ENDOHELMINTHS FROM SIX RARE SPECIES OF TURTLES (BATAGURIDAE) FROM SOUTHEAST ASIA CONFISCATED BY INTERNATIONAL AUTHORITIES IN HONG KONG, CHINA

A Thesis

by

REBECCA ANN MURRAY

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2004

Major Subject: Wildlife and Fisheries Sciences

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Norman Dronen, Jr. (Chair of Committee)	Merrill Sweet (Member)
Lee Fitzgerald (Member)	Robert Brown (Head of Department)

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ABSTRACT

Endohelminths from Six Rare Species of Turtles (Bataguridae) from Southeast Asia Confiscated by International Authorities in Hong Kong, China. (May 2004)

Rebecca Ann Murray, B.S., University of Florida

Chair of Advisory Committee: Dr. Norman Dronen, Jr.

Specimens of 6 species of threatened, vulnerable, and endangered turtles (*Cuora amboinensis, Cyclemys dentata, Heosemys grandis, Orlitia borneensis, Pyxidea mouhotii*, and *Siebenrockiella crassicollis)* belonging to family Bataguridae, were confiscated in Hong Kong, China on 11 December 2001 by international authorities. Endohelminth studies on these turtle species are scarce, and this study provided a rare opportunity to examine a limited number of specimens for endohelminths. Ten different parasite species were collected and there were 16 new host records. This is the first record of a parasite from *P. mouhotii*. The parasite prevalences found in this study provide a basis for a better understanding of the phylogenetic relationships of the family Bataguridae to other families, especially Testudinidae. Based on known life cycles, parasites found provided an indication of food preferences of these 6 turtle species that support previous studies of the turtles' feeding habits. However, the results of the parasite survey from *O. borneensis* provided additional feeding habit information. The list of endohelminths herein is intended to provide a foundation for future parasite studies of the 6 species of Asian turtles.

ACKNOWLEDGEMENTS

I couldn't have done this without Dr. Norman Dronen, my committee chair, for all of his assistance since I've been at Texas A&M University. I truly appreciate all of his help with teaching me the ins and outs of studying parasites and writing manuscripts.

Thank you to Dr. Merrill Sweet and Dr. Lee Fitzgerald for their help in reviewing my thesis and offering suggestions. It made this thesis much more well-rounded.

I would like to acknowledge Dr. Chuck Blend. You always had time for me and answered all of my questions (no matter how inane) with such enthusiasm. Your help with my publication was instrumental as you are also a very thorough reviewer.

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Thanks to Kathryn Vaughan and the folks out at the TCWC for all of your help in providing me with the turtles to examine and providing me with information.

Special thanks to Miss Suzi Flack for all of your assistance examining turtles and collecting the parasites. Not only were you a smiling face in the morning but you never complained about helping me count all of those nematodes.

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INTRODUCTION

On 11 December 2001, the Agricultural Fisheries and Conservation Department of the Hong Kong Special Administrative Region (SAR) of the People's Republic of China in concert with the Customs and Excise Department confiscated approximately 10,000 turtles in Hong Kong, China. The majority of the species are listed as endangered, threatened, or vulnerable species. The seizure had an estimated black-market value of $3.2 million (Ades and Crow, 2002). Turtles were taken to the United States with the intent of rehabilitation and distributed to protection groups (Bursey and Kinsella, 2003). Deceased turtles, representing 6 species, were sent frozen or on ice to the Texas Cooperative Wildlife Collection (TCWC) in College Station, Texas.

The confiscated turtles held at the TCWC are the southern Asian box turtle *Cuora amboinensis* (Daudin, 1802), the Asian leaf turtle *Cyclemys denata* (Gray, 1831), the giant Asian pond turtle *Heosemys grandis* (Gray, 1860), the Malaysian giant turtle *Orlitia borneensis* Gray, 1873, the keeled box turtle *Pyxidea mouhotii* (Gray, 1862), and the black marsh turtle *Siebenrockiella crassicollis* (Gray, 1831). All the turtles belong to the family Bataguridae (McDowell, 1964), which includes species that range from northwest Africa, Europe to western Asia and the Middle East, across southern Asia to China, Japan, the Philippines, and the islands of the Sunda Shelf; with the exception

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This thesis follows the style and format of Comparative Parasitology.

of members of the genus *Rhinoclemmys*, that occur from Mexico to northern South America. Within the family Bataguridae, there are 23 genera and 65 species (Pough et al., 2004). Figure 1 shows a map of the ranges of extant species in Bataguridae (Zug et al., 2001).

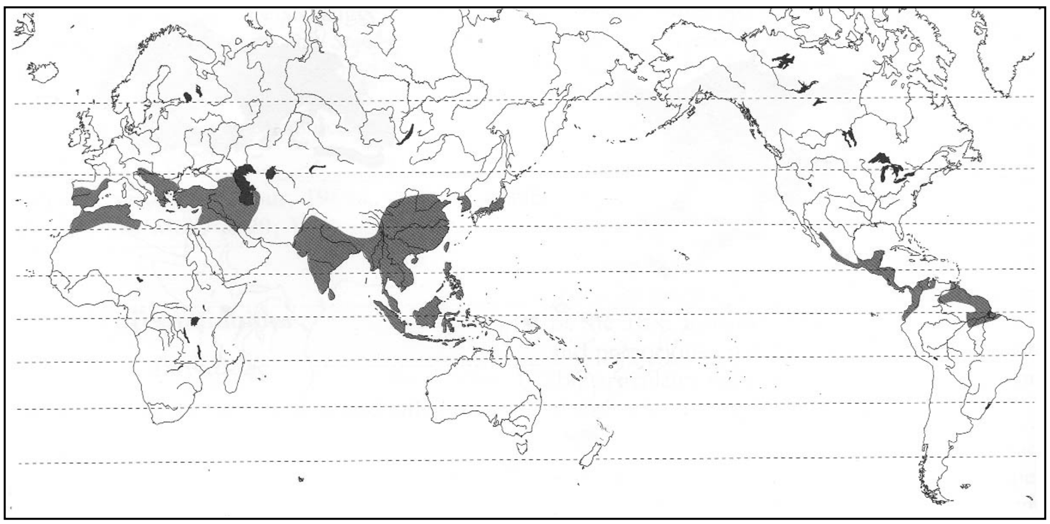

Figure 1. Range of extant Bataguridae. *

Literature review

The majority of previous parasite studies on batagurid turtles were done on *Cuora amboinensis* (Table 1). There have been 4 species of nematodes, 12 species of trematodes, and 2 species of Monogenea reported from this turtle. There have been 4

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species of trematodes and 1 species of Monogenea reported from *Cyclemys dentata* (Table 2); 5 Nematoda species and 1 species of Trematoda reported from *Heosemys grandis* (Table 3); 1 Nematoda species reported from *Orlitia borneensis* (Table 4); no parasite reports from *Pyxidea mouhotii*; and 1 Nematoda species, 1 Trematoda species, and 1 Monogenea species reported from *Siebenrockiella crassicollis* (Table 5).

Table 1. Endohelminths previously reported from *Cuora amboinensis,* location in host, citation, and geographic location.

Parasite species	**Location in host**	**Citation**	**Geographic location**
Nematoda			
Camallanus intermedius Hsu & Hoeppli, 1931	Intestine	Myers and Kuntz, 1969	Malaysia
Falcaustra duyagi (Tubangui and Villaamil, 1933)	Caecum	Tubangui and Villaamil, 1933	Philippines
Falcaustra duyagi (Tubangui & Villaamil, 1933)	Large intestine	Berry, 1984	Malaysia

Table 1. Continued.

Parasite species	**Location in host**	**Citation**	**Geographic location**
Serpinema octorugatum (Baylis, 1933)	Intestine	Sharma et al. 2002	Malaysia
Spironoura robert, Chou & Lowe, 1984	Rectum	Chou and Lowe, 1984	Singapore: Imported from Malaysia or Indonesia
Trematoda			
Diaschorchis multitesticularis Rohde, 1962	Intestine	Brooks and Palmieri, 1978	Malaysia
Hemiclepsis guandongenis Tan & Liu, 2001	Skin	Tan and Liu, 2001	China
Multicotyle purvisi Dawes, 1941	Stomach and duodenum	Rohde, 1971	Malaysia
Neopolystoma liewi Du Preez & Lim, 2000	Eye	Du Preez and Lim, 2000	Malaysia

Table 1. Continued.

