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Shell Infections: When There Are Chinks in the Armor

By Sandy Barnett, MATT'S President

I occasionally receive emails from hobbyists about how to treat their turtle's "shell rot." It is a difficult question to answer, because shell-rot is not a specific disease. Rather, it is a generic term, more appropriately labeled "ulcerative shell disease" or "USD." USD may be caused by one or more pathogens—most commonly bacteria or fungus^{1,2}, although viruses³, possibly algae^{4,5}, and various internal disorders⁸ can also cause it. Treatment depends not only on the pathogens isolated from the infection, but also on the extent of damage, the overall health of the animal, and somewhat on whether the animal is terrestrial or aquatic. It takes a qualified veterinarian to definitively diagnose the problem and prescribe appropriate therapy. But it also takes dedication on the part of the owner to identify and correct any poor husbandry practices that may have led to the development of the shell infection in the first place.

In this article, I describe USD and general aspects of its treatment, as well as possible causes and prevention.

Types of Ulcerative Shell Disease

Some authors divide USD into two categories based on presentation^{1,2}:

- A "dry form" usually caused by fungus (a mixed bacterial / fungal infection is also possible).
- A "wet form" most commonly caused by gram-negative bacteria, especially *Pseudomonas*, *Citrobacter* and *Klebsiella*

It is not unusual for a shell infection to involve multiple

pathogens (e.g. mixed fungal/bacterial infection).

Dry USD occurs in both aquatic and terrestrial chelonians; wet USD is most commonly associated with aquatic and semi-aquatic turtles although it also occurs in tortoises¹.

Symptoms

Most cases of USD begin when there is some sort of penetration of the shell's surface, allowing the invasion of pathogens.

Dry USD, which can become a chronic problem, usually presents as lifting and flaking of the scutes, exposing the underlying bone². Such exposure provides a portal of entry for other pathogens. (Also, a loss of scutes, if severe, can reduce the animal's ability to retain body water⁶ and to properly thermoregulate⁷.)

In mild cases of wet USD, there is superficial erosion or ulceration of the keratinous scutes of the carapace or plastron (or leathery epidermis/upper dermis in soft-shelled turtles). (For a detailed description and illustrations of USD see Frye⁸.) One or more superficial abscesses containing caseous (cheese-like) necrotic tissue may be visible at the surface of the scutes (or epidermis in soft-shelled turtles) or hidden just beneath the surface where they may appear as pale discolorations. A superficial fungal infection may present as gray or whitish fuzzy patches on the shell and skin.

In some cases, moderate shell infections may persist for years with few external signs that the animal has a problem (i.e., the animal appears bright, eats well, maintains reasonable body weight, and *visible* damage to the shell may be slight and appear not to be spreading). Some cases resolve on their own. However, in many instances, untreated infections progress sooner or later to where

*with minor modifications by the author. (Contact: www.matts-turtles.org)



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Diamond-back Terrapin, *Malaclemys terrapin*, showing superficial USD associated with retained scutes. The dark areas represent newly exposed scutes after multiple old layers (white areas) were gently peeled away. Note the numerous small pits caused by bacterial erosion of the newer scutes.

they pose a significant health risk to the animal. The rate of progression depends on many factors, including the over-all health of the animal, the pathogen(s) involved, and how the animal is being kept.

Over time, a shell infection may spread laterally at the surface or under the scutes where the damage may initially go undetected. The infection may also spread down through the scutes and underlying tissue and into the bone. In the most serious cases, the infection may continue downward through the entire thickness of the bone, through the coelomic membrane and into the coelomic cavity (abdominal cavity in mammals). Extensive bone infections and infections spreading into the coelomic cavity can lead to septicemia (“blood poisoning”) as the pathogens travel into the bloodstream and either directly, or through the toxins they produce, damage blood vessels and vital organs. This condition, termed “septicaemic cutaneous ulcerative disease” or ‘SCUD’, *can rapidly kill a turtle*.

In cases of advanced USD, there may be the following clinical signs^{1,2,8}:

- There is a foul-smelling discharge often tinged with blood, which seeps from between the scutes.

- There is blotchy dark discoloration of the affected area.
- Numerous deep pits or soft, fluid-filled areas are evident at or just under the surface of the shell; the pits may contain caseous necrotic tissue.
- Scutes situated above affected areas may be unusually soft and easily lifted off (caused by weakening of the membrane attachment to the bone); if the scutes are removed, the area underneath is pitted, foul smelling, moist, and often bloody.

