When leeches feed on aquatic animals, the resultant lesion may allow secondary bacteria to invade and establish infections. Marine leeches (*Ozobranchus margoi*) are found in massive numbers on Green Seaturtles (*Chelonia mydas*), Atlantic Hawksbill (*Eretmochelys imbricata*), Loggerhead Seaturtles (*Caretta caretta*), and Atlantic Ridleys (*Lepidochelys kempi*). High populations of this leech usually are seen on severely emaciated turtles (see Chapter 76).

ENDOPARASITES

Endoparasites live throughout the bodies of most reptiles. Some are pathogens, and some are benign (commensals). These parasites range in size from unicellular intracellular parasites that measure a few microns to tapeworms that measure 15 to 20 centimeters in length. These are considered infections and not infestations. Each has its peculiar aspects of its life cycle, physiology, behavior, and anatomy to assist in its success as a parasite.

Because of some of the needs of many life cycles, the infections may be self-limiting, although some parasites appear to be long lived. In efforts to approach a natural-appearing setting, zoologic collections sometimes mix species, which might allow continuity of an indirect life cycle without knowledge. Some invertebrate hosts gain access to such natural settings with addition of plants in which the invertebrates are living. Thus, care must be taken to monitor the animals for parasitic infections as outlined earlier in this chapter.

Protozoa[7]

Amoebiasis, caused by *Entamoeba invadens*, in reptiles is an important disease in captive snakes, lizards, and chelonians (Figure 21-7). This is a protozoan that moves and feeds by forming pseudopodia, thus changing shape while in the trophozoite stage. The cyst is a resting stage in which a wall is produced by the trophozoite to encapsulate and protect the parasite while it is in the abiotic environment.

The cyst is the infective stage and enters the host via ingestion. It has a direct life cycle. Once in the host, it becomes a feeding motile trophozoite in the large intestine where it begins to reproduce (Figure 21-8). Some become cysts and leave the host in the feces. This parasite can move quickly through collections, resulting in large numbers of infected individuals. In one example of a major snake mortality, multiple deaths occurred within 10 weeks of the indicator case.[8] In another case involving Red-footed Tortoises (*Geochelone carbonaria*) imported into south Florida, 200 of 500 tortoises died over a 6-week period. The deaths began after a cold snap, and the tortoises became depressed, listless, and dehydrated and had watery diarrhea.[9] Histologic examination of the gut and the liver revealed *Entamoeba*.

Depending on the trophozoite's host immune status, this parasite may burrow into the mucosa and cause ulcerations. In immune-competent animals, the infection may stay in the lumen of the large intestine. Moving animals between reptile collections has been suggested to potentially result in outbreaks of amoebiasis as individuals are introduced to strains of *E. invadens* that they are not protected against.[10] Although this has not been proven, it is a logical explanation for acute outbreaks.

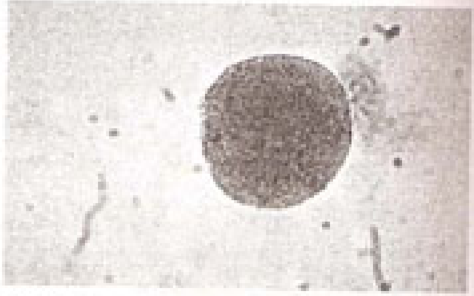

FIGURE 21-7 Ameba, *Entamoeba invadens* trophozoite. Photomicrograph magnification, 1000×.

FIGURE 21-8 Ciliate trophozoite from a Star Tortoise (*Geochelone elegans*). Photomicrograph magnification, 160×.

Signs of amoebiasis include anorexia, dehydration, and wasting. Ulcerative gastritis develops, as does colitis, inducing dysentery with mucus and blood. The liver and kidney may be reached via trophozoites in the blood. The parasite then colonizes these organs, and further damage is done, leading to necrosis and abscess formation. Diagnosis may be aided with direct smear of feces, but the best method is examination of histologic sections of the gut and liver at necropsy. The sections should be stained with trichrome or iron hematoxylin stain for better demonstration of the vesicular nucleus in the trophozoites than with the standard hematoxylin and eosin (H&E) stains.

Trophozoites are found in extracellular spaces near the ulcers or necrotic portions of the tissues. They also are found in other organs such as liver, kidney, and lung. During epizootics of amoebiasis, performance of necropsies on freshly dead or moribund animals is essential.

These parasites damage the host tissue and provide portals of entry for opportunistic bacteria and other pathogens. Therefore, one may have bacterial overgrowth along with amoebiasis simultaneously in a reptile collection.

Coccidiosis

The protozoans that may cause this disease produce an oocyst from development in the epithelial cells that line the

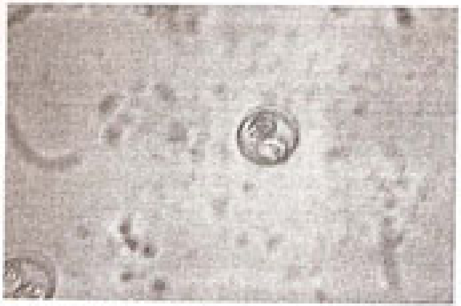

FIGURE 21-9 *Isospora amphiboluri* from a Bearded Dragon (*Pogona vitticeps*). Photomicrograph magnification, 400×.

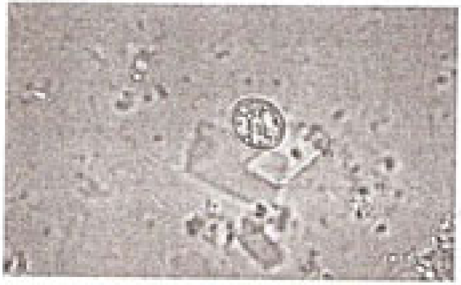

FIGURE 21-10 *Sarcocystis* sp. sporocyst from a viper. Photomicrograph magnification, 1000×.

gut. Not all infections with coccidians cause disease, and sometimes this condition is correctly called **coccidiasis** (infection with coccidians, but not disease). This is opposed to **coccidiosis**, in which the parasite causes disease.

An example of coccidiasis is seen in the Bearded Dragons. It is not uncommon to find coccidia in clinically healthy Bearded Dragons on routine fecal examinations. Many healthy individuals shed large numbers of *Isospora amphiboluri* oocysts. **These animals are infected, not diseased. There is no reason to treat these animals.**

In many cases in which coccidian oocysts are seen in the feces, whether disease or simply infection exists is unknown. Some coccidians (species of *Isospora*, *Eimeria*, and *Cryptosporidium*) have direct life cycles with a single host with the oocysts produced and passed in the feces (Figures 21-9 to 21-12). Others such as *Sarcocystis* spp. are obligate two host cycles normally with a predator-prey relationship and potentially with a reptile for either IH or DH. An exception to the norm was shown with a species of lizard that was able to function as both hosts.[18]

Oocysts are the infective stages to the next host. Most oocysts can be identified to genus by the number of **sporocysts** and sporozoites per sporocyst per **oocyst** (Table 21-2).

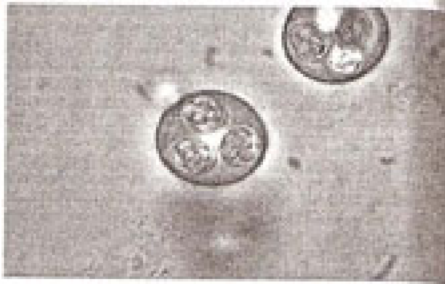

FIGURE 21-11 *Eimeria tokayae* from a Tokay Gecko (*Gekko ge*[...]). Photomicrograph magnification, 1000×.

FIGURE 21-12 *Eimeria* sp. from a Bearded Dragon (*Pogona vitticeps*). Photomicrograph magnification, 1000×.

Table 21-2 Generic Oocyst Morphology

	Sporocyst No.	Sporozoites/ Sporocyst No.
Cryptosporidium	0	4/oocyst
Caryospora	1	8
Isospora	2	4
Sarcocystis	2	4*
Eimeria	4	2

*Oocysts of *Sarcocystis* rupture while passing through the gut; thus, one typ[...] sees sporulated sporocyst.