Parasite species	**Location in host**	**Citation**	**Geographic location**
Neopronocephalus orientalis Brooks & Palmieri, 1979	Upper small intestine	Brooks and Palmieri, 1979	Malaysia
Parapleurogonius brevicaecum Sullivan 1977	Intestine	Brooks and Palmieri, 1978	Malaysia
Renigonius cuorensis, Brooks & Palmieri 1978	Small intestine	Brooks and Palmieri, 1978	Malaysia
Spinometra gigantica Dwivedi, 1965	Duodenum and ileum	Dwivedi, 1965	India
Spirhapalum elongatum Rohde, Lee, Lim, 1968	Mesentary near artery	Rohde et al, 1968	Malaysia
Spirhapalum elongatum Rohde, Lee, Lim, 1968	Mesentary near artery	Brooks and Palmieri, 1979	Malaysia

Table 1. Continued.

Parasite species	**Location in host**	**Citation**	**Geographic location**
Stunkardia dilymphosa Bhalerao,1931	Large intestine	Rohde, 1962a	Malaysia
Stunkardia dilymphosa Bhalerao,1931	Duodenum and Ileum	Dwivedi, 1967	India
Stunkardia minuta Palmieri & Sullivan, 1977	Small intestine and rectum	Palmieri and Sullivan, 1977	Malaysia
Stunkardia minuta Palmieri & Sullivan, 1977	Intestine	Sey and Palmieri, 1978	Malaysia
Telorchis cyclemidis (Tubangui, 1933)	Intestine	Tubangui, 1933	Philippines
Telorchis cyclemidis (Tubangui, 1933)	Intestine	Wharton, 1970	Philippines
Monogenea			
Polystomoides malayi Rohde, 1963	Urinary bladder	Rohde, 1963	Malaysia

Table 1. Continued.

Parasite species	**Location in host**	**Citation**	**Geographic location**
Polystomoides malayi Rohde, 1963	Urinary bladder	Rohde, 1972b	Malaysia
Polystomoidella mayesi Richardson & Brooks, 1987	Urinary bladder	Richardson and Brooks, 1987	Malaysia

Table 2. Endohelminths previously reported from *Cyclemys dentata,* location in host, citation, and geographic location.

Parasite species	Location in host	Citation	Geographic location
Trematoda			
Astiotrema cyclemysi Siddiqi, 1965	Small intestine	Siddiqi, 1965a	India
Neopronocephalus rotundus Siddiqi, 1965	Small intestine	Siddiqi, 1965b	India
Stunkardia dilymphosa Bhalerao,1931	Small intestine	Siddiqi, 1965c	India
Telorchis philippinesis Fischthal & Kuntz, 1964	Stomach	Fischthal and Kuntz, 1964	Philippines
Monogenea			
Polystomoides cyclemydis Fischthal & Kuntz, 1964	Large intestine	Fischthal and Kuntz, 1964	Philippines

Table 3. Endohelminths previously reported from *Heosemys grandis*, location in host, citation, and geographic location.

Parasite species	Location in host	Citation	Geographic location
Nematoda			
Serpinema octorugatum (Baylis, 1933)	Small intestine	Baylis, 1933	Malaysia
Oswaldocruzia malayan Baylis, 1933	Small intestine	Baylis, 1933	Malaysia
Spironoura siamensis (Baylis, 1920)	Intestine	Baylis, 1933	Malaysia
Spironoura stewarti (Baylis & Daubney,1922)	Intestine	Baylis, 1933	Malaysia
Zanclophorus purvisi Baylis, 1933	Large intestine	Baylis, 1933	Malaysia
Trematoda			
Quasichorchis purvisi Southwell & Kirshner, 1937	Stomach	Balasingam, 1964	Purchased in China

Table 4. Endohelminths previously reported from *Orlitia borneensis,* location in host, citation, and geographic location.

Parasite species	**Location in host**	**Citation**	**Geographic location**
Nematoda			
Falcaustra greineri Bursey and Kinsella, 2003	Large intestine	Bursey and Kinsella, 2003	Malaysia

Table 5. Endohelminths previously reported from *Siebenrockiella crassicollis,* location in host, citation, and geographic location.

Parasite species	**Location in host**	**Citation**	**Geographic location**
Nematoda			
Serpinema microcephalus Dujardin, 1845	Intestine	Suzuki and Asakawa, 2000	Purchased in Japan
Trematoda			
Multicotyle purvisi Dawes, 1941	Intestine	Dawes, 1941	Malaysia
Multicotyle purvisi Dawes, 1941	Intestine	Rohde, 1971	Malaysia
Multicotyle purvisi Dawes, 1941	Stomach	Rohde, 1990	Malaysia
Monogenea			
Polystomoides renschi Rohde, 1965	Oral cavity	Rohde, 1972b	Malaysia
Polystomoides renschi Rohde, 1965	Oral and pharyngeal cavity	Rohde, 1973	Malaysia
Polystomoides renschi Rohde, 1965	Oral cavity	Littlewood, et al. 1997	Malaysia

Biodiversity

Many authors have emphasized the need for more parasite research, especially in the area of systematics because only a small percentage of parasite species have been identified (e.g. Monis, 1999; Brooks and Hoberg , 2001). Taxonomy, the naming of organisms, is essential to systematics and the study of biodiversity. Systematics encompasses taxonomy within the evolutionary context of relationships amoung clades. It seeks to understand the processes that produce species diversity (Whitehead, 1990) and is the basis of comparing and learning about organisms (Monis, 1999). The Convention of Biological Diversity group, formed in 1992 at the Earth Summit in Rio de Janeiro, called for a Global Taxonomic Outlook in 1995 to increase taxonomic data to benefit biodiversity knowledge and conservation efforts (Gardner and Campbell, 1992). As an example, Gardner and Campbell (1992) studied marsupial cestodes in Bolivia and determined that the area supports an ancient, biodiverse, ecological community.

Host disease

All of the confiscated turtle species from the Hong Kong confiscation deposited at the TCWC are listed as threatened, vulnerable, or endangered due to habitat loss and/or hunting (Hilton-Taylor, 2000). Habitat loss, effectively concentrates these turtles which increases the probability of transmission of diseases and parasites (Poulin, 1998). Many of the Asian turtle populations are so small that population recovery after a disease breakout would be unlikely (Klemens, 2000). The study of endohelminth parasites of these 6 species can provide valuable insight into disease factors affecting their populations and assist scientists in the development of more comprehensive management strategies and recovery plans.

Host phylogeny

Parasites have previously been used to develop a better understanding of host phylogenetics especially where these parasites are host specific (e.g. Ernst and Ernest, 1980; Euzet et al., 1989; Paugy et al., 1990; Lambert and El Gharbi, 1995; Thomas et al., 1996). Treating a parasite species as a host characteristic is helpful in constructing cladograms by providing more information to compare between groups and thus developing a more robust cladogram; however, such robust phylogenies are in shortage (Brooks and Hoberg, 2001). This is especially true for Bataguridae as there is confusion over the phylogenetics of the family (Shaffer et al., 1997). Based on morphological data, Hirayama (1984) considered the Bataguridae to be a paraphyletic group. In opposition, Lamb and Lydeard (1994) found weak support for Bataguridae as a paraphyletic group based on molecular data. Shaffer et al. (1997) combined both molecular and morphological data to construct cladograms that indicated the Bataguridae were monophyletic. However, the authors suggested that the phylogeny of the Bataguridae is still not clearly resolved. Surveys of parasites species, as done in this project, may be useful as additional characteristics for comparison of Bataguridae with other turtle groups.

A study comparing the parasite species of Bataguridae with the common parasite species of Testudinidae (Batsch, 1788), the closest related group, could help our understanding of the Bataguridae phylogeny. A map showing the distribution of the 11 genera with 45 species members of the family Testudinidae is shown in Figure 2 (Zug et al., 2001). There are only 2 species of family Testudinidae, the Burmese mountain tortoise, *Manouria emys* (Schlegel and Müller, 1840), and the impressed tortoise, *M. impressa* Günther, 1882, that occupy that same geographic range as the Bataguridae studied here. These would be logical species for a phylogenetic comparison between these families. Specimens of *Manouria emys* were also confiscated from Hong Kong, but were not deposited at the TCWC with the 6 species I examined and therefore were not available for inspection. Table 6 lists the endohelminths previously reported from *M. emys,* locations in host, references, and geographic locations. Only nematodes have previously been reported from *M. emys*: *Atractis granulosa* Raillet and Henry, 1912; *Cissophyllus laverani* Raillet and Henry, 1912; and *Falcaustra onama* (Karve, 1927). There have been no previous reports of endohelminths from *M. impressa*.