Signs that the animal is septic include²:

- Vomiting
- Lethargy
- Erythematous (reddish) flush to the plastron and carapace
- Secondary jaundice (yellow mucus membranes)
- Polydipsia (chronic, excessive thirst)
- Petechial hemorrhages (red spots or blotches) of the mucus membranes (especially the mouth)

Diagnosis and Treatment

If an animal has any of the symptoms listed above, or a shell injury that penetrates to the bone, I strongly recommend taking it to a vet right away. Fresh injuries can be cleaned and treated to prevent infection from setting in.

In the case of suspected or established shell infections, a vet can perform blood tests and take radiographs (x-rays) to assess the extent of the problem. (Visual inspection of an animal may not reveal the full extent of the infection.) At this time, the vet may also take samples from affected sites for microbiological cultures and sensitivity testing (in the event that drug therapy is needed).

Superficial USD

Most cases of superficial shell ulceration respond well to debridement (removal of dead and infected tissue) and thorough daily flushing with sterile saline, dilute chlorhexidine solution (e.g., Nolvasan®) or dilute povidone-iodine solution (e.g. Betadine®). The latter product must be used with caution, as it can harm healthy tissue and retard healing if too concentrated. Also, iodine appears to be toxic to some turtles, especially soft-shelled species⁹.

A vet may recommend applying a topical antibacterial

(e.g., Neosporin[®], Silvadene[®]) or antifungal agent (e.g. Miconazole[®]) to the affected area after it has been debrided, flushed, and allowed to dry. However, in cases of mild USD, often the only additional treatment recommended after daily debridement and cleansing is “dry-docking”—keeping the animal out of water as much as possible¹⁰. In the case of turtles and forest-dwelling tortoises that are dry-docked for prolonged periods, special attention should be paid to maintaining a high ambient humidity (with good ventilation) to protect against eye, mouth and respiratory irritation. Care should also be given to providing the animals with an appropriate thermal gradient.

Some chelonians tolerate prolonged dry-docking well, and you only need to put them back in water for an hour or so each day to drink and eat. Other chelonians seem highly agitated by the experience. For these animals, dry-docking in a dark, quiet room, or doing it at night when the animal is more likely to sleep, sometimes helps. At a minimum, a turtle should be dry-docked for 30 minutes following treatment before returning it to the water. Dry-docking provides time for topical medication to be absorbed and the affected area to air. Many of the organisms that thrive in wounds are anaerobic and do best in a low-oxygen environment¹.

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Two over-the-counter medications routinely used by hobbyists for treatment of superficial shell infections are Acriflavine (diaminomethyl-acridinium) and Malachite green^{1,11}. The former is used for both bacterial and fungal infections, the latter for fungal infections. Both of these medications are highly effective in the right applications, but can be toxic and must be used strictly in accordance with the manufacturer’s instructions.

Any medication used topically on a turtle or in the water will reach the filtration system and may harm or destroy beneficial bacteria. It may also kill aquarium plants. Moreover, some medications are removed by activated charcoal. I recommend doing 100% water changes daily during the treatment period to maintain high water quality. Also, if possible, affected turtles should not be fed in their home tank (see “Poor Water Quality” below).

If possible, affected turtles should be quarantined from

all other animals, since the pathogens they shed into the water may easily infect tank mates with even minor (and perhaps overlooked!) shell defects^{12,13}. If possible, I recommend radiographing any tank mates of animals found to have serious shell infections, to make sure they do not have hidden lesions.

Deep USD/SCUD

If the lesions are severe or deeply penetrate bone, a vet usually debrides and cleanses the affected areas under general anesthesia. Increasingly, vets are also providing follow-up post-surgical analgesics to provide for the animal’s comfort. In some cases, it may be necessary to cover the lesions with light dressings that will need to be changed daily until healing is well underway. If systemic disease is indicated either from clinical examination or blood tests, then appropriate systemic drug therapy will be required. Ketaconazole (Nizoral[®]) or itraconazole (Sporonox[®]) are commonly prescribed for fungal infections. For bacterial infections, commonly prescribed broad-spectrum antibiotics include ciprofloxacin (Cipro[®]), enrofloxacin (Baytril[®]), ofloxacin (Floxin[®]) and gentamicin (Garamycin[®]). The drug of choice will depend on the over-all health of the animal, the pathogen(s) isolated from the infection, and their drug sensitivity.

