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Arthropods -Crustaceans: Morphology; Taxonomy; Biology; Ecology

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Abstract

Crustacea is a diverse group of arthropods that includes familiar organisms such as crabs, lobsters, shrimp, crayfish, and barnacles, as well as many other less well-known species. They are found in marine, freshwater, and terrestrial environments and are characterized by a hard exoskeleton, jointed limbs, and two pairs of antennae.Crustaceans range in size from tiny planktonic copepods to the giant Japanese spider crab, which can have a leg span of up to 4 meters. Many species are important both ecologically and economically, serving as food sources for larger organisms or as valuable seafood for humans.Crustaceans have a variety of feeding strategies, including filter feeding, scavenging, and predation. They are also known for their complex behaviors and communication methods, such as chemical signaling and visual displays.The reproductive strategies of crustaceans vary widely depending on the species, with some laying thousands of eggs at once and others carrying their eggs on their bodies until they hatch. Many crustaceans also undergo complex developmental stages, such as metamorphosis, during their life cycle.

Introduction

Crustacea is a diverse group of arthropods that includes over 67,000 species, making it one of the largest groups of animals on the planet (Scholtz, & Richter ,1995). They are found in a wide variety of habitats, ranging from deep-sea trenches to freshwater streams, and are characterized by a hard exoskeleton, jointed limbs, and two pairs of antennae(Martin& Davis ,2001).

Crustaceans play important ecological roles as primary consumers, predators, and decomposers in aquatic ecosystems, and many species are also commercially important as seafood (Lotze *etal*.,2006). Some examples of economically important crustaceans include crabs, lobsters, and shrimp.

The classification and phylogeny of crustaceans have been studied extensively, with numerous studies using molecular and morphological data to improve our understanding of their relationships (Bracken *etal*. ,2010).One recent study used genomic data to investigate the evolutionary relationships among major crustacean lineages, shedding light on the evolution of key traits such as appendage morphology(Tan, *etal*. ,2018).

In addition to their ecological and economic importance, crustaceans are also of interest to scientists due to their complex behaviors and communication methods. Many species use chemical signaling to communicate with one another, and some, such as fiddler crabs, engage in elaborate visual displays to attract mates Salmon (1974).

Characteristics of Crustaceans

Arthropods that exhibit a wide range of characteristics. Some notable features of crustaceans include their segmented bodies, Chitinous exoskeletons, jointed limbs, and a variety of specialized appendages used for feeding, locomotion, and reproduction.

Segmentation ;Crustaceans, like all arthropods, have segmented bodies with a head, thorax, and abdomen. The number of segments can vary greatly between different species, ranging from a few segments in some copepods to over 100 segments in some shrimp and lobster species (Brusca& Brusca,2003).

Exoskeleton ;The exoskeleton of crustaceans is made up of chitin, a tough, polysaccharide material that provides protection and support for the animal's body. The exoskeleton is also periodically shed during growth, a process known as molting, which allows the animal to increase in size (Price ,1973).

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Limb structure; Crustaceans have jointed limbs that are used for a variety of functions, such as feeding, locomotion, and reproduction. In many species, the limbs are highly specialized, with modified structures such as pincers or swimmerets Walossek (1993).

Specialized appendages; Crustaceans have a variety of specialized appendages that are used for feeding, sensing, and reproduction. For example, the antennae of many species are used for chemosensory perception, while the mandibles and maxillae are used for grasping and processing food. Some species also have specialized appendages for swimming, such as the uropods of shrimp and the tail fan of lobsters **Body plan**

Crustaceans have a unique body plan that is characterized by a segmented body, a hard exoskeleton, and jointed appendages. Here is an overview of crustacean anatomy and some references for further reading:

Head

The head of a crustacean contains the animal's brain, eyes, and mouthparts. Crustaceans have compound eyes that are composed of many small lenses, allowing them to detect movement and changes in light. The mouthparts of crustaceans vary depending on the species, but typically include mandibles and maxillae for biting and crushing food.

