An appraisal of the problems related to species identity and species diversity within chelonian polystomes (Polystomatidae: Monogenea)

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ABSTRACT

An appraisal of the problems related to species identity and species diversity within chelonian polystomes (Polystomatidae: Monogenea)

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The subfamily Polystomoidinae Yamaguti, 1963, belongs to the class Monogenea that are parasites of terrapins and of the caecilian polystome *Nanopolystoma* Du Preez *et al.*, 2008. Chelonian polystomes include three genera: *Neopolystoma* Price, 1939, whose members have no hamuli, or large hooks, *Polystomoidella* Price, 1939, whose members possess one pair of hamuli, and finally *Polystomoides* Ward, 1917, whose members possess two pairs of hamuli.

Chelonian polystomes comprise of a total of 59 species collectively, with *Neopolystoma* having 21, *Polystomoidella* three, and *Polystomoides* 35 species respectively. Together with these species names, it is unfortunately true that a great many synonyms also exist. This is as a result of the polystomes of chelonians that have been poorly studied, and/or a large number of the species that have been described in obscure journals. To further complicate matters, terrapin classification is not stable and various changes have occurred over the past few decades. This taxonomic complexity is further exacerbated by the fact that no definite protocol exists for one to follow in the event of describing new species, and very important measurements and characteristics are often omitted.

The aims of this study are, firstly, to provide a systematic summary of the existing chelonian polystome species in order to simplify the clutter of information that currently exists and also to facilitate the identification of new species by presenting the data in the form of a simple reference system. Secondly, the paucity of morphometric polystome marginal hooklet measurements is addressed, and a protocol is developed and proposed for a simplified measurement strategy to facilitate distinguishing between chelonian polystomes. Finally, two new eye polystome species from two Florida terrapin hosts collected in 2004 are reported and described.

OPSOMMING

'n Ondersoek na die identifikasie en spesie-diversiteit van waterskilpad polistoom-parasiete (Polystomatidae: Monogenea)

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Die subfamilie Polystomoidinae Yamaguti, 1963 is 'n lid van die klas Monogenea wat polistome van varswaterskilpaaie insluit, asook die polistoom *Nanopolystoma* Du Preez *et al.*, 2008 wat bekend is van wurmamfibiëers. Skilpadpolistome sluit drie genera in: *Neopolystoma* Price, 1939, met geen hamuli (groot hake) nie, *Polystomoidella* Price, 1939, met een paar hamuli, en *Polystomoides* Ward, 1917 met twee pare hamuli.

'n Totaal van 59 spesies skilpadpolistome is bekend waarvan 21 tot *Neopolystoma*, drie tot *Polystomoidella*, en 35 tot *Polystomoides* behoort. Aangesien van hierdie polistome nog nie breedvoerig bestudeer is nie en omdat heelwat van hierdie studies in obskure tydskrifte gepubliseer is, bestaan 'n aantal sinonieme vir spesiename. Om dinge verder te bemoeilik is waterskilpadklassifikasie nie stabiel nie en verskeie veranderinge het in hierdie verband oor die afgelope aantal dekades voorgekom. Hierdie taksonomiese kompleksiteit word vererger deur die feit dat daar geen vaste protokol is wat gevolg kan word wanneer nuwe spesies beskryf word nie, en daarom word baie belangrike afmetings en eienskappe dikwels nie gerapporteer nie.

Die doel van hierdie studie is eerstens om 'n sistematiese opsomming van die bestaande waterskilpad-polistome te verskaf om die warboel van inligting wat tans bestaan te vereenvoudig, en ook om die identifikasie van 'n nuwe spesie te vergemaklik deur die data in die vorm van 'n eenvoudige verwysingsisteem aan te bied. Tweedens stel die studie homself ten doel om die gebrek aan morfometriese marginale haakafmetings aan te spreek deur 'n protokol te ontwikkel en voor te stel vir 'n eenvoudiger afmetingstrategie wat die onderskeid tussen waterskilpad-polistome vergemaklik. Laastens word twee nuwe polistoom-parasiete uit Florida (VSA) beskryf.


Apalone spinifera
Spiny softshell turtle

CHAPTER 1

GENERAL INTRODUCTION AND LITERATURE OVERVIEW

"You're a parasite for sore eyes"
Gregory Ratoff (1897 – 1960)

1.1 General Appraisal

Animals are in constant association with one another (homogenetic associations) as well as with other species (heterogenetic associations). Heterogenetic associations have developed into a variety of successful survival strategies, some of which can be described as commensalism, phoresis, mutualism and, finally, parasitism; perhaps the most successful of all (Smyth, 1994). According to Roberts and Janovy Jr. (2008), parasitism can be defined as a symbiosis, or interaction, in which the symbiont, or parasite, benefits from the association, while the host is harmed in some way or another. Parasitism constitutes one of the most successful survival strategies, and can be found in almost every phylum within the animal kingdom. According to Du Preez (1986), animals that are not parasites themselves will at one point or another act as a host for parasites, and parasites themselves may serve as hosts for other parasites as well.

Parasites are dependent on their hosts for a variety of reasons, including developmental stimuli, nutritional materials, digestive enzymes, and control of maturation and mitosis. Parasites can be divided further into two groups with regards to their site of occupancy: ectoparasites, which live on the outside of their hosts, and endoparasites, that live in the inside of their hosts (Smyth, 1994). According to Kennedy (1975), a successful host-parasite system is dependent on three criteria: contact with a potential host, a suitable habitat for the parasites, and the ability of parasites to cope with the host's defence system. Many groups of parasites have perfected this system and have radiated or diversified extensively.

The Monogenea Carus, 1863 are hermaphroditic flatworms that are mainly external parasites of vertebrates, primarily of the gills and external surfaces of fish (Roberts & Janovy Jr., 2008), but can also be found in other organs such as the nostril, eye, ear, cloaca, rectal gland, urinary bladder – all of which have a direct or indirect passage to the outside – and sometimes on the skin or buccopharyngeal cavity of aquatic or amphibious vertebrates (Yamaguti, 1963). They are classified under the phylum Platyhelminthes, thus displaying characteristics such as bilateral symmetry and the possession of flame cells (protonephridia), and their bodies are dorsoventrally flattened with a syncytial tegument as epidermis (Hickman *et al.*, 2004).

According to Rohde (1996), only a small fraction of the Monogenea are known, and it is estimated that there are more than 20 000 species. Their classification and subdivision for this particular study are as follows:

Kingdom	:	Animalia Linnaeus, 1758
Phylum	:	Platyhelminthes Gegenbaur, 1859
Class	:	Monogenea Carus, 1863
Subclass	:	Polystomationea Lebedev, 1986
Order	:	Polystomatidea Lebedev, 1988
Superfamily	:	Polystomatoidea Price, 1936
Family	:	Polystomatidae Carus, 1863
Subfamily	:	Polystomoidinae Yamaguti, 1968

Boeger and Kritsky (1993) proposed a reclassification of the Monogenea to Monogenoidea Bychowsky, 1937, although this has not gained general acceptance. Monogenoidea have been given class status by some authors, while others have awarded it infraclass status (Roberts & Janovy Jr., 2008). Despite this, Boeger, Kritsky and associates have continued to make use of Monogenoidea when referring to this class of the Platyhelminthes (Boeger *et al.*, 1994; Boeger & Kritsky, 1997).

Flatworms belonging to the family Polystomatidae are generally referred to as polystomes and are known from all three orders of the Amphibia, the Australian lungfish, the hippopotamus and from freshwater chelonians. Currently the Polystomatidae are represented by 21 genera, originating from different aquatic tetrapod hosts (Du Preez *et al.*, 2008): *Diplorchis* Ozaki, 1931, *Eupolystoma* Kaw, 1950, *Mesopolystoma* Vaucher, 1981, *Metapolystoma* Combes, 1976, *Neodiplorchis* Yamaguti, 1963, *Parapolystoma* Ozaki, 1935, *Parapseudopolystoma* Nasir & Fuentes Ambrano, 1983, *Polystoma* Zeder, 1800, *Protopolystoma* Bychowsky, 1957, *Pseudodiplorchis* Yamaguti, 1963, *Riojatrema* Lamothe-Argumento, 1964, *Sundapolystoma* Lim & Du Preez, 2001, and *Wetapolystoma* Gray, 1983 are found in anuran hosts, mainly in the urinary bladder of adult frogs as well as the gills of tadpoles. *Pseudopolystoma* Yamaguti, 1963 and *Sphyranura* Wright, 1879 are found in caudate hosts, in the urinary bladder of adults and the external gills of juveniles and axolotls. *Concinnocotyla* Pichelin, Whittington & Pearson, 1991 are found in the Australian lungfish, and are found only in the oral cavity, while *Nanopolystoma* Du Preez, Wilkinson & Huyse, 2008 is found in caecilian hosts, in the urinary bladder and phallodeum. *Oculotrema* Stunkard, 1924, can be found in a mammal host, the hippopotamus, exclusively on the eye, usually in clusters. Finally, *Neopolystoma* Price, 1939, *Polystomoidella* Price, 1939, and *Polystomoides* Ward, 1917 are associated with chelonian

hosts in a variety of sites, such as the urinary bladder and cloaca, the cavity of the eye, nose and mouth, and the pharynx. This study will focus on polystomes parasitising terrapins.

Chelonians are reptiles from the order Chelonia, which include turtles, tortoises and terrapins. Freshwater turtles are referred to as terrapins, and they are classified as follows:

Kingdom	:	Animalia	Linnaeus, 1758
Phylum	:	Chordata	Bateson, 1885
Subphylum	:	Vertebrata	Cuvier, 1812
Class	:	Reptilia	Laurenti, 1768
Order	:	Testudines	Linnaeus, 1758
Suborder	:	Cryptodira	Linnaeus, 1758

Terrapins have bodies that are protected by a bony case which consists of a dorsal carapace and ventral plastron, and while teeth are absent, they do have horny beaks. Their vertebrae and ribs are fused to form the overlying carapace, and their necks are usually retractable. Their tongues are not extendible, and they possess a middle and an inner ear, although their perception of sound is poor (Hickman *et al.*, 2004).

Chelonians are divided in two suborders: Cryptodira (Cope, 1868) and Pleurodira (Cope, 1864), distinguished by four major features. Firstly, the head and neck, where representatives of the Cryptodira's head is withdrawn vertically and is protected by its forelimbs, representatives of the Pleurodira's head is withdrawn sideways and is not protected by its forelimbs. Secondly, the plastron scutes: both groups have six pairs, but in representatives of the Cryptodira only the anterior gulars may fuse and the horny scutes are lost in some groups, whereas representatives of the Pleurodira have an additional anterior intergular, and the horny scutes are never lost. Thirdly, the pelvic girdle: where representatives of the Cryptodira's pelvis is not fused to the shell, it is attached by ligaments, but representatives of the Pleurodira's is fused to its shell. Lastly, the skull structure: representatives of the Cryptodira's skull is reinforced with pterygoid bone, and representatives of the Pleurodira's is reinforced with quadrate bone (Branch, 2008). Representatives of the Cryptodira is the larger group, comprising of eleven families: Carettochelyidae Boulenger, 1887, Cheloniidae Oppel, 1811, Chelydridae Gray, 1831, Dermatemydidae Gray, 1870, Dermochelyidae Fitzinger, 1843, Emydidae Rafinesque, 1815, Geoemydidae Theobald, 1868, Kinosternidae, Agassiz, 1857, Platysternidae Gray, 1869, Testudinidae Batsch, 1788, Trionychidae Fitzinger, 1826. Pleurodira comprises of three families: Chelidae Gray, 1825, Pelomedusidae Cope, 1868, and Podocnemididae Cope, 1868. Each of these can be distinguished by unique diagnostic characteristics (Bonin *et al.*, 2006; Fritz & Havaš, 2007).

Species of *Neopolystoma* Price, 1939, *Polystomoides* Ward, 1917, and *Polystomoidella* Price, 1939, belonging to the Polystomoidinae Yamaguti, 1968, radiated in their chelonian hosts and utilise a variety of sites in the terrapin body throughout the world. Chelonian polystomes share a uniform general morphology (see Figure 1.1), but differ principally in the number of hamuli they possess. *Neopolystoma* have no hamuli while *Polystomoidella* have one pair, and *Polystomoides* have two pairs (Pichelin, 1995).

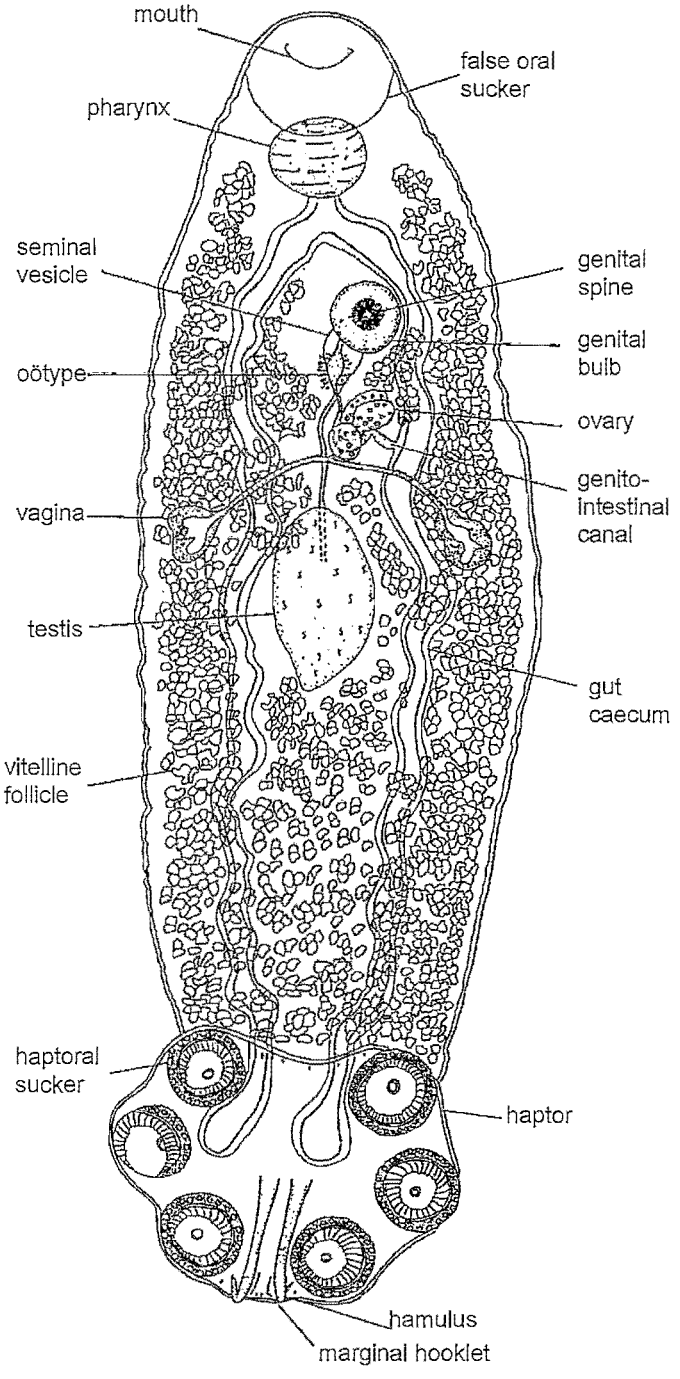


Figure 1.1: Diagrammatic drawing of *Polystomoides scottae* Pichelin, 1995, adapted from Pichelin (1995).

The life cycles of terrapin polystomatids have not been studied thoroughly (Pichelin, 1995), but all three genera do have a general life cycle (Figure 1.2).

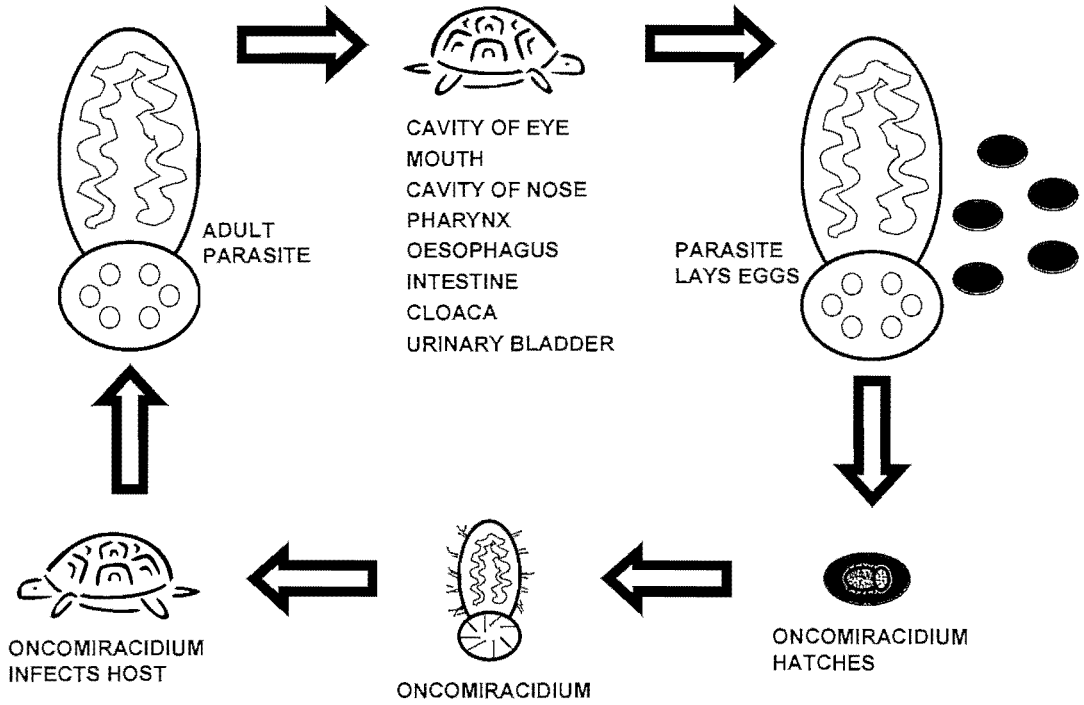


Figure 1.2: General life cycle of chelonian polystomes.

The only detailed account of the reproductive biology of a chelonian polystome is found in studies on *Polystomoidella oblonga* (Wright, 1879), a polystome that produces advanced juveniles *in utero* (Pichelin, 1995). Unlike some of the anuran polystomes, chelonian polystomes do not have neotenic phases. Ciliated oncomiracidia hatch from operculated eggs and enter the host through openings they can access from the outside, such as the eye cavity, the mouth, the nose cavity, the pharynx, the oesophagus, intestine, cloaca, and the urinary bladder. They have a large geographical distribution and occur in Australia, North and South America, Mexico, Japan, Wales, Canada, India, and Europe. Presently there are 57 known species, but it is very likely that several undescribed species exist.

1.2 Overview

1.2.1 Research Problem

Although there are 57 known polystome species that infect terrapins, many synonyms also exist. This is mainly because many polystomes of chelonians have been poorly studied and some of the species have been described in obscure journals. To complicate matters further, terrapin classification is not stable and various taxonomic changes were made over the past few decades. A systematic summary of all the chelonian polystomes is urgently needed to address this taxonomic complexity. A further problem with the species identity and species diversity of chelonian polystomes is that no set protocol exists for one to follow in the event of describing a

new species. Every scientist describes a species in his or her own way, without a proper plan to follow, with the result that important information or measurements are often not reported. As is the case with anuran polystomes, chelonian polystomes show large intraspecies variation and little interspecies variation and more reliable measurements have often not been reported. Marginal hooklets provide one such a measurable and reliable characteristic. Their shape and size remain constant throughout the development of the parasite; also, within each species their morphology is stable, but may differ between species (Du Preez & Maritz, 2006). This has already been demonstrated for the anuran polystome genus *Polystoma*. A standardised protocol for the description of chelonian polystomes would complement the systematic list and provide a standardised protocol when describing yet unknown forms. To contribute towards developing such a protocol an aim of this study was to evaluate the marginal hooklet C1 as taxonomic characteristic and provide a set of prescribed measurements when describing a new species.

During 2004, Louis du Preez (supervisor of the current study) spent three months in Gainsville, Florida, where he screened a number of terrapins for polystome parasites. Six species of terrapins were dissected and all were found to be infected with one or more species of polystome. A preliminary investigation was conducted on the parasites and it was found that some were new chelonian polystome species.

1.2.2 Chelonian Polystomes

Chelonian polystomes are distinguished from other polystome genera by the combination of the following five characteristics:

1. Undiverticulated intestinal gut caecae of equal length that do not form any anastomoses.
2. Distribution of the yolk into lateral fields.
3. A compact spherical testis, situated in the middle of the parasite.
4. Skeletal elements in the suckers that improve the parasite's grip on the host.
5. The genital bulb may have a large amount of genital spines, with some species even possessing two rows of different sizes.

Of the 57 known species, *Neopolystoma* has 21 species, with *N. kreffti* Rohde, 1984 having one synonym, and *N. orbiculare* (Stunkard, 1916) six. *Polystomoidella* has three species, with *P. oblongum* (Wright, 1879) having one synonym, and *P. whartoni* Price, 1939 one. Finally, *Polystomoides*, the largest genus, has 33 species, with *P. coronatum* (Leidy, 1888) having five synonyms, and *P. multifalx* (Stunkard, 1924) one. Chelonian and certain other polystome genera have a reproductive strategy that have adapted to their hosts' almost permanent water-living habits. Adult parasites produce eggs all of the time, but not in large quantities. The eggs can be ellipsoid to fusoid or ovoid and are not retained in a uterus, but released into the water,

and hatch after a relatively long period of time. For example, the eggs of *Polystomoides australiensis* Rohde & Pearson, 1980 take 33 to 57 days at 18 – 24°C, and 30 to 33 days at 24 – 28°C to embryonate and hatch (Pichelin, 1995). Maturation can take up to 208 days. Adapting to the aquatic environment, chelonian polystomes have developed the following (Figure 1.3):

- A small uterus. They do not need to store a large number of eggs.
- Eggs are released into the water almost as soon as they are released from the ootype.
- The ovary is relatively small and cannot produce eggs in rapid succession.
- They usually do not have well-defined vaginae.
- The ciliated oncomiracidium has signficant longevity, allowing the parasite larva time to find a suitable host.

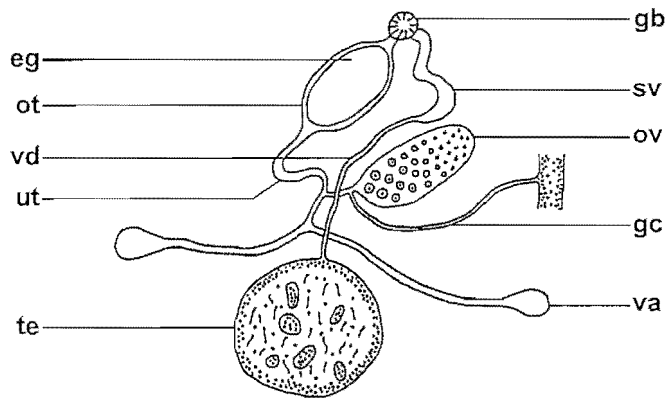


Figure 1.3: An example of a chelonian polystome's reproductive organs: *Neopolystoma liewi* Du Preez & Lim, 2000. Abbreviations: eg – egg; gb – genital bulb; gc – genitointestinal canal; ot – ootype; ov – ovary; sv – seminal vesicle; te – testis; ut – uterus; va – vagina; vd – vas deferens. Adapted from Du Preez & Lim (2000).

The three genera have unique distributions (Du Preez, *pers. com.*): Species of *Neopolystoma* and *Polystomoides* are relatively cosmopolitan, while species of *Polystomoidella* are very restricted (see Figures 1.4 - 1.6). While a concrete theory that explains *Polystomoidella*'s distribution does not exist, their distribution may be heavily influenced by human activities, such as the translocation of terrapins for food or pets. *Polystomoidella mayesi*'s host, *Cuora amboinensis* has been exported extensively in the past, and is seen in many Western collections. The same can be said for *Polystomoidella oblongum* and *P. whartoni*'s hosts, which have also been exported to Asia in the past. While nothing can be deduced from any of the genera's distribution patterns because of the biased dispersal of scientists and research, a great deal can be observed regarding their biogeographical distribution. No species occur in the northern parts of the distribution maps, but this can be attributed to the fact that very few terrapin species occur there. North America, Australia and Asia have the largest distribution of species, while Africa has very little. This is because the three continents have a greater terrapin diversity, with North America, for example, boasting up to 46 different species.

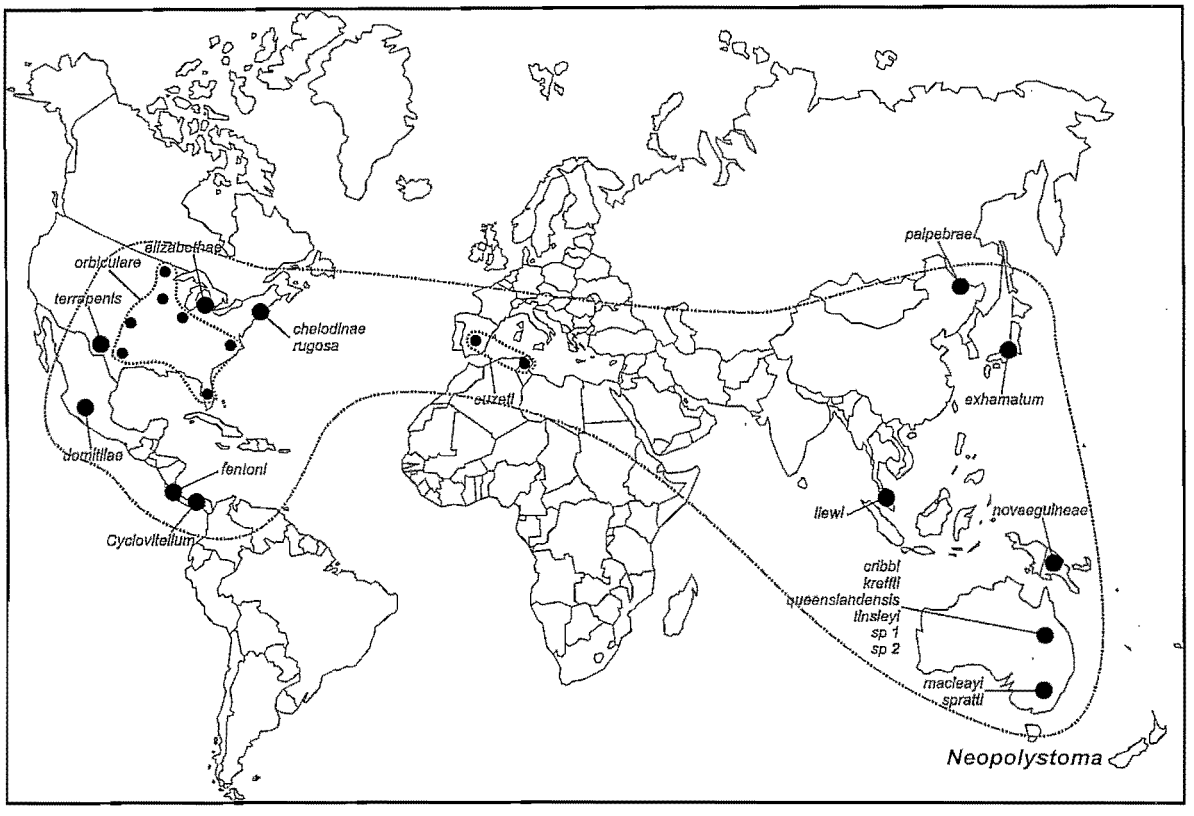


Figure 1.4: A distribution map for the polystome genus *Neopolystoma*.

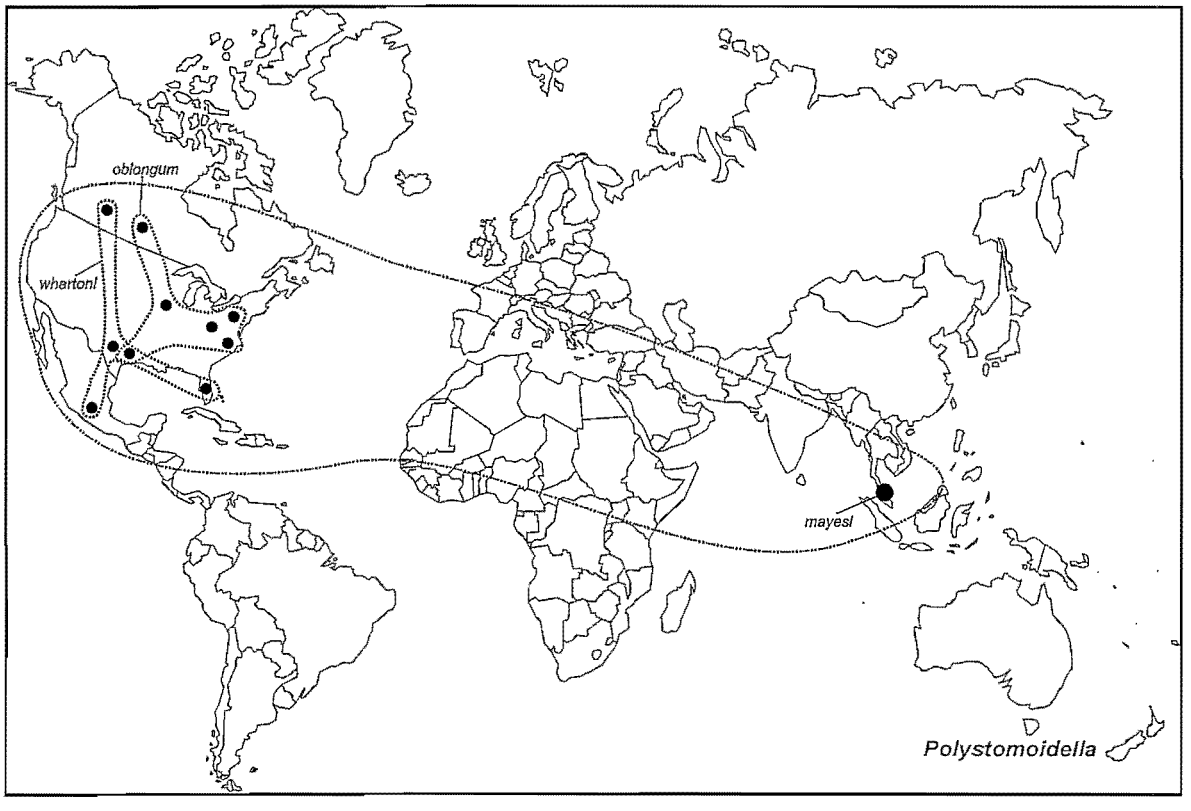


Figure 1.5: A distribution map for the polystome genus *Polystomoidella*.

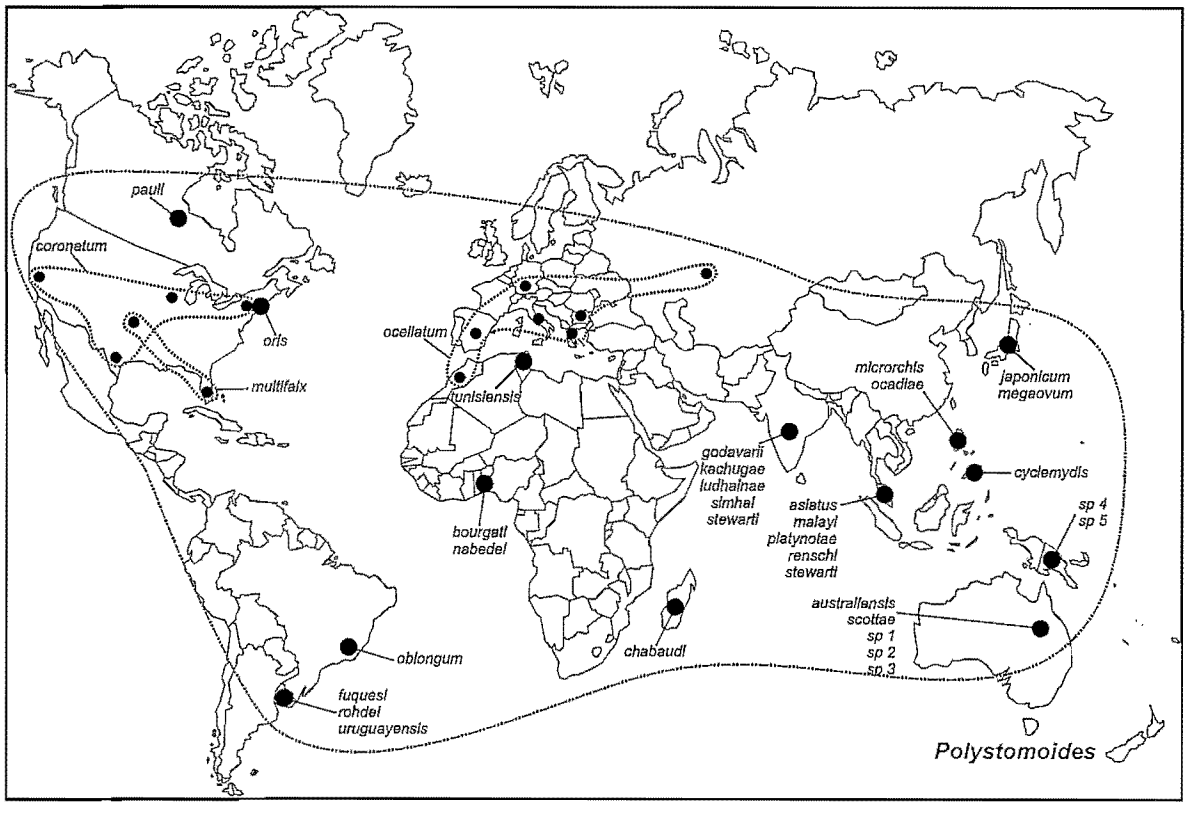


Figure 1.6: A distribution map for the polystome genus *Polystomoides*.

Various attempts have been made to find chelonian polystomes in South Africa mainly from *Pelomedusa subrufra* and *Pelusius sinuatus*, but to date no infected hosts have been found. This does not mean that chelonian polystomes do not occur in South Africa, because polystome parasites are inclined to be over-dispersed and concentrated.

If one takes the global zoogeographical zones into account, most of the three genera's species occur in the Palaearctic, Nearctic, Oriental and Australian zones, but they do occur in every zone except the Antarctic. The large circles represent the overall distribution of the genus as a whole. In each of the genera there are species that are widely distributed (represented by the smaller circles): *Neopolystoma orbiculare*, *Polystomoidella whartoni* and *P. oblongum*, and *Polystomoides occelatum* (Rudolphi, 1819). The distribution of *Neopolystoma* and *Polystomoidella* species can be explained by the rich terrapin diversity that exists where they occur, as well as synonyms that were described. *Polystomoides occelatum*'s host, *Emys orbicularis*, has a very wide distribution, found from Northern Africa and Eastern Europe to Asia Minor and the coast of Iran, and this species has also been found in another host species, *Mauremys caspica*, which has a much more eastern distribution, for example occuring as far as Turkey and Saudi Arabia (Bonin *et al.*, 2006; Fritz & Havaš, 2007).

1.2.3 Hosts

The development and distribution of their terrapin hosts have a significant influence on the chelonian polystome's biogeographical distribution. Much of the distributions of the genera can be explained by the exploitation of terrapins for food, cultural uses, medicine, and the pet trade. The most salient example of this is *Trachemys scripta*, or the red-eared terrapin, which is the most exploited terrapin in the world, with over two million a year being exported for the pet trade. The terrapins are then either released when they grow too big, or they escape, invading the natural environment.

200 million years ago, Laurasia and Gondwanaland split from one another, which makes Pangaea irrelevant for terrapin distribution, because terrapins also diversified around that time. Polystomes also switched hosts around a similar time (200mya), which makes Pangaea also irrelevant for their distribution. Chelonian polystomes and their distribution are thus related to their hosts and followed their distribution paths. North American and European terrapins, and Australian, Indian and African terrapins are more closely related to each other, likewise their polystomes will also cluster together. This has been proven through molecular work (Verneau, 2002).

1.3 Objectives

1.3.1 Objective 1 - Systematic List

Compose a systematic list that summarises the known species of the three genera of chelonian polystomes with their diagnostic and descriptive information.

1.3.2 Objective 2 - Marginal Hooklet Measurement: Morphometric Protocol

Develop a morphometric protocol for the standard description of new species of chelonian polystomes by determining which measurements of the marginal hooklets of chelonian polystomes have the most measurability and classification potential with less than five measurements. The protocol developed by Du Preez and Maritz (2006) will be followed to achieve this objective.

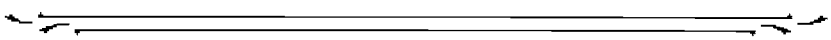
1.3.3 Objective 3 - Florida Study: Protocol Application

Evaluate all North American polystomes and study the polystomes found in Gainsville by applying standard measurements as well as the new morphometric protocol. Develop formal descriptions of any new species.

1.4 Chaptering

- Chapter 1: General Introduction and Literature Overview
- Chapter 2: General Materials and Methods
- Chapter 3: Systematic List
- Chapter 4: Evaluation of Marginal Hooklet Measurements as Taxonomic Character
- Chapter 5: Florida Polystome Species Descriptions
- Chapter 6: General Discussion
- Chapter 7: Conclusion

Chapter 1 and 2 are structured as general overviews regarding the field of study. Chapters 3, 4, and 5 have topic-specific Introductions, Materials and methods, and Discussions.



CHAPTER 2

GENERAL MATERIAL AND METHODS

2.1 General Procedure

2.1.1 Capture of Terrapins

Terrapins were collected using basking traps as well as baited crayfish traps which were baited with fish or ox liver and set in such a way that approximately one third of the trap was above the waterline to allow terrapins to surface and breathe. Trapped terrapins were removed, put into a suitable bucket, and transported to the laboratory. Detailed notes on the locality as well as GPS coordinates were taken. Animals were not fed and were immediately screened for the release of polystome eggs.

2.1.2 Screening of Captured Terrapins for Polystome Parasites

Captured terrapins were placed individually into buckets containing water (approximately 30 mm deep). These were then left undisturbed for 24 hours after which the terrapins were removed and the water screened for the presence of polystome eggs. The water in which the terrapins were kept was filtered through a series of plankton sieves. Firstly, a 500 µm net was used, which removed coarse material, but let the parasite eggs through. The surface of the net was then sprayed with water to ensure that all eggs would wash through the net. Water was then poured through a 112 µm net to capture eggs, but which allowed fine debris through. The contents of the 112 µm plankton net was then carefully rinsed into a glass petri dish, and slowly rotated in a circular motion to concentrate polystome eggs to the middle of the dish through centripetal force.

The contents was examined under a dissecting microscope to determine the presence of polystome eggs, which are shiny golden-brown and oval for urinary bladder or oral region parasites (Figure 2.1A) or elongated for eye parasites (Figure 2.1B). The presence of polystome eggs indicated a positive infection. To retrieve parasites, terrapins were euthanized and dissected. When no polystome eggs were detected, the terrapin was screened for a second or third time and if found to be uninfected, released where collected.

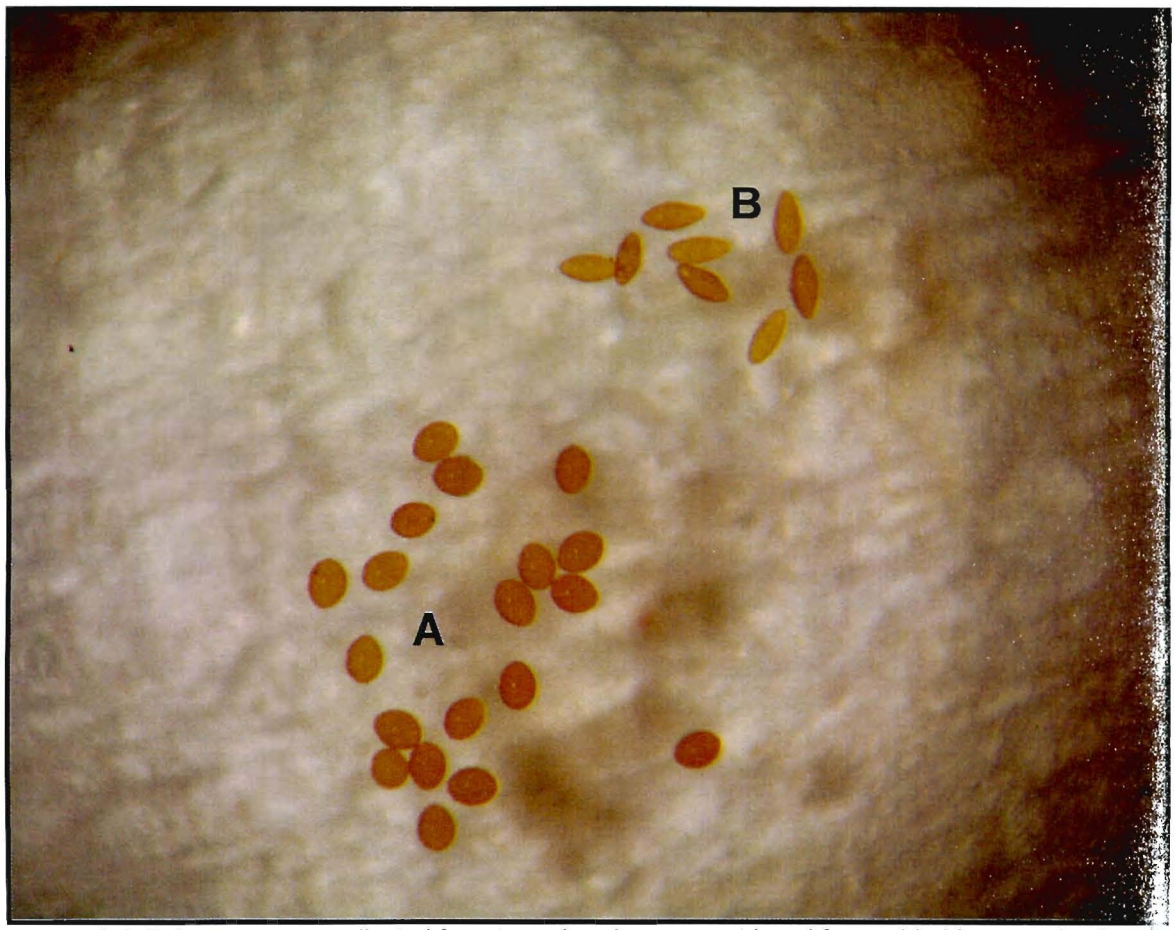


Figure 2.1: Polystome eggs collected from terrapins. A – eggs retrieved from a bladder or oral polystome and B – eggs from an eye polystome.

2.1.3 Euthanasia (humane killing) of Terrapins

Positively infected terrapins were humanely killed with an injection of 5ml Sodium Pentabarbitone (Uthapent). 0.5ml Uthapent was drawn into a syringe together with 4.5ml lukewarm water to a total of 5ml. This lethal solution was injected into the thorax cavity of the terrapin, aiming for the heart. To test for any vital signs, the terrapin's leg and tail were pulled and from the time that no response was noticeable, another 10 minutes was allowed to lapse before dissecting.

2.1.4 Dissection of Terrapins to Inspect for Polystome Parasites

The plastron was cut through on both sides, loosened and removed. The urinary bladder together with the accessory bladders, cloaca and tail in tact was removed and transferred to a Petri dish containing a 0.06% saline solution. Removed organs were inspected for the presence of any polystome parasites, which were collected. Finally, the head was removed, and the oral, pharyngeal and nasal cavities, as well as the eye surface and cavity under the nictitating membrane were inspected for the presence of polystome parasites. The terrapin carcasses were refrigerated until they could be incinerated.

2.1.5 Temporary Storage of Polystome Parasites

Collected polystomes were fixated individually under cover slip pressure in 10% Neutral Buffered Formalin (NBF). The parasite was placed in a drop of water on a microscope slide, and a cover slip was placed on top of it. A drop of 10% NBF was placed on the edge of the cover slip, while a piece of tissue paper was placed on the other edge to draw the fixative over the parasite. The parasite was then left in the 10% NBF under the cover slip for one hour to fixate in a flattened position. The cover slip was gently removed and the parasite was transferred to a vial containing 10% NBF, and labelled.

2.1.6 Staining and Permanent Storage of Polystome Parasites

Formalin fixed parasites were hydrated in de-chlorinated tap water for one hour. The parasite was placed in a small Petri dish or cavity block and stained overnight in a diluted acetocarmyn solution. Parasites were dehydrated to absolute ethanol in a graded alcohol series (30%, 50%, 80%, 96% and finally 100%) with 10min intervals. Specimens were then cleared in a 1:1 ratio mix of 100% EtOH and Xylene for 20min followed by two 20min steps of Xylene. Stained, cleared specimens were mounted permanently on microscope slides using Canada Balsam, by placing the parasite on a microscope slide and positioning a cover slip with a drop of Canada Balsam on it. The mounted specimens were dried in an oven set at 40°C for 24 hours. Preparations were removed and left to dry further. Slides were labelled with the relevant information pertaining to the parasite, host, and site.

Throughout these procedures, good laboratory practice (GLP) was maintained. Ethical clearance (**01D04**) was obtained from the North-West University Ethical Committee.

CHAPTER 3

REVIEW OF SPECIES

3.1 Introduction

Even before Darwin introduced his theory of common descent, mankind has been searching for order in the diversity of animal life. This has led to the concept that animals sharing common features have relatively recent common ancestry, and can thus be grouped together in a taxonomic classification. Taxonomy can be defined as the study of the principles of scientific classification, systematic ordering, as well as the naming of organisms (Hickman *et al.*, 2004). The Greek philosopher and biologist Aristotle was the first to classify organisms on the basis of their structural similarities, and this culminated in the work of Carolus Linnaeus, who developed the scheme of classification used today, namely the binomial classification, building on foundations put down by pioneers such as Aristotle, Ceasalpino, Bouhin and Lobelius, Bauhin and Ray. This system includes seven mandatory ranks for the animal kingdom: kingdom, phylum, class, order, family, genus, and species. Together with these big names in taxonomy, many more have contributed to the classification system as we know it today, starting with the work of George Buffon, Bernard de Jussieu, Charles Bonnet, and Jean Baptiste Lamark, and finally coming to the work of Georges Cuvier, Erasmus Darwin, and Charles Darwin.

Linnaeus himself is credited with the description of a parasite (the sheep liver fluke *Fasciola hepatica)* and since then, many parasites as well as their developmental stages were described (Roberts & Janovy Jr., 2008). Several new species of protozoans, helminths and arthropods are described every year. These descriptions gave rise not only to a massive body of literature - some published in obscure and foreign journals - but also to quite a large number of synonyms.

The subfamily Polystomoidinae was erected by Satyu Yamaguti in 1963 to accommodate the three genera of the family Polystomatidae that parasitise terrapins: *Neopolystoma*, *Polystomoidella* and *Polystomoides*. The first polystome parasitic on a terrapin was described in 1819 by Carolo Rudolphi from the European terrapin *Emys orbicularis* and was given the name *Polystoma ocellatum* (Rudolphi, 1819). No more species were described until 1879, when *Polystomum oblongum* was described by Ramsay Wright (Wright, 1879). This paved the way for more intense research on the polystome parasites of terrapins, and today 57 species exist, the most recent having been described in 2008 by Vieira, Novelli, Sousa & De Souza Lima (2008). The species are organised into three genera. *Polystomoides* was proposed as a subgenus of *Polystoma* in 1917 by Ward to represent the species that possess two pairs of hamuli. It was

given generic rank by Stunkard (1924a) and redefined by Price (1939). Its type species is *P. coronatum*, described by Leidy in 1888 (Leidy, 1888). *Neopolystoma* was created by Price in 1939 to represent the species that have no hamuli. Its type species is *N. orbiculare*, described by Stunkard in 1916. Finally, *Polystomoidella* was also created by Price in 1939 to represent the species that possesses one pair of hamuli. Its type species is *P. oblonga*, described by Wright in 1879 (Yamaguti, 1963).

Several taxonomists have described chelonian polystomes, but a few names stand out as having made significant contributions. Emmett Price has conducted a thorough study on North American terrapin polystomes, and reviewed eight species. The Australian scientist Sylvie Pichelin studied Australian chelonian polystomes and described five new species and re-described four others. However, despite the contributions of these and other authors, there are some problems regarding the taxonomy of the species. For example, G.A. MacCallum described nine new species of terrapin polystomes, of which seven are synonyms for already established species. *Neopolystoma orbiculare* has six synonyms, *Polystomoidella oblongum* and *P. whartoni* both have one, *Polystomoides coronatum* has five, and *P. multifalx* has one. Together with this problematic state of affairs, the classification of terrapins is not stable and various changes have occurred over the past few decades, further complicating polystome classification. Contributing to the taxonomic complexity is the fact that many chelonian polystomes have been poorly studied, and that research is, in many cases, biased towards certain terrapin species and geographic areas. Synonyms and other faulty descriptions also exist because some of the species have been described in obscure journals, and because no proper protocol exists that is followed in the event of the description of a new species.

In light of this, the present study was undertaken with a view to achieve the following objectives:
1) to summarise the present knowledge available on the Polystomatidae of chelonians from the original authors' articles, and
2) present the data in a format that can be used as a reference system. Although great care was taken to ensure that the species list is as comprehensive as possible, it cannot be presumed that this study eliminates the problems that are present in the species identity and species diversity of chelonian polystomes. Rather, the aim of this study is to aid toward lending the taxonomy of this group of parasites greater stability. The aim of this study was not to re-evaluate or re-examine type specimens, as this would require visiting the respective parasite collections.

3.2 Materials and Methods

3.2.1 Overview

Neopolystoma has 21 species described in 14 different publications, *Polystomoidella* has three species described in three different articles, and *Polystomoides* has 33 species described in 27 different articles. The original authors' articles were obtained together with any articles which may have contributed to the taxonomy of the species (articles that renamed the species). Relevant information was extracted from the articles and placed into a standard format. Sketches of the parasite, genital spine(s), large and small hamuli (where applicable), and marginal hooklet(s) were also extracted (where available). If no sketches whatsoever were made by the original author, sketches were made of specimens of the concerned species that were in the African Amphibian Conservation Research Group (AACRG) parasite collection of the North-West University, Potchefstroom Campus. If no material was available, other articles were obtained that provided sketches of the species. Synonyms are also included in the systematic list, because they provide additional information of the type species.

In the event of articles that are written in other languages, these were translated into English using the SDL Free Translation website (http://www.freetranslation.com) to render the relevant information accessible. Information obtained from the original article is provided without any modification. The species are given in the following order: *Neopolystoma*, *Polystomoidella*, and *Polystomoides*, in alphabetic order.

3.2.2 Format Used

The information that is given for each species (if provided) is presented in the following format:

General

1. *Collection:* The institution(s) where the type material is housed.
2. *Holotype no:* Museum code or number of the name-bearing type specimen known as the holotype.
3. *Paratype no:* Museum codes or numbers of the paratype specimens.
4. *Original description:* The article where the original authors published the species.
5. *Reprint no:* The number allocated to the specific article (if available) in the AACRG literature collection at the North-West University, Potchefstroom Campus.
6. *Other taxonomic contributions:* Authors who have contributed to the taxonomy of the species.
7. *Synonyms:* Any junior synonyms of the species that may exist.
8. *Type locality:* The location where the type specimen was collected.
9. *Other localities:* Other locations where the author(s) collected the species.

10. *Host:* Scientific name of the type host as given by the author(s), followed by the latest acknowledged name where names have changed, and the common name of the species.
11. *Site on type host:* Site location on the host where the parasite was found.

Information on the parasite

A table with standard measurements of the species is given (Figure 3.1), with contributions of the original author(s), as well as taxonomically significant author(s). DNA information (where available) is also provided.

Information on the host

1. *Taxonomy:* Any taxonomic changes of the host species, together with any subspecies that may exist.
2. *Geographical distribution:* The distribution of the host species in its natural habitat.
3. *Ecology:* The ecological and conservation status of the host species.

Remarks

Any additional information applicable to the parasite species or information that is considered relevant in terms of further understanding of the data available for the species is provided.

3.2.3 Dimensions used

The following dimensions applicable to the type species where available are given (Figure 3.1):

Body: body length; greatest width; width at vagina; haptor length; haptor width; oral diameter; pharynx length; pharynx diameter; testis length; testis width; ovary length; ovary width; egg length; egg diameter; genital bulb diameter and haptoral sucker diameter.

Genital bulb: Genital bulb diameter; one or two sets of genital hooks; genital hook length.

Large hamuli: Large hamulus length (Length 1); large hamulus hook length (Length 1).

Small hamuli: small hamulus length (Length 2); small hamulus hook length (Length 2).

Marginal hooklet: Marginal hooklet length.

Other information provided in the table (where available) include the egg incubation time, the number of intra-uterine eggs present, the number of genital bulb hook sets (see discussion), and the haptor length / body length ratio. Where two sets of genital bulb hooks are given, Gen. Bulb Hooks 2, and Gen Bulb Hook Length 2 are applicable.

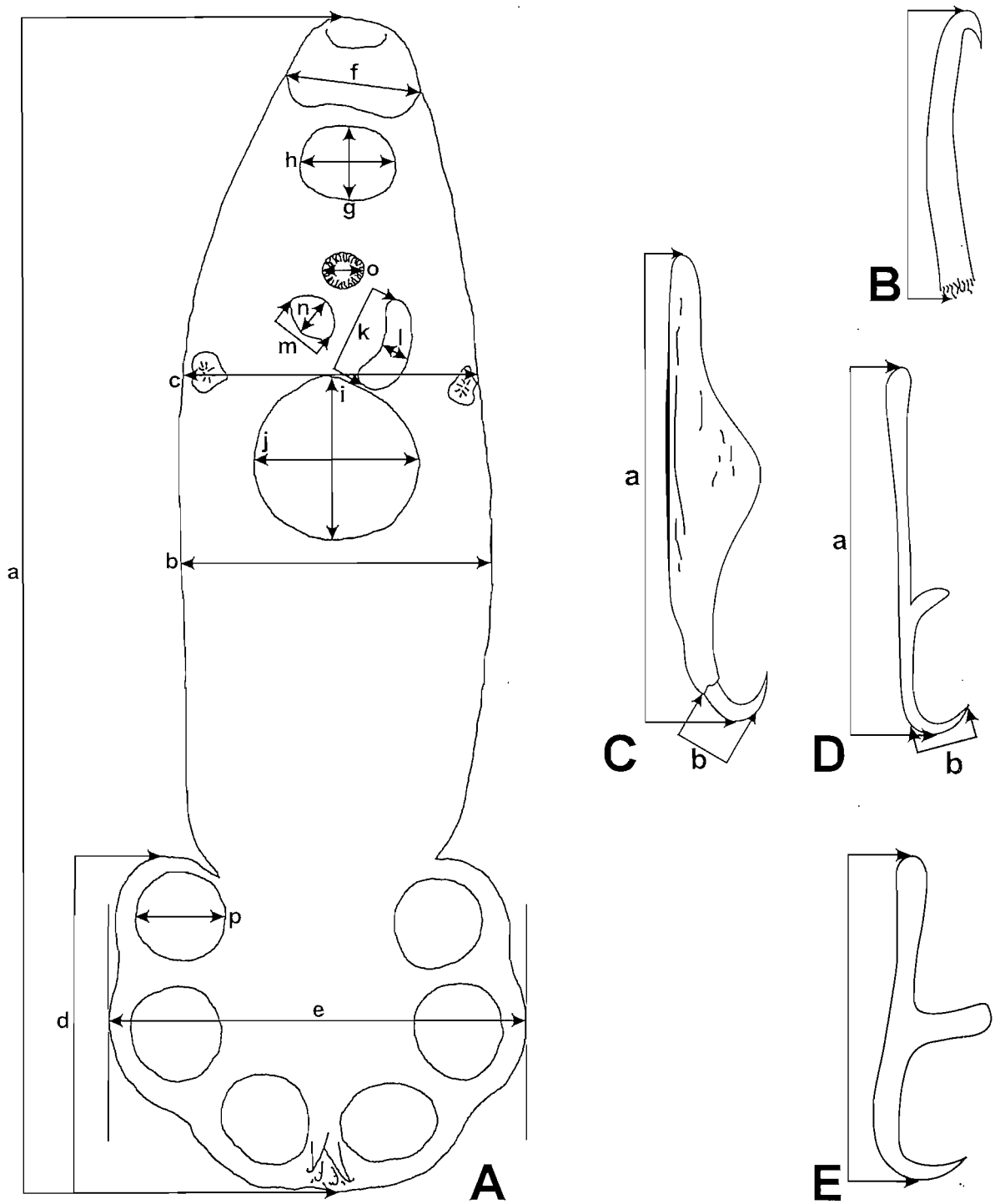
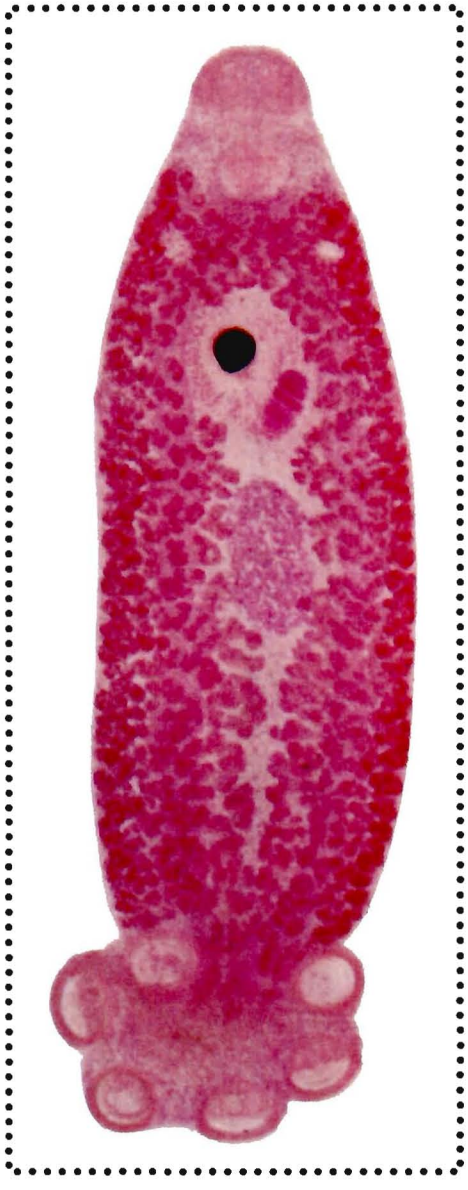


Figure 3.1: Illustrations showing the dimensions referred to in the table given under information on the parasite. Abbreviations: (A) a – body length; b – greatest width; c – width at vagina; d – haptor length; e – haptor width; f – oral diameter; g – pharynx length; h – pharynx diameter; i – testis length; j – testis width; k – ovary length; l – ovary width; m – egg length; n – egg diameter; o – genital bulb diameter; p – haptoral sucker diameter; (B) Genital bulb hook length; (C) a – large hamulus length (Length 1); a – large hamulus hook length (Length 1); (D) a – small hamulus length (Length 2); b – large hamulus hook length (Length 2); (E) Marginal hooklet length.

NEOPOLYSTOMA



Kingdom	:	Animalia	Linnaeus, 1753
Phylum	:	Platyhelminthes	Gegenbaur, 1859
Class	:	Monogenea	Carus, 1863
Subclass	:	Polystomationea	Lebedev, 1986
Order	:	Polystomatidea	Lebedev, 1988
Superfamily	:	Polystomatoidea	Price, 1936
Family	:	Polystomatidae	Carus, 1863
Subfamily	:	Polystomoidinae	Yamaguti, 1968
Genus	:	*Neopolystoma*	Price, 1939

Generic diagnosis: *Neopolystoma* share the typical characteristics for chelonian polystomes namely undiverticulated gut caecae of equal length, compact medial testis, diet of mucous, but differs from *Polystomoides* and *Polystomoidella*, in that it has no hamuli. Species of *Neopolystoma* is parasitic in the urinary bladder, the cavity of the eye or nose, the mouth, pharynx or cloaca of terrapins.

Neopolystoma

Neopolystoma chelodinae

(MacCallum, 1918)

Table 3.1; Figure 3.2

General

Collection: United States National Museum Helminthological Collection.

Holotype no: 36583.

Paratype no: None.

Original description: MacCallum (1918).

Other taxonomic contributions: Price, E.W. 1939. Proceedings of the Helminthological Society of Washington 6: 80 – 92.

Synonyms: None.

Type locality: United States (New York Zoological Park), North America.

Other localities: See Remarks.

Type host: *Chelodina longicollis* (Shaw, 1794). Eastern snake-necked turtle; Long-necked turtle.

Additional hosts: *Chelodina* sp.

Site on type host: Urinary Bladder.

Information on the host

Taxonomy: None.

Geographical distribution: Eastern and South-eastern Australia, from central Queensland (Charters Towers) to Adelaide in the south.

Ecology: This species is a popular pet and zoo animal, and there is a definite drain upon wild populations.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Remarks

- MacCallum (1918) omitted a 0 from the end of each of the measurements given in µm, eg. 30 instead of 300. All measurements given in mm, however, were normal.
- Although this Australian terrapin was kept and dissected in America, later localities where the parasite was found suggests that the terrapin did not obtain the parasite in America, but in Australia.
- Price (1939) speculated that *N. chelodinae* and *N. orbiculare* (Stunkard, 1916) are the same species.
- Rohde and Pearson (1980) gave a new host site for this species: The cloaca.
- Rohde and Pearson (1980) gave new localities for this species: Brisbane (3.1960) (Brisbane River); Mt. Cootha, Brisbane; Armidale, New South Wales (Australia), also found in *Chelodina longicollis*.
- Rohde (1984) gave new information on this species: From *Chelodina longicollis* in the Murray River near Adelaide, South Australia.
- Pichelin (1995) gave a new host for this species: *Chelodina* sp. (Chelidae). The specimen could not be identified because it was in poor condition, but Pichelin (1995) stated that it could be *Chelodinae expansa* [*Macrochelodinae expansa* (Gray, 1857)] because this species occurs in South Australia.
- Pichelin (1995) gave new localities for this species: Tailem Bend (South Australia) and Lake Manchester (Queensland).
- Pichelin (1995) stated that *N. chelodinae* differs from all other species of *Neopolystoma* in that it has a testis that has an irregular margin and vitelline follicles that are irregular in shape and size.

~ Price (1939) and Pichelin (1995) mistakenly referred to MacCallum (1918) as MacCallum (1919).