Only species of *Sarcocystis* and *Cryptosporidium* pass fu[...] infective when they exit the host that produced them. Spec[...] of the other genera need to develop (sporulate) in the abi[...] environment. In no instance has anyone proven that the co[...]cidia that infect reptiles can go vertically through the egg in[...] the progeny. In general, once the sporulated oocyst i[...] ingested, the sporozoites leave the oocyst and penetrate in[...] epithelial cells that line the mucosa. The development i[...] intracellular, and with each phase of the cycle, more host cel[...]

are killed as the parasites exit the host cells in which they were produced and enter other cells.

Set numbers of asexual generations exist within one life cycle, and then the sexual phase ensues and produces gametes and zygotes. A wall is produced by the parasite around the zygote that is now an oocyst. It is expelled from the host cell and passes in the feces.

Whether disease is caused by the developing coccidian depends on the number of oocysts initially ingested, the ability of the host to replace the cells killed quickly enough to preclude clinical disease, the genetics of the parasite itself, and the host immune status. Coccidiosis is usually a disease of young animals.

Clinical signs are usually not detected, but a stunting or slowing of growth and maturation may be seen in lizard hosts. Coccidiosis apparently is important in rearing captive crocodilians in Zimbabwe. To compound this problem, oocysts are rarely found in the feces of these hosts, and diagnosis is with histopathologic examination of the gut tissues. This coccidian evidently develops in other organs than the gut as well. Signs in this case are hemorrhagic enteritis with swelling and congestion of the small intestine.

Cryptosporidiosis

Cryptosporidiosis is caused by species of *Cryptosporidium*. In reptiles this tiny coccidian (oocysts less than 8 microns in diameter) is caused by two species: *C. serpentis* in snakes and *C. saurophylum* in lizards.[13] The former develops on the gastric mucosa, and the latter develops on the mucosa of the small intestine.

This disease is usually fatal in snakes, but the diagnosis is confused by oocysts of rodents fed to the snakes as rodents have their own species of *Cryptosporidium*. These species are not infective to reptiles, but because they are so close in size, they cause serious confusion. **The gold standard for proving a snake is infected with *Cryptosporidium* is by gastric biopsy.**

If the stages are present in classic manner as little round bodies sitting on the surface of the mucosa, the snake is infected. Gastric lavages, direct or fecal flotation examinations, and enzyme-linked immunosorbent assays (ELISAs) to date are insufficient proof for euthanasia of a snake.

Clinical signs in snakes include a midbody swelling and regurgitation of food items 2 to 3 days after eating. Lizards are harmed by their form of cryptosporidiosis and become stunted and sometimes die. Reports of *Cryptosporidium* developing aural-pharyngeal polyps in the ear canal of Green Iguanas are bizarre but do represent an unusual site for development of this coccidian genus.[19] See Chapter 48 for a thorough discussion of reptilian cryptosporidiosis, diagnosis, and management.

HEMOPARASITES OF REPTILES

Species of blood parasites of lizards represent several genera. All of these reside in the blood, and some of these genera are common, with others rarely reported.

Hemoparasites have indirect life cycles. Most are arthropod transmitted, at least in the terrestrial reptiles. Some of the blood parasites of aquatic blood parasites are transmitted by leeches. Most hemoparasites are intracellular, but one genus remains extracellular and is found free in the plasma. Most of these are not considered to be pathogens even though they are killing cells in circulation.

The genera most commonly found are *Plasmodium*, *Haemoproteus*, *Haemogregarina*, *Hepatozoon*, and *Trypanosoma*, and the remainder are minor players that include *Schellackia*, *Lankesterella*, *Fallisia*, and *Saurocytozoon*. The most complete summary of these parasites is that of Telford,[14] and although this publication is somewhat dated, it is still the best starting place for these parasites. Telford[14] indicated that reptiles in some areas were commonly infected with these parasites, whereas in other places, either the prevalence was low or the parasites were not detected. For the most part, these infections are of little significance because most are considered nonpathogenic. Schall[15] has shown that some species of *Plasmodium* do have an impact on their lizard host reproductive capabilities as infected females have smaller clutch sizes and infected males may not be able to defend their territories as well as uninfected males.

The diagrammatic figures in *A Veterinary Guide to the Parasites of Reptiles: Protozoa* by Barnard and Upton[7] illustrate the basic morphology of these parasites. The clinical significance and the management of the hemoparasites are discussed in Chapter 55.

GUT-INHABITING FLAGELLATED PROTOZOA

All parasites in this group have direct life cycles and include species of *Hexamita*, *Monocercomonoides*, *Proteromonas*, *Monocercomonas*, and *Giardia*. The arrangement of the flagella on these motile forms is characteristic of the genera. Many of these have not been proven to be pathogens for their reptilian hosts (*Monocercomonoides* and *Proteromonas*). Some are pathogens at times but are apparently not under other circumstances.

Intestinal flagellates may be disconcerting because permanent slides for staining are nearly impossible. Most of these must be examined in the fresh condition. This is aided with examination of the slides after the flagellates begin to slow down. *Hexamita* is smaller than the rest, usually less than 8 microns in length, and quickly swims directly out of the field of view at high magnifications (Figure 21-13).

If one has the potential to process these for scanning electron microscopy, then the identification is more easily determined. Hexamitiasis in tortoises is caused by *Hexamita parva*, which normally resides in the lumen of the intestines but sometimes enters the biliary tract and the urinary tract in which changes are caused. Pale and enlarged kidneys were seen in some cases. Collecting tubules were dilated. In the liver, bile ducts were thickened and the lumen was dilated. Trophozoites were present in the lumen of tubules in both organs. No specific signs were recognized.[16]

Giardia is a graceful swimmer, and as it rolls over, one can see the concave sucking disc (Figure 21-14). No proof exists that species of this genus cause disease in reptiles.

Monocercomonas has a stiff axostyle running its length, three anterior flagella, and a single trailing flagellum. Monocercomoniosis has been reported in snakes and lizards. Clinical signs include anorexia, wasting, and behavioral changes; individuals may become aggressive. Occasionally, the

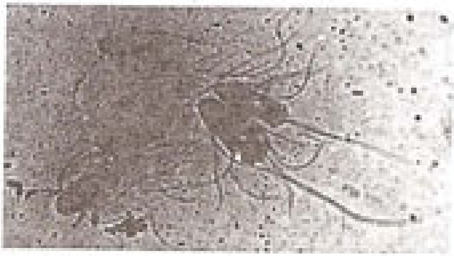

FIGURE 21-13 *Hexamita* from *Clemmys marmorata*. (*Photograph courtesy F.L. Frye.*)

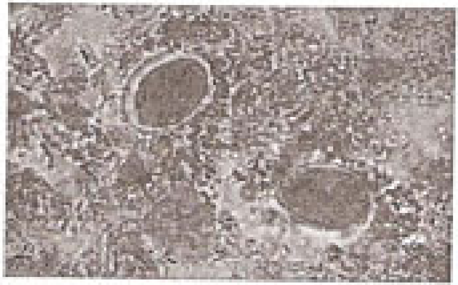

FIGURE 21-14 *Giardia lamblia*. (*Photograph courtesy F.L. Frye.*)

flagellates are found in the reproductive tract, liver, and lungs. The most common lesion is an undermining of the intestinal epithelium and a separation from the underlying propria. Ronidazole (Ridzol, Merck, Iselin, NJ) has been used orally at 10 mg active ingredient/kg 8 to 10 days or 150 mg/liter of drinking water. Supportive therapy may be needed.

CILIATED PROTOZOA

Ciliated protozoa are more commonly found in herbivorous reptiles such as tortoises and some species of lizards. The more common genera are *Balantidium* and *Nyctotherus* (Figures 21-15 and 21-16). These are large ciliates, usually more than 60 microns in length, uniformly covered with cilia. The trophozoites are hard to miss on a direct smear, and the cysts are the means of transmission to the next host via fecal-oral contamination. If stained, the large macronucleus is obvious, but the micronucleus is rarely seen. No indication is seen that these cause disease in reptiles.