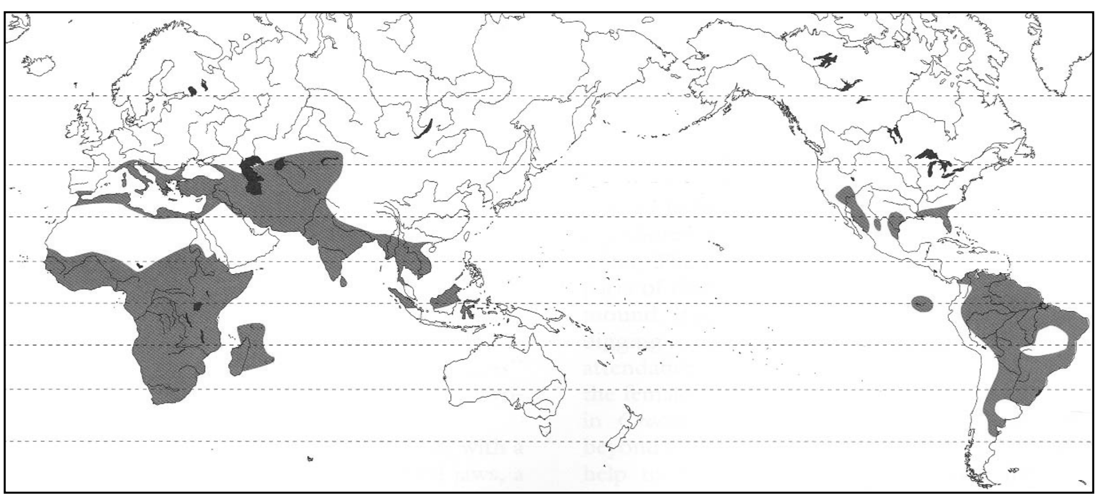

Figure 2. Range of extant Testudinidae.[•]

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Table 6. Endohelminths previously reported from *Manouria emys,* location in host, citation, and geographic location.

Parasite species	Location in host	Citation	Geographic location
Nematoda			
Atractis granulosa Raillet and Henry, 1912	Large intestine	Balasingam, 1964	Singapore
Cissophyllus laverani Raillet and Henry, 1912	Caecum	Balasingam, 1964	Malaysia
Falcaustra onama (Karve, 1927)	Large intestine	Balasingam, 1964	Singapore
Falcaustra onama (Karve, 1927)	Rectum	Karve, 1927	Singapore

Host feeding habits

Parasites can be helpful in understanding host ecology. Researchers can learn about host feeding habits through knowledge of a parasite's intermediate host, as a food item of the turtle. This enriches our comprehension of the host's relationship with other organisms and its habitat (Gardner and Campbell, 1992) and provides information about the trophic interactions within the environment (Brooks and Hoberg, 2001). Knowledge gained by parasite and intermediate host identification enhances the development of more complete ecological models (Monis, 1999). Examples are shown by Des Clers

(1991) who used *Psuedoterranova decipiens* (Nematoda) to predict the size of the host, *Gadus morhua* (Atlantic cod); Bouloux et al. (1998) used *Diplectanum aequans* (Monogenea) to predict population sizes of *Dicentrarchus labrax* (Sea Bass); and Grenfell (1992) who used mathematical models to examine the impact of parasites on populations of ungulates.

Host descriptions

Cuora amboinensis

The southern Asian box turtle is distributed from the Nicabar Islands, Bangladesh, and Assam, south through Burma, Thailand, Kampuchea, Vietnam, and Malaya, east in Indonesia to Sulawesi and Amboina. It is also located in the Philippines and Celebes. It inhabits lowland water bodies with soft bottoms and slow currents (Ernst and Barbour, 1989). Juveniles are thought to be entirely aquatic (Taylor, 1920), while adults have been found far from water. It is differentiated from other species by its highly arched, dark brown or black carapace, with three stripes on each side of its head, and it is capable of completely closing all openings. It is herbivorous, though has been noted to consume various animal foods in captivity (Ernst and Barbour, 1989). *Cuora amboinensis* is listed as a vulnerable species (Hilton-Taylor, 2000).

Cyclemys dentata

The Asian leaf turtle is one of two members of the genus *Cyclemys*. It is distributed from northern India, southward through Burma, Thailand, Kampuchea, Vietnam, and Malaya, to Sumatra, Java, and Borneo, as well as occurring in the Philippines (Ernst and Barbour, 1989). While, typically found in shallow streams (Ernst and Barbour, 1989), Daniel (2002) noted that it may be found up to 1,000 m elevation. It has an oval carapace that is slightly arched, and longer than wide. It is differentiated from other turtle species by the lateral stripes near the corner of the mouth that rarely reach the side of the head. It is an omnivorous turtle. It is listed as being near threatened due to harvesting as food (Hilton-Taylor, 2000).

Heosemys grandis

The giant Asian pond turtle is one of the largest hard-shelled, semi-aquatic Asian turtles. It is distributed from Vietnam to Burma and west Malaysia (King and Burke, 1989), and is known to inhabit various freshwater and marsh areas, from sea level to hill country (Ernst and Barbour, 1989). It is differentiated by its broad, oval carapace that can grow up to 43.5 cm long, is highly arched, depressed dorsally, and serrated posteriorly (Ernst and Barbour, 1989). In the wild *H. grandis* is thought to only consume aquatic plants (Wirot, 1979 and Taylor, 1920). However, in captivity the turtle is omnivorous (Ernst and Barbour, 1989). It is listed as a vulnerable species throughout its range (Hilton-Taylor, 2000).

Orlitia borneensis

The Malaysian giant turtle is the only member of the genus. It is distributed in Malaysia, Sumatra, and Borneo, where it inhabits large bodies of waters, such as rivers and lakes (Ernst and Barbour, 1989). It has a dark gray, brown, or black carapace that is narrow and oval. It is larger than *H. grandis*, with a length of 80 cm. Captive turtles are known to eat animals, as well as some ripe fruits, but not vegetation (Mehrtens, 1970). It is listed as an endangered species due to harvesting large numbers of the population for food, especially in Indonesia, despite official protection (Hilton-Taylor, 2000).

Pyxidea mouhotii

The keeled box turtle is the only species of the genus. It is distributed from extreme eastern India to Vietnam, including the Hainan Islands, China (Daniel, 2002). It has 3 prominent keels, lending the common name of the keeled box turtle, as well as a deeply serrate margin on the carapace, and a very flat carapace. It is a terrestrial species that rarely enters the water. Pope (1935) reported the turtle from mountainous areas in Hainan. Reports are mixed about the diet of *P. mouhotii*. Ernst and Barbour (1989) stated it to be exclusively herbivorous, while Daniel (2002) listed it as omnivorous. *Pyxidea mouhotii* is listed as an endangered species (Hilton-Taylor, 2000).

Siebenrockiella crassicollis

The black marsh turtle is the only member of the genus and is distributed throughout Burma, Thailand, southern Vietnam to Sumatra, and Borneo (King and Burke, 1989). It lives in highly vegetated, slow moving bodies of water (Ernst and Barbour, 1989). It is known to be carnivorous, eating amphibians, snails, slugs, shrimps, but have also been noted to eat rotten plants (Wirot, 1979). The black marsh turtle is currently listed as a vulnerable species throughout Southeast Asia due to habitat loss and illegal trade (Hilton-Taylor, 2000).

Purpose

Although the circumstances of their origin were unfortunate, the confiscated specimens provided a rare opportunity to examine a number of relatively rare freshwater

Asian turtles for endohelminths. The purpose of my study was to provide a survey of endohelminths from the 6 turtle species, which would serve as a foundation for future studies on the parasites of Asian turtles. I focused on identifying and cataloging the endohelminths of these turtles, noting any new host records, and comparing my data to previous endohelminth studies of other turtles. I compared the prevalences of endohelminth species among the 6 species of turtles to better understand the phylogenetic relationship of the turtle species within the family Bataguridae. The parasites of Bataguridae were compared with the parasites of Testudinidae in an attempt to better understand their phylogenetic host-parasite relationship. I used what is known about the life cycles of parasites found to gain more insights about the turtles' feeding habits.

MATERIALS AND METHODS

On 11 December 2001, the Agricultural Fisheries and Conservation Department of the Hong Kong SAR government, in concert with the Customs and Excise Department confiscated approximately 10,000 turtles in Hong Kong, China. Deceased turtles were sent frozen or on ice to the Texas Cooperative Wildlife Collection (TCWC) in College Station, Texas, U.S.A. to be used as museum specimens (Table 7).

