sensory system in the epidermis and a motor system in the lining of the coelomic cavity. Neurons passing through the dermis connect the two [23]. The starfish does not have the capacity to plan its actions. If one arm detects an attractive odour, it becomes dominant and temporarily over-rides the other arms to initiate movement towards the prey. The mechanism for this is not fully understood [23].

Circulatory system

The body cavity contains the circulatory or haemal system. The vessels form three rings: one around the mouth (the hyponeural haemal ring), another around the digestive system (the gastric ring) and the third near the aboral surface (the genital ring). The heart beats about six times a minute and is at the apex of a vertical channel (the axial vessel) that connects the three rings. At the base of each arm are paired gonads; a lateral vessel extends from the genital ring past the gonads to the tip of the arm. This vessel has a blind end and there is no continuous circulation of the fluid within it. This liquid does not contain a pigment and has little or no respiratory function but is probably used to transport nutrients around the body [24].

Secondary metabolites

Starfish produce a large number of secondary metabolites in the form of lipids, including steroidal derivatives of cholesterol, and fatty acid amides of sphingosine. The steroids are mostly saponins, known as asterosaponins, and their sulphated derivatives. They vary between species and are typically formed from up to six sugar molecules (usually glucose and galactose) connected by up to three glycosidic chains. Long-chain fatty acid amides of sphingosine occur frequently and some of them have known pharmacological activity. Some are feeding deterrents used by the starfish to discourage predation. Others are antifoulants and supplement the pedicellariae to prevent other organisms from settling on the starfish's aboral surface. Some are alarm pheromones and escape-eliciting chemicals, the release of which trigger responses in conspecific starfish but often produce escape responses in potential prey [25]. Research into the efficacy of these compounds for possible pharmacological or industrial use occurs worldwide [26].

Sexual reproduction

Most species of starfish are gonochorous, there being separate male and female individuals. Some species are simultaneous hermaphrodites, producing eggs and sperm at the same time and in a few of these, the same gonad, called an ovotestis, produces both eggs and sperm [27]. When these grow large enough they change back into females [28]. In others, the eggs may be stuck to the undersides of rocks [29]. In certain species of starfish, the females brood their eggs – either by simply enveloping them [29] or by holding them in specialized structures. Brooding may be done in pockets on the starfish's aboral surface, [30-31] inside the pyloric stomach (*Leptasterias tenera*) [32] or even in the interior of the gonads themselves [27]. Those starfish that brood their eggs by "sitting" on them usually assume a humped posture with their discs raised off the substrate [33]. *Pteraster militaris* broods a few of its young and disperses the remaining eggs, that are too numerous to fit into its pouch [29]. In these brooding species, the eggs are relatively large, and supplied with yolk, and they generally develop directly into miniature starfish without an intervening larval stage [27]. An intragonadal brooder, the young starfish obtain nutrients by eating other eggs and embryos in the brood pouch [34]. Brooding is especially common in polar and deep-sea species that live in environments unfavorable for larval development [36] and in smaller species that produce just a few eggs [40-41].

Spawning takes place at any time of year, each species having its own characteristic breeding season [37]. The first individual of a species to spawn may release a pheromone that serves to attract other starfish to aggregate and to release their gametes synchronously [38]. In other species, a male and female may come together and form a pair [39-40]. This behavior is called pseudocopulation [41] and the male climbs on top, placing his arms between those of the female. When she releases eggs into the water, he is induced to spawn [38]. Starfish may use environmental signals to coordinate the time of spawning (day length to indicate the correct time of the year, [39] dawn or dusk to indicate the correct time of day), and chemical signals to indicate their readiness to breed. In some species, mature females produce chemicals to attract sperm in the sea water [42].

Asexual reproduction

Some species of starfish are able to reproduce asexually as adults either by fission of their central discs [48] or by autonomy of one or more of their arms. Which of these processes occurs depends on the genus. Among starfish that are able to regenerate their whole body from a single arm, some can do so even from fragments just 1 cm (0.4 in) long [49]. Single arms that regenerate a whole individual are called comet forms. The division of the starfish, either across its disc or at the base of the arm, is usually accompanied by a weakness in the structure that provides a fracture zone [50].

The larvae of several species of starfish can reproduce asexually before they reach maturity [51]. They do this by autotomizing some parts of their bodies or by budding [52]. When such a larva senses that food is plentiful, it takes the path of asexual reproduction rather than normal development [53]. Though this costs it time and energy and delays maturity, it allows a single larva to give rise to multiple adults when the conditions are appropriate [52].