Table 3.1: Measurements of *N. chelodinae*

CHARACTERISTICS	MacCallum (1918)	Price (1939)	Rohde & Pearson (1980)	Pichelin (1995)
Mature specimens (n)	1	1	5	4
Body Length	3500	2900	3210 – 5320 (4658)	3646 – 4712 (4115)
Greatest Width	1000		1110 – 1990 (1684)	1353 – 1608 (1508)
Width at Vagina		1100		
Haptor Length	1750	935	990 – 1480 (874)	987 – 1274 (1119)
Haptor Width		1230	1490 – 1670 (1590)	1449 – 1815 (1648)
Oral Diameter	300	265 x 500	470 – 580 (510) x 610 – 790 (730)	350 – 462 (422) x 589 – 748 (669)
Pharynx Length	350	340	320 – 420 (356)	276 – 360 (305)
Pharynx Diameter		425	320 – 490	289 – 327 (315)
Testis Length	400		440 – 790 (680)	509 – 764 (653)
Testis Width			510 – 700 (472)	669 – 828 (764)
Ovary Length		340		
Ovary Width		170		
Egg Length				
Egg Diameter				
Egg incubation time				
Intra-Uterine Eggs (n)	1	0		0
Genital Bulb Diameter		250	94 – 148 (128) x 104 – 160 (128)	68 – 113 (87) x 71 – 113 (88)
Gen. Bulb Hook set (n)	1	1	1	1
Gen. Bulb Hooks 1 (n)	15	14	12 – 16 (14)	13 – 15 (14)
Gen. Bulb Hooks 2 (n)				
Gen. Bulb Hook Length 1		15		20.8 – 27.2 (23.6)
Gen. Bulb Hook Length 2				
Haptoral Sucker Diameter	300	340	350 – 470 (388)	417 – 499 (449)
Hamulus Length 1				
Hamulus Length 2				
Hamulus Hook Length 1				
Hamulus Hook Length 2				
Marginal Hooklet Length				
Haptor L/Body L	0.5	0.3224	0.1876	0.2719

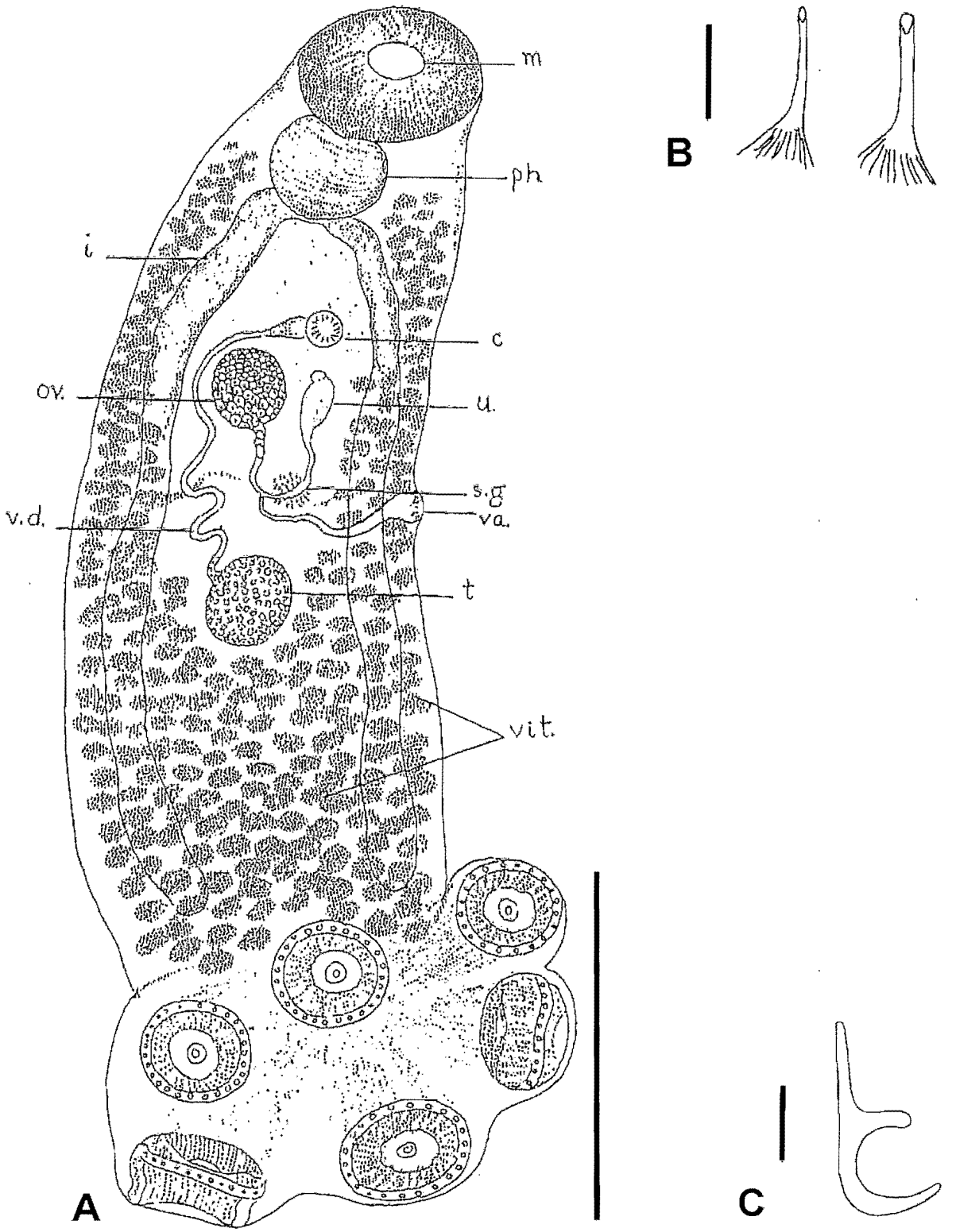


Figure 3.2: (A) *Neopolystoma chelodinae* (MacCallum, 1918). Abbreviations: c – cirrus; i – intestine; m – mouth; ov – ovary; ph – pharynx; s.g. – shell gland; t – testis; u – uterus; va. – vagina; v.d. – vas deferens; vit. – vitellaria (Scale bar = 1000µm). According to MacCallum (1918); (B) Genital spines (Scale bar = 15µm); (C) Marginal hooklet (Scale bar = 10µm). Copied from Pichelin (1995).

Neopolystoma cribbi

Pichelin, 1995

Table 3.2; Figure 3.3

General

Collection: Queensland Museum.
Holotype no: QM GL 18004.
Paratype no: QM GL 18005, 18006.

Original description: Pichelin (1995).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: University of Queensland Veterinary Farm dam (27°32'S, 152°54'E) Pinjarra Hills, Queensland, Australia.

Other localities: Darling Downs, Queensland, Australia: Canal Creek (28°01'S, 151°35'E) and Leslie Dam (28°01'S, 152°55'E).

Type host: *Emydura signata* [*Emydura macquarii signata* Ahl, 1932]. Brisbane River turtle.
Additional hosts: *Elseya latisternum*; *Emydura macquarii*; *Macrochelodina expansa*.

Site on type host: Conjunctival sac of the eye.

Information on the host

Taxonomy: *Emydura signata* has changed to *Emydura macquarii signata* Ahl, 1932. *Emydura macquarii* (Gray, 1931) has eight other subspecies: *E. m. macquarii* (Gray, 1831), *E. m. binjing* Cann, 1998, *E. m. dharra* Cann, 1998, *E. m. dharuk* Cann, 1998, *E. m. emmotti* Cann, McCord & Joseph-Ouni, 2003, *E. m. gunabarra* Cann, 1998, *E. m. krefftii* (Gray, 1871), and *E. m. nigra* McCord, Cann & Joseph-Ouni, 2003.

Geographical distribution: This species has only been found in the Brisbane River drainage in south-eastern Queensland, Australia.

Ecology: This species is one of the terrapins that is most frequently found in Western Collections, but it is still abundant in nature.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.2: Measurements of *N. cribbi*	
CHARACTERISTICS	**Pichelin (1995)**
Mature specimens (n)	10
Body Length	1433 – 1688 (1581)
Greatest Width	509 – 669 (619)
Width at Vagina	
Haptor Length	446 – 541 (505)
Haptor Width	700 – 812 (770)
Oral Diameter	193 – 257 (229) x 270 – 315 (295)
Pharynx Length	116 – 154 (135)
Pharynx Diameter	128 – 180 (159)
Testis Length	161 – 308 (249)
Testis Width	154 – 295 (240)
Ovary Length	
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	0
Genital Bulb Diameter	71 – 83 (75) x 64 – 96 (78)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	40 (curved)[♂]; 13 (straight)[♀]
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	6 – 10 (8)[♂], 11.2 – 22.4 (17.8)[♀]
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	190 – 231 (215)
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	15.2 – 17.6 (16.5)
Haptor L/Body L	0.3194

Remarks

~ Pichelin (1995) named more hosts for this species: *Elseya latisternum* Gray, 1867, *Emydura macquarii* (Gray, 1831) which has nine subspecies, and *Macrochelodina expansa* (Gray, 1857).

~ There are differences in the literature examined in terms of the year that Gray described *Emydura macquarii*. Fritz and Havaš (2007) stated the species as *Emydura macquarii* (Gray, 1831), and is favoured because it is the most recent literature stated.

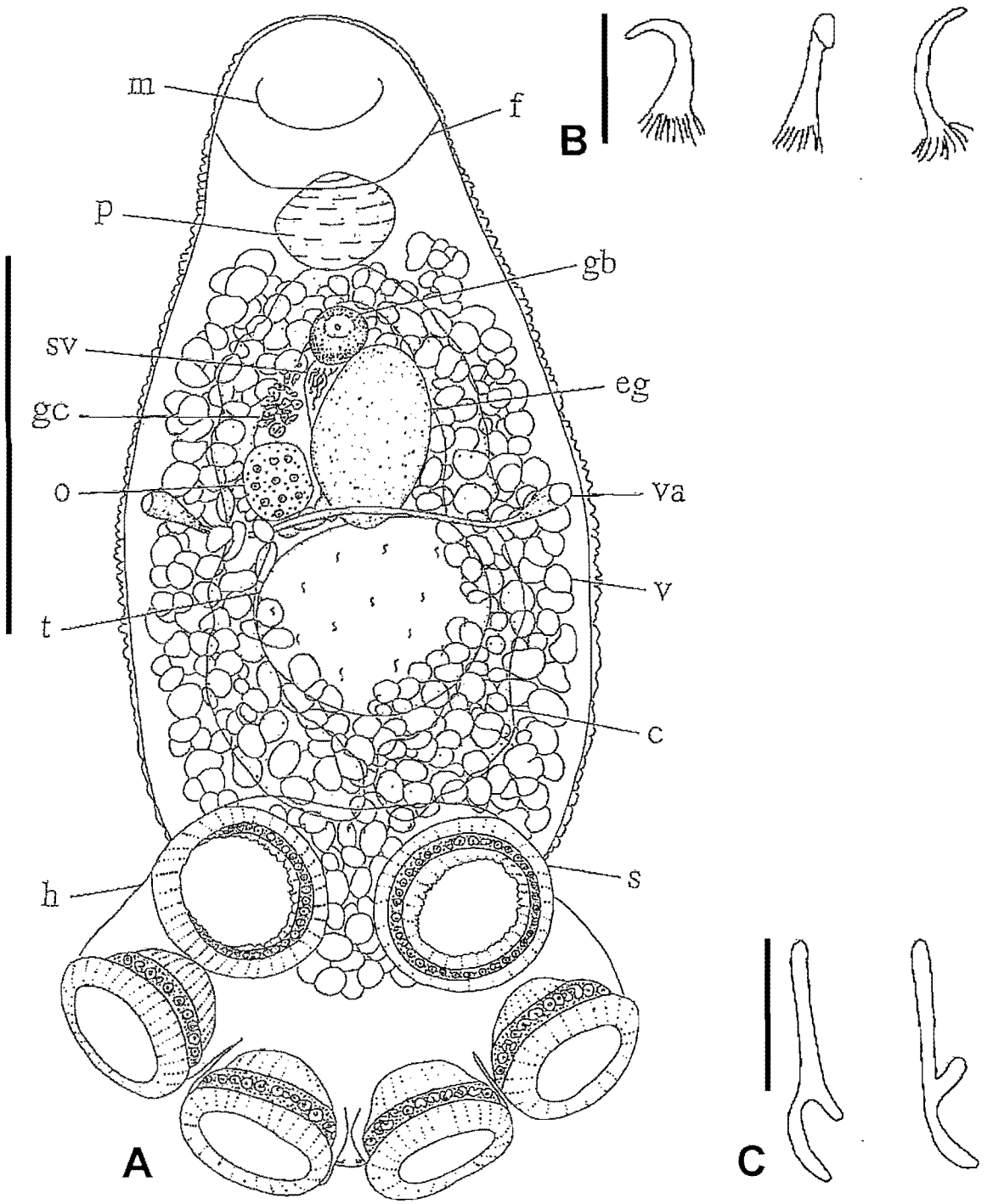


Figure 3.3: (A) *Neopolystoma cribbi* Pichelin, 1995. Abbreviations: c – gut caecum; eg – egg; f – false oral sucker; gb – genital bulb; gc – gland cell; h – haptor; m – mouth; o – ovary; p – pharynx; s – haptoral sucker; sv – seminal vesicle; t – testis; v – vitelline follicle; va – vagina (Scale bar = 500µm); (B) Genital spines (Scale bar = 15µm); (C) Marginal hooklets (Scale bar = 10µm). Copied from Pichelin (1995).

Neopolystoma cyclovitellum

Caballero, Zerecero & Grocott, 1956

Table 3.3; Figure 3.4

General

Collection: Helminthological collection of the Institute of Biology (National University of Mexico).
Holotype no: 214-4.
Paratype no: None.

Original description: Caballero, Zerecero and Grocott (1956).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: City of Panama, Panama, Central America.

Other localities: None.

Type host: *Geomyda melanosterna* [*Rhinoclemmys melanosterna* (Gray, 1861)]. Colombian wood turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Geoemyda melanosterns* has changed to *Thinoclemmys melanosterna* (Gray, 1861).

Geographical distribution: Caribbean drainage basins of south–eastern Panama and northern Colombia, as well as the Pacific drainages of western Colombia and north-western Ecuador (Southern Central America and northern South America).

Ecology: This terrapin species is consumed by local people, but no information is available on its current conservation status.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.3: Measurements of *N. cyclovitellum*	
CHARACTERISTICS	Caballero, Zerecero & Grocott (1956)
Mature specimens (n)	5
Body Length	3486 – 3652
Greatest Width	1112 – 1610
Width at Vagina	
Haptor Length	747
Haptor Width	996 – 1046
Oral Diameter	171 – 183 x 334 – 349
Pharynx Length	213 – 232
Pharynx Diameter	277 – 282
Testis Length	730 – 747
Testis Width	498 – 664
Ovary Length	201 – 239
Ovary Width	80 – 84
Egg Length	232
Egg Diameter	149
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	87 x 95
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	16
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	19 – 23 x 2
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	217 – 232 x 239 – 243
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	

Remarks

~ This species resembles *N. orbiculare* (Stunkard, 1916) and *N. terrapenis* (Harwood, 1932). It differs from both species by the unique distribution of its vitellaria, the position of its vaginae, the shape of its ovary, and the size of its testis and eggs (Caballero *et al.*, 1956).

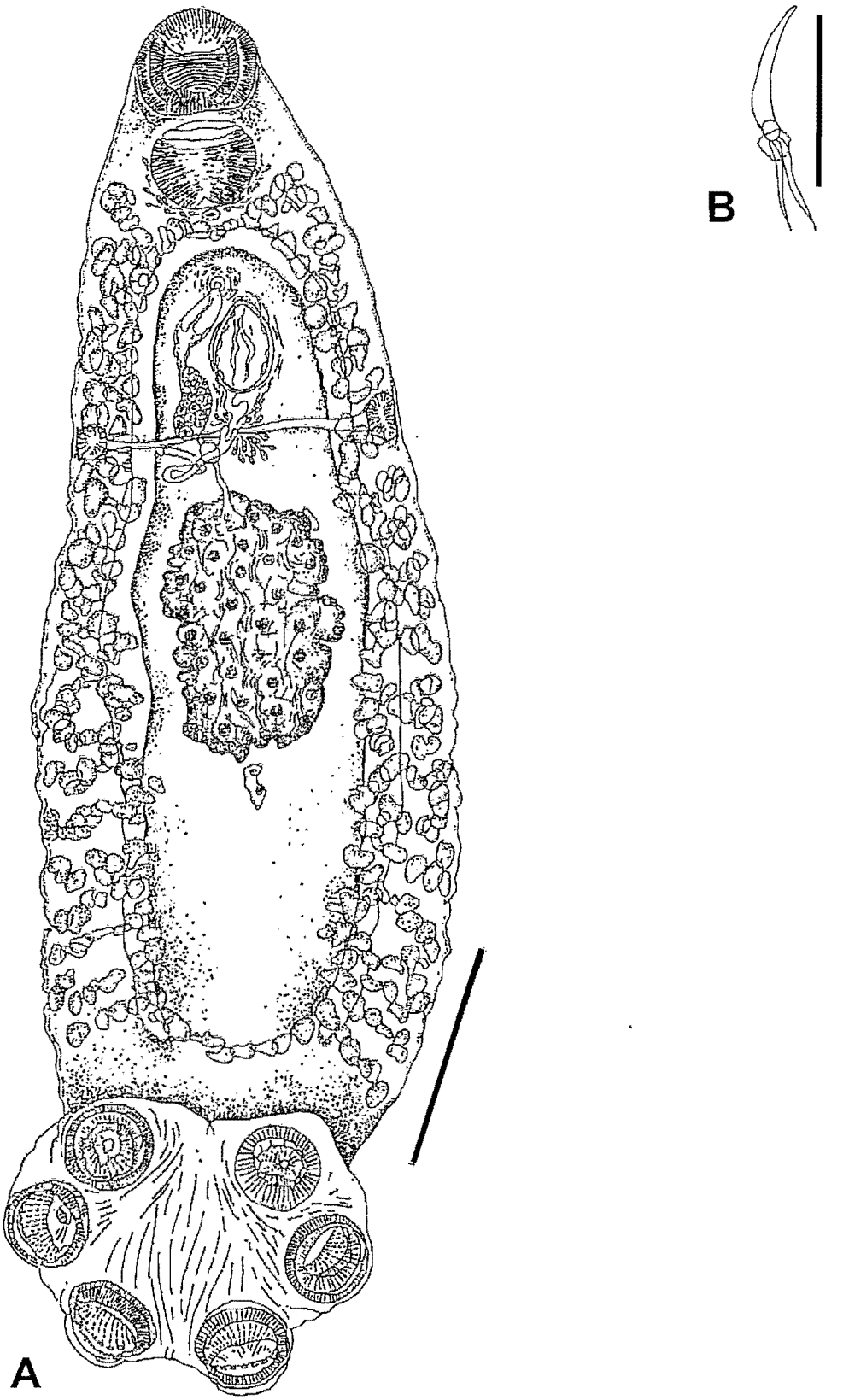


Figure 3.4: (A) *Neopolystoma cyclovitellum* Caballero, Zerecero & Grocott, 1939 (Scale bar = 3652µm); (B) Genital spine (Scale bar = 19µm). Copied from Caballero *et al.* (1956).

Neopolystoma domitilae

(Caballero, 1938)

Table 3.4; Figure 3.5

General

Collection: Helminthological collection of the Institute of Biology (University of Mexico).
Holotype no: 19-7 (Now lost).
Paratype no: 225-19 (New).
Neotype no: 225-18.

Original description: Caballero (1938).

Other taxonomic contributions: Price, E.W. 1939. Proceedings of the Helminthological Society of Washington 6: 80 – 92.

Synonyms: None.

Type locality: Alvarado, Veracruz (Mexico).

Other localities: None.

Type host: *Chrysemys ornate* [*Trachemys ornata*] (Gray, 1831). Ornate slider turtle.
Additional hosts: *Chelydra serpentine.*

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Crysemys ornate* has changed to *Trachemys ornate* (Gray, 1831).

Geographical distribution: Along the Pacific coastal plane (western side) of Mexico and the American tropics (below 300m), from the Mexican coastal plain in northern Sinaloa to central Oaxaca, and also in Guatemala and all through central America to northern Colombia. This range has major gaps in it however.

Ecology: This terrapin is collected for the pet trade as well as for collections, and with the added threats of habitat degradation and pollution, some populations have become almost depleted.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.4: Measurements of *N. domitilae*		
CHARACTERISTICS	Caballero (1938)	Lamothe-Argumedo (1972)
Mature specimens (n)	2	2
Body Length		4039 – 4057
Greatest Width		1320 – 1722
Width at Vagina		
Haptor Length	624 – 780	1046 – 1067
Haptor Width	877 – 975	1416 – 1851
Oral Diameter	273 – 312 x 351 – 429	370 – 450 x 547
Pharynx Length	205 – 225	305 – 322
Pharynx Diameter	295 – 303	328
Testis Length	585 – 224	450 – 644
Testis Width	390 – 526	289 – 338
Ovary Length	253	322 – 402
Ovary Width	117	112 – 127
Egg Length	155.8	305
Egg Diameter	104.5	177
Egg incubation time		
Intra-Uterine Eggs (n)	1	1
Genital Bulb Diameter	164	209 – 273 x 241 – 273
Gen. Bulb Hook set (n)	1	1
Gen. Bulb Hooks 1 (n)	19 – 20	20 – 21
Gen. Bulb Hooks 2 (n)		
Gen. Bulb Hook Length 1	45	55 – 71 x 7
Gen. Bulb Hook Length 2		
Haptoral Sucker Diameter	273 – 292	305 – 322 x 305 – 483
Hamulus Length 1		
Hamulus Length 2		
Hamulus Hook Length 1		
Hamulus Hook Length 2		
Marginal Hooklet Length	24.6	
Haptor L/Body L		

Remarks

~ This species is similar to *N. orbiculare*, *N. opacum*, *N. floridanum* and *N. exhamatum*, but differs from them in the number of genital spines it possesses as well as the blind ending intestines that reach the haptor (Caballero, 1938).

~ Lamothe-Argumedo (1972) stated that the original type and paratype was lost upon the changing of the collection in 1954. He used a new neotype and paratype provided by Dr. Venon E. Thatcher to redescribe the species. The neotype was found in *Trachemys ornata* (Gray, 1831) and the paratype in *Chelydra serpentina* (Linnaeus, 1758), both from Tabasco, Mexico.

~ Lamothe-Argumedo (1972) justified the allocation of the neotype because of the following reasons: (1) The lost original material has been fully verified; (2) The neotype is from almost the same area as the holotype; (3) The host species is the same; (4) The new material is deposited in the same institution.

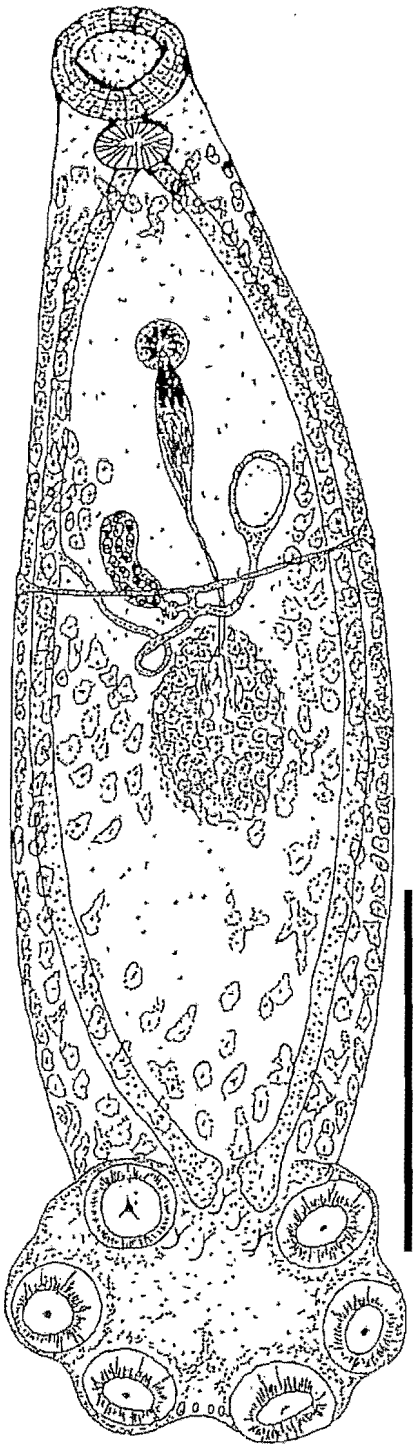


Figure 3.5: *Neolystoma domitilae* (Caballero, 1938) (Scale bar = 1000µm)*. Copied from Caballero (1938).

** The scale bar for this specimen is based on the average of the two specimens that the author (Caballero, 1938) studied, and is therefore an estimation.*

Neopolystoma elizabethae

Platt, 2000

Table 3.5; Figure 3.6

General

Collection: United States National Museum.
Holotype no: U.S.N.M. coll. no. 89400.
Paratype no: U.S.N.M. coll. no. 89401 – 2. (Voucher: U.S.N.M. coll. no. 89403).

Original description: Platt (2000a).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Kinwamakwad Lake (46'14"N, 89'30"W), UNDERC, Gogebic County, Michigan. University of Notre Dame Environmental Research Centre, North America.

Other localities: Plum Lake (46'13"N, 89'30"W), UNDERC, Gogebic County, Michigan and Vilas County, Wisconsin, Unnamed pond (41'37"N, 86'17"W), Centre Township, St Joseph County, Indiana.

Type host: *Chrysemys picta bellii* (Gray, 1831). Western painted turtle.
Additional hosts: None.

Site on type host: Conjunctival sac of the eye.

Information on the host

Taxonomy: *Chrysemys picta* (Schneider, 1783) has three other subspecies: *C. p. picta* (Schneider, 1783), *C. p. dorsalis* Agassiz, 1857, and *C. p. marginata* Agassiz, 1857.

Geographical distribution: This species is found in Canada and Western and central North America, from western Ontario across southern Canada to British Columbia, Canada, and south to Missouri, northern Oklahoma, eastern Colorado, Wyoming, Idaho, and northern Oregon. It also occurs in many scattered localities in south-west U.S.A and in one area in Chihuahua, Mexico.

Ecology: Raccoons prey on this species, easily locating and consuming their eggs, but other dangers are death by vehicles when crossing roads, and their habitats being severely degraded.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.5: Measurements of *N. elizabethae*	
CHARACTERISTICS	**Platt (2000a)**
Mature specimens (n)	4
Body Length	2550 – 3675 (3125)
Greatest Width	640 – 990 (823)
Width at Vagina	
Haptor Length	790 – 970 (865)
Haptor Width	880 – 1070 (975)
Oral Diameter	251 – 292 (271) x 449 – 540 (473)
Pharynx Length	216 – 269 (255)
Pharynx Diameter	268 – 320 (305)
Testis Length	178 – 262 (208)
Testis Width	140 – 192 (155)
Ovary Length	218 – 350 (301)
Ovary Width	100 – 146 (122)
Egg Length	322 – 367 (348)
Egg Diameter	117 – 122 (120)
Egg incubation time	
Intra-Uterine Eggs (n)	3
Genital Bulb Diameter	50 – 63 (58) x 45 – 63 (57)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	8
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	10
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	344 – 408 (372)
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	11.8 – 12.7 (12.3); n = 8
Haptor L/Body L	0.2768

Remarks

~ None.

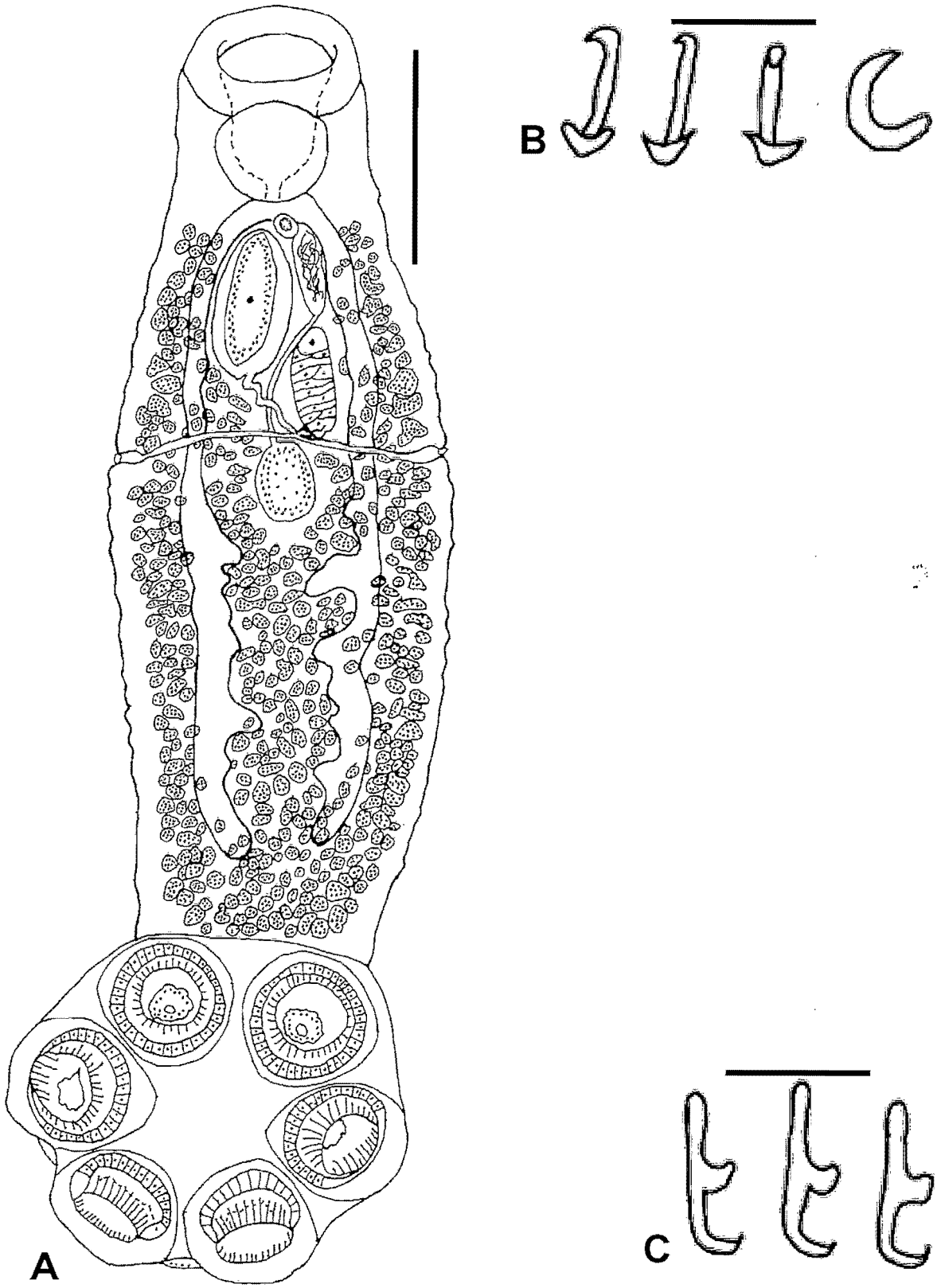


Figure 3.6: (A) *Neopolystoma elizabethae* Platt, 2000 (Scale bar = 500µm); (B) Genital spines (Scale bar = 10µm); (C) Marginal hooklets (Scale bar = 10µm). Copied from Platt (2000a).

Neopolystoma euzeti

Combes & Ktari, 1976

Table 3.6; Figure 3.7

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Combes and Ktari (1976).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Streams in the West of Tunisia, Africa.

Other localities: None.

Type host: *Clemmys* (*Mauremys*) *caspica* var. *leprosa*. [*Mauremys leprosa leprosa*] (Schweigger, 1912). Spanish terrapin.
Additional hosts: None.

Site on type host: Urinary bladder and rectum.

Information on the host

Taxonomy: *Clemmys* (*Mauremys*) *leprosa* has changed to *Mauremys leprosa leprosa* (Schweigger, 1912). One other subspecies currently exist: *M. l. saharica* Schleich, 1996.

Geographical distribution: This terrapin occurs in the western part of the Mediterranean region in the Iberian Peninsula (Spain, Portugal) and the south of France (Banyuls), and the northwestern part of Africa (Morocco, Algeria, Tunisia, and Libya). There are also unconfirmed records from Niger and Mauritania.

Ecology: This terrapin is not heavily collected, very resistant to pollution, and not really threatened by habitat destruction. However the residual population in France is restricted to 100 individuals, thus a monitoring and preservation program is currently in place.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.6: Measurements of *N. euzeti*	
CHARACTERISTICS	**Combes & Ktari (1976)**
Mature specimens (n)	6
Body Length	4548 (3790 – 5780)
Greatest Width	1683 (1570 – 1880)
Width at Vagina	1510 (1420 – 1600)
Haptor Length	1195 (100 – 1380)
Haptor Width	1668 (1340 – 2180)
Oral Diameter	364 (286 – 411) x 527 (457 – 640)
Pharynx Length	363 (340 – 423)
Pharynx Diameter	411 (350 – 570)
Testis Length	680 (605 – 730)
Testis Width	557 (420 – 710)
Ovary Length	302 (260 – 350)
Ovary Width	148 (115 – 180)
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	0
Genital Bulb Diameter	209 (183 – 240)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	34 (33 – 36)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	48 and 57
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	320 – 390
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.2628

Remarks

~ This polystome species differs from other existing *Neopolystoma* species by the number of genital hooks and their size, as well as the unique development of the vittelaria. The locality of this species is also far removed from the other species' distributions (Combes & Ktari, 1976).

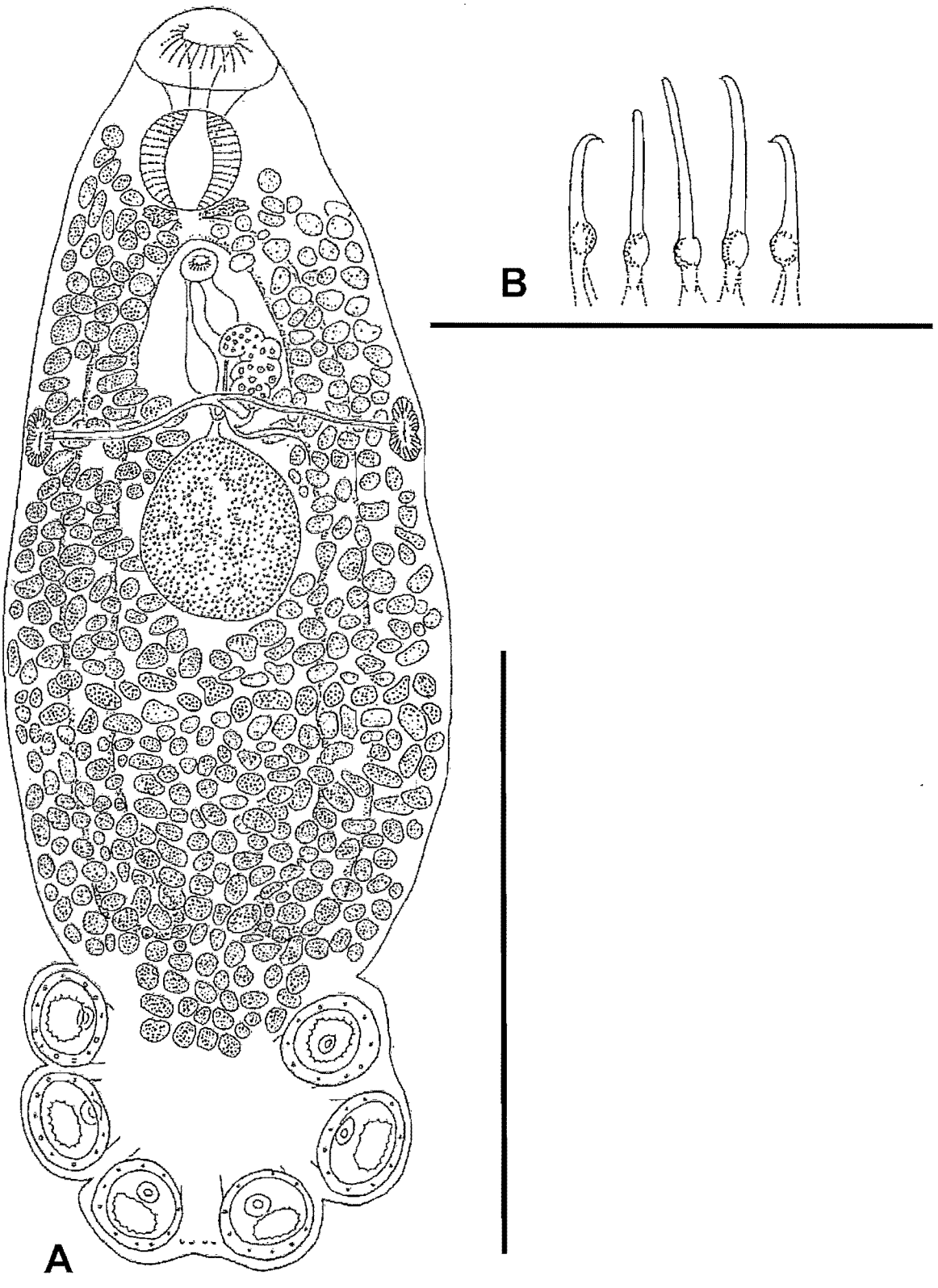


Figure 3.7: (A) *Neopolystoma euzeti* Combes & Ktari, 1976 (Scale bar = 2000µm); (B) Genital spines (Scale bar = 100µm). Modified from Combes and Ktari (1976).

Neopolystoma exhamatum

(Ozaki, 1935)

Table 3.7; Figure 3.8

General

Collection: Zoological Laboratory of Hiroshima University.
Holotype no: None.
Paratype no: None.

Original description: Ozaki (1935).

Other taxonomic contributions: Price, E.W. 1939. Proceedings of the Helminthological Society of Washington 6: 80 – 92.

Synonyms: None.

Type locality: Hiroshima, Japan.

Other localities: None.

Type host: *Clemmys japonica* [*Mauremys japonica* (Temminck & Schlegel, 1835)]. Yellow pond turtle.
Additional hosts: None.

Site on type host: Urinary Bladder.

Information on the host

Taxonomy: *Clemmys japonica* has been placed in a new genus: *Mauremys japonica* (Temminck & Schlegel, 1835).

Geographical distribution: This species can be found in central and southern Japan, on islands such as Honshu, Kyoshu, and Shikoku.

Ecology: This species is protected at national level, and population numbers are being reduced by degradation of their habitat, vehicle deaths, and the wildlife trade. Reduction of populations is increasing.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.7: Measurements of *N. exhamatum*	
CHARACTERISTICS	Ozaki (1935)
Mature specimens (n)	
Body Length	4600 – 5400
Greatest Width	1500 – 2000
Width at Vagina	
Haptor Length	850 – 1000
Haptor Width	1400 – 2000
Oral Diameter	
Pharynx Length	370 – 400
Pharynx Diameter	
Testis Length	1200 – 1600
Testis Width	700 – 1300
Ovary Length	370 – 500
Ovary Width	170 – 200
Egg Length	260 – 300
Egg Diameter	190 – 210
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	240
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	16 – 18
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	300 – 350
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	12.6 (12.2 – 12.7)
Haptor L/Body L	

Remarks

~ This parasite species resembles *N. orbiculare* in terms of the form of the haptor and the absence of hamuli, but differs from each other in terms of the form and size of the testis and the number of hooks in the genital bulb (Ozaki, 1935).

~ Price (1939) renamed *Polystomoides exhamatum* as *Neopolystoma exhamatum* but gave no other information on the parasite.

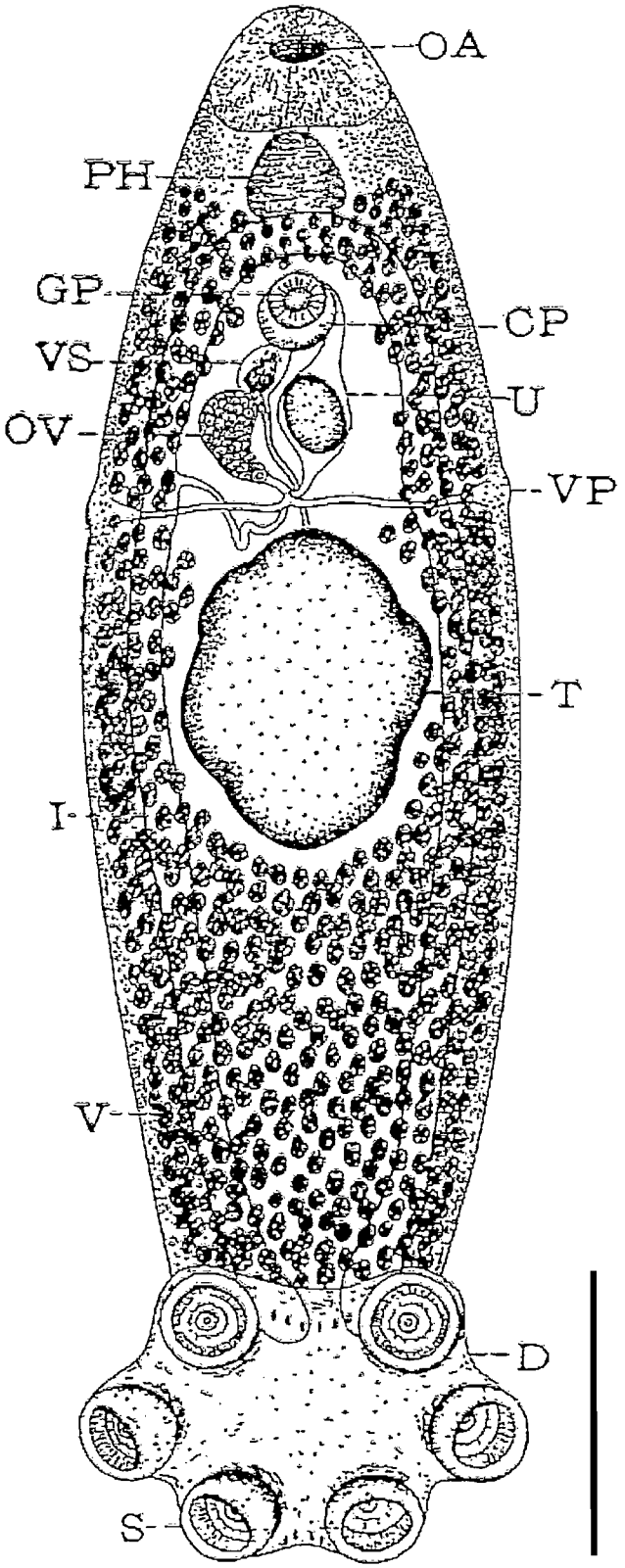


Figure 3.8: *Neopolystoma exhamatum* (Ozaki, 1935). Abbreviations: CP – cirrus pouch; D – disc or cotylophore; GP – genital pore; I – intestine; OA – oral aperture; OV – ovary; PH – pharynx; S – sucker; T – testis; U – uterus; V – vitellaria; VP – vagina; VS – vesicula seminis (Scale bar = 1000µm). Copied from Ozaki (1935).

Neopolystoma fentoni

Platt, 2000

Table 3.8; Figure 3.9

General

Collection: United States National Parasitological Collection[①]; Helminthological Collection of the Oswaldo Cruz Institute[②].
Holotype no: 89943 (n = 1)[①].
Paratype no: 89944 – 6 (n = 4)[①]. 34292; 34293a – b; 34294[②].

Original description: Platt (2000b).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Quebrada Costa Rica (10°49.666'N; 85°38.216'W), Guanacaste Conservation Area, Santa Rosa, Guanacaste, Costa Rica, South America.

Other localities: Quebrada el Duende (10°50.236'N; 85°38.724'W) and San Gerardo (10°52.55'N; 85°23.27'W), Guanacaste Conservation Area, Santa Rosa, Guanacaste, Costa Rica.

Type host: *Kinosternon leucostomum* Duméril & Bibron, 1851. White-lipped mud turtle.
Additional hosts: *Rhinoclemmys pulcherrima.*

Site on type host: Conjunctival sac of the eye.

Information on the host

Taxonomy: *Kinosternon leucostomum* has two subspecies: *K. l. leucostomum* Duméril & Bibron, 1851, and *K. l. postinguinale* Cope, 1887.

Geographical distribution: This terrapin has a wide range from Mexico to Equador. It occurs in the north from central Verácruz, Mexico, in the rivers that drain into the Gulf of Mexico, southward in the Atlantic drainages to Nicaragua, and southward in both Atlantic and Pacific drainages to Colombia, Ecuador, and north-western Peru.

Ecology: The species is regularly captured and consumed, but still seems to be abundant in nature.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.8: Measurements of *N. fentoni*	
CHARACTERISTICS	Platt (2000b)
Mature specimens (n)	10
Body Length	1500 – 2450 (1985)
Greatest Width	426 – 760 (568)
Width at Vagina	
Haptor Length	449 – 690 (571)
Haptor Width	550 – 850 (683)
Oral Diameter	150 – 303 (230) x 240 – 496 (370)
Pharynx Length	156 – 257 (216)
Pharynx Diameter	185 – 367 (278)
Testis Length	98 – 367 (225)
Testis Width	78 – 251 (181)
Ovary Length	80 – 245 (103)
Ovary Width	55 – 169 (105)
Egg Length	245 – 332 (286); n = 7,3
Egg Diameter	122 – 146 (136)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	43 – 70 (55) x 30 – 83 (60)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	8
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	11
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	210 – 326 (265); n = 60, 24
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	11.8 – 12.7 (12.5); n = 4
Haptor L/Body L	0.2877

Remarks

~ Platt (2000b) gave another known host: *Rhinoclemmys pulcherrima* (Gray, 1856). *R. pulcherrima* has four subspecies.

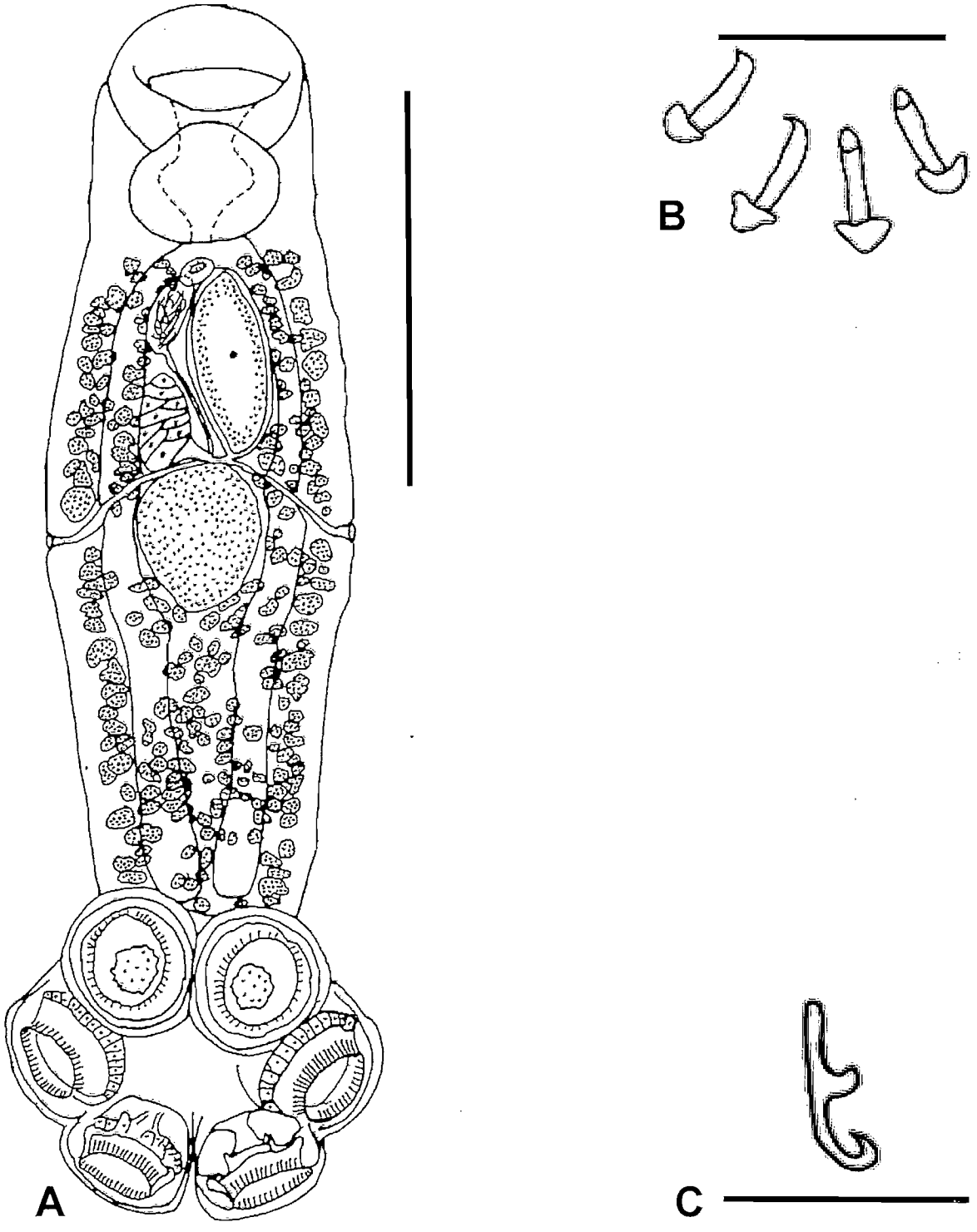


Figure 3.9: (A) *Neopolystoma fentoni* Platt, 2000 (Scale bar = 500µm); (B) Genital spines (Scale bar = 20µm); (C) Marginal spine (Scale Bar = 20µm). Copied from Platt (2000b).

Neopolystoma kreffti

Rohde, 1984

Table 3.9; Figure 3.10

General

Collection: Australian Museum, Sydney[①]; United States National Museum Helminthological Collection[②]; British Museum (Natural History)[③].
Holotype no: W19291[①].
Paratype no: 77256[②]; 1982.11.3.22[③].

Original description: Rohde (1984).

Other taxonomic contributions: None.

Synonyms: *Neopolystoma australis* Rohde, 1984

Type locality: Fragmore Lagoon 23°26½'S; 150°32'E, Fitzroy drainage, Queensland, Australia.

Other localities: Barambah Creek 25°41'S; 150°48'E, Burnett drainage, Queensland, Australia.

Type host: *Emydura krefftii* [*Emydura maquarii krefftii* (Gray, 1871)]. Krefft's river turtle.
Additional hosts: *Emydura macquarii signata*; *Emydura macquarii*; *Elseya latisternum*.

Site on type host: Mouth and pharyngeal cavity.

Information on the host

Taxonomy: *Emydura krefftii* has changed to *Emydura macquarii krefftii* (Gray, 1871). *Emydura macquarii* (Gray, 1831) has seven other subspecies: *E. m. macquarii* (Gray, 1831), *E. m. binjing* Cann, 1998, *E. m. dharra* Cann, 1998, *E. m. dharuk* Cann, 1998, *E. m. emmotii* Cann, McCord & Joseph-Ouni, 2003, *E. m. gunabarra* Cann, 1998, *E. m. nigra* McCord, Cann & Joseph-Ouni, 2003, and *E. m. signata* Ahl, 1932.

Geographical distribution: This species occurs in a narrow stretch of north-eastern coastal Australia in the coastal river drainages of eastern Queensland, extending south to Fraser Island.

Ecology: These terrapins do have legal protection, but they also constitute the most abundant terrapin species that occur on Fraser Island.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.9: Measurements of *N. kreffti*		
CHARACTERISTICS	**Rohde (1984)**	**Pichelin (1995)**
Mature specimens (n)	3	9
Body Length	2900 / 4100 / 4600	2324 – 3741 (2958)
Greatest Width	1000 / 1500 / 1500	637 – 1226 (922)
Width at Vagina		
Haptor Length	890 / 950 / 1500	748 – 1067 (892)
Haptor Width	1170 / 1640 / 1300	971 – 1433 (1150)
Oral Diameter	290 x 460 / 380 x 590 / 510 x 540	289 – 480 (388) x 360 – 642 (501)
Pharynx Length	320 / 510	270 – 494 (348)
Pharynx Diameter	440 / 540	295 – 520 (404)
Testis Length	270 / 290 / 370	257 – 404 (301)
Testis Width	360 / 400 / 370	205 – 282 (245)
Ovary Length		
Ovary Width		
Egg Length	290 / 300 / 240	
Egg Diameter	230 / 250 / 210	
Egg incubation time		
Intra-Uterine Eggs (n)	1	1
Genital Bulb Diameter	1st specimen unmeasurable / 150 x 160 / 200 x 220	141 – 199 (165) x 128 – 218 (169)
Gen. Bulb Hook set (n)	1	1
Gen. Bulb Hooks 1 (n)	27 / 22 / 18	20 – 26 (24)
Gen. Bulb Hooks 2 (n)		24 – 32 (27.5)
Gen. Bulb Hook Length 1	17 – 20	
Gen. Bulb Hook Length 2		
Haptoral Sucker Diameter	300 / 390 / 390	279 – 427 (244)
Hamulus Length 1		
Hamulus Length 2		
Hamulus Hook Length 1		
Hamulus Hook Length 2		
Marginal Hooklet Length	20 – 28	22.4 – 27.2 (26.1)
Haptor L/Body L	0.3069 / 0.2317 / 0.3261	0.3016

Remarks

~ Differs from all other species of the genus except *N. domitilae* (Caballero, 1938) in the number of genital hooks, but differs from *N. domitilae* in the shape of the genital hooks (Rohde, 1984).
~ Rohde (1984) mistakenly stated the length of the marginal hooklets as 200 – 28 µm.
~ Fairfax (1990) gave new information on this species: Mouth of *Emydura maquarii krefftii* (Gray, 1871) in the Mulgrave river, near Aloomba, North Queensland, 17°7'S; 145°53'E.

~ Pichelin (1995) gave new hosts for this species: *Emydura macquarii signata* Ahl, 1932, *Emydura macquarii* (Gray, 1831), and *Elseya latisternum* Gray, 1867.

~ Pichelin (1995) also gave new localities for this species: Leslie Dam (28°01'S; 152°55'E), Canal Cr. (28°01'S; 151°35'E), College's Crossing (27°33'S; 152°48'E), Lockyer Cr. (27°35'S; 152°07'E) and The University of Queensland Veterinary Farm dam (27°32'S; 152°54'E), all in Queensland, Australia.

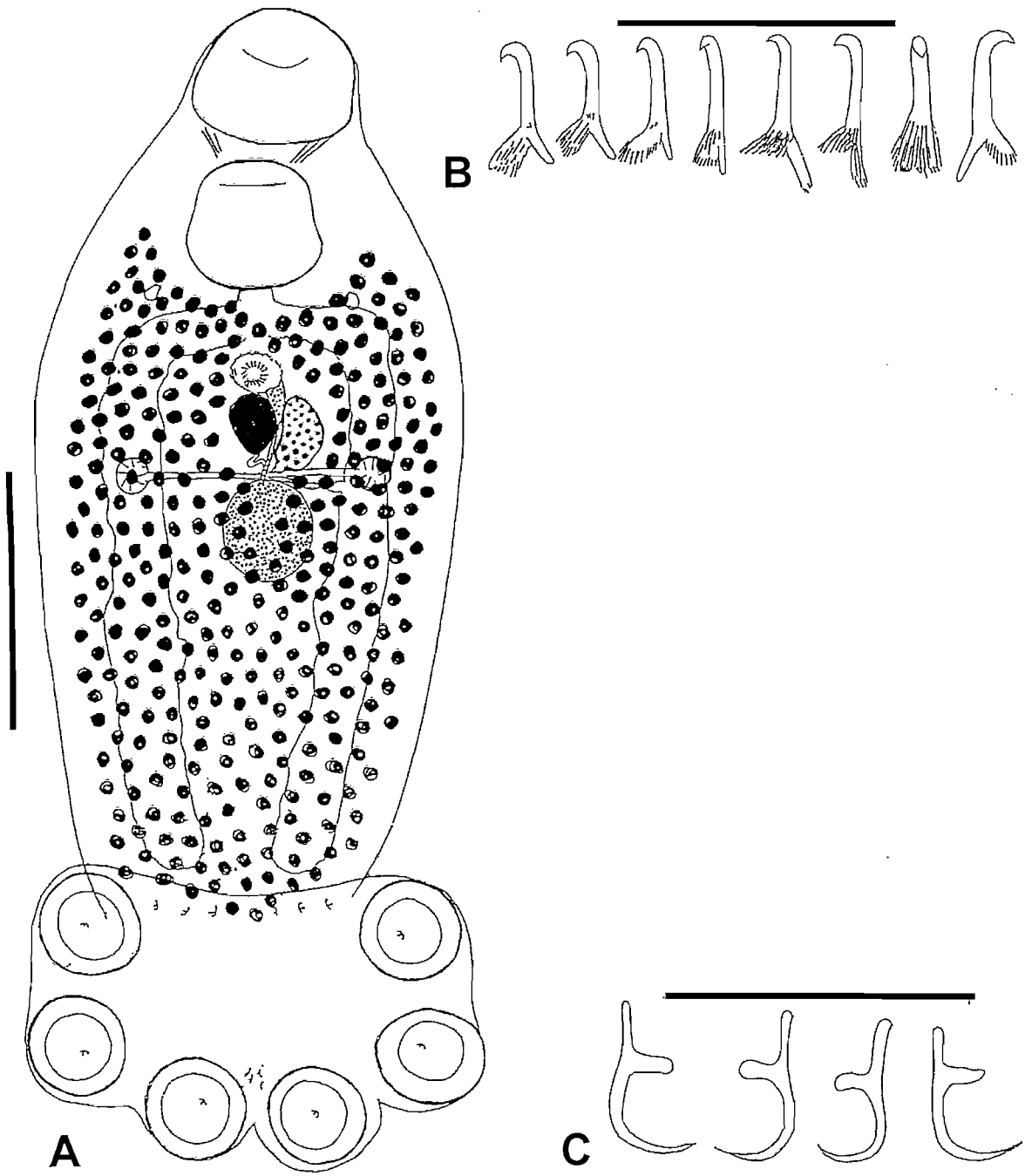


Figure 3.10: (A) *Neopolystoma kreffti* Rohde, 1984 (Scale bar = 1000µm); (B) Genital spines (Scale bar = 50µm); (C) Marginal hooklets (Scale bar = 50µm). Copied from Rohde (1984).

Junior synonym of *Neopolystoma kreffti*

Tables 3.10 and 3.11; Figure 3.11

General

	Table 3.10: *Neopolystoma australis* Rohde, 1984	
Collection	①Australian Museum, Sydney; ②United States National Museum Helminthological Collection; ③British Museum (Natural History)	
	Holotype no	①19290.
	Paratype no	②77258; ③1982.11.3.23.
Original description	Rohde (1984).	
Type locality	Georges Creek 30°43'S; 152°11'E, Macleay drainage, Australia.	
Host	*Emydura sp.*	
Additional hosts	*Emydura macquarii signata.*	
Site on host	Mouth and pharyngeal cavity.	

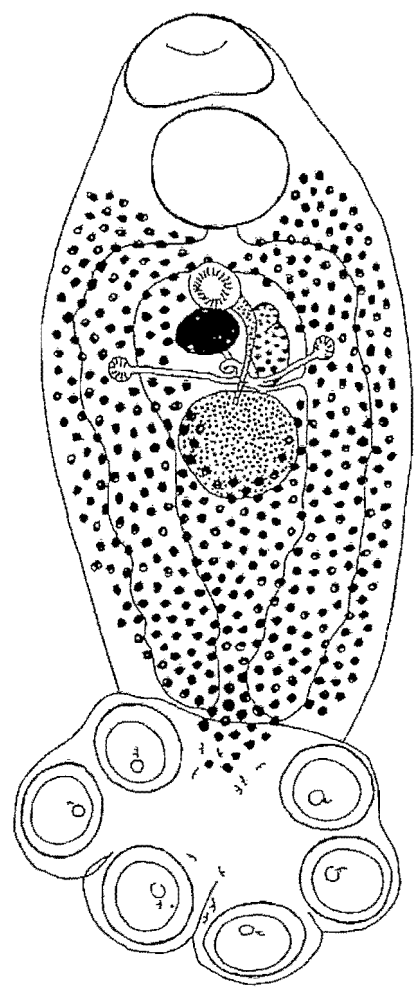


Figure 3.11: *Neopolystoma australis*. Copied from Rohde (1984).

Remarks

~ According to Rohde (1984), the *Emydura* sp. from the Macleay drainage differs from *E. macquarii kreffti* (Gray, 1871) and needs to be described as a new species (According to Professor John Legler,

University of Utah). Fairfax (1990), however, reported that Professor Legler had identified the species as *Emydura signata*. *Emydura signata* has changed to *Emydura macquarii signata* Ahl, 1932 in 1993, and is known as the Brisbane River turtle.

~ Fairfax (1990) gave new information on this species: two specimens from *Emydura macquarii signata* Ahl, 1932, one with 23 genital spines, and one with 16, from Scrubby Creek, Logan River drainage, 27°42'S; 153°13'E, south of Brisbane, Queensland, Australia.

Information on the parasite

Table 3.11*: Measurements of *N. australis

CHARACTERISTICS	Rohde (1984)
Mature specimens (n)	3
Body Length	2900 / 3000 / 3500
Greatest Width	1000 / 1200 / 1300
Width at Vagina	
Haptor Length	790 / 820 / 890
Haptor Width	1340 / 1200 / 1300
Oral Diameter	280 x 470 / 270 x 490 / 340 x 540
Pharynx Length	290 / 340 / 380
Pharynx Diameter	450 / 490 / 540
Testis Length	320 / 330 / 340
Testis Width	380 / 430 / 390
Ovary Length	
Ovary Width	
Egg Length	0 / 0 / 290
Egg Diameter	0 / 0 / 240
Egg Incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	130 x 190 / 160 x 190 / 140 x 230
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	24 / 24 / 23 / 24
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	20 – 21 (short root); 26 – 31 (long root)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	280 / 300 / 290
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	23 – 27
Haptor L/Body L	0.2724 / 0.2733 / 0.2543

Neopolystoma liewi

Du Preez & Lim, 2000

Table 3.21; Figure 3.12

General

Collection: Parasitic Worms Collection, Natural History Museum, Cromwell Road, London SW75BD United Kingdom[①]; Institute of Parasitology, Academy of Sciences of the Czeck Republic, Branišovská 31, 370 05 České, Czech Republic[②]; Parasitic Worm Collection, National Museum, Aliwal Street, Bloemfontein 9301, South Africa[③].

Holotype no: 1999.10.29.1[①].

Paratype no: 1999.10.29.2 – 4 (n = 3)[①]; M 355 (n = 1)[②]; NMB P222 – NMB P227 (n = 6)[③].

Original description: Du Preez and Lim (2000).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Well vegetated earth-walled dam in the Botanical Garden (Hutan Rimbat) on the campus of the University of Malaya, Kuala Lumpur, Malaysia.

Other localities: Pet shops in Kuala Lumpur, collected in the Perak area.

Type host: *Cuora amboinensis* (Daudin, 1801). Article: Malayan box turtle. Otherwise known as the East Indian box turtle.
Additional hosts: None.

Site on type host: Conjunctival cavity, under the lower eyelid.

Information on the host

Taxonomy: *Cuora amboinensis* (Daudin, 1801) has four subspecies: *C. a. amboinensis* (Daudin, 1801); *C. a. couro* (Schweigger, 1812); *C.a. kamaroma* Rummler & Fritz, 1991; *C. a. lineate* McCord & Philippen, 1998.

Geographical distribution: Widely distributed in north-eastern India and Bangladesh and in Southeast Asia, surviving today in isolated residual areas, demonstrating a breakdown of the integrity of the overall range. Occurs in Bangladesh, the Nicobar Islands, and Assam, in the Kaziranga National Park. It also occurs in southern Myanmar, Malaysia, Sumatra, Java, and the Philippines and in Indonesia, as far east as the Moluccas.

