Introduction to Invertebrate Medicine

Neutering the Female Virginia Opossum
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Invertebrate animals comprise 95% of the animal kingdom, yet non-parasitic invertebrates are vastly underrepresented in the typical veterinary curriculum. These notes provide a brief introduction to some of the more prominent invertebrate groups: sponges, coelenterates, echinoderms, crustaceans, mollusks, horseshoe crab, insects, the annelids and spiders.

Porifera (Sponges)

The phylum Porifera is a diverse group of primitive animals commonly referred to as the sponges. Until about 200 years ago sponges were actually classified as plants. Sponges occur in the fossil record back to the Precambrian era (over 600 million years ago) and were the most important contributors to reefs during the Paleozoic and Mesozoic eras. All members lack defined organs; differentiated cells within connective tissue perform necessary biological functions. A unique system of water canals facilitates transport of food, waste products, and gametes. Nearly all sponges are sessile. While most of the 15,000 species are marine, about 3% of sponges live in freshwater environments. Sponges are normally found on firm substrates in shallow water, although some occur on soft bottoms.

Sponge Quick Facts

- Sponges maintain a close association with a variety of bacterial genera, some of which can be pathogenic.
- Virtually nothing is known about analgesia, anesthesia and therapeutics of sponges.
- Sponges seem to tolerate surgical manipulation in the form of cutting and auto-grafting.
- Sponges are an integral part of coral reef and other aquatic communities.
- Natural products produced by sponges are important to biomedical science.

Coelenterates

This large phylum includes the comb jellies (ctenophores), hydrozoans (hydras, fire coral, Portuguese man-of-war), scyphozoans (jellyfish, Fig 1), and anthozoans (sea anemones, corals, Fig 2). This is an economically important group for research, environmental monitoring, public and private display, and tourism. Coral reefs collectively are one of the most beautiful, diverse, and fragile ecosystems on the planet. Jellyfish exhibits are now some of the most popular displays in public aquariums throughout the world.

Coelenterate Quick Facts
- Some diseases of hard and soft corals have been well documented.
- Many coelenterates are important indicators of tropical ecosystem health.
- Trauma is a major concern when keeping captive jellyfish.
- Various therapeutic compounds have been used in this phylum.
- Our knowledge of coelenterate medicine and surgery is minimal but growing steadily.

Fig 1. Jellyfish, like these moon jellies (Aurelia aurita), are frequently displayed in public aquariums and some upscale restaurants. Cylindrical aquaria with carefully regulated water currents are used to maintain these delicate animals. Common problems include trauma and “inversion,” an idiopathic syndrome characterized by the normally concave bell (primary portion of the body) becoming convex.

Echinoderms

This interesting and diverse group of animals includes the sea stars, brittle stars, sea cucumbers, sea urchins (Fig 3), and crinoids. Many are commonly displayed in aquaria and used in research. Humans do not consume most species but the gonads of sea urchins are a popular food item in parts of the world.

Echinoderm Quick Facts
- Very little is published with regards to medicine and surgery.
- Some species are easy to maintain in captivity, making them popular as “pets” and for research.
- Some species have regenerative capabilities and generally heal well and quickly.
- Information on anesthesia and sedation can be found in the basic scientific literature.
- In some groups the external shell or “test” can make clinical evaluation difficult.

Fig 2. Coral reef aquariums, many of which include fishes and other types of marine invertebrates, are gaining rapidly in popularity. Many of the hard and soft corals are propagated in captivity through a simple surgical process called fragmentation, or “fragging.”

Fig 3. Many aquatic invertebrates, including these purple sea urchins (Arbacia punctulata), are sensitive to copper sulfate and other heavy metals. The animals pictured here were part of a copper toxicity study and have lost spines, a common clinical sign for debilitated sea urchins.
Crustaceans

The crustaceans are a highly successful class of the phylum Arthropoda. This group includes the well-known lobsters, crabs, crayfish, shrimp, barnacles and hermit crabs. Numerous other taxa belong to this class including isopods, amphipods and brine shrimp. Economically, this is one of the most important groups of invertebrates. Its members are important for food, research and as display animals.