Some species of starfish have the ability to regenerate lost arms and can regrow an entire new limb given time [49]. A few can regrow a complete new disc from a single arm, while others need at least part of the central disc to be attached to the detached part [24]. Regrowth can take several months or years [49] and starfish are vulnerable to infections during the early stages after the loss of an arm. A separated limb lives off stored nutrients until it regrows a disc and mouth, and is able to feed again [49]. Other than fragmentation carried out for the purpose of reproduction, the division of the body may happen inadvertently due to part being detached by a predator, or part may be actively shed by the starfish in an escape response [24]. The loss of parts of the body is achieved by the rapid softening of a special type of connective tissue in response to nervous signals. This type of tissue is called catch connective tissue and is found in most echinoderms [54]. An autonomy-promoting factor has been identified which, when injected into another starfish, causes rapid shedding of arms [55].

Larval development and maturation

Most starfish embryos hatch at the blastula stage. The original ball of cells develops a lateral pouch, the archenteron. The entrance to this is known as the blastopore and it will later develop into the anus. Another invagination of the surface will fuse with the tip of the archenteron as the mouth while the interior section will become the gut. At the same time, a band of cilia develops on the exterior. This enlarges and extends around the surface and eventually onto two developing arm-like outgrowths. At this stage the larva is known as a bipinnaria. The cilia are used for locomotion and feeding, their

Figure 1: Diversity of different types of sea stars in the marine coastal ecosystem.

rhythmic beat wafting phytoplankton towards the mouth [8].

The lifecycle of a starfish varies considerably between species, generally being longer in larger forms and in those with planktonic larvae. For example, *Leptasterias bexactis* broods a small number of large-yolked eggs. It has an adult weight of 20g, reaches sexual maturity in two years and lives for about ten years [8]. *Pisaster ochraceus* releases a large number of eggs into the sea each year and has an adult weight of 80g. It reaches maturity in five years and has a maximum recorded lifespan of 34 years [8].

Starfish Ecology

Distribution and habitat

Echinoderms, including starfish, maintain a delicate internal electrolyte balance that is in equilibrium with seawater. This means that it is only possible for them to live in a marine environment and they are not found in any freshwater habitats. Starfish species inhabit all of the world's oceans. Habitats range from tropical coral reefs, rocky shores, tidal pools, mud, and sand to kelp forests, sea grass and the deep-sea floor down to at least 6,000m [51]. The greatest diversity of species occurs in coastal areas, some of which are shown in Figure 1.

Diet preference

Most species of starfish are generalist predators, eating microalgae, sponges, bivalves, snails and other small animals [52]. The crown-of-thorns starfish consumes coral polyps, [53] while other species are detritivores, feeding on decomposing organic material and faecal matter [52,54]. A few are suspension feeders, gathering in phytoplankton; *Henricia* and *Enhinaster* often occur in association with sponges, benefiting from the water current they produce [55]. Various species have been shown to be able to absorb organic nutrients from the surrounding water, and this may form a significant portion of their diet [55]. The processes of feeding and capture may be aided by special parts; *Pisaster brevispinus*, the short-spined pisaster from the West Coast of America, can use a set of specialized tube feet to dig itself deep into the soft substrate to extract prey [56].

Ecological impact

Starfish are keystone species in their respective marine communities. Their relatively large sizes, diverse diets and ability to adapt to different environments makes them ecologically important [57]. Experimental removals of this top predator from a stretch of shoreline resulted in lower species diversity and the eventual domination of *Mytilus* mussels, which were able to outcompete other organisms for space and resources [58]. Similar results were found in a 1971 study of *Stichasrter australis* on the intertidal coast of the South Island of New Zealand. *S. australis* was found to have removed most of a batch of transplanted mussels within two or three months of their placement, while in an area from which *S. australis* had been removed, the mussels increased in number dramatically, overwhelming the area and threatening biodiversity [59]. The feeding activity of the omnivorous starfish *Oreaster reticulatus* on sandy and seagrass bottoms in the Virgin Islands appears to regulate the diversity, distribution and abundance of microorganisms. These starfish engulf piles of sediment removing the surface films and algae adhering to the particles [60]. In addition, foraging by these migratory starfish creates diverse patches of organic matter, which may play a role in the distribution and abundance of organisms such as fish, crabs and sea urchins that feed on the sediment [61]. Starfish sometimes have negative effects on ecosystems. Outbreaks of crown-of-thorns starfish have caused damage to coral reefs in Northeast Australia and French Polynesia [62]. The species has since grown in numbers to the point where they threaten commercially important bivalve populations. As such, they are considered pests, and are on the Invasive Species Specialist Group's list of the world's 100 worst invasive species [63].