Ecology: This is the most frequently consumed terrapin species in China restaurants, also captured and released in Buddhist temple ponds, and gathered for exports. This may lead to a population collapse in the future.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.12: Measurements of *N. liewi*	
CHARACTERISTICS	**Du Preez & Lim (2000)**
Mature specimens (n)	11
Body Length	2120 – 4169 (3474)
Greatest Width	1012 – 1566 (1321)
Width at Vagina	1012 – 1446 (1246)
Haptor Length	795 – 1205 (921)
Haptor Width	988 – 1470 (1179)
Oral Diameter	252 – 446 (367)
Pharynx Length	296 – 398 (349)
Pharynx Diameter	330 – 417 (382)
Testis Length	271 – 446 (341)
Testis Width	349 – 436 (363)
Ovary Length	213 – 339 (287)
Ovary Width	116 – 155 (136)
Egg Length	265 – 294 (283)
Egg Diameter	109 – 126 (120)
Egg incubation time	1.5 (0 – 3) eggs per 24h
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	63 – 87 (78) x 53 – 92 (72)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	8 – 11
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	10.8 – 13.2 (11.8)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	184 – 252 (217)
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	12.2 – 12.7 (12.6)
Haptor L/Body L	0.2651

Remarks

~ A complete description of the species' oncomiracidium was also given (Du Preez & Lim, 2000).

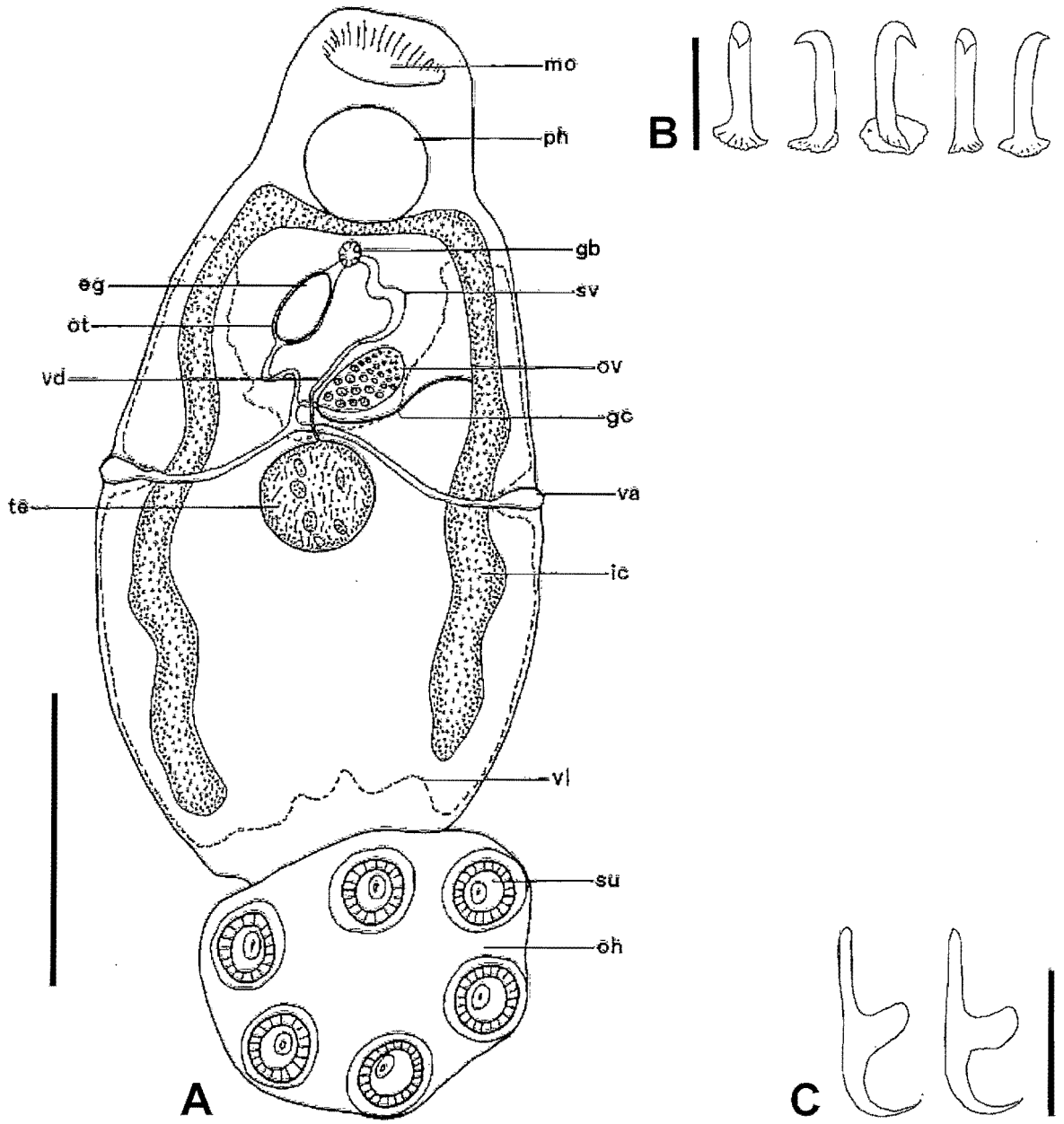


Figure 3.12: (A) *Neopolystoma liewi* Du Preez & Lim, 2000. Abbreviations: eg – egg; gb – genital bulb; gc – genitointestinal canal; ic – intestinal caecum; mo – mouth; oh – opisthaptor; ot – ootype; ov – ovary; ph – pharynx; su – sucker; sv – seminal vesicle; te – testis; va – vagina; vd – vas deferens; vi – vitelline distribution (Scale bar = 1000µm); (B) Genital spines (Scale bar = 10µm); (C) Marginal hooklets (Scale bar = 10µm). Copied from Du Preez and Lim (2000).

Neopolystoma macleayi

Rohde, 1984

Table 3.13; Figure 3.13

General

Collection: Australian Museum, Sydney[①]; United States National Museum Helminthological Collection[②]; British Museum (Natural History)[③].
Holotype no: 19292[①].
Paratype no: 77257[②]; 1982.11.3.24[③].

Original description: Rohde (1984).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Georges Creek, 30°43'S; 152°11'E, Macleay drainage, New South Wales, Australia.

Other localities: Apsley River, 31°4'S; 152°1'E, Macleay drainage, New South Wales, Australia.

Type host: *Emydura* sp.
Additional hosts: *Emydura macquarii signata*; *Elseya latisternum*.

Site on type host: Cloacal bursa.

Information on the host

Taxonomy: None.

Geographical distribution: None

Ecology: None

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.13: Measurements of *N. macleayi*		
CHARACTERISTICS	**Rohde (1984)**	**Pichelin (1995)**
Mature specimens (n)	4	7
Body Length	2800 / 3500 / 3700 / 4000	2690 – 3184 (2907)
Greatest Width	760 / 1400 / 1600 / 1300	669 – 971 (855)
Width at Vagina		
Haptor Length	630 / 860 / 1000 / 950	844 – 923 (885)
Haptor Width	1000 / 1200 / 1600 / 1400	987 – 1067 (1019)
Oral Diameter	290 x 330 / 390 x 460 / 290 x 460 / 380 x 490	350 – 411 (380) x 366 – 475 (440)
Pharynx Length	200 / 190 / 220 / 220	207 – 263 (231)
Pharynx Diameter	210 / 340 / 330 / 330	255 – 287 (271)
Testis Length	270 / ? / 730 / 700	462 – 571 (507)
Testis Width	190 / ? / 820 / 660	327 – 379 (354)
Ovary Length		
Ovary Width		
Egg Length	0 / 360 / 360 / 320	
Egg Diameter	0 / 290 / 260 / 260	
Egg incubation time		
Intra-Uterine Eggs (n)	1	1
Genital Bulb Diameter	70 x 80 / 100 x 100 / ? / 140 x 120	74 – 104 (93) x 64 – 115 (90)
Gen. Bulb Hook set (n)	1	1
Gen. Bulb Hooks 1 (n)	12 (or 13) / 12 / ca. 15 / 12	11 – 13 (12)
Gen. Bulb Hooks 2 (n)		
Gen. Bulb Hook Length 1	13 – 15	20.8 – 27.4 (23.6)
Gen. Bulb Hook Length 2		
Haptoral Sucker Diameter	240 / 320 / 320 / 340	302 – 326 (306)
Hamulus Length 1		
Hamulus Length 2		
Hamulus Hook Length 1		
Hamulus Hook Length 2		
Marginal Hooklet Length	22 – 28	25.6 – 28.8 (26.4)
Haptor L/Body L	0.225 / 0.2457 / 0.2703 / 0.2375	

Remarks

~ Fairfax (1990) gave new information on this parasite: From an accessory bladder of *Emydura macquarii signata* Ahl, 1932 from Scrubby Creek, Logan River drainage, 27°42'S; 153°13'E, south of Brisbane, Queensland.

~ Pichelin (1995) gave new hosts for this species: *Emydura macquari signata* Ahl, 1932, and *Elseya latisternum* Gray, 1867.

~ Pichelin (1995) gave new host localities for this species: Urinary and accessory bladders.
~ Pichelin (1995) gave new localities for this species: the University of Queensland Veterinary Farm dam (27°32'S, 152°54'E) in south-east Queensland and the Tinaroo Falls Dam (17°10'S, 145°33'E) in northern Queensland (Australia).
~ Pichelin (1995) stated that this is the first record of *Neopolystoma macleayi* Rohde, 1984 from a species of *Elseya*.

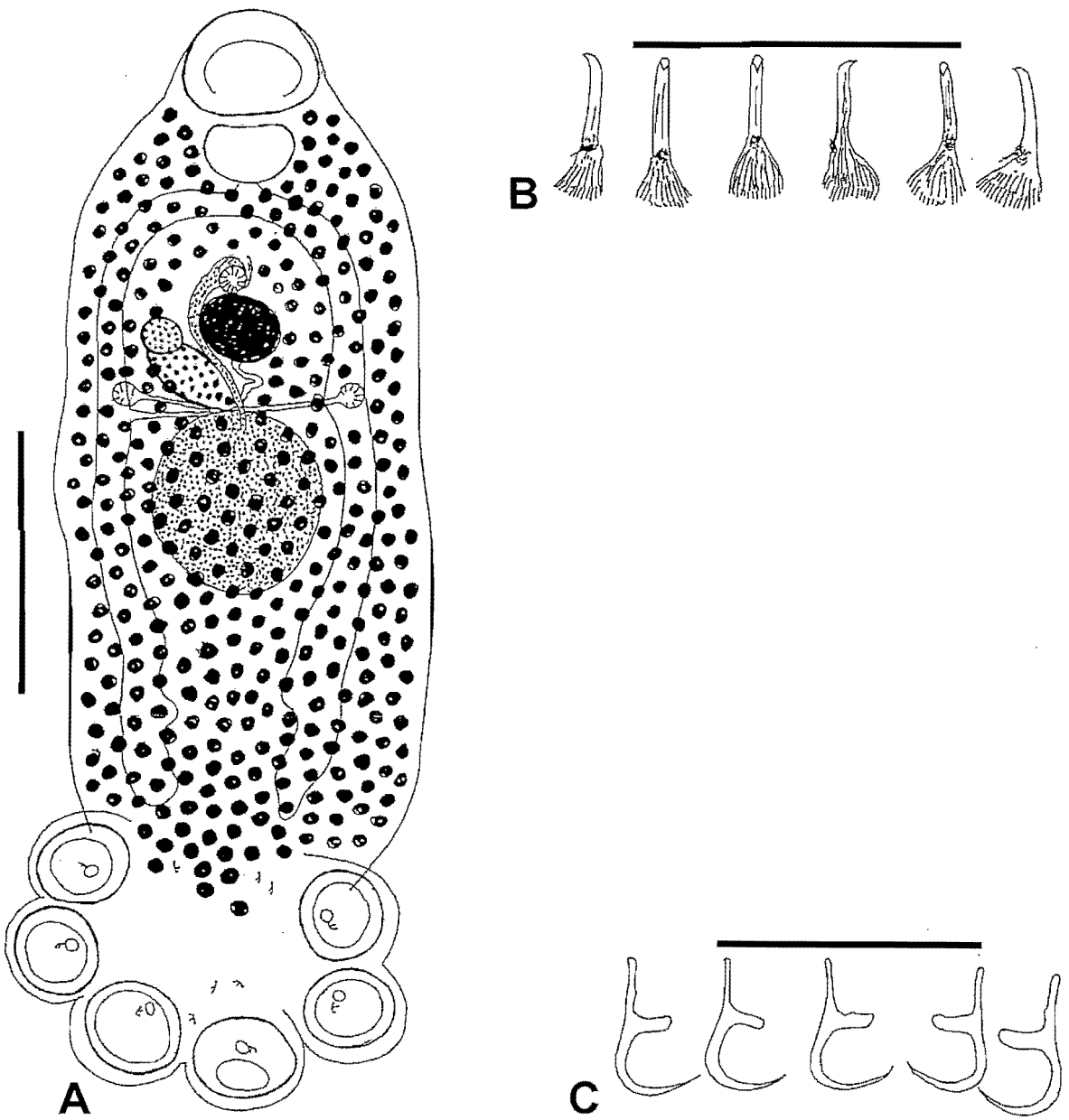


Figure 3.13: (A) *Neopolystoma macleayi* Rohde, 1984 (Scale bar = 1000µm); (B) Genital spines (Scale bar = 50µm); (C) Marginal hooklets (Scale bar = 50µm). Copied from Rhode (1984).

Neopolystoma novaeguineae

Fairfax, 1990

Table 3.14; Figure 3.14

General

Collection: Australian Museum, Sydney, Australia.
Holotype no: None.
Paratype no: Cat. nos. R 125031 – 9.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Mount Garagos near Gabensis Village, Morobe Province, Papua New Guinea. Watul River drainage, 6°47'S; 146°46'E, elevation 400 m.

Other localities: None.

Type host: *Elseya novaeguineae* (Meyer, 1874). New Guinea snapping turtle, New Guinea snapper.
Additional hosts:

Site on type host: Mouth and pharyngeal cavity.

Information on the host

Taxonomy: None.

Geographical distribution: This species of terrapin occurs in Northwestern Irian Jaya, Indonesia, in West Papua and Papua New Guinea (TransFly Region of Papua New Guinea).

Ecology: This terrapin is regularly caught for food, but despite this populations in nature are in sound condition.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.14: Measurements of *N. novaeguineae*	
CHARACTERISTICS	Fairfax (1990)
Mature specimens (n)	9
Body Length	1300 – 3530 (2190)
Greatest Width	510 – 1230 (840)
Width at Vagina	
Haptor Length	510 – 920 (690)
Haptor Width	720 – 1300 (950)
Oral Diameter	150 – 510 (250) x 200 – 470 (380)
Pharynx Length	170 – 410 (270)
Pharynx Diameter	220 – 470 (320)
Testis Length	90 – 290 (220)
Testis Width	150 – 350 (220)
Ovary Length	
Ovary Width	
Egg Length	180 – 240 (210)
Egg Diameter	180 – 220 (200)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	90 – 230 (170) x 100 – 240 (190)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	32 (usually)/33
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	23 – 29 (26)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	200 – 320 (270)
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	18 – 23 (23)
Haptor L/Body L	0.3151

Remarks

~ Fairfax (1990) also gave new information for *N. kreffti* Rohde, 1984, *N. macleayi* Rohde, 1984, and *N. australis* Rohde, 1984 (synonym for *N. kreffti* Rohde, 1984), as well as new information on two unknown species of *Neopolystoma* and five unknown species of *Polystomoides*.

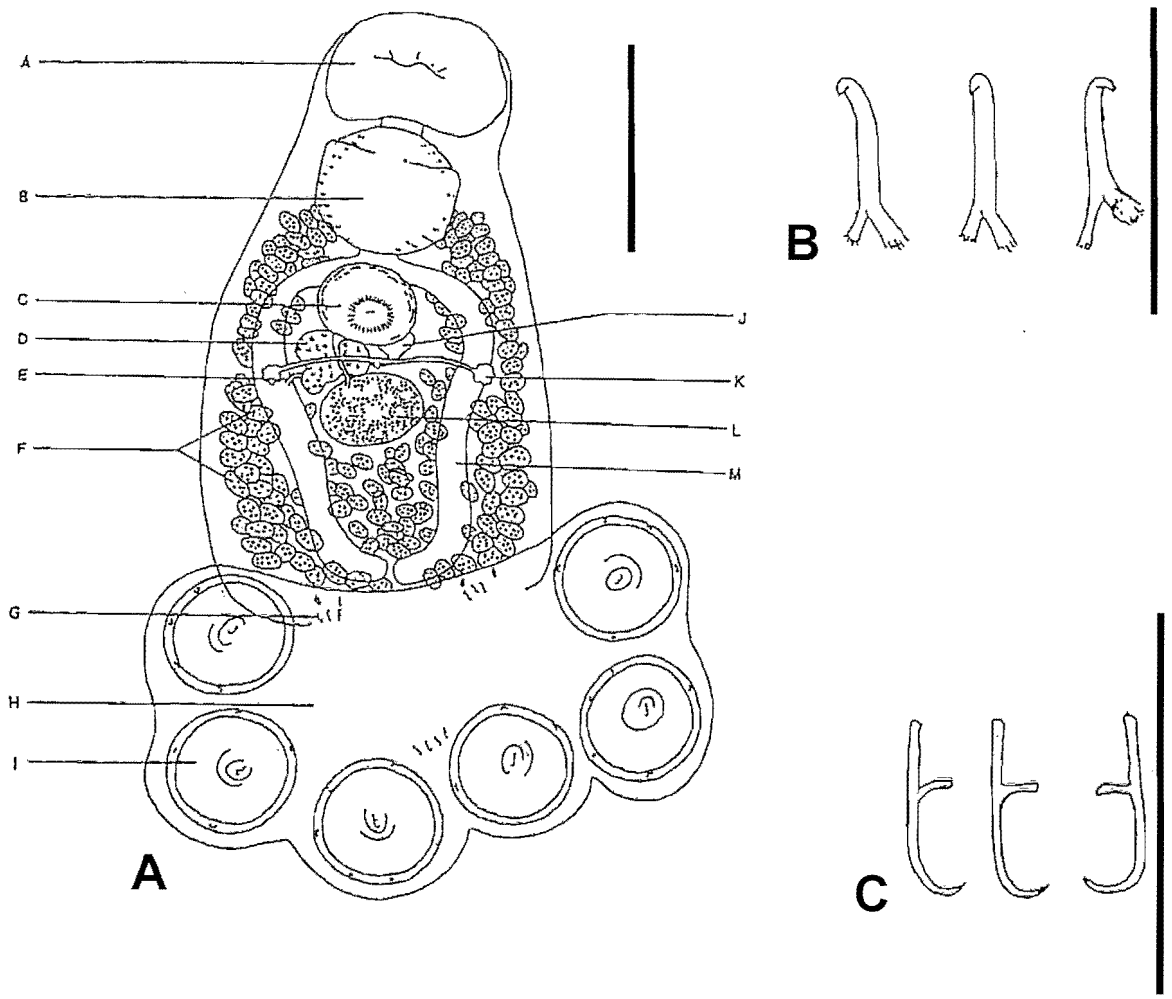


Figure 3.14: (A) *Neopolystoma novaeguineae* Fairfax, 1990. Abbreviations: A – oral sucker; B – pharynx; C – genital bulb; D – ovary; E – genitor–intestinal canal; F – vitellaria; G – marginal hooklets; H – haptor; I – sucker; J – uterus; K – vagina; L – testis; M – intestinal caecum (Scale bar = 300µm); (B) Genital spines (Scale bar = 50µm); (C) Marginal hooklets (Scale bar = 50µm). Copied from Fairfax (1990).

Neopolystoma orbiculare

(Stunkard, 1916)

Table 3.15; Figure 3.15

General

Collection: Helminthological Collection of the University of Illinois (Stunkard, 1916); United States National Museum Helminthological Collection (Price, 1939).

Holotype no: None.

Paratype no: 3991, 35101, 35298, 35576, 35577, 35578, 35579, 35580, 41156 (Price, 1939).

Original description: Stunkard (1916).

Other taxonomic contributions: Price, E.W. 1939. Proceedings of the Helminthological Society of Washington 6: 80 – 92.

Synonyms: *Polystoma aspidonectis* MacCallum, 1918; *Polystoma elegans* MacCallum, 1918; *Polysoma inerme* MacCallum, 1918; *Polystoma spinulosum* MacCallum, 1918; *Polystoma troosti* MacCallum, 1918; *Polystoma floridanum* Stunkard, 1924; *Polystoma oblongum* Wright, of Leidy 1888.

Type locality: Raleigh, N.C., and Chicago, Illinois and Creston, Iowa, North America.

Other localities: United States (North Carolina, Illinois, Iowa, New York, Minnesota, Oklahoma, Florida, and Texas).

Type host: [1]*Pseudemys scripta* [*Trachemys scripta* (Schoepff, 1792)]. Common slider turtle. AND [2]*Chrysemys marginata* [*Chrysemys picta marginata* (Agassiz, 1857)]. Central Painted turtle.
Additional hosts: *Pseudemys alabamensis*; *Trachemys scripta troostii*; *T. s. elegans*; *Chrysemys picta*; *Apalone ferox*; *Malaclemys terrapin terrapin*; *Kinosternon leucostomum*; *Trachemys decussata decussate*; *Chrysemys venusta cataspila*.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: [1]*Pseudymys scripta* has changed to *Trachemys scripta* (Schoepff, 1792). There are three subspecies: *T. s. scripta* (Schoepff, 1792), *T. s. elegans* (Wied, 1839), and *T. s. troostii* (Holbrook, 1836). [2]*Chrysemys marginata* has changed to *Chrysemys picta marginata* (Agassiz, 1857). *Chrysemys picta* (Schneider, 1783) has three other subspecies: *C. p. picta* (Schneider, 1783), *C. p. bellii* (Gray, 1831), and *C. p. dorsalis* Agassiz, 1857.

Geographical distribution: [1]This particular species occurs in south-central and eastern United States, from southeastern Virginia to northern Florida. The subspecies *Trachemys scripta elegans* (Wied, 1839) has been introduced in many countries worldwide. [2]This terrapin occurs in Canada (southern Quebec to Ontario) and southern United States (Tennessee, northern Alabama, Pennsylvania and Virginia).

Ecology: [1]This terrapin is not really threatened and is a popular pet, but causes the endangerement of other terrapin species in the wild. [2]Raccoons feed on this species' eggs, and vehicles and habitat destruction can be problems.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.15: Measurements of *N. orbiculare*			
CHARACTERISTICS	Stunkard (1916)	Price (1939)	Lamothe-Argumedo (1972)
Mature specimens (n)			2
Body Length	2700 – 3750	2400 – 5800	3703 – 4701
Greatest Width	900 – 1200	318 – 1600	1110 – 1690
Width at Vagina			
Haptor Length			756 – 1046
Haptor Width	800 – 1070 (circular)	700 – 1600	1062 – 1642
Oral Diameter		170 – 340 x 272 – 588	322 x 483 – 575
Pharynx Length	240 – 280 (spherical)	187 – 300	241 – 257
Pharynx Diameter		204 – 390	257 – 289
Testis Length	360 – 500	425 – 1000	563
Testis Width	290 – 390	340 – 680	322 – 402
Ovary Length	140 – 185	120 – 375	257 – 289
Ovary Width	100 – 140	65 – 170	80
Egg Length		228 – 272	281
Egg Diameter		153 – 170	206
Egg incubation time			
Intra-Uterine Eggs (n)		1	1
Genital Bulb Diameter		76 – 148	150 – 193
Gen. Bulb Hook set (n)	1	1	1
Gen. Bulb Hooks 1 (n)	16	16	16 – 17
Gen. Bulb Hooks 2 (n)			
Gen. Bulb Hook Length 1		20	33 – 37 x 7
Gen. Bulb Hook Length 2			
Haptoral Sucker Diameter	250 – 270 x 370 – 420	170 – 425	177 – 402 x 305 – 402
Hamulus Length 1			
Hamulus Length 2			
Hamulus Hook Length 1			
Hamulus Hook Length 2			
Marginal Hooklet Length		20	
Haptor L/Body L			

Remarks

~ Harwood (1931) gave new information on this species: Urinary bladder of *Trachemys scripta elegans* (Wied, 1839) and *Pseudemys concinna concinna* (LeConte, 1830) from Lake Taliwanda, McAlester, Oklahoma. Harwood (1932) found the species again in *Trachemys scripta elegans* from Texas.

~ Price (1939) gave new host information: *Pseudemys alabamensis* (Baur, 1893), *Chrysemys picta marginata* Agassiz, 1857, *Trachemys scripta troostii* (Holbrook, 1836), *T. s. elegans* (Wied, 1839), *Chrysemys picta* (Schneider, 1783) which has four subspecies, *Apalone ferox* (Schneider, 1783), *Malaclemys terrapin terrapin* (Schoepff, 1793), and "terrapin".

~ Zereco (1948) found the species in *Kinosternon leucostomum* (Duméril & Bibron, 1851) and commented that the species' vaginas are dorsolateral but inconspicuous, the intestine does not end in the haptor, and there are 15 – 16 genital spines.
~ Baruš and Moravec (1967) gave a new host: *Trachemys decussata decussata* (Gray, 1831) in Cuba.
~ Lamothe-Argumedo (1972) found the species in *Trachemys venusta cataspila* (Günther, 1885) from the River Tamesí, Tamaulipas, Mexico.

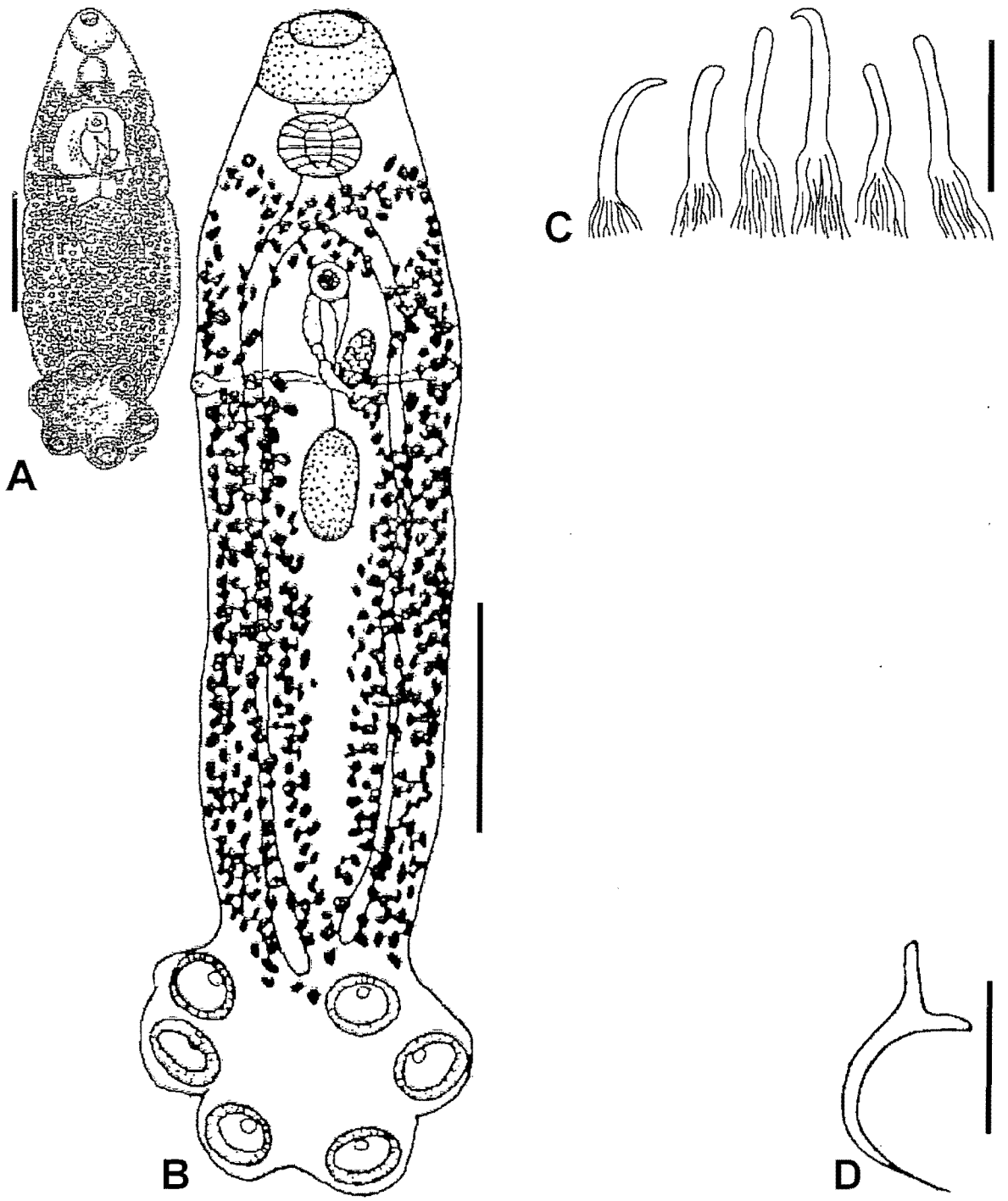
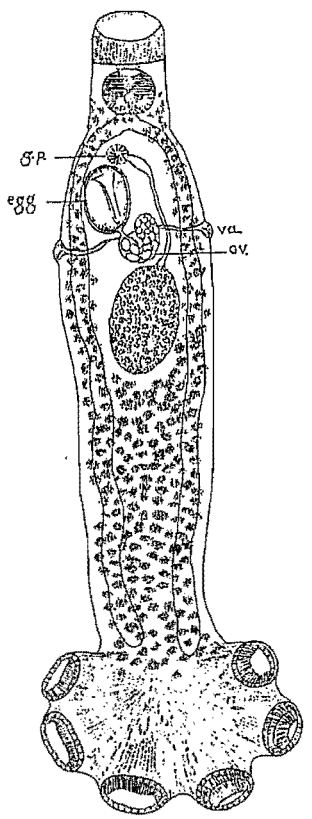
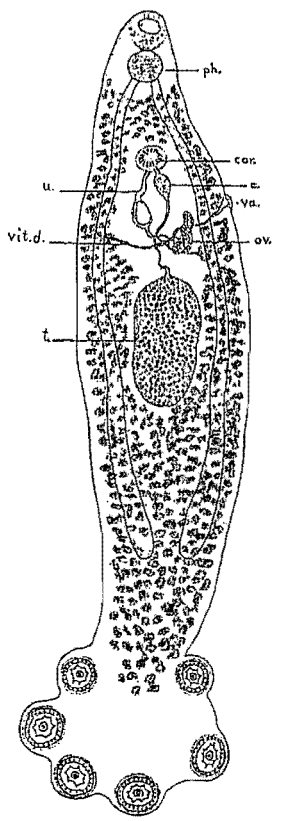
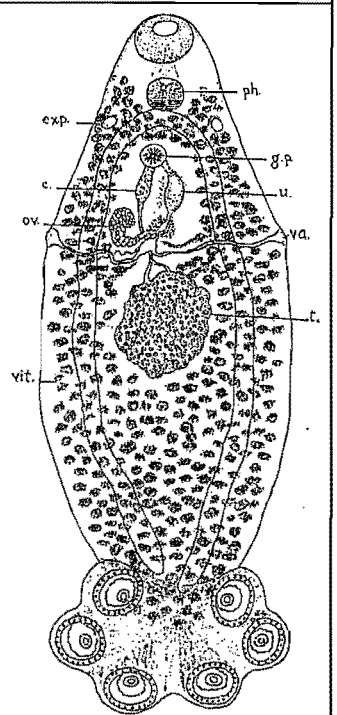


Figure 3.15: (A) *Neopolystoma orbiculare* (Stunkard, 1916). According to Price (1939) (original) (Scale bar = 1000µm); (B) *Neopolystoma orbiculare* (Stunkard, 1916) (Scale bar = 100µm); (C) Genital spines (Scale bar = 30µm); (D) Marginal hooklet (Scale bar = 10µm). Modified from Baruš & Moravec (1967).

Junior synonyms of *Neopolystoma orbiculare*

Tables 3.16 and 3.17; Figures 3.16 – 3.18

General

Table 3.16: *Polystoma aspidonectis*, *P. elegans* and *P. inerme*			
	***P. aspidonectis* MacCallum, 1918**	***P. elegans* MacCallum, 1918**	***P. inerme* MacCallum, 1918**
Collection	None.	None.	None.
Original description	MacCallum (1918).	MacCallum (1918).	MacCallum (1918).
Type locality	New York Aquarium, United States.	New York Aquarium, United States.	New York Aquarium, United States.
Type host	*Trionyx ferox* [*Apalone ferox* (Schneider, 1783)]. Florida softshell turtle.	*Chrysemys elegans* [*Trachemys scripta elegans* (Wied, 1839)]. Red-eared slider.	*Chrysemys elegans* [*Trachemys scripta elegans* (Wied, 1839)]. Red-eared slider.
Site on host	Nasal cavities, lung, and intestines.	Urinary bladder.	Urinary bladder.
	 ***Figure 3.16***: *Polystoma aspidonectis*. Copied from MacCallum (1918).	 ***Figure 3.17***: *Polystoma elegans*. Copied from MacCallum (1918).	 ***Figure 3.18***: *Polystoma inerme*. Copied from MacCallum (1918).
	Abbreviations: c. – cirrus; cor. – coronet; ex.p. – excretory pore; g.p. – genital pore; ov. – ovary; ph. – pharynx; t. – testis; u. – uterus; va. – vagina; vit. – vitellaria; vit.d. – vitelline duct.		

Remarks

~ None.

Information on the parasite

Table 3.17: Measurements of *P. aspidonectis*, *P. elegans* and *P. inerme*

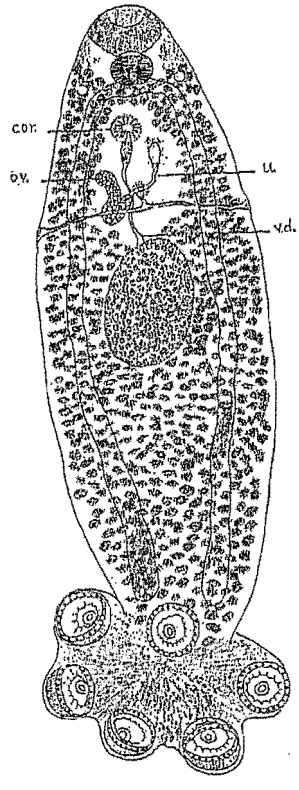
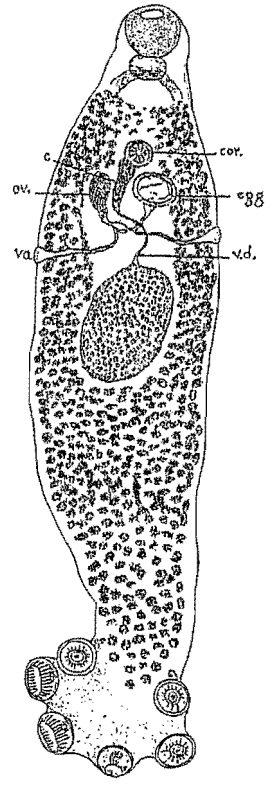
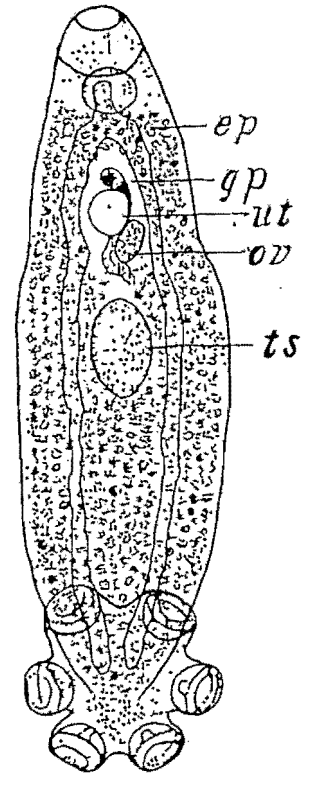
CHARACTERISTICS	MacCallum (1918)	MacCallum (1918)	MacCallum (1918)
Mature specimens (n)	5		3
Body Length	2600	9000	4000 – 5400
Greatest Width		2000	1500 – 2000
Width at Vagina			1200
Haptor Length			2000
Haptor Width	800	2200	600
Oral Diameter		60	
Pharynx Length			
Pharynx Diameter			1000
Testis Length	600	1600	
Testis Width		800	
Ovary Length	200	60	
Ovary Width		20	
Egg Length	200		
Egg Diameter		120	
Egg incubation time			
Intra-Uterine Eggs (n)	1	1	
Genital Bulb Diameter		75	
Gen. Bulb Hook set (n)		1	1
Gen. Bulb Hooks 1 (n)		17	16/17/15
Gen. Bulb Hooks 2 (n)			
Gen. Bulb Hook Length 1		20	
Gen. Bulb Hook Length 2			
Haptoral Sucker Diameter		400	400
Hamulus Length 1			
Hamulus Length 2			
Hamulus Hook Length 1			
Hamulus Hook Length 2			
Marginal Hooklet Length			
Haptor L/Body L			

Junior synonyms of *Neopolystoma orbiculare* [continued]

Tables 3.18 and 3.19; Figures 3.19 – 3.21

General

Table 3.18: *Polystoma spinulosum*, *P. troosti* and *P. floridanum*

	P. spinulosum MacCallum, 1918	*P. troosti* MacCallum, 1918	*P. floridanum* Stunkard, 1924
Collection	None.	None.	None.
Original description	MacCallum (1918).	MacCallum (1918).	Stunkard (1924b).
Type locality	New York Aquarium, United States	New York Aquarium, United States	Near Lakeland, Florida, United States.
Type host	*Chrysemys picta* (Schneider, 1783). Painted turtle.	*Chrysemys troosti* [*Trachemys scripta troostii* (Holbrook, 1836)]. The Cumberland turtle.	*Pseudemys floridana* (LeConte, 1830). Common cooter.
Site on host	Urinary bladder.	Urinary bladder.	Urinary bladder.
	 ***Figure 3.19***: *Polystoma spinulosum*. Copied from MacCallum (1918).	 ***Figure 3.20***: *Polystoma troosti*. Copied from MacCallum (1918).	 ***Figure 3.21***: *Polystoma floridanum*. Copied from Stunkard (1924b).
	Abbreviations: c. – cirrus; cor. – coronet; ep – excretory pore; gp – genital pore; ov. – ovary; ts – testis; u. – uterus; ut – uterus; va. – vagina; v.d. – vas deferens.		

Remarks

~ ***P. troosti***: Fritz and Havaš (2007) stated that *Trachemys scripta elegans* (Wied, 1839) and *Trachemys scripta troostii* (Holbrook, 1836) have often been confused with each other in older literature.

~ ***P. floridanum***: Stunkard (1924b) stated that *Polystoma floridanum* Stunkard, 1924 is very similar to *Neopolystoma orbiculare* (Stunkard, 1916), but gave a few differences: *P. floridanum* has a more delicate body, its musculature is weaker, its pharynx and caudal sucker is relatively smaller, and its cirrus sac and genital hooks are half as big as in *N. orbiculare*. Despite this, *P. floridanum* is now seen as a synonym for *N. orbiculare*.

Information on the parasite

Table 3.19*: Measurements of *P. spinulosum*, *P. troosti* and *P. floridanum

CHARACTERISTICS	MacCallum (1918)	MacCallum (1918)	Stunkard (1924b)
Mature specimen (n)			
Body Length	5600	4000	3000 – 3700
Greatest Width	1800	1000	640 – 830
Width at Vagina			
Haptor Length			
Haptor Width	2000	800	560 – 800
Oral Diameter	400		290 – 320 x 30 – 350
Pharynx Length			
Pharynx Diameter			180 – 190 (circular)
Testis Length	1000		320 – 410
Testis Width		800	180 – 220
Ovary Length	400	400	
Ovary Width		100	
Egg Length			190 – 200
Egg Diameter		300 (round)	160 – 180
Egg incubation time			
Intra-Uterine Eggs (n)		1	1
Genital Bulb Diameter			100 – 120
Gen. Bulb Hook set (n)			1
Gen. Bulb Hooks 1 (n)			16
Gen. Bulb Hooks 2 (n)			
Gen. Bulb Hook Length 1			
Gen. Bulb Hook Length 2			
Haptoral Sucker Diameter		200	160 – 210
Hamulus Length 1			
Hamulus Length 2			
Hamulus Hook Length 1			
Hamulus Hook Length 2			
Marginal Hooklet Length			15
Haptor L/Body L			

Neopolystoma palpebrae

Strelkov, 1950

Table 3.20; Figure 3.22

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Strelkov (1950).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Lake Hanka, east Asia.

Other localities: None.

Type host: *Amyda sinensis* [*Pelodiscus sinensis* (Weigmann, 1834)]. Chinese softshell turtle.
Additional hosts: None.

Site on type host: Under lower eyelid.

Information on the host

Taxonomy: *Amyda sinensis* has changed to *Pelodiscus sinensis* (Wiegmann, 1834).

Geographical distribution: This species of terrapin occurs throughout central and eastern China to Vietnam, Hainan and the Taiwan islands, except the provinces of Xinjiang, Qinghai, Xizang and Ningxia. It has also been introduced to Thailand as well as Japan (the Hawaiian Islands, Mariana Islands, Bonin Islands, Timor, Japan, Cebu and Luzon). Reports from Korea and extreme south-eastern Russia need to be confirmed.

Ecology: This species is bred and sold for its meat, thus natural populations have almost disappeared. Another problem is that their habitats have been almost completely altered or cleared. The status of this species in the wild needs to be evaluated.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.20: Measurements of *N. palpebrae*	
CHARACTERISTICS	Strelkov (1950)
Mature specimens (n)	
Body Length	2200 – 5100
Greatest Width	1100 – 1800
Width at Vagina	
Haptor Length	
Haptor Width	1000 – 1600
Oral Diameter	280 – 350
Pharynx Length	180 – 330
Pharynx Diameter	250 – 480
Testis Length	
Testis Width	150 – 180
Ovary Length	190 – 310
Ovary Width	110 – 150
Egg Length	280 – 300
Egg Diameter	130 – 150
Egg incubation time	24 days in 18 - 25°C
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	20 – 60
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	16
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	16 – 14
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	260 – 420
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	11 – 14
Haptor L/Body L	

Remarks

~ This species' mean intensity is two to three worms per host with a maximum of five (Strelkov, 1950).
~ Strelkov (1950) stated that this species is very similar to *Neopolystoma orbiculare* (Stunkard, 1916), but differs in the form and sizes of its copulatory spines.

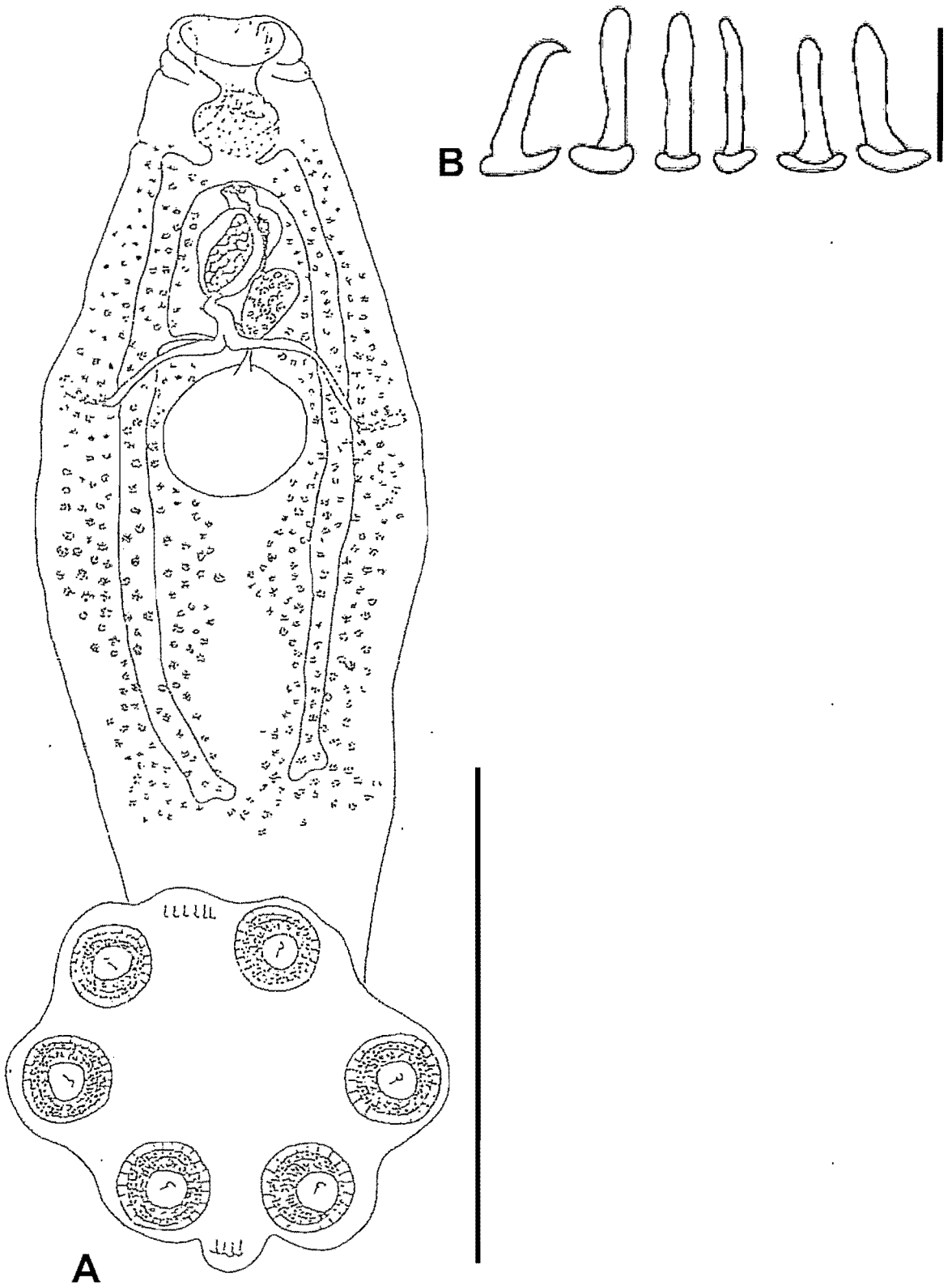


Figure 3.22: (A) *Neopolystoma palpebrae* Strelkov, 1950 (Scale bar = 2000µm); (B) Genital spines (Scale bar = 10µm). Modified from Strelkov (1950).

Neopolystoma queenslandensis

Pichelin, 1995

Table 3.21; Figure 3.23

General

Collection: Queensland Museum.
Holotype no: QM GL 18010.
Paratype no: QM GL 18011.

Original description: Pichelin (1995).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Lockyer Creek (27°35'S; 152°07'E), Queensland, Australia.

Other localities: Lake Clarendon (27°30'S; 152°21'E), Queensland, Australia; and Canal Creek (28°01'S; 151°35'E), Queensland, Australia.

Type host: *Emydura signata* [*Emydura macquarii signata* (Ahl, 1932)]. Brisbane River turtle.
Additional hosts: None.

Site on type host: Conjunctival sac of the eye.

Information on the host

Taxonomy: *Emydura signata* has changed to *Emydura macuarii signata* Ahl, 1932. *Emydura macquarii* (Gray, 1831) has seven other subspecies: *E. m. macquarii* (Gray, 1831), *E. m. binjing* Cann, 1998, *E. m. dharra* Cann, 1998, *E. m. dharuk* Cann, 1998, *E. m. emmotti* Cann, McCord & Joseph-Ouni, 2003, *E. m. gunabarra* Cann, 1998, *E. m. krefftii* (Gray, 1871), and *E. m. nigra* McCord, Cann & Joseph-Ouni, 2003.

Geographical distribution: This species occurs in the Brisbane River drainage, in south-eastern Queensland, Australia.

Ecology: This species is heavily collected for parks and zoos, and is one of the Australian terrapin species that is most frequently found in Western collections. Nevertheless, the species is still abundant in nature.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.21: Measurements of *N. queenslandensis*	
CHARACTERISTICS	Pichelin (1995)
Mature specimens (n)	3
Body Length	1369 – 1560 (1480)
Greatest Width	462 – 653 (563)
Width at Vagina	
Haptor Length	557 – 621 (578)
Haptor Width	732 – 828 (785)
Oral Diameter	231 – 244 (233) x 263 – 308 (289)
Pharynx Length	199 – 218 (210)
Pharynx Diameter	212 – 238 (225)
Testis Length	77 – 135 (103)
Testis Width	77 – 135 (103)
Ovary Length	
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	0
Genital Bulb Diameter	96 – 135 (111) x 103 – 128 (116)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	22 – 28 or 29
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	19.2 – 25.6 (21.6)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	207 – 215 (211)
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	16.8 – 19.2 (17.8)
Haptor L/Body L	0.3905

Remarks

~ Another host recorded for this species is the main species *Emydura macquarii* (Gray, 1831) (Pichelin, 1995).

~ This species differs from other *Neopolystoma* species by a number of characteristics: 22 to 28 (or 29) straight genital spines with hooked tips, a genital bulb located near the intestinal bifurcation, the caeca extend well beyond the posterior margin of the testis, possibly the size of the testis, and it is parasitic in the conjunctival sac (Pichelin, 1995).

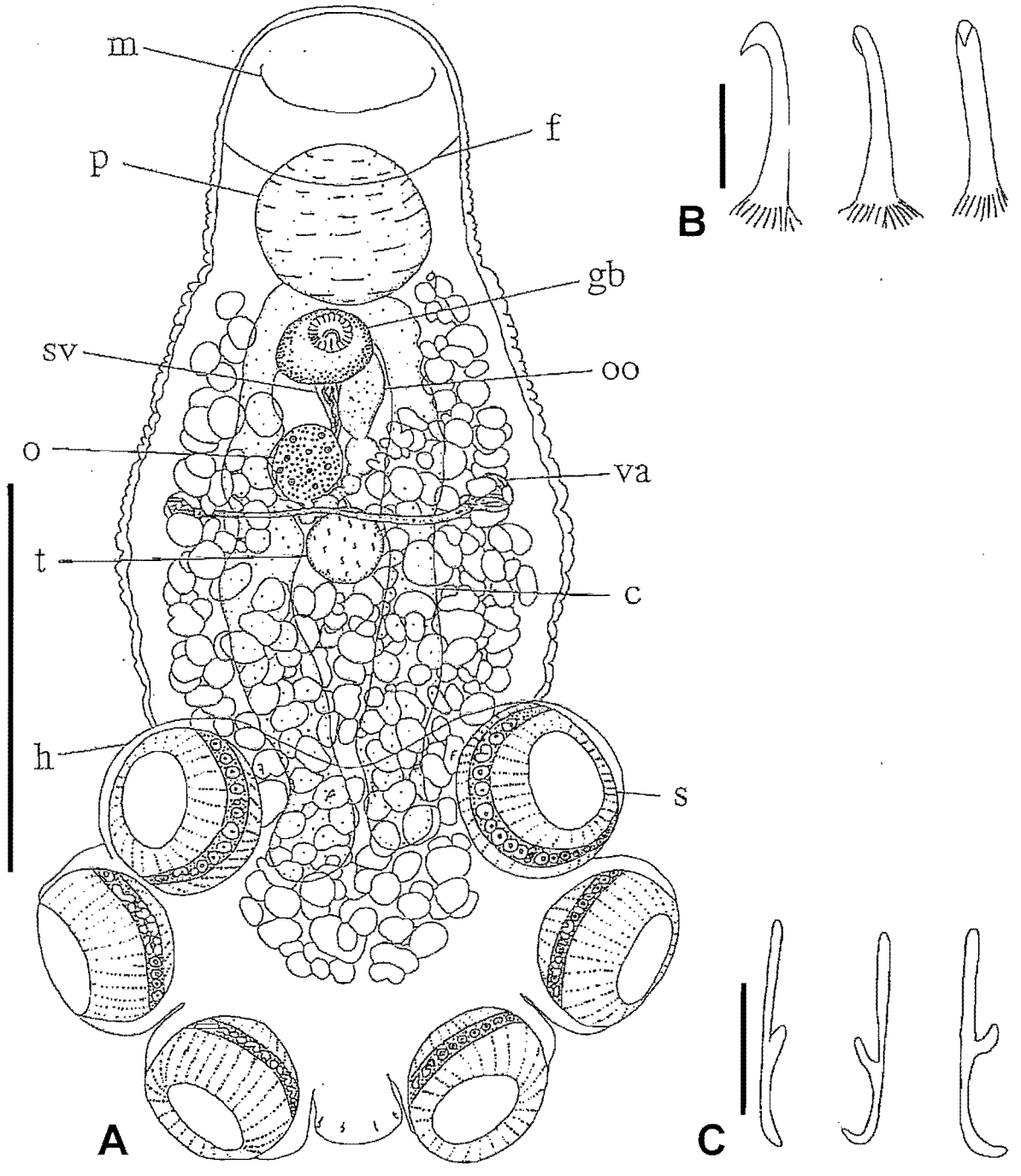


Figure 3.23: (A) *Neopolystoma queenslandensis* Pichelin, 1995. Abbreviations: c – gut caecum; f – false oral sucker; gb – genital bulb; h – haptor; m – mouth; o – ovary; oo – oötype; p – pharynx; s – haptoral sucker; sv – seminal vesicle; t – testis; va – vagina (Scale bar = 500µm); (B) Genital spines (Scale bar = 10µm); (C) Marginal hooklets (Scale bar = 10µm). Copied from Pichelin (1995).

Neopolystoma rugosa

(MacCallum, 1918)

Table 3.22; Figure 3.24

General

Collection: United States National Museum Helminthological Collection.
Holotype no: None.
Paratype no: 35581.

Original description: MacCallum (1918).

Other taxonomic contributions: Price, E.W. 1939. Proceedings of the Helminthological Society of Washington 6: 80 – 92.

Synonyms: None.

Type locality: New York Aquarium (United States).

Other localities: None.

Type host: *Trionyx ferox* (*Amyda ferox*) [*Apalone ferox* (Schneider, 1783)]. Florida softshell turtle.
Additional hosts: None.

Site on type host: Nostrils.

Information on the host

Taxonomy: *Trionyx ferox* has changed to *Amyda ferox* in 1816, and to *Apalone ferox* (Schneider, 1783) in 1987.

Geographical distribution: This species occurs in south-eastern United States, from southern Alabama (reaching as far as Baldwin County and Mobile Bay) through peninsular Florida (excluding the Keys) to southern South Carolina (through part of Georgia).

Ecology: This terrapin's predators include large fish, birds, certain terrapins, and many kinds of mammals. They are also affected by pollution, habitat desiccation, and roads. They are considered rare in many areas, but today there are breeding centres.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.22: Measurements of *N. rugosa*		
CHARACTERISTICS	**MacCallum (1918)**	**Price (1939)**
Mature specimens (n)	4	4
Body Length	4000	2960 – 3710
Greatest Width	2000	1920 – 1960
Width at Vagina		
Haptor Length		
Haptor Width	1400	1260 – 1370
Oral Diameter	30	425 x 510
Pharynx Length		290 – 340
Pharynx Diameter	45	340 – 400
Testis Length	600	340 – 680
Testis Width	300	510 – 765
Ovary Length	200	340
Ovary Width	150	136
Egg Length	400	360
Egg Diameter	200	150
Egg incubation time		
Intra-Uterine Eggs (n)	1	1
Genital Bulb Diameter		40
Gen. Bulb Hook set (n)		1
Gen. Bulb Hooks 1 (n)		14
Gen. Bulb Hooks 2 (n)		
Gen. Bulb Hook Length 1		9
Gen. Bulb Hook Length 2		
Haptoral Sucker Diameter	40	306 – 340
Hamulus Length 1		
Hamulus Length 2		
Hamulus Hook Length 1		
Hamulus Hook Length 2		
Marginal Hooklet Length	12.6 (12.2 – 12.7)	
Haptor L/Body L		

Remarks

~ Price (1939) stated that *Neopolystoma rugosa* (MacCallum, 1918) is similar to *N. orbiculare* (Stunkard, 1916), *N. chelodinae* (MacCallum, 1918), and *N. terrapenis* (Harwood, 1932), but differs in that it has smaller genital hooks, and the vitellaria do not meet in the median line posterior to the pharynx.

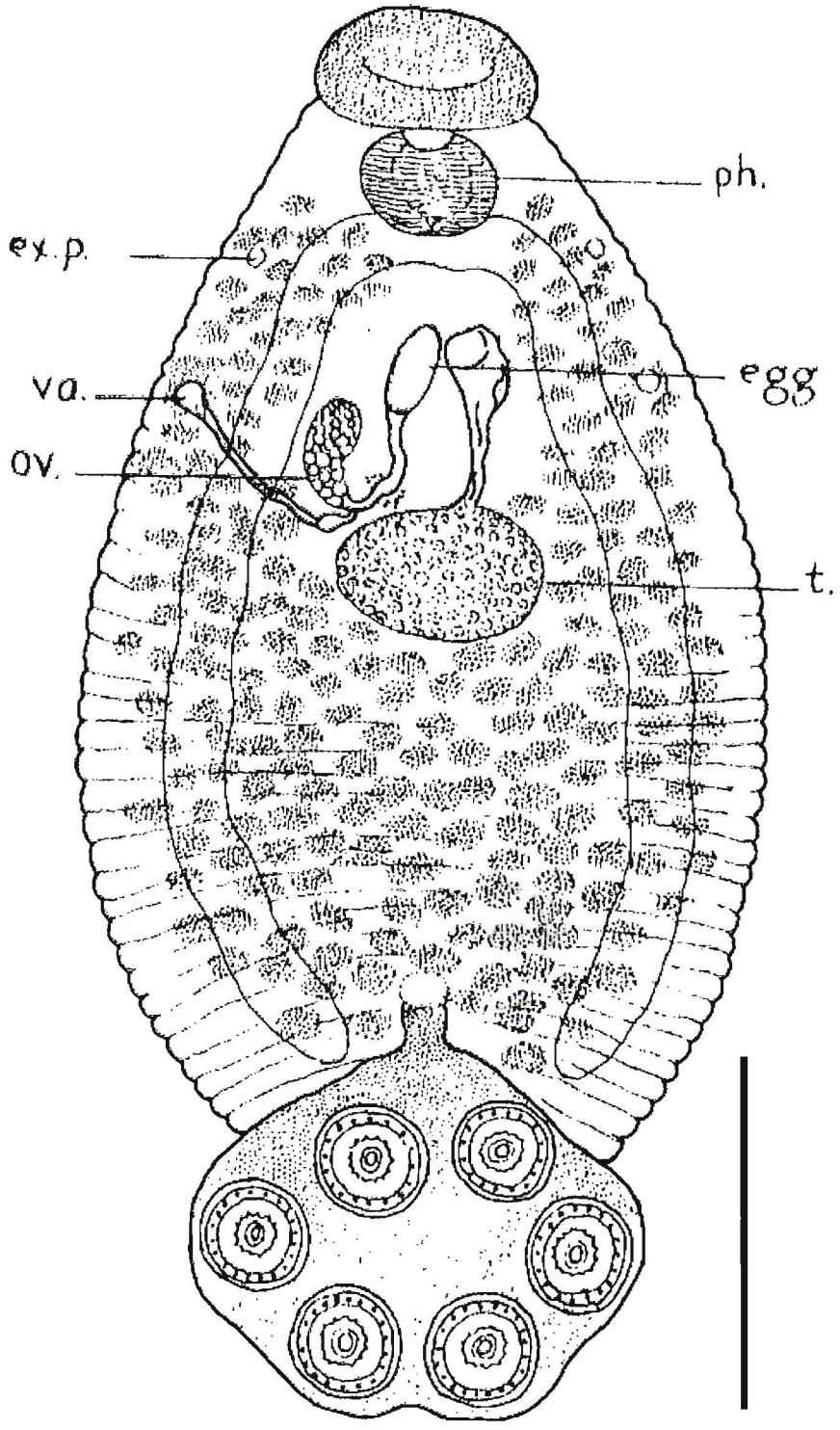


Figure 3.24: *Polystoma rugosa* (MacCallum, 1918). Abbreviations: ex.p. – excretory pore; ov. – ovary; ph. – pharynx; t. – testis; va. – vagina (Scale bar = 1000µm). Copied from MacCallum (1918).

Neopolystoma spratti

Pichelin, 1995

Table 3.23; Figure 3.25

General

Collection: Queensland Museum.
Holotype no: QM GL 18001.
Paratype no: QM GL 18002, 18003.

Original description: Pichelin (1995).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Macquarie Marshes, New South Wales, Australia.

Other localities: None.

Type host: *Chelodina longicollis* (Shaw, 1794). Eastern snake-necked turtle, long-necked turtle.
Additional hosts: None.

Site on type host: Conjunctival sac of the eye.

Information on the host

Taxonomy: None.

Geographical distribution: This terrapin occurs in a wide range from south-eastern South Australia to eastern Queensland (Charters Towers) to as far as Adelaide in the south.

Ecology: This species is a popular pet, often seen in Australian zoos and Western collections. This means there is a continuing drain on wild populations, and no breeding centres exist.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.23: Measurements of *N. spratti*	
CHARACTERISTICS	Pichelin (1995)
Mature specimens (n)	5
Body Length	1146 – 1305 (1239)
Greatest Width	823 – 923 (866)
Width at Vagina	
Haptor Length	589 – 716 (665)
Haptor Width	828 – 955 (907)
Oral Diameter	180 – 257 (229) x 302 – 385 (351)
Pharynx Length	167 – 238 (209)
Pharynx Diameter	193 – 231 (217)
Testis Length	205 – 321 (287)
Testis Width	289 – 360 (315)
Ovary Length	
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	77 – 109 (94) x 97 – 135 (114)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	20 – 26 (23)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	19.2 – 27.2 (23.9)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	178 – 212 (202)
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	14.4 – 19.2 (17.3)
Haptor L/Body L	0.5367

Remarks

~ *Neopolystoma spratti* Pichelin, 1995 differs from other *Neopolystoma* species due to a number of characteristics: 20 – 26 sickle-shaped genital spines with subterminal roots, the genital spines are longer than the marginal hooks, the ends of the caeca are contiguous with the posterior margin of the testis, the genital bulb is close to the intestinal bifurcation, the testis is large and occupies a large proportion of the intercaecal space, the egg is probably globose or ellipsoid to ovoid, and it is parasitic in the conjunctival sac (Pichelin, 1995).

~ The species was also found in *Chelodina longicollis* by Watson and Rohde (1995) and Watson and Whittington (1996), both in Australia.