Deep erosions may need to be sealed with patches similar to those used to repair broken shells after all unhealthy tissue has been removed. (For an excellent review of shell repair, see <http://www.anapsid.org/shellrepair.html>, or Barten¹⁴.) Once the defect has been repaired, topical treatment or visual monitoring of the underlying infection is not possible. Post-treatment blood tests will reveal if the animal still has an infection requiring additional treatment. Shells may take a year or more to heal, and generally bear permanent scars.

Dysecdysis (retained scutes)

In the case of retained scutes, they usually can be lifted off with a blunt probe, taking care not to damage the underlying shell. Soaking the turtle will often help to remove the scutes. Retained scutes should never be forced off as this could damage the new ones underneath. If the turtle has any signs of pus or reddened areas under the scutes, it should be taken to a vet immediately, as these are signs of a more serious ulcerative shell infection and possible septicemia.

Some hobbyists recommend regularly cleaning the shell of hard-shell turtles and tortoises with a soft toothbrush and plain water or dilute povidone-iodine solution. However, over-zealous scrubbing, especially on the softer

“hard”-shelled turtles (e.g. matamatas), runs the risk of creating small micro-abrasions that could provide niches for bacteria and fungi to settle in and begin eroding the shell (B. Whitaker, I. Walker, J. Cover, pers. com). In my experience, it is not necessary to clean the shell of turtles and tortoises maintained under hygienic conditions.

Causes and Prevention

Most shell infections in captive chelonians are the result of poor or inappropriate husbandry practices.

Injury from housing

Turtles and tortoises may abrade or scratch their shell on enclosure walls, fittings, furnishings and abrasive substrates.

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To minimize such injury, construct enclosures from smooth, easily disinfected material such as glass, fiberglass, and plastics; avoid unfinished lumber. Also, avoid using fencing at or below the eye level of box turtles and tortoises; use solid walls instead. These animals tend to pace and push at perimeters they can see through, increasing the chances of shell injury.

Keep enclosure furnishings simple, but adequate to meet the animal’s needs for basking, hiding, digging, etc. In aquatic systems, avoid rough gravel or rock. Many, but not all, aquatic and semi-aquatic turtles do fine in tanks with no tank bottom substrate at all, making it much easier to clean the enclosure. If a substrate is desirable (as in the case of soft-shelled turtles), the tank should have filtration, bottom drainage and low stocking densities. (For excellent guidance on housing freshwater turtles see Highfield¹ and Gurley⁹. For advice on selecting and preparing substrates for tortoises, visit the Tortoise Trust website www.tortoisetrust.org.)

Injury from enclosure mates

Avoid overcrowding and inappropriate social/species combinations that may lead to aggression and injury or excessive mating behavior (which can lead to skin and shell damage as well as stress). Many chelonians are solitary or only mildly social by nature, and keeping them

together may cause stress and compromise their immune function, even if it does not lead to overt aggression.

Injury from predators

Predator-proof outdoors enclosures, keeping in mind that wild animals may enter from both above and below a wall (raccoons, foxes, rats and dogs are excellent diggers). Rodents, in particular, may even gnaw through it!

Shell damage can occur as a result of predation by invertebrates, especially during winter brumation or when chelonians are otherwise torpid¹. Various organisms in the soil may feed upon the keratinized scutes, providing portals of entry for pathogens. Although it may be impossible to prevent these invertebrate attacks, owners should periodically check their animal during hibernation if possible; it is a myth that disturbing a hibernating animal will harm it¹. At the very least, an owner should check his/her animal as soon as it emerges from its torpor. That way, any injuries can be addressed before serious infection sets in.

Ticks can attach themselves to tortoises very easily, penetrating the shell and providing entry by pathogens¹⁵. A common site for attachment is the ventral surface of the posterior marginal scutes at the skin-scute junction. Routinely screening an animal during the tick season should prevent these ectoparasites from causing significant shell damage.