Threats

Starfish may be preyed on by conspecifics, other starfish species, tritons, crabs, fish, gulls and sea otters [64,65]. Their first lines of defense are the saponins present in their body walls, which have unpleasant flavours [66]. Several species sometimes suffer from a wasting condition caused by bacteria in the genus *Vibrio*; [64] however, a more widespread wasting disease, causing mass mortalities among starfish, appears sporadically. A paper published in November 2014 revealed the most likely cause of this disease to be a densovirus the authors named sea star-associated densovirus (SSaDV) [67]. The protozoan *Orchitophrya stellarum* is known to infect the gonads of starfish and damage tissue [64]. Starfish are vulnerable to high temperatures. Experiments have shown that the feeding and growth rates of *P. ochraceus* reduce greatly when their body temperatures rise above 23°C (73°F) and that they die when their temperature rises to 30°C (86°F) [68,69]. This species has a unique

Table 1: Breakdown of living taxa among the Neoasteroidea from Foltz and Mah [75,90].

Superorder	Order	Family	genera	species
Forcipulatacea	**Forcipulatida**	**Asteriidae**	**35**	**178**
		Heliasteridae	2	9
		Stichasteridae	9	28
		"Pedicellasteridae"	7	32
		Zoroasteridae	7	36
		Total Forcipulatida	60	283
	Brisingida	Brisingidae	10	63
		Freyellidae	7	47
		TOTAL Brisingida	17	110
		TOTAL Forcipulatacea	77	393
	Spinulosida	Echinasteridae	8	133
		TOTAL Spinulosida	8	133
Valvatacea		**Poraniidae**	7	22
	Valvatida	Acanthasteridae	1	2
		Archasteridae	1	3
		"Asterinidae"	**25**	**147**
		Asterodiscididae	4	20
		Asteropseidae	5	6
		Chaetasteridae	1	4
		Ganeriidae	9	21
		Goniasteridae	**65**	**256**
		Leilasteridae	2	4
		Mithrodiidae	2	7
		Odontasteridae	6	28
		Ophidiasteridae	**27**	**106**
		Oreasteridae	**20**	**74**
		Podospherasteridae	1	6
		Solasteridae	9	51
		Caymanostellidae	2	6
		TOTAL Valvatida	187	763
Valvatacea	**Paxillosida**	**Astropectinidae**	**26**	**243**
		Benthopectinidae	8	69
		Ctenodiscidae	1	5
		Goniopectinidae	3	10
		Luidiidae	1	49
		Porcellanasteridae	12	30
		Radiasteridae	1	5
		Pseudarchasteridae	4	29
		TOTAL Paxillosida	56	439
		TOTAL Valvatacea	243	1224
	Velatida	**Korethrasteridae**	3	7
		Myxasteridae	3	9
		Pterasteridae	**8**	**116**
	Concentricycloidea	Xyloplacidae	1	3
		Total Species	**343**	**1890**

ability to absorb seawater to keep itself cool when it is exposed to sunlight by a receding tide [70]. It also appears to rely on its arms to absorb heat, so as to protect the central disc and vital organs like the stomach [71]. Starfish and other echinoderms are sensitive to marine pollution [72]. The common starfish is considered to be a bioindicator for marine ecosystems [73]. Their survival is likely due to the nodular nature of their skeletons, which are able to compensate for a shortage of carbonate by growing more fleshy tissue [74].

Starfish Evolution

Taxonomic diversity and diversity trends

In terms of total number of species, the Asteroidea (n=1890 species) (Table 1) and the Ophiuroidea (n=2064 species) [75] comprise the two most diverse classes within the living Echinodermata. Species counts and names utilized are those nominally accepted by the World Asteroidea Database as valid (or "accepted" by the database). Following Blake's classification with modification by Mah and Foltz [76] the Valvatacea (Valvatida+Paxillosida) includes the greatest number of species (n = 1224), followed by the Forcipulatacea (n=393 species), the Velatida (n=145 species) and finally the Spinulosida (Echinasteridae), which includes 135 species (Table 1) [77]. Mah and Foltz [76] changed the composition of the Valvatacea to include the Solasteridae, but even with this difference (n=51 species), from Blake, prior versions of the Valvatida included more genera and species than the Paxillosida [78]. Species diversity is disproportionately distributed among the 36 families of living Asteroidea (Table 1). Seven families, Ophidiasteridae, Pterasteridae, Echinasteridae, Asterinidae, Asteriidae, Goniasteridae and Astropectinidae, each include more than 100 species. The Goniasteridae (n=256) and the Astropectinidae (n=243) include the largest number of species within the Asteroidea. Species are not evenly distributed among genera. Within the Astropectinidae, Astropecten alone includes 43% (104/243) of the total number of species in the family [79]. The Goniasteridae includes 65 genera, most of which include multiple species [80]. At least eight goniasterid genera include more than 10 species. Several genera possess disproportionately high numbers of species relative to other genera within the family. Henricia includes some 68% (91/133) of the total known species in the Echinasteridae [77]. Pteraster (n=45) and Hymenaster (n=50) together account for 82% of the total number of species (n=116) in the Pterasteridae [81]. The aforementioned illustrate the extreme cases, but several more examples of disproportionately high numbers of species/ family exist. In nearly every instance of a genus with a disproportionately high numbers of species, these taxa include a global or widely distributed range. Astropecten is limited largely to tropical and temperate settings, but Henricia, Pteraster, and Hymenaster all have cosmopolitan distributions in cold to temperate water settings.