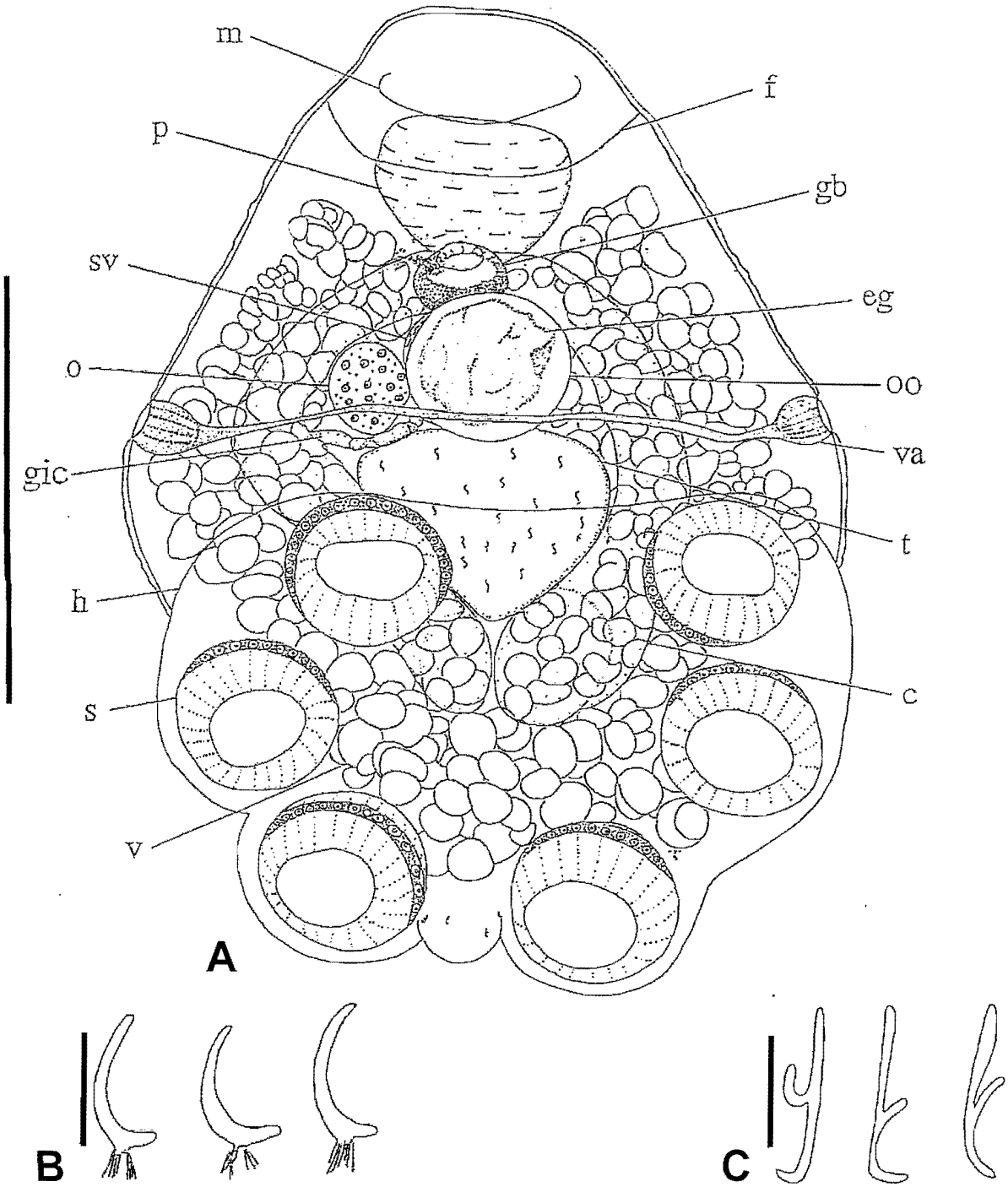


Figure 3.25: (A) *Neopolystoma spratti* Pichelin, 1995. Abbreviations: c – gut caecum; eg – egg; f – false oral sucker; gb – genital bulb; gic – genito-intestinal canal; h – haptor; m – mouth; o – ovary; oo – oötype; p – pharynx; s – haptoral sucker; sv – seminal vesicle; t – testis; v – vitelline follicle; va – vagina (Scale bar = 500µm); (B) Genital spines (Scale bar = 15µm); (C) Marginal hooklets (Scale bar = 10µm). Copied from Pichelin (1995).

Neopolystoma terrapenis

(Harwood, 1932)

Table 3.24; Figure 3.26

General

Collection: United States National Museum Helminthological Collection.
Holotype no: 30864.
Paratype no: None.

Original description: Harwood (1932).

Other taxonomic contributions: Price, E.W. 1939. Proceedings of the Helminthological Society of Washington 6: 80 – 92.

Synonyms: None.

Type locality: Houston, Texas, North America.

Other localities: None.

Type host: *Terrapene carolina triunguis* (Agassiz, 1857). Carolina box turtle.
Additional host: *Chelodina longicollis.*

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Terrapene carolina* (Linnaeus, 1758) has five other subspecies: *T. c. carolina* (Linnaeus, 1758), *T. c. bauri* Taylor, 1895, *T. c. major* (Agassiz, 1857), *T. c. mexicana* (Gray, 1849), and *T. c. yucatana* (Boulenger, 1895).

Geographical distribution: This terrapin occurs in south-central U.S.A., from Missouri to southern Texas and as far east as Alabama.

Ecology: Although its export is controlled today, this species is in decline in some areas. It suffers from drying of wetlands, urban development, agricultural proliferation, and overgrazing.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.24: Measurements of *N. terrapenis*	
CHARACTERISTICS	**Harwood (1932)**
Mature specimens (n)	
Body Length	1900 – 2500
Greatest Width	720 – 820
Width at Vagina	
Haptor Length	
Haptor Width	640 – 800
Oral Diameter	260 – 280 x 290 – 360
Pharynx Length	130 – 170
Pharynx Diameter	190 – 220
Testis Length	300 – 330
Testis Width	230 – 280
Ovary Length	
Ovary Width	67 – 85 (spherical)
Egg Length	
Egg Diameter	18 – 220
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	82 – 90
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	16
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	180 – 200
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	20
Haptor L/Body L	

Remarks

~ Harwood (1932) stated that *Neopolystoma terrapenis* (Harwood, 1932) is similar to *N. orbiculare* (Stunkard, 1916) and *N. floridanum* Stunkard, 1924, but differs in that: it is smaller, the vitellaria do not crowd into the intercecal area posterior to the testis, and the pharynx and cirrus sac are smaller.

~ Price (1939) stated that *N. orbiculare* (Stunkard, 1916) and *N. terrapenis* (Harwood, 1932) are very similar to each other, and if the vitellaria's dispersal wasn't viewed as a constant diagnostic characteristic in both species, they could be seen as identical.

~ Price (1939) gave no measurements for the species.
~ Lamothe-Argumendo (1972) stated that *N. terrapenis* was found in a *Chelodina longicollis* specimen from New York Zoo by Harwood in 1919. He explained that although the terrapin is an Australian species, he and Price (1939) maintained that the specimen was most likely infected by *P. terrapenis* after arriving in America.
~ Lamothe-Argumendo (1972) stated that Harwood (1932) found *N. terrapenis* again, but maintained that the specimen may be *N. orbiculare*, although the specimen's distribution of vittelaria is more similar to *N. terrapenis*. The two species are extremely similar.

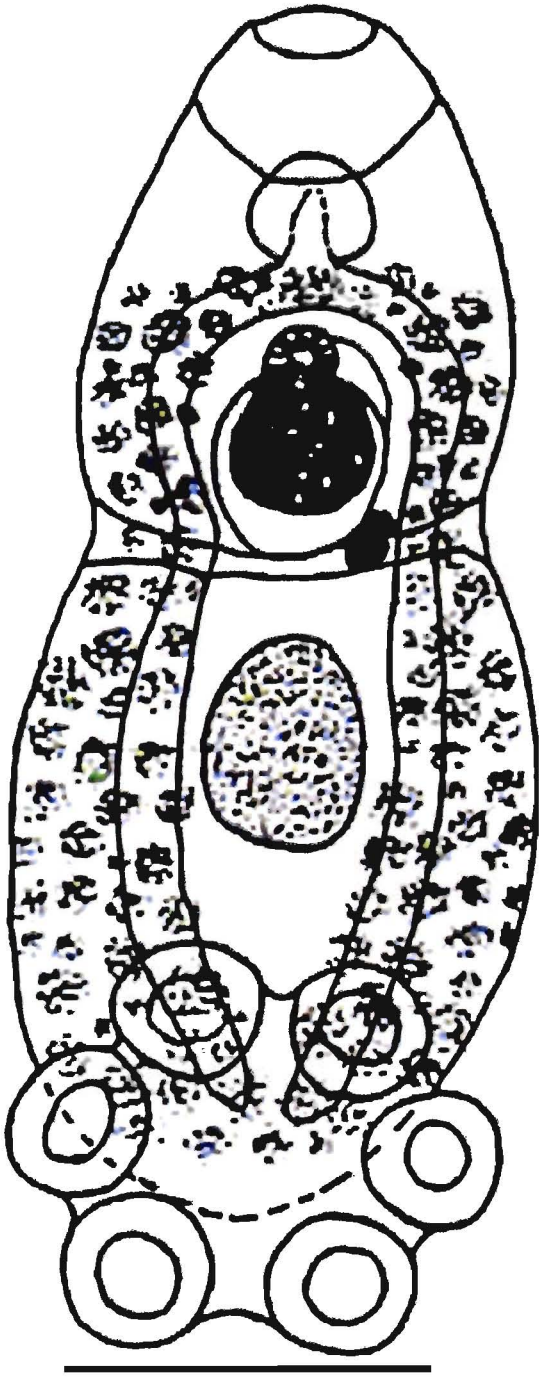


Figure 3.26: *Neopolystoma terrapenis* (Harwood, 1932) (Scale bar = 500µm). Copied from Harwood (1932).

Neopolystoma tinsleyi

Pichelin, 1995

Table 3.25; Figure 3.27

General

Collection: Queensland Museum.
Holotype no: QM GL 18007.
Paratype no: QM GL 18008, 18009.

Original description: Pichelin (1995).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Canal Creek (28°01'S, 151°35'E), Darling Downs, Queensland, Australia.

Other localities: Queensland, Australia – The university of Queensland Veterinary Farm dam (37°32'S, 152°54'E).

Type host: *Chelodina expansa* [*Macrochelodina expansa* (Gray, 1857)]. Broad-shelled river turtle, giant snake-necked turtle.
Additional hosts: None.

Site on type host: Conjunctival sac of the eye.

Information on the host

Taxonomy: *Chelodina expansa* has changed to *Macrochelodina expansa* (Gray, 1857).

Geographical distribution: This terrapin has a wide, boomerang-shaped range in the south-east of Australia, northern Victoria, central New South Wales, to south-eastern Queensland. It occurs far from the coast almost throughout its range, apart from the extreme east, where it can be found on Fraser Island, where it was possibly introduced through human agency.

Ecology: This species of terrapin make popular pets. Precise counts of populations in the wild are extremely difficult because they hide very effectively and are almost impossible to find.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.25: Measurements of *N. tinsleyi*	
CHARACTERISTICS	Pichelin (1995)
Mature specimens (n)	9
Body Length	1305 – 1656 (1500)
Greatest Width	557 – 732 (640)
Width at Vagina	
Haptor Length	509 – 685 (601)
Haptor Width	700 – 877 (804)
Oral Diameter	218 – 321 (246) x 244 – 321 (276)
Pharynx Length	167 – 205 (188)
Pharynx Diameter	199 – 238 (219)
Testis Length	315 – 482 (383)
Testis Width	289 – 398 (332)
Ovary Length	
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	83 – 96 (92) x 83 – 96 (87)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	21 – 27 (23)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	14.4 – 20.8 (16.8)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	180 – 212 (193)
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	14.4 – 19.2 (17.1)
Haptor L/Body L	0.2651

Remarks

~ *Neopolystoma tinsleyi* Pichelin, 1995 differs from other species due to a number of characteristics: 21 – 27 genital spines with slightly hooked tips and terminal roots, a large testis, the ends of the caeca are near the posterior margin of the testis, the vaginal pores are capped, and it is parasitic in the conjunctival sac (Pichelin, 1995).

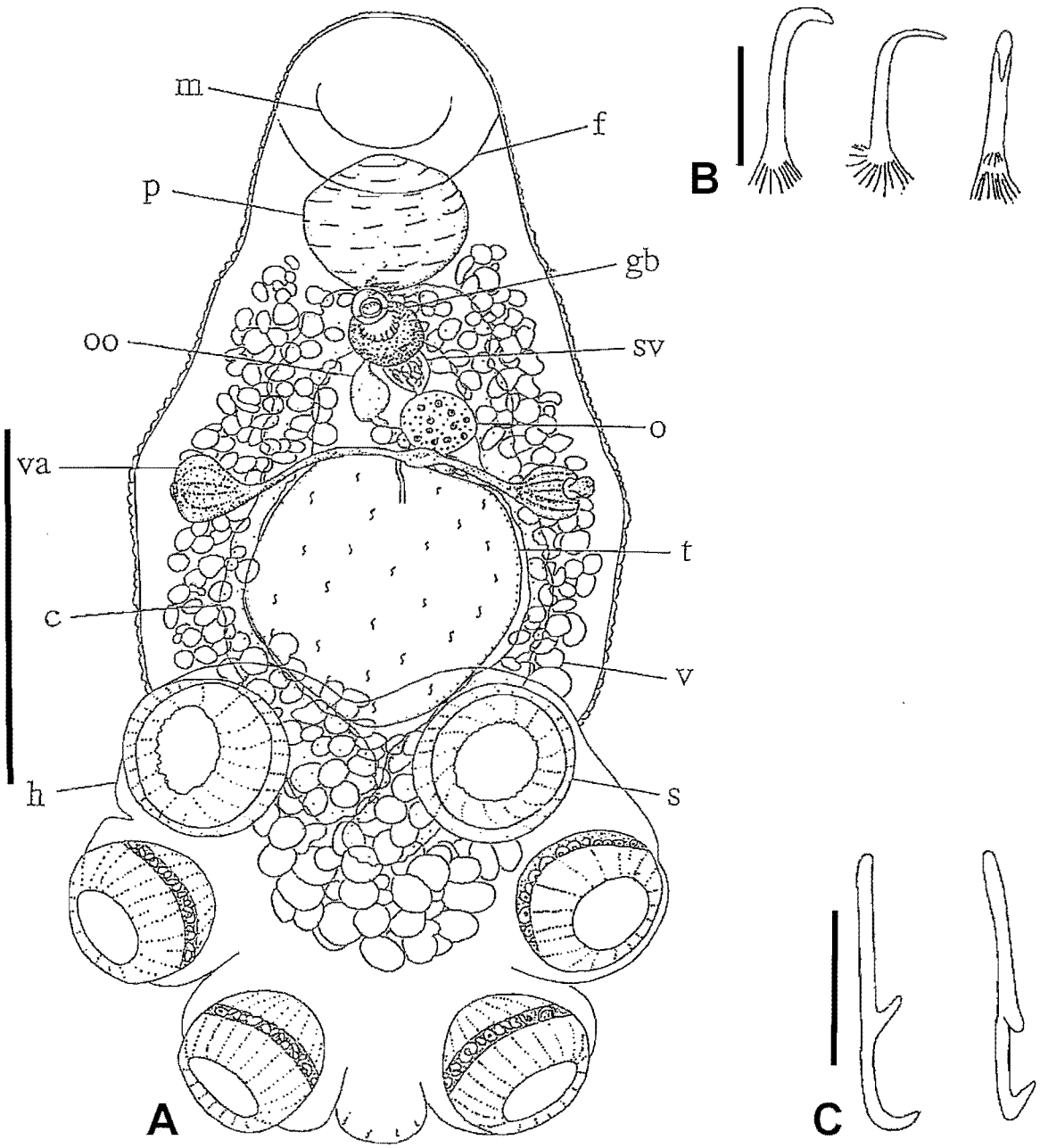


Figure 3.27: (A) *Neopolystoma tinsleyi* Pichelin, 1995. Abbreviations: c – gut caecum; f – false oral sucker; gb – genital bulb; h – haptor; m – mouth; o – ovary; oo – oötype; p – pharynx; s – haptoral sucker; sv – seminal vesicle; t – testis; v – vitelline follicle; va – vagina (Scale bar = 500µm); (B) Genital spines (Scale bar = 10µm); (C) Marginal hooklets (Scale bar = 10µm). Copied from Pichelin (1995).

Neopolystoma sp. (1)

by Fairfax (1990)

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Stewart Creek, Daintree River (16°13'S; 145°40'E), north Queensland, Australia.

Other localities: None.

Type host: *Elseya latisternum* Gray, 1867. Saw-shelled turtle, serrated snapping turtle.
Additional hosts: None.

Site on type host: Mouth.

Information on the host

Taxonomy: None.

Geographical distribution: This species has a huge and discontinuous range in northern and eastern Australia, from the Richmond River, New south Wales, along the Coastal area to the South Alligator River, Northern Territory. It abounds in the Flinders River and reaches 1000 m altitudes in the Atherton Tableland.

Ecology: There is no evidence that natural populations of this species are depleted.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Remarks

~ This species has not yet been identified. Fairfax (1990) only stated that only one specimen was found.
~ Fairfax (1990) stated that the only previous report of *Neopolystoma* infecting the genus *Elseya* in Australia was that of a specimen of undetermined status in *E. dentate*, also from Queensland.

Neopolystoma sp. (2)
by Fairfax (1990)

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Scrubby Creek, Logan River drainage (27°42'S; 153°13'E), south of Brisbane, Queensland, Australia.

Other localities: None.

Type host: *Emydura signata* [*Emydura macquarii signata* Ahl, 1932]. Brisbane River turtle.
Additional hosts: None.

Site on type host: Palate (Mouth).

Information on the host

Taxonomy: *Emydure signata* has changed to *Emydura macquarii signata* Ahl, 1932. *Emydura macquarii* (Gray, 1831) has eight other subspecies: *E. m. macquarii* (Gray, 1831), *E. m. binjing* Cann, 1998), *E. m.* dharra Cann, 1998, *E. m. dharuk* Cann, 1998, *E. m. emmotti* Cann, McCord & Joseph-Ouni 2003, *E. m. gunabarra* Cann, 1998, *E. m. krefftii* (Gray, 1871), and *E. m. nigra* McCord, Cann & Joseph-Ouni, 2003.

Geographical distribution: This terrapin is found in the Brisbane river drainage, south-eastern Queensland, Australia.

Ecology: This terrapin is abundant in nature, although it is heavily collected and is present in many wildlife parks and zoos. This is one of the Australian species of terrapins that is most frequently found in Western Collections.

Information on the parasite

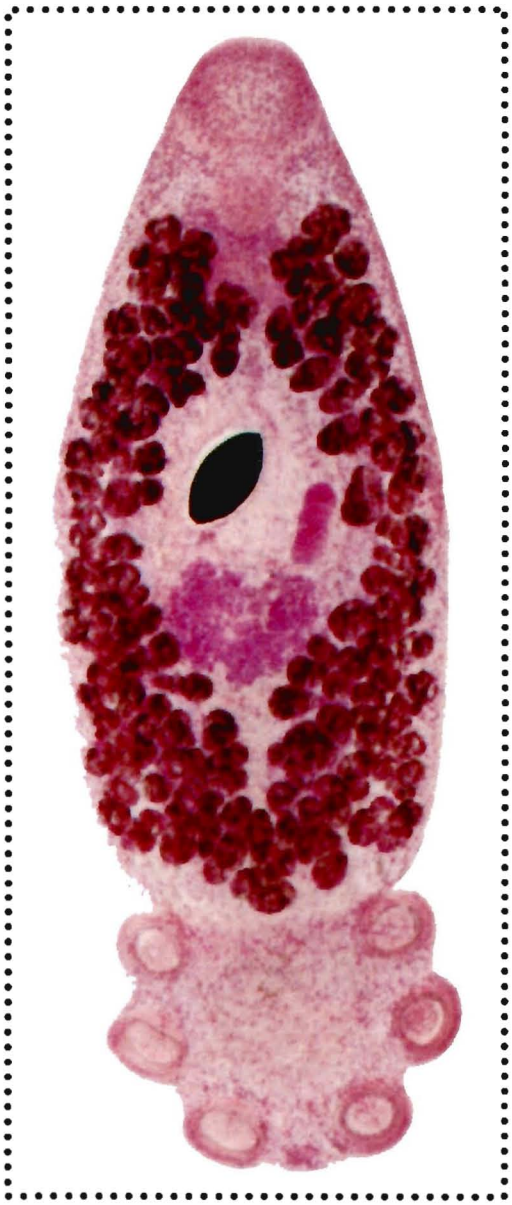
Tissue in EtOH: None.

DNA Sequence: None.

Remarks

~ This species has not yet been identified. Fairfax (1990) only stated that the specimens found have one set of 16 genital spines.

POLYSTOMOIDELLA



Kingdom	:	Animalia	Linnaeus, 1753
Phylum	:	Platyhelminthes	Gegenbaur, 1859
Class	:	Monogenea	Carus, 1863
Subclass	:	Polystomationea	Lebedev, 1986
Order	:	Polystomatidea	Lebedev, 1988
Superfamily	:	Polystomatoidea	Price, 1936
Family	:	Polystomatidae	Carus, 1863
Subfamily	:	Polystomoidinae	Yamaguti, 1968
Genus	:	*Polystomoidella*	Price, 1939

Generic diagnosis: This genus is similar to *Neopolystoma* and *Polystomoides*, but differs in the fact that the haptor of it's representatives only has one pair of hamuli. *Polystomoidella* is parasitic in the urinary bladder of terrapins.

Polystomoidella

Polystomoidella mayesi

Richardson & Brooks, 1987

Table 3.26; Figure 3.28

General

Collection: Invertebrate Collection (Parasites), National Museum of Natural Sciences, Canada.
Holotype no: NMCP 1987-1609.
Paratype no: NMCP 1987-1610 to 1614.

Original description: Richardson and Brooks (1987).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Telok Anson, Malaysia.

Other localities: None.

Type host: *Cuora amboinensis* (Daudin, 1801). East Indian box turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Cuora amboinensis* (Daudin, 1802) has four subspecies: *C. a. amboinensis* (Daudin, 1801); *C. a. couro* (Schweigger, 1812); *C.a. kamaroma* Rummler & Fritz, 1991; *C. a. lineate* McCord & Philippen, 1998.

Geographical distribution: Widely distributed in northeastern India and Bangladesh and in Southeast Asia, surviving today in isolated residual areas, demonstrating a breakdown of the integrity of the overall range. Occurs in Bangladesh, the Nicobar Islands, and Assam, in the Kaziranga National Park. It also occurs in southern Myanmar, Malaysia, Sumatra, Java, the Philippines, and Indonesia, as far east as the Moluccas.

Ecology: This is the most frequently consumed terrapin species in restaurants in China, also captured and released in Buddhist temple ponds, and gathered for exports. This may lead to a population collapse in the future.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.26: Measurements of *P. mayesi*	
CHARACTERISTICS	Richardson & Brooks (1987)
Mature specimens (n)	7
Body Length	2136 (1652 – 2734)
Greatest Width	863 (612 – 1142)
Width at Vagina	
Haptor Length	835 (530 – 1428)
Haptor Width	859 (669 – 1061)
Oral Diameter	293 (171 – 377) x 352 (282 – 439)
Pharynx Length	231 (196 – 296)
Pharynx Diameter	276 (235 – 347)
Testis Length	392 (135 – 612)
Testis Width	250 (122 – 408)
Ovary Length	163 (110 – 216)
Ovary Width	98 (82 – 112)
Egg Length	233 (153 – 285)
Egg Diameter	116 (102 – 138)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	126 (86 – 173) x 71 (47 – 112)
Gen. Bulb Hook set (n)	
Gen. Bulb Hooks 1 (n)	
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	234 (184 – 296)
Hamulus Length 1	74 (58 – 82)
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.3909

Remarks

~ This species differs from other species due to the cirrus lacking a coronet of hooklets, and differs from other polystomes that possess a single pair of hamuli by having a single testis and only one egg, while genera such as *Polystoma* may have numerous eggs present in an elongated coiled uterus (Richardson & Brooks, 1987).

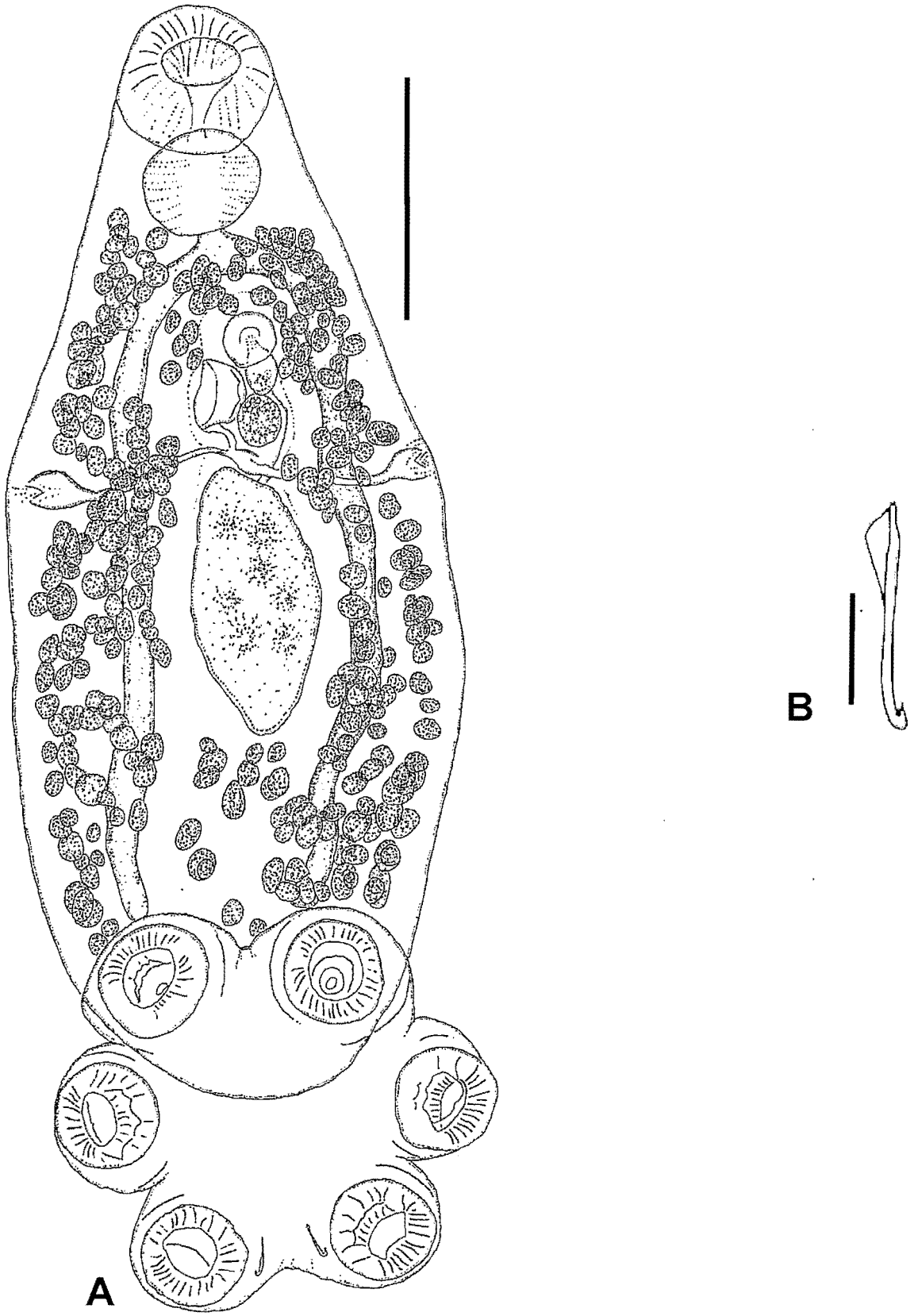


Figure 3.28: (A) *Polystomoidella mayesi* Richardson & Brooks, 1987 (Scale bar = 500µm); (B) Hamulus (Scale bar = 40µm). Copied from Richardson and Brooks (1987).

Polystomoidella oblongum

(Wright, 1879)

Table 3.27; Figure 3.29

General

Collection: U.S.N.M. Helm. Coll. (United States National Museum Helminthological Collection).
Holotype no: None.
Paratype no: 1619, 19428, 39576, 39577.

Original description: Wright (1879).

Other taxonomic contributions: Price, E.W. 1939. Proceedings of the Helminthological Society of Washington 6: 80 – 92.

Synonyms: This species has one synonym: *Polystomoides hassalli* (Goto, 1899).

Type locality: Toronto, Canada.

Other localities: Canada and United States (Maryland, North Carolina, Texas, Iowa and Virginia).

Type host: *Aromochelys odoratus* [*Sternothaerus odoratus*] (Latreille, 1801). Common musk turtle, or stinkpot.
Additional hosts: *Sternotherus carinatus*; *Chrysemys picta*; *Chelydra serpentina*; *Kinosternon subrumbrum subrumbrum*; *Kinosternon integrum*; *Kinosternon hirtipes*.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Aromochelys odoratus* has changed to *Sternothaerus odoratus* (Latreille, 1801).

Geographical distribution: From southern Canada (Ontario and Quebee), to the eastern half of the U.S.A., and from New England to the tip of Florida and in southern Kansas, west Texas, and isolated populations in Chihuahua, Mexico.

Ecology: Although its eggs are eaten by predators and human threats such as boat propeller impacts and pollution and drying exist, this species is not rare.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.27: Measurements of *P. oblongum*			
CHARACTERISTICS	Wright (1879)	Price (1939)	Lamothe-Argumedo (1972)
Mature specimens (n)	4		
Body Length	2500	1300 – 2300	2720 – 3332
Greatest Width	1500		885 – 1181
Width at Vagina		510 – 616	
Haptor Length			676 – 724
Haptor Width		460 – 715	998 – 1014
Oral Diameter		95 – 190 x 210 – 360	161 – 322 x 513 x 531
Pharynx Length		114 – 190	198 – 232
Pharynx Diameter		95 – 190	198 – 225
Testis Length		250	305 – 445
Testis Width		340	515 – 611
Ovary Length			210 – 257
Ovary Width		76	116 – 128
Egg Length	235	235	289 – 354
Egg Diameter	195	195	183 – 241
Egg incubation time			
Intra-Uterine Eggs (n)	1	1	1
Genital Bulb Diameter			
Gen. Bulb Hook set (n)	2	2	2
Gen. Bulb Hooks 1 (n)	16 (all)	16 (all)	16 (all)
Gen. Bulb Hooks 2 (n)			
Gen. Bulb Hook Length 1	20	20	18 – 22
Gen. Bulb Hook Length 2	15	15	11 – 15
Haptoral Sucker Diameter	200	133 – 190	177 – 209 x 177 – 209
Hamulus Length 1	150	121 – 152	131 – 161 x 71 – 75
Hamulus Length 2			
Hamulus Hook Length 1			
Hamulus Hook Length 2			
Marginal Hooklet Length	15		18 x 1
Haptor L/Body L			

Remarks

~ Price (1939) gave more hosts in which this species was found: *Sternotherus carinatus* (Gray, 1856), *Chrysemys picta* (Schneider, 1783), *Chelydra serpentina* (Linnaeus, 1758), and *Kinosternon subrumbrum subrumbrum* (Lacépède, 1788). According to Price (1939), *Chrysemys picta* is open to question because the specimens were found in the mouth.

~ Caballero (1940) found the species in *Kinosternon integrum* LeConte, 1854 in Cacahuamilpa, Mexico.

~ Caballero & Herrera (1947) also found the species in *Kinosternon integrum* from Palo Verde, District of Casasano, Mexico.

~ Herrera (1951) found the species in *Kinosternon leucostomum* Duméril & Bibron, 1851 from Alvarado, Mexico.
~ Oglesby (1961) also found the species in *Sternotherus odoratus* from Florida, U.S.A.
~ Lamothe-Argumedo (1972) found the species in *Kinosternon hirtipes* Wagler, 1833, from Xochimilco, Mexico. He deposited the specimens in the Helminthological Collection of the Institute of Biology of the University of Mexico (226-18; 226-19; 226-20).
~ Lamothe-Argumedo (1972) gave data on the larvae present in the eggs of the parasite. He also stated that this species differs from *P. whartoni* in that it possesses bigger and forked hamuli roots. Although Price (1939) stated that it also has smaller hamuli, it is not a valid difference because of the larger specimens he studied.

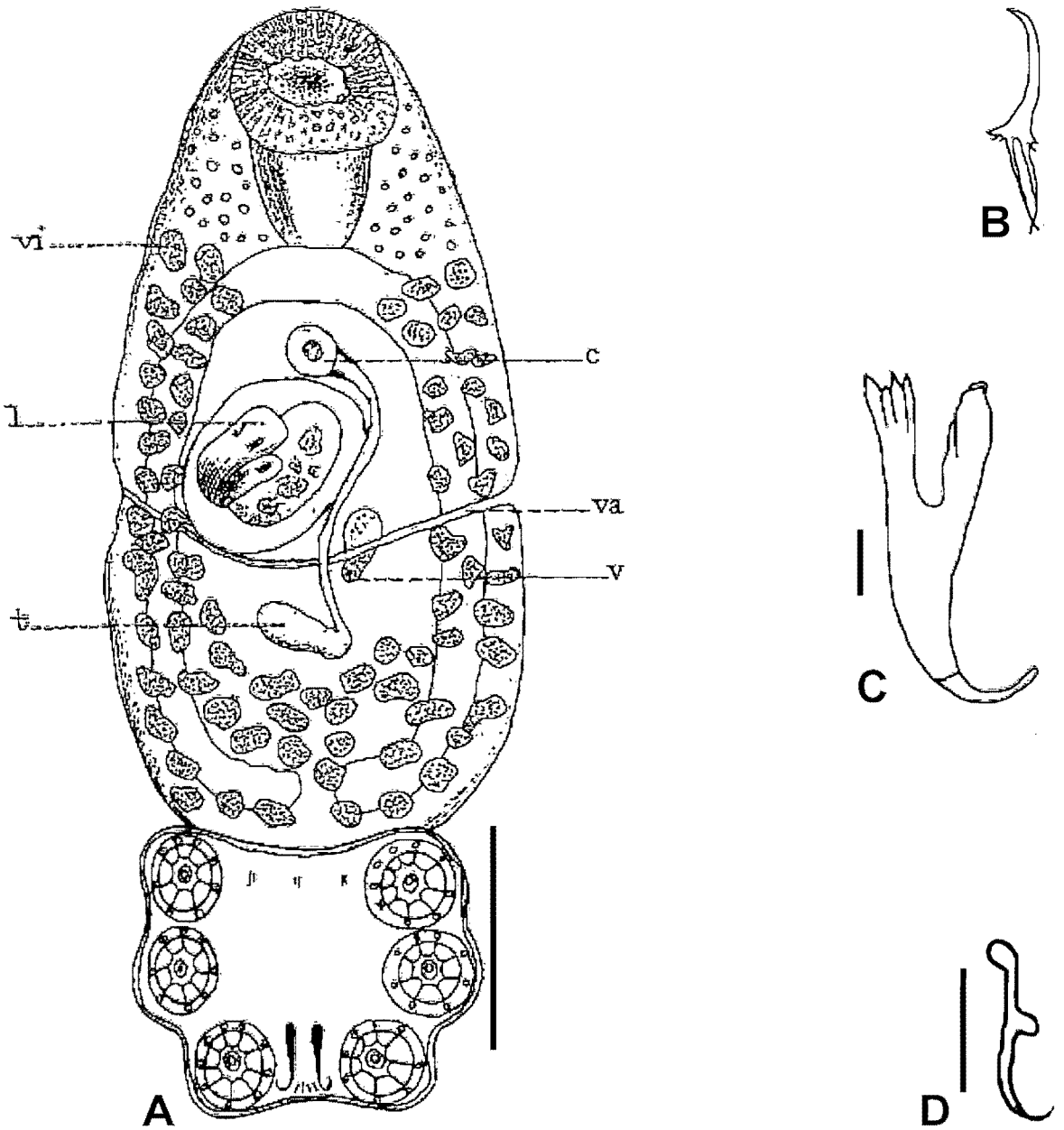
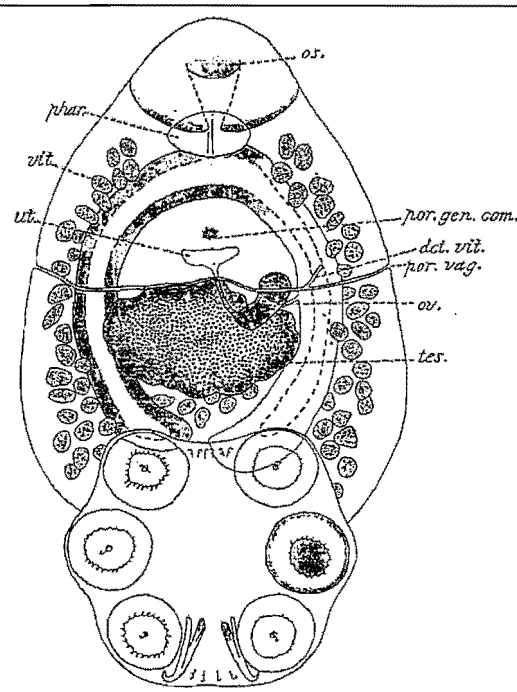


Figure 3.29: (A) *Polystomoidella oblongum* (Wright, 1879). Abbreviations: c – cirrus pouch; l – larva; t – testis; v – ovary; va – vagina; vi – vitellaria (Scale bar = 500µm). According to Wright (1879); (B) Genital spine (Scale unknown). According to Goto (1899); (C) Hamulus (Scale bar = 300µm); (C) Marginal hooklet (Scale bar = 100µm). Copied from Wright (1879).

Junior synonym of *Polystomoidella oblongum*

Tables 3.28 and 3.29; Figure 3.30

General

	Table 3.28: *Polystomoides hassalli* (Goto, 1899)
Collection	None.
Original description	Goto (1899).
Other taxonomic contributions	Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.
Type locality	Bowie Prince George County, Md (Maryland), North America.
Type host	*Kinosternon pennsylvanicum* [*Kinosternon subrumbrum subrumbrum* (Lacépède, 1788). The Eastern mud turtle.
Additional hosts	*Sternotherus carinatus*; *Chelydra serpetina*.
Site on host	Urinary bladder.
	 ***Figure 3.30***: *Polystomoides hassalli*. According to Goto (1899).
	Abbreviations: dct. vit. – yolk duct; os. – oral sucker; ov. – ovary; phar. – pharynx; por. gen. com. – common genital pore; por. vag. – vaginal pore; tes. – testis; ut. – uterus; vit. – vitellarium.

Remarks

~ Goto (1899) stated that there may be 16 genital spines in this species.

~ Harwood (1932) found the species in *Kinosternon subrubrum hippocrepis* Gray, 1856 and *Chelydra serpetina* (Linnaeus, 1758) from Texas, U.S.A.

~ Ozaki (1935) did not give any additional information on this species, but only renamed it from *Polystomum hassalli* to *Polystomoides hassalli*.

~ Price (1939) reported that the synonym was found in *Kinosternon subrubrum subrubrum* (Lacépède, 1788) from Iowa, *K. subrubrum* (Lacépède, 1788) from Virginia, and *Sternotherus carinatus* (Gray, 1856) from Texas and North Carolina, U.S.A.

~ Lamothe-Argumedo (1972) stated that *P. oblongum* and *P. hassalli* differs by their genital spines: *P. oblongum* has alternately large and small spines, while *P. hassalli* has uniformly sized spines. He said

that Oglesby (1961) found *P. hassalli* specimens that have genital spines that are almost all the same size, and because this aspect is the only difference between the two species, *P. hassalli* was seen as a synonym of *P. oblongum*, although he did not agree. However, further investigation into this matter is definitely needed.

~ Dr. O. Verneau (personal correspondence) reported that the species has also been found in Louisiana, U.S.A.

Information on the parasite

Table 3.29*: Measurements of *P. hassalli

CHARACTERISTICS	Goto (1899)
Mature specimens (n)	
Body Length	1500
Greatest Width	
Width at Vagina	
Haptor Length	
Haptor Width	
Oral Diameter	
Pharynx Length	
Pharynx Diameter	
Testis Length	
Testis Width	
Ovary Length	
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	15
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	28
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	
Hamulus Length 1	125
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	330
Haptor L/Body L	

Polystomoidella whartoni

Price, 1939

Table 3.30; Figure 3.31

General

Collection: U.S.N.M. Helm. Coll. (United States Natural Museum Helminthological Collection).
Holotype no: 41152.
Paratype no: 41153, 41154, 41155.

Original description: Price (1939).

Other taxonomic contributions: None.

Synonyms: *Polystomoidella whartoni* has one synonym: *Polystoma* (*Polystomoides*) *oblongum* Caballero, 1938.

Type locality: Canada, United States (Florida and Texas), and Mexico.

Other localities: None.

Type host: [1]*Kinosternon baurii* Garman, 1891, striped mud turtle; [2]*Kinsoternon steindachneri* [*Kinosternon subrumbrum steindachneri*] Siebenrock, 1906, Florida mud turtle; [3]*Kinosternon subrumbrum* (Lacépède, 1788), eastern mud turtle.
Additional hosts: *Kinosternon leucostomum*; *K. integrum*; *K. hirtipes*.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: [1]Some authors recognise two subspecies: *Kinosternon baurii baurii* and *K. b. palmarum*, but it is not valid; [2]*Kinosternon steindachneri* has changed to *K. subrumbrum steindachneri* Siebenrock, 1906. There are two other subspecies: *K. s. subrumbrum* (Lacépède, 1788) and *K. s. hippocrepis* Gray, 1856; [3]*Kinosternon subrumbrum* has three subspecies (see above).

Geographical distribution: [1]This species occurs in the southeast corner of the United States, from King and Queen County in southern Virginia to the Florida Keys, including North and South Carolina and Georgia; [2]This subspecies can only be found in Peninsular Florida, U.S.A; [3]This species can be found in the south-eastern quadrant of the U.S.A., from Connecticut to Florida, including central Texas, the Mississippi Valley, Missouri, southern Illinois, and southern Indiana. Isolated populations may exist in northwestern Indiana and central Missouri.

Ecology: [1]This species appears to be endangered, its habitat altered by humans, with progressive drying of areas in Florida also being a threat. [2]This subspecies occurs only in Florida, U.S.A., and with natural and human activity threats its numbers have fallen. [3]This species is preyed upon by snakes, mammals and raptors, and other threats include habitat destruction and highway mortalities. In the past, up to 260 have been recorded per hectare, but this is not the case today.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.30: Measurements of *P. whartoni*

CHARACTERISTICS	Price (1939)	Lamothe-Argumedo (1972)	AACRG collection specimens
Mature specimens (n)		3	3
Body Length	2700	2189 – 2640	2581.90 (1916.73 – 3008.42)
Greatest Width	1000	660 – 821	993.33 (749.52 – 1181.81)
Width at Vagina			967.85 (728.99 – 1149.30)
Haptor Length		483 – 563	575.55 (472.61 – 661.68)
Haptor Width	680	756 – 933	869.16 (733.71 – 937.98)
Oral Diameter	375	209 – 273 x 289 – 370	358.39 (313.74 – 388.89)
Pharynx Length		128 – 193	221.69 (159.01 – 254.45)
Pharynx Diameter	100	161 – 177	201.43 (175.49 – 235.87)
Testis Length		414 – 322	329.14 (295.07 – 346.75)
Testis Width		289 – 450	408.53 (215.41 – 624.37)
Ovary Length		144 – 193	202.24 (134.36 – 237.73)
Ovary Width		96 – 112	98.76 (81.27 – 118.50)
Egg Length	290	322 – 418	248.12 (282.93 & 213.30)
Egg Diameter	190	225 – 241	158.86 (148.89 & 168.82)
Egg incubation time			
Intra-Uterine Eggs (n)	1	1	1
Genital Bulb Diameter			71.81 (57.58 – 90.02)
Gen. Bulb Hook set (n)		2 (16 in total)	2
Gen. Bulb Hooks 1 (n)		8	8
Gen. Bulb Hooks 2 (n)		8	7 (6 – 8)
Gen. Bulb Hook Length 1		15 – 18	15.39 (11.18 – 19.39)
Gen. Bulb Hook Length 2		11	8.36 (7.08 – 10.70)
Haptoral Sucker Diameter	200	161 – 193 x 161 – 193	161.40 (136.32 – 176.16)
Hamulus Length 1	148 – 185		137.81 (127.65 – 146.53)
Hamulus Length 2			
Hamulus Hook Length 1			28.43 (27.91 – 29.00)
Hamulus Hook Length 2			
Marginal Hooklet Length	20	18 x 7	19.16 (18.33 – 20.06)
Haptor L/Body L			0.2255 (0.2100 – 0.2466)

Remarks

~ *Polystomoidella whartoni* differs from *Polystomoidella oblongum* in the form of their hamuli: *P. whartoni* is big and have nonbifid roots, while *P. oblongum* is smaller and possesses deeply bifid roots (Price, 1939).

~ Caballero & Herrera (1947) found the species in *Kinosternon leucostomum* Duméril & Bibron, 1851 from Palo Verde, Casano, Mexico. Herrera (1951) found the species in *K. integrum* LeConte, 1854, from the same locality.

~ Price (1939), Caballero (1940) and Lamothe-Argumedo (1972) found this species in *Kinosternon hirtipes*. Two of the localities are Río Verde (Caballero, 1940), and Lake Yiriria (Lamothe-Argumedo, 1972), State of Guanajuato, Mexico, the latter deposited in the Helminthological Collection of the Institute of Biology of the University of Mexico (226-16).

~ Lamothe-Argumedo (1972) gave data on the larvae present in the eggs of the species.

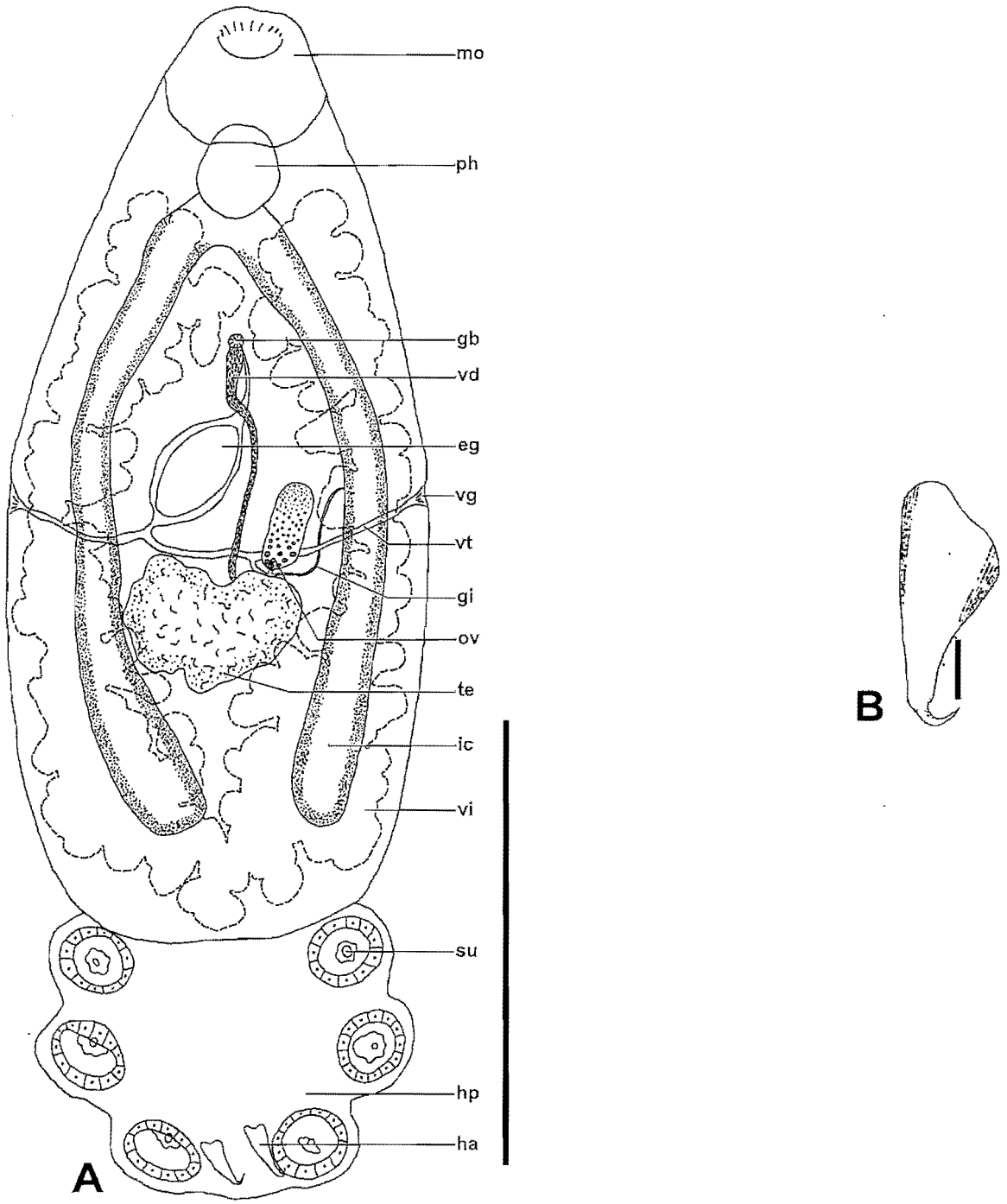


Figure 3.31: (A) *Polystomoides whartoni* Price, 1939. Personally sketched figure. Abbreviations: eg – egg; gb – genital bulb; gi – genito-intestinal canal; ha – hamulus; hp – haptor; ic – intestinal caecum; mo – mouth; ov – ovary; ph – pharynx; su – sucker; te – testis; vd – vas deference; vg – vagina; vi – vitelline distribution; vt – vitelline duct (Scale bar = 1000µm); (B) Hamulus (Scale bar = 50µm). Copied from Price (1939).

Junior synonym of *Polystomoidella whartoni*

Tables 3.31 and 3.32; Figure 3.32

General

	Table 3.31: *Polystoma (Polystomoides) oblongum* Caballero, 1938
Collection	The Helminthological collection of the Institute of Biology (University of Mexico).
Original description	Caballero (1938).
Type locality	Tasquillo, Hidalgo, Mexico.
Type host	*Kinosternon hirtipes* Wagler, 1833. Mexican rough-footed mud turtle.
Additional hosts	None.
Site on host	Urinary bladder.

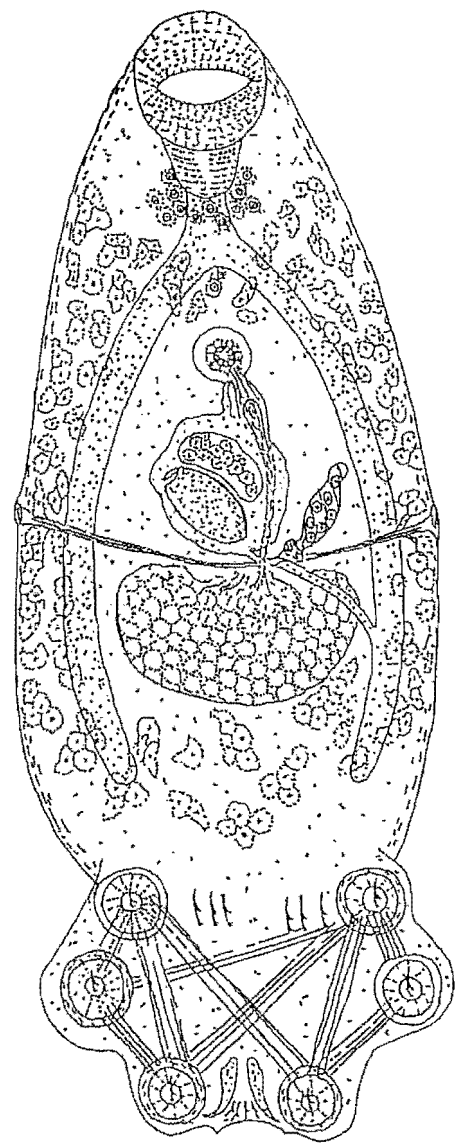


Figure 3.32: *Polystoma (Polystomoides) oblongum*. Copied from Caballero (1938).

Remarks

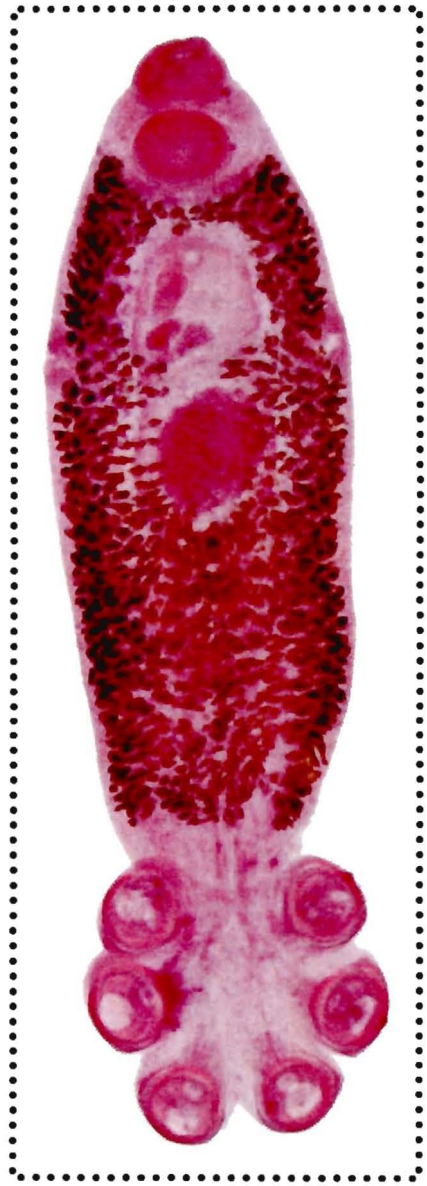
~ None.

Information on the parasite

Table 3.32: **Measurements of *P. (Polystomoides) oblongum***

CHARACTERISTICS	Caballero (1938)
Mature specimens (n)	
Body Length	3650 – 4500
Greatest Width	1400
Width at Vagina	
Haptor Length	700
Haptor Width	1300
Oral Diameter	273 – 429 x 370 – 546
Pharynx Length	234 – 253
Pharynx Diameter	195
Testis Length	643 – 975
Testis Width	390 – 448
Ovary Length	214 – 234
Ovary Width	136
Egg Length	300 – 351
Egg Diameter	195 – 200
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	78 - 98
Gen. Bulb Hook set (n)	
Gen. Bulb Hooks 1 (n)	
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	250 – 273
Hamulus Length 1	196 x 98
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	16 – 20
Haptor L/Body L	

POLYSTOMOIDES



Kingdom	:	Animalia	Linnaeus, 1753
Phylum	:	Platyhelminthes	Gegenbaur, 1859
Class	:	Monogenea	Carus, 1863
Subclass	:	Polystomationea	Lebedev, 1986
Order	:	Polystomatidea	Lebedev, 1988
Superfamily	:	Polystomatoidea	Price, 1936
Family	:	Polystomatidae	Carus, 1863
Subfamily	:	Polystomoidinae	Yamaguti, 1968
Genus	:	*Polystomoides*	Ward, 1917

Generic diagnosis: This genus is similar to *Neopolystoma* and *Polystomoidella*, but differs in the fact that its species possess two pairs of hamuli, the outer pair larger than the inner. Representatives of *Polystomoides* are parasitic in the urinary bladder, the cavity of the eye and nose, pharynx, cloaca, and mouth of terrapins.

Polystomoides

Polystomoides asiaticus

Rohde, 1965

Table 3.33; Figure 3.33

General

Collection: Helminthological Collection, Zoology Department, University of Malaya.
Holotype no: None.
Paratype no: R223 – 227 and R310.

Original description: Rohde (1965).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Malaysia (Chinese shop in Kuala Lumpur).

Other localities: None.

Type host: *Cyclemys amboinensis* [*Cuora amboinensis* (Daudin, 1801)]. East Indian box turtle.
Additional hosts: None.

Site on type host: Pharyngeal cavity.

Information on the host

Taxonomy: *Cyclemys amboinensis* has changed to *Cuora amboinensis* (Daudin, 1802) and has four subspecies: *C. a. amboinensis* (Daudin, 1801); *C. a. couro* (Schweigger, 1812); *C. a. kamaroma* Rummler & Fritz, 1991; *C. a. lineate* McCord & Philippen, 1998.

Geographical distribution: This terrapin is widely distributed in northeastern India and Bangladesh and in Southeast Asia, surviving today in isolated residual areas, demonstrating a breakdown of the integrity of the overall range. Occurs in Bangladesh, the Nicobar Islands, and Assam, in the Kaziranga National Park. It also occurs in southern Myanmar, Malaysia, Sumatra, Java, and the Philippines and in Indonesia, as far east as the Moluccas.

Ecology: This is the most frequently consumed terrapin species in restaurants in China, also captured and released in Buddhist temple ponds, and gathered for exports. This may lead to a population collapse in the future.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.33: Measurements of *P. asiaticus*	
CHARACTERISTICS	**Rhode (1965)**
Mature specimens (n)	10
Body Length	4600 (3700 – 5600)
Greatest Width	1400 (110 – 1700)
Width at Vagina	
Haptor Length	1100 (1000 – 1000)
Haptor Width	1700 (1100 – 2500)
Oral Diameter	380 (300 – 530) x 630 (550 – 620)
Pharynx Length	450 (400 – 510)
Pharynx Diameter	570 (470 – 610)
Testis Length	450 (240 – 710)
Testis Width	360 (240 – 520)
Ovary Length	140 (90 – 150)
Ovary Width	280 (150 – 390)
Egg Length	240 x 180; 270 x 230; 290 x 210
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	180 (150 – 210) x 190 (150 – 220)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	37 (34 – 40)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	Short: 36 (30 – 45); Long: 50 (39 – 60)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	340 (290 – 410)
Hamulus Length 1	140 (110 – 160)
Hamulus Length 2	60 (40 – 70)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.2391

Remarks

~ Rohde (1965) deposited further specimens in: Helminthologische Sammlung der Humboldt – Universität, Berlin; Helminthological Collection of the British Museum (Natural History); U.S. National Helminthological Collection.

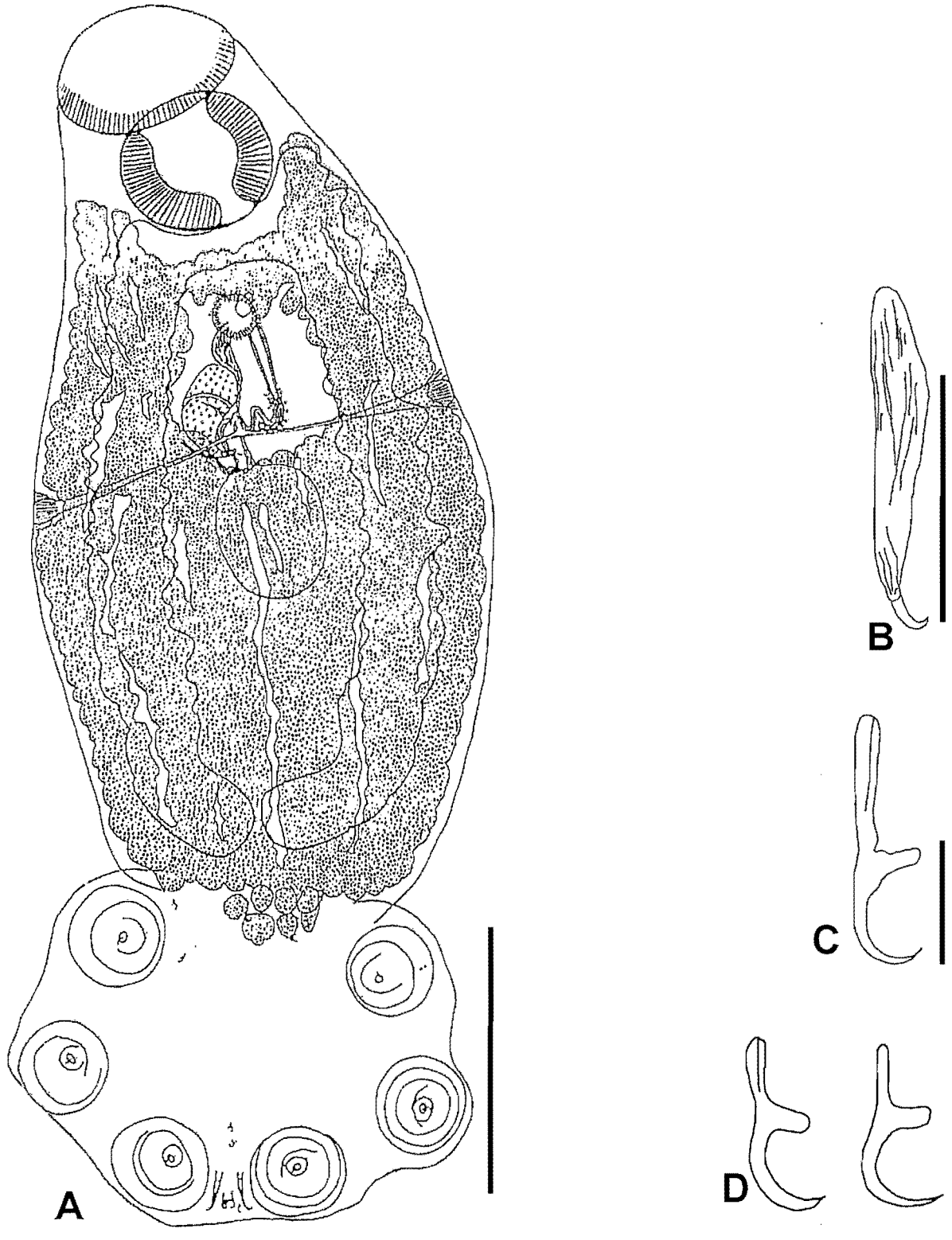


Figure 3.33: (A) *Polystomoides asiaticus* Rohde, 1965 (Scale bar = 1000µm); (B) Large hamulus (Scale bar = 100µm); (C) Small hamulus (Scale bar = 30µm); (D) Marginal hooklets (Scale unknown). Copied from Rohde (1965).

Polystomoides australiensis

Rohde & Pearson, 1980

Table 3.34; Figure 3.34

General

Collection: Australian Museum, Sydney[①]; Australian Museum, Sydney[②]; U.S. Natural Museum Helminthological Collection[③].
Holotype no: W 15050[①].
Paratype no: W 15051[②]; 14856[③].

Original description: Rohde and Pearson (1980).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Mt. Crosby weir and Brisbane River (3.1969), Queensland, Australia.

Other localities: Ugly Gully, Pullenvale, a branch of the Brisbane River (26.2.1968), Queensland, and male Fitzroy River, 149°55'E 23°11'S, 25km east and 63km north of Qualinga, Queensland, Australia.

Type host: *Emydura krefftii* [*Emydura macquarii krefftii* (Gray, 1871)]. Krefft's river turtle.
Additional hosts: *Emydrua macquarii signata*; *Elseya latisternum*.

Site on type host: Bladder and cloacal bursa.

Information on the host

Taxonomy: *Emydura krefftii* is now considered a subspecies of *E. macquarii* (Gray, 1831). There are eight other subspecies: *E. m. macquarii* (Gray, 1831), *E. m. binjing* Cann, 1998, *E. m. dharra* Cann, 1998, *E. m. dharuk* Cann, 1998, *E. m. emmotti* Cann, McCord & Joseph-Ouni, 2003, *E. m. gunabarra* Cann, 1998, *E. m. nigra* McCord, Cann & Joseph-Ouni, 2003, and *E. m. signata* Ahl, 1932.

Geographical distribution: This terrapin is found on a narrow stretch of northeastern coastal Australia in Queensland, extending south to Fraser Island and the coastal river drainages.