**Crustacean Quick Facts**
- The infectious diseases of the Penaeid shrimp have been described in great detail, especially some of the viral and bacterial problems.
- There is data for some antimicrobial treatments in the literature.
- There are published protocols for anesthesia and euthanasia.
- Funds are available to study the disease of economically important groups like crabs, shrimp and lobsters.
- Hemolymph is easy to extract and analyze (Fig 4).

Bivalve Mollusks

This class of mollusks contains many common animals including the clams, mussels, oysters, and scallops. This is an extremely economically important group, especially as a food source for humans. Many species are both captured and cultured for food worldwide. There are more than 10,000 species recognized, found in freshwater, estuarine and marine surface waters. Bivalves fill a critical niche within aquatic ecosystems, the majority functioning as living filters. They comprise a large portion of the shell fauna collected by amateur or professional conchologists on our beaches and freshwater stream banks and historically have played a significant role in the apparel industry as a source of buttons or pearls and as a frequent item on the shelves of novelty shops. Bivalves are popular in display aquariums (private and public aquaria) and as research animals. (Adapted from Levine, Law and Corsin, 2006).

**Bivalve Mollusk Quick Facts**
- Numerous major bacterial, viral, and protozoal diseases of bivalves have been described.
- Despite this fact, knowledge of appropriate chemotherapeutics is minimal.
- Diagnostic techniques have been described, including antemortem hemolymph collection.
- Many bivalves can live for decades and as such can be quite valuable.
- Some species are critically endangered, including a number of freshwater mussels.

Limulus

_Limulus polyphemus_, the American horseshoe crab, is actually not a crab at all but a member of the class Merostomata in the phylum Chelicerata. Horseshoe crabs are more closely related to arachnids than crustaceans. This is the only species that occurs on the Western Atlantic coast of the United States, but there are other species of horseshoe crabs that occur in Asia. _Limulus_ is a very important animal for biomedical research and is (controversially) used as bait and fertilizer. It is also an important display and “touch tank” animal in public aquaria.

**Limulus Quick Facts**
- The anatomy and physiology of this animal have been thoroughly researched.
- They are easy to handle and work with.
- Trauma cases can be surgically repaired.
- Very little work has been done with regards to chemotherapeutic treatment.
- These animals would make good subjects for pharmacokinetics studies.
Gastropod Mollusks

The gastropods belong in the phylum Mollusca and include over 80,000 marine, fresh water and terrestrial species (Fig 5). All gastropods have a ventrally flattened foot that provides locomotion along the various surfaces of their habitats. The group includes snails, slugs, sea hares, nudibranchs, slipper shells, conchs, whelks and abalone. The use of gastropods as laboratory animals and in aquaculture is limited but does occur. They are, however, important display and food animals. (Adapted from Smolowitz, 2006).

Gastropod Mollusk Quick Facts
- Some species can be quite large, and these animals are relatively easy to work with.
- Numerous infectious diseases have been well described in this group.
- Fractured shells can be repaired with external fixation methods.
- A number of therapeutic and anesthetic techniques have been described.
- Some species can be long-lived and may be quite valuable.

Insects

This is by far the largest group of invertebrates and possibly the most economically important. Insects are loved and hated worldwide and occupy nearly all niches except the marine environment. They are important as a human food source in parts of the world and both sustain and destroy agricultural crops, depending on the species of insect and plant.

Insect Quick Facts
- Important research and display animals include beetles, butterflies, grasshoppers, walking sticks, and ants.
- Much research has focused on the diseases of insects (Fig 6), in some cases to help and in some cases to harm them.
- Management of infectious diseases of honeybees has been well studied.
- Honeybees (which are not native to North America) can be successfully anesthetized prior to a variety of diagnostic procedures.
- Butterfly houses are becoming very popular at zoos and natural history museums.