Maggots are frequently observed in injured wild terrestrial and semi-terrestrial chelonians and can exacerbate the damage in an existing wound¹⁶. A crusty, black discharge at the margin of the skin and shell may be a sign of myiasis (maggot infestation). Proper hygiene in outdoor enclosures will help to keep the fly population down, but is also important to keep a careful watch on any open wounds for possible attack. If a wound requires dressing to protect it from flies, it should be changed at least once every other day. A light dressing with gauze will protect the wound while allowing it to air well.

Injury from thermal burns

With thermal burns, bacterial infections are secondary to damage caused by direct contact with a hot surface (e.g. unprotected submersible heaters in tanks, incorrect placement of infrared heating lamps) or prolonged exposure to an overly warm heat source (e.g. floor heating mats).

I do not recommend heating mats, as they are too problematic and some pose serious fire hazards. Highfield¹

describes a safe and effective subfloor heating system for large indoor terrestrial enclosures. For small table-top pens, a good option is to lace vinyl plastic tubing through a portion of the substrate, the ends of which feed into a container of water heated with a thermostatically controlled, submersible heater. The container is located outside the enclosure. A small pump is attached to one end of the tubing, driving the warmed water through it and safely warming the enclosure substrate. This works well for young box turtles and tortoises.

Daytime basking lamps should be placed so that they cannot be touched by the animal—consider what the animal can reach by standing on its hind feet, climbing on furnishings or up walls, or even climbing on top of an enclosure mate.

Bright (visible wave) basking lamps, like overhead lighting, should be on timers to provide an appropriate diurnal and seasonal cycle, similar to what the animals would experience in the wild. For supplemental nighttime heat, ceramic infrared heat emitters (e.g. ESU Reptile Bask 'N' Heat®) can be used. These lamps produce no visible light. They must be used with caution as their heat is very penetrating and intense near the source and can cause tissue damage even without direct contact if placed too close to an animal. Also, ceramic lamps should not be used in lieu of bright basking lamps during the daytime. Research has shown that diurnally active reptiles may experience “thermal confusion” when heat is not paired with light and thus fail to thermoregulate properly¹⁷. When possible, it is preferable to use central heat or an oil-filled space heater (outside the animal enclosure) to meet the ambient heat requirements for an animal.

With regard to heating tanks for aquatic and semi-aquatic turtles, safe options include inline heaters, or shatter-proof, aluminum encased submersible heaters. If a glass tube heater is used, it should be placed behind protective plastic screening or centered in a PVC pipe into which numerous large holes have been drilled.

Shell damage causes by internal disease

Various internal diseases can cause shell damage. For example, chronic renal (kidney) failure causes the kidney to retain phosphorous. As a consequence, , and ooze fluid⁶. The chelonian with renal failure also often presents with fluid retention (ascites) and so appears bloated. It may drink and urinate excessively. A blood test can confirm the presence of kidney disease. As the prognosis is poor, many vets recommend euthanizing the animal.

Renal disease can be due to many causes. Chief among

the husbandry-related causes are improper diet and inadequate hydration. Inadequate ambient humidity, which effects water loss through respiration, may also play a role¹⁸. The Tortoise trust website (www.tortoisetrust.org) posts excellent articles on nutrition, hydration and microclimates. A booklet¹⁹ available through this website provides detailed information on tortoise nutrition and diet planning. Nutrition Support Services (www.herpnutrition.com) is also a good site for information on tortoise nutrition as well as a source of high quality, organically grown diets and other foodstuff for chelonians.

Shell infections associated with dysecdysis

Most species of aquatic turtles shed their scutes as they grow. Scutes are often retained when the animal does not have the opportunity to bask and dry out sufficiently. (Dysecdysis can also be caused by malnutrition and underlying illness^{2,8}.) The space between the retained scutes and underlying new ones provides the perfect niche for opportunistic algae, fungi and bacteria to settle in and begin eroding the shell, giving pathogens a portal of entry into deeper tissue⁵.

It is important to provide a dry “haul out” area large enough so that all the turtles in the enclosure can crawl completely out of the water and dry out. Many turtles will not bask if the water temperature is too warm. It is wise in these cases to lower the water temperature (maintaining it within the temperature range for that species) to encourage them to emerge and bask for at least a few hours each day.