Ecology: These terrapins have legal protection and they also constitute the most abundant terrapin species on Fraser Island.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.34: Measurements of *P. australiensis*	
CHARACTERISTICS	**Rohde & Pearson (1980)**
Mature specimens (n)	4
Body Length	6193 (4680 – 9290)
Greatest Width	2190 (1370 – 3030)
Width at Vagina	
Haptor Length	1353 (1110 – 1900)
Haptor Width	1920 (1260 – 2970)
Oral Diameter	650 x 795 (630 x 600 – 880 x 1300)
Pharynx Length	410 (360 – 590)
Pharynx Diameter	398 (360 – 450)
Testis Length	420 (300 – 560)
Testis Width	653 (430 – 830)
Ovary Length	
Ovary Width	
Egg Length	ca. 298
Egg Diameter	ca. 195
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	ca. 598 x 558 (ca. 360 – 980 x 360 – 850)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	78 (74 – 95)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	ca. 93 (78 – ca. 105)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	380 (310 – 620)
Hamulus Length 1	593 (ca. 490 – 770); 605 (500 – 800)
Hamulus Length 2	227 (220 – 270); 185 (210 – 160)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.2185

Remarks

- Rohde and Pearson (1980) also reported the species from the Fitzroy River, 149°55'E 23°11'S (Australia).
- Rohde (1984) gave new localities for *P. australiensis*: Frogmore lagoon, 23°26½'S, 150°32'E; Fitzroy River Barrage 23°22'S, 150°30'E; and Raglan Creek, 23°45'S, 150°52'E, all in the Fitzroy drainage, Queensland, Australia from *Emydura krefftii*.
- Pichelin (1995) reported finding the species in *Emydura macquarii* (Gray, 1831), *Emydrua macquarii signata* Ahl, 1932, and *Elseya latisternum* Gray, 1867.

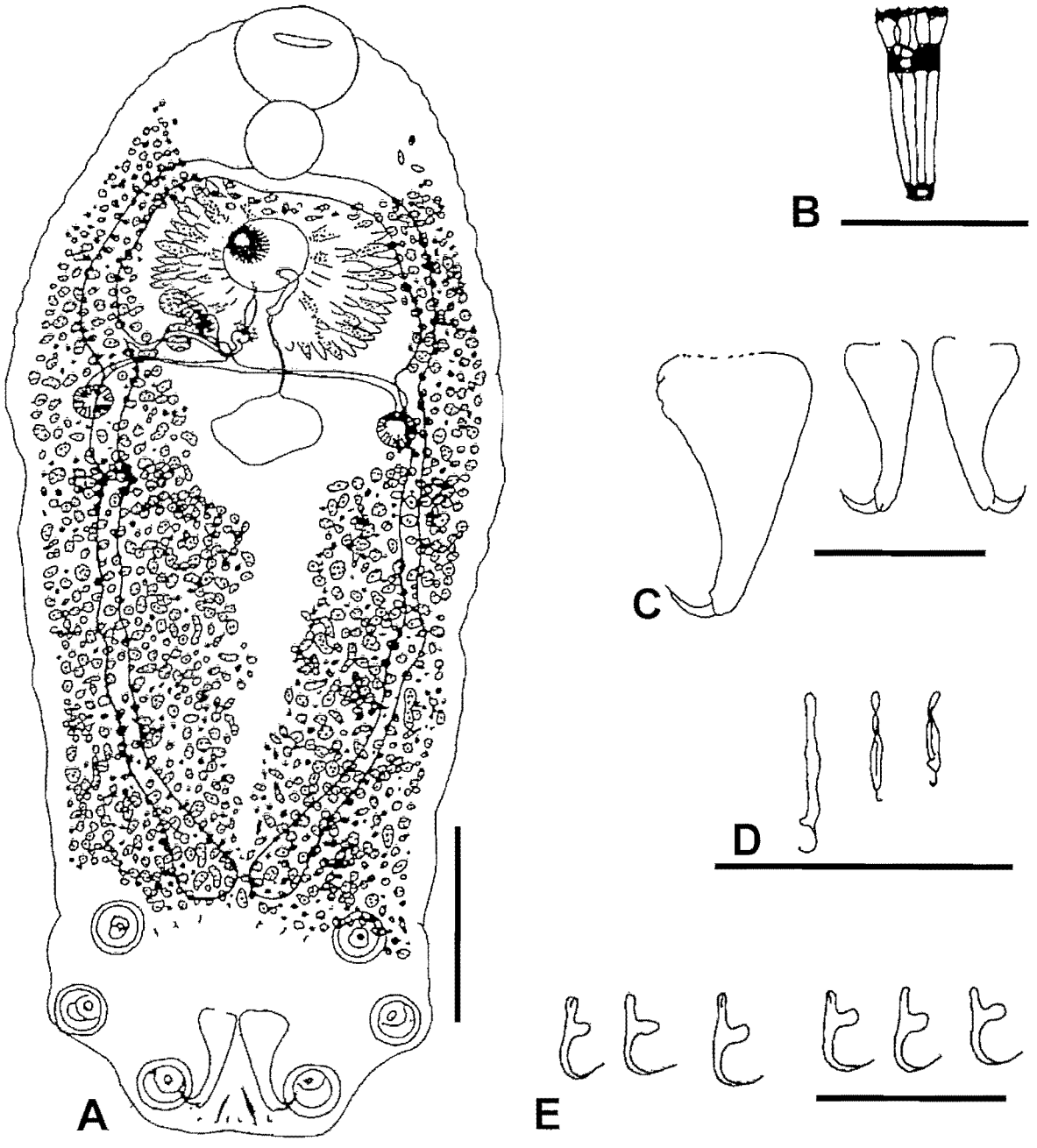


Figure 3.34: (A) *Polystomoides australiensis* Rohde & Pearson, 1980 (Scale bar = 1000µm); (B) Genital spines (Scale bar = 100µm); (C) Large hamuli (Scale bar = 500µm); (D) Small hamuli (Scale bar = 500µm); (E) Marginal hooklets (Scale bar = 50µm). Copied from Rohde and Pearson (1980).

Polystomoides bourgati

Combes & Kulo, 1978

Table 3.35; Figure 3.35

General

Collection: Royal Museum of Central Africa (Tervuren – Belgium).
Holotype no: M.R.A.C. 36.521.
Paratype no: M.R.A.C. 36.522.

Original description: Combes and Kulo (1978).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Vicinity of Lomé (Togo), Africa.

Other localities: None.

Type host: *Pelusios castaneus derbianus* [*Pelusios castaneus* (Schweigger, 1812)]. West African mud turtle.
Additional hosts: *Pelusios adansonii.*

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Pelusios castaneus derbianus* is known only as *P. castaneus* (Schweigger, 1812).

Geographical distribution: This species is found in a wide coastal band in West Africa, from Senegal to northwestern Angola and the Central African Republic in West Africa, as well as the Island of São Tomé. The species has also been introduced on Guadeloupe and the Lesser Antilles.

Ecology: This species is heavily harvested for food, and also suffers from the drying of its habitats, and is also offered as stuffed specimens to tourists.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.35: Measurements of *P. bourgati*	
CHARACTERISTICS	Combes & Kulo (1978)
Mature specimens (n)	6
Body Length	2733 (2340 – 2900)
Greatest Width	893 (800 – 960)
Width at Vagina	
Haptor Length	618 (540 – 680)
Haptor Width	835 (720 – 920)
Oral Diameter	278 (240 – 325) x 367 (337 – 394)
Pharynx Length	168 (137 – 190)
Pharynx Diameter	154 (131 – 177)
Testis Length	216 (154 – 290)
Testis Width	210 (148 – 263)
Ovary Length	104 (74 – 131)
Ovary Width	69 (50 – 86)
Egg Length	270 (240 – 300)
Egg Diameter	196 (183 – 212)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	110 (103 – 120)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	26 – 29
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	24
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	163 (154 – 171)
Hamulus Length 1	279 (257 – 314)
Hamulus Length 2	85 (80 – 90)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	

Remarks

~ This species differs from other species in the unique distribution of its vitellaria, and other differences include the large hamuli that are well developed, a smaller pharynx, the intestine that does not merge posteriorly, and the large egg (Combes & Kulo, 1978).

~ Combes and Justine (1982) found the species in *Pelusios adansonii* (Schweigger, 1812) from Senegal, Africa.

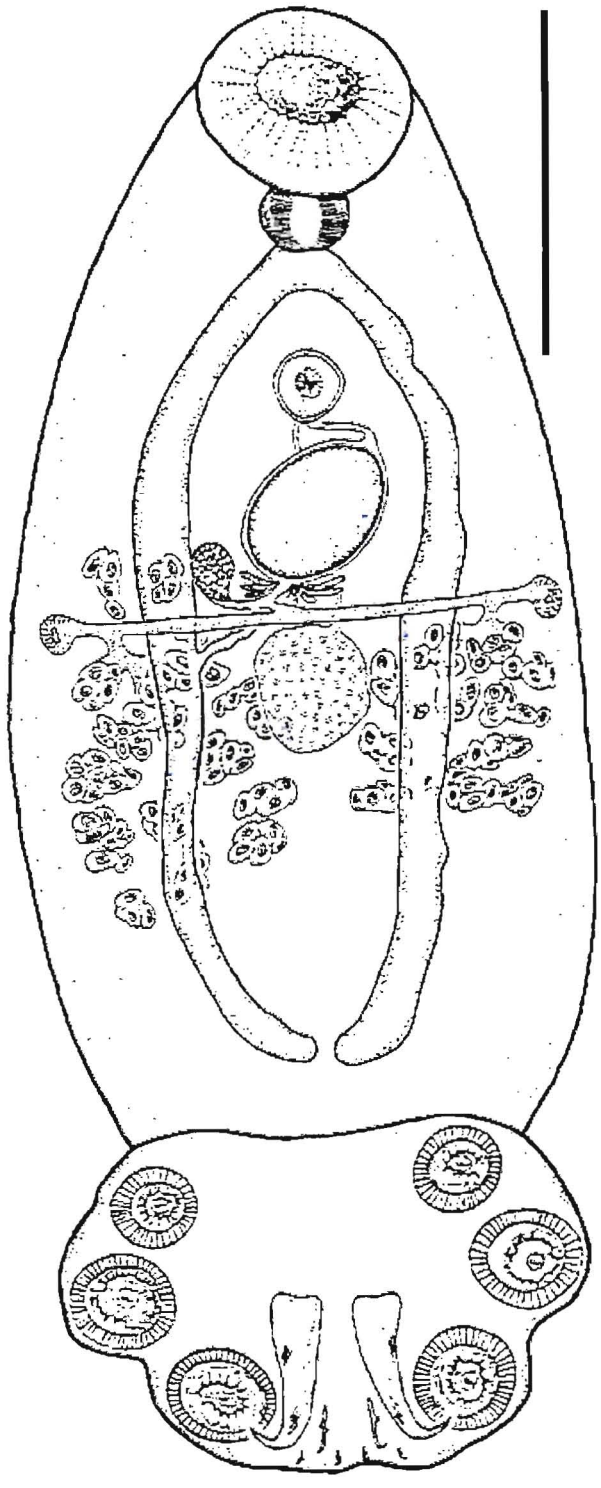


Figure 3.35: *Polystomoides bourgati* Combes & Kulo, 1978 (Scale bar = 500µm). Copied from Comes and Kulo (1978).

Polystomoides brasiliensis

Vieira, Novelli, Sousa & de SouzaLima, 2008

Table 3.36; Figure 3.36

General

Collection: Helminthological Collection of the Instituto Oswaldo Cruz, Rio de Janeiro, Brazil.
Holotype no: 36902.
Paratype no: 36903a – d.

Original description: Vieira *et al.* (2008).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Juiz de For a, Minas Gerais, Brazil, 21°41'20"S, 43°20'40"W.

Other localities: None.

Type host: *Hydromedusa maximiliani* (Mikan, 1825). Brazilian snake-necked turtle.
Additional hosts: *Phrynops geoffroanus*.

Site on type host: Buccal and pharyngeal cavities.

Information on the host

Taxonomy: The description date for this species is generally given as 1820, but this is incorrect. According to Fritz & Havaš (2007), the correct year is 1825.

Geographical distribution: This terrapin has a restricted range in the eastern coast of Brazil, in the states of Espírito Santo, Minas Gerais, Rio de Janeiro, and São Paulo, as well as the island of São Sebastião, in southeastern Brazil.

Ecology: The range of this species, in densely inhabited Atlantic forest area, is threatened by human caused habitat degradation. The species is threatened and vulnerable at national and international levels.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.36: Measurements of *P. brasiliensis*	
CHARACTERISTICS	Vieira *et al.* (2008)
Mature specimens (n)	8
Body Length	3600 ± 1479 (2450 – 6062)
Greatest Width	
Width at Vagina	1100 ± 592 (545 – 1875)
Haptor Length	1325 ± 503 (998 – 2200)
Haptor Width	1503 ± 484 (1100 – 2325)
Oral Diameter	312 ± 102 (245 – 490) x 364 ± 89 (290 – 520)
Pharynx Length	249 ± 96 (175 – 415)
Pharynx Diameter	290 ± 99 (205 – 460)
Testis Length	633 ± 308 (370 – 1125)
Testis Width	538 ± 298 (330 – 1050)
Ovary Length	161.5 ± 63 (95 – 250)
Ovary Width	
Egg Length	220 ± 35 (195 – 245)
Egg Diameter	185 ± 14 (175 – 195)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	8 – 9
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	12.8 ± 1.6 (11.3 – 17.5)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	455 ± 179 (300 – 813)
Hamulus Length 1	72.1 ± 5.5 (62.5 – 80)
Hamulus Length 2	65.1 ± 4.9 (55 – 71.3)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	31.9 ± (25 – 36.3)
Haptor L/Body L	0.4073

Remarks

~ This species differs from all other *Polystomoides* species by possessing eight to nine genital spines. It also differs from *P. uruguayensis*, which also possesses eight to nine genital spines, by having bigger hamuli and having a testis that is bigger than its oral sucker and pharynx (Vieira *et al.*, 2008).

~ According to Vieira *et al.* (2008), another host of this species is *Phrynops geoffroanus* (Schweigger, 1812).

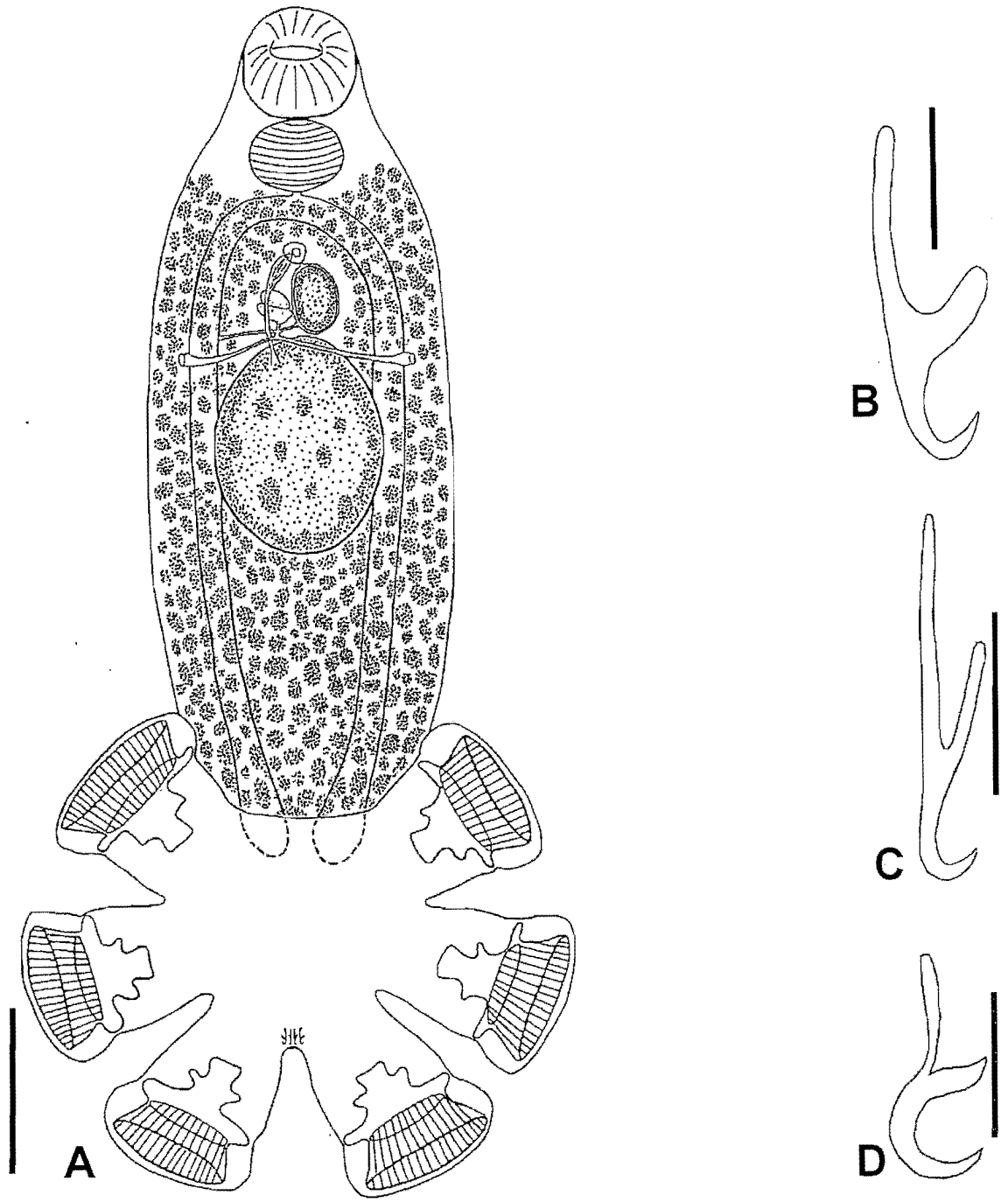


Figure 3.36: (A) *Polystomoides brasiliensis* Vieira, Novelli, Sousa & de SouzaLima, 2008 (Scale bar = 500µm); (B) Large hamulus (Scale bar = 30µm); (C) Small hamulus (Scale bar = 30µm); (D) Marginal hooklet (Scale bar = 20µm). Copied from Vieira *et al.* (2008).

Polystomoides chabaudi

Euzet & Combes, 1965

Table 3.37; Figure 3.37

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Euzet and Combes (1965).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Betioky, Madagascar.

Other localities: None.

Type host: *Pelomedusa subrufa* (Lacépède, 1788). Common African helmeted turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: Although three subspecies were distinguished [*P. s. subrufa* (Lacépède, 1788), *P. s. nigra* (Gray, 1863), and *P. s. olivacea* (Schweigger, 1812)], Fritz & Havaš (2007) refers to Gasperetti *et al.* (1993) (who states that *P. subrufa* should be treated as a monotypical species because morphological variation does not conform with the suggested subspecies delineation), and states that a rangewide morphological and phylogeographic investigation is in urgent need.

Geographical distribution: This species occupies the entire African continent south of the Sahara (southern Arab Peninsula, subtropical and tropical Africa from Ethiopia, southern Saudi-Arabia, and the Sudan westward to Ghana, Senegal, Mali, Nigeria, and Cameroon, and southward to the Cape Provinces of South Africa), and also occurs in western and southern Madagascar and Yemen, presumably introduced there by humans.

Ecology: The species is widely captured for food as well as sold to motorists, but its modest size does not make them a cherished food item, thus collection does not lead to drastic declines, and the populations seem to be in good shape.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.37: Measurements of *P. chabaudi*	
CHARACTERISTICS	Euzet & Combes (1965)
Mature specimens (n)	9
Body Length	2910(2280 – 3290)
Greatest Width	850(760 – 1070)
Width at Vagina	
Haptor Length	620 (570 – 720)
Haptor Width	880 (800 – 1070)
Oral Diameter	
Pharynx Length	
Pharynx Diameter	
Testis Length	
Testis Width	
Ovary Length	
Ovary Width	
Egg Length	270 (260 – 280)
Egg Diameter	180 (170 – 200)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	120 (105 – 162)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	31 – 36
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	27 (22 – 31)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	150 (108 – 183)
Hamulus Length 1	268 (251 – 314)
Hamulus Length 2	91 (80 – 103)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	24 (22 – 25)
Haptor L/Body L	0.2131

Remarks

~ This species differs from *P. kachugae*, *P. microrchis*, *P. multifax*, and *P. ocadiae* in having less genital spines, and from *P. megaovum* in having more genital spines (Euzet & Combes, 1965).

~ The species also differs from *P. coronatum*, *P. japonicum*, *P. ocellatum*, *P. uruguayensis* and *P. fuquesi* in the fact that its large hamuli's cut is not inferior to the diameter of the suckers (Euzet & Combes, 1965).

~ Finally, the species differs from *P. oris* in the fact that it does not have diverticulated intestinal branches (Euzet & Combes, 1965).

~ Tinsley (1973) also found the species in *Pelomedusa subrufa* from Kampala, Uganda, Africa.

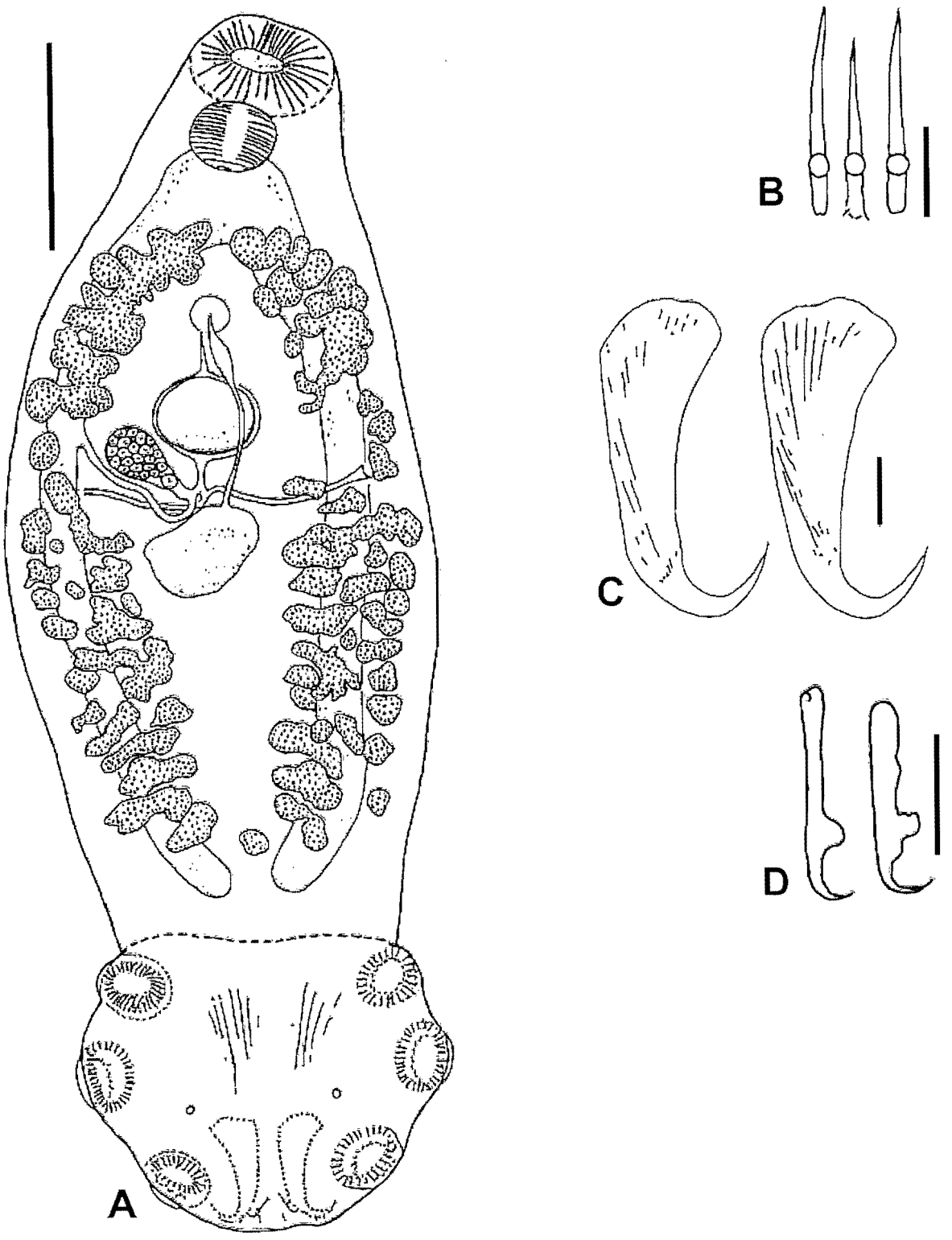


***Figure* 3.37:** (A) *Polystomoides chabaudi* Euzet & Combes, 1965 (Scale bar = 500µm); (B) Genital spines (Scale bar = 50µm); (C) Large hamuli (Scale bar = 50µm); (D) Small hamuli (Scale bar = 50µm). Copied from Euzet & Combes (1965).

Polystomoides chauhani

Pandey & Agarwal, 1980

Table 3.38; Figure 3.38

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Pandey & Agarwal (1980).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Ghaghra river, district Faizabad, India.

Other localities: None.

Type host: *Hardella thurgi* [*Hardella thurjii thurjii* (Gray, 1831)]. Ganges crowned river turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Hardella thurgi* has changed to *Hardella thurjii thurjii* (Gray, 1831). There is one other subspecies: *H. t. indi* Gray, 1870.

Geographical distribution: The subspecies can be found in northern India and Bangladesh, in the effluents and tributaries of the Ganges and Brahmaputra River systems.

Ecology: The species is found in markets in eastern India and in Bangladesh, having a long history of human consumption, and is sometimes collected for export to China, thus populations are becoming increasingly decimated.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.38: Measurements of *P. chauhani*	
CHARACTERISTICS	Pandey & Agarwal (1980)
Mature specimens (n)	2
Body Length	3640 – 3840
Greatest Width	1120 – 1450
Width at Vagina	
Haptor Length	
Haptor Width	
Oral Diameter	
Pharynx Length	210 – 240
Pharynx Diameter	280 – 330
Testis Length	920 – 960
Testis Width	480 – 500
Ovary Length	80 – 96
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	0
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	40
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	48
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	170 – 240
Hamulus Length 1	330 – 400 (Base: 96 – 190)
Hamulus Length 2	140 – 160
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	

Remarks

~ This species resembles *Polystomoides kachugae*, *P. oris*, *P. malayai*, *P. stewarti*, *P. ludhianae*, *P. sinhai*, and *P. godavarii*. It differs from these species in the shape of the hooks and topography of the organs, as well as the number of hooklets.

~ The latter difference mentioned by the authors, the number of hooklets, is not seen as a valid difference as all species possess 16 marginal hooklets.

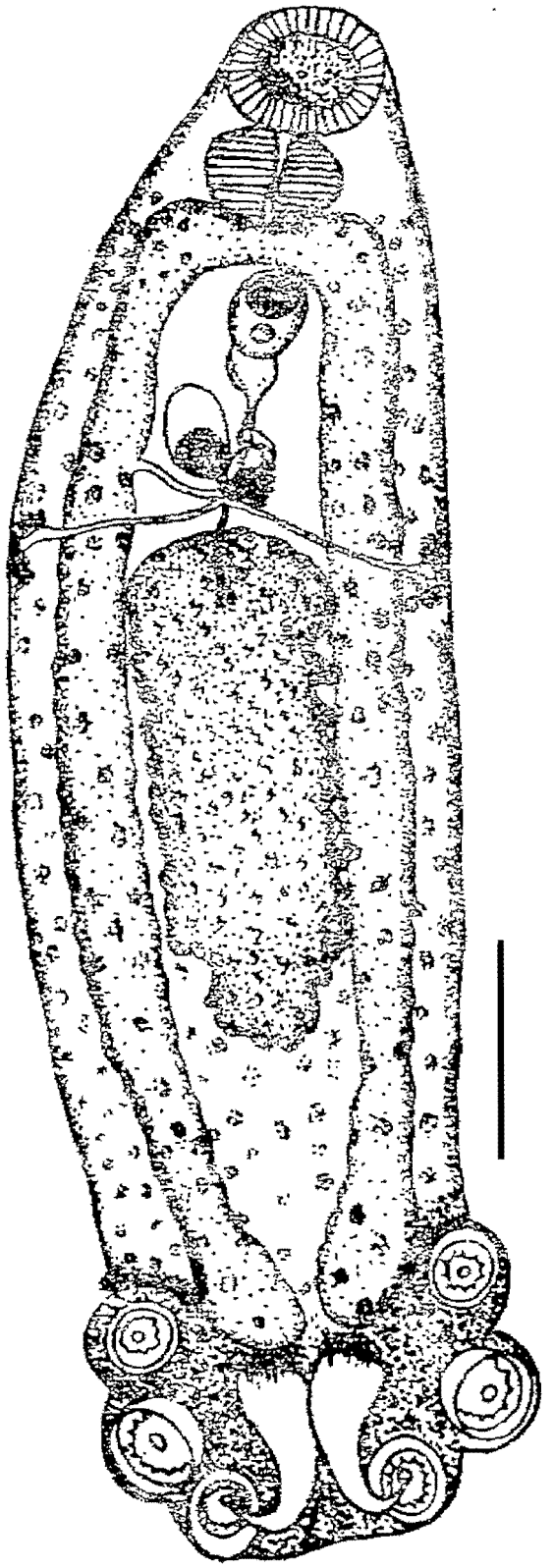


Figure 3.38: *Polystomoides chauhani* Pandey & Agarwal, 1973 (Scale bar = 500µm). Copied from Pandey & Agarwal (1980).

Polystomoides coronatum

(Leidy, 1888)

Table 3.39; Figure 3.39

General

Collection: United States National Museum (Stunkard, 1917).
Holotype no: None.
Paratype no: None.

Original description: Leidy (1888).

Other taxonomic contributions: Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.

Synonyms: *P. coronatum* has five synonyms: *P. megacotyle* (Stunkard, 1916), *P. opacum* (Stunkard, 1916), *P. microcotyle* (Stunkard, 1916), *Polystoma albicollis* MacCallum, 1918, and *Polystoma digitatum* MacCallum, 1918.

Type locality: North and South America (Mañé-Garzón & Gil, 1962).

Other localities: None.

Type host: Leidy (1888) only states that the host is a food terrapin. Stunkard (1917) gives three possibilities: *Emys palustris* [*Trachemys terrapin* (Lacépède, 1788)] Jamaican slider[①], *Emys rugosa* [*Trachemys decussata decussata* (Gray, 1831)] North Antillean slider[②], and *Cistudo Carolina* [*Terrapene carolina carolina* (Linnaeus, 1758)] Carolina box turtle[③].
Additional hosts: *Chrysemys picta*; *Chelydra serpentine*; *Trachemys scripta scripta*; *Apalone ferox*; *Apalone spinifera*; *Trachemys scripta elegans*; *Graptemys pseudogeographica pseudogeographica*; *Trachemys dorbigni*; *Actinemys marmorata.*

Site on type host: Mouth and throat (fauces).

Information on the host

Taxonomy: [①]*Emys palustris* is now known as *Trachemys terrapin* (Lacépède, 1788); [②]*Emys rugosa* has changed to *Trachemys decussata decussata* (Gray, 1831). There is one other subspecies: *T. d. angusta* (Barbour & Carr, 1940); [③]*Cistudo carolina* is now known as *Terrapene carolina carolina* (Linnaeus, 1758). There are five other subspecies: *T. c. bauri* Taylor, 1895, *T. c. major* (Agassiz, 1857), *t. c. mexicana* (Gray, 1849), *t. c. triunguis* (Agassiz, 1857), and *T. c. yucatana* (Boulenger, 1895).

Geographical distribution: [①]Jamaica, introduced to islands in the Bahamas, including Cat Island, southern Eleuthera, and southern Andros; [②]Extreme eastern Cuba; [③]Eastern and southeastern U.S.A. (from southern Maine south to Georgia and west to Michigan, Illinois, and Tennessee).

Ecology: [①]None available; [②]None available; [③]Export is controlled, but in some areas the species is in decline, suffering mainly from human activities, drying of wetlands, urban development, agricultural proliferation, and overgrazing.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.39: Measurements of *P. coronatum*		
CHARACTERISTICS	Leidy (1888)	Stunkard (1917)
Mature specimens (n)		1
Body Length	4000 – 6000	3150
Greatest Width		
Width at Vagina		830
Haptor Length		
Haptor Width		1240
Oral Diameter		160 x 400
Pharynx Length		
Pharynx Diameter		300 (circular)
Testis Length		
Testis Width		300 (circular)
Ovary Length		
Ovary Width		94 (circular)
Egg Length		
Egg Diameter		
Egg incubation time		
Intra-Uterine Eggs (n)		1
Genital Bulb Diameter		190
Gen. Bulb Hook set (n)	1	1
Gen. Bulb Hooks 1 (n)	32	32
Gen. Bulb Hooks 2 (n)		
Gen. Bulb Hook Length 1		
Gen. Bulb Hook Length 2		
Haptoral Sucker Diameter		370
Hamulus Length 1		132
Hamulus Length 2		51
Hamulus Hook Length 1		
Hamulus Hook Length 2		
Marginal Hooklet Length		20
Haptor L/Body L		

Remarks

~ Ozaki (1935) only renamed *Polystomum coronatum* to *Polystomoides coronatum*, but gave no other information on the species.

~ Mañé-Garzón and Gil (1962) also found the species in the nose and mouth of *Apalone ferox* (Schneider, 1783), *Apalone spinifera* (LeSueur, 1827), *Trachemys scripta elegans* (Wied, 1839), *Trachemys scripta scripta* (Schoepff, 1792), *Chelydra serpentina* (Linnaeus, 1758), *Graptemys*

pseudogeographica pseudogeographica (Gray, 1831) from North America, and *Trachemys dorbigni* (Duméril & Bibron, 1835) from South America.

~ Baruš and Moravec (1967) found the species in *Actinemys marmorata* (Baird & Girard, 1852) from Oregon, North America.

~ Esch and Gibbons (1967) found *P. coronatum* in *Chrysemys picta* (Schneider, 1783).

~ Martin (1972) found *P. coronatum* in *Chelydra serpentina* (Linnaeus, 1758), and *Trachemys scripta scripta* (Schoepff, 1792).

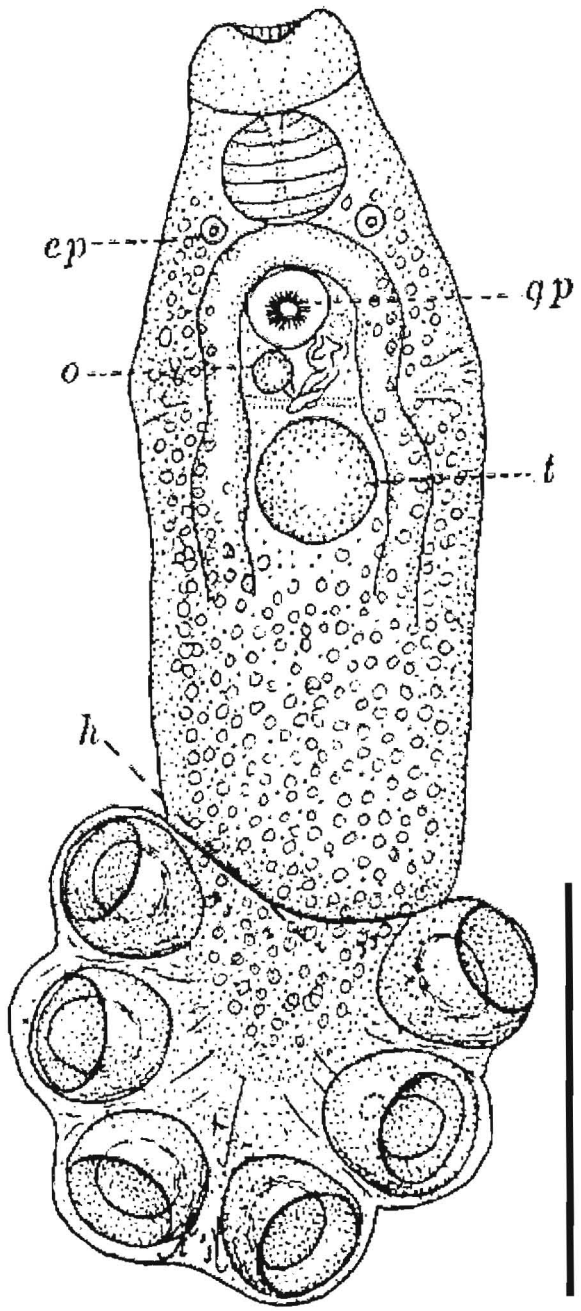


Figure 3.39: *Polystomoides coronatum* (Leidy, 1888). Abbreviations: ep – excretory pore; gp – genital pore; h – small hooklets; o – ovary; t – testis (Scale bar = 1000µm). Copied from Stunkard (1917).

Junior synonyms of *Polystomoides coronatum*

Tables 3.40 and 3.41

General

Table 3.40: Polystomoides megacotyle, P. opacum and *P. microcotyle*

	P. megacotyle (Stunkard, 1916)	*P. opacum* (Stunkard, 1916)	*P. microcotyle* (Stunkard, 1916)
Collection	Helminthological Collection of the University of Illinois.	Helminthological Collection of the University of Illinois.	Helminthological Collection of the University of Illinois.
Original description	Stunkard (1916).	Stunkard (1916).	Stunkard (1916).
Other taxonomic contributions	Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.	Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.	Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.
Type locality	Creston, Iowa, North America.	Newton, Texas, North America.	Creston, Iowa, North America.
Type host	*Chrysemys marginata* [*Chrysemys picta marginata* Agassiz, 1857]. Central painted turtle.	①*Trionyx ferox* [*Apalone ferox* (Schneider, 1783)]. Florida softshell turtle; ②*Malacoclemmys leseurii* [*Graptemys pseudogeographica pseudogeographica* (Gray, 1831)]. False map turtle.	*Chrysemys marginata* [*Chrysemys picta marginata* Agassiz, 1857]. Central painted turtle.
Additional hosts	*Trachemys scripta elegans.*	None.	None.
Site on host	Oral cavity.	Oesophagus.	Oral cavity.

Remarks

- ***P. megacotyle***: Harwood (1931) gave new information on the species: From *Trachemys scripta elegans* (Wied, 1839) from Lake Taliwanda, McAlester, Oklahoma.
- Harwood (1932) stated that *P. microcotype* and *P. megacotyle* may be the same species.
- Ozaki (1935) only renamed the species from *Polystoma megacotyle* to *Polystomoides megacotyle*.
- Stunkard (1916) and Ozaki (1935) provided no sketches of the species and none could be located.
- ***P. opacum***: Ozaki (1935) only renamed the species from *Polystoma opacum* to *Polystomoides opacum*.
- Stunkard (1916) and Ozaki (1935) provided no sketches of the species and none could be located.
- ***P. microcotyle***: Ozaki (1935) only renamed the species from *Polystoma microcotyle* to *Polystomoides microcotyle*.
- Stunkard (1916) and Ozaki (1935) provided no sketches of the species and none could be located.

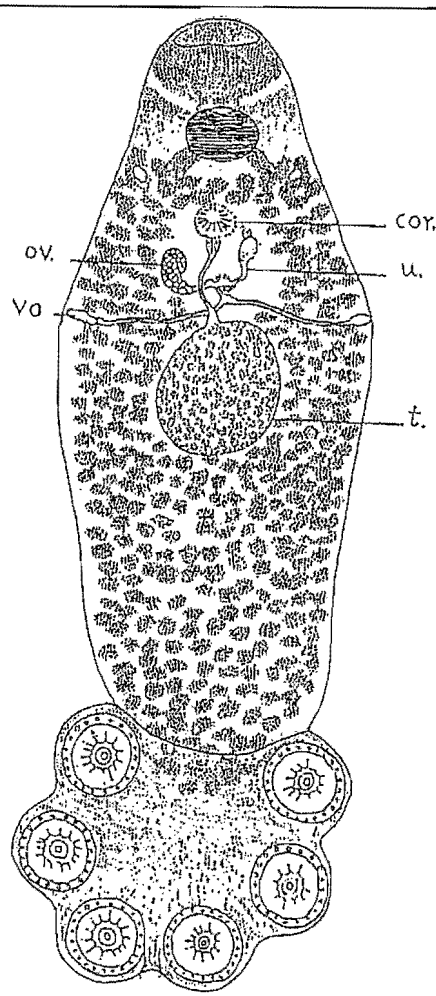
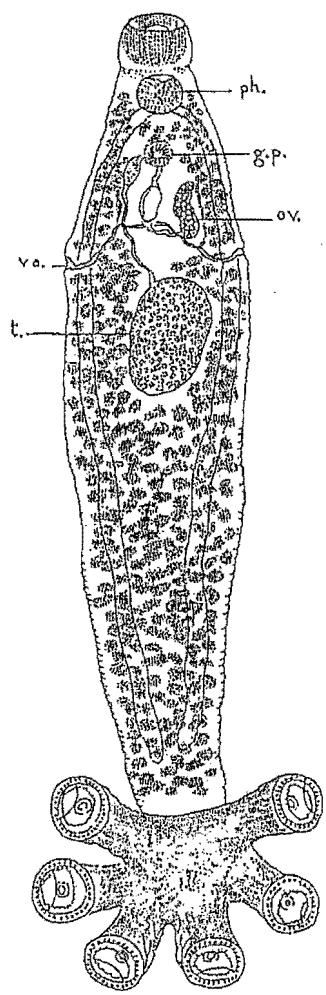
Table 3.41: Measurements of *P. megacotyle, P. opacum* and *P. microcotyle*

CHARACTERISTICS	Stunkard (1916)	Stunkard (1916)	Stunkard (1916)
Mature specimens (n)			
Body Length	2500 – 2700	3250 – 4000	3000
Greatest Width	710 – 780	800 – 1000	780
Width at Vagina			
Haptor Length			
Haptor Width			
Oral Diameter	280 x 350 – 420	200 – 220 x 230	200 x 420
Pharynx Length	350 – 380		370
Pharynx Diameter	380 – 440	300 (spherical)	400
Testis Length	280 – 330		360
Testis Width	330 – 380	400 – 500	420
Ovary Length	100	160 – 200	75
Ovary Width	75	800 – 1200	100
Egg Length			
Egg Diameter			
Egg incubation time			
Intra-Uterine Eggs (n)			
Genital Bulb Diameter			
Gen. Bulb Hook set (n)	1	1	1
Gen. Bulb Hooks 1 (n)	36; 42	32	32
Gen. Bulb Hooks 2 (n)			
Gen. Bulb Hook Length 1			
Gen. Bulb Hook Length 2			
Haptoral Sucker Diameter			280
Hamulus Length 1	116		116
Hamulus Length 2			
Hamulus Hook Length 1			
Hamulus Hook Length 2			
Marginal Hooklet Length			
Haptor L/Body L			

Junior synonyms of *Polystomoides coronatum* [continued]

Tables 3.42 and 3.43; Figures 3.40 and 3.41

General

Table 3.42: *Polystoma albicollis* and *P. digitatum*		
	***P. albicollis* MacCallum, 1918**	***P. digitatum* MacCallum, 1918**
Collection	None.	None.
Original description	MacCallum (1918).	MacCallum (1918).
Type locality	New York Aquarium, U.S.A.	New York Aquarium, U.S.A.
Type host	*Chrysemys elegans* [*Trachemys scripta elegans* (Wied, 1839)]. Red-eared slider.	*Aspidonectes spinifer* [*Apalone spinifera* (LeSueur, 1827)]. Spiny soft-shell turtle.
Additional hosts	None.	*Apalone ferox*.
Site on host	Urinary bladder.	Nasal cavities.
	 ***Figure 3.40***: *Polystoma albicollis*. Copied from MacCallum (1918).	 ***Figure 3.41***: *Polystoma troosti*. Copied from MacCallum (1918).
	Abbreviations: cor. – coronet; g.p. – genital pore; ov. – ovary; ph. – pharynx; t. – testis; u. – uterus; va. – vagina.	

Remarks

~ ***P. digitatum***: This species was also found in *Apalone ferox* with as many as 50 specimens found in one terrapin (MacCallum, 1918).

Information on the parasite

Table 3.43*: Measurements of *P. albicollis* and *digitatum

CHARACTERISTICS	MacCallum (1918)	MacCallum (1918)
Mature specimens (n)	3	3
Body Length	5000 – 5400	4000
Greatest Width	1800	800
Width at Vagina		
Haptor Length		
Haptor Width	2000	1400
Oral Diameter	400	
Pharynx Length		200
Pharynx Diameter		
Testis Length	400	600
Testis Width		
Ovary Length		300
Ovary Width		
Egg Length		
Egg Diameter		
Egg incubation time		
Intra-Uterine Eggs (n)	1	1
Genital Bulb Diameter		
Gen. Bulb Hook set (n)	1	1
Gen. Bulb Hooks 1 (n)	33; 34; 17	31 – 35 or 36
Gen. Bulb Hooks 2 (n)		
Gen. Bulb Hook Length 1	80	
Gen. Bulb Hook Length 2		
Haptoral Sucker Diameter	400 – 450	300 or 400
Hamulus Length 1		
Hamulus Length 2		
Hamulus Hook Length 1		
Hamulus Hook Length 2		
Marginal Hooklet Length		
Haptor L/Body L		

Polystomoides cyclemydis

Fischthal & Kuntz, 1964

Table 3.44; Figure 3.42

General

Collection: United States National Museum Helminthological Collection.
Holotype no: 60192 (1 slide of the holotype and one of the paratype).
Paratype no: None.

Original description: Fischthal and Kuntz (1964).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Puerto Princesa, Palawan Island, Philippines.

Other localities: None.

Type host: *Cyclemys dentata* (Gray, 1831). Asian leaf turtle.
Additional hosts: None.

Site on type host: Large intestine.

Information on the host

Taxonomy: None.

Geographical distribution: This species can be found in the southern Malay Peninsula, Thailand, Malaysia, Sumatra, and Java, as well as Borneo, the Philippines, and near the islands of Palawan and Sulu, and Tawitawi.

Ecology: This species is widespread and reasonably abundant although it is exploited for food and pets. It has no special protection apart from the inclusive national protection of all terrapins.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.44: Measurements of *P. cyclemydis*	
CHARACTERISTICS	Fischthal & Kuntz (1964)
Mature specimens (n)	2
Body Length	1733 – 2178 (without haptor)
Greatest Width	859 – 882
Width at Vagina	
Haptor Length	706 – 851
Haptor Width	815 – 994
Oral Diameter	242 – 295 x 324 – 390
Pharynx Length	222 – 265
Pharynx Diameter	242 – 310
Testis Length	340 – 350
Testis Width	210 – 270
Ovary Length	126 – 182
Ovary Width	92 – 97
Egg Length	232 and 242
Egg Diameter	182 and 162
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	99 – 136 x 92 – 106
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	32
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	30 – 37 (large); 23 – 24 (small)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	215 – 295 x 225 – 295
Hamulus Length 1	72 – 91
Hamulus Length 2	32 – 47
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	17 – 23
Haptor L/Body L	0.3907 – 0.4074

Remarks

~ This species is most similar to *P. ocellatum*, but differs in the form of the large pair of hamuli, and the smaller size of the genital hooks (Fischthal & Kuntz, 1964).

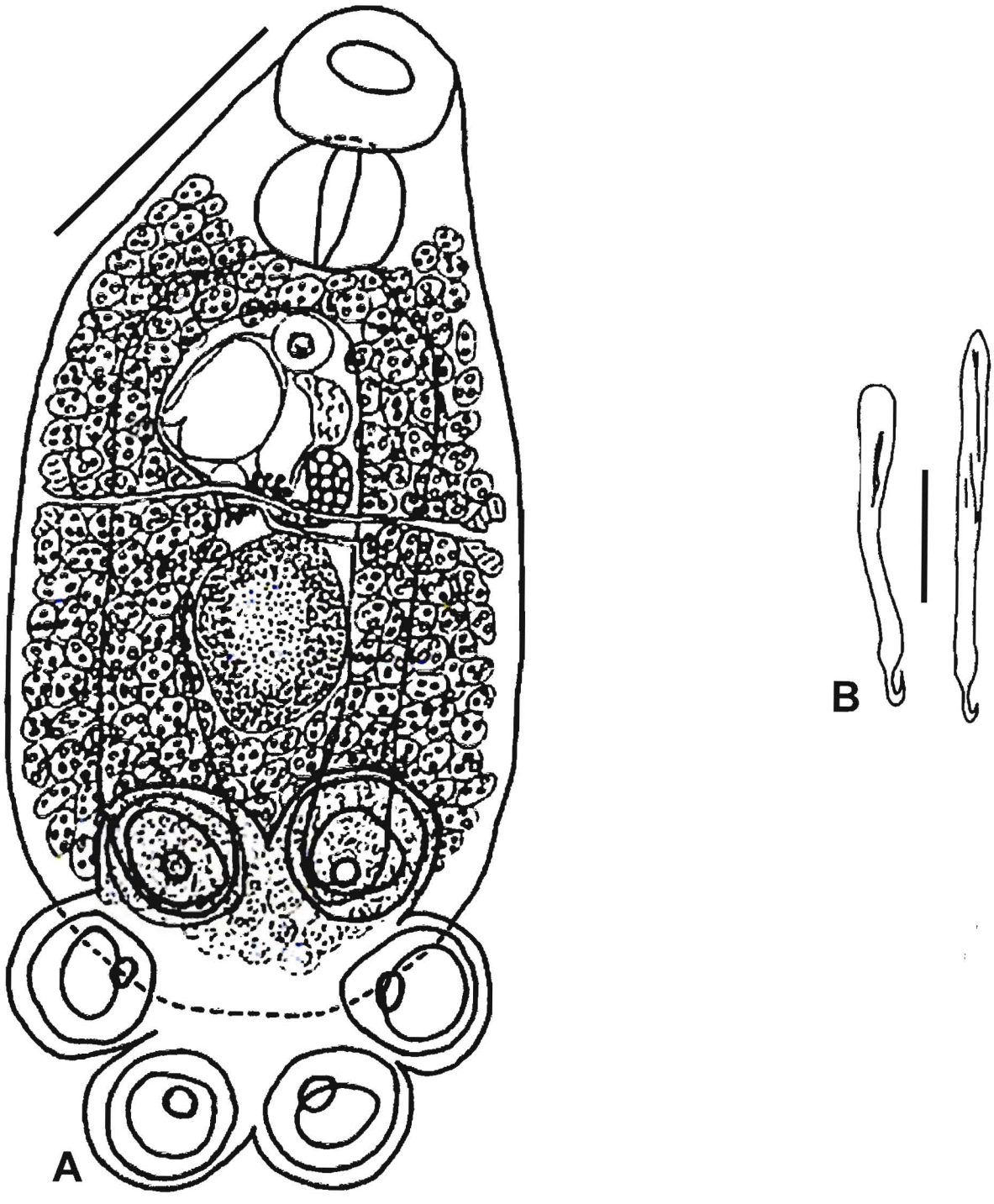


Figure 3.42: (A) *Polystomoides cyclemydis* Fischthal & Kuntz, 1964 (Scale bar = 500µm); (B) Large hamuli (Scale bar = 30µm). Copied from Fischthal and Kuntz (1964).

Polystomoides fuquesi

Mañé-Garzón & Gil, 1962

Table 3.45; Figure 3.43

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Mañé-Garzón and Gil (1962).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Uruguay, South America.

Other localities: None.

Type host: *Phrynops geoffroana hillarii* [*Phrynops hilarii* (Duméril & Bibron, 1835)]. Halaire's side-necked turtle; spotted-bellied side-necked turtle.
Additional hosts: None.

Site on type host: Pharynx.

Information on the host

Taxonomy: *Phrynops geoffroana hillarii* is now known as *Phrynops hilarii* (Duméril & Bibron, 1835).

Geographical distribution: The species can be found in eastern central South America, in southern Brazil in the provinces of Rio Grande do Sul, Santa Cterina, and Paraná, and in Uruguay, as well as in northern Argentina in the provinces of Córdoba and Santiago del Estero, southern Paraguay, and north-eastern Argentina. It may be present in Bolivia, but this needs investigation.

Ecology: This terrapin is captured by collectors, and it and its eggs are also eaten, but some local people consider it to be poisonous. Despite its habitat being altered and destroyed, the species does not appear on any protected list.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.45: Measurements of *P. fuquesi*	
CHARACTERISTICS	Mañé-Garzón & Gil (1967)
Mature specimens (n)	17
Body Length	7480 – 7550
Greatest Width	2300 – 2600
Width at Vagina	
Haptor Length	
Haptor Width	2660 – 2780
Oral Diameter	450 x 670 – 700
Pharynx Length	480 – 510
Pharynx Diameter	660 – 700
Testis Length	114 – 1400
Testis Width	1000 – 1100
Ovary Length	1179
Ovary Width	900
Egg Length	
Egg Diameter	250 – 360
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	176 x 118
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	2
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	56
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	481 – 518
Hamulus Length 1	65 – 68
Hamulus Length 2	45
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	24 - 27
Haptor L/Body L	

Remarks

~ The species differs from other species in having two genital spines, as well as in the form of the ovary that is extended and sinuous (Mañé-Garzón and Gil, 1962).

~ The authors noted that the parasite's sexual maturation may co-inside with their hosts' sexual ripening, and advised more investigation into this (Mañé-Garzón and Gil, 1962).

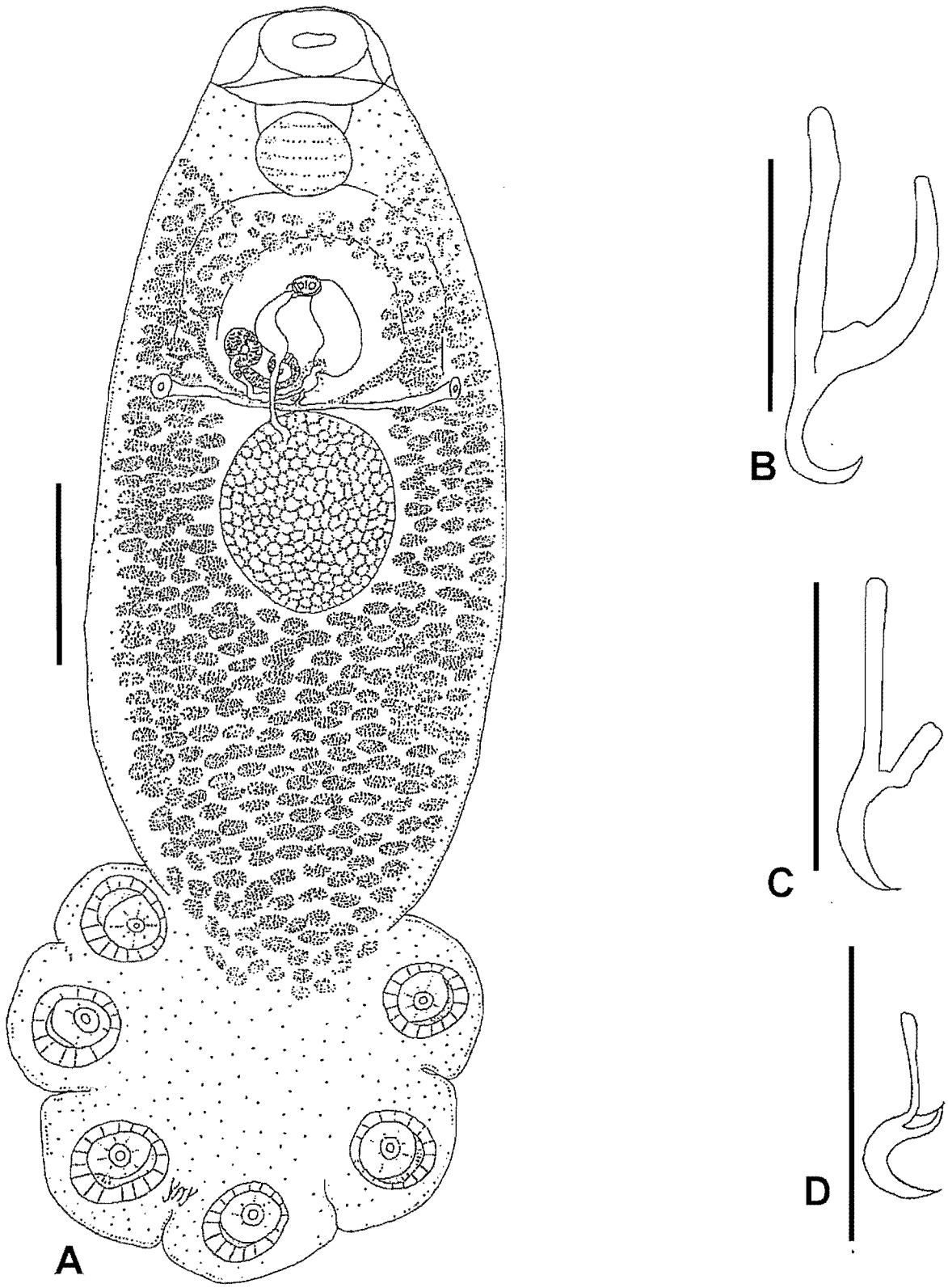


Figure 3.43: (A) *Polystomoides fuquesi* Mañé-Garzón & Gil, 1962 (Scale bar = 1000µm); (B) Large hamulus (Scale bar = 50µm); (C) Small hamulus (Scale bar = 50µm); (D) Marginal hooklet (Scale bar = 50µm). Copied from Mañé-Garzón and Gil (1962).

Polystomoides godavarii

Rao, 1975

Table 3.46; Figure 3.44

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Rao (1975).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Godavary river, Pochamped area, District Nizamabad, Andhra Pradesh, India.

Other localities: None.

Type host: *Kachuga tectum tentoria* [*Pangshura tentoria tentoria* (Gray, 1834)]. India tent turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Kachuga tectum tentoria* has changed to *Pangshura tentoria tentoria* (Gray, 1834). *Pangshura tentoria* (Gray, 1834) has two other subspecies: *P. t. circumdata* (Mertens, 1969), and *P. t. flaviventer* Günther, 1864.

Geographical distribution: This subspecies occurs in north-eastern India (Orissa, Andhra Pradesh, Madhya Pradesh, Maharashtra, as well as the Mahandi and Krishna Rivers), and northern, and part central Bangladesh.

Ecology: The natural predators of this species include hyenas and jackals, and they are captured by fishermen or placed in temple ponds. However, it has been reported that comsumption of the flesh can bring a variety of maladies, thus limiting the numbers that has been taken for consumption.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.46: Measurements of *P. godavarii*	
CHARACTERISTICS	Rao (1975)
Mature specimens (n)	7
Body Length	4200 – 8030
Greatest Width	
Width at Vagina	1440 – 2100
Haptor Length	1120 – 1620
Haptor Width	1250 – 1710
Oral Diameter	540 – 690 x 300 – 490
Pharynx Length	250 – 360
Pharynx Diameter	160 – 310
Testis Length	770 – 1150
Testis Width	610 – 900
Ovary Length	260 – 460
Ovary Width	110 – 220
Egg Length	250 – 300
Egg Diameter	170 – 210
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	64 – 66
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	260 – 310 x 320 – 360
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	

Remarks

~ This species is most similar to *P. simhai* and *P. coronatum*, but differs from the first in the shape of the testis, the general topography of the organs, and possessing an extra pair of hooks with a bifid base between the anchors and great hooks, and from the second in the shape of hooks and anchors and the broad base of the anchors as opposed to *P. coronatum*'s elongated and sabre shaped hooks (Rao, 1975).

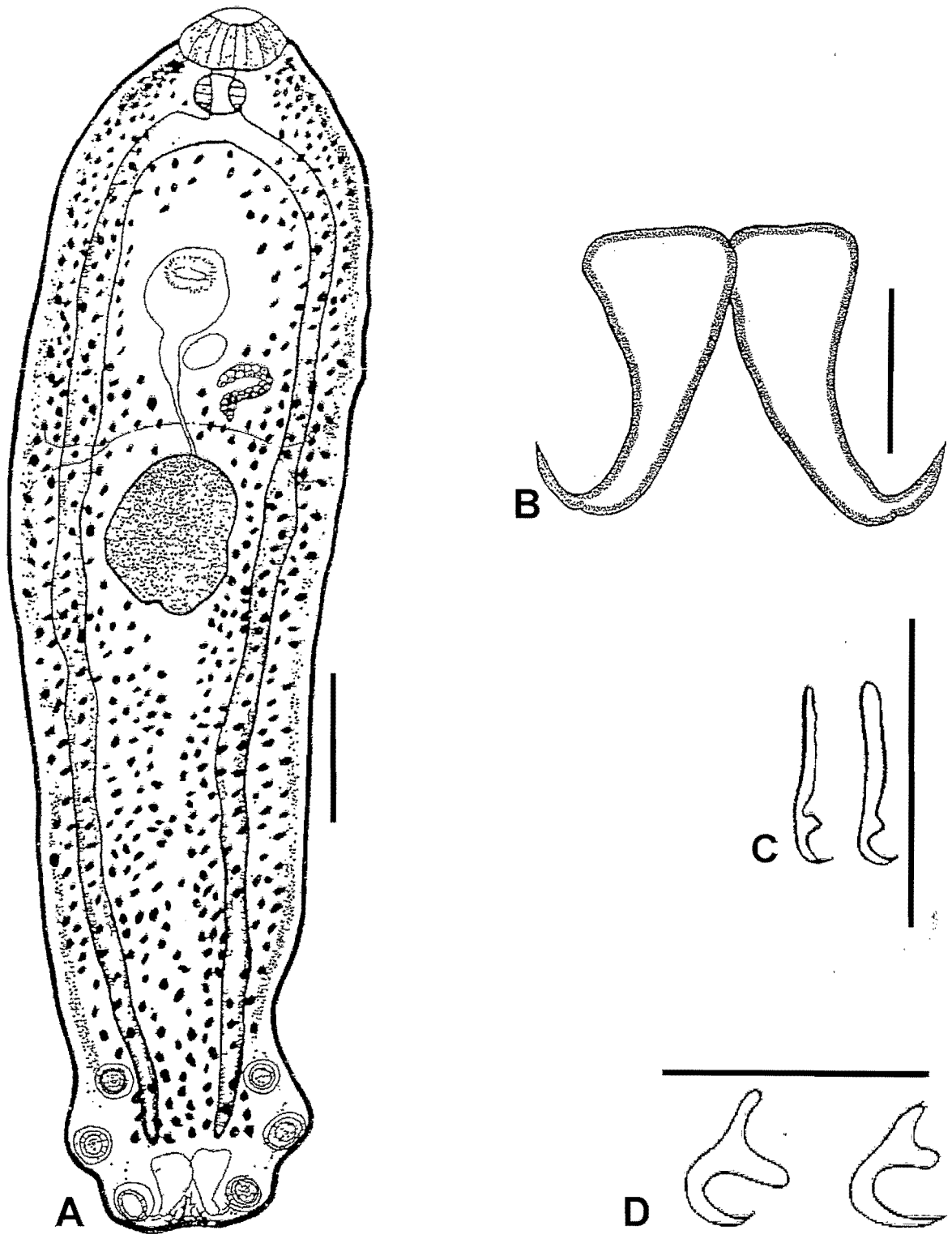


Figure 3.44: (A) *Polystomoides godavarii* Rao, 1975 (Scale bar = 1000µm); (B) Large hamuli (Scale bar = 250µm); (C) Small hamuli (Scale bar = 250µm); (D) Marginal hooklets (Scale bar = 50µm). Copied from Rao (1975).

Polystomoides japonicum

Ozaki, 1935

Table 3.47; Figure 3.45

General

Collection: Zoological Laboratory of Hiroshima University, Japan.
Holotype no: None.
Paratype no: None.