MICROSPORIDIOSIS

Although this group of complex protozoans is rarely a problem in reptiles, now and then reptiles are infected and these

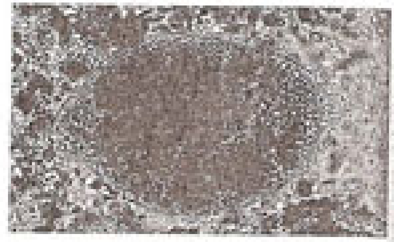

FIGURE 21-15 *Nyctotherus* (merthiolate stain). (*Photograph courtesy F.L. Frye.*)

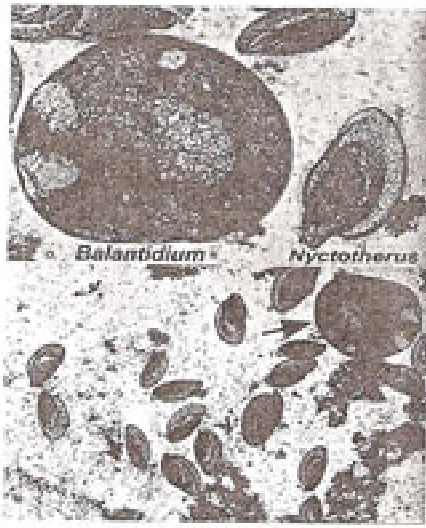

FIGURE 21-16 A, *Balantidium* (left), *Nyctotherus* (right). Note si[ze] difference. B, *Balantidium* (larger, upper right, arrow), *Nyctotherus* (numerous). (*Photographs courtesy F.L. Frye.*)

parasites may lead to the death of the infected host. Most [of] the infections in reptiles (snakes, turtles, and lizards) a[re] caused by species of *Pleistophora*. These are usually repr[e]sented by cyst-like masses of the spores in muscles but m[ay] occur in other tissues as well. Little is known about their bi[ol]ogy in their reptilian hosts.

Bearded Dragons were recently found to be infected wi[th] microsporidians. The spores were found mainly in th[e] livers of the dragons.[17] This group of parasites is becomin[g] recognized more commonly in various classes of vertebrate[s] whereas most of them are parasites of invertebrates, predom[in]inantly arthropods.

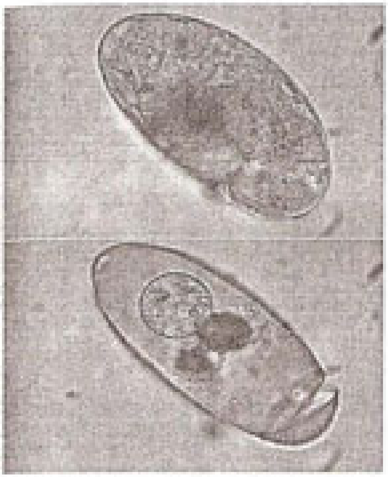

FIGURE 21-17 A, Fluke egg (*Lophotaspis vallei*) containing larva. B, *L. vallei* egg that has hatched from a Loggerhead Seaturtle (*Caretta caretta*). Photomicrograph magnification, 400×.

TREMATODES

These metazoans are all parasitic flatworms. Some have direct life cycles (**monogenetic flukes** and aspidobothrid flukes), and the remainder have indirect life cycles (**digenetic flukes**). The latter is commonly found in all groups of reptiles, and some are extremely pathogenic.

Monogenetic trematodes are primarily found as ectoparasites of fish. A few species parasitize fresh water turtles. They reside in the urinary bladders, oral cavity, and associated spaces of their turtle hosts. They are not known to be pathogenic to their reptilian hosts and are included here for completeness.

Aspidobothrid trematodes have the ventral surface subdivided as a holdfast organ. These are considered intermediate between the monogenetic and digenetic flukes. Most of these are parasites of molluscs, but a few species are parasites of turtles. *Lophotaspis vallei* resides mainly in the stomach and upper small intestine of Loggerhead Seaturtles (Figure 21-17). They are not known to cause any damage to their hosts.

Digenetic trematodes are the most diverse group of trematodes (Figures 21-18 to 21-24). They all require at least one IH to complete their cycles, and some require two or more. These live in nearly every soft tissue organ in the body of their reptilian hosts, although most reside in the gastrointestinal tract. They all have the potential to alternate between generations of sexual reproduction and asexual reproduction. The former occurs in the DH, and the latter occurs in the first IH, which is normally a mollusc. Some use terrestrial gastropods for their IHs and are therefore not tied to an aquatic habitat.

Other digenetic trematodes need aquatic snails for their first IH, and thus, flukes have different potentials to be found in captive reptilian collections kept in natural settings.

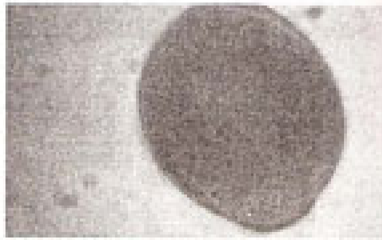

FIGURE 21-18 *Nematophila* sp. egg from a Yellow-footed Tortoise (*Geochelone denticulata*). Photomicrograph magnification, 400×.

FIGURE 21-19 *Euparadistomum* sp. from a Green-eyed Gecko (*Gekko smithii*). Photomicrograph magnification, 400×.

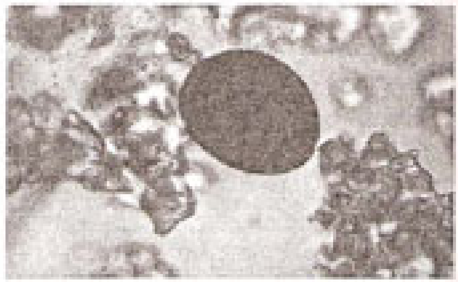

FIGURE 21-20 *Orchidasma amphiorchis* from a Loggerhead Seaturtle (*Caretta caretta*). Photomicrograph magnification, 400×.

Most digenetic trematodes have evolved to a level of mutual coexistence, and little or no pathology is inflicted. However, when a reptile keeper opens the mouth of a snake and sees worms attached to the oral mucosa and in the esophagus, they are a problem that needs to be eliminated for aesthetic reasons. These flukes include *Haplometroides*, *Ochetosoma*, *Pneumatophilus*, *Stomatrema*, and *Zeugorchis*. They are acquired with eating a vertebrate second IH that contains encysted metacercariae.

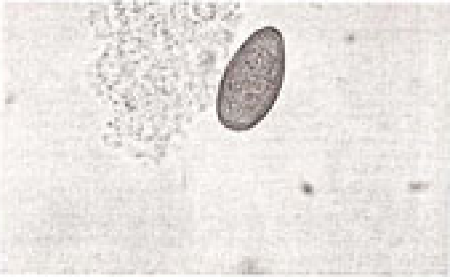

FIGURE 21-21 *Enodiotrema* sp. from a Loggerhead Seaturtle (*Caretta caretta*). Photomicrograph magnification, 400×.

FIGURE 21-24 *Learedius learedi* from a Green Seaturtle (*Chelo mydas*). Photomicrograph magnification, 400×.

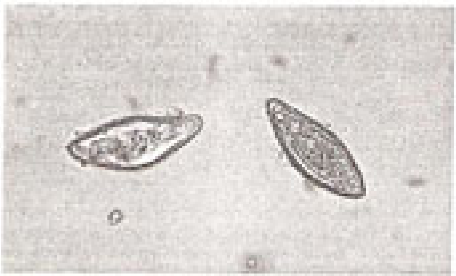

FIGURE 21-22 *Pachypsolus irroratus* from a Loggerhead Seaturtle (*Caretta caretta*). Photomicrograph magnification, 400×.

FIGURE 21-25 *Neospirorchis* sp. from a Loggerhead Seatu (*Caretta caretta*). Photomicrograph magnification, 400×.

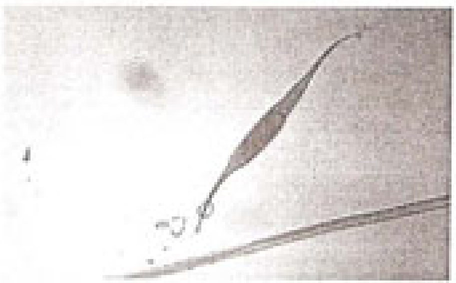

FIGURE 21-23 *Hapalotrema loossi* from a Loggerhead Seaturtle (*Caretta caretta*). Photomicrograph magnification, 400×.