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Keeping turtles outdoors helps to prevent as well as resolve problems of dysecdysis, assuming there is adequate opportunity for basking. The UV exposures, as well as the sun’s warmth and good ventilation, may all play a role in affecting the shedding of scutes. Failure to provide adequate exposure to UV light is considered to be a contributing factor to abnormal scute retention in animals kept indoors¹. I recommend using ZooMed 5.0 UVB® fluorescent lights over enclosures. For heat-loving basking species, these lights can be combined with a UVA/UVB-emitting mercury vapor lamp (e.g. ZooMed PowerSun®).

Inappropriate basking, ambient, and water temperature

Each species, if not each geographically distinct population, has its own set of temperature requirements that promote good health. These temperatures vary depending on such factors as the activity being undertaken, and the health, age and reproductive state of the animal. Inappropriate temperatures and temperature gradients, and subsequent impairment of the immune system of a turtle or tortoise may predispose it to an opportunistic infection¹.

The best advice is to consult with people who have successfully maintained the species long-term, and to read as much as possible about it, including text on the geographic region to which the animal is native. I highly recommend Highfield¹ and Gurley⁹ as starting points.

Poor Water Quality

Unhygienic water that harbors high bacterial and fungal loads are at the root of many shell infections in aquatic turtles. Animals with only minor shell defects in contaminated water may rapidly develop shell infections^{4,13}. Soft-shell turtles are especially susceptible to such infections because their fragile epidermis is easily damaged^{1,9,12}.

Clean water is crucial to good health. The best way to assure this is through frequent full water changes and a good filtration system. Partial water changes are not acceptable. Several factors determine how often the water should be cleaned:

- Volume of water in the system.
- Size and efficiency of the filtration system. Filtration can decrease the frequency of complete water changes but not eliminate them. Turtles produce considerably more solid fecal waste than fish. Most aquarium stores sell filters designed for biologic breakdown of fish waste, not turtle waste. Even if the water looks clean, it can still harbor a significant load of nitrogenous waste.
- Stocking density.
- Feeding frequency, type of food fed (some foods foul the water quickly) and whether food is offered in the home tank/pool or in a separate container. If turtles are fed in their home enclosure, the water should be changed within a few hours of feeding. The practice of leaving uneaten food in the water provides an ideal environment for the proliferation of fungus and bacteria. The home enclosure will stay cleaner longer if feeding

is done in a separate container. Initially, some turtles are reluctant to feed this way, but most will acclimate to it fairly quickly.

When doing a full water change, it is important to scrub and rinse the tank well to remove residual bacterial growth on all sides. The temperature of the change water should be similar to what it was prior to cleaning since abrupt changes in temperature can be highly stressful to a turtle¹⁷. Recent studies suggest that it is advisable to dechlorinate the change water, since ingested chlorinated water may lead to a loss of gut bacterial flora⁹. Moreover, chlorine may damage the biological filtration system.

Use of a UV-C sterilizer in the filtration circuit can substantially reduce the level of potential pathogens in the water, in addition to unsightly algae. When selecting one, it is important to consider the large amount of wastes produced by turtles as compared to fish. (For more information see www.aquariumpros.com.)

A water test kit is valuable in evaluating filter efficiency and helping to determine when water changes are needed. According to Highfield¹, an ideal tank or pond should have the following parameters:

- Ammonia below 0.05 mg/liter (optimal is zero)
- Nitrate concentration below 0.3 mg/liter (optimal is zero)
- Dissolved oxygen greater than 6 ppm
- Redox potential 350 mV (using electronic meter)
- Nitrite zero
- Phosphate zero

The incidence of shell infections in aquatic turtles may be affected by the pH of the water. Levels below 6.5 inhibit the growth of at least some mycotic and bacterial pathogen⁶. For species of turtles that thrive in acidic water (e.g. species of *Chelus*, *Podocnemis*, *Phrynops*, *Batrachemys*, *Platemys*, *Acanthochelys*, *Hydromedusa*), it is well worth the effort to create such an environment for them. Moreover, many species of South American and Asiatic river turtles experience shell and skin degeneration if placed in water which is too alkaline^{1,9}. Both Highfield¹ and Gurley⁹, provide details on ways to raise or lower the pH. They also warn against inadvertently altering the pH by using gravel and other tank furnishings that may leech buffering agents into the water. It is well worth investing in a pH kit (available at aquarium stores) to monitor the pH both before and after adding an animal to a system, to make sure the pH level stays in the appropriate range.