Table 7. Turtle species examined with their TCWC accession numbers.

Host species	**Accession number**
Cuora amboinensis	187, 655, 657, 991, 998, 999, 1005
Cyclemys denata	130, 188
Heosemys grandis	174, 180, 328, 356
Orlitia borneensis	100, 126, 140, 146, 173, 203, 10360, 10361, 10451
Pyxidea mouhotii	10355
Siebenrockiella crassicollis	23, 82, 443, 493, 620, 650, 658, 675, 678, 752, 770, 799, 818, 820, 855, 972, 978, RKVIT

A total of 41 turtles were examined for endohelminths. Turtles were dissected using a bone saw to open the plastron and removing the intestine and internal organs. The eyes, mouth, and body cavity were also examined. Parasites were removed from the turtles by pipette, forceps, or wooden applicator stick and placed in 70% ethanol.

Methods of preserving and making whole mounts followed those outlined by Cable (1958). Trematode parasites were overstained in Semichon's carmine, destained with acid alcohol (99 parts 70% ETOH and 1 part HCl), dehydrated in an increasing sequence of ethanol solution (70%, 80%, 95%, and 100%), cleared with xylene, and mounted in Canada balsam. Nematodes were preserved in 70% ethanol and cleared in a 50/50 mixture of glycerine and 70% ethanol and either stored in vials or mounted in glycerin jelly. Voucher specimens were deposited in the United States National Parasite Collection (USNPC) (Table 8)

Table 8. Parasite species collected with their hosts and USNPC accession numbers.

Parasite species	**Host species**	**Accession number**
Nematoda		
Falcaustra sp.	*C. dentata*	094522
Falcaustra sp.	*C. amboinensis*	094523-094527
Falcaustra sp.	*O. borneensis*	094528-094534
Falcaustra sp.	*H. grandis*	094535
Falcaustra duyagi	*C. amboinensis*	094536, 094537
Falcaustra duyagi	*S. crassicollis*	094538, 094539
Falcaustra duyagi	*O. borneensis*	094540
Falcaustra greineri	*S. crassicollis*	094374-094382, 094541-094544
Falcaustra greineri	*C. amboinensis*	094545

Table 8. Continued

Parasite species	**Host species**	**Accession number**
Nematoda		
Falcaustra greineri	*O. borneensis*	094546, 094547
Serpinema octorugatum	*C. amboinensis*	094548-094550
Serpinema octorugatum	*H. grandis*	094551
Serpinema octortugatum	*S. crassicollis*	094383
Trematoda		
Diaschistorchis multitesticularis	*S. crassicollis*	094384
Multicotyle purvisi	*S. crassicollis*	094386-094388
Stunkardia dilymphosa	*C. amboinensis*	094514
Stunkardia dilymphosa	*C. dentata*	094515
Stunkardia dilymphosa	*H. grandis*	094516
Stunkardia dilymphosa	*O. borneensis*	094517, 094518
Stunkardia dilymphosa	*P. mouhotii*	094519
Stunkardia dilymphosa	*S. crassicollis*	094389, 094390
Telorchis clemmydis	*C. amboinensis*	094520
Telorchis clemmydis	*H. grandis*	094521
Telorchis clemmydis	*S. crassicollis*	094391-094393
Monogenea		
Polystomoides malayi	*C. amboinensis*	094503-094513

A one sample t-test was used to test whether there were significant differences in the amount of parasite species collected from each host species and if there were significant differences in the prevalence of each parasite species. Linear regression was used to test for linearity between the number of hosts examined and the number of parasite species found.

RESULTS AND DISCUSSION

Helminth survey

Ninety percent of the turtles examined were infected with at least 1 endohelminth. Infected turtles had a mean of 1.73 parasite species (range = 1-3). In all, 10 different parasite species were recovered. There were 3 species of nematodes: *Falcaustra duyagi* (Tubangui and Villaamil, 1933), *Falcaustra greineri* Bursey and Kinsella, 2003, and *Serpinema octorugatum* (Baylis, 1933). Identification of the *Falcaustra* species was only possible when mature males were present. Only 1 Monogenea species was collected, *Polystomoides malayi* Rohde, 1961. Four digenean trematodes were recovered: *Diaschistorchis multitesticularis* Rohde, 1962, *Stunkardia dilymphosa* Bhalerao, 1931, *Telorchis clemmydis* Yamaguti, 1933 and spirorchid eggs. Adult specimens of Spirorchidae were not found. One aspidogastrid trematode, *Multicotyle purvisi* (Dawes, 1941) was collected. One partial cestode was recovered but could be only identified as being a proteocephalid cestode.

Cuora amboinensis

Eighty-six percent (6 of 7) of *Cuora amboinensis* were infected with at least 1 endohelminth, with a mean of 2 (range =1-3) helminth species (Table 9). The most prevalent parasite found was *Falcaustra* (intestine). I collected *Falcaustra* from 7 turtles. *Falcaustra duyagi* and *F. greineri* were identified from 3 turtles. *Serpinema octorugatum* (intestine) had the second highest prevalence. The prevalence of *P. malayi* (urinary bladder), *S. dilymphosa* (lower intestine), *T. clemmydis* (upper to mid intestine), and spirorchid eggs (intestinal wall) represented the lowest prevalences (14%). This is the first report of *F. greineri* found in *C. amboinensis*.

Table 9. Prevalences and intensities of endohelminths from *Cuora amboinensis* (n=7).

Helminth	**Prevalence (%)**	**Intensity mean (range)**
Nematoda		
Falcaustra sp.	86	1237 (7-2,500)
Falcaustra duyagi (Tubangui & Villaamil, 1933)	29	2,200 (2,000-2,400)
Falcaustra greineri Bursey and Kinsella, 2003	29	945 (91-1,800)
Serpinema octorugatum (Baylis, 1933)	57	508 (79-2,500)
Trematoda		
Stunkardia dilymphosa Bhalerao, 1931	14	1
Telorchis clemmydis Yamaguti, 1933	14	1
Spirorchid eggs	14	-
Monogenea		
Polystomoides malayi Rohde, 1965	14	1

Cyclemys dentata

Fifty percent (1 of 2) of *Cyclemys dentata* were infected with at least 1 endohelminth, with a mean of 2 helminth species (Table 10). There was an equal prevalence of *Falcaustra sp.* (intestine) and *S. dilymphosa* (lower intestine). In the 2 host specimens examined, there were no male *Falcaustra* to distinguish to species level. The identification of this nematode genus provides the first report of a nematode infection in *C. dentata*.

Table 10. Prevalences and intensities of endohelminths from *Cyclemys denata* (n=2).

Helminth	**Prevalence (%)**	**Intensity mean (range)**
Nematoda		
Falcaustra sp.	50	19 (1-37)
Trematoda		
Stunkardia dilymphosa Bhalerao 1931	50	1

Heosemys grandis

Seventy-five percent (3 of 4) of *Heosemys grandis* were infected with at least 1 endohelminth, with a mean of 1.67 (range =1-2) helminth species (Table 11). The most prevalent parasite found was *Falcaustra sp*. (intestine), followed by an equal prevalence of *S. octorugatum* (intestine), *S. dilymphosa* (lower intestine), and *T. clemmydis* (upper to mid intestine). There were no male *Falcaustra* to distinguish to species level. This is a new parasite host record for *Falcaustra sp.* and *T. clemmydis*.

Table 11. Prevalences and intensities of endohelminths from *Heosemys grandis* (n=4).

Helminth	**Prevalence (%)**	**Intensity mean (range)**
Nematoda		
Falcaustra sp.	50	33 (5-61)
Serpinema octorugatum (Baylis, 1933)	25	11
Trematoda		
Stunkardia dilymphosa Bhalerao, 1931	25	2
Telorchis clemmydis Yamaguti, 1933	25	28

Orlitia borneensis

All *Orlitia borneensis* (n=9) were infected with at least 1 endohelminth, with a mean of 1.44 (range =1-3) helminth species (Table 12). The most prevalent parasite was *Falcaustra* (intestine), followed by *S. octorugatum* (intestine), spirorchid eggs (intestinal wall), and *S. dilymphosa* (lower intestine). I collected members of *Falcaustra* from 8 turtles, *F. duyagi* and *F. greineri* were identified from 4 turtles; however, I was unable to identify the species of *Falcaustra* from the other turtles as there were no males. This is the first record of infection by trematodes in *O. borneensis*. It is also a new parasite host record for *S. octorugatum* and *F. duyagi.*

Table 12. Prevalences and intensities of endohelminths from *Orlitia borneensis* (n=9).