Original description: Ozaki (1935).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Saijo, Hiroshima Prefecture, Japan.

Other localities: Author notes that he has collected the species in other localities as well, but provides no other details.

Type host: *Clemmys japonica* [*Mauremys japonica* (Temminck & Schlegel, 1835)]. Japanese pond turtle.
Additional hosts: None.

Site on type host: Mouth and Oesophagus.

Information on the host

Taxonomy: *Clemmys japonica* has changed to *Mauremys japonica* (Temminck & Schlegel, 1835).

Geographical distribution: This species occurs in central and southern Japan, on the Honshu, Kyushu, and Shikoku islands.

Ecology: This species is protected at national level, but certain populations do suffer from degradation of their natural habitat, as well as highway vehicular mortality, being gathered for the wildlife trade, or to show to children. Populations are progressively lowering, and in recent times this drop has gained momentum.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.47: Measurements of *P. japonicum*	
CHARACTERISTICS	Ozaki (1935)
Mature specimens (n)	
Body Length	3000 – 3400
Greatest Width	1250 – 1700
Width at Vagina	
Haptor Length	1100 – 1450
Haptor Width	1500 – 1800
Oral Diameter	
Pharynx Length	
Pharynx Diameter	350 – 400
Testis Length	850 – 900
Testis Width	650 – 700
Ovary Length	300
Ovary Width	150
Egg Length	245 – 265
Egg Diameter	155 – 160
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	31 – 39
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	300 – 350
Hamulus Length 1	100 – 120
Hamulus Length 2	50
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	

Remarks

~ This species differs from *P. ocellatum* in the position of the vaginas, the form of the ovary, and the armature of the disk. While *P. ocellatum* has vaginal swellings that lie between the pharynx and genital pore, a deformed square shaped ovary, and two different types of hooks on the haptor (two large definitive hooks and eight small larval hooklets lie between the posterior two suckers), *P. japonicum* has vaginal swellings that are a considerable distance behind the genital pore, a ovoid ovary, and three types of hooks (two large definitive hooks, two middle sized larval hooklets and four small larval hooklets between two posterior suckers) (Ozaki, 1935).

~ The species also differs from *P. megacotyle* and *P. microcotyle* (synonyms of *P. coronatum*) in the number of genital spines, as well as the arrangement of the hooklets on the haptor (Ozaki, 1935).

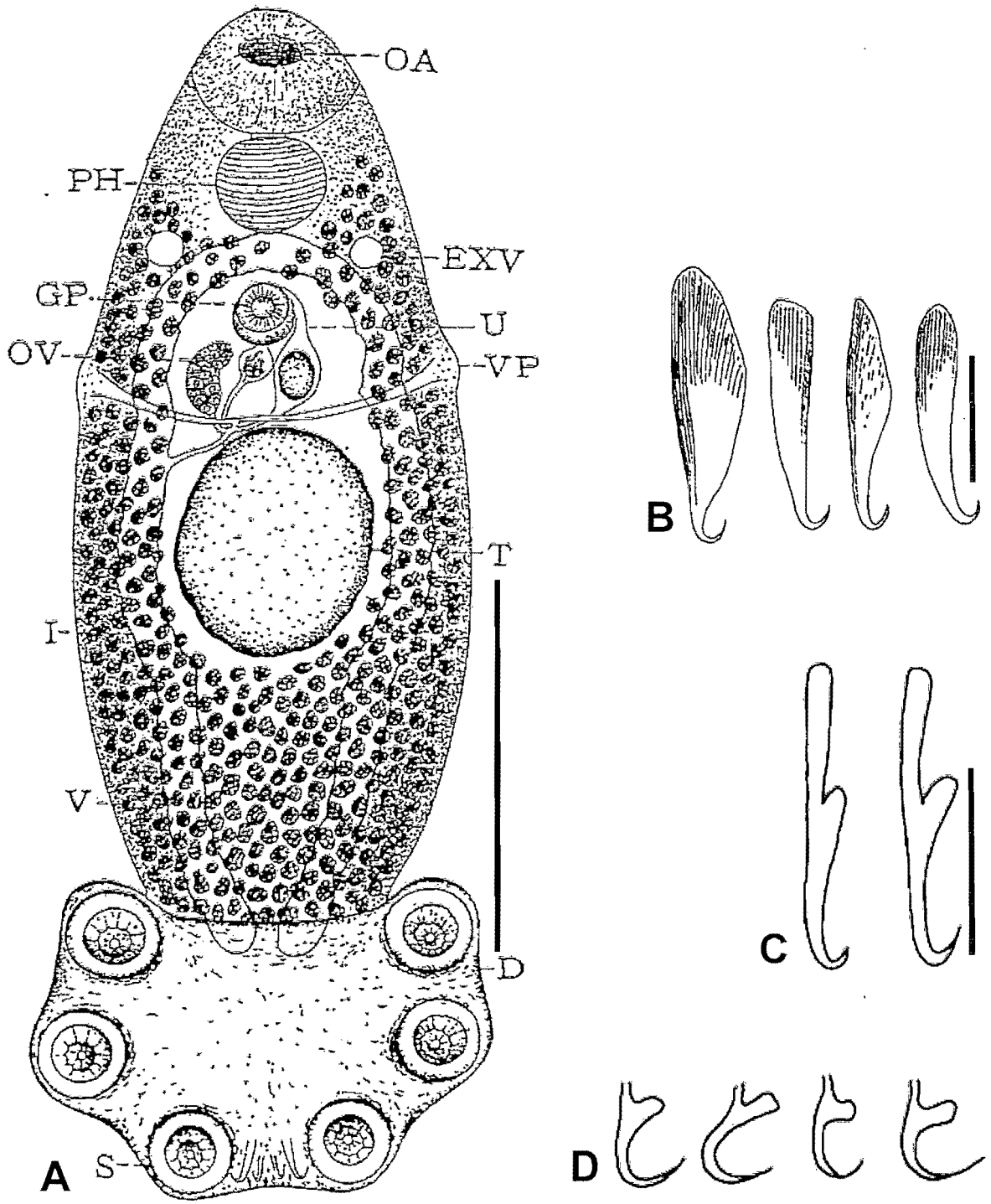


Figure 3.45: (A) *Polystomoides japonicum* Ozaki, 1935. Abbreviations: D – disc or cotylophore; EXV – excretory bladder; GP – genital pore; I – intestine; OA – oral aperture; OV – ovary; PH – pharynx; S – sucker; T – testis; U – uterus; V – vitellaria; VP – vagina (Scale bar = 1000µm); (B) Large hamuli (Scale bar = 50µm); (C) Small hamuli (Scale bar = 30µm); (D) Marginal hooklets (Scale unknown). Copied from Ozaki (1935).

Polystomoides kachugae

(Stewart, 1914)

Table 3.48; Figure 3.46

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Stewart (1914).

Other taxonomic contributions: Ozaki (1935); [756].

Synonyms: None.

Type locality: Lucknow, India.

Other localities: None.

Type host: *Kachuga lineata* [*Kachuga kachuga* (Gray, 1831)]. Red-crowned roofed turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Kachuga lineata* has changed to *Kachuga kachuga* (Gray, 1831).

Geographical distribution: This species is found in southern Nepal, Bangladesh, and adjacent northeastern India, in the basins of the Ganges, Brahmaputra, Godavari, and Kristna Rivers.

Ecology: This species is heavily fished for its meat, and reintroduction programs are necessary to restock some of the former colonies, because degradation of habitats, barrages, sand mining, and water pollution are also problems. The species is classified as endangered by the Turtle Conservation Fund.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.48: Measurements of *P. kachugae*	
CHARACTERISTICS	**Stewart (1914)**
Mature specimens (n)	2
Body Length	6500
Greatest Width	2000
Width at Vagina	
Haptor Length	
Haptor Width	1330
Oral Diameter	
Pharynx Length	
Pharynx Diameter	
Testis Length	2200
Testis Width	1000
Ovary Length	
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	40
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	400
Hamulus Length 1	900
Hamulus Length 2	166
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	

Remarks

~ This species differs from *P. ocellatum* in the position of the vulvae: *P. ocellatum*'s vulvae are between the pharynx and genital aperture, whereas in *P. kachugae* these lie at a relatively big distance behind the genital aperture (Stewart, 1914).

~ The species also differs from *P. coronatum* in that the haptor is narrower, not wider than the body, no hooks are found between the anterior pair of suckers, one pair of big and one pair of small hooks are found between the posterior pair of suckers, and the genital aperture possesses 40 hooks, not 32 (Stewart, 1914).

~ Ozaki (1935) only renamed *Polystomum kachugae* as *Polystomoides kachugae*, and gave no information on the parasite.

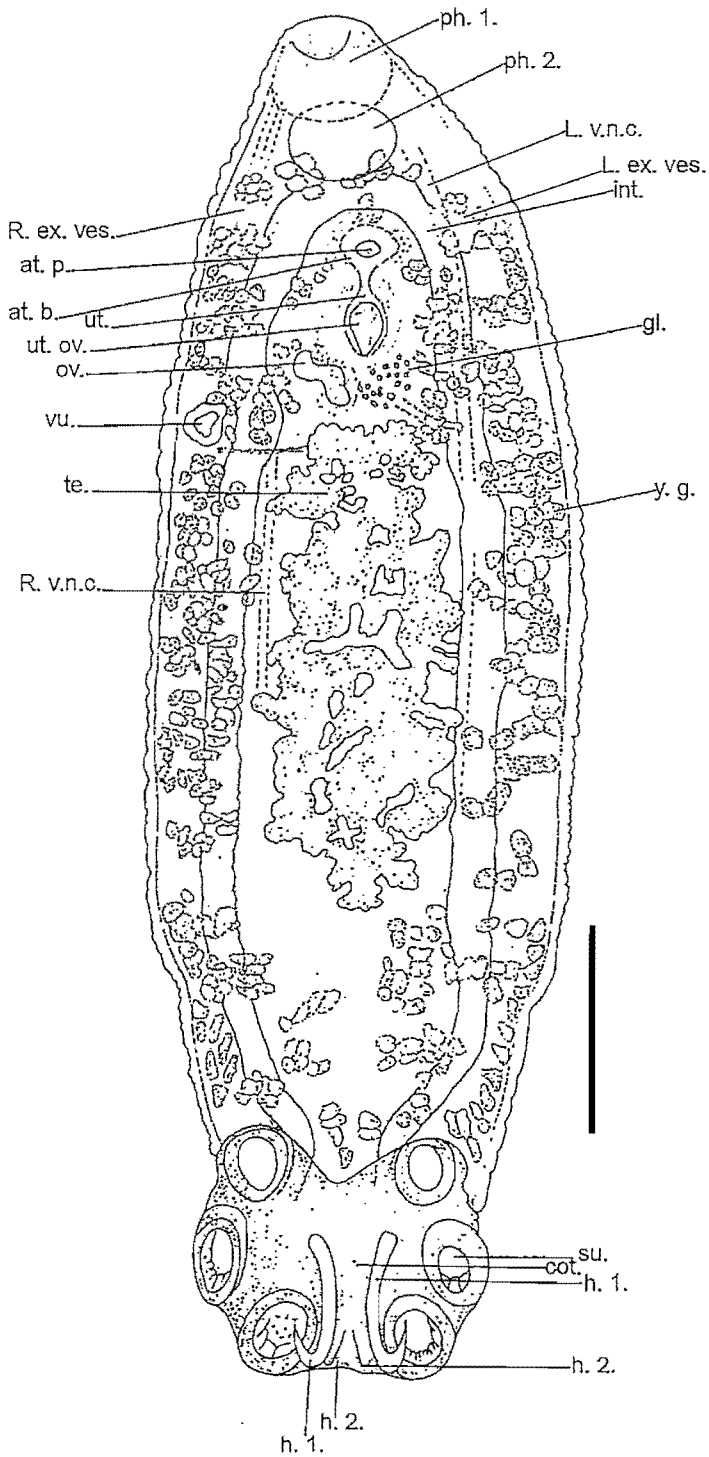


Figure 3.46: *Polystomoides kachugae* (Stewart, 1914). Abbreviations: at. B. – atrial bulb; at. P. – atrial pore; cot. – cotylophore; gl. – gland innominate; h. 1. – hook 1; h. 2. – hook 2; int. – intestine; L. ex. Ves. – Left excretory vesicle; L. v.n.c. – Left ventral nerve cord; ov. – ovary; ph. 1. – pharynx 1; ph. 2. – pharynx 2; R. ex. Ves. – Right excretory vesicle; R. v.n.c. – Right ventral nerve cord; su. – sucker; te. – testis; ut. – uterus; ut. Ov. – uterine ovum; vu. – vulva; y. g. – yolk gland (Scale bar = 1000µm). Copied from Stewart (1914).

Polystomoides ludhianae

Gupta & Randev, 1974

Table 3.49; Figure 3.47

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Gupta and Randev (1974).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Ludhiana (Punjab), India.

Other localities: None.

Type host: [1]*Kachuga tectum* [*Pangshura tecta* (Gray, 1830)]. Indian roofed turtle; [2]*Kachuga smithi* [*Pangshura smithii* (Gray, 1863)]. Brown roofed turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: [1]*Kachuga tectum* is now known as *Pangshura tecta* (Gray, 1830); [2]*Kachuga smithi* is now known as *Pangshura smithii* (Gray, 1963), and has two subspecies: *P. s. smithii* (Gray, 1863) and *P. s. pallidipes* (Moll, 1987).

Geographical distribution: [1]This terrapin has a wide range in northern India, in the drainages of the Indus, Ganges, Narmada and Brahmaputra Rivers in Pakistan, northern India, Nepal, and Bangladesh; [2]This terrapin can be found in an elongate, narrow band of territory in the north of the Indian subcontinent, Pakistan, Nepal, and Bangladesh, in the basins of the Ganges and Brahmaputra.

Ecology: [1]This species is listed in Appendix 1 of CITES, but population are reasonably abundant. They are collected for consumption and sales, and the collection of eggs, habitat destruction, dams and barrages, and the destruction of nesting sites have made the species highly vulnerable; [2]This species is heavily collected and consumed, but the knowledge of its status and populations is insufficient.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.49: Measurements of *P. ludhianae*	
CHARACTERISTICS	**Gupta & Randev (1974)**
Mature specimens (n)	
Body Length	6640 – 10060
Greatest Width	2430 – 3050
Width at Vagina	
Haptor Length	
Haptor Width	1742 – 2396
Oral Diameter	399 – 726 x 577 – 799
Pharynx Length	218 – 290
Pharynx Diameter	254 – 363
Testis Length	1488 – 2214
Testis Width	1416 – 2033
Ovary Length	
Ovary Width	109 – 182
Egg Length	182 – 290
Egg Diameter	145 – 218
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	49 – 53 x 504 – 748
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	54 – 64
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	254 – 363
Hamulus Length 1	545 – 617
Hamulus Length 2	136 – 154
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	

Remarks

~ This species differs from *P. kachugae* in the form of the gonads, the haptoral hooks, the number of genital hooks, and the extent of the vitellaria.
~ The species also differs from *P. oris* because *P. oris* has a diverticulated intestine.
~ *P. megaovum* has an egg size that is half or the same as the width of the body.
~ *P. occelatum* has vaginas that open at the level between the pharynx and the genital pore.

~ The species also differs from other species in the number of genital hooks it possesses: *P. coronatum* has 14 – 40 hooks, *P. japonicum* has 31 – 39 hooks, *P. multifalx* has 82 – 130 hooks, *P. uruguayensis* has eight to ten hooks, *P. cyclemydis* has 32 hooks, *P. fuquesi* has two, *P. microrchis* has 42 – 47 hooks, *P. ocadia* has 46 – 59, and *P. chabaudi* has 31 – 36 (Gupta & Randev, 1974).

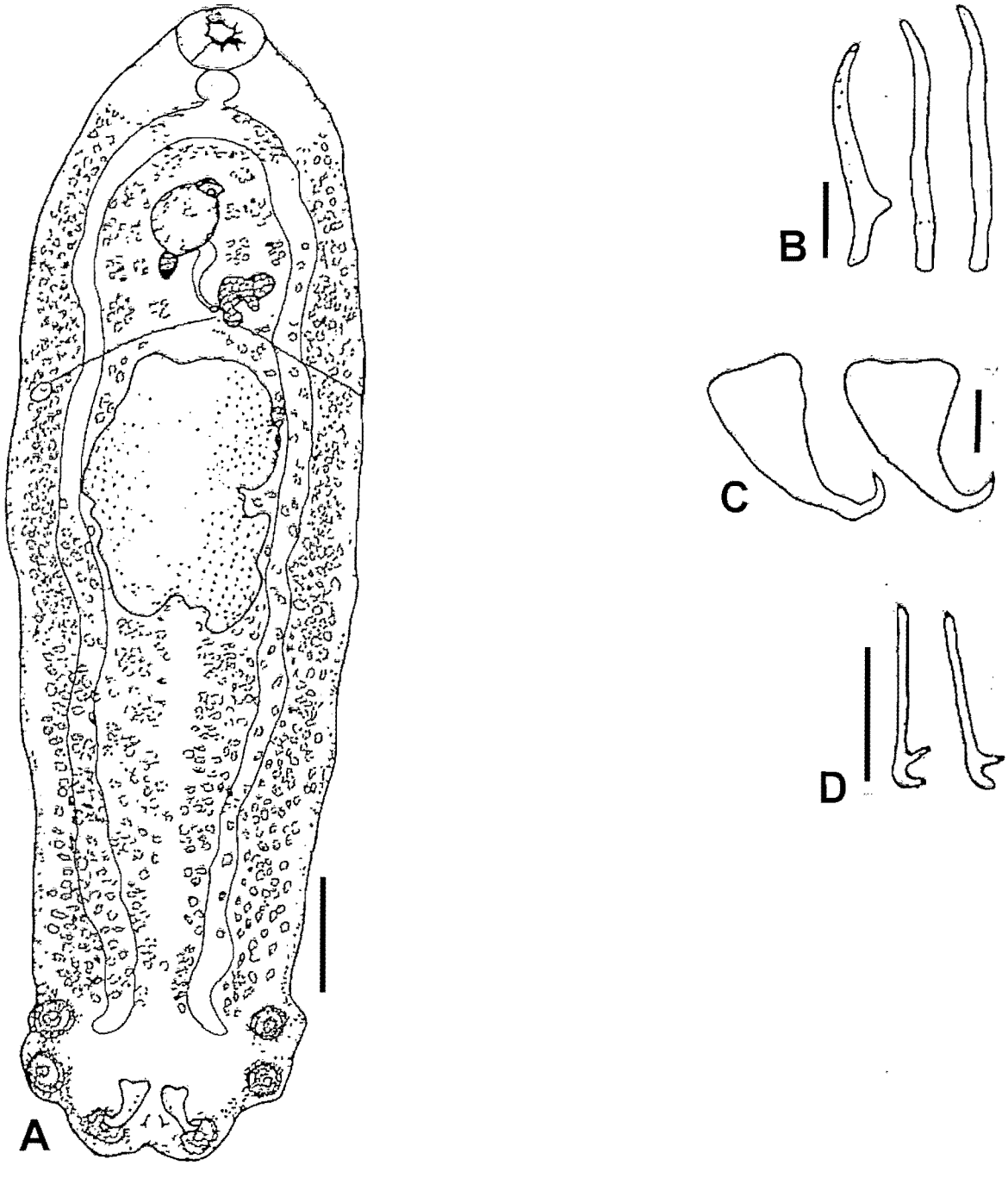


Figure 3.47: (A) *Polystomoides ludhianae* Gupta & Randev, 1974 (Scale bar = 1000µm); (B) Genital spines (Scale bar = 25µm); (C) Large hamuli (Scale bar = 20µm); (D) Small hamuli (Scale bar = 15µm). Copied from Gupta and Randev (1974).

Polystomoides magdalenensis

Lenis & García-Prieto, 2009

Table 3.50; Figure 3.48

General

Collection: Colección de Trematodos de la Universidad de Antioquia (CTUA); Laboratio de Malacología Médica y Trematodos, Medellín, Colombia; and Colección Nacional de Helmintos (CNHE), Instituto de Biología, Universidad Nacional Autónoma de México, Mexico City.
Holotype no: CTUA (116.10.001); n = 1.
Paratype no: CNHE (6470-71); CTUA (116.02 – 116.09); n = 12.

Original description: Lenis & García-Prieto (2009).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Coyongal (08°55'11"N, 74°29'25"W), Río Magdalena, Departamento de Bolivar, Colombia.

Other localities: Mompox (09°14'40"N, 74°25'29"W) (Departemento de Bolívar); Ricaurte (09°7'7"N, 74°11'40"W) (Departemento del Magdalena), Colombia.

Type host: *Trachemys callirostris callirostris* (Gray, 1856). Colombian slider.
Additional hosts: None.

Site on type host: Buccal cavity (52 hosts), incidentally in cloaca (1 turtle).

Information on the host

Taxonomy: *Trachemys callirostris callirostris* (Gray, 1856) is a subspecies of *Trachemys callirostris* (Gray, 1856). *T. callirostris* has one other subspecies: *T. c. chichiriviche* (Pritchard & Trebbau, 1984).

Geographical distribution: This subspecies occurs in Northern Colombia (Antióquia, Atlántico, Bolívar, Cesár, Córdoba, Guajira, Magdalena) and northwestern Venezuela (Edo. Zulia) in Caribbean drainage systems.

Ecology: This species is heavily exploited for meat and eggs. Harvesting is especially heavy during Holy Week (Semana Santa), even though the species is protected by law in both Colombia and Venezuele, because the tradition has been hard to break.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.50: Measurements of *P. magdalenensis*	
CHARACTERISTICS	Lenis & García-Prieto (2009)
Mature specimens (n)	13
Body Length	2400 (1600 – 3100)
Greatest Width	
Width at Vagina	1114 (775 – 1157)
Haptor Length	1159 (840 – 1469)
Haptor Width	1290 (1020 – 1570)
Oral Diameter	220 (166 – 428) x 392 (317 – 483)
Pharynx Length	249 (158 – 333)
Pharynx Diameter	333 (238 – 428)
Testis Length	454 (261 – 554)
Testis Width	556 (388 – 768)
Ovary Length	131 (79 – 239)
Ovary Width	
Egg Length	219 (166 – 246)
Egg Diameter	176 (150 – 214)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	188 (143 – 238) x 215 (158 – 309)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	29 – 35
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	48 (45 – 51)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	362 (301 – 451) x 437 (316 – 554)
Hamulus Length 1	137 (123 – 150); n = 6
Hamulus Length 2	57 (54 – 63); n = 6
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	25 (21 – 27); n = 10
Haptor L/Body L	0.4829

Remarks

~ This species is distinguished from the existing *Polystomoides* species by one or a combination of the following: Smaller or greater number of genital spines, infecting the buccal cavity, occurring in a different geographical zone, the size, number, and distribution of the vitelline follicles, the outer and inner hamuli size, the size of the testis, the marginal hooklet size, the armature of the genital bulb, length of the intestinal cecae, the size of the pharynx, the absence of cecal diverticula, parasitizing Nearctic turtles, and different pharynx, testis, and/or haptor size ratios.

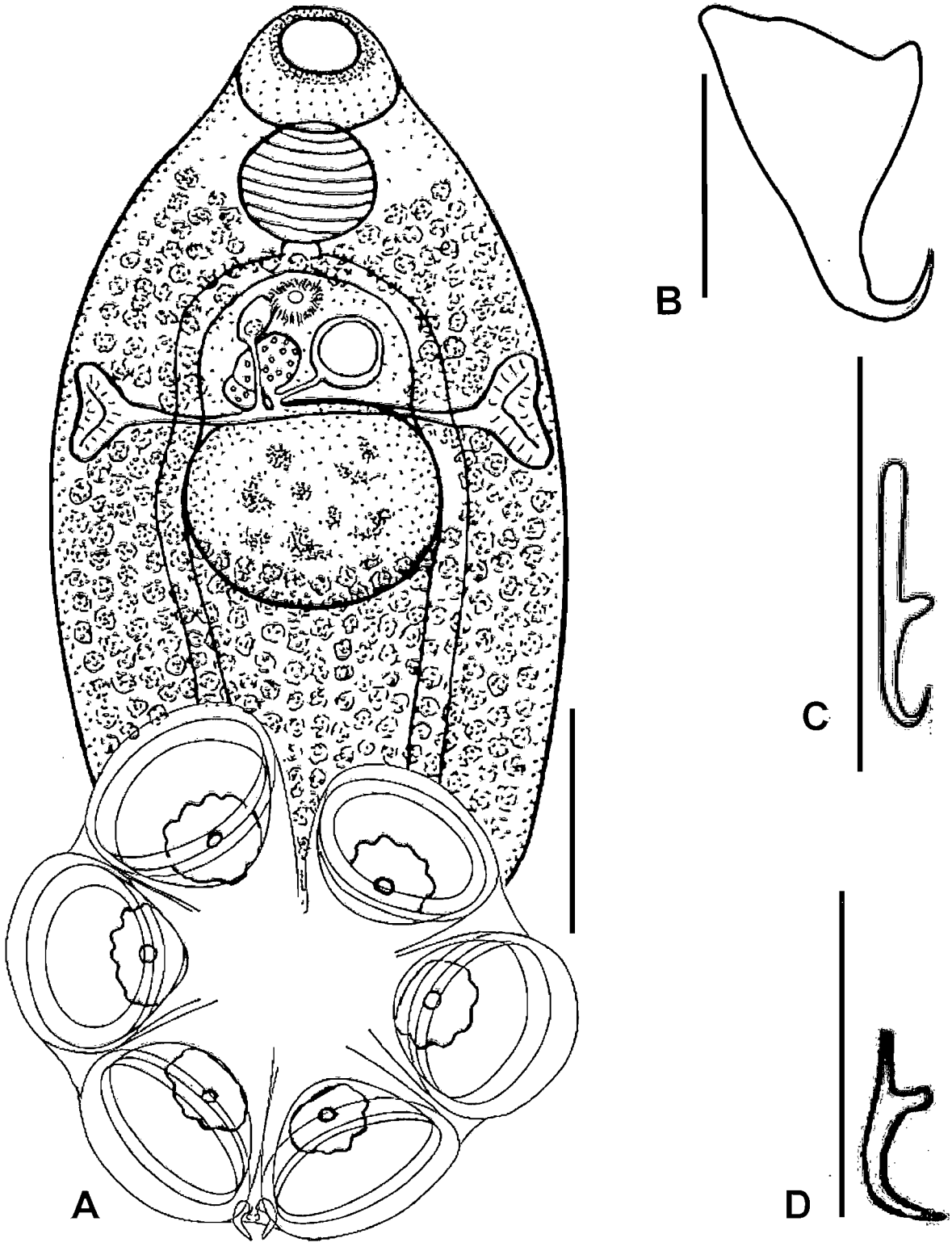


Figure 3.48: (A) *Polystomoides magdalenensis* Lenis & García-Prieto, 2009 (Scale bar = 500µm); (B) Large hamulus (Scale bar = 100µm); (C) Small hamuli (Scale bar = 100µm); (D) Marginal hooklet (Scale bar = 50µm). Copied from Lenis & García-Prieto (2009).

Polystomoides malayi

Rohde, 1963

Table 3.51; Figure 3.49

General

Collection: Helminthological Collection, Zoology department, University of Malaysia, Kuala Lumpur[Φ]; Helminthological collection of the Humbolt University of Berlin; Helminthological collection of the British Museum (Natural History); U.S. National Museum Helminthological Collection.

Holotype no: None.
Paratype no: R. 129 – 135[Φ].

Original description: Rohde (1963).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Different localities in Selangor, Malaysia.

Other localities: None.

Type host: *Cuora amboinensis* (Daubin, 1802). East Indian box turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Cuora amboinensis* (Daudin, 1802) has four subspecies: *C. a. amboinensis* (Daudin, 1801); *C. a. couro* (Schweigger, 1812); *C.a. kamaroma* Rummler & Fritz, 1991; *C. a. lineate* McCord & Philippen, 1998.

Geographical distribution: Widely distributed in northeastern India and Bangladesh and in Southeast Asia, surviving today in isolated residual areas, demonstrating a breakdown of the integrity of the overall range. Occurs in Bangladesh, the Nicobar Islands, and Assam, in the Kaziranga National Park. It also occurs in southern Myanmar, Malaysia, Sumatra, Java, Borneo, Sumbawa, Sulawesi, the Philippines and in Indonesia, as far east as the Moluccas.

Ecology: This is the most frequently consumed terrapin species in restaurants in China, also captured and released in Buddhist temple ponds, and gathered for exports. This may lead to a population collapse in the future.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.51: Measurements of *P. malayi*	
CHARACTERISTICS	**Rohde (1963)**
Mature specimens (n)	5
Body Length	7200 (5900 – 8200)
Greatest Width	290 (2300 – 3300)
Width at Vagina	
Haptor Length	1500 (1200 – 1700)
Haptor Width	2000 (1500 – 2400)
Oral Diameter	480 (460 – 500) x 790 (690 – 870)
Pharynx Length	380 (370 – 420)
Pharynx Diameter	480 (460 – 520)
Testis Length	370 (320 – 430)
Testis Width	690 (530 – 960)
Ovary Length	
Ovary Width	
Egg Length	280 (270 – 300)
Egg Diameter	230 (220 – 230)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	570 (490 – 630) x 520 (440 – 540)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	77 (70 – 80)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	320 (270 – 390) x 320 (260 – 390)
Hamulus Length 1	630 (570 – 680)
Hamulus Length 2	220 (120 – 320)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	26 (21 – 31)
Haptor L/Body L	0.2083

Remarks

~ Rohde (1965) again found the species in *Cuora amboinensis* from Malaysia.

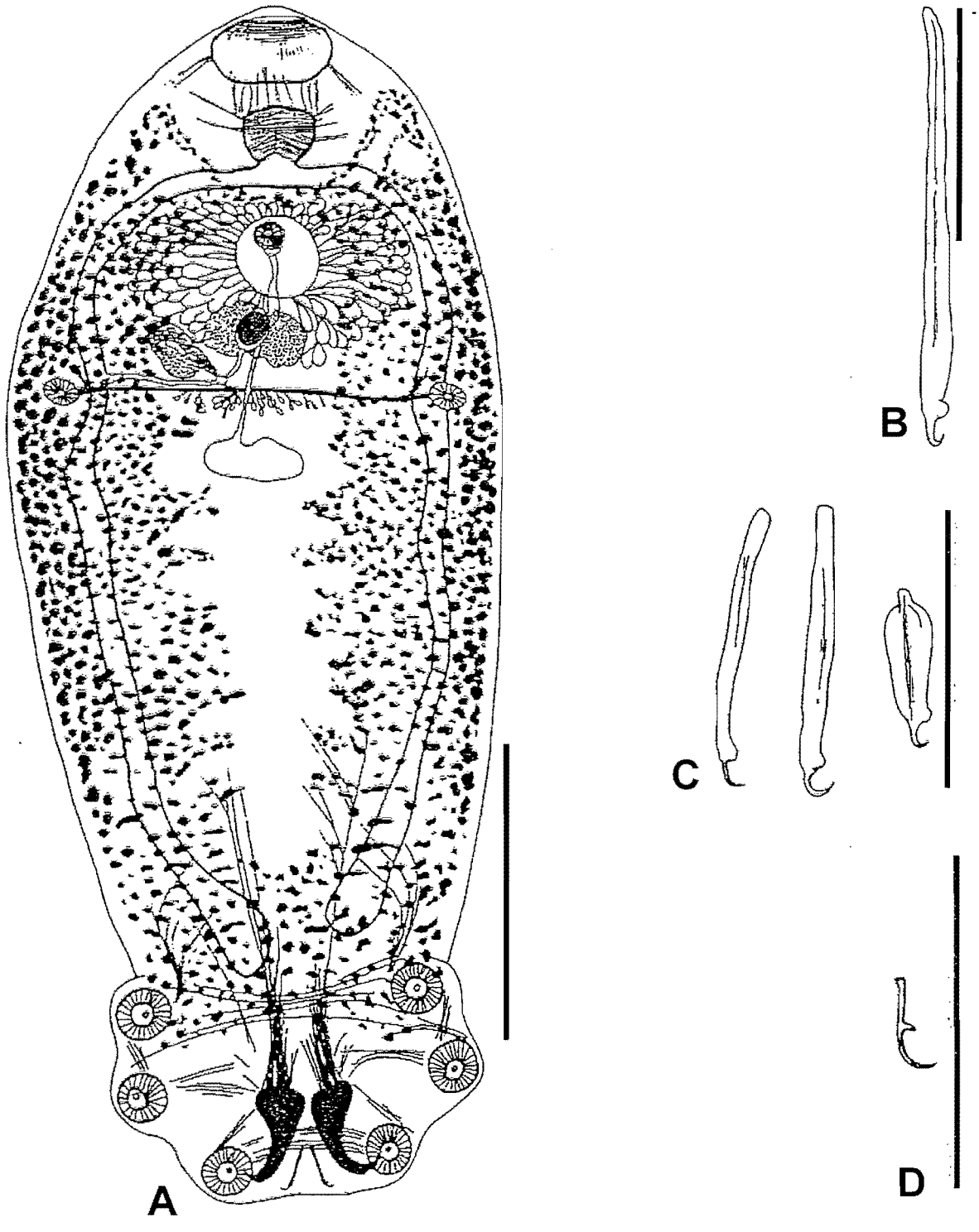


Figure 3.49: (A) *Polystomoides malayi* Rohde, 1963 (Scale bar = 2000µm); (B) Large hamulus (Scale bar = 200µm); (C) Small hamuli (Scale bar = 200µm); (D) Marginal hooklet (Scale bar = 200µm). Copied from Rohde (1963).

Polystomoides megaovum

Ozaki, 1936

Table 3.52; Figure 3.50

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Ozaki (1936).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Kunigami district of the Loochoo Island proper, China.

Other localities: None.

Type host: *Geoemyda spengleri* (Gmelin, 1789). Black-breasted leaf turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: None.

Geographical distribution: This species can be found in southern China (Guangxi, Guangdong, Hunan, and Hainan Island to Indochina), northern and central Vietnam, and possibly in Borneo.

Ecology: This species is attractive to hobbyists because it is a small and attractive terrapin. Populations are reduced and it is classified as endangered by the Turtle Conservation Fund.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.52: Measurements of *P. megaovum*	
CHARACTERISTICS	**Ozaki (1936)**
Mature specimens (n)	21
Body Length	1350 – 2100
Greatest Width	420 – 650
Width at Vagina	
Haptor Length	
Haptor Width	480 – 720
Oral Diameter	140 x 300 – 370
Pharynx Length	130 – 180
Pharynx Diameter	130 – 160
Testis Length	130 – 230
Testis Width	80 – 170
Ovary Length	100 – 190
Ovary Width	40 – 100
Egg Length	240 – 400
Egg Diameter	160 – 320
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	80
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	12 – 14
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	150
Hamulus Length 1	
Hamulus Length 2	
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	25
Haptor L/Body L	

Remarks

~ Ozaki (1936) noted that this species' egg is very large, often displacing the testis and ovary.
~ The species also differs from *P. hassalli* in the number of genital spines (*P. hassalli* has 16), the armature of the caudal disc (the small hamuli are not present), and *P. hassalli* has a smaller egg (Ozaki, 1936).

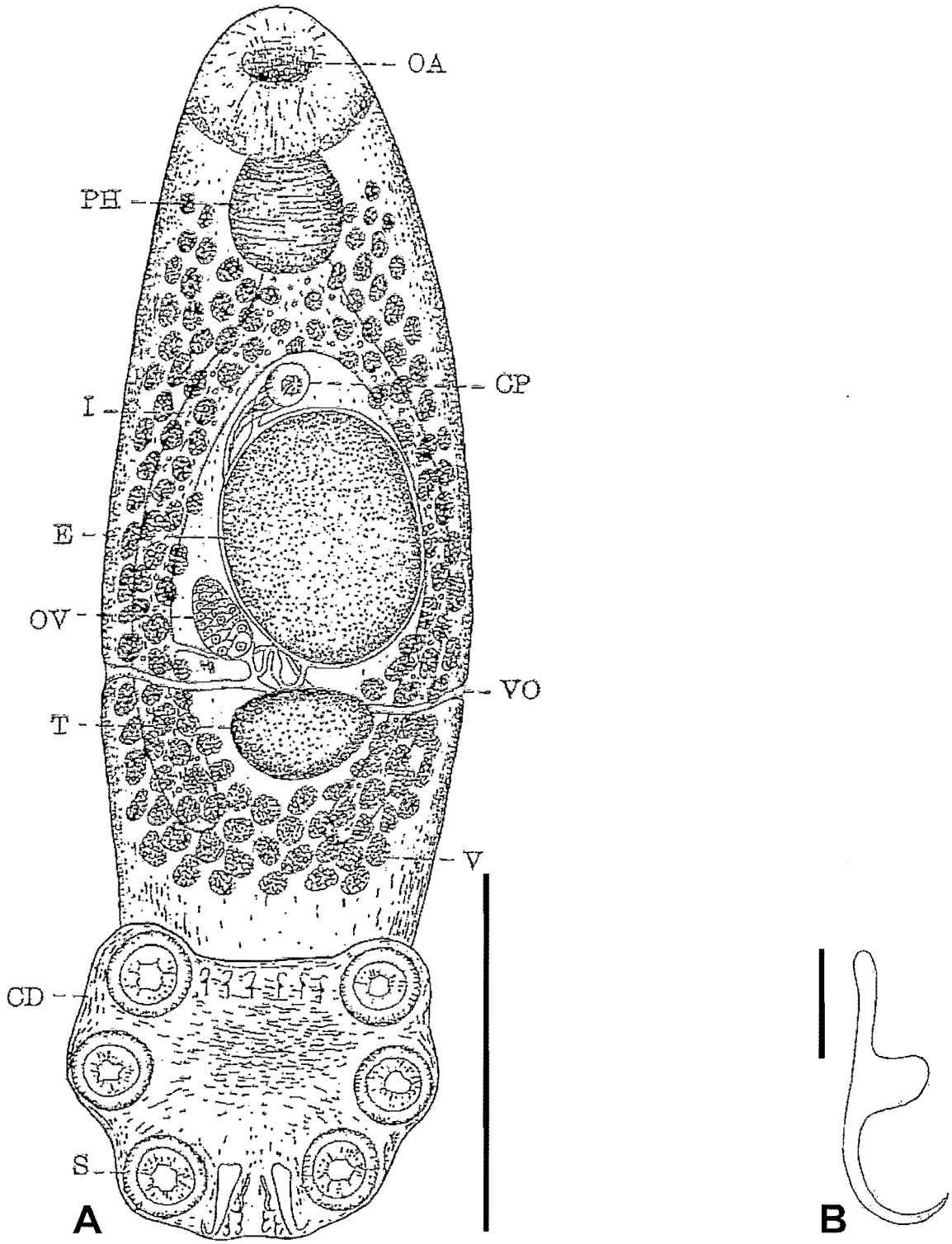


Figure 3.50: (A) *Polystomoides megaovum* Ozaki, 1936 (Scale bar = 500µm). Abbreviations: CD – caudal disc; CP – cirrus pouch; E – egg; I – intestinal diverticulum; OA – oral aperture; OV – ovary; PH – pharynx; S – sucker; T – testis; V – vitellarium; VO – vaginal opening; (B) Marginal hooklet (Scale bar = 10µm). Copied from Ozaki (1936).

Polystomoides microrchis

Fukui & Ogata, 1936

Table 3.53; Figure 3.51

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fukui and Ogata (1936).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: In the Taipei area, Formosa, China.

Other localities: None.

Type host: *Ocadia sinensis* [*Mauremys sinensis* (Gray, 1834)]. Chinese stripe-necked turtle.
Additional hosts: None.

Site on type host: Mouth.

Information on the host

Taxonomy: *Ocadia sinensis* is now known as *Mauremys sinensis* (Gray, 1834).

Geographical distribution: This species has a fragmented range in southern China (Fujian, Hangzhou, Suzhou, Kwangju, Shanghai, Taiwan and Hainan), and at least the Red River watershed of Vietnam.

Ecology: This species is classified as endangered by the Turtle Conservation Fund.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.53: Measurements of *P. microrchis*	
CHARACTERISTICS	Fukui & Ogata (1936)
Mature specimens (n)	
Body Length	5300
Greatest Width	2035
Width at Vagina	
Haptor Length	1270
Haptor Width	1900
Oral Diameter	730 x 400
Pharynx Length	430
Pharynx Diameter	540
Testis Length	540
Testis Width	430
Ovary Length	330
Ovary Width	190
Egg Length	270
Egg Diameter	190
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	270 x 250
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	42 – 47
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	75 – 88
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	390 – 430
Hamulus Length 1	97 – 110 x 17 – 22
Hamulus Length 2	47 – 55
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	22 – 25
Haptor L/Body L	0.2396

Remarks

~ This species is similar to *P. japonicum*, but differs in the fact that it has a substantially smaller testis, more genital spines, and a larger egg (Fukui & Ogata, 1936).

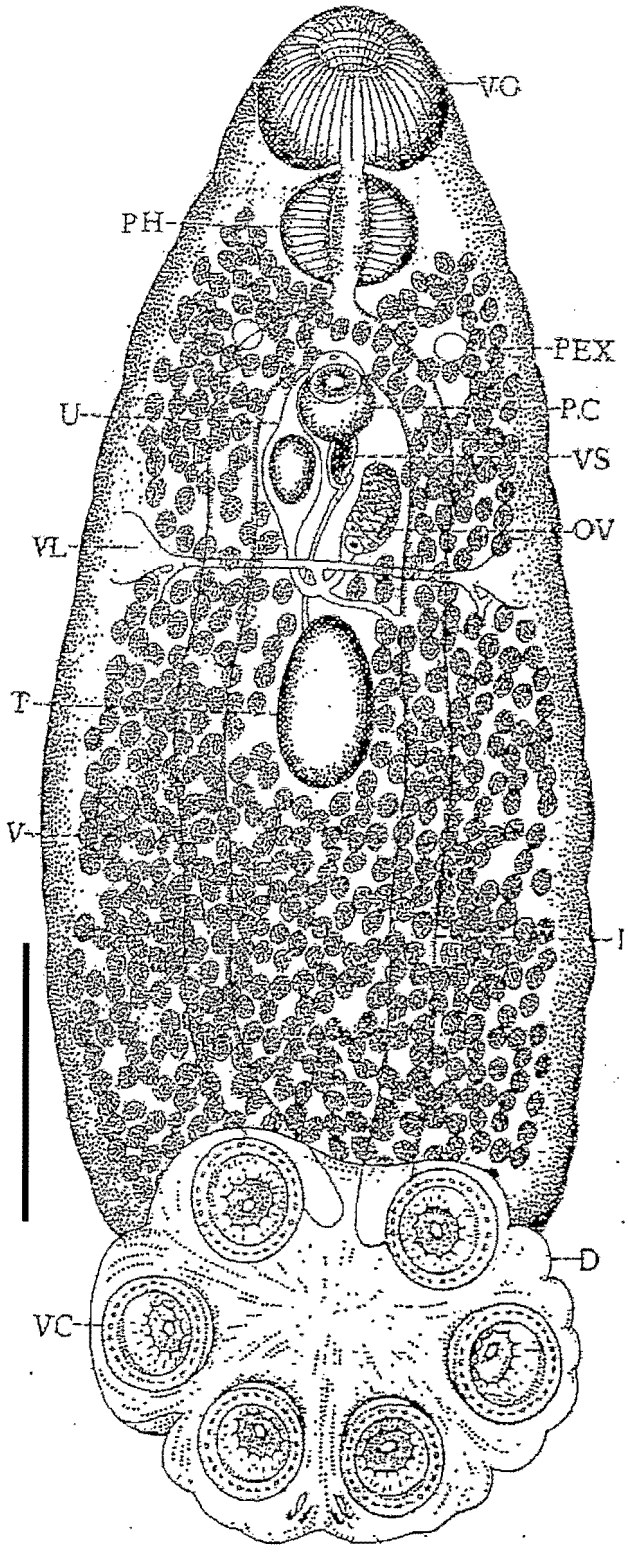


Figure 3.51: *Polystomoides microrchis* Fukui & Ogata, 1935. Abbreviations: D – haptor; I – intestine; OV – ovary; PC – genital bulb; PEX – excretory pore; PH – pharynx; T – testis; U – uterus; V – vitellaria; VC – haptoral sucker; VO – oral sucker; VL – vagina; VS – seminal vesicle (Scale bar = 1000µm). Copied from Fukui and Ogata (1936).

Polystomoides multifalx

(Stunkard, 1924)

Table 3.54; Figure 3.52

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Stunkard (1924b).

Other taxonomic contributions: Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.

Synonyms: *P. multifalx* has one synonym: *P. stunkardi* (Harwood, 1931).

Type locality: Central Florida, U.S.A.

Other localities: None.

Type host: *Pseudemys floridana* (LeConte, 1830). Common cooter.
Additional hosts: *Pseudemys concinna concinna.*

Site on type host: Pharyngeal region.

Information on the host

Taxonomy: *Pseudemys floridana* has two subspecies: *P. f. floridana* (LeConte, 1830) and *P. f. peninsularis* Carr, 1938.

Geographical distribution: This species occurs in south-eastern U.S.A., along the Atlantic coastal plain down to south Florida, and north to Virginia Western. The distribution reaches as far as Mobile Bay, Alabama. The species is also abundant in Georgia and South Carolina.

Ecology: This species is widely distributed but suffers from predation by raccoons, opossums, certain carnivorous fish, other terrapins, alligators, and birds. Populations seem to be dropping because of pollution due to fertilizers and chemicals.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.54: Measurements of *P. multifalx*	
CHARACTERISTICS	**Stunkard (1924b)**
Mature specimens (n)	2
Body Length	4000 – 5000
Greatest Width	1400 – 2100
Width at Vagina	
Haptor Length	
Haptor Width	
Oral Diameter	600 x 800
Pharynx Length	460
Pharynx Diameter	620
Testis Length	430 – 540
Testis Width	400 – 520
Ovary Length	90 – 100
Ovary Width	
Egg Length	210
Egg Diameter	200 – 180
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	370 – 460 x 460 – 530
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	120 – 124
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	400 – 460
Hamulus Length 1	200
Hamulus Length 2	100
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	30
Haptor L/Body L	

Remarks

~ Stunkard (1924b) noted that the species is characterised by heavy musculature, the large size of the oral sucker pharynx, the large cirrus sac bearing many hooks in the genital coronet.
~ Ozaki (1935) simply changed the name from *Polystoma* to *Polystomoides*, but gave no other details.
~ Mañé-Garzón and Gil (1962) stated that the species was also found in the oesophagus of *Pseudemys concinna concinna* (LeConte, 1830) from North America.

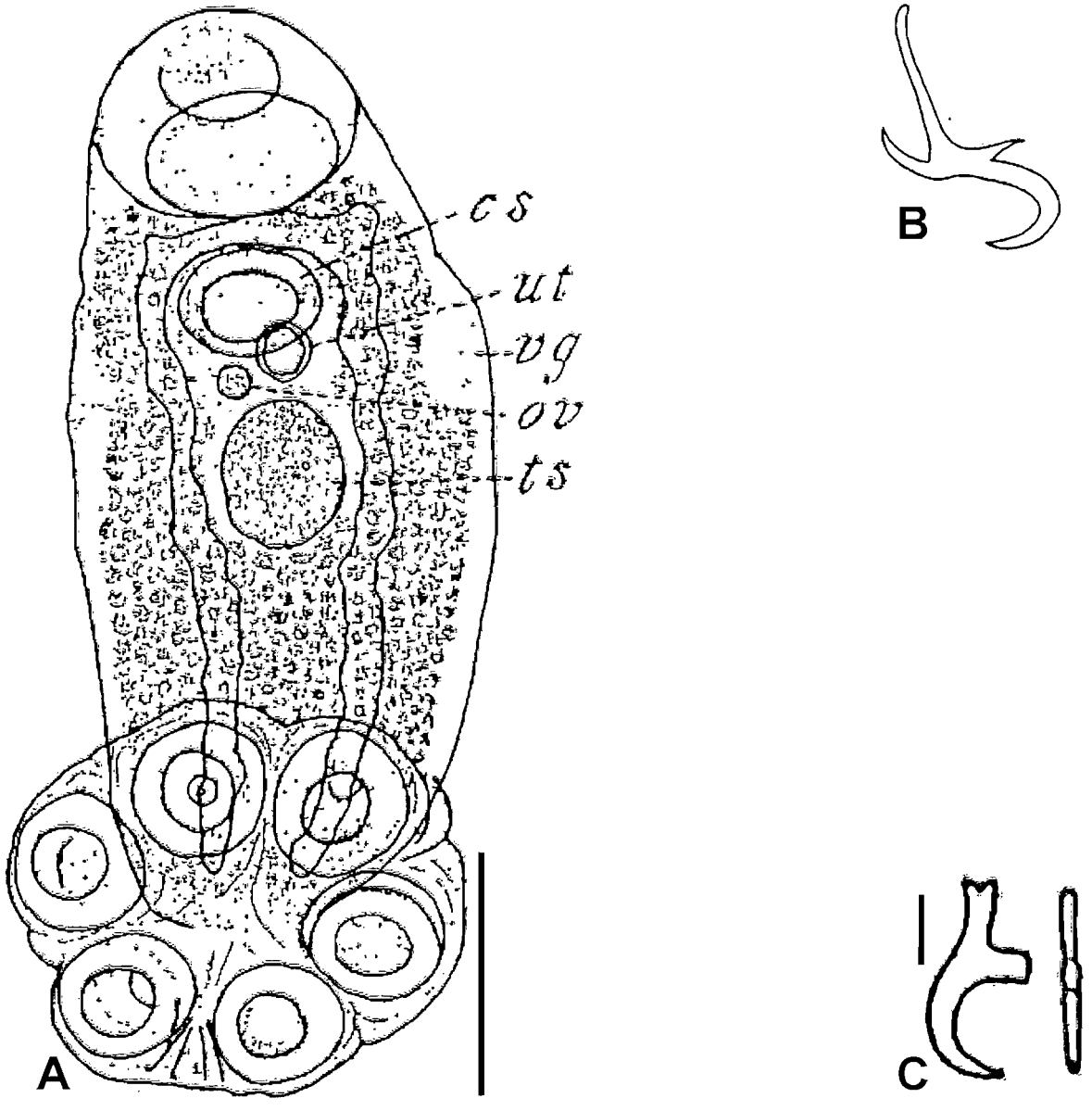


Figure 3.52: (A) *Polystomoides multifalx* (Stunkard, 1924). Abbreviations: cs – cirrus sac; ov – ovary; ts – testis; ut – uterus; vg – vagina (Scale bar = 1000µm); (B) Genital spine (Scale unknown); (C) marginal hooklets (Scale bar = 10µm). Copied from Stunkard (1924b).

Junior synonym of *Polystomoidella multifalx*

Tables 3.55 and 3.56; Figure 3.53

General

	Table 3.55: *Polystomoides stunkardi* (Harwood, 1931)
Collection	U.S. National Museum.
Original description	Harwood (1931).
Reprint no	[3980]
Other taxonomic contributions	Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.
Type locality	Lake Taliwanda, McAlester, Oklahoma, U.S.A.
Type host	*Pseudemys hieroglyphica* [*Pseudemys concinna concinna* (LeConte, 1830)]. Eastern River turtle.
Additional hosts	None.
Site on host	Mouth.

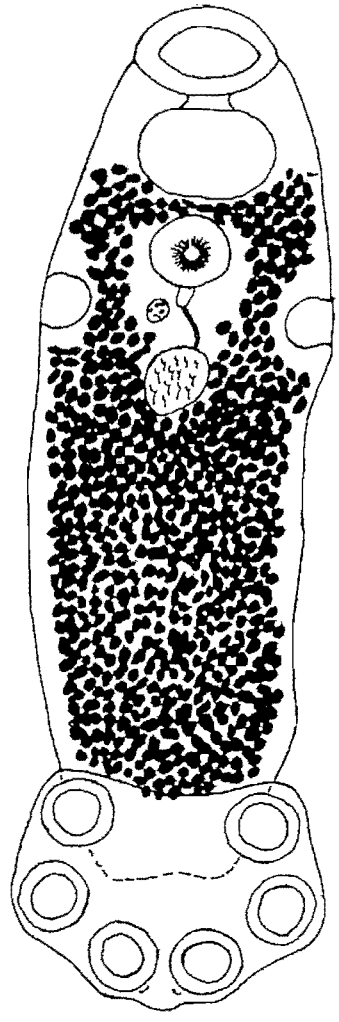


Figure 3.53: *Polystomoides stunkardi*. Copied from Harwood (1931).

Remarks

~ This species is very similar to *P. multifalx*, but has fewer genital hooks (120 – 124), a smaller cirrus sac and testis, and differs in the arrangement of the suckers on the haptor (Harwood, 1931).

Information on the parasite

Table 3.56*: Measurements of *P. stunkardi

CHARACTERISTICS	Harwood (1931)
Mature specimens (n)	
Body Length	3600 – 5000
Greatest Width	1200 – 1800
Width at Vagina	
Haptor Length	
Haptor Width	
Oral Diameter	360 – 500 x 550 – 750
Pharynx Length	360 – 550
Pharynx Diameter	500 – 750
Testis Length	300 – 410 (circular)
Testis Width	
Ovary Length	75 – 115 (spherical)
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	250 – 380
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	92 – 109
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	80
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	
Hamulus Length 1	125 – 140
Hamulus Length 2	24 – 80
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	20
Haptor L/Body L	

Polystomoides nabedei

Kulo, 1980

Table 3.57; Figure 3.54

General

Collection: National Museum of Natural History of Paris.
Holotype no: TJ 63.
Paratype no: None.

Original description: Kulo (1980).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Temporary pond in Siborototi (Dapaong, Togo), Africa.

Other localities: None.

Type host: *Pelomedusa subrufa* (Lacépède, 1788). Common African helmeted turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: Although three subspecies were distinguished (*P. s. subrufa* (Lacépède, 1788), *P. s. nigra* (Gray, 1863), and *P. s. olivacea* (Schweigger, 1812)), Fritz & Havaš (2007) refers to Gasperetti *et al.* (1993) (who states that *P. subrufa* should be treated as a monotypical species because morphological variation does not conform with the suggested subspecies delineation), and states that a range wide morphological and phylogeographic investigation is in urgent need.

Geographical distribution: This species occupies the entire African continent south of the Sahara (southern Arab Peninsula, subtropical and tropical Africa from Ethiopia, southern Saudi-Arabia, and the Sudan westward to Ghana, Senegal, Mali, Nigeria, and Cameroon, and southward to the Cape Provinces of South Africa), and also occurs in western and southern Madagascar and Yemen, presumably introduced there by humans.

Ecology: The species is widely captured for food as well as sold to motorists, but its modest size does not make them a cherished food item, thus collection does not lead to drastic declines, and the populations seem to be in good shape.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.57: Measurements of *P. nabedei*	
CHARACTERISTICS	**Kulo (1980)**
Mature specimens (n)	10
Body Length	2940 (2280 – 3370)
Greatest Width	1080 (860 – 1210)
Width at Vagina	
Haptor Length	650 (460 – 760)
Haptor Width	900 (760 – 1010)
Oral Diameter	356 (284 – 445) x 248 (210 – 294)
Pharynx Length	223 (142 – 285)
Pharynx Diameter	185 (134 – 226)
Testis Length	413 (294 – 588)
Testis Width	254 (142 – 420)
Ovary Length	167 (126 – 252)
Ovary Width	79 (58 – 109)
Egg Length	275 – 332
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	140 (126 – 168)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	36 – 39
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	42 – 46
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	156 (152 – 163)
Hamulus Length 1	324 (294 – 344)
Hamulus Length 2	110 (92 – 151)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	23 – 24
Haptor L/Body L	0.2211

Remarks

~ This species is similar to *P. chabaudi*, but its large hamuli are longer, the insertion of the hilt of the small hamuli is near the end and not the middle, and its vitellaria is more developed in the post-testicular area of the parasite (Kulo, 1980).

~ This species' biological cycle is similar to *Eupolystoma alluaudi* (De Beauchamp, 1913): egg development in the uterus, existence of two types of larvae, population inflation in the bladder by an internal cycle, and development of the larvae in the uterus (Kulo, 1980).

~ Kulo (1980) speculated that because they share the same host and circumstances, *P. chabaudi* and *P. nabedei* may have a common ancestor.

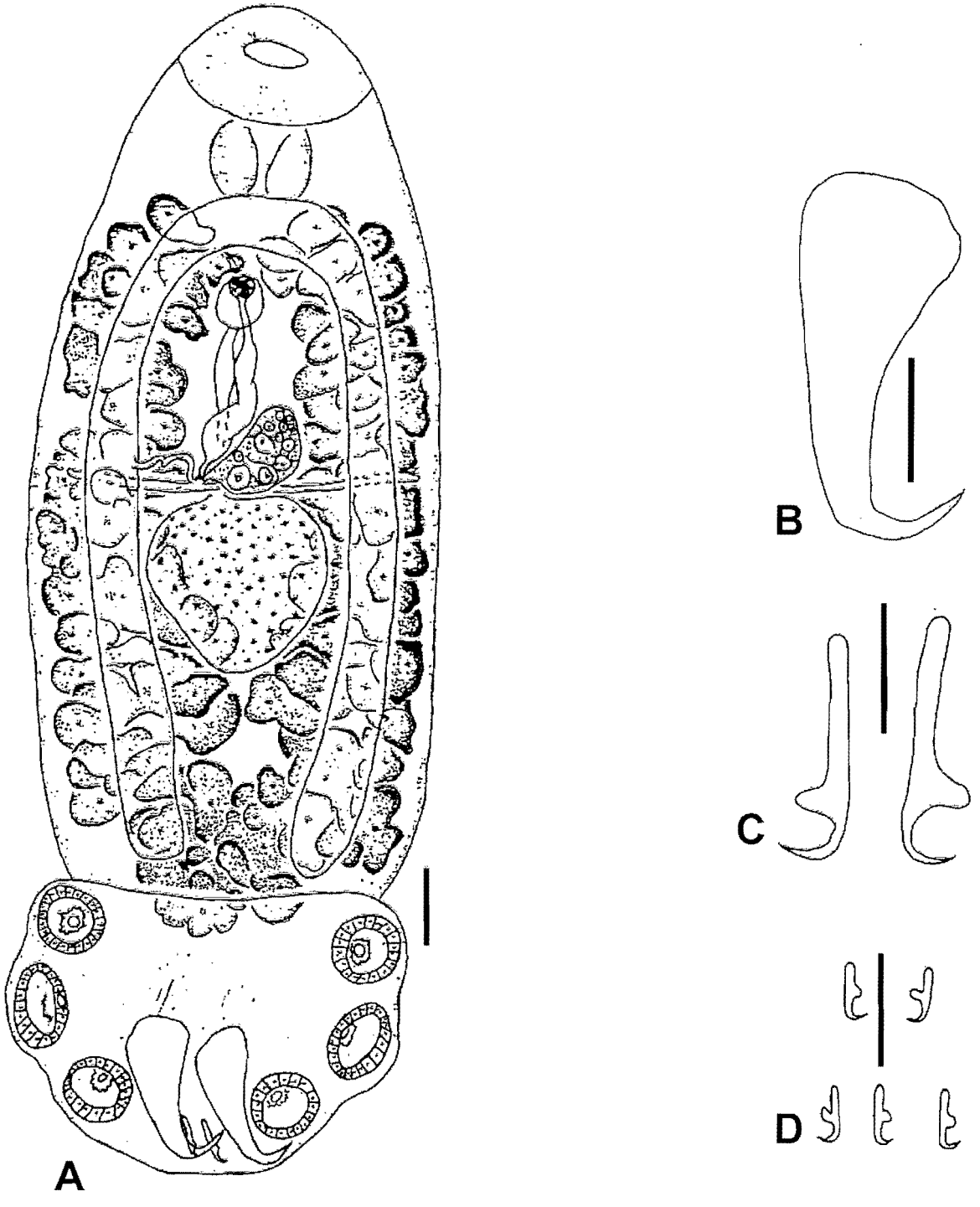


Figure 3.54: (A) *Polystomoides nabedei* Kulo, 1980 (Scale bar = 150µm); (B) Large hamulus (Scale bar = 100µm); (C) Small hamuli (Scale bar = 50µm); (D) Marginal hooklet (Scale bar = 50µm). Copied from Kulo (1980).

Polystomoides ocadiae

Fukui & Ogata, 1936

Table 3.58; Figure 3.55

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fukui and Ogata (1936).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Taipei, Formosa, China.

Other localities: None.

Type host: *Ocadia sinensis* [*Mauremys sinensis* (Gray, 1834)]. Chinese stripe-necked turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Ocadia sinensis* is now known as *Mauremys sinensis* (Gray, 1834).

Geographical distribution: This species has a fragmented range in southern China (Fujian, Hangzhou, Suzhou, Kwangju, Shanghai, Taiwan and Hainan), and at least the Red River watershed of Vietnam.

Ecology: This species is classified as endangered by the Turtle Conservation Fund.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.58: Measurements of *P. ocadiae*	
CHARACTERISTICS	Fukui & Ogata (1936)
Mature specimens (n)	
Body Length	7300 – 9000; 3200 – 5240; 3950
Greatest Width	1800 – 2200; 1140 – 1850; 1560
Width at Vagina	
Haptor Length	860
Haptor Width	1270
Oral Diameter	390 x 490
Pharynx Length	
Pharynx Diameter	250
Testis Length	560
Testis Width	830
Ovary Length	270
Ovary Width	130
Egg Length	330
Egg Diameter	220
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	250
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	46 – 59
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	69
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	270 – 320
Hamulus Length 1	640 x 190
Hamulus Length 2	330
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	25
Haptor L/Body L	0.2177

Remarks

~ This species is similar to *Neopolystoma exhamatum* in terms of the shape of the haptoral suckers, spreading of the vitellaria, the features and structures of the sex organs, and the non-smoothness of the haptor. However, it is distinguished by having a different number of genital spines as well as possessing two pairs of well-defined hamuli (Fukui & Ogata, 1936).