Thorax

The thorax of a crustacean is divided into several segments, each of which is equipped with a pair of jointed appendages. These appendages are used for locomotion and may be modified for other functions, such as feeding or reproduction.

Abdomen

The abdomen of a crustacean is also divided into several segments, but these segments do not usually have appendages. Instead, the abdomen is used for swimming and reproduction. In males, the first pair of appendages may be modified into reproductive structures called

Exoskeleton

The exoskeleton of crustaceans is made of chitin, a complex carbohydrate that provides support and protection to the animal's body. The exoskeleton is divided into several segments that are joined together by flexible membranes, allowing the animal to move and flex. The exoskeleton also serves as an attachment point for the animal's muscles. The exoskeleton is composed of chitin and is periodically shed during molting

Internal organs

Crustaceans have a complex network of internal organs, including a digestive system, circulatory system, and nervous system. The digestive system includes a mouth, esophagus, stomach, and intestine. The circulatory system includes a heart, blood vessels, and hemolymph (the animal's equivalent of blood). The nervous system includes a brain and several ganglia that control the animal's movements and behaviors.
(Brusca& Brusca ,2003); (Charmantier-Daures& Charmantier ,2005); (Martin & Davis ,2001);(Scholtz ,2002); (Wägele ,2012); (Scholtz & Richter ,1995).

Taxonomy of Crustaceans

The taxonomic classification of crustaceans has undergone significant changes over time, reflecting advances in our understanding of their evolutionary relationships and phylogeny. Currently, crustaceans are classified into five subphyla, each with a number of different classes and orders.The five subphyla of crustaceans, along with some of their representative classes and orders, are:

Phyllocarida: This subphylum includes only one extant order, the Leptostraca, which includes small, shrimp-like crustaceans that live in shallow marine environments(Martin& Davis ,2001).

Branchiopoda: This subphylum includes several different orders, including the Anostraca (fairy shrimp), Notostraca (tadpole shrimp), and Cladocera (water fleas) (Belk& Brusca ,2019). Branchiopods are primarily found in freshwater environments and exhibit a range of morphological and behavioral adaptations for life in these habitats.

Cephalocarida: This subphylum includes only one extant order, the Brachiopoda, which includes small, shrimp-like crustaceans that live in marine environments (Boxshall ,2004).

Maxillopoda: This subphylum includes several different classes, including the Ostracoda (seed shrimp), Copepoda (copepods), and Cirripedia (barnacles) (Huys& Boxshall ,1991). Maxillopodans are found in a variety of marine and freshwater habitats and exhibit a range of morphological and behavioral adaptations.

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Malacostraca: This subphylum includes a diverse array of crustaceans, including the Decapoda (shrimp, crab, lobster), Amphipoda (amphipods), Isopoda (isopods), and Euphausiacea (krill) (Scholtz, & Richter ,1995). Malacostracans are found in a wide range of marine and freshwater habitats and exhibit a variety of morphological and behavioral adaptations**.**

Biology of Crustacea

Some notable features of crustacean biology include their complex sensory systems, developmental plasticity, and diverse reproductive strategies.

Sensory systems Crustaceans possess complex sensory systems that enable them to detect and respond to a variety of stimuli in their environment. For example, they have a range of photoreceptor cells in their eyes that allow them to see in different light conditions, and many species also use chemical cues for communication and detection of prey or predators (Cronin *etal*. ,2014). Some species, such as lobsters and crabs, have highly developed olfactory systems that allow them to detect and track odors in their environment (Derby ,2014).

Developmental plasticity Many crustaceans exhibit developmental plasticity, meaning that their physical characteristics and behavior can be influenced by environmental factors such as temperature, food availability, and predation risk(Jara & Navarrete ,2016). For example, some species may alter their growth rate or body size depending on environmental conditions, while others may develop specialized morphological features such as spines or camouflage to avoid predation.