Spirorchiidae, a group of flukes whose adults live in blood vessels and the heart, are pathogenic. As for all parasites that are going to exist in nature, they have to get their offspring (eggs) out of the host as a source of infection to another host and perpetuation of the species. Because no direct means exists to eliminate eggs from the blood, the eggs are trappe in capillary beds and then essentially are worked passiv through the host tissue into the gut where they may be sh in the feces. Sometimes the adults may be numerous enoug to block smaller vessels (capillaries) and cause ischemia an damage to the tissue not being fed or oxygenated. Sometim the eggs can pile up and cause the same problem, and so of those eggs that leave the gut are trapped by the host an form granulomas. These can be found in most soft tissues the body, and the more of these that develop in an organ, t less functional that organ becomes.[18] Marine turtles may b seriously affected by these flukes (Figure 21-25; see Chapter 7

Other flukes, such as *Styphlodora* spp., live in the excreto system. This is a common parasite in free-ranging snak with up to 66% of some snakes infected. A captive boa di after about 6 months of anorexia, and the adults of *Styphlod horrida* were recovered from the preserved kidneys.[18] Th flukes were believed to be the cause of death.

TAPEWORMS

Tapeworms are flatworms comprising a scolex (holdfa organ) and a chain of repetitive sections (proglottids

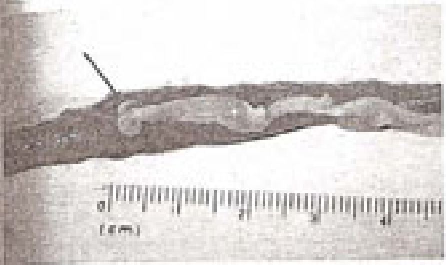

FIGURE 21-26 *Bothridium* sp. tapeworm in the intestine of a Ball python (*Python regius*). Note the scolex on the left side of the photograph (arrow). (Photograph courtesy S. Barten.)

Each proglottid increases in maturity as they move farther from the scolex with budding of new sections. The adults reside in the small intestine of their DH, and they all have indirect life cycles (Figure 21-26). Tapeworms parasitize all groups of reptiles except crocodilians.

Tapeworms can outcompete the host for basic nutrients, but if the host is on a good plane of nutrition, tapeworms are not considered to be pathogens. Reptiles may serve as an IH as the larvae tapeworms, not the adult, are found in the reptiles. These larvae are often subcutaneous, causing bumps or ridges in the skin, and make a reptile less attractive for display purposes.

Many of the adult tapeworms of reptiles are in the families Anoplocephalidae, Diphyllobothriidae, and Proteocephalidae. Anoplocephalidae typically use a mite or an insect as the IH. Diphyllobothriidae life cycle uses two IHs, typically an aquatic crustacean as the first and a vertebrate as the second (Table 21-3).

Proteocephalidae cycles have the eggs eaten by copepods in which the procercoid larva develops, and these are infective to the DH. But they first develop into plerocercoids, and these develop in the solid organs, such as the liver. The parasite then wanders through the host, and if it reaches the lumen of the intestine, it attaches and matures. Adult tapeworms may be diagnosed with fecal flotation if the eggs are released from the proglottids or with visualization of free proglottids in the feces and then a search for eggs in normal saline solution. All of the tapeworm eggs (except species of the Diphyllobothriidae) from reptile feces should contain a fully formed oncosphere with six hooks (Figures 21-27 to 21-33).

Larval tapeworms of *Spirometra* (spargana) may be found in the viscera (see Figure 72-11) or subcutaneously in snakes and lizards, and the same is true for the tetrathyridia of *Mesocestoides*. The latter should contain an inverted scolex with four suckers, but this is not always obvious in the experience of the senior author.

ACANTHOCEPHALA

The spiny headed worms are the acanthocephala, and the adults all live within the small intestines. They have a retractable proboscis armed with spines that is inserted into the mucosa as a holdfast. They have separate sexes and lack a digestive system. These helminths have indirect life cycles, usually with an arthropod as the IH, but occasionally they use a terrestrial reptile (usually a lizard) as a paratenic host.

Cystacanth larvae are encysted usually in the abdominal cavity, and these are infective to the DH as the cystacanths in the normal arthropod IHs.

The eggs of acanthocephalans are usually complex with multiple layers enclosing the acanthor larva (Figure 21-34). Some of these rise on fecal flotation, and others must be detected with a sedimentation procedure. Perhaps the best examples of acanths in reptiles are the species of

Table 21-3 Tapeworm Genera and Reptile Hosts

Genus	Reptiles Infected	Intermediate Hosts
Anoplocephalidae		Mites and insects
Oochoristica	Snakes, lizards, turtles	
Panceriella	Varanids	
Diochetos	Lizards	
Semenoviella	Lizards	
Diphyllobothriidae		Freshwater crustaceans then vertebrates
Scyphocephalus	Varanids	
Bothridium	Varanids, boids	
Duthiersia	Varanids	
Proteocephalidae		Freshwater crustaceans
Ophiotaenia	Snakes, lizards	
Macrobothriotaenia	Snakes	
Kapsulotaenia	Varanids	
Acanthotaenia	Varanids	
Crepidobothrium	Snakes	
Deblocktaenia	Snakes	
Tejidotaenia	Lizards	

From Schmidt GD: *Handbook of tapeworm identification*, Boca Raton, Fla, 1986, CRC Press.

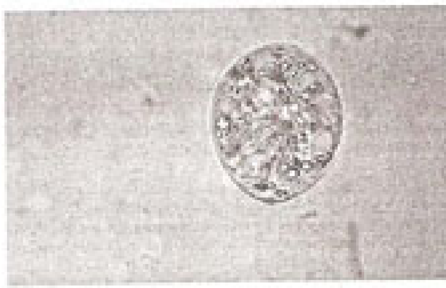

FIGURE 21-27 Cestode eggs as passed in feces from a python (*Python* sp.). Photomicrograph magnification, 400×.

FIGURE 21-28 Cestode larva from a python (*Python* sp.). Photomicrograph magnification, 400×.

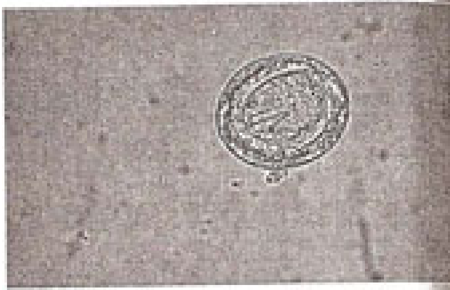

FIGURE 21-30 Unknown tapeworm egg from a Rhinoceros Iguana (*Cyclura cyclura*). Photomicrograph magnification, 400×.

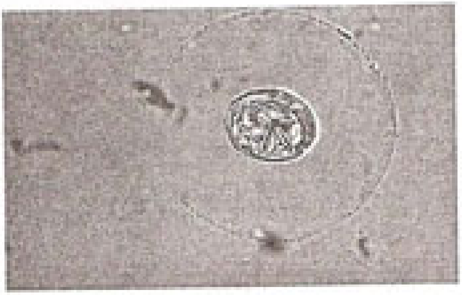

FIGURE 21-29 *Oochoristica* from a Tokay Gecko (*Gekko gecko*). Photomicrograph magnification, 400×.

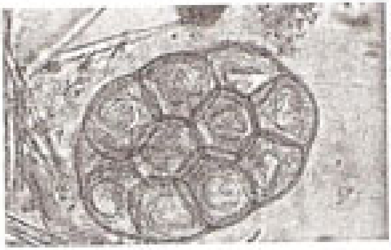

FIGURE 21-31 Unknown tapeworm egg from a boa. Photomicrograph magnification, 400×.

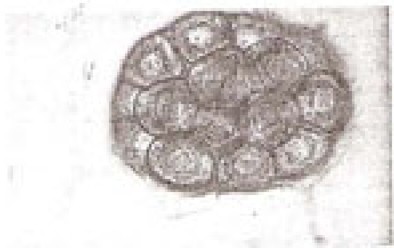

FIGURE 21-32 Unknown tapeworm egg from a Green Tree Python (*Morelia viridis*). Photomicrograph magnification, 400×.

Neoechinorhynchus, which infect freshwater turtles. The proboscis spination of these is reduced, and they are unlikely to cause much damage.

NEMATODES

Nematodes are tubular worms and are round in cross section and thus called round worms. They are parasites of all groups of reptiles. Adults live in tubular organs such as the gut, free in the body cavity, in the lungs and nasal passages, and subcutaneously in their reptilian hosts (see Figure 15-31). They may have either direct or indirect life cycles. They have separate sexes and complete digestive systems.