Helminth	**Prevalence (%)**	**Intensity mean (range)**
Nematoda		
Falcaustra sp.	89	20,692 (12-164,280)
Falcaustra duyagi (Tubangui & Villaamil, 1933)	11	559
Falcaustra greineri Bursey and Kinsella, 2003	44	402 (75-791)
Serpinema octorugatum (Baylis, 1933)	33	144 (2-424)
Trematoda		
Stunkardia dilymphosa Bhalerao, 1931	22	8 (4-11)
Spirorchid eggs	33	-

Pyxidea mouhotii

There was 1 *Pyxidea mouhotii* examined and it was found to have 1 helminth species, *S. dilymphosa* (lower intestine), Table 13. This is the first report of any parasite from *P. mouhotii*.

Table 13. Prevalences and intensities of endohelminths from *Pyxidea mouhotii* (n=1).

Helminth	**Prevalence (%)**	**Intensity mean (range)**
Trematoda		
Stunkardia dilymphosa Bhalerao, 1931	100	1

Siebenrockiella crassicollis

Eighty-nine percent (17 of 19) of *Siebenrockiella crassicollis* were infected with at least 1 endohelminth, with a mean of 1.6 (range = 1-3) helminth species (Table 14). *Falcaustra sp.* (intestine) was the most prevalent helminth, followed by *M. purvisi* (upper intestine), *S. octorugatum* (intestine), *T. clemmydis* (upper to mid intestine), *S. dilymphosa* (lower intestine), *D. multitesticularis* (upper intestine), and the partial cestode. Although adult specimens of Spirorchidae were not observed, their eggs were found in the intestinal wall of 1 turtle. There were no male *Falcaustra* to distinguish species. This is the first record of infection by a cestode, digeneans, and the nematodes *Falcaustra sp.* and *S. octorugatum* from *S. crassicollis*.

Table 14. Prevalences and intensities of endohelminths from *Siebenrockiella crassicollis* (n=19).

Helminth	**Prevalence (%)**	**Intensity mean (range)**
Cestoda		
Unknown sp.	5	1
Nematoda		
Falcaustra sp.	74	222 (1-1,529)
Serpinema octorugatum (Baylis, 1933)	21	13 (1-46)
Trematoda		
Diaschistorchis multitesticularis Rohde, 1962	11	2 (1-3)
Multicotyle purvisi (Dawes, 1941)	26	2 (1-8)
Stunkardia dilymphosa Bhalerao, 1931	11	1
Telorchis clemmydis Yamaguti, 1933	21	28 (2-76)

Table 14. Continued

Helminth	**Prevalence (%)**	**Intensity mean (range)**
Spirorchid eggs	5	-

Parasite species

Falcaustra

Falcaustra was the second most common parasite collected from the six turtle species, being found in all species except *P. mouhotii* (Table 15). Although the genus *Falcaustra* is cosmopolitan and is known to occur in frogs, fish, turtles, and salamanders (Bursey and Kinsella, 2003), *F. duyagi* and *F. greineri* are only known from batagurid turtles.

Table 15. List of collected parasite species with the host species from which they were collected.

Parasite /Host species	***C. amboinensis***	***C. denata***	***H. grandis***	***O. borneensis***	***P. mouhotii***	***S .crassicollis***
Falcaustra sp.	x	x	x	x		x
S. octorugatum	x		x	x		x
P. malayi	x					
D. multitesticularis						x
M. purvisi						x
S. dilymphosa	x	x	x	x	x	x
T. clemmydis	x		x			x
spirorchid eggs	x			x		x
Proteocephalata						x

Falcaustra duyagi

Falcaustra duyagi is a nematode found in the large intestine. The identifying features found on the male, which is typically 7.2-10.5 mm long, with a width of 0.4-0.72 mm, are the presence of 2 caudal pseudosuckers, with the anterior one being relatively indistinct, and spicule length within the range of 525-600 um long (Berry, 1984). Although, the specimens I collected had one visible pseudosucker, an average body length of 8.2 mm, width of 0.45 mm, and spicule length of 460 um and may represent a new species, I tentatively identify this species as *F. duyagi*. *Falcaustra duyagi* has been collected from *C. amboinensis* in Malaysia (Berry, 1984) and the Philippines (Tubangui and Villaamil, 1933). This is the first report of *F. duyagi* in *O. borneensis*.

Falcaustra greineri

Falcaustra greineri is a nematode described from the large intestine. The male is typically 14.0-17.5 mm, with a width of 0.61-0.70 mm. The distinguishing features, found only on the male, are spicules 1.07-1.33 mm long and a lack of caudal pseudosuckers (Bursey and Kinsella, 2003). Specimens I collected had an average body length of 15.33 mm, width of 0.91 mm, and spicule length of 0.9 mm. Although the width of my specimens was slightly greater and the spicule length was slightly less than the original description, my specimens most closely resemble *F. greineri* best, as the spicules are significantly larger than other species of *Falcaustra* without a pseudosucker. *Falcaustra greineri* has been collected from *O. borneensis* from Malaysia (Bursey and Kinsella, 2003). This is the first report of *F. greineri* in C. *amboinensis*.

Serpinema octorugatum

Serpinema octorugatum is a nematode found in the duodenum of its host. The identifying feature is the presence of longitudinal ridges in the buccal capsule. There is an average of 8 complete ridges (Sharma et al., 2002). My specimens had 8 ridges. *Serpinema octorugatum* has been collected from *C. amboinensis* in Malaysia (Sharma, et. al, 2002). This is the first report of *S. octorugatum* in *O. borneensis* and *S. crassicollis*. *Serpinema octorugatum* was the third most common parasite species from the six examined turtle species, found in all species with the exception of *P. mouhotii* and *C. dentata* (Table 15). This species is only known from the batagurid turtles.

Diaschistorchis multitesticularis

Diaschistorchis multitesticularis is a digenetic trematode described from the stomach. The identifying characteristics are the size of the oral sucker (range of 0.59-0.68 x 0.68-0.79 mm), the anterior extent of the vitellaria reach the level of the side of the genital opening, the size of the testis (range 0.24-0.48 x 0.15-0.33 mm), the number of testis (range of 25-31), and the testes form a U-shape at the posterior end (Rohde, 1962b). My specimens had an average oral sucker size of 0.62 x 0.74 mm, the vitellaria reach the level of the genital opening anteriorly, and there was an average of 27 testes in a distinct U-shape, with an average size of 0.3 x 0.2mm. *Diaschistorchis multitesticularis* has been collected from *Hieremys annandalei* Boulenger, 1903 (Bataguridae) in Malaysia (Rohde, 1962b). This is the first report of *D. multitesticularis* in *S. crassicollis*. In my survey, *D. multitesticularis* was only found in *S. crassicollis* (Table 15) and thus appears to be very host specific.

Multicotyle purvisi

Multicotyle purvisi is an aspidogastrid trematode found in the intestine. The identifying characteristics are the presence of several rows of alveoli and two testes. They are an average of 2.75 mm long (Dawes, 1941). My specimens were 2.3 mm long, had multiple rows of alveoli, and had two testes. *Multicotyle purvisi* has been collected from *S. crassicollis* in Malaysia (Dawes, 1941). In my survey, *Multicotyle purvisi* was only found in *S. crassicollis* (Table 15) and thus appears to be very host specific and useful in phylogenetic comparisons.

Polystomoides malayi

Polystomoides malayi is a monogenean found in the urinary bladder. The identifying characteristics are the location in the host, the body size (range of 5.9-8.2 mm long, 2.3-3.3 mm wide), and the presences of two hooks, one large (range of 0.57-0.68 mm) and one smaller (range of 0.12-0.32 mm) (Rohde, 1963). My specimens which were also found from the urinary bladder, were an average body size of 5.06 mm long, 2.84 mm wide, and had 1 large hook (average of 0.66 mm) and 1 small hook (average of 0.198mm). My measurements indicate my specimens were *P. malayi*, but there is a discrepancy in the location of the genital canal. The literature states that the genital canal is posterior to the ovary and anterior to the testis (Rohde, 1963). However, the genital canal in my specimens appeared to be posterior to both the ovary and the testis. Balasingam (1964) noted that reproductive organs can move after preservation, so this may be an explanation for the difference. Otherwise, it is possible that this may be a new species. *Polystomoides malayi* has been collected from *C. amboinensis* in Malaysia

(Rohde, 1963). In my survey, *P. malayi* was only found in *C. amboinensis* (Table 15), indicating that this parasite is very host specific and may be useful in phylogenetic comparisons.