Fig 5. There are left-handed and right-handed spiral-shelled gastropods (usually a species is predominantly one way or the other). Pictured here are seven species of temperate Atlantic marine gastropods from North Carolina (clockwise from bottom: Moon snail (Polinices duplicatus), channeled whelk (Busycon canaliculatum), lightning whelk (Busycon contrarium), helmet (Cassis sp.), Scotch bonnet (Phalium granulatum), knobbed whelk (Busycon carica), and lettered olive (Oliva sayana). All have dextral whorls (opening to the right when the animal’s soft parts are facing the observer) except the lightning whelk, which has a sinistral opening.

Fig 6. A section of clean, transparent tape can be used to capture the spores of the protozoal parasite Ophryocystis elektroscirrh from monarch butterflies (Danaus plexippus). The tape is then placed on a clean glass slide and examined microscopically for the presence of small, brown or gold “football-shaped” spores.
Annelids

The annelids are a large and diverse group of segmented worm-like animals that are divided into three main classes: the polychaetes, oligochaetes and hirudineans. All are characterized by regular segmentation of the trunk. It is believed this segmentation evolved as a means of burrowing via peristaltic contractions. Annelids possess a coelomic cavity that is divided into segments by regular septa. The circulatory, excretory, and nervous systems are also segmented. A cuticle covers the animal and segmented setae occur in nearly all members of the phylum. The mouth is located anteriorly and the anus posteriorly with a straight gut between the two openings.

Spiders

This is a huge group of animals (over 30,000 species) that belong to the class Arachnida. Less conspicuous arachnids include the mites, ticks, and scorpions. Numerous texts describe the biology, natural history, and husbandry of these fascinating creatures.

Annelid Quick Facts

- Some polychaetes and oligochaetes have the capacity to regenerate portions of their bodies.
- A lot of early research on tissue grafting and rejection was performed on earthworms (terrestrial oligochaetes).
- Virtually nothing is known about the chemotherapeutic treatment of these animals.
- Very few infectious diseases have been described from this group (except where these animals are the intermediate host for diseases of vertebrates).
- Some species (tropical marine polychaetes) are important and valuable display animals.

Spider Quick Facts

- By far the most popular group of spiders kept as pets in the home are the tarantulas.
- Many clinical techniques have been described for tarantulas, including hemolymph collection (Fig 7) and anesthesia (Fig 8).
- Female spiders can be long-lived (several decades) and may be quite valuable.
- Common clinical problems include trauma, limb autotomy, and difficulty molting.
- Surgical repair of the fractured exoskeleton is commonly managed with surgical adhesives.

Fig 7. While tarantulas can be examined without anesthesia, sedation can make hemolymph collection (from the cardiac sinus in this case) safe for both handler and patient.

Fig 8. Tarantulas and other spiders are relatively easy to anesthetize using inhalant anesthetics like isoflurane. Here data is being recorded as part of a project investigating anesthetic protocols in the Chilean rose tarantula (Grammostola rosea). Any clear secure container can be readily used for this purpose.
Cephalopod Mollusks

There are about 650 species of cephalopods, a group that includes the octopuses, squids, cuttlefish, and the chambered nautilus. This is an important economic group in that they serve as a food source for humans and other animals, are popular display animals, and have been frequently employed in a variety of research projects.

Cephalopod Mollusk Quick Facts

- These are highly visual, intelligent animals that can make good clinical patients.
- Common problems in captivity include trauma, anorexia, bacterial infections, and water quality problems.
- Anesthetic and surgical protocols have been established for some species.
- In Great Britain, an Institutional Animal Care and Use Committee application is required to perform research on cephalopods.
- With their closed circulatory system, these animals make good subjects for pharmacokinetic studies.

References and Further Reading

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