Some are pathogenic, and some may be beneficial. The effects of most nematodes are unknown, and many could be neutral in their influence on their hosts. Nematodes are the most diverse group of helminths that infect reptiles. Some produce eggs, some release L_1 larvae, and some produce microfilariae that are actually motile embryos. Those that produce eggs are diagnosed with fecal flotation, and those that release larvae are easily diagnosed with a Baermann funnel. These larvae do float but are greatly distorted by the flotation medium. Those nematodes that produce microfilariae can be detected with a finding of microfilariae in the blood. Members of the Rhabditida, Strongylida, Spirurida, Ascarida, and Oxyurida, and superfamilies Trichuroidea and Filarioidea will be discussed.

The order **Rhabditoidea** includes *Strongyloides* and *Rhabdias* (Figures 21-35 and 21-36). These tiny nematodes are represented as parthenogenetic females in the homogonic cycle and also have a free-living phase called the heterogonic phase. Both have direct life cycles, and the infective stage

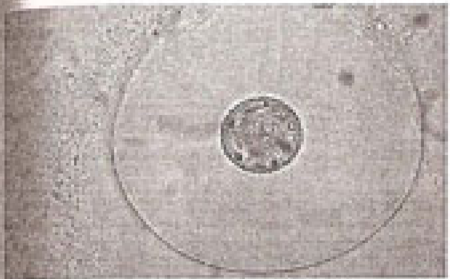

FIGURE 21-33 Unknown tapeworm egg from a python (*Python* sp.). Photomicrograph magnification, 400x.

FIGURE 21-36 Nematode egg from a Blue-tailed Monitor (*Varanus doreanus*). Photomicrograph magnification, 400x.

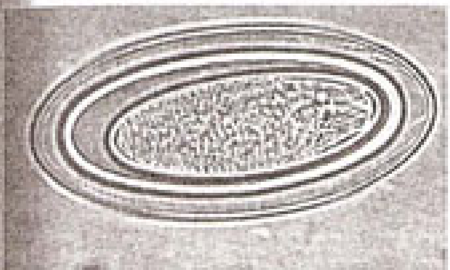

FIGURE 21-34 Acanthocephalan egg from a monitor lizard. Note the multiple layers enclosing the acanthor larva. (*Photograph courtesy ... Frye.*)

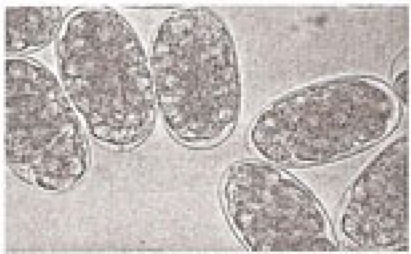

FIGURE 21-37 *Kalicephalus* sp. eggs from a Black Racer (*Coluber constrictor*). Photomicrograph magnification, 400x.

FIGURE 21-35 Nematode egg (*Rhabdias* sp.) from a Red Ratsnake (Cornsnake) (*Elaphe guttata*). Photomicrograph magnification, 400x.

...h penetrate intact skin and move to the site of adult development. Adults of *Rhabdias* spp. reside in the lungs, and infections may be benign or they may induce great quantities of mucus production, pneumonia, and gasping for air. This may be fatal if the hygiene is poor and high temperature and humidity exist, which are ideal for the free-living heterogonic cycle to increase the populations of infective larvae.

The eggs are larvated when shed by the females, and these may hatch as they exit the host. Adults of *Strongyloides* reside in the small intestine and may become entwined in and out of the mucosa. In a case of a Burmese Python (*Python molurus bivittatus*) infected with *Strongyloides*, the python became anorexic and died. On necropsy, the ureters were obstructed and distended and ureteritis, nephritis, and gastroenteritis developed. Multiple sections of worms were found in these tissues. Whether the entire problem was caused by the nematode infection or merely associated with it is unresolved.[30]

The Strongylida has some important blood-sucking nematodes. These include *Kalicephalus* of snakes (Figure 21-37). They normally reside in the small intestine but have been presented to the senior author from the mouth and esophagus of snakes (Figure 21-38). The oral cavity is fairly distinctive (Figure 21-39), and the males have a prominent copulatory bursa (Figure 21-40).

Another genus found in stomachs of tortoises is *Chapiniella* (Figure 21-41). This species has a different oral appearance because of a large oral cavity that is preceded by two rows of sensory papillae that compose the leaf crowns.[31] They have direct life cycles, and the infective larvae are eaten and usually

FIGURE 21-38 *Kalicephalus* sp. larva in the oral cavity of a snake. (*Photograph courtesy D. Mader.*)

FIGURE 21-39 *Kalicephalus* sp. Anterior end shows the distinctive oral cavity (from *Bothrops* sp.). Photomicrograph magnification, 160×.

FIGURE 21-40 *Kalicephalus* sp. Prominent copulatory bursa (from a Black Racer). Photomicrograph magnification, 100×.

FIGURE 21-41 *Capillaria* sp. egg from an Ornate Box T[...] (*Terrapene ornata*). Photomicrograph magnification, 400×.

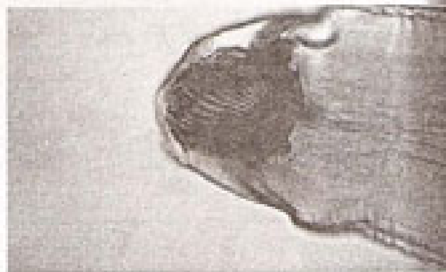

FIGURE 21-42 *Serpinema* sp. Common Spirurid from a freshwa[...] turtle. Note the distinctive buccal capsule. Photomicrograph mag[...] fication, 160×.

enter the wall of the stomach or intestines, mature, and th[...] return to the lumen and attach to the mucosa.

The Spirurida are a group of nematodes that use an I[...] (usually an arthropod) and live in the upper digestive syste[...] primarily in the stomach. *Serpinema* is common in freshwa[...] turtles. The distinctive buccal capsule helps identify spe[...] of this genus (Figure 21-42). *Spiroxys* lives in the stomachs [...] freshwater turtles, and their mouths are also distinct[...] (Figure 21-43). Species of this genus use microcrustacean[...] IHs and then in *Spiroxys* are able to use a variety of aqua[...] organisms ranging from fish and amphibians to snails an[...] dragonfly naiads as paratenic hosts.

Another important order is the Ascarida. These are lar[...] worms with three prominent lips (Figure 21-44). The spec[...] of *Hexametra*, *Amplicaecum*, *Ophidascaris*, and *Polydelphis* p[...] marily infect the stomachs and intestines of snakes and ha[...] indirect life cycles (Figure 21-45). *Dujardinascaris* is a genus [...] stomach worm of crocodilians (Figure 21-46). They u[...] amphibians, reptiles, and small mammals as IHs. Some [...] these induce deep pits where the worms attach, and sometime[...] many worms can be attached in a single crater-like lesion.

Sulcascaris sulcata is a parasite of the stomach of Loggerhea[...] Seaturtles and uses oysters as its IH (Figures 21-47 and 21-48[...]

FIGURE 21-43 Distinctive mouth parts of *Spiroxis* sp. from a freshwater turtle. Photomicrograph magnification, 400×.

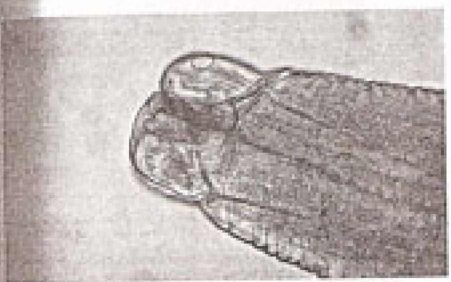

FIGURE 21-44 Prominent lips on the mouthpart of an Ascarid nematode. Photomicrograph magnification, 100×.

FIGURE 21-45 *Polydelphis* sp. from a Reticulated Python (*Python reticulatus*). Photomicrograph magnification, 400×.

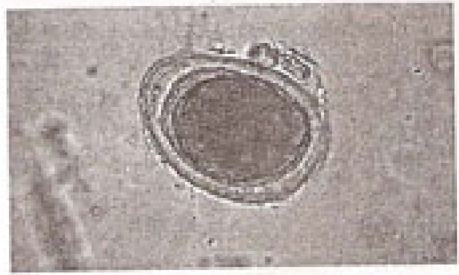

FIGURE 21-46 *Dujardinascaris* sp. from an American Alligator (*Alligator mississippiensis*). Photomicrograph magnification, 400×.