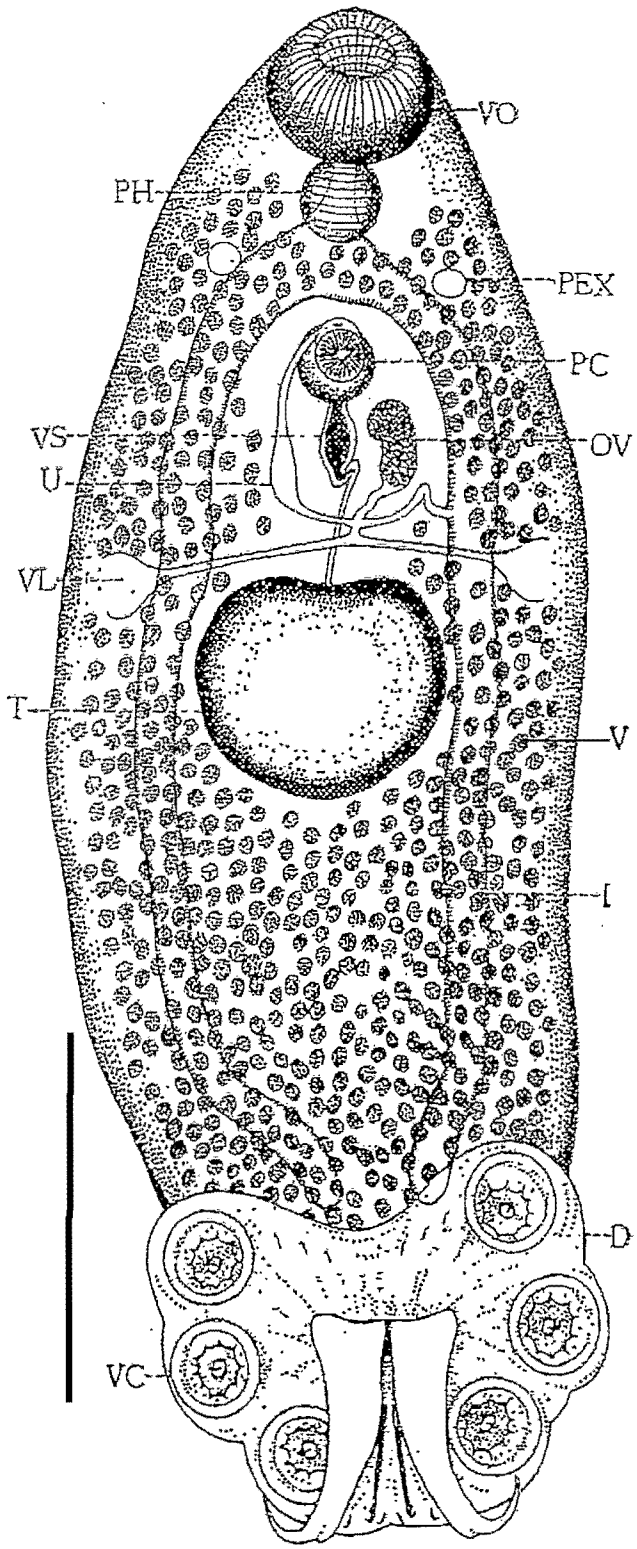


Figure 3.55: *Polystomoides ocadiae* Fukui & Ogata, 1935. Abbreviations: D – haptor; I – intestine; OV – ovary; PC – genital bulb; PEX – excretory pore; PH – pharynx; T – testis; U – uterus; V – vitellaria; VC – haptoral sucker; VO – oral sucker; VL – vagina; VS – seminal vesicle (Scale bar = 1000µm). Copied from Fukui and Ogata (1935).

Polystomoides ocellatum

(Rudolphi, 1819)

Table 3.59; Figure 3.56

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Rudolphi (1819).

Other taxonomic contributions: Ozaki, Y. 1935. Journal of Science of the Hiroshima University 3: 193 – 223.

Synonyms: None.

Type locality: Europe, France (Knoepffler & Combes, 1977).

Other localities: None.

Type host: *Testudinis orbicularis* [*Emys orbicularis* (Linnaeus, 1758)]. Common European pond turtle.
Additional hosts: *Emys orbicularis orbicularis*; *Caretta caretta*; *Mauremys caspica*.

Site on type host: Oral and nasal cavities.

Information on the host

Taxonomy: *Testudinis orbicularis* is now known as *Emys orbicularis* and has 14 subspecies: *E. o. orbicularis* (Linnaeus, 1758), *E. o. capolongoi* Fritz, 1995, *E. o. colchica* Fritz, 1994, *E. o. eiselti* Fritz, Baran, Budak & Amthauer, 1998, *E. o. fritzjuergenobsti* Fritz, 1993, *E. o. galloitalica* Fritz, 1995, *E. o. hellenica* (Valenciennes, 1832), *E. o. hispaica* Fritz, Keller & Budde, 1996, *E. o. iberica* Eichwald, 1831, *E. o. ingauna* Jesu, Piombo, Salvidio, Lamagni, Ortale & Genta, 2004, *E. o. lanzai* Fritz, 1995, *E. o. luteofusca* Fritz, 1989, *E. o. occidentalis* Fritz, 1993, and *E. o. persica* Eichwald, 1831.

Geographical distribution: This species has a very wide range from western North Africa over most of southern, central, and eastern Europe. It occurs from northern Germany and Poland in the north to Morocco in the south and the Caspian coast of Iran in the east, and also occurs in Lithuania, France, Portugal, Spain, Tunisia, Italy, Sardinia, Corsica, Asia Minor, Aral Seas, and all the nations of the former Yugoslavia, Albania, Greece, Turkey, and northern Black Sea nations.

Ecology: The species is completely protected by law throughout its range, but its habitats are being degraded, and American terrapins that are released or escaped are encroaching on their habitat and food. More and more protection measurements are being taken, and this is now one of the most studied and best protected species due to the mobilization of specialists.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.59: Measurements of *P. ocellatum*	
CHARACTERISTICS	**Knoepffler & Combes (1977)**
Mature specimens (n)	4
Body Length	3463 (3130 – 4060)
Greatest Width	1143 (110 – 1170)
Width at Vagina	
Haptor Length	1125 (1000 – 1200)
Haptor Width	1323 (1230 – 1370)
Oral Diameter	333 (318 – 350)
Pharynx Length	221 (193 – 248)
Pharynx Diameter	311 (276 – 331)
Testis Length	536 (400 – 660)
Testis Width	501 (415 – 590)
Ovary Length	235 (219 – 260)
Ovary Width	122 (114 – 130)
Egg Length	248 (230 – 260)
Egg Diameter	193 (172 – 200)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	139 (115 – 170)
Gen. Bulb Hook set (n)	
Gen. Bulb Hooks 1 (n)	29 – 34
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	short = 27 – 28; long = 25 – 37
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	
Hamulus Length 1	58 (55 – 62)
Hamulus Length 2	55 (43 – 68)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.3249

Remarks

~ Rudolphi (1819) provided no measurements or sketches of the species.
~ Ozaki (1935) only renamed *Polystoma ocellatum* to *Polystomoides ocellatum*, and gave no other information.
~ Mañé-Garzón and Gil (1962) reported the species in the nose and pharynx of *Emys orbicularis orbicularis* (Linnaeus, 1758) and *Caretta caretta* (Linnaeus, 1758) from Europe.
~ Knoepffler and Combes (1977) stated that the data body of the species gives the number of genital spines as 23 – 41, and also found the species in *Emys orbicularis* from Corsica.

~ Combes and Thierry (1983) found the species in *Mauremys caspica* (Gmelin, 1774) from Morocco.

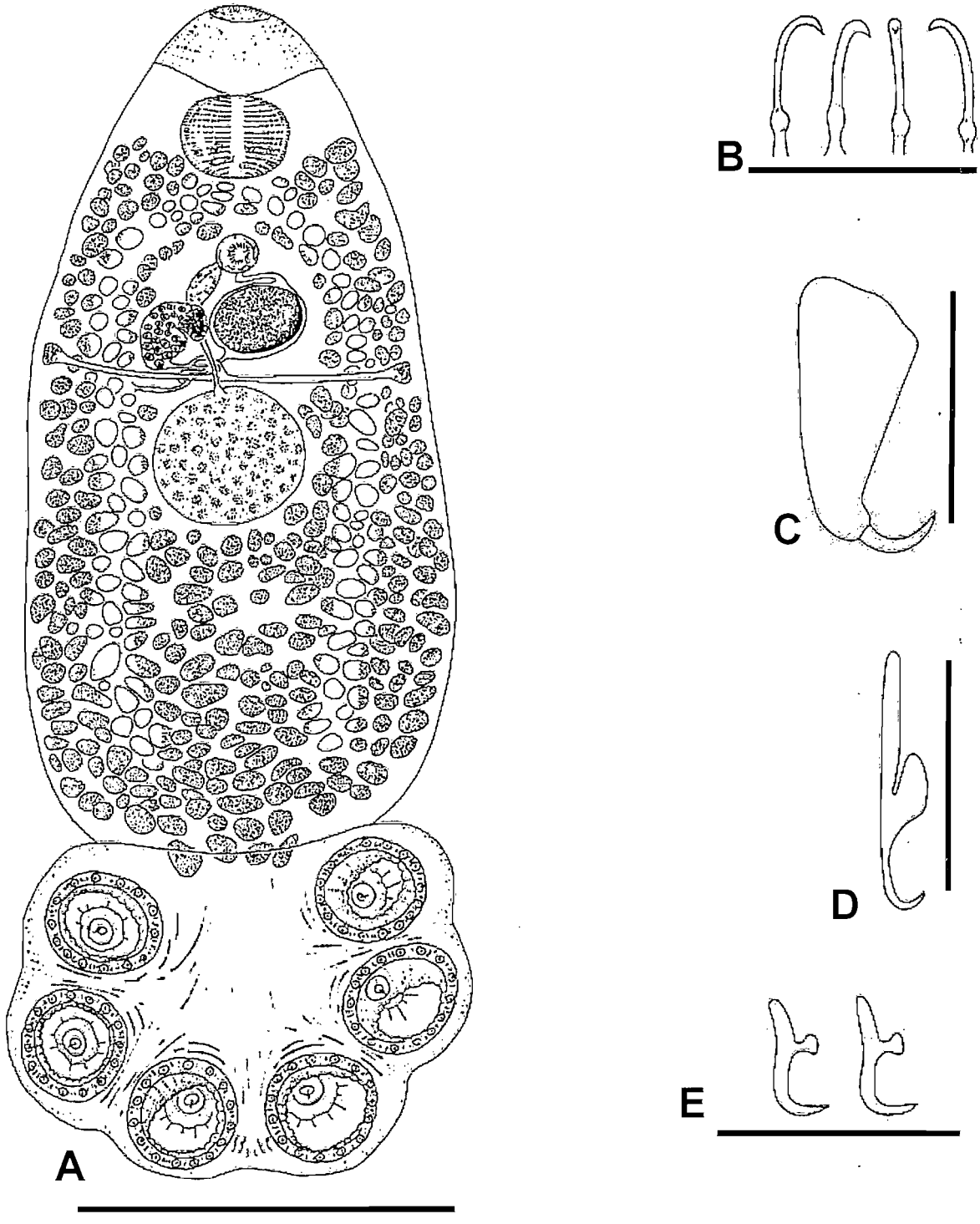


Figure 3.56: (A) *Polystomoides ocellatum* (Rudolphi, 1819) (Scale bar = 1000µm); (B) Genital spines (Scale bar = 50µm); (C) Large hamulus (Scale bar = 50µm); (D) Small hamulus (Scale bar = 50µm); (E) Marginal hooklets (Scale bar = 50µm). Copied from Knoepffler & Combes (1977).

Polystomoides oris

Paul, 1938

Table 3.60; Figure 3.57

General

Collection: American Museum of Natural History, New York, U.S.A.
Holotype no: None.
Paratype no: None.

Original description: Paul (1938).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Cold Spring, New York, U.S.A.

Other localities: None.

Type host: *Chrysemys picta* (Schneider, 1783). Painted turtle.
Additional hosts: None.

Site on type host: Oral cavity.

Information on the host

Taxonomy: *Chrysemys picta* has four subspecies: *C. p. picta* (Schneider, 1783), *C. p. bellii* (Gray, 1831), *C. p. dorsalis* Agassiz, 1857, and *C. p. marginata* Agassiz, 1857.

Geographical distribution: This species has a very wide range in most of the United States, in Souuthern Canada, from Nova Scotia to British Columbia, and south to Georgia, Alabama, Mississippi, Louisiana, Oklahoma, Colorado, Wyoming, Idaho, and Oregon. The species can also be found in scattered localities in Texas, New Mexico, Arizona, Utah, and Chihuahua, Mexico, and has also been introduced in California.

Ecology: This species' worst predator is the raccoon, which can detect and excavate eggs. Other threats also include habitat degradation and highways.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.60: Measurements of *P. oris*	
CHARACTERISTICS	Paul (1938)
Mature specimens (n)	12
Body Length	3600 (2900 – 4200)
Greatest Width	1100 (800 – 1600)
Width at Vagina	
Haptor Length	720 – 1100
Haptor Width	950 – 1300
Oral Diameter	570
Pharynx Length	
Pharynx Diameter	555 (500 – 650)
Testis Length	200 – 450
Testis Width	240 – 500
Ovary Length	90 – 260
Ovary Width	
Egg Length	250
Egg Diameter	180
Egg incubation time	2/3 per 24h
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	24 – 28 (usually 27)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	58
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	315 (300 – 360)
Hamulus Length 1	120
Hamulus Length 2	65
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	30
Haptor L/Body L	

Remarks

~ This species differs from other polystome species in the relative size of the pharynx, the form of the intestine, and the number of cirrus spines (Paul, 1938).

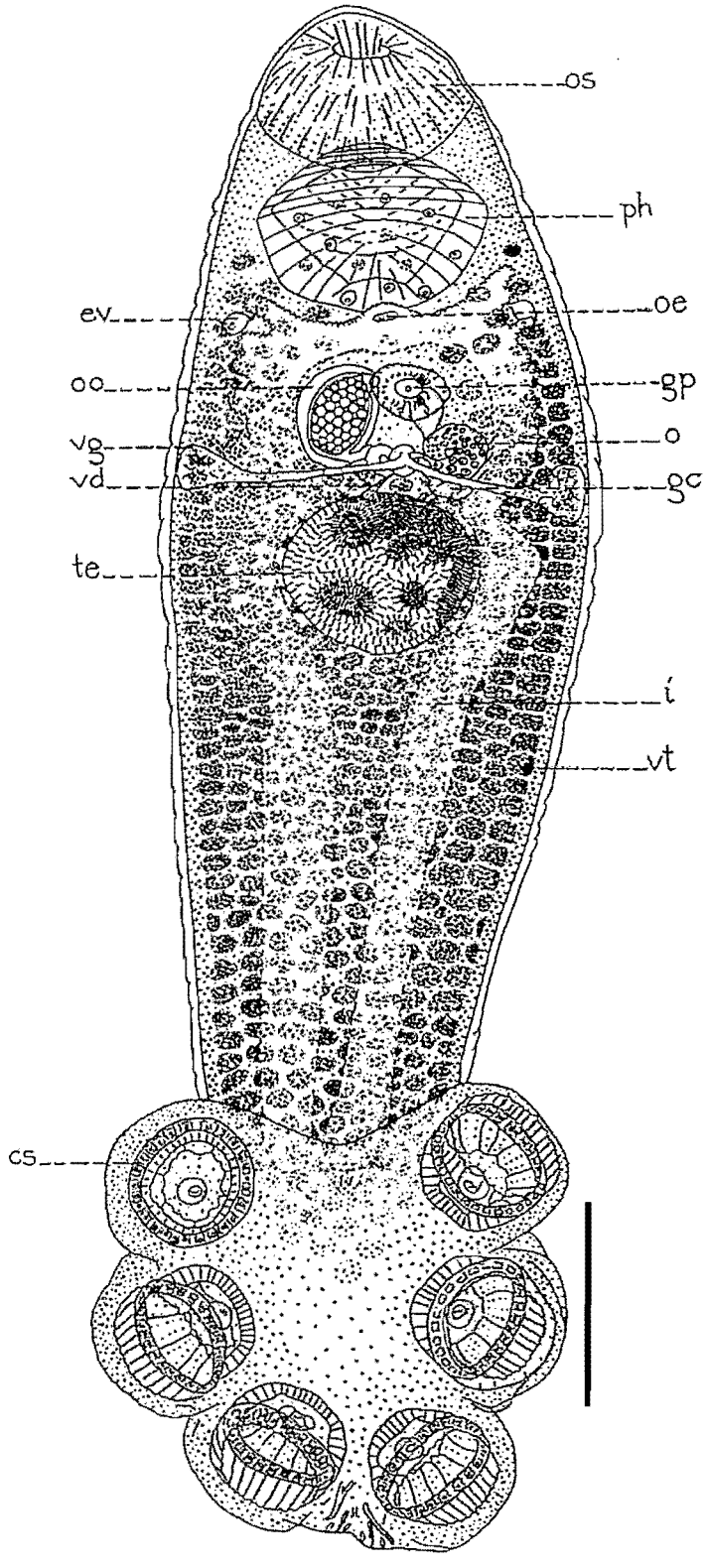


Figure 3.57: *Polystomoides oris* Paul, 1938. Abbreviations: cs – caudal sucker; ev – excretory vesicle; gc – genito-intestinal canal; gp – genital pore; I – intestine; o – ovary; oe – esophagus; oo – oötype; os – oral sucker; ph – pharynx; te – testis; vd – vas deferens; vg – vagina; vt – vitellaria (Scale bar = 500µm). Copied from Paul (1938).

Polystomoides pauli

Timmers & Lewis, 1979

Table 3.61; Figure 3.58

General

Collection: National Museum Helminthological Collection[Φ]; National Museum of Canada Parasitology Collection[Φ]; and in the author's private collection.
Holotype no: 74736[Φ].
Paratype no: 74737[Φ]; 1978-187[Φ].

Original description: Timmers and Lewis (1979).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Brokenhead River and Whitemouth River, Manitoba, Canada.

Other localities: None.

Type host: *Chrysemys picta belli* (Gray, 1831). Western painted turtle.
Additional hosts: *Chrysemys picta dorsalis*.

Site on type host: Oral mucosa.

Information on the host

Taxonomy: *Chrysemys pictq* (Schneider, 1783) has three subspecies: *C. p. picta* (Schneider, 1783), *C. p. dorsalis* Agassiz, 1857, and *C. p. marginata* Agassiz, 1857.

Geographical distribution: This species can be found in western and central North America, from western Ontario across southern Canada to British Columbia, Canada, and south to Missouri, northern Oklahoma, eastern Colorado, Wyoming, Idaho, and northern Oregon. It also occurs in scattered localities in the south-western U.S.A., and in one area in Chihuahua, Mexico.

Ecology: The worst predator for this species is the raccoon, which detects its nests and eats its eggs. Other threats include highways and habitat degradation.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.61: Measurements of *P. pauli*	
CHARACTERISTICS	Timmers & Lewis (1979)
Mature specimens (n)	10
Body Length	6120 (4950 – 7830)
Greatest Width	
Width at Vagina	1660 (1410 – 1990)
Haptor Length	1790 (1480 – 2150)
Haptor Width	1700 (1480 – 2130)
Oral Diameter	537 (430 – 722) x 833 (612 – 951)
Pharynx Length	642 (503 – 777)
Pharynx Diameter	795 (631 – 941)
Testis Length	543 (402 – 740)
Testis Width	513 (338 – 658)
Ovary Length	405 (329 – 448)
Ovary Width	129 (100 – 155)
Egg Length	228 (213 – 241)
Egg Diameter	157 (143 – 170)
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	39 (36 – 49)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	408 (366 – 466)
Hamulus Length 1	135 (116 – 146)
Hamulus Length 2	70 (61 – 77)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	27 (25 – 27)
Haptor L/Body L	0.2925

Remarks

~ This species is similar to *P. coronatum*, *P. oris*, *P. kachugai*, *P. asiaticus*, and *P. japonicus* in three or more of the following characteristics: the relative sizes of the pharynx and oral sucker, number of genital coronet spines, the length of the great hooks, the shape of the great hooks, or the presence of cecal diverticula anterior to the excretory bladders. Despite all of this, *P. pauli* most closely resembles *P. coronatum* and *P. oris*. It differs from *P. coronatum* in having a larger number of genital coronet spines, larger genital coronet spines, and in the possession of anterior cecal diverticula. It also differs

from *P. oris* in its greater size, larger number of genital coronet spines, and in the possession of great hooks having entire roots (Timmers & Lewis, 1979).

~ Platt (2000a) found the species in *Chrysemys picta dorsalis* (Gray, 1831) from Michigan, U.S.A.

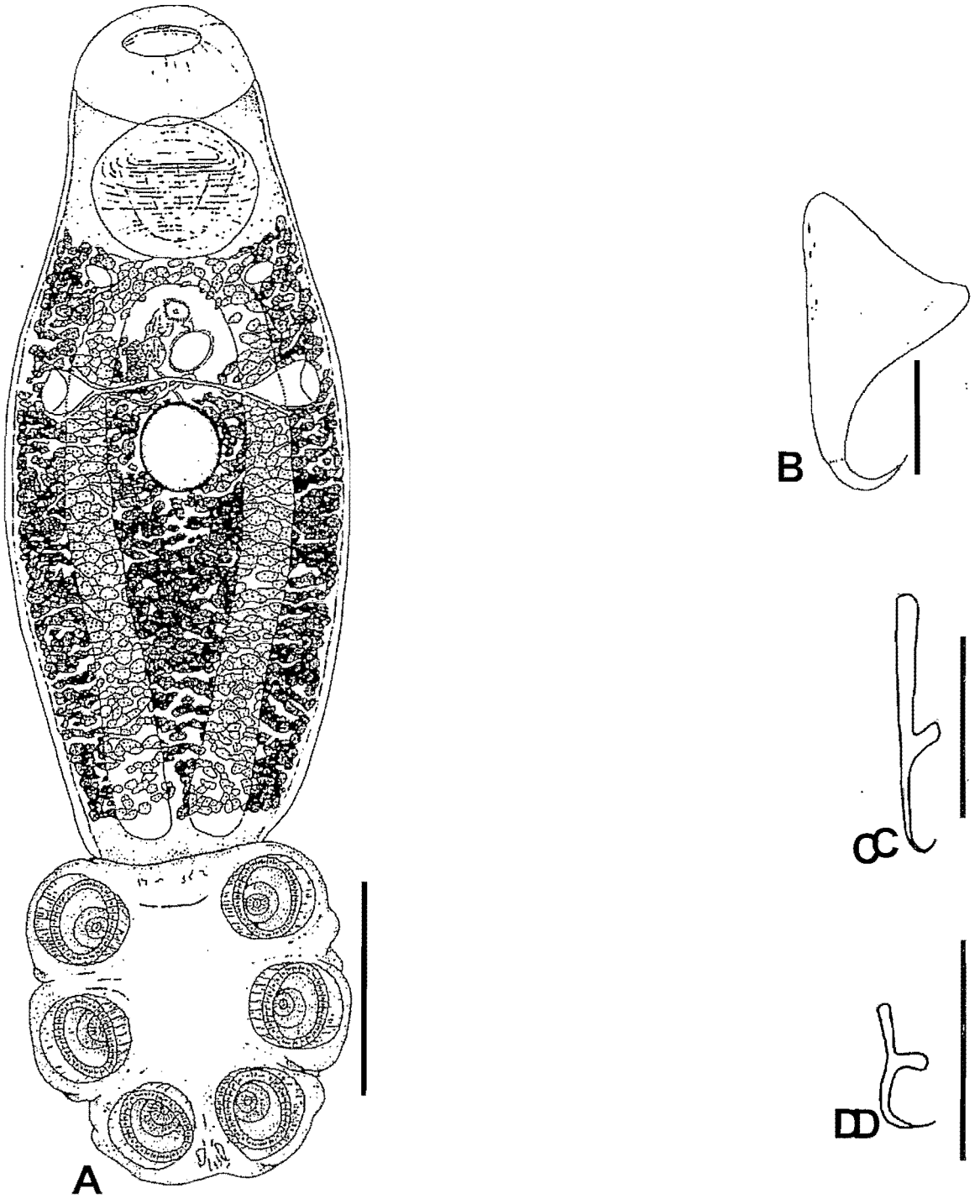


Figure 3.58: (A) *Polystomoides pauli* Timmers & Lewis, 1979 (Scale bar = 1000µm); (B) Large hamulus (Scale bar = 50µm); (C) Small hamulus (Scale bar = 50µm); (D) Marginal hooklet (Scale bar = 50µm). Copied from Timmers and Lewis (1979).

Polystomoides platynotae

Combes & Rohde, 1979

Table 3.62; Figure 3.59

General

Collection: National Museum of Natural History of Paris.
Holotype no: 238 PE (blade Tj 50).
Paratype no: 239 PE (blade Tj 51).

Original description: Combes and Rohde (1979).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Malaysia.

Other localities: None.

Type host: *Notochelys platynota* (Gray, 1834). Malayan flat-shelled turtle.
Additional hosts: None.

Site on type host: Oral cavity.

Information on the host

Taxonomy: None.

Geographical distribution: This species occurs from peninsular Thailand southward through Malaysia, Sumatra, and Java to Borneo.

Ecology: This terrapin is scarce and poorly known, and for lack of information receives no legal protection. However, the species is sometimes eaten, kept in ponds, and captured for export.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.62: Measurements of *P. platynotae*	
CHARACTERISTICS	**Combes & Rohde (1979)**
Mature specimens (n)	2
Body Length	5070 (4920 – 5220)
Greatest Width	1835 (1610 – 2060)
Width at Vagina	
Haptor Length	1455 (1440 – 1470)
Haptor Width	1855 (1820 – 1890)
Oral Diameter	455 (440 – 470) x 761 (732 – 790)
Pharynx Length	470 (455 – 485)
Pharynx Diameter	510 (470 – 550)
Testis Length	490 (470 – 510)
Testis Width	388 (360 – 415)
Ovary Length	293 (285 – 300)
Ovary Width	105 (95 – 115)
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	0
Genital Bulb Diameter	233 (225 – 240)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	27 – 30
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	60 – 70
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	394 (373 – 414)
Hamulus Length 1	104 (100 – 108)
Hamulus Length 2	61 (60 – 62)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.2870

Remarks

~ This species is similar to *P. ocellatum*, *P. japonicum*, *P. asiaticus*, *P. renschi*, *P. microrchis*, and *P. cyclemydis*, but differs in the dimensions of the hamuli and genital spines, as well as other dimensions of the parasite (Combes & Rohde, 1979).

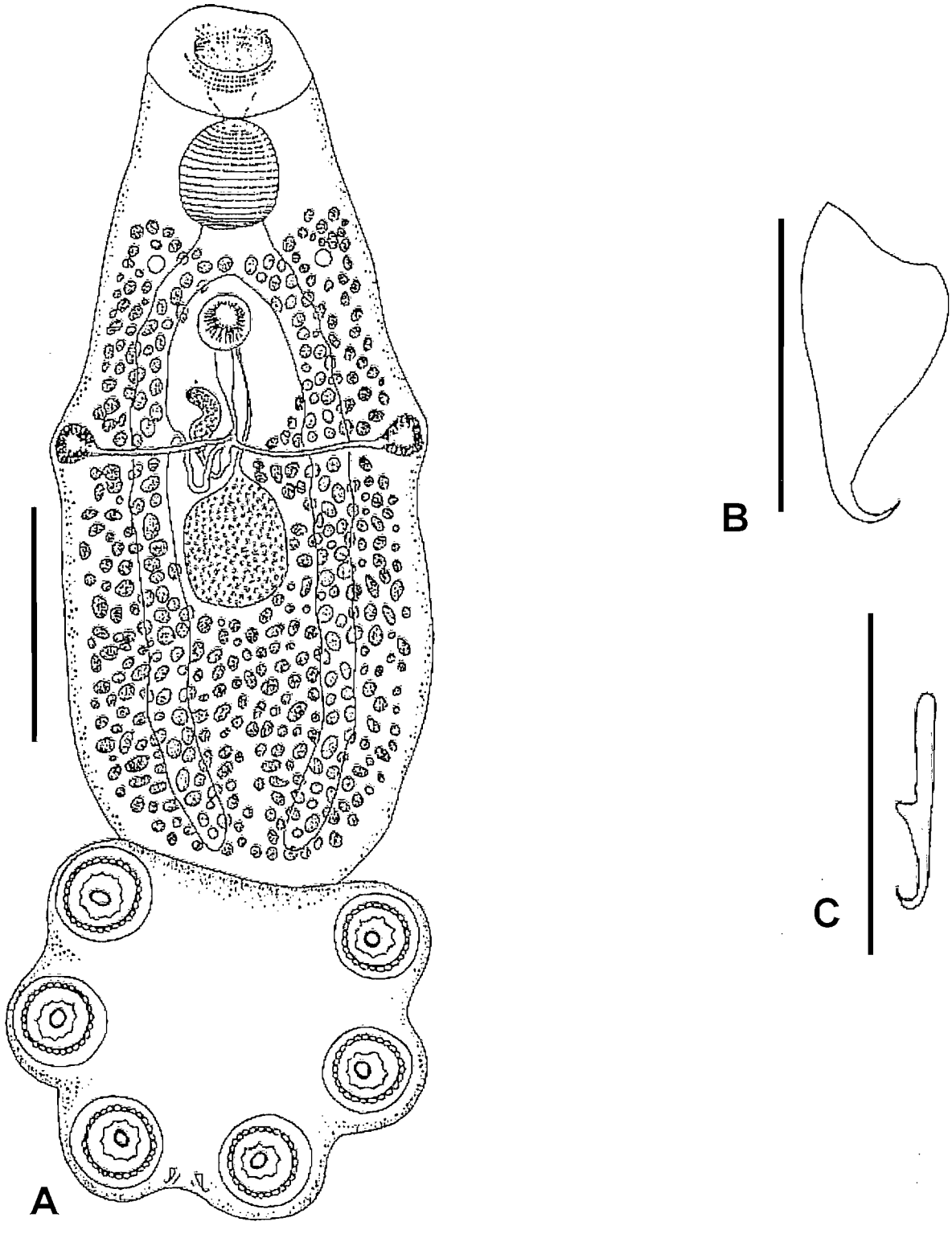


Figure 3.59: (A) *Polystomoides platynotae* Combes & Rohde, 1979 (Scale bar = 1000µm); (B) Large hamulus (Scale bar = 100µm); (C) Small hamulus (Scale bar = 100µm). Copied from Combes and Rohde (1979).

Polystomoides renschi

Rohde, 1965

Table 3.63; Figure 3.60

General

Collection: Syntypes are in the Helminthological Collection, Zoology Department, University of Malaya. Further specimens are in Helminthologische Sammlung der Humboldt University, Berlin, Helminthological Collection of the British Museum (Natural History), and the U.S. National Helminthological Collection.
Holotype no: None.
Paratype no: R220 – 222.

Original description: Rohde (1965).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Malaysia (Chinese shop in Kuala Lumpur).

Other localities: None.

Type host: *Siebenrockiella crassicollis* (Gray, 1831). Black marsh turtle.
Additional hosts: None.

Site on type host: Pharyngeal cavity.

Information on the host

Taxonomy: None.

Geographical distribution: This species has a fragmented range in south-east Asia, from southern Vietnam westward through Thailand to Tenasserim (Myanmar), and southward through Malaysia to Sumatra, Java, and Borneo (Thailand, southern Vietnam, the Malay Peninsula, Singapore).

Ecology: The species is sometimes consumed or sold in markets, but the flesh is little sought after. Despite this, populations may be dropping because of progressive fragmentation of their habitat.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.63: Measurements of *P. renschi*	
CHARACTERISTICS	**Rohde (1965)**
Mature specimens (n)	9
Body Length	2600 (1800 – 3700)
Greatest Width	770 (430 – 110)
Width at Vagina	
Haptor Length	950 (650 – 1200)
Haptor Width	960 (800 – 150)
Oral Diameter	240 (220 – 300) x 340 (250 – 460)
Pharynx Length	200 (120 – 300)
Pharynx Diameter	270 (160 – 330)
Testis Length	220 (120 – 450)
Testis Width	200 (100 – 280)
Ovary Length	90 (40 – 100)
Ovary Width	150 (60 – 220)
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	100 (93 – 140) x 120 (105 – 140)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	24 (20 – 25)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	15 (short); 17 – 20 (long)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	250 (180 – 360)
Hamulus Length 1	88 (70 – 100)
Hamulus Length 2	54 (42 – 60)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.3654

Remarks

~ None.

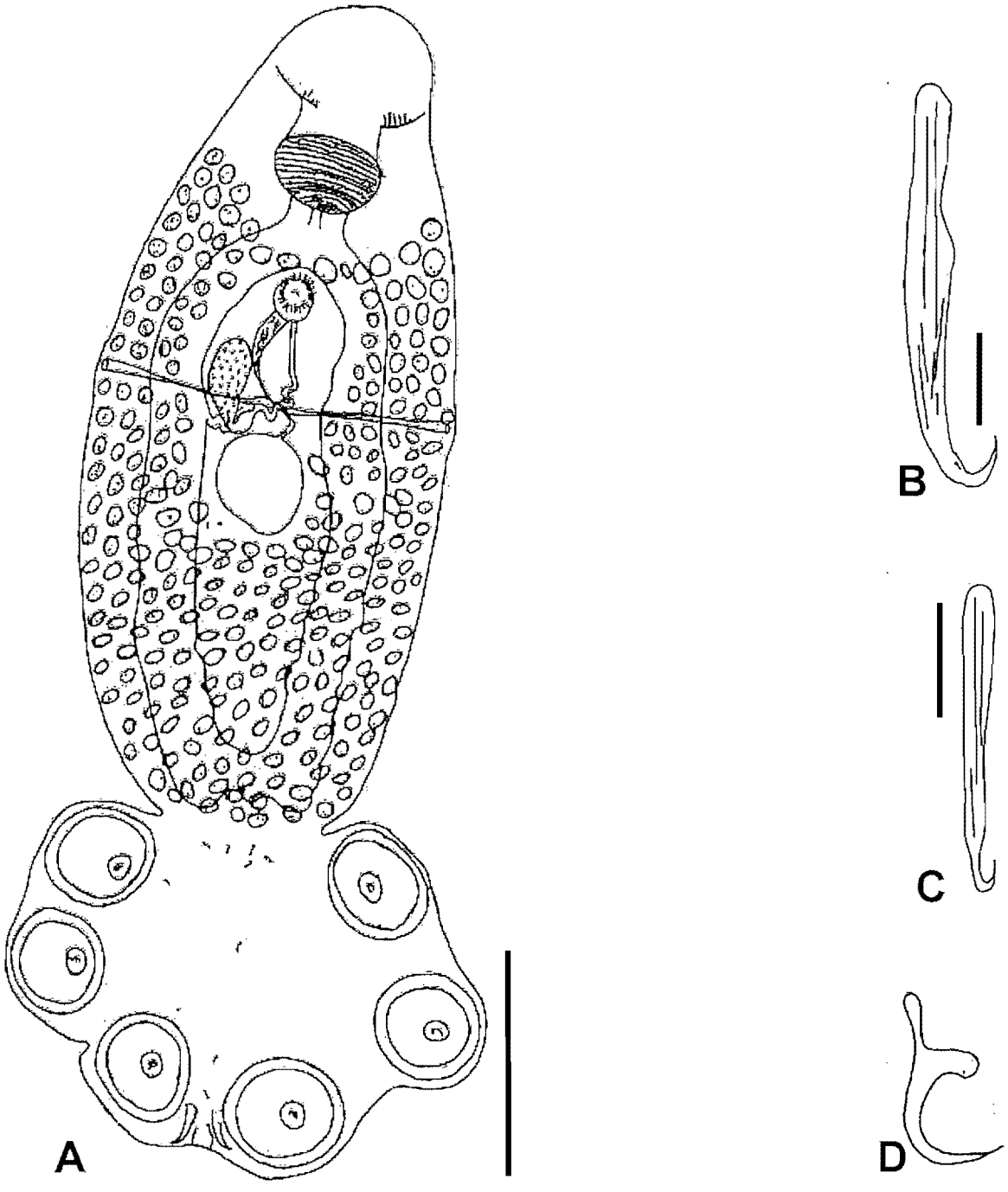


Figure 3.60: (A) *Polystomoides renschi* Rohde, 1965 (Scale bar = 500µm); (B) Large hamulus (Scale bar = 20µm); (C) Small hamulus (Scale bar = 20µm); (D) Marginal hooklet (Scale unknown). Copied from Rohde (1965).

Polystomoides rohdei

Mañé-Garzón & Holcman-Spector, 1968

Table 3.64; Figure 3.61

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Mañé-Garzón and Holcman-Spector (1968).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Uruguay, South America.

Other localities: None.

Type host: *Pseudemys dorbigni* [*Trachemys dorbigni* (Duméril & Bibron, 1835)]. D'Orbigny's slider turtle.
Additional hosts: None.

Site on type host: Oral cavity.

Information on the host

Taxonomy: *Pseudemys dorbigni* is now known as *Trachemys dorbigni*. The subspecies *T. d. dorbigni* (Duméril & Bibron, 1835) and *T. d. brasiliensis* (Freiberg, 1969) were synonymised.

Geographical distribution: This species is found in south-eastern South America: north-eastern Argentina, Uruguay, and Brazil (Rio Guaíba, Rio Grande do Sul).

Ecology: None available.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.64: Measurements of *P. rohdei*	
CHARACTERISTICS	**Mañé-Garzón & Holcman-Spector (1968)**
Mature specimens (n)	
Body Length	3000 – 4020
Greatest Width	930 – 1300
Width at Vagina	
Haptor Length	
Haptor Width	1260 – 1960
Oral Diameter	250 – 300 x 330 – 440
Pharynx Length	200 – 290
Pharynx Diameter	210 – 290
Testis Length	540 – 810
Testis Width	510 – 740
Ovary Length	
Ovary Width	
Egg Length	230 – 270
Egg Diameter	200
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	200 – 220
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	29 – 32
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	34 – 52
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	340 – 470
Hamulus Length 1	160
Hamulus Length 2	70
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	30
Haptor L/Body L	

Remarks

~ This species most resembles *P. coronatum*, but differs in having smaller pharynx, a better developed testis, and longer genital spines (Mañé-Garzón & Holcman-Spector, 1968).

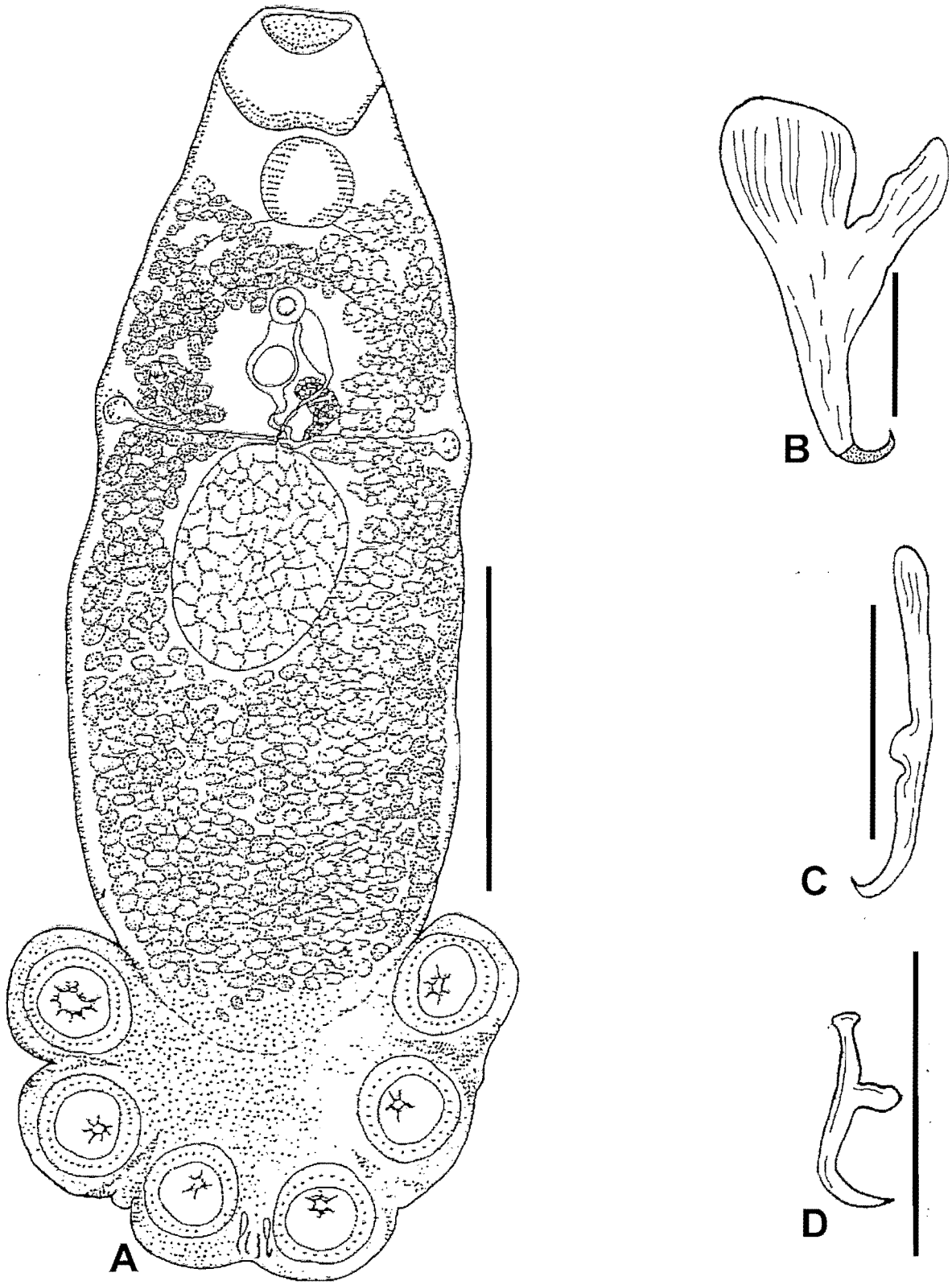


Figure 3.61: (A) *Polystomoides rohdei* Mañé-Garzón & Holcman-Spector, 1968 (Scale bar = 1000µm); (B) Large hamulus (Scale bar = 50µm); (C) Small hamulus (Scale bar = 100µm); (D) Marginal hooklet (Scale bar = 100µm). Copied from Mañé-Garzón & Holcman-Spector (1968).

Polystomoides scottae

Pichelin, 1995

Table 3.65; Figure 3.62

General

Collection: Queensland Museum, Australia.
Holotype no: QM G211517.
Paratype no: QM G211518.

Original description: Pichelin (1995).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Downfall Cr. (27°40'S, 153°0.'E), Brisbane, Australia.

Other localities: Queensland, Australia – Canal Cr. (28°01'S, 151°35'E), Darling Downs and The University of Queensland Veterinary Farm (27°32'S, 152°54'E), Prinjarra Hills.

Type host: *Chelodina expansa* [*Macrochelodina expansa* (Gray, 1857)]. Broad-shelled river turtle; giant snake-necked turtle.
Additional hosts: None.

Site on type host: Accessory bladders.

Information on the host

Taxonomy: *Chelodina expansa* is currently known as *Macrochelodina expansa* (Gray, 1857).

Geographical distribution: The species can be found in south-eastern South Australia, a wide boomerang shaped range, including the Murray River, up to mid-Queensland (Rockhampton), northern Victoria, central New South Wales, to south-eastern Queensland and Fraser Island, occurring far from the coast almost throughout its range, apart from the extreme east (Fraser Island), where it was possibly brought by human agency.

Ecology: This species is a favourite among hobbyists, but it is difficult to census populations because they hide very effectively, making precise counts difficult if not impossible.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.65: Measurements of *P. scottae*	
CHARACTERISTICS	**Pichelin (1995)**
Mature specimens (n)	7
Body Length	4978 (3948 – 5588)
Greatest Width	1760 (1576 – 2054)
Width at Vagina	
Haptor Length	1201 (1114 – 1274)
Haptor Width	1597 (1465 – 1735)
Oral Diameter	523 (469 – 578) x 648 (591 – 687)
Pharynx Length	383 (347 – 424)
Pharynx Diameter	416 (379 – 475)
Testis Length	652 (475 – 854)
Testis Width	506 (449 – 559)
Ovary Length	
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	289 (276 – 308) x 253 (257 – 308)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	73 (68 – 79)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	60.4 (54.4 – 65.6)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	347 (313 – 417)
Hamulus Length 1	632 (565 – 725)
Hamulus Length 2	186 (148 – 225)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	22.1 (20.8 – 23.2)
Haptor L/Body L	0.2413

Remarks

~ The species was found on other sites on the terrapins: the urinary bladder and cloaca (Pichelin, 1995).

~ Pichelin (1995) stated that the material examined are 23 individuals from the Veterinary farm, two individuals from Downfall Cr, and two individuals from Canal Cr. The host voucher individuals are: *C. expansa* QM J54643 (Canal Cr.).

~ Pichelin (1995) stated that *P. scottae* (68 – 79), *P. australiensis* (67 – 97), *P. malayi* (57 – 83), *P. simhai* (60), and *P. godavarii* (64 – 66) have similar numbers of genital spines. *P. scottae* differs from these in

that its genital bulb is smaller than the pharynx and not in the midline (close to or contiguous with caeca), it has broader hamuli, and smaller genital spines.

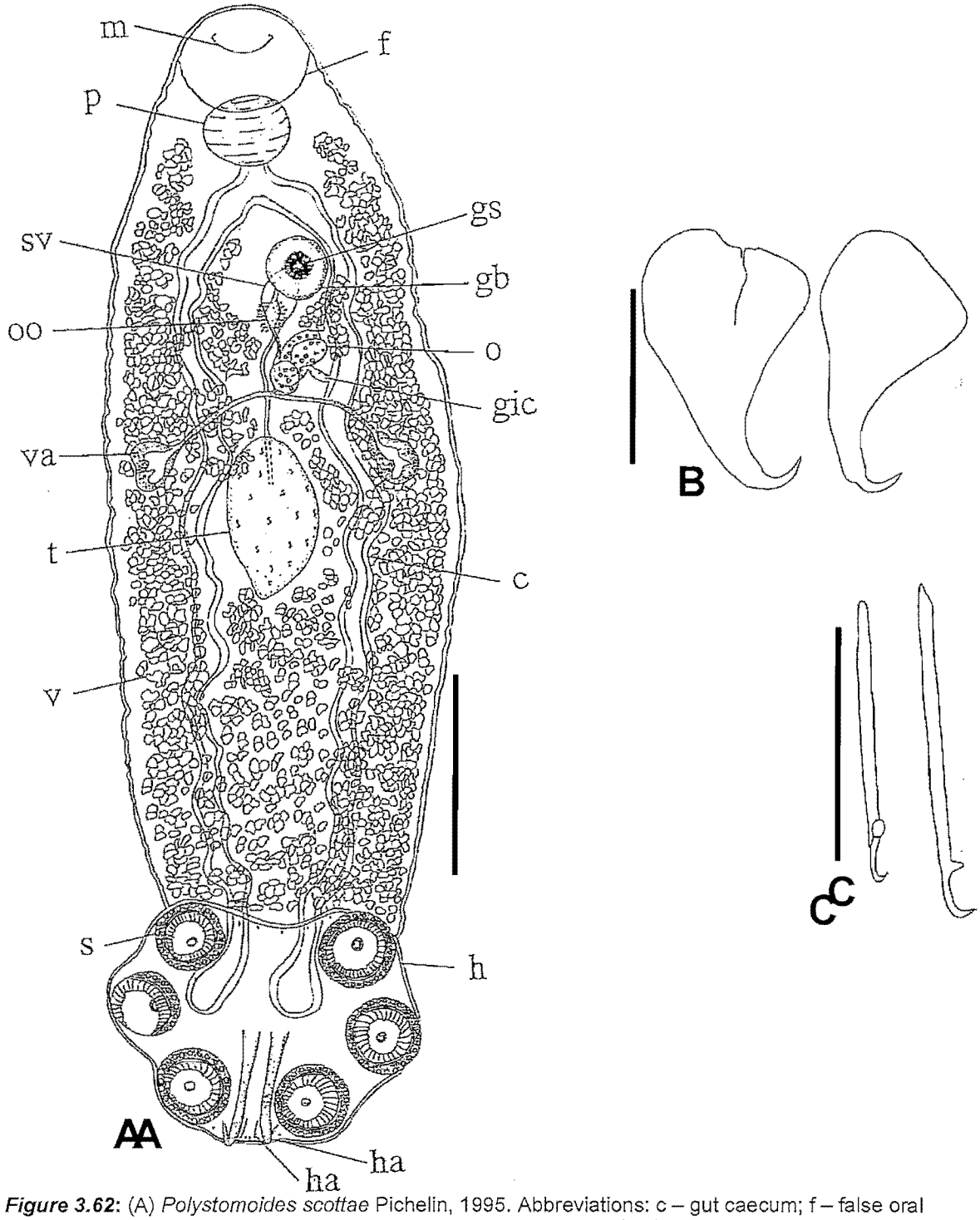


Figure 3.62: (A) *Polystomoides scottae* Pichelin, 1995. Abbreviations: c – gut caecum; f – false oral sucker; gb – genital bulb; gic – genitor-rintestinal canal; gs – genital spine; h – haptor; ha – hamulus; m – mouth; o – ovary; oo – oötype; p – pharynx; s – haptoral sucker; sv – seminal vesicle; t – testis; v – vitelline follicle; va – vagina (Scale bar = 1000µm); (B) Large hamuli (Scale bar = 400µm); (C) Small hamuli (Scale bar = 150µm). According to Pichelin (1995).

Polystomoides siebenrockiella

Rohde, 1965

Table 3.66; Figure 3.63

General

Collection: Helminthological Collection, Zoology Department, University of Malaya. Further specimens were deposited in: Helminthologische SammlungHumboldt University, Berlin, the Helminthological collection of the British Museum (Natural History), the U.S. National Helminthological Collection.

Holotype no: None.
Paratype no: R 228 – 230.

Original description: Rohde (1965).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Malaysia (Chinese shop in Kuala Lumpur).

Other localities: None.

Type host: *Siebenrockiella crassicollis* (Gray, 1831). Black marsh turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: None.

Geographical distribution: This species has a fragmented range in south-east Asia, from southern Vietnam westward through Thailand to Tenasserim (Myanmar), and southward through Malaysia to Sumatra, Java, and Borneo, including the Malay Peninsula and Singapore.

Ecology: The species is sometimes consumed or sold in markets, but the flesh is little sought after. Despite this, populations may be dropping because of progressive fragmentations of the habitat.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.66: Measurements of *P. siebenrockiella*	
CHARACTERISTICS	**Rohde (1965)**
Mature specimens (n)	5
Body Length	3580 (1900 – 4400)
Greatest Width	1082 (710 – 1200)
Width at Vagina	
Haptor Length	780 (500 – 1000)
Haptor Width	1060 (600 – 1300)
Oral Diameter	354 (210 – 400) x 510 (350 – 590)
Pharynx Length	216 (140 – 280)
Pharynx Diameter	262 (200 – 310)
Testis Length	323 (300 – 360)
Testis Width	543 (480 – 610)
Ovary Length	207 (190 – 220)
Ovary Width	80
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	272 (150 – 360) x 252 (150 – 300)
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	51 (45 – 56)
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	58 (54 – 60)
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	176 (130 – 210)
Hamulus Length 1	390 (270 – 440) / 366 (250 – 420)
Hamulus Length 2	174 (130 – 230) / 187 (150 – 230)
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.2179

Remarks

~ None.

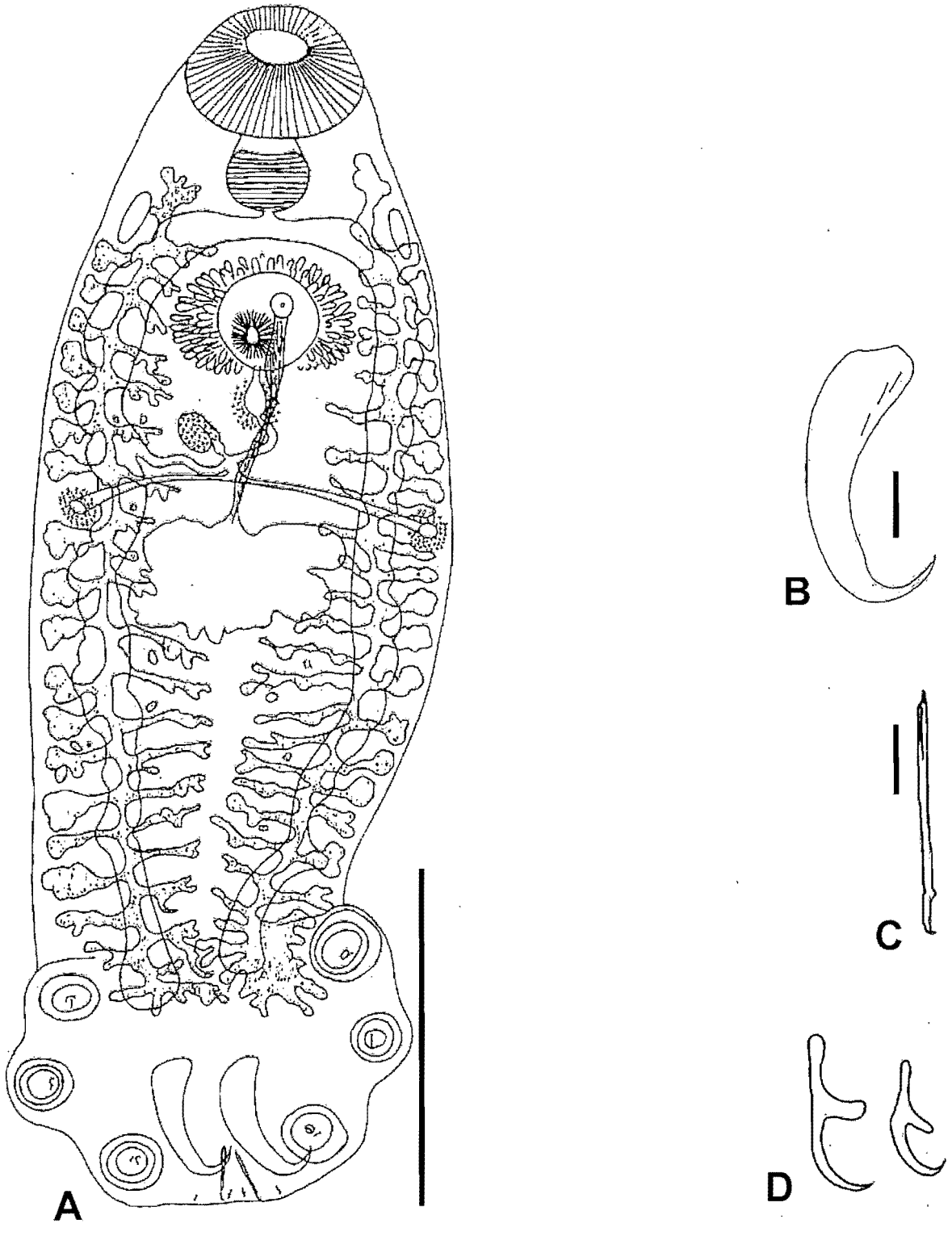


***Figure* 3.63:** (A) *Polystomoides siebenrockiellae* Rohde, 1965 (Scale bar = 1000µm); (B) Large hamulus (Scale bar = 100µm); (C) Small hamulus (Scale bar = 50µm); (D) Marginal hooklet (Scale unknown). According to Rohde (1965).

Polystomoides simhai

Rao, 1975

Table 3.67; Figure 3.64

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Rao (1975).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Godavary river, Pochampad area, District Nizamabad, Andhra Pradesh, India.

Other localities: None.

Type host: *Kachuga tectum tentoria* [*Pangshura tentoria tentoria* (Gray, 1834)]. Indian tent turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Kachuga tectum tentoria* is now known as *Pangshura tentoria tentoria* (Gray, 1834). There are two other subspecies: *P. t. circumdata* (Mertens, 1969), and *P. t. flaviventer* Günther, 1864.

Geographical distribution: This species can be found in north-eastern India (Orissa, Andhra Pradesh, Madhya Pradesh, Maharashtra, and the Mahanadi and Krishna rivers), and in the northern and central parts of Bangladesh.

Ecology: This species' natural predators include hyenas and jackals, and they are captured by fishermen for consumption, or placed in temple ponds, but despite this the numbers taken by people are limited.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.67: Measurements of *P. simhai*	
CHARACTERISTICS	**Rao (1975)**
Mature specimens (n)	8
Body Length	3520 – 3610
Greatest Width	1800 – 1820
Width at Vagina	
Haptor Length	840 – 1150
Haptor Width	1450 – 1590
Oral Diameter	660 – 740 x 330 – 490
Pharynx Length	280 – 330
Pharynx Diameter	230 – 280
Testis Length	890 – 920
Testis Width	740 – 820
Ovary Length	410 – 520
Ovary Width	250 – 360
Egg Length	240 – 290
Egg Diameter	140 – 190
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	490 – 620 x 380 – 420
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	60
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	210 – 270 x 240 – 380
Hamulus Length 1	560 – 630 x 210 – 310
Hamulus Length 2	71 – 91
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	10 - 14
Haptor L/Body L	

Remarks

~ This species is very similar to *P. kachugae*, but differs in having 60 chitinoid spines and having an oval testis with entire margins. It is characterised further in having an anchor with a broad base and tapering shaft, with a curved hook (Rao, 1975).

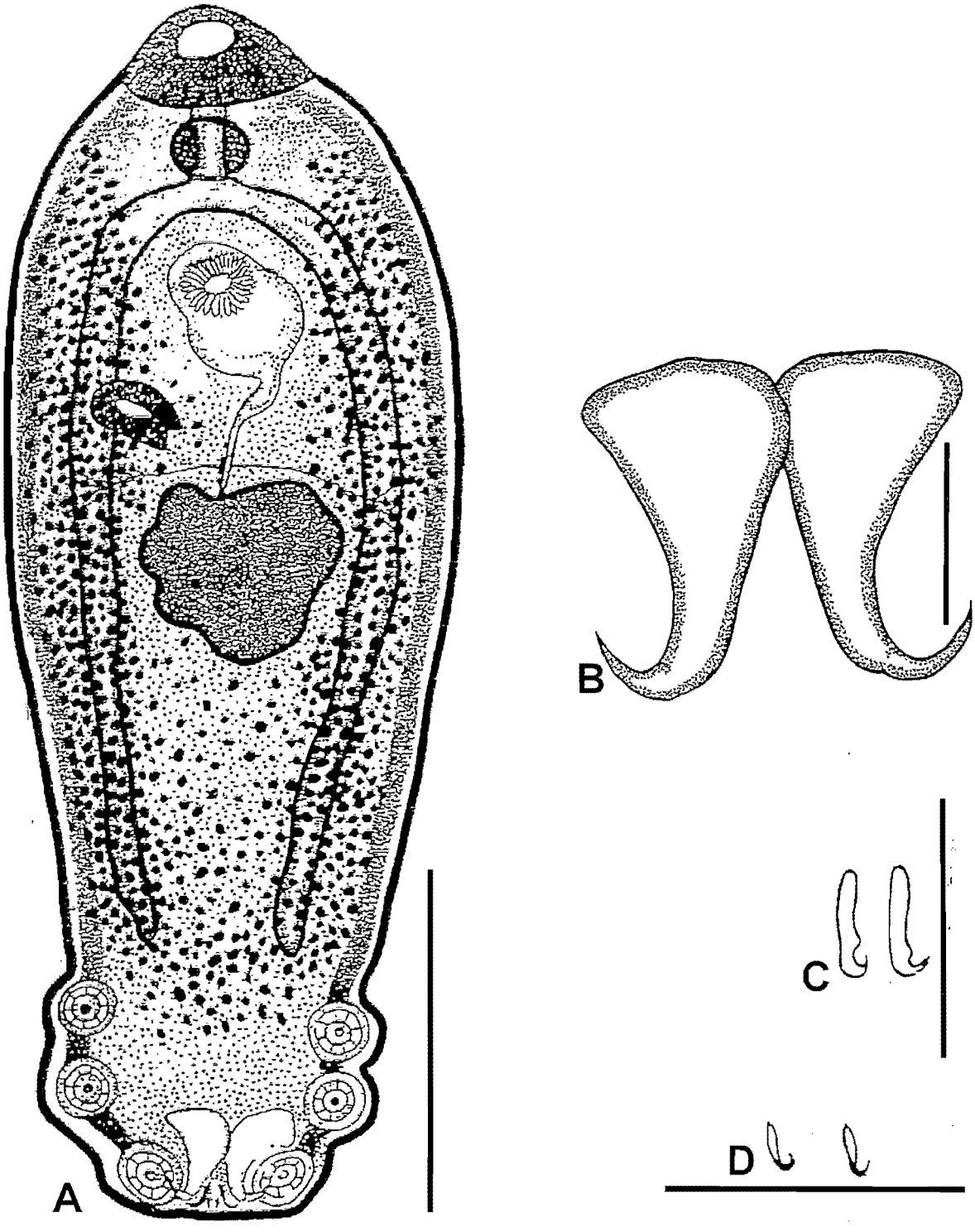


Figure 3.64: (A) *Polystomoides simhai* Rao, 1975 (Scale bar = 1000µm); (B) Large hamuli (Scale bar = 250µm); (C) Small hamuli (Scale bar = 250µm); (D) Marginal hooklets (Scale bar = 250µm). Copied from Rao (1975).

Polystomoides stewarti

Pandy, 1973

Table 3.68; Figure 3.65

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Pandey (1973).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Lucknow, India.

Other localities: None.

Type host: *Hardella thurgi* [*Hardella thurjii thurjii* (Gray, 1831)]. Ganges crowned river turtle.
Additional hosts: None.

Site on type host: Urinary bladder.

Information on the host

Taxonomy: *Hardella thurgi* has changed to *Hardella thurjii thurjii* (Gray, 1831). There is one other subspecies: *H. t. indi* Gray, 1870.

Geographical distribution: The subspecies can be found in northern India and Bangladesh, in the effluents and tributaries of the Ganges and Brahmaputra River systems.

Ecology: The species is found in markets in eastern India and in Bangladesh, having a long history of human consumption, and is sometimes collected for export to China, thus populations are becoming increasingly decimated.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.68: Measurements of *P. stewarti*	
CHARACTERISTICS	**Pandey (1973)**
Mature specimens (n)	1
Body Length	4240
Greatest Width	1320
Width at Vagina	
Haptor Length	810
Haptor Width	1250
Oral Diameter	210 x 360
Pharynx Length	120 – 150
Pharynx Diameter	
Testis Length	320
Testis Width	210
Ovary Length	90 – 120
Ovary Width	
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	36
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	220 x 270
Hamulus Length 1	120 – 150 x 180 – 210
Hamulus Length 2	80 – 110
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	
Haptor L/Body L	0.1906

Remarks

~ This species resembles *P. kachugae* and *P. chabaudi*, but differs from *P. kachugae* in the number of haptoral hooks and from *P. chabaudi* in the number of haptoral hooks, shape of the testis, and in the extension of vitellaria (Pandey, 1973).

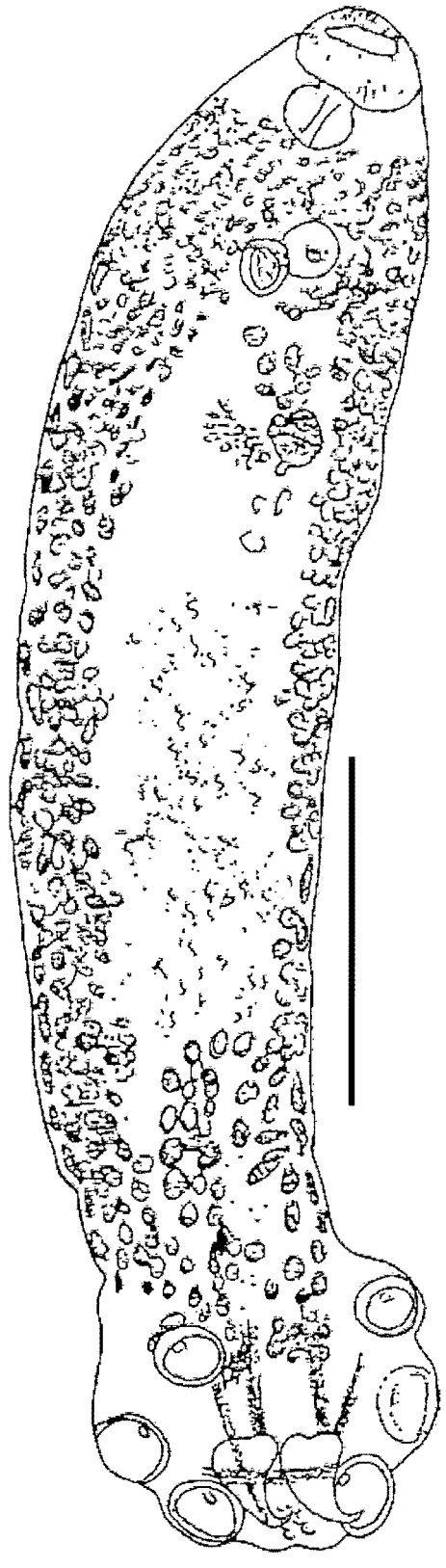


Figure 3.65: *Polystomoides stewarti* Pandey, 1973 (Scale bar = 1000µm). Copied from Pandey (1973).