Reproductive strategies Crustaceans have a diverse array of reproductive strategies, ranging from broadcast spawning to parental care (Bauer ,2011). Some species, such as barnacles and copepods, release their eggs and sperm into the water, while others, such as lobsters and crabs, carry their eggs externally or internally until they hatch. In some cases, males may engage in elaborate courtship rituals to attract a mate, while females may choose mates based on physical characteristics or other factors. (Bauer ,2011).

Ecology

Crustaceans are found in aquatic and terrestrial environments. They play important roles in ecosystems as predators, herbivores, detritivores, and prey for other organisms. Here are some examples of their ecological roles:

Predators: Many crustaceans are predators, feeding on a variety of prey including plankton, small fish, and invertebrates. For example, crabs and lobsters are important predators in marine ecosystems, while freshwater crayfish and shrimp prey on small invertebrates and fish in rivers and streams (Anger ,2013).

Herbivores: Some crustaceans, such as the amphipod Gammarus pulex, feed on algae and plant material in freshwater ecosystems (Bilton& Freeland ,2006). In marine environments, krill are important herbivores, grazing on phytoplankton and playing a crucial role in the marine food web (Siegel ,2005).

Detritivores: Many crustaceans are detritivores, feeding on decaying organic matter in aquatic and terrestrial environments. For example, freshwater crayfish and shrimp consume leaf litter and other detritus in streams and rivers, while marine crabs and shrimp feed on dead and decaying plant and animal material (Anderson ,1995).

Prey: Crustaceans are an important food source for many other organisms, including fish, birds, and marine mammals. For example, krill are a critical food source for many species of baleen whales, while smaller crustaceans such as copepods and amphipods are important prey for many fish species (Dall *etal*. ,1990).

In addition to their ecological roles, crustaceans are also important indicators of environmental health and can be used to monitor water quality and other environmental factors. For example, the presence or absence of certain species of crustaceans can indicate pollution or other changes in aquatic ecosystems (Peck ,2005).

Habitat

Crustaceans are inhabit a wide range of aquatic and terrestrial habitats, including marine and freshwater environments, as well as terrestrial ecosystems such as forests and deserts. Here are some examples of their habitats:

Marine environments: Many crustaceans, such as crabs, lobsters, shrimp, and krill, are found in marine environments, including intertidal zones, estuaries, and the deep sea (Koenemann, & Jenner ,2018). For example, the common shore crab (*Carcinus maenas*) is found in intertidal zones along rocky shores, while the deep-sea amphipod *Eurythenes gryllus* is found at depths of up to 7,000 meters (Schotte *etal*. ,2021).

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Freshwater environments: Crustaceans such as crayfish, shrimp, and copepods are common in freshwater habitats such as rivers, lakes, and streams (Van Damme& D'hondt ,2018). For example, the signal crayfish (*Pacifastacus leniusculus*) is found in freshwater habitats throughout North America and Europe, while the freshwater shrimp (*Gammarus pulex*) is common in streams and rivers in Europe (Bilton& Freeland ,2006).

Terrestrial environments: Although less common than aquatic crustaceans, some species are adapted to life on land. For example, the terrestrial isopod (Armadillidium vulgare) is found in forests and other terrestrial habitats, while the pillbug (Oniscus asellus) is commonly found in gardens and other urban environments Hassall& Sutton (2015).

Crustaceans are highly adapted to their specific habitats, with many species exhibiting specialized morphological, physiological, and behavioral adaptations that allow them to survive and thrive in their environments Thiel& Gutow (2019).

Development

The development of crustaceans is a complex process that involves several stages. Here is a brief overview of crustacean development and some references for further reading:

Egg: Crustacean development begins with the egg, which is usually fertilized externally. The eggs are either released into the water or carried by the female until they hatch. (Charmantier-Daures& Charmantier ,2005).

Nauplius: The first larval stage of crustaceans is called the nauplius. Nauplii have a simple body plan with three pairs of appendages, including antennae and mandibles. They also have a single eye and a simple digestive system.(Martin& Davis ,2001).

Zoea: The next larval stage is the zoea, which has more complex appendages and a more developed digestive system. Zoeae also have a pair of compound eyes. (Scholtz ,2002).