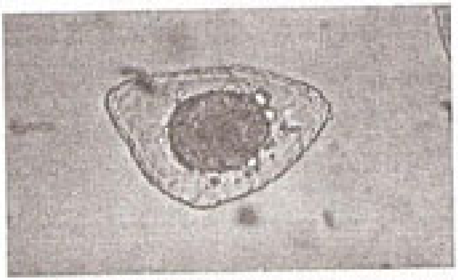

FIGURE 21-47 *Sulcascaris sulcata* from a Loggerhead Seaturtle (*Caretta caretta*). Photomicrograph magnification, 400×.

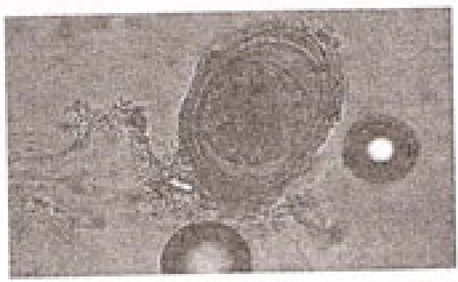

FIGURE 21-48 *Sulcascaris sulcata* from a Loggerhead Seaturtle (*Caretta caretta*). Photomicrograph magnification, 400×.

The eggs of all of these are large and pitted or roughened on the shell.

The order Oxyurida has many genera (Table 21-4) that infect reptiles. The eggs are smooth and elongate, with a straight side and a lens-shaped plug at one end (Figures 21-49 to 21-51). Most lizards have at least one species, and some have

Table 21-4	Genera of Oxyurida (Pinworms) of Reptilian Hosts
Genus	**Definitive Hosts**
Ozolaimus	Iguanids
Pentluria	Iguanids
Parapharyngodon	Lizards
Pharyngodon	Lizards
Skrjabinodon	Lizard
Spauligodon	Lizards and tortoises
Tachygonetria	Uromastix and tortoises
Alaeuris	Lizards and tortoises
Thelandros	Lizards and tortoises
Mehdiella	Tortoises
Ortleppnema	Tortoises
Thaparia	Tortoises

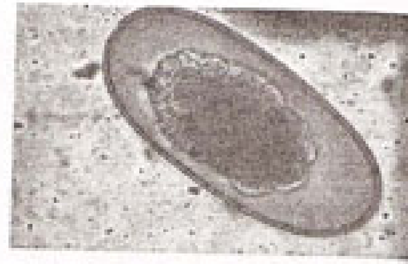

FIGURE 21-51 Unknown pinworm from a spur-thighed (Gre... Tortoise (*Testudo graeca*). Photomicrograph magnification, 400×.

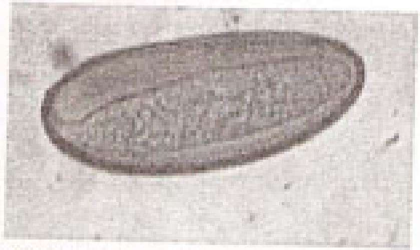

FIGURE 21-49 *Ozolaimus* sp. from a Green Iguana (*Iguana iguana*). Photomicrograph magnification, 400×.

FIGURE 21-52 Large colon from a Desert Tortoise (*Gopherus ag... sizii*) impacted with Oxyurid larva. (*Photograph courtesy D. Mader*...)

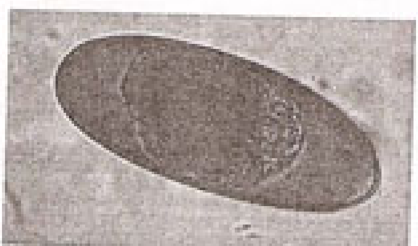

FIGURE 21-50 Unknown pinworm from a Spur-thighed (Greek) Tortoise (*Testudo graeca*). Photomicrograph magnification, 400×.

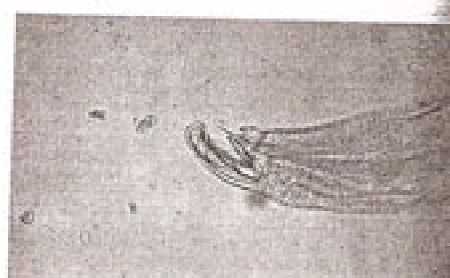

FIGURE 21-53 Posterior end of male *Ozolaimus* sp., lateral vi... This is an important distinction for identification of different spe... of pinworms.

several. The tortoises often have a community of multiple species of these short worms (Figure 21-52). These worms all have an esophageal bulb that helps to distinguish them. They are short worms, and the females have a long tapering tail that gives them their name. The male posterior ends are all important in identification, and two such tails are illustrated: *Ozolaimus* lateral view (Figure 21-53) and *Alaeuris* sp. ventral view (Figure 21-54). They live in the lumen of the large intestine (Figure 21-55). They all have direct life cycles, and for the main part, these should be left intact. Many people have tri... to eliminate them and have not had great success. Sometim... harm is done to the host with the drugs whose application i... unwarranted.

The Trichuroidea of reptiles are in two genera. *Capillaria* sp... are tiny worms that live mainly in the small intestine, and th...

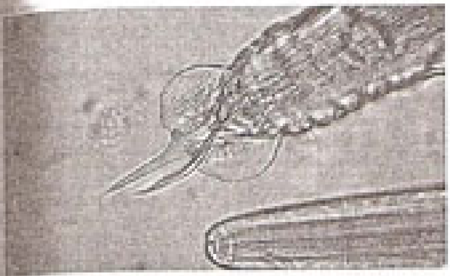

FIGURE 21-54 Posterior end of a male *Aleuris* sp., ventral view.

FIGURE 21-55 Oxyurids in the distended colon of a Green Iguana (*Iguana iguana*). (*Photograph courtesy S. Barten.*)

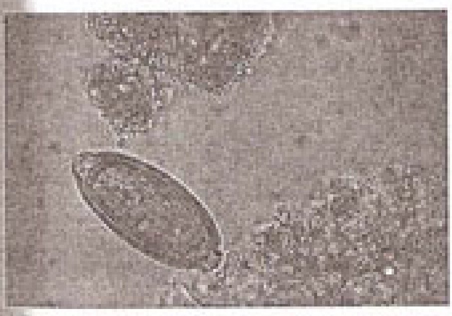

FIGURE 21-56 *Capillaria* sp. egg from a Green Tree Python (*Morelia viridis*). Photomicrograph magnification, 400×.

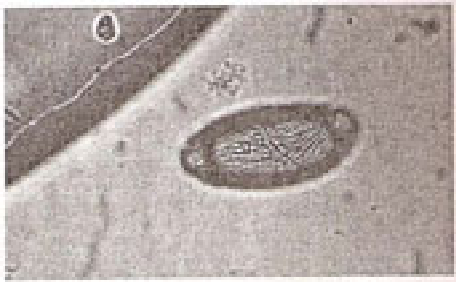

FIGURE 21-57 *Capillaria* sp. egg from a Green Tree Python (*Morelia viridis*) (same egg as in Figure 21-56—focus is on the shell surface). Photomicrograph magnification, 400×.

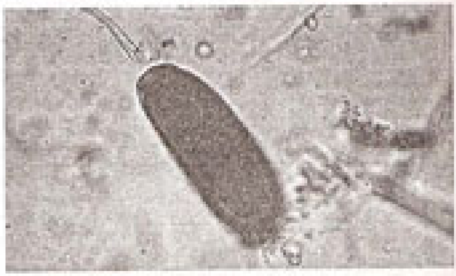

FIGURE 21-58 *Capillaria* sp. egg from a boa. Photomicrograph magnification, 400×.

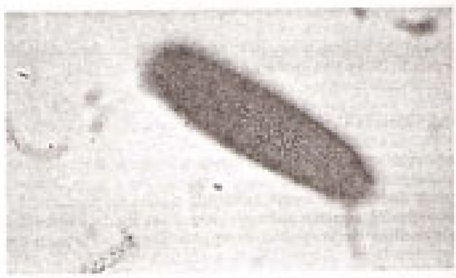

FIGURE 21-59 *Capillaria* sp. egg from a boa (same egg as in Figure 21-58—focus is on the shell surface). Photomicrograph magnification, 400×.