Stunkardia dilymphosa

Stunkardia dilymphosa is a digenetic trematode collected from the intestine. It has a length range of 2.51-20.0 mm and width range of 0.58-5.6 mm. The distinguishing characteristics are the presence of diverticula on the pharynx, and the presence of a large acetabulum (range of 520-740 x 460-720 um) with lateral diverticula (may become indistinct after preservation) (Premavati and Agarwal, 1981). My specimens were an average of 9.6 mm long, 2.1 mm wide, had diverticula on the pharynx, and had an average acetabulum size of 1.4 long x 1.3 mm wide. Some had visible diverticula on their acetabulum. *Stunkardia dilymphosa* has a wide host range, and has been collected from several fresh water turtles from 3 turtle families, Geoemydidae Theobald, 1868, Bataguridae (McDowell, 1964), and Trionychidae (Fitzinger, 1826), including *Batagur baska* (Gray, 1831) in Burma, *C. amboinensis* in Malaysia, *C. dentata* in India, *Hardella thurgi* (Gray, 1831) in India, *Trionyx gangeticus* (Forskål, 1775) in India, *T. formusus* (Forskål, 1775) in Malaysia, *Kachugo kachuga* (Gray, 1831) in India, *Lissemys punctata* (Bonnaterre, 1789) in India (Premavati and Agarwal, 1981), and *C. amboinensis* in Malaysia as summarized by Sey and Palmieri (1978). This is the first report of *S. dilymphosa* in *P. mouhotii* and *S. crassicollis*. *Stunkardia dilymphosa* was the most common parasite, collected from all 6 turtle species (Table 15). This parasite has a wide host distribution, as it has also been reported from the families Geoemydidae and Trionychidae.

Telorchis clemmydis

Telorchis clemmydis is a digenetic trematode from the small intestine. It has a range of 3.0-4.4 mm long, and 0.35-0.5 mm wide. The distinguishing characteristics that the 2 testes are close together but are not contiguous. The anterior testis is 0.15-0.25 x 0.16-0.33 mm (Yamaguti, 1933). My specimens were an average of 3.2 mm long, 0.59 mm wide, with 2 non-contiguous testes an average of 0.19 x 0.22 mm. *Telorchis clemmydis* has been collected from *Mauremys japonica* (Temminck and Schlegel, 1835) and *Geoclemmys reevisi* (Gray, 1831) in Japan (Yamaguti, 1933). This is the first report of *T. clemmydis* found in Malaysia and in *H. grandis* and *S. crassicollis*. In my survey, *T. clemmydis* was found in 50% of the turtle species (Table 15). *Telorchis clemmydis* has also been reported from Geoemydidae. Geoemydidae is closely related to Bataguridae (Shaffer et al., 1997), suggesting that *T. clemmydis* was a parasite of the turtle families' ancestor and is able to transfer between the 2 host families.

Host phylogeny

The batagurid turtle phylogenetic tree is not clearly resolved (Shaffer et al., 1997). Treating the parasite species as a host characteristic, I am able to provide a base for future comparison with other turtle families. In comparing the number of parasite species collected from each host species (Table 16), there was a significant difference between the number of parasite species for each turtle species (p value of .069, alpha .10). However, it should be kept in mind that this analysis was based on small sample sizes. Table 17 shows the number of different parasite species and the sample size for each host. The number of parasite species within a host species seems to be linearly dependant on the sample size (R-square = .807). Future work needs to done with larger sample sizes.

Table 16. The number of endohelminth species in each host species.

Host species	**Number of endohelminth species**
C. amboinensis	6
C. dentata	2
H. grandis	4
O. borneensis	4
P. mouhotii	1
S. crassicollis	8

Table 17. The sample size and the number of endohelminth species in each host species.

Host species	**Sample size**	**Number of endohelminth species**
P. mouhotii	1	1
C. dentata	2	2
H. grandis	4	4
C. amboinensis	7	6
O. borneensis	9	4
S. crassicollis	19	8

The comparison of prevalences in each of the 6 turtle species (Table 18) showed significant differences between parasite species (p value of .002, alpha of .01). *Stunkardia dilymphosa*, *Falcaustra sp*., and *S. octorugatum* were the most common parasites, but they are not host specific and therefore are not helpful in a phylogenetic comparison. *Polystomoides malayi* and *M. purvisi* were parasites with low prevalences (17%) that seem to be very host specific, *C. amboinensis* and S. *crassicollis*, respectively. These parasites are transmitted vertically, and may be useful in phylogenetic comparisons as host characteristics.

Table 18. Endohelminth species prevalences from all 6 species of examined turtles.

Parasite species	**Prevalence**
Falcaustra sp.	83%
S. octorugatum	67%
P. malayi	17%
D. multitesticularis	17%
M. purvisi	17%
S. dilymphosa	100%
T. clemmydis	50%
Spirorchidae eggs	50%
Proteocephalata	17%

None of the batagurid turtles, from this study or previous studies, have parasite species in common with *M. emys*, although they share *Falcaustra* in common. Eighty-three percent of the batagurid turtles in this study were infected with members of *Falcaustra,* a cosmopolitan genus with a wide host range covering different classes of vertebrates. Before meaningful comparisons with *M. emys* and *M. impressa* can be carried on, it is essential to conduct more parasite surveys on these hosts. This would be difficult though, as *M. emys* is listed as an endangered species, and *M. impressa* is listed as a vulnerable species (Hilton-Taylor, 2002).

Host feeding habits

Cuora amboinensis

The parasites *F. duyagi*, *P. malayi*, and spirorchids have a direct life cycle, which requires no intermediate host (Olsen, 1974; Yamaguti, 1975). The presence of *S. octorugatum* (copepod as intermediate host; Olsen, 1974) and *S. dilymphosa* (metacercaria on vegetation; Yamaguti, 1975) would indicate that this turtle ate vegetation, inadvertently ingesting copepods. The presence of *T. clemmydis* (tadpole as intermediate host; Yamaguti, 1971) indicates that the turtles are also carnivorous. This is in agreement with previous findings by Ernst and Barbour (1989) that the turtles are omnivorous.

Cyclemys dentata

There was only 1 infected *C. dentata*. The presence of *S. dilymphosa* (metacercaria on vegetation) indicates the turtle ate vegetation. This is in agreement with previous work by Daniel (2002) that described *C. dentata* as an omnivorous turtle.

Heosemys grandis

In the wild *H. grandis* is thought to only consume aquatic plants (Taylor, 1920; Wirot, 1979). However, in captivity the turtle is omnivorous (Ernst and Barbour, 1989). My findings are in agreement with Ernst and Barbour (1989). The presence of *S. octorugatum* (crustacean as intermediate host) and *S. dilymphosa* (metacercariae on vegetation), and the presence of *T. clemmydis* (tadpole as intermediate host) indicates that they are omnivorous.

Orlitia borneensis

Nothing is known of *O. borneensis* feeding habits in the wild. In captivity the turtles will consume animals as well as fruits, but no vegetation (Mehrtens, 1970). The presence of S. *octorugatum* (crustacean as intermediate host) and *S. dilymphosa* (metacercariae on vegetation) indicate that the turtles also will eat vegetation in the wild.

Pyxidea mouhotii

One parasite was found in the specimen of *P. mouhotii*. The presence of *S. dilymphosa* (metacercariae on vegetation) indicates that this turtle ate vegetation. This agrees with both previous accounts by Barbour (1989) and Daniel (2002) of the species eating vegetation.

Siebenrockiella crassicollis

The presence of *D. multitesticularis* (snail second intermediate hosts; Yamaguti, 1971), *S. octorugatum* (copepod) and *S. dilymphosa* (metacercariae on vegetation) suggest a vegetation component in the *S. crassicollis* diet. The presence of a proteocephalid tapeworm (fish or tadpole; Yamaguti, 1959), *M. purvisi* (snails; Rohde, 1972a), and *T. clemmydis* (tadpole) suggest some animals are also eaten. This information supports Wirot's description of *S. crassicollis* being omnivorous (1979).

SUMMARY

For this study, I assumed that the turtles acquired their food from their natural habitat. I do not believe they were fed on the vessel they were confiscated from, as most examined had large fishing hooks lodged in their throats which would impede food consumption. Life cycles for each parasite species were examined and most supported previous literature of the turtle's feeding habits, although the results of the parasite survey from *O. borneensis* provided new feeding habit information.