Starfish Bioactives

Starfish imply a special source of polar steroids of an immense structural diversity, showing a range of biological activities. The bioactive compounds such as steroids which act as an integral part of the cell membrane. The steroidal components namely saponins, asterosaponins, and astropectenol are the major source of compounds abundantly found in sea stars [82-88]. A basic study of these facts reveals the search for "Drugs from the Sea" progresses at the rate of a 10 percent increase in new compounds per year [79]. The isolation and characterization of bioactive compounds from the sea stars in the marine ecosystem is serving a good resource for the human population to fight against the deadly diseases like cancer.

Elucidation of novel compounds from far eastern sea star *Leptasterias ochotensis* illustrated cytotoxic activity towards cancer cell lines RPMI-7951 and T-47D [82]. Steroidal compounds and asterosaponins were isolated from cold water star fish *Ctenodiscus crispatus* and *Culcita novaeguineae*, respectively, showing cytotoxicity against human carcinoma cell lines HepG2 and U87MG ensuing the apoptosis of the cells, hence playing a significant role in the anti-tumor chemotherapy [83,84]. Steroidal compounds were elucidated from one another species of sea star Astropecten polyacanthus, which showed cytotoxic activity against the human cancer cell lines HL-60, PC-3 and SNU-C5 [85]. The crude extracts of the same species of starfish (*A. polyacanthus*) also possessed inhibitory effects against the inflammatory components (TNF-α and IL-6) [86]. A polysaccharide compound extracted from the starfish *Asterina pectinifera* showed a chemo-preventive activity against human colon cancer (HT-29) and human breast cancer by initiating the enzymatic activity which plays a key task in the carcinogenesis inhibition [87,88]. Few new compounds of asterosaponins from the starfish *Archaster typicus* showed cytotoxic activity against human cervical cancer cell lines and mouse epidermal cell line [89]. Glycolipids isolated from starfish *Narcissia canariensis*, harvested from the coast of Africa showed cytotoxicity against various adherent human cancerous cell lines (multiple myeloma, colorectal adenocarcinoma and glioblastoma multiform) [88]. A comparative study was made between the crude extract from *Acanthaster planci* starfish with conventional medicine tamoxifen, a drug used against the human breast cancer and the extract showed effective apoptotic activity than the drug tamoxifen in human breast cancer cell line [90-96]. Hemolytic activity was also studied from various star fish namely *Ophiocoma erinaceus, Acanthaster planci* (crown of thorn), *Protoreaster linckii* (red knobbed), and *Holothuria polii* showed hemolysis when tested against human, chicken, goat and rabbit red blood cells, hence having a naturally secondary metabolite possessing hemolytic properties [85-89].

Conclusions

Starfish are some of the unique and most treasured creatures in the sea, and these fascinating species are the images of the seashore. They have profound biological, ecological, cultural, pharmaceutical and taxonomical significance. Ecological roles of the starfishes in marine ecosystems are addressed at varied levels. The most prominent and best-known impact of starfishes is due to the common predatory species in coastal areas. The population dynamics of prey strongly depends on predation pressure (e.g. the relationship between asteriids and mussel populations). The rises of falls of the starfish populations typically depend on the young juvenile recruitment. He fluctuation in settlement success depends on the abundance and health of the planktonic larvae, and therefore on the phytoplankton enrichment.

Recently starfish have attracted organic chemists, biochemists, and pharmacologists as a mesmerizing source of marine bioactive natural products. Numerous secondary metabolites including steroids, steroidal glycosides, anthraquinones, alkaloids, phospholipids, peptides, and fatty acids were reported from starfish. These biochemical constituents exhibit cytotoxic, hemolytic, antiviral, antifungal, and antimicrobial, antiaging and antidiabetic activities and therefore have important implications for the improvement of general body tone as well as treatment of a number of serious diseases and health ailments.

Asteroid biodiversity and systematics remains an active area of research that has brought additional depth to our understanding of echinoderm evolution and historical changes in the marine setting. Although much asteroid taxonomy is stable, many new taxa remain to be discovered with many new species currently awaiting description. However, until now, the phylogeny of starfishes remains a highly debated topic. Some key issues are central to the debate, including the monophyly of traditional orders and families as well as the relationships among the major clades. Morphology-based and molecular approaches of phylogeny tend to converge, and future studies should help to minimize the debate. The new data derived from molecular phylogenetics and the advent of global biodiversity databases will also present important new springboards for understanding the global biodiversity and evolution of asteroids.

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