Females contain the bipolar eggs as illustrated previously (Figures 21-56 to 21-59). The second genus is *Paratrichosoma*; these worms live under the abdominal skin of crocodilians in Asia and make black tracks in the skin as they migrate.[21]

Members of the final order, Filarioidea, all require some sort of vector to deliver the infective larvae to the DH. Adults live in blood vessels, in body cavities, subcutaneously, and in connective tissues. *Foleyella furcata* resides in the subcutaneous tissues and body cavity of chameleons (Figure 21-60). *Macdonaldius oschei* adults live in the major arteries of Pythons, and the microfilariae are in the blood. Frank[33] found necrotic lesion in the muscle that he attributed to being

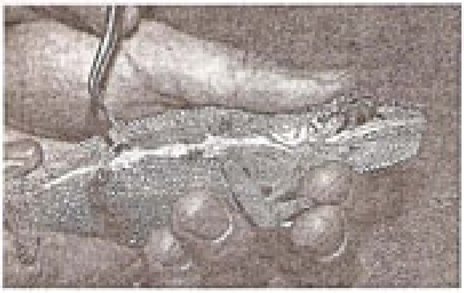

FIGURE 21-60 *Foleyella furcata* being removed from the subcutaneous tissue of a chameleon. (*Photograph courtesy D. Mader.*)

Table 21-5 Genera of Filarioidea in Reptilian Definitive Hosts

Hosts	Genera
Crocodilians	*Oswaldocruzia*
Crocodilians and lacertid lizards	*Befilaria*
	Conispiculum
	Gonofilaria
	Piratuba
	Piratuboides
	Solafilaria
Chameleons and lacertid lizards	*Foleyella*
Chelonians and lacertid lizards	*Cardianema*
	Pseudothamugadia
	Madathamugadia
	Thamugadia (gecko)
Lacertid lizards	*Saurositus*
Snakes and lizards	*Macdonaldius*

caused by occluded arteries. Five species of *Oswaldocruzia* reside in different locations in their DHs (Table 21-5).

PENTASTOMIDS

About 70 species of pentastomids are recognized worldwide. These primitive arthropods, which look like a cross between a helminth and an insect, belong to their own phylum. The majority of pentastomids are found as adult worms (as opposed to larval stages) in reptiles. The adult worms are segmented and worm-like, measuring from 0.5 to 20 cm in length, and are exclusively internal and usually occur in the lungs of snakes, lizards, and crocodilians (Table 21-6).[38] Evidence of the adult worms living in the lungs on survey radiographs is not uncommon (Figure 21-61).

Turtles may be occasionally infected. The most common genera of reptilian Pentastomes are *Raillietiella, Porocephalus, Kiricephalus, Armillifer*, and *Sebekia*.

Raillietiella spp. occur in lizards and snakes, and *Kiricephalus* spp. may be found in nonpoisonous snakes of the United States. The American Rattlesnake and the Cottonmouth Moccasin harbor the *Porocephalus crotali*. *Armillifer* spp. infect the vipers and

Table 21-6 Pentastomids and Reptilian Hosts

Host	Genera
Crocodilians	*Sebekia* spp.
Monitor Lizards	*Elenia* spp. and *Sambonia* sp
Lizards, snakes	*Raillietiella* spp.
Nonpoisonous snakes in the United States	*Kiricephalus* spp.
Rattlesnakes and Cottonmouth	*Porocephalus* spp.
African Python	*Armillifer* spp.

FIGURE 21-61 Radiograph of a wild Indigo Snake (*Drymarch* *couperi*). Note the radiodense serpiginous pattern within the lun (*yellow arrows*). These are internal pentastomid parasites. (*Photogra courtesy D. Mader.*)

African Python, and *Sebekia* spp. have the crocodilians a hosts.

Pentastomids have an ability to bore through tissue, an adult worms occasionally may pierce through the lung a body and protrude from the skin. Pentastome infections m be asymptomatic with little inflammatory response, but other instances, significant damage and destruction of tis of the host may be seen.

The life cycle consists of the adult parasites in the lun depositing eggs that contain larvae and have four leg-li appendages (see Figure 21-1). These eggs are coughed u swallowed, and then passed in the fecal material. A fe examination reveals characteristic pentastomid ova: a d tended thin-walled capsule that measures up to 130 micro eters in diameter. Larvae, with four hooklets, are seen wit the egg (Figures 21-62 to 21-65).

The eggs develop to an infective stage and are swallowe by an IH where larval development takes place. The larv develop into infective nymphs in the IH and then into adul in the reptile host after ingestion of the IH. The infective la vae perforate the intestinal wall of the host and migr through the body to enter the lungs. The major pathology the host is the local tissue damage that results from attac ment in the lung (Figure 21-66).

The severity and nature of the host's response are depend ent on the immune status of the host, the number and sta of the invading parasite, and presence or absence of co current disease. Despite the migratory passages,

FIGURE 21-42 *Pentastome* eggs are characteristically thin walled and can measure up to 130 μm in diameter. Larvae with four hooklets are typically seen within eggs. This is an unidentified pentastome from a Water Monitor (*Varanus* sp.).

FIGURE 21-43 *Raillietiella frenatus* from a Tokay Gecko (*Gekko gecko*). Photomicrograph magnification, 400x.

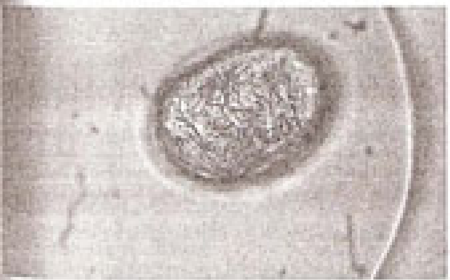

FIGURE 21-44 *Sebekia* sp. from a Softshell Turtle (*Apalone* sp.). Photomicrograph magnification, 400x.

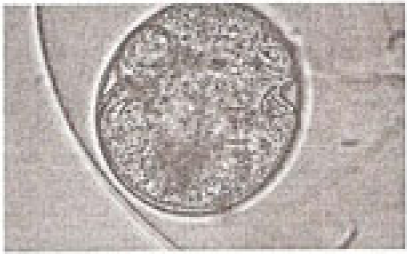

FIGURE 21-45 Unknown pentastome from a Narrowhead Softshell Turtle (*Chitra indica*). Photomicrograph magnification, 400x.

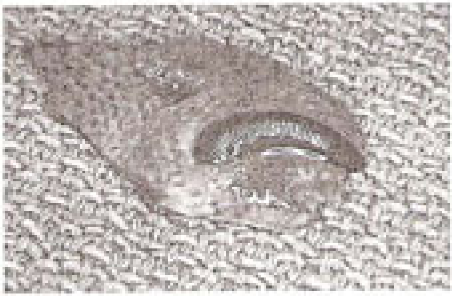

FIGURE 21-46 Close-up of a pentastomid parasite adhering to the inside of the lung tissue from a python (*Python* sp.). (*Photograph courtesy D. Mader.*)

infections with pentastomids, especially in wild reptiles, are asymptomatic.

Young hatchling crocodilians in captivity seem the most susceptible, and severe tissue and pulmonary damage may result from a *Sebekia* spp. infection. Usually, focal tissue damage in the lungs is seen at the site of attachment. Cherry and Ayer[3] report a prevalence of 93% *Sebekia oxycephala* in their survey of alligators. Diagnosis can be accomplished with the finding of eggs in feces. The eggs contain a larva form with hooks, which can be seen inside the egg.

Deakins[24] ascribed the death of American Alligators (*A. mississippiensis*) to an infection with *S. oxycephala*. Cause of death was pulmonary damage and intestinal hemorrhage. The pentastomid hooks, besides serving to hold the adult parasite to the lung tissue, may facilitate the entry of bacteria into the tissue and result in chronic pneumonia.