Comparisons of the parasite prevalences did not result in useable data for a phylogeny comparison between host species, due to a linear correlation between the number of parasite species collected and the host sample size. However, this information is still useful to understanding Bataguridae relationship with their parasites and to other turtle families and encourages a comparative parasite survey of the Testudinidae, especially the *Manouria* genus. Though this would be difficult as *M. emys* is listed as an endangered species and *M. impressa* is listed as a vulnerable species (Hilton-Taylor, 2002).

The linear correlation between the number of parasite species collected and the host sample size also seemed to affect how many host species each parasite species was collected from. However, from the literature review and this current survey is it clear that some parasites are more cosmopolitan (e.g. *S. dilymphosa* and *Falcaustra sp*.) than others (e.g. *P. malayi* and *M. purvisi*). *Stunkardia dilymphosa* was the most prevalent parasite species, collected in all 6 turtle species and is also known from the turtle families Geoemydidae and Trionychidae. I believe this parasite is horizontally

transferred among these 3 turtle families. Although the presence of males limited my identification, the *Falcaustra* genus was the second most commonly collected parasite from the 6 turtle species, found in all species except for *P. mouhotii*. The genus *Falcaustra* is cosmopolitan and is known to occur in frogs, fish, turtles, and salamanders. This parasite seems to be horizontally transmitted among all vertebrates with the exception of mammals. *Polystomoides malayi* and *M. purvisi* were parasites with low prevalences (17%) that seem to have evolved with a specific host, *C. amboinensis* and S. *crassicollis,* respectively. These parasites are transmitted vertically, and may be useful in phylogenetic comparisons as they are host specific.

It is important to note that some species of parasites may have been undetected due to the preservation of the hosts, arriving to TCWC frozen or on ice with many turtles decomposing, and my inability to examine entire turtles as they were primarily intended for museum use. In spite of this, I found 10 different parasite species and 16 new host records. All but 2 parasites, *M. purvisi* and *P. malayi*, had new host records. It also provided the first record of any parasite from *P. mouhotii*. The list of endohelminths herein is intended to provide a foundation for future parasite studies of the 6 freshwater Asian turtles.

LITERATURE CITED

Ades, G., and P. Crow. 2002. The Asian turtle rescue operation: Temporary holding and placement at Kadoorie Farm and Botanic Garden, Hong Kong. Turtle and Tortoise Newsletter 6:2-7.

Balasingam, E. 1964. Some helminth parasites of Malayan reptiles. Bulletin of the Singapore Natural Museum 32: 103-127.

Baylis, H.A. 1933. On a collection of nematodes from Malayan reptiles. The Annals and Magazine of Natural History 66: 615-633.

Berry, J. F. 1984. Redescription of *Falcaustra duyagi* (Tubangui & Villaamil, 1933) Freitas & Lent, 1941 (Nematoda: Cosmocercoidea) from *Cuora amboinensis* (Testudinidae) of Malaysia. Canadian Journal of Zoology 62:1685-1688.

Brooks, D. R., and E. P. Hoberg. 2001. Parasite systematics in the 21st century: opportunities and obstacles. Trends in Parasitology 17:273-275.

Brooks, D. R., and J. R. Palmieri. 1978. Pronocephalid trematodes from a Malaysian box turtle including a new species of *Renigonius* Mehra, 1939. Proceedings of the Helminthological Society of Washington 45:34-36.

Brooks, D.R., and J. R. Palmieri. 1979. *Neopronocephalus orientalis sp. n*. (Digenea: Pronocephalidae) and *Spirhapalum elongatum* Rohde, Lee, and Lim, 1968 (Digenea: Spirorchiidae) from *Cuora amboinensis* (Daudin) in Malaysia. Proceedings of the Helminthological Society of Washington 46:55-57.

Bouloux, C., M. Langlais, and P. Silan. 1998. A marine host–parasite model with direct biological cycle and age structure. Ecological Modelling 107: 73-86.

Bursey, C. R., and J. M. Kinsella. 2003. *Falcaustra greineri* n. sp. (Nematoda: Kathlanidae) from *Orlitia borneensis* (Testudines: Emydidae). Journal of Parasitology 89:961-964.

Cable, R. M. 1958. An Illustrated Laboratory Manual of Parasitology. 4th ed. Burgess Publishing Company, Minneapolis, Minnesota. 165 pp.

Chou, L. M., and Lowe, C. M. 1984. *Spironoura roberti* sp. n. (Nematoda: Kathlaniidae) from the Malayan box-tortoise *Cuora amboinensis*. Malayan Nature Journal 38:67-72.

Daniel, J. C. 2002. The Book of Indian Reptiles and Amphibians. Oxford University Press, Oxford, United Kingdom. 238pp.

Dawes, B. 1941. On *Multicotyle purvisi*, N.G., N.SP. an aspidogastrid trematode from the river turtle, *Siebenrockiella crassicollis*, in Malaya. Parasitology 33:300-305.

Des Clers, S. 1991. Functional relationship between sealworm (*Psuedoterranova decipiens*, Nematoda, Ascaridoidea) burden and host size in Atlantic cod (*Gadus morhua*). Proceedings of the Royal Society of London 245:85-89.

Du Preez, L. H., and L. H. S. Lim. 2000. *Neopolystoma liewi* sp. n. (Monogenean: Polystomatidae) from the eye of the Malayan box turtle (*Cuora amboinensis*). Folia Parasitologica 47:11-16.

Dwivedi, M. P. 1965. On a new sp. of the genus *Spinometra* Mehra, 1931 (Plagiorchiidae: Astiotrematinae). Revista de Biología Tropical 13:91-99.

Dwivedi, M. P. 1967. *Kachugotrema amboinensis* n.g. n. sp. (Paramphistomidae: Trematode). Indian Journal of Helminthology 19: 45-55.

Ernst, C. H., and R. W. Barbour. 1989. Turtles of the World. Smithsonian Institution Press, Washington, D.C. 313 pp.

Ernst, C. H., and E. M. Ernst. 1980. Relationship between North American turtles of the *Chrysemy* complex as indicated by their endoparasitic helminths. Proceedings of the Biological Society of Washington. 93:339-345.

Euzet, L., J. F. Agnese, and A. Lambert. 1989. Valeur des parasites comme critére d'identification de l'espéce hôte: démonstartion convergente parasitologique des monogénes branchiaux et l'analyse génétique des hôtes. Comptes Rendus de l' Academie des Sciences, Paris, France 308:385-388.

Fischthal, J. H., and R. F. Kuntz. 1964. A monogenetic and seven digenetic trematodes. Proceedings of the Helminthology Society of Washington 31:230-240.

Gardner, S. L., and M. L. Campbell. 1992. Parasites as probes for biodiversity. Journal of Parasitology 78:596-600.

Grenfel, B. T. 1992. Parasitism and the dynamics of ungulate grazing systems. American Naturalist 139:907–929.

Hilton-Taylor, C., ed. 2000. 2000 IUCN Red List of Threatened Species. IUCN/SSC, Gland, Cambridge, United Kingdom. 61 pp.

Hirayama R. 1984. Cladistic analysis of batagurine turtles (Batagurine: Emydidae: Testudinoidea); a preliminary result. Studia Geologica Salmanticensia 1:141-157.

King, F. W., and R. L. Burke, eds. 1989. Crocodilian, Tuatara, and Turtle Species of the World. Association of Systematics Collections, Washington D.C. 216 pp.

Klemens, M. W., ed. 2000. Turtle Conservation. Smithsonian Institution Press, Washington, D.C. 334 pp.

Lamb, T., and C. Lydeard.1994. A molecular phylogeny of the gopher tortoises, with comments on familial relationships within the Testudinoidea. Molecular Phylogenics and Evolution 3:283-291.

Lambert, A., and S. El Gharbi. 1995. Monogenean host specificity as a biological and taxonomic indicator for fish. Biological Conservation 72:227-235.

Littlewood, D. T. J., K. Rohde, and K. A. Clough. 1997. Parasite speciation within or between host species?–phylogenetic evidence from site specific polystome monogeneans. International Journal for Parasitology 27:1289-1297.

Mehrtens, J. M. 1970. *Orlitia* the Bornean terrapin. International Turtle and Tortoise Society Journal 5:6-33.

Monis, P. T. 1999. The importance of systematics in parasitological research. International Journal for Parasitology 29:381-388.