Mysis: Some crustaceans, such as shrimp, have an additional larval stage called the mysis. Mysids have a more advanced digestive system and appendages that are adapted for swimming.

Adult: Crustaceans reach adulthood after several molts, during which they shed their exoskeleton and grow a new one. (Tan& Ng ,2005)

Reproductive and life cycles

Crustaceans exhibit a wide range of reproductive strategies and life cycles, depending on the species. Here is an overview of crustacean reproduction and life cycles and some references for further reading:

Reproduction: Most crustaceans have separate sexes, and fertilization is usually external. Some species, however, have internal fertilization, and females may carry the eggs until they hatch. Some crustaceans also exhibit hermaphroditism, where an individual has both male and female reproductive organs.

Larval stages: Crustaceans undergo several larval stages before reaching adulthood. These larval stages are usually different from the adult form and may have specialized appendages for feeding or swimming.

Molting: Crustaceans have a hard exoskeleton that must be periodically shed to allow for growth. Molting is a complex process that involves the production of a new exoskeleton and the shedding of the old one.

Life cycle: The life cycle of crustaceans varies widely depending on the species. Some species have a simple life cycle with few larval stages, while others have more complex life cycles with multiple larval stages.

Charmantier-Daures& Charmantier (2005). Martin& Davis (2001).; Scholtz (2002); Wicksten (2015).

Medical and Economic importance

Crustaceans have both medical and economic importance. Here are some examples:

Medical Importance

Chitin: Crustaceans produce chitin, which is a biopolymer that has various medical applications. For example, chitin is used in wound dressings, surgical sutures, and tissue engineering(Khor,2003).

Astaxanthin: This carotenoid pigment is produced by some crustaceans, such as krill and shrimp, and has antioxidant properties. Astaxanthin is used in the treatment of Alzheimer's disease, Parkinson's disease, and other neurodegenerative disorders (Ambati *etal*. ,2014).

Economic Importance

Fisheries: Many crustaceans are commercially important, including shrimp, crabs, and lobsters. These species are harvested from both wild populations and aquaculture facilities and are an important source of protein for human consumption (FAO ,2021).

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Aquaculture: Several crustacean species, including shrimp and crayfish, are cultured in aquaculture facilities for commercial purposes (4). The global production of farmed crustaceans has increased significantly in recent years, and this trend is expected to continue as demand for seafood increases (New ,2002).

Biotechnology: Crustaceans are also used in biotechnology applications, such as the production of enzymes used in the food and pharmaceutical industries(König& Fröhlich ,2015).

Molecular biology and evolution

The study of molecular biology and evolution of crustaceans has provided insight into the phylogenetic relationships, genetic diversity, and adaptation of these animals. In this answer, we will explore some of the key findings in this field, along with relevant references.

Phylogenetic relationships Molecular data has been used to refine the phylogenetic relationships of crustaceans. For example, molecular studies have supported the Pancrustacea hypothesis, which suggests that crustaceans and insects form a monophyletic group. Molecular data has also been used to investigate the relationships among major crustacean groups, such as the Malacostraca and the Branchiopoda. (Regier *etal*. ,2005); (Oakley *etal*. ,2013).

Genetic diversity and adaptation Molecular studies have also provided insight into the genetic diversity and adaptation of crustaceans. For example, studies have investigated the genetic basis of color variation in crustaceans, as well as the genetic basis of resistance to environmental stressors such as temperature and salinity. Additionally, molecular studies have been used to investigate the evolution of crustacean vision and the genes involved in the development of crustacean appendages. (Le Luyer *etal*. ,2021); (Tagmount *etal*. ,2019). (Oakley; ,2003).

Genomics and transcriptomics Recent advances in genomics and transcriptomics have enabled more comprehensive studies of crustacean biology. For example, the sequencing of crustacean genomes has provided insight into the evolution of gene families and the genetic basis of adaptation. Transcriptomics studies have also been used to investigate gene expression patterns in different crustacean tissues and developmental stages. (Shen *etal*. ,2020). (Pilling& Stewart ,2020).

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