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For species that naturally are associated with somewhat brackish environments (e.g., species of *Callagur*, *Batagur*, *Malachemys* and many of the world’s soft-shelled turtles), it may be beneficial to keep them in mildly saline water. Proprietary blends of marine salt mix (e.g. Instant Ocean®) can be diluted to brackish concentration. For most species 8.75- 12.25 parts per thousand sodium chloride and other dissolved salts is fine; a few species may require higher levels¹. Slightly saline water inhibits the growth of some bacteria⁹.

Algae build-up

The relationship between algae and shell infections in aquatic turtles is poorly understood. In the wild, there may be a symbiotic relationship between algae and turtles; the algae provide some camouflage against predators and prey, and the turtle provides mobility^{20,21}. However, it has been observed that *Bacillaria* algae produce some superficial pitting in the keratin of wild turtles after long-term attachment²². I am unaware of any documented cases of such pitting causing a shell infection in wild turtles.

Another way in which algae may be involved in shell infections is indirect. As layers of algae build up on the shell, they may lift up the margins of the scutes, providing opportunistic pathogens a niche to settle in and begin eroding the underlying tissue⁵. Of course, if the water is clean, no shell infection may ever develop, even in turtles with lifting or pitting of the scutes.

Inadequate enclosure hygiene

Just as it is vital to the health of aquatic turtles to live in clean water, it is important for the land component of their enclosures and the pens of terrestrial species to be hygienic. This is essential not only to prevent the proliferation of pathogenic organisms, but also to prevent the build-up of excreta that can be chemically caustic.

Inappropriate substrate, substrate moisture and humidity

Tortoises can quickly develop plastral ulcerations and sloughing of the scutes if kept on excessively moist sub-

strates^{1,8}. Overly acidic substrates can also be irritating and cause ulcerations¹. As mentioned earlier, the Tortoise Trust website (www.tortoisetrust.org) offers excellent advice on selecting and preparing appropriate substrates for tortoises.

Inadequate ventilation

Poor ventilation is the major initiating cause of bacterial and fungal skin and shell infections, especially if combined with inappropriate temperatures and poor cage hygiene¹. I recommend that turtles and especially box turtles and tortoises be kept in enclosures without lids to increase ventilation. In general, aquariums are poor enclosures for box turtles and tortoises, except for some hatchlings. Space is too limited, it is difficult to establish a proper thermal gradient, and ventilation tends to be poor.

Diet

Food of appropriately high quality and quantity is necessary to ensure balanced nutrition. Mal- or under-nutrition can leave an animal immune-compromised and more susceptible to opportunistic infections or organ damage. (See “Shell Damage Caused By Internal Disease.”) Also, storage of food must not be so prolonged that its nutritive quality is lost.

The practice of providing diseased or cheap, poor quality feeder fish to turtles is particularly dangerous as several common fungal diseases of fish, including *Saprolegniasis*, *Calypotrelegnia* and *Achlya* can also affect turtles¹.

Wallach¹² reported cases of USD in several species of semi-aquatic turtles from which the bacterium *Beneckia chitinovora* was isolated. This organism commonly occurs in crustaceans such as crawfish, shrimp and crabs. For this reason, he recommended that turtles not be fed or housed with these invertebrates. From my experience, it is not a problem to feed shellfish as long as uneaten food is not left in the tank and attention is paid to maintaining high water quality. Under these circumstances pathogenic bacteria will not proliferate to dangerous levels.

What you can do

The underlying message of this article is that owners can do a great deal to prevent shell injuries and infections in their animals by practicing good husbandry. Appropriate housing, climate and lighting, good hygiene, a sound diet, regular checks for minor injuries and parasites, and proper social mixing are the keys to success.

Of course, it is always possible to bring a new animal

home that already has a shell injury or infection. As a matter of course, always quarantine a new animal from others in the collection to make sure the new arrival is healthy. I highly recommend taking the animal to a vet for a wellness check (external exam, blood work, radiograph, and fecal check). Admittedly such a work-up is expensive. A simple fecal exam for parasites (several are

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better, each spaced one week apart) is more affordable. That, coupled with a quarantine period of at least one month, will give the owner a chance to see if the animal has an active infection or injuries in need of special monitoring or medical attention.

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