Boyce and coworkers[25] reported an infestation of *Sebekia* in captive hatchling alligators. The hatchlings were infected with *S. oxycephala* with ingestion of live mosquito fish

A B C D

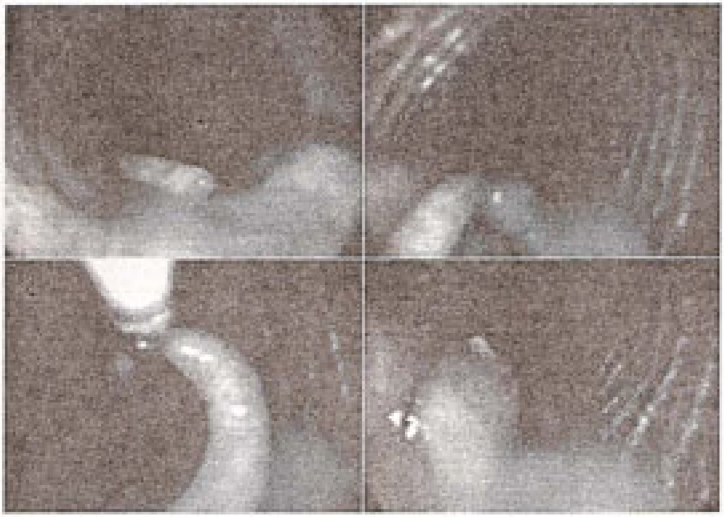

FIGURE 21-67 A, Adult pentastomid in the lung of an Indigo Snake (*Drymarchon couperi*). B, Attachment of the mouth part to the lung tissue. Note the raised inflammatory response associated with attachment. C, Grasping the pentastomid near the attachment so as not to allow the parasite to break into pieces when traction is applied. D, Inflamed tissue left behind after the parasite has been removed. (*Photographs courtesy D. Mader.*)

(*Gambusia affinis*). Anorexia, weight loss, and respiratory distress were reported for the 4-week-old hatchlings. *S. oxycephala* larvae were recovered from lung tissue. Freezing the mosquito fish at 10°C for 72 hours was found to kill the *S. oxycephala* larvae in the fish. In most situations, control of *Sebekia* infections can be accomplished through hygiene and the control of dietary materials.

Treatment is controversial. Because an IH is necessary for completion of the life cycle, infections in animals in captivity should be self-limiting and treatment may not be needed.

Reports are found with use of levamisole and ivermectin, but because infections may be self-limiting, without controlled studies, conclusion that the chemotherapeutics were effective is difficult. Surgical or endoscopic retrieval of the adult parasites offers a viable option for removal of parasites from animals with high intensities (Figures 21-67 and 21-68).[36]

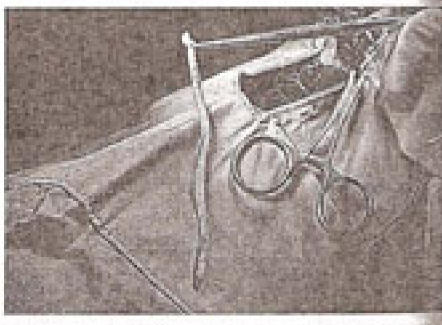

FIGURE 21-68 Extracted adult pentastomid from the lung of [a] Indigo Snake (*Drymarchon couperi*). Endoscopy allows simple, [...] extraction of the typically low worm burden. (*Photograph courtesy D. Mader.*)

PARASITE TREATMENT

An important consideration in treatment of parasites is the nature of the parasite's life cycle. Remember that a parasite with a direct life cycle has the potential of reinfecting its host over and over again. A parasite with an indirect life cycle requires an IH, such as a mouse, before it can once again reinfect its original host or others in the same enclosure. Because of this, eradication of parasites with a direct life cycle is much more difficult.

An animal infected with a parasite that has an indirect li[fe] cycle can be rid of the parasite with treatment with the appro[-] priate antiparasite drug and then ensuring that it does no[t] have access to any IHs that are affected by the same parasit[e]. For instance, if a snake is infected with roundworms should be dewormed (or "wormed" as it is called by herpetologists) and then fed only parasite-free mice.

A knowledge of a parasite's direct life cycle is helpful in eradication from a reptile's environment. For instance, the hookworm has a direct life cycle. It passes from one snake to the next, or back to itself, with either food, such as a plate of vegetables, contaminated with infected feces or with direct contamination and infection through the skin (as happens when a lizard steps in infected feces within its cage).

If these types of transmission can be stopped, then the parasite's life cycle can be broken. This process involves cleaning of the cage on a frequent basis. For instance, if a pet is dewormed and then any fresh feces from within the cage is immediately removed, the parasite cannot reinfect the host. After the appropriate treatment is finished, no parasites are left to reinfect or pass along to another host.

Medical treatments vary depending on the type of parasite present. Because of the anatomic location of some parasites, treatment may not be possible or may not be attempted. The spiny-headed worms are an example. They live in various locations throughout the abdominal cavity, but in general do no harm to the host. Because deworming drugs may not be effective at some of these locations and little risk of danger exists, these parasites are often left untreated.

Treatment times and amounts also vary depending on the type of parasite identified. Research in Ball Pythons suggests that reptiles parasitized with roundworms should be treated a minimum of three consecutive times, separated each time with a 2-week interval. Some protozoan, or one-celled parasites, can be effectively treated with a single dose. Certain protozoans (such as ciliates in tortoises or herbivorous lizards such as the Green Iguana *[Iguana iguana]*) need not be treated, and others may need to be treated daily for 3 weeks (coccidia).

Many different types of deworming medications are found. Most are in the form of a paste or pill given orally. Oral albendazole has been shown effective when given **per rectum** for difficult-to-eradicate parasites. Injectable dewormers have the advantage of ease of administration. For instance, opening the mouth of a large tortoise to pass a stomach tube full of deworming medicine is often impossible; however, administration of an injection under the skin is usually easy.

Prevention is always better than treatment. All deworming medications used in reptiles are drugs that have been developed and evaluated in other species. Little toxicity, safety, and pharmacokinetic research has been conducted in reptiles, and as a result, veterinarians are constantly learning more and more about the side effects of the drugs used to treat parasites.

For instance, ivermectin, a drug used extensively in cattle and other species, has proven to be effective in snakes and lizards for the treatment of various common parasites. However, **ivermectin has been proven lethal in chelonians and should never be used in any of these species.** Although this has been common knowledge for almost 20 years, improperly trained individuals still use this drug to treat parasites in turtles.

A simple technique frequently used to help decrease or eliminate parasites from prey items is to feed previously frozen dead meals or prey. Some research indicates that freezing a prey item for at least 30 days before thawing and feeding kills or destroys any parasites that it might be harboring.[38,39]

Some herpetologists recommend feeding alternate prey. For instance, if a snake normally eats lizards, the parasite life cycle can be broken by switching from lizard prey to mouse prey. Be careful with this technique because some reptiles may refuse alternate prey species. Also, the risk always exists for induction of subtle nutrient deficiencies with a nonnormal prey item.

A reptile's parasite burden can be decreased by feeding parasite-free prey only. If a need exists for large numbers of mice or rats, herpetologists might be wise to raise their own. Advise breeder clients to start out with a pair of parasite-free breeders, which should result in all of the offspring being free of parasites.

Chapter 89 lists the more common antiparasiticides used in reptile medicine.

CONCLUSION

All wild reptiles have a normal parasite burden. Some are truly parasitic; some are commensals. In the balance of nature, these organisms coexist. In captivity, however, when stress, poor nutrition, crowding, and more are added, even a "normal" parasite load can be a serious problem. Some apparent parasites (such as ciliates in tortoises) should not be treated because they are as much a part of the digestive process as the flora in a hind gut. However, others, because of complications of biologic concentration (in captivity) and stress, must be treated or death of the host might result.

As with most anything in captive reptile husbandry, the parasite load is almost always the result of husbandry and management imbalances. In addition to the medical intervention needed to treat the parasites, problems with husbandry must also be addressed.

Parasites are a real threat to captive reptiles. Whether the client's animals are pets or commercial breeders, an effective parasite treatment/prevention program is essential. Parasitized animals have poor growth rates, are unthrifty, have reproductive problems, and are generally more susceptible to disease than parasite-free animals. Because complete avoidance of parasites is almost impossible, especially for those reptiles that eat live food, evaluation of animals at least on a yearly basis is wise.

The most important control practice is quarantine of all new animals for at least 30 days. This allows diagnosis of most parasite infections and infestations and works to remove them before they become fully established. Precluding a parasite from entering a facility should be easier than eliminating it.

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