Myers, B. J., and R. E. Kuntz. 1969. Nematodes of fishes, amphibians, and reptiles taken by U.S. Naval Medical Research Unit No. 2 expedition to North Borneo (Malaysia). Journal of the Fisheries Research Board of Canada 26: 793-797.

Olsen, O. W. 1974. Animal Parasites: Their life Cycles and Ecology, 3rd ed. University Park Press, Baltimore, Maryland. 562 pp.

Palmieri, J. R., and J. T. Sullivan. 1977. *Stunkardia minuta* sp. n. (Trematoda: Paramphistomidae) from the Malayan box-tortoise *Cuora amboinensis*. Journal of Helminthology. 51: 21-124.

Paugy, D., J. F. Guegan, and J. F. Agnese. 1990. Three simultaneous and independant approaches to characterise a new species of *Labeo* (Pisces, Characidae) from Western Africa. Followed by description of *Labeo roseopunctatus* n. sp. Canadian Journal of Zoology 68:1124-1131.

Pope, C. H. 1935. Natural History of Central Asia. Vol. 10. The Reptiles of China. American Museum of Natural History, New York. 604pp.

Pough, F. H., R. M. Andrews, J. E. Cadle, M. L. Crump, A. H. Savitzky, K. D. Wells. 2004. Herpetology, 3rd ed. Pearson, Prentice Hall, Upper Saddle River, New Jersey. 726 pp.

Poulin, R. 1998. Evolutionary Ecology of Parasites from Individuals to Communities. Chapman and Hall, London,United Kingdom. 212 pp.

Richardson, J. P. M., and D. R. Brooks. 1987. *Polystomoidella mayesi* n. sp. (Monogenean: Polystomatidae) from the urinary bladder on a Malaysian box turtle, *Cuora amboinensis*. Canadian Journal of Zoology 65:1567-1569.

Rohde, K. 1962a. A new trematode, *Diaschistorchis multitesticularis* sp. n., from a Malayan tortoise, *Hieremys annandalei* (Boulenger). Journal of Parasitology 48: 296-297.

Rohde, K. 1962b. *Parorientodiscus magnus* n.g., n. sp., ein trematode aus dem darm von *Cyclemys amboinensis* (Daudin) in Malaya. Zeitschrift fur Parasitenkunde 21: 457-464.

Rohde, K. 1963. *Polystomoides malayi* n. sp. (Monogenea, Polystomatidae) aus der harnblase von *Cyclemys amboinensis* in Malaya. Zeitschrift für Parasitenkunde 22:278-282.

Rohde, K. 1971. Untersuchungen an *Multicotyle purvisi* Dawes, 1941 (Trematoda: Aspidogastrea). I. Entwicklung und morphologie [English Summary]. Zoologische Jahrbücher, Abteilung für Anatomie 88:138-187.

Rohde, K. 1972a. Ultrastructure of the nerves and sense receptors of *Polystomoides renschi* Rohde and *P. malayi* Rohde (Monogenean: Polystomoidae). Zeitschrift fur Parasitenkunde 40:307-320.

Rohde, K. 1972b. The Aspidogastrea, especially *Multicotyle purvisi* Dawes, 1941. Advances in Parasitology 10: 77-151.

Rohde, K. 1973. Ultrastructure of the caecum of *Polystomoides malayi* Rohde and *P. renschi* Rohde (Monogenean: Polystomoidae). International Journal for Parasitology 3:461-466.

Rohde, K. 1990. Ultrastructure of the sense receptors of adult *Multicotyle purvisi* (Trematoda, Aspidogastrea). Zoologica scripta 19:233-241.

Rohde, K., S. K. Lee, and H. W. Lim. 1968. Ueber drei malayische Trematoden. Annales de Parasitologie 43:33-43.

Sey, O., and J. R. Palmieri. 1978. Histo-morphological structure of the muscular organs of *Stunkardia minuta* Palmieri et Sullivan, 1977 (Trematoda: Paramphistomata). Parasitologia Hungarica 11:27-29.

Shaffer, H. B., P. Meylan, and M. L. McKnight. 1997. Tests of turtle phylogeny: Molecular, morphological, and paleontological approaches. Systematic Biology 46:235-268.

Sharma, R. S. K. , M. C. Rigby, S. Sumita, R. A. Sani, M. K. Vidyadaran, S. Jansi, and M. D. Dailey. 2002. Redescription of *Serpinema octorugatum* (Baylis, 1933) (Nematoda: Camallanidae) from the Malayan box turtle *Cuora amboinensis* (Daudin) (Chelonia: Bataguridae). Systematic Parasitology 53:19-28.

Siddiqi, A. M. 1965a. A new species of the genus *Astiotrema* Looss, 1900 with a key to its species. Journal Helminthology 39:113-116.

Siddiqi, A. M. 1965b. Two new trematodes from freshwater turtles in India. Journal of Helminthology 39:277-289.

Siddiqi, A. M. 1965c. Three new species of *Orientodiscus* (Trematoda: Paramphistomata) from freshwater turtles. Journal of Helminthology 39:37-382.

Suzuki, Y., and M. Asakawa. 2000. Parasitic helminths of pet tortoises of Emydidae and other families sold in Sapporo, Hokkaido, Japan with special reference to *Serpinema spp*. Japanese Journal of Zoo Wildlife and Medicine 5:163-170.

Tan, E. G., and X. Q. Liu. 2001. One new species of the genus *Hemiclepsis* (Rhynchobdellida: Glossiphoniidae). Acta Zootaxonomica Sinica 26: 289-291.

Taylor, E. H. 1920. Philippine turtles. Philippine Journal of Science. 16: 111-444.

Thomas, F., O. Verneau, T. De Meeûs, and F. Renaud. 1996. Parasites as to host evolutionary prints: insights into host evolution from parasitological data. International Journal for Parasitology 26:677-686.

Tubangui, M. A. 1933. Trematode parasites of Philippine Vertebrates, VI. The Philippine Journal of Science 52:167-197.

Tubangui, M. A., and R. Villaamil. 1933. Nematodes in the collection of the Philippine bureau of science, I: Oxyuridea. The Philippine Journal of Science 51:607-615.

Wharton, G. W. 1970. The genera *Teleorchis*, *Protenes*, and *Auridistomum* (Trematoda: Reniferidae). The Journal of Parasitology 52:497-518.

Whitehead, P. 1990. Systematics: an endangered species. Systematic Zoology 39:179-184.

Wirot, N. 1979. The Turtles of Thailand. Mitbhadung Press, Bangkok, Thailand. 222pp.

Yamaguti, S. 1933. II. Reptilian trematodes. Japanese Journal of Zoology 5:74-79.

Yamaguti, S. 1959. The Cestodes of Vertebrates Vol. II. Interscience Publishers Incorporated, New York City. 860pp.

Yamaguti, S. 1971. Synopsis of digenetic vertebrates Vol. II. Keigaku Publishing Company, Toyko, Japan. 860pp.

Yamaguti, S. 1975. A synoptical review of life histories of digenetic trematodes of vertebrates. Keigaku Publishing Company, Toyko, Japan. 590pp.

Zug, G. R., L. J. Vitt, and J. P. Caldwell. 2001. Herpetology: An Introductory Biology of Amphibians and Reptiles, 2nd ed. Academic Press, San Diego, California. 630pp.

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Presentations

Murray, R.A., N.O. Dronen, and C.K. Blend. 2002 Endohelminths of six species of vulnerable and endangered species of turtles confiscated by international authorities in Hong Kong. A paper presented by R. Murray at the annual meeting of the Southwestern Association of Parasitologists at Lake Texoma, Oklahoma, April 18.

Murray, R.A., N.O. Dronen, and C.K. Blend. 2003 An update: Endohelminths of six species of vulnerable and endangered species of turtles confiscated by international authorities in Hong Kong. A paper presented by R. Murray at the annual meeting of the Southwestern Association of Parasitologists at Lake Texoma, Oklahoma, April 24.

Murray, R. A. 2003. Wildlife diseases. Presented to Texas A&M University, Wildlife and Fisheries Conclave team at College Station, Texas, February 21.

Murray, R.A., N.O. Dronen, and C.K. Blend. 2003 In conclusion: Endohelminths of six species of vulnerable and endangered species of turtles confiscated by international authorities in Hong Kong. A paper presented by R. Murray at the annual Ecological Student Symposium meeting at College Station, Texas, February 21.

Submitted papers

Murray, R. A., N. O. Dronen, and C. K. Blend. Endohelminths from the black marsh turtle, *Siebenrockiella crassicollis*, confiscated from international authorities in Hong Kong, China. Accepted by Comparative Parasitology.