Polystomoides tunisiensis

Gonzales & Mishra, 1977

Table 3.69; Figure 3.66

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Gonzales and Mishra (1977).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Tunisia, Africa.

Other localities: None.

Type host: *Clemmys casipca leprosa* [*Mauremys leprosa leprosa* (Schweigger, 1812)]. Spanish terrapin.
Additional hosts: None.

Site on type host: Oral cavity, pharynx, oesophagus.

Information on the host

Taxonomy: *Clemmys caspica leprosa* has changed to *Mauremys leprosa leprosa*. There is one other subspecies: *M. l. saharica* Schleich, 1996.

Geographical distribution: This subspecies occurs in the western part of the Mediterranean, in Spain, Portugal, the south of France (Banyuls), and the north-western part of Africa (Morocco, Algeria, Tunisia, and Libya).

Ecology: This subspecies is not collected, is resistant to pollution, and in no danger of habitat destruction. However, there is only one population of about 100 individuals in France, and is thus protected.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.69: Measurements of *P. tunisiensis*	
CHARACTERISTICS	**Gonzales & Mishra (1977)**
Mature specimens (n)	
Body Length	1500 – 5700
Greatest Width	
Width at Vagina	
Haptor Length	900 – 2200
Haptor Width	500 – 1700
Oral Diameter	100 – 400 x 200 – 500
Pharynx Length	200 – 500
Pharynx Diameter	150 – 600
Testis Length	200 – 700
Testis Width	300 – 500
Ovary Length	
Ovary Width	100 – 400
Egg Length	300 – 600
Egg Diameter	200 – 400
Egg incubation time	
Intra-Uterine Eggs (n)	1
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	26 – 28
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	40 – 50
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	300 – 500
Hamulus Length 1	90 – 120 x
Hamulus Length 2	50 – 70
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	10 – 40
Haptor L/Body L	

Remarks

~ This species differs from other species in the number and size of the genital spines (Gonzales & Mishra, 1977).

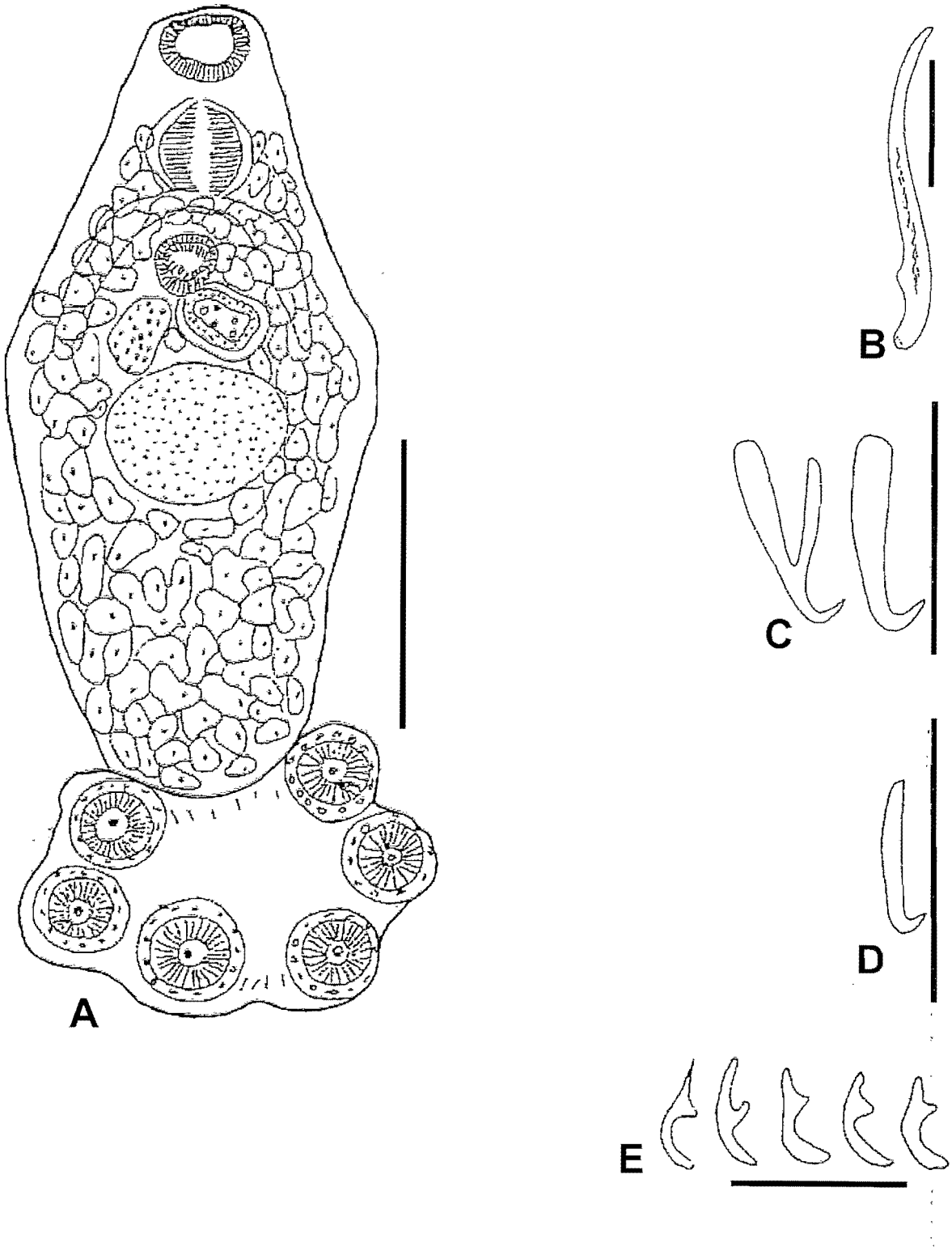


Figure 3.66: (A) *Polystomoides tunisiensis* Gonzales & Mishra, 1977 (Scale bar = 1000µm); (B) Genital spines (Scale bar = 20µm); (C) Large hamuli (Scale bar = 100µm); (D) Small hamulus (Scale bar = 100µm); (E) Marginal hooklets (Scale bar = 50µm). Copied from Gonzales & Mishra (1977).

Polystomoides uruguayensis

Mañé-Garzón & Gil, 1961

Table 3.70; Figure 3.67

General

Collection: Museum of Natural History of Montevideo, S. Alfredo Ximenez collection.
Holotype no: 10.III.1960.
Paratype no: None.

Original description: Mañé-Garzón and Gil (1961).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Cuaró stream, Department of Artigas, Uruguay, South America.

Other localities: None.

Type host: *Phrynops geoffroana hillarii* [*Phrynops hillari* (Duméril & Bibron, 1835)]. Halaire's side-necked turtle; spotted-bellied side-necked turtle.
Additional hosts: None.

Site on type host: Oral cavity.

Information on the host

Taxonomy: *Phrynops geoffroana hillarii* is now known as *Phrynops hilarii* (Duméril & Bibron, 1835).

Geographical distribution: The species can be found in eastern central South America, in southern Brazil in the provinces of Rio Grande do Sul, Santa Cterina, and Paraná, and in Uruguay, as well as in northern Argentina in the provinces of Córdoba and Santiago del Estero, southern Paraguay, and north-eastern Argentina. It may be present in Bolivia, but this needs investigation.

Ecology: This terrapin is captured by collectors, and it and its eggs are also eaten, but some local people consider it to be poisonous. Despite its habitat being altered and destroyed, the species does not appear on any protected list.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Table 3.70: Measurements of *P. uruguayensis*	
CHARACTERISTICS	**Mañé-Garzón & Gil (1961)**
Mature specimens (n)	2
Body Length	2560 – 2650
Greatest Width	780 – 800
Width at Vagina	
Haptor Length	
Haptor Width	1250 – 1310
Oral Diameter	350 x 270
Pharynx Length	
Pharynx Diameter	210
Testis Length	300 – 390
Testis Width	230 – 290
Ovary Length	
Ovary Width	100 – 120
Egg Length	
Egg Diameter	
Egg incubation time	
Intra-Uterine Eggs (n)	
Genital Bulb Diameter	
Gen. Bulb Hook set (n)	1
Gen. Bulb Hooks 1 (n)	8 – 10
Gen. Bulb Hooks 2 (n)	
Gen. Bulb Hook Length 1	10
Gen. Bulb Hook Length 2	
Haptoral Sucker Diameter	310 – 320
Hamulus Length 1	52
Hamulus Length 2	38
Hamulus Hook Length 1	
Hamulus Hook Length 2	
Marginal Hooklet Length	21
Haptor L/Body L	

Remarks

~ This species is characterised by the morphology of its genital crown and spines, and the short vagina and ventral vaginal pores (Mañé-Garzón and Gil, 1961).

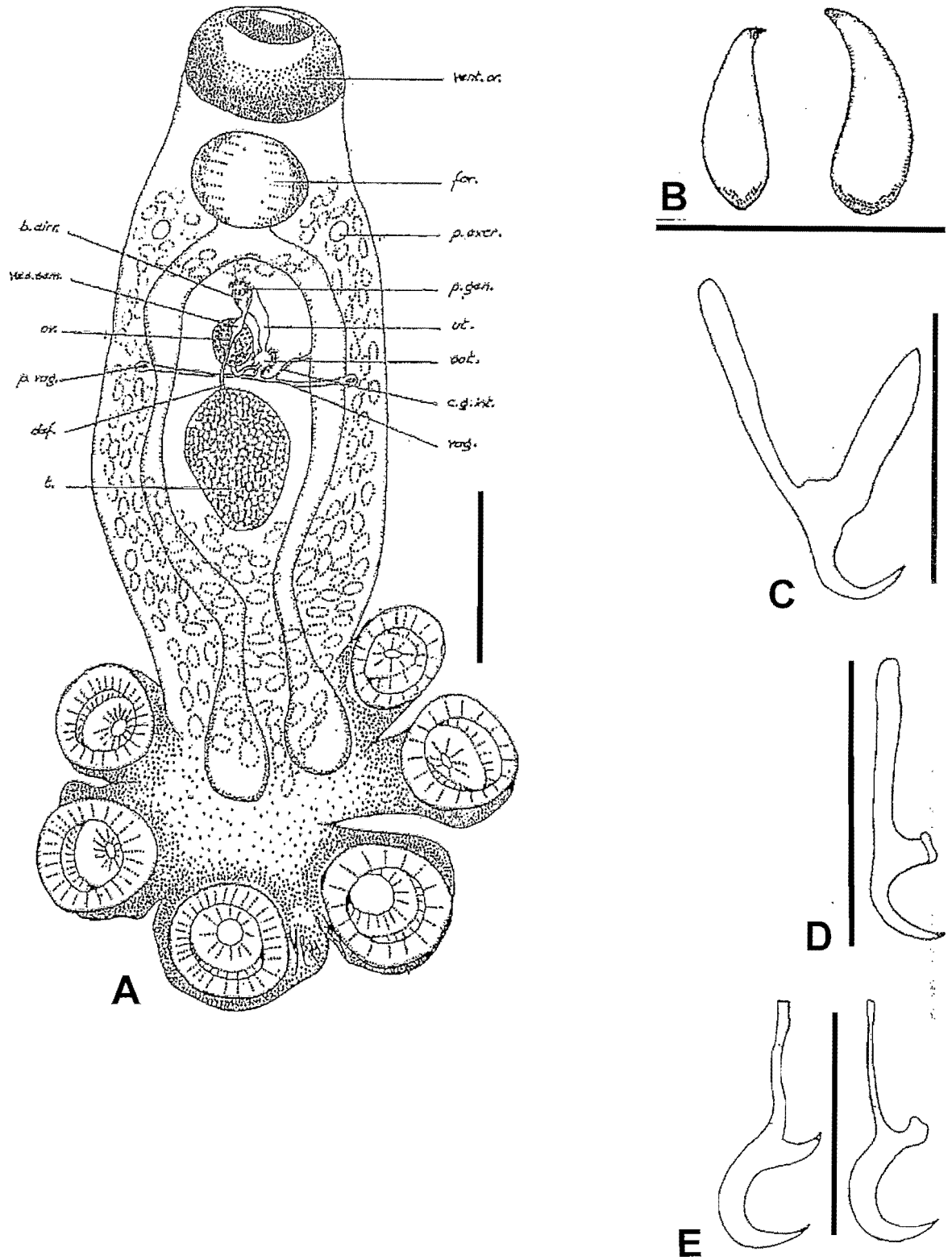


Figure 3.67: (A) *Polystomoides uruguayensis* Mañé-Garzón & Gil, 1961. Abbreviations: b. virr. – genital bulb; c. g. int. – genito-intestinal canal; def. – vas deference; far. – pharynx; oot. – ootype; ov. – ovary; p. excr. – excretory pore; p. gen. – genital pore; p. vag. – vaginal pore; t. – testis; ut. – uterus; vag. – vagina; vent. or. – oral sucker; ves. sem. – seminal vesicle (Scale bar = 500µm); (B) Genital spines (Scale bar = 25µm); (C) Large hamulus (Scale bar = 50µm); (D) Small hamulus (Scale bar = 50µm); (E) Marginal hooklets (Scale bar = 25µm). Copied from Mañé-Garzón and Gill (1961).

Polystomoides sp. (1)
by Fairfax (1990)

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Daintree, Australia.

Other localities: None.

Type host: *Elseya latisternum* Gray, 1867. Saw-shelled turtle; serrated snapping turtle.
Additional hosts: None.

Site on type host: None.

Information on the host

Taxonomy: None.

Geographical distribution: This species' range is huge and discontinuous in northern and eastern Australia, from the Richmond River, New South Wales, along the coastal area to the South Alligator River, Northern Territory, and the Liverpool River in Arnhem Land, as well as the Gregory River and down to southern Queensland. It abounds in the Flinders River and reaches 1000 m altitude in the Atherton Tableland.

Ecology: There is no evidence that natural populations of this species are depleted.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Remarks

~ Fairfax (1990) gave this data as new host records for Australian polystomes, but the status of this polystome is undetermined.

Polystomoides sp. (2)

by Fairfax (1990)

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Scrubby Creek, south-east Queensland, Australia.

Other localities: None.

Type host: *Emydura signata* [*Emydura macquarii signata* Ahl, 1932]. Brisbane River turtle.
Additional hosts: None.

Site on type host: None.

Information on the host

Taxonomy: *Emydura signata* is now known as *Emydura macquarii signata* Ahl, 1932. There is eight other subspecies: *E. m. macquarii* (Gray, 1831), *E. m. binjing* Cann, 1998, *E. m. dharra* Cann, 1998, *E. m dharuk* Cann, 1998, *E. m. emmotti* Cann, McCord & Joseph-Ouni, 2003, *E. m. gunabarra* Cann, 1998, *E. m. krefftii* (Gray, 1871), and *E. m. nigra* McCord, Cann & Joseph-Ouni, 2003.

Geographical distribution: This subspecies is found in the Brisbane river drainage, in south-eastern Queensland, Australia.

Ecology: This species is abundant in nature, but is heavily collected and is present in many wildlife parks and zoos. It is one of the Australian species that is most frequently found in Western collections.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Remarks

~ Fairfax (1990) gave this data as new host records for Australian Polystomes, but the status of this polystome is undetermined.

Polystomoides sp. (3)
by Fairfax (1990)

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Wilson River area near Thargomindah in south-west Queensland, Australia.

Other localities: None.

Type host: An undescribed species of *Emydura* Bonaparte, 1836.
Additional hosts: None.

Site on type host: None.

Information on the host

Taxonomy: None.

Geographical distribution: None.

Ecology: None.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Remarks

~ Fairfax (1990) gave this data as new host records for Australian polystomes, but the status of this polystome is undetermined.

Polystomoides sp. (4)

by Fairfax (1990)

General

Collection: Australian Museum, Sydney, Australia.
Holotype no: R 127898.
Paratype no: None.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Awaba, Aramia River drainage, Western Province, 8°00'S; 142°35'E, Papua New Guinea.

Other localities: None.

Type host: *Chelodina siebenrocki* [*Macrochelodina rugosa* (Ogilby, 1890)]. Siebenrock's turtle.
Additional hosts: None.

Site on type host: Bladder.

Information on the host

Taxonomy: *Chelodina siebenrocki* is now known as *Macrochelodina rugosa* (Ogilby, 1890).

Geographical distribution: This species is endemic to Papua New Guinea, and occurs along the south coast, as well as northeastern Western Australia, through northern part of Northern Territory, to northern Queensland, and finally islands in Torres Strait, southeastern Irian Jaya (Indonesia).

Ecology: The species' exports from Papua New Guinea are controlled, but are frequent from West Papua. Nevertheless, the species appears to be abundant and breeds freely in captivity. The captive population in the U.S.A. and Europe is very large.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Remarks

~ Fairfax (1990) stated that this is the first record from *Chelodina*, and that this is more than likely a member of a new species.

Polystomoides sp. (5)

by Fairfax (1990)

General

Collection: None.
Holotype no: None.
Paratype no: None.

Original description: Fairfax (1990).

Other taxonomic contributions: None.

Synonyms: None.

Type locality: Papua New Guinea.

Other localities: None.

Type host: *Elseya novaeguineae* Meyer, 1874. New Guinea snapping turtle, New Guinea snapper.
Additional hosts: None.

Site on type host: None.

Information on the host

Taxonomy: None.

Geographical distribution: This species of terrapin occurs in Northwestern Irian Jaya, Indonesia, in West Papua and Papua New Guinea (TransFly Region of Papua New Guinea).

Ecology: This terrapin is regularly caught for food, but despite this populations in nature are in sound condition.

Information on the parasite

Tissue in EtOH: None.

DNA Sequence: None.

Remarks

~ The status of this species is not yet determined.

3.4 Discussion

Chelonian polystomes constitute a unique group of parasites which can be easily separated from other polystomatids. Unlike amphibian polystomes, chelonian polystomes appear to not be strictly host-specific. Pichelin (1995) suggested that because of this lack of strict host-specificity, the host's identity choice cannot be used as a reliable taxonomic character when differentiating between species. This holds true for species of the same genus, for example *Neopolystoma chelodinae* and *Neopolystoma spratti* (both in *Chelodina longicollis*), as well as for species of different genera, for example *Neopolystoma liewi* and *Polystomoides asiaticus* (both in *Cuora amboinensis*). Furthermore, more than one species of polystome can infect not only the same host species, but also the same host individual – for example, *Cuora amboinensis* acts as host for all three chelonian polystome genera. It is also possible for two different species to be found on the same site of a host, for example *Neopolystoma cribbi* and *Neopolystoma queenslandensis* both occur on the eye of *Emydura macquarii*. However, it has been found that congeneric species that infect the same site in different hosts are more closely related than congeneric species infecting different sites in the same host (Littlewood *et al.*, 1997).

As a result of the extensive host distribution of some species and a lack of strict host-specificity, chelonian polystomes can occur over a very large geographical area. When studyng the distribution maps for chelonian and, for that matter, all polystomes, it becomes clear that known sites for parasites are not distributed homogenously but are rather concentrated in centra. This state of affairs actually reflects the distribution of areas where scientists focused their efforts and is not an accurate reflection of the parasites' actual distribution. It is quite likely that several undescribed chelonian polystome species do exist and will be discovered in future. There is, however, no guarantee that chelonian polystomes will be discovered everywhere. For example, in spite of several intensive surveys of *Pelomedusa* and *Pelusios* in South Africa, no chelonian polystomes have been detected to date Du Preez, *pers. com.*

While extensive research has been conducted on the biology and internal and external structures of polystomes, little is known about the life cycles of chelonian polystomes (Pichelin, 1995). According to Pichelin (1995), the only detailed account of a chelonian polystome parasite is that of *Polystomoidella oblonga*, although more attention is currently directed towards this field of research. Despite this, Rohde (1965) conducted extensive research on the morphological characters of the genus *Polystomoides*, and suggested five characters that are more or less constant in the species: (1) the relative size of oral sucker and pharynx, (2) the size and shape of testis, (3) the hamulus length, (4) the number of genital spines, and (5) the length of genital spines. Most of these are applicable to the other genera as well. Vieira *et al.* (2008) used morphometric data of the outer and inner hamuli, testis, pharynx and oral suckers, and well as quantitative and morphometric data for the genital spines to distinguish between

species. Paul (1938) reported that using the uterus for distinguishing between species as well as genera should be avoided, because in the literature the term uterus has been incorrectly applied to the oötype, thus creating confusion. He propounded that there are three main characters which distinguish chelonian polystomes from amphibian polystomes. These are the reptilian host, only one generation, and skeletal elements in the suckers. Amphibian polystomes, on the other hand, have an amphibian host, often two generations in a form of a neotenic phase in the tadpole and a bladder phase in the urinary bladder of metamorths and adults, and no skeletalised suckers except for representatives of *Nanopolystoma* that infect caecileans.

The main objective of this study was to organise existing information rather than to provide definitive answers or solutions to the problems concerning species identity and species diversity of chelonian polystomes. This has led to the development of a simple reference system that summarises - and provides easy access to - the information available for the existing species of chelonian polystomes, and also assists in distinguishing new species from existing ones. However, the system has highlighted several discrepancies and problems within the taxonomy and descriptions of the different species.

Although great care was taken to ensure that species data is as comprehensive as possible, it has become apparent that not all species were equally well described. This is especially true for those described in very old literature. For example, some species descriptions only report the host species, the site on the host species and the locality of the species, but offer no further information. Leidy (1888), for example, provided very little information on species, and this gave rise to more recent authors attempting to address these shortcomings in several subsequent articles. Furthermore, authors did not always provide drawings of the parasite and often made no mention of where the type material was deposited. Other information that is often absent includes details on the development of the eggs, the oncomiracidium, the width of the parasite at the vagina level, the length of the hamuli hooks, the number of genital spine rows and detail on the marginal hooklets.

It would appear that the arrangement of genital spines differ at the generic level. *Neopolystoma* has a single ring with all spines of equal length. *Polystomoidella* has two rings, with long and shorter spines irregularly alternating. *Polystomoides* also seems to have two rows, with long and slightly shorter spines alternating. This is, however, only a casual observation, and requires further validation. The species list does not assume the presence of two rows, even if two measurements are given, and only states that two rows are present if the author confirmed it, or indicated the presence of two spines.

Together with the irregular nature of the information that could be obtained from the literature, discrepancies in the data have also been identified. Leidy (1888) described a new species, *Polystomoides coronatum*, but also referred to another polystome he had found, *Polystoma oblongum*. Although he stated that the species is a synonym of *Polystomoidella oblongum* (Wright, 1879), Price (1939) named it as a synonym of *Neopolystoma orbiculare*. Because Leidy (1888) provided no information on the specimens found (and thus on the presence of hamuli), and did not specify the host species, there is too little evidence to state definitively that the specimens were actually from the genus *Neopolystoma*, and since the probability that Leidy also took the hamuli into account is quite high, this study allocates the specimens to *P. oblongum*.

Goto (1899) made a very important remark on the specimen of *Polystomum oblongum* that Leidy (1888) referred to in his publication. Although Leidy stated that the specimen found was *P. oblongum* of Wright (1879), Goto had the opportunity to re-examine it and found that although the specimen was in poor condition, it was possible to prove that the specimen was in fact not Wright's *P. oblongum*. He stated that the specimen has 16 genital spines, measuring 660 µm in length, and while *P. oblongum* also has 16 spines, these are alternately small and large and differ considerably from the specimen in question's spines. Thus, it must be a new species, but because the specimen is in a highly deteriorated state, and there is no adequate description, it would be useless (Goto, 1899).

Furthermore, Price (1939) stated that *Polystomoidella whartoni* has two synonyms: *Polystoma (Polystomoides) hassalli* Harwood, 1932, and *Polystoma (Polystomoides) oblongum* Caballero, 1938. However, upon studying Harwood (1932), it was found that Harwood did not describe a new species or new data, but actually referred to *Polystomoides hassalli* (Goto, 1899), a synonym of *Polystomoidella oblongum*. Thus the present study does not include *P. (P.) hassalli* as a synonym of *Polystomoidella whartoni*. There is definite confusion regarding *P. hassalli*, for Lamothe-Argumedo (1972) argued that it should be a valid species (see Remarks, pg. 97). The species is a spiecies inquirenda, or species of doubtfull identity, and needs further investigation urgently.

Despite these shortcomings and discrepancies, the present knowledge of the Polystomatidae of chelonians was summarised and formatted as a reference system that includes all known species that parasitise terrapins. Their vital information and characteristics were included where possible, rendering the system convenient and compact, with a view to assist researchers in further studies on chelonian polystomes as well as the identification of new species..

CHAPTER 4

EVALUATION OF MARGINAL HOOKLET MEASUREMENTS AS TAXONOMIC CHARACTER

4.1 Introduction

The second phase of this study was to evaluate marginal hooklet morphology (Fig. 4.1) to determine the most informative combination of measurements in order to propose a protocol for future species descriptions.

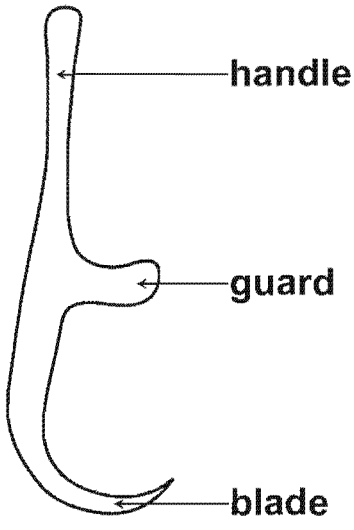


Figure 4.1: Diagrammatic illustration of the general structure of a marginal hooklet of a polystome.

This chapter was drafted as a publication that will be submitted to African Zoology.

4.2 Article 1

Marginal hooklet morphometrics as taxonomic characteristic for chelonian polystomes

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Taxonomy frequently makes use of morphometrics, basing the classification of organisms on measurements or combinations of measurements and ratios between measurements. Polystome flatworms have 16 marginal hooklets that remain constant throughout the development of the parasite and their morphology is stable within a species. However, differences do occur between species, which makes marginal hooklets important taxonomic characteristics. For this study, six chelonian polystome species' marginal hooklets have been measured according to 13 parameters and inserted into a pre-developed program to determine the combinations with the highest classification potentials. The combinations with the best measurements have been used to draw scatter plots with confidence eclipses to differentiate different species. Out of this pre-developed statistical process, a protocol for chelonian polystomes has been developed which might prove to be a valuable tool in the separation of different polystome species.

Key words:

Classification protocol, new species, polystomatidae, turtle.

INTRODUCTION

Monogenea Carus, 1863 are hermaphroditic flatworms and are mainly external parasites of fish (Roberts & Janovy Jr., 2008). The monogenean family Polystomatidae Carus, 1863 includes 21 genera which infect the Australian lungfish, anurans, caudates, caecilians, chelonians and the hippopotamus. Chelonian polystomes include the genera *Neopolystoma, Polystomoides* and *Polystomoidella* that parasitize the urinary bladder, cloaca, nostrils, mouth, pharynx and eye cavity of terrapins. Chelonian polystomes share five diagnostic characteristics: 1) undiverticulated gut cecae of equal length that do not form anastomoses in the haptor, 2) confinement of vitellaria in two lateral fields, 3) a prominent medial spherical testis situated in the middle of the parasite, 4) the presence of skeletal elements in the haptoral suckers, and 5) a genital bulb that possess many spines, organised in two rows in some. The three genera can be distinguished by the presence/absence of hamuli. Representatives of the genus *Neopolystoma* have no hamuli, *Polystomoidella* have one pair, and *Polystomoides* have two pairs.

Taxonomy frequently makes use of morphometrics as a diagnostic characteristic, by using measurements or combinations of measurements and ratios between measurements (Du Preez *et al.*, 2007; Du Preez *et al.* 2008; Du Preez & Maritz, 2006; Lim & Du Preez, 2001). Being flatworms, polystomes have a soft, flexible body structure characterised by profound intraspecies variation and limited interspecies variation. The amount of pressure on the specimen during fixation directly affects the dimensions of soft body parts, rendering the use of body measurements for distinguishing between species imprecise (Du Preez & Maritz, 2006). Sclerites in the form of hamuli, marginal

hooklets and genital spines, on the other hand, provide reliably measurable structures provided that they are not oblique. The hamuli undergo a slow development and can vary significantly in shape and size and, as such, have limited morphometric value as a taxonomic characteristic for subadult parasites. Genital spines are imbedded in the muscular genital bulb, and even when the parasite is flattened under cover slip pressure during fixation, these structures rarely flatten properly for measurement. When sufficient material is available, proteolytic digestion of specimens would provide properly flattened material. The 16 marginal hooklets, on the other hand, are retained from the larval stage, but they become non-functional in adult parasites when the role of attachment is taken over by the hamuli and suckers. Marginal hooklet pairs 1 and 2 are retained between posterior-most sucker pair 1; hooklet pairs 3, 4 and 5 are respectively retained within sucker pairs 1, 2 and 3; and marginal hooklet pairs 6, 7 and 8 are retained between sucker pair 3 according to the protocol developed by Murith (1981). These can often be measured in flat fixed specimens, using the number, position, shape and length of hooklets.

Since the marginal hooklets remain constant throughout the development of the parasite and their morphology is stable within a species, they could serve as a reliable species specific taxonomic characteristic (Murith, Miremad-Gassmann & Vaucher, 1978). Murith (1981) recognised this potential, and studied the posterior-most pair marginal hooklets of *Metapolystoma cachani* (Gallien, 1956) Combes, 1976, *Polystoma baeri* Maeder, Euzet & Combes, 1970, *P. dorsale* Maeder, Euzet & Combes, 1970, *P. ebriense* Maeder, 1973 and *P. mangenoti* Gallien, 1956 and came up with a protocol of three measurements.

In 2006, Du Preez and Maritz studied the measurements of the marginal hooklets proposed by Murith (1979) and set criteria for the reliability and objectivity of measurements. Du Preez and Maritz (2006) defined good parameters for the

measurability of marginal hooklets as being easily measurable, repeatable, not geometrically redundant, representative, and non-negative. A good classification potential should have a misclassification rate that is as low as possible; in other words, the parameters that fall into a group should belong to the same species, ensuring that the groups are concentrated and far apart. Du Preez and Maritz (2006) applied these criteria to Murith's protocol and found that one of her measurements was not objectively measurable and had a low repeatability since the measurement operated from a fixed point to an estimated position. Du Preez and Maritz (2006) evaluated 11 different measurements, as well as the measurements proposed by Murith, on ten different *Polystoma* species and proposed a new protocol for the genus. This protocol was based on three objectively measurable measurements that do not take into account only the length of the hooklet, but also its shape. Delport (2007) repeated the process for the anuran polystome genus *Eupolystoma* and found another combination of characters to have a slightly higher classification potential. This combination was, however, only marginally better than the Du Preez and Maritz protocol, and thus for the sake of uniformity, the same protocol was proposed for *Eupolystoma*.

For this study, the aim was to repeat the process for chelonian polystomes and determine the combination of characteristics with the highest classification potential, while applying the criteria for good characters as stipulated by Du Preez and Maritz (2006).

MATERIALS AND METHODS

Material examined

This study was based on material in the collection of the second author (LdP). Measurements were taken from oncomiracidia temporarily mounted in ammonium picrate. Details pertaining to the terrapin species examined as well as number of

marginal hooklets measured are reported in Table 1. A maximum of 15 measurements of marginal hooklet 1 were measured for each species.

Table 1. The terrapin species examined together with the number of oncomiracidia found and the total number marginal hooklets measured. All localities are in Florida, U.S.A., except Kuala Lumpur (Malaysia).

Host genus	Locality	Number of oncomiracidia examined	Number of marginal hooklet 1's measured
Neopolystoma			
Pseudemys floredana peninsularis	Lake Griffon	22	15
Trachemys scripta scripta	Deer Run pond	8	10
Polystomoides			
Pseudemys nelsoni	USGS pond 1; Lake Griffon	24	15
Pseudemys floredana	USGS pond 1	23	15
Trachemys scripta scripta	Deer Run pond	34	15
Cuora amboinensis	Kuala Lumpur	3	6

Only one oncomiracidium was found for *Polystomoidella*. However, it did not have any measurable marginal hooklet 1, thus only *Neopolystoma* and *Polystomoides* were included.

Equipment used

Marginal hooklets were studied using a Nikon Eclipse E800 compound microscope fitted with a Nikon DXM1200F Digital Camera connected to a computer with the Eclipse Net version 1.2 software program. Measurements were captured from live images. A total of 76 marginal hooklets were measured. In order to evaluate the measurements, all 13 parameters, as outlined by Du Preez and Maritz (2006), were taken from each hooklet (Fig. 1). Parameters 1 to 13 are labelled p_1 to p_{13}, where p_1 is the length of the

hooklet itself; p_2 is the tangent from the tip of the blade to the guard; p_3 is the distance from the tip of the guard to the tip of the handle; p_4 is the distance from a tangent between the tip of the blade and the guard to the reference line; p_5 is the distance from the corner the handle and guard makes to the reference line; p_6 is the distance from the mid-point of the guard base to the tip of the handle; p_7 is the distance through the centre of the guard to the edge of the hooklet; p_8 is the length from the tip of the handle to the tip of the blade; p_9 is the width of the hooklet measured perpendicular from the tip of the guard to the edge of the hooklet; p_{10} is the distance from a tangent between the tip of the guard to the tip of the blade, to the back of the blade curve; p_{11} is the widest point of the handle; p_{12} is the narrowest point of the handle; p_{13} is the shortest distance from the guard to the reference line (Du Preez & Maritz, 2006). According to Du Preez and Maritz (2006), measurements 1 and 6 were taken from Murith (1979), while the rest are novel measurements.

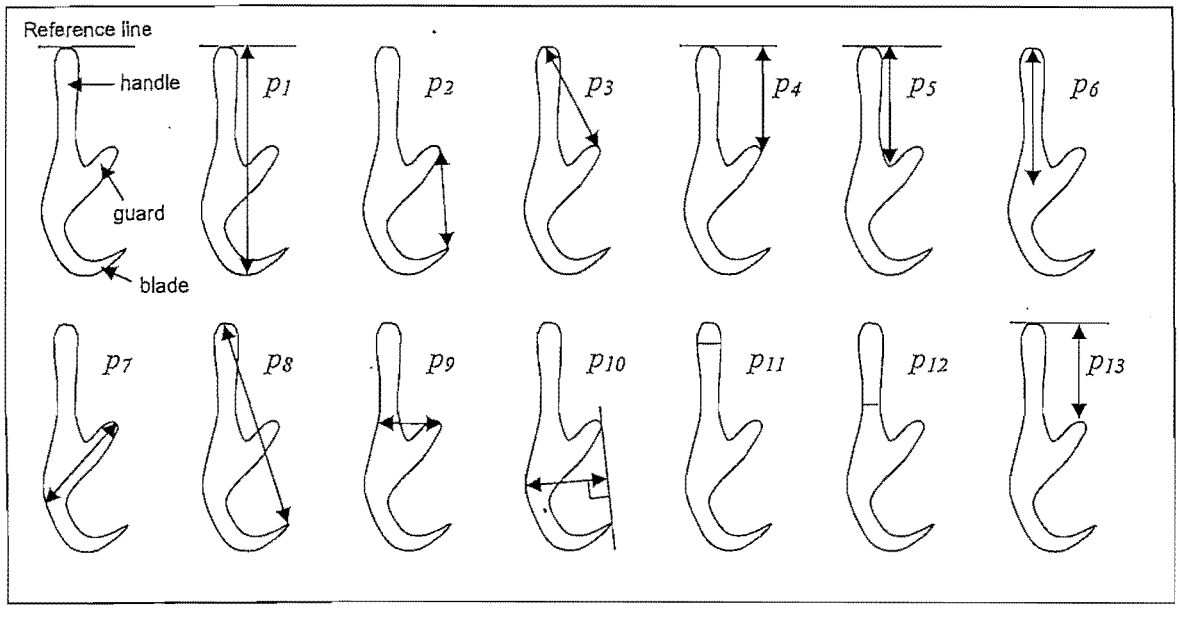

Fig. 1. Illustration of the 13 marginal hooklet measurements that were evaluated according to the protocol developed by Du Preez and Maritz (2006).

Statistical procedure

Various classification techniques exist for providing mathematical models that train on given data clusters, such as for example discriminant analysis, and multi class support vector machines. These techniques are often referred to as "supervised learning models", and are intended to be used for automated classification of new data points.

However, the aim of this paper is not towards automated classification using all the available characters, but rather to identify a small set of those characters that will provide the best clustering. The method proposed in Du Preez and Maritz (2006) will be used here as well. It applies standard bivariate Gaussian fits to the data clusters and assigns a score to each pair of characters based on how good it separates the clusters. This score is referred to the "classification potential" (CP).

Each cluster of data points is modelled by a bivariate Gaussian distribution and a confidence ellipse, centred at the mean coordinates of the cluster, may be drawn around each cluster. All ellipses are scaled by the same parameter, χ. The fraction of data points p that is expected to lie inside each ellipse depends on the scaling χ, and is given by $p = 1 - e^{-1/2\chi^2}$.

As proposed by Du Preez and Maritz (2006), the points may be classified into four categories: (1) points only inside their own correct confidence ellipses, i.e. points correctly classified, (2) points only inside the confidence ellipse of any other species i.e. points misclassified, (3) points which lie inside the intersection of two or more confidence ellipses, i.e. points with multiple classification, (4) and points which lie outside any ellipse, i.e. points not classified. Rename the number of points in category

(1) to N_{cor}, those in catergory (2) to N_{mis}, those in category (3) to N_{mult} and those points in category (4) to N_{not}. Du Preez and Maritz (2006) proposed that the CP be given by the function $P = N_{cor} - N_{mis} - \frac{1}{2}N_{mult}$, thus ensuring that P increases with N_{cor}, that it decreases with N_{mis}, and N_{mult}, and it disregards the number of unclassified points, N_{not}.

The particular value of the CP is not meaningful as such, since it depends on the number of data points. Technically the highest CP possible for any set of n data points is n (i.e. in the case when every point has been correctly classified). However, the CP is employed here to find the relative performance of one pair of characters with respect to other pairs.

Software was developed in Matrix Laboratory (MATLAB) to calculate the maximum CP and chi-value by evaluating all pair-wise combinations of the 13 parameters. Confidence ellipses for *Neopolystoma* and *Polystomoides* were created in Excel.

Results

Combinations of the 13 parameters (Fig. 1) were used to calculate the maximum CP together with the cluster scale value (χ), and cases with the greatest CP values (P) were selected. Table 2 lists the 20 combinations with the best CP values.

Table 2. Top 20 best pair-wise combinations of the 13 parameters with the highest classification potentials.

Performance grade	First parameter	Second parameter	Scaling constant (X)	Classification potential ($P = N_{cor} - N_{mis} - \frac{1}{2}N_{mult}$)
1	p_6	p_8	1.35	34.5
2	p_5	p_8	1.40	31.0
3	p_6	p_9	1.20	25.0
4	p_1	p_6	1.35	24.5
5	p_1	p_3	1.15	20.5
6	p_1	p_{11}	0.95	19.0
7	p_1	p_5	1.70	18.5
8	p_5	p_9	1.20	18.0
9	p_3	p_6	1.15	17.0
10	p_6	p_{11}	1.30	16.5
11	p_2	p_6	1.40	16.0
12	p_6	p_7	1.15	16.0
13	p_2	p_5	1.45	14.5
14	p_6	p_{12}	0.85	14.5
15	p_1	p_9	0.90	13.5
16	p_1	p_{10}	0.75	13.5
17	p_5	p_{11}	1.60	13.5
18	p_8	p_{13}	1.80	13.5
19	p_1	p_2	0.90	13.0
20	p_4	p_8	1.30	13.0

The highest CP, namely 34.5, was achieved by parameter p_6 and parameter p_8, with a scale of 1.35. However, parameter p_6 (one of the parameters proposed by Murith, 1981) is not always easily measurable and does not comply with the set criteria for a good character. The second best combination - parameter p_5 and parameter p_8, with a CP of 31.0 and a scale of 1.40 - is thus the best option for the two-parameter protocol. Fig. 2 shows a scatter plot for these parameters.

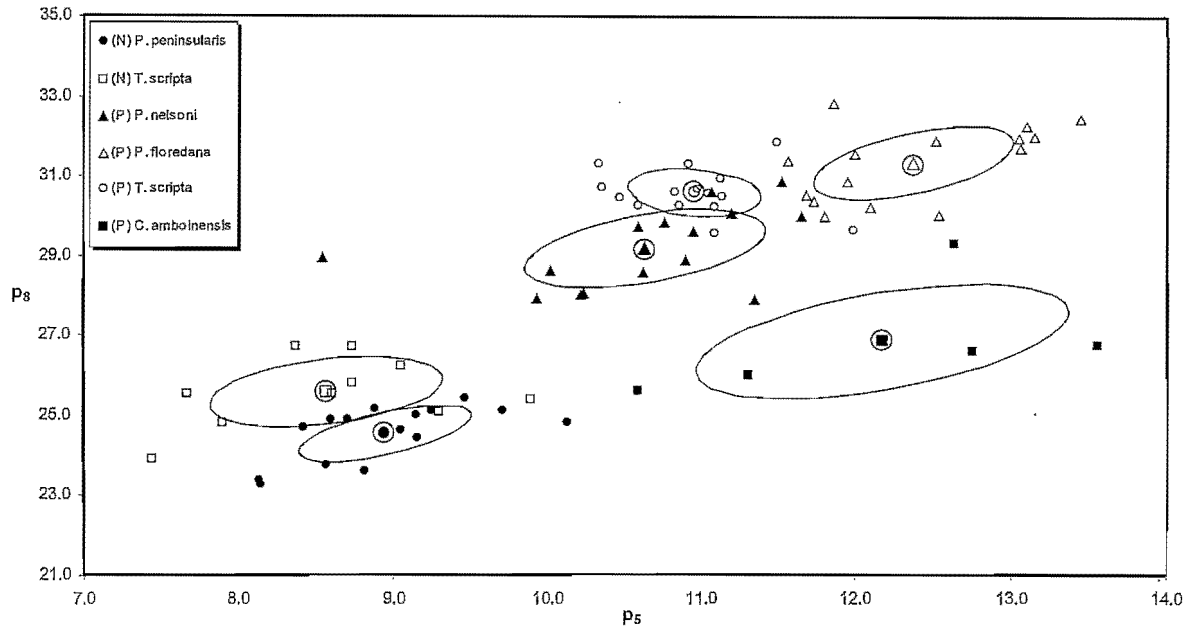

Fig. 2. Scatter plot of parameters p_5 vs. p_8 for six chelonian polystome species, with a scaling factor of X = 1.00 for all confidence ellipses.

Since there are, however, a number of weaknesses in the use of only two parameters, all pair wise products of pairs of parameters were also tested. Table 3 lists the top 20 results from the pairs of the products of the parameters that were tested and which yielded the highest CPs.

Table 3. Top 20 best combinations for the products of the 13 parameters with the highest CPs.

Performance grade	First parameter	Second parameter	Scaling constant (X)	Classification potential ($P = N_{cor} - N_{mis} - \frac{1}{2}N_{mult}$)
1	$p_6 \times p_9$	$p_8 \times p_9$	1.4	43.5
2	$p_5 \times p_6$	$p_8 \times p_9$	1.65	43
3	$p_5 \times p_9$	$p_8 \times p_9$	1.4	42.5
4	$p_1 \times p_6$	$p_8 \times p_9$	1.55	39.5
5	$p_6 \times p_{13}$	$p_8 \times p_9$	1.55	39.5
6	$p_1 \times p_6$	$p_2 \times p_3$	1.45	39
7	$p_1 \times p_9$	$p_5 \times p_6$	1.7	38.5
8	$p_2 \times p_3$	$p_5 \times p_6$	1.6	37.5
9	$p_2 \times p_3$	$p_6 \times p_8$	1.5	37.5
10	$p_3 \times p_6$	$p_3 \times p_8$	1.45	37.5
11	$p_5 \times p_8$	$p_8 \times p_9$	1.5	37
12	$p_6 \times p_8$	$p_8 \times p_9$	1.6	37
13	$p_1 \times p_6$	$p_1 \times p_9$	1.4	36
14	$p_4 \times p_5$	$p_8 \times p_9$	1.6	36
15	$p_5 \times p_6$	$p_5 \times p_8$	1.35	36
16	$p_6 \times p_7$	$p_7 \times p_8$	1.4	36
17	$p_1 \times p_5$	$p_8 \times p_9$	1.7	35.5
18	$p_2 \times p_3$	$p_5 \times p_8$	1.45	35.5
19	$p_5 \times p_7$	$p_8 \times p_9$	1.25	35.5
20	$p_2 \times p_3$	$p_2 \times p_6$	1.65	35

The CP values are notably higher for products than for single combinations. The top score was achieved by parameters $p_6 \times p_9$ vs. parameters $p_8 \times p_9$, with a CP of 43.5 and a scale of 1.4. Parameter p_6 has, however, already been disqualified and was only used to improve on the protocol proposed by Murith (1981). The next combination in line, namely $p_5 \times p_6$ vs. parameters $p_8 \times p_9$, with a CP of 43 and a scale of 1.65, also contains parameter p_6, rendering this combination unsuitable as well. However, the third

combination, that of parameters p_5 x p_9 vs. parameters p_8 x p_9, with a CP of 42.5 and a scale of 1.4, gives three easily measurable, repeatable and representative parameters, and the CP value of 42.5 is only marginally lower than that of the top scorer of 43.5. Fig. 3 represents the scatter plot of these parameters. This combination of parameters is therefore the best for the proposed protocol for *Neopolystoma* and *Polystomoides* and involves taking only three measurements.

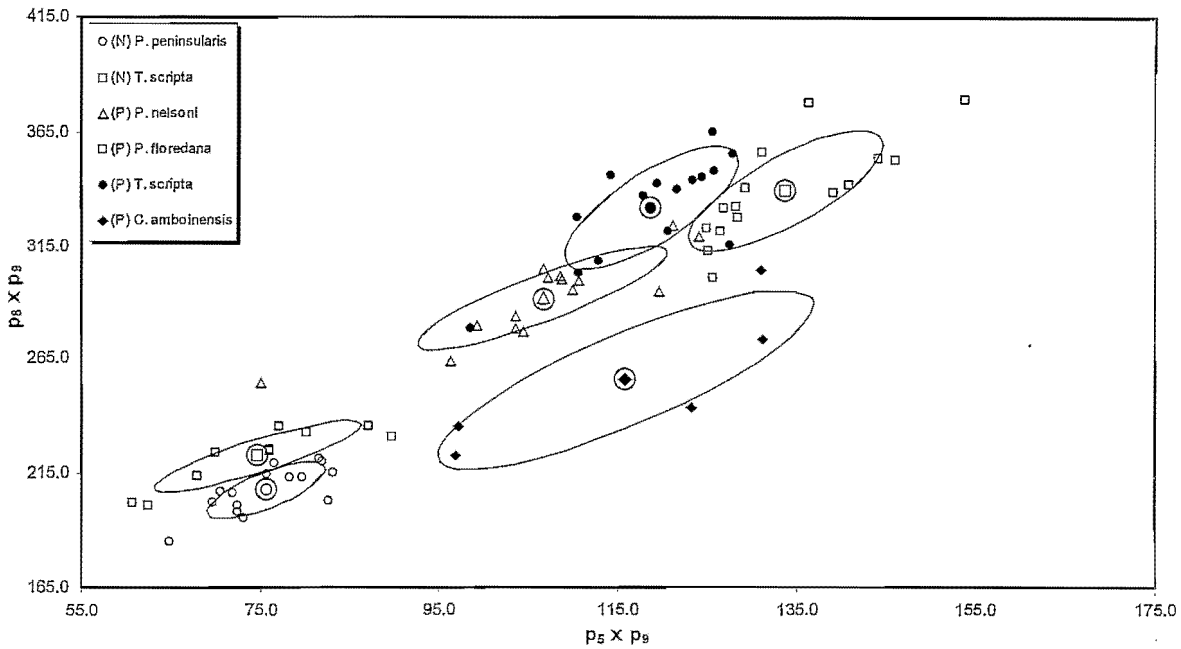

Fig. 3. Scatter plot of parameters p_5 x p_9 vs. p_8 x p_9 for six species of chelonian polystomes, with a scaling factor of X = 1.20 for all confidence ellipses.

DISCUSSION

Extensive research has been conducted on marginal hooklet measurements and morphometrics (Mo, 1991a; Mo, 1991b; Jackson & Tinsley, 1995; Shinn *et al.*, 2000) and their usefulness as a taxonomic characteristic has repeatedly been illustrated, especially because their shape and size remain constant throughout the development of the parasite (Murith *et al.*, 1978). Based on a set of sclerite measurements, Shinn *et al.* (2000) developed an automated classification system for *Gyrodactylus* species. In

polystomes, the marginal hooklets are often used to distinguish between genera and species. Marginal hooks proved to be a very useful tool in separating species of polystomes and have played a key role in describing numerous species (Kok & Van Wyk, 1986; Kok & Seaman, 1987; Du Preez & Kok, 1992, 1993, 1995; Van Niekerk *et al.*, 1993; Du Preez & Lim, 2000; Lim & Du Preez, 2001; Du Preez *et al.*, 2002, 2003).

It is, however, of the utmost importance that the marginal hooklets are flat when attempting to measure them. Mo and Appleby (1990) as well as Shinn *et al.* (2000) reported on techniques for clearing the hooks as well as taking accurate measurements. Polystomes are, however, seldom abundantly found and there are usually not enough to allow for the use of some of these in tissue digestion techniques.

The three parameters identified in the present study measure three very different and representative measurements, revealing the shape and size of the hooklet (Fig. 4). Measuring p_5 (a), the length between the corner that the handle and guard makes and the reference line, p_8 (b) the length from the tip of the handle to the tip of the blade, and p_9 (c), the width of the hooklet measured from the tip of the guard to the edge of the hooklet, and plotting them as a x c vs. b x c will provide a valuable tool to characterise the species.

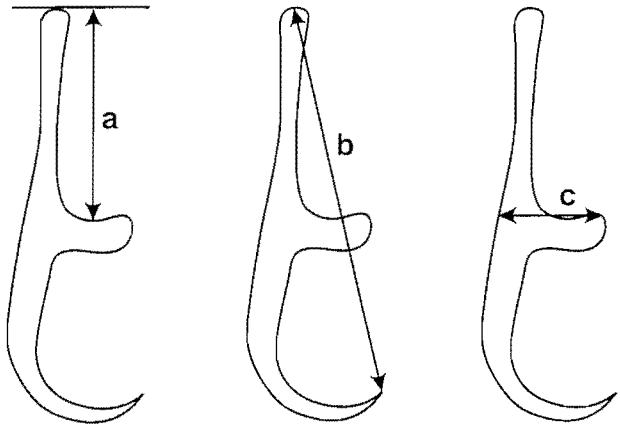

Fig. 4. The proposed protocol for marginal hooklet 1 measurements for the genera *Neopolystoma* and *Polystomoides* (a x c; b x c). Measurement (a) represents the width of the hooklet measured from the tip of the guard to the edge of the hooklet, measurement (b) represents the length between the corner of the handle and guard and the reference line, and measurement (c) represents the length from the tip of the handle to the tip of the blade.

The protocol proposed by Du Preez and Maritz (2006) scorred a CP of 40.5. Although it is desirable to have a standerdised protocol for all polystomes, the protocol proposed here for chelonian polystomes provides a better CP and is therefore proposed for the three genera *Neopolystoma* and *Polystomoides*. It is important to note that the protocol will not separate all species equally well, and therefore overlapping will still occur. This protocol only provides an additional tool and will not replace all the other morphological features of chelonian polystomes. Other characteristics that are frequently used to describe polystomes are still of the utmost importance. These include measurements of the parasite and its structures, as well as features such as the position of the reproductive organs, the genital spines, and the haptor as well as comparison at the genetic level.

Acknowledgements

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CHAPTER 5

FLORIDA POLYSTOME SPECIES DESCRIPTIONS

5.1 Introduction

The third phase of this study was to examine parasite material collected in Florida, U.S.A. and identify species. Two new species from the eye of *Apalone ferox* and *Pseudemys floredana* respectively were identified. A paper describing these new species was drafted for submission to Zootaxa.

No viable eggs were retrieved from any of the two parasites and oncomiracidia were thus not available. Marginal hooklets were located in the mature specimens but none were in a flat orientation and the newly proposed protocol (Chapter 4) could thus not be applied fully in this study.

5.2 Article 2

Two new polystomes (Monogenea: Polystomatidae) from the eyes of North American terrapins

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Abstract

Neopolystoma moleri n. sp. and *Neopolystoma grossi* n. sp. are described as new species of the monogenean family Polystomatidae parasitic on the eye of *Apalone ferox* and *Pseudemys floredana* respectively from Florida, USA. Nine other polystome species are currently known from chelonian hosts in the USA, but only two of these - *Neopolystoma elizabethae* and *N. fentoni* - are from the eyes. The two new species can be distinguished from other known *Neopolystoma* species by a combination of characteristics, including unique characteristics possessed by eye parasites such as semi-transparency, yellow spindle-shaped eggs, a very firm grip on the host, as well as the ability to stretch, which gives them the advantage of being stationary while feeding to avoid being dislodged. They were found on five adult specimens from an individual *Apalone ferox* and three adult specimens from an individual *Pseudemys floredana*. Representatives of *Neopolystoma*, *Polystomoides*, *Polystomoidella*, *Oculotrema*, and *Concinnocotyla* also share some characteristics, pointing to a possible common ancestry.

Key words: *Neopolystoma*, Polystomatidae, conjunctival sack

Introduction

Monogenea were revised in 1858 to form two families: the Tristomidae, with representatives possessing which possess a single posterior sucker, and Polystomidae (changed to Polystomatidae by Carus in 1863), where members possess several posterior suckers (Paul 1938). Polystomes belong to the family Polystomatidae Carus, 1863, and are currently represented by 21 genera. The subfamily Polystomoidinae Yamaguti, 1963, are parasites of terrapins and are characterised by undiverticulated intestinal gut cecae of equal length that do not form prehaptoral or haptoral anastomoses; the distribution of vitellaria in two lateral fields; a prominent compact and medial spherical testis; skeletal elements present in the haptoral suckers, and a genital

bulb which may contain a large number of genital spines that may be arranged in two rings. Chelonian polystomatids are represented by three genera: *Polystomoides* Ward, 1917, with two pairs of hamuli; *Polystomoidella* Price, 1939, with one pair, and *Neopolystoma* Price, 1939, with none.

According to Du Preez *et al.* (2007) the polystomes of anurans are poorly studied in North America and chelonian polystomes have so far received limited attention globally. According to Loftin (1960) only two species of polystomatids were known from North American terrapins at that time, namely *Polystomoidella oblongum* (Wright, 1879) and *Neopolystoma orbiculare* (Stunkard, 1916). As the study of chelonian polystomes began to receive greater attention, the number of species identified increased, with 56 species from about 45 host species currently known from a variety of locations around the world - including 10 species from North America. These include two *Polystomoidella* species: *P. oblongum* (Wright, 1879) and *P. whartoni* (Wright, 1879); four *Polystomoides* species: *P. coronatum* (Leidy, 1888), *P. multifalx* (Stunkard, 1924), *P. oris* Paul, 1938, and *P. pauli* Timmers & Lewis, 1979; and five *Neopolystoma* species: *N. elizabethae* Platt, 2000, *N. fentoni* Platt, 2000, *N. orbiculare* (Stunkard, 1916), *N. rugosa* (MacCallum, 1918), and *N. terrapenis* (Harwood, 1932). Of these, only *N. elizabethae* and *N. fentoni* are known from the conjunctival sack of the eye.

America is blessed with a rich terrapin diversity, with 46 species occurring in North America alone (Bonin *et al.,* 2006), which explains the rich polystome biodiversity, as this group of parasites has low interspecies variation.

The specimens found in the host species *Apalone ferox* and *Pseudemys floredana* do not conform to any existing *Neopolystoma* species and are thus identified and described as new species from the USA.

Material and methods

Terrapins were obtained by trapping live specimens as well as examining frozen road kills obtained from the Fish and Wildlife Division in Gainesville. Baited crayfish traps were set in several ponds on the premises of the United States Geological Survey (USGS) research facility in Gainesville as well as in ponds from the Gainesville surroundings. Captured terrapins were placed individually in 20 L plastic buckets containing 1 L of pond water. After 24 hours, terrapins were transferred to clean buckets and the water in which the terrapins were kept was screened for the presence of polystome eggs. Water was poured through a pair of plankton sieves with respective

mesh sizes of 500 µm and 120 µm. The first sieve removed the coarse debris from the water while the second retained any polystome eggs. Hereafter, the contents of both sieves were rinsed into glass Petri dishes and examined under a microscope. The contents from the coarse sieve were scanned for adult parasites that stereo dissecting may have dislodged, and the fine sieve's contents were examined for the presence of polystome eggs. Recovered eggs were removed and incubated at room temperature in Petri dishes containing filtered pond water. Terrapins for which no eggs were detected were screened a second and third time and, if no polystome eggs were found, the animals were released at the site of collection. Oncomiracidia that hatched were collected and mounted in ammonium-picrate for further studies according to the method of Malmberg (1956). Infected terrapins were euthanised by means of an injection of 0.5ml Uthapent (sodium pentabarbitone) diluted with 4.5ml water, and dissected for examination of the bladder, cloaca, eyes, and oral, pharyngeal, and nasal cavities using a stereo binocular rnicroscope. Frozen terrapins obtained from Fish and Wildlife Division in Gainesville were thawed, dissected and examined using the same procedure as for fresh material. Coverslips of ammonium-picrate mounts were secured and sealed using clear nail varnish.

Parasites were fixed for 24 hours in 70% EtOH under coverslip pressure. Parasites allocated for permanent mounts were hydrated to 30% EtOH, stained with Alum Carmine, gradually dehydrated to absolute EtOH, cleared in a 1:1 solution of 100% EtOH and Xylene and then pure Xylene, and mounted in Canada balsam. Parasites allocated for DNA extraction were maintained overnight in a 0.6% saline solution. After a 24 hour period, the gut contents were removed by applying pressure in a rolling motion using a camel hair brush laterally over the parasite from the haptor towards the mouth to force out the gut contents and minimise contamination. Parasites were then fixed in 96% EtOH. DNA extractions and molecular analyses were conducted at the University of Perpignan, France. Unfortunately, attempts to extract DNA from the parasites found in road killed hosts were unsuccessful as parasites were partially deteriorated since they were not properly fixed.

Six species of terrapins were examined: *Trachemys scripta scripta* (Schoepff), *Kinonsternon baurii* Garman, *Pseudemys nelsoni* Carr, *Pseudemys peninsularis* Carr, *Pseudemys floredana* (LeConte), and *Apalone ferox* (Schneider).

Since no viable eggs could be retrieved from the frozen material and since marginal hooklets in the mature specimens were not orientated horizontally, marginal hooklets of the two new species could not be studied properly and warrants further investigation.

However, the limited available material was measured and applied according to the marginal hooklet protocol (Figure 1) for chelonian polystomes (Unpublished data, see Chapter 4).

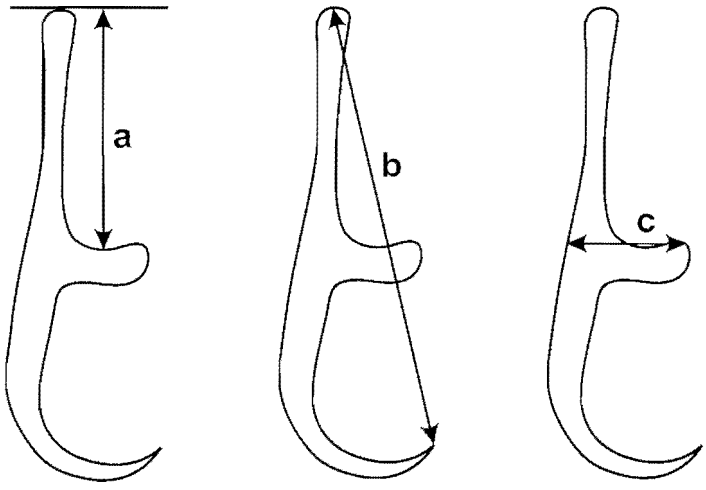

FIGURE 1: The proposed protocol for marginal hooklet 1 measurements for the genera *Neopolystoma* and *Polystomoides* (a x c; b x c). Measurement (a) represents the width of the hooklet measured from the tip of the guard to the edge of the hooklet, measurement (b) represents the length between the corner of the handle and guard and the reference line, and measurement (c) represents the length from the tip of the handle to the tip of the blade (Unpublished data, see Chapter 4).

Results

Terrapins screened and polystomes retrieved

Terrapins examined and parasites retrieved are reported in Table 1.

Table 1. Terrapins collected and screened for polystomes.

Host species	No examined	Prevalence based on egg production	Sample dissected	Polystome species	Mean intensity of dissected terrapins	Site on host
Trachemys scripta scripta	27	93%	12	*Neopolystoma orbiculare* *Polystomoides sp.*	0.58 2.08	Bladder Mouth; Pharynx
Kinosternon bauri	5	40%	2	*Polystomoidella whartoni*	2.5	Bladder
Pseudemys nelsoni	9	33%	2	*Neopolystoma sp.* *Polystomoides sp.*	0.5 4	Eye Mouth
Pseudemys floridana peninsularis	4	50%	2	*Neopolystoma sp.* *Polystomoides sp.*	0.5 1.5	Cloaca Mouth
Pseudemys floridana	1	100%	1	*Neopolystoma grossi* n. sp. *Polystomoides multifalx*	1.5 0.5	Eye Mouth
Apalone ferox	1	100%	1	*Neopolystoma moleri* n. sp. *Polystomoides sp.*	6 5	Eye Mouth; Nose

Levels of infection

Out of a total of 47 terrapins collected and processed, 33 (70.2%) were infected with a collective total of six polystome species. A representative sample of the positive terrapins was dissected for parasites to limit unnecessary killing. In total, 21 *Neopolystoma*, 65 *Polystomoides*, and five *Polystomoidella* specimens were recovered, a total of 91 parasites (Table 1). After the investigation of three *Neopolystoma* specimens from the eye of *Pseudemys floredana*, and six *Neopolystoma* specimens from the eye of *Apalone ferox*, it was found that these did not conform to any of the 21 existing *Neopolystoma* species.

Hosts

Apalone ferox (Florida soft-shell turtle) occurs in the south-eastern United States, and can reach 600 mm in length although males do not exceed 330 mm. They possess a flat, grey to brown carapace with a series of wide, short tubercles. They can be very aggressive and live in the calm backwaters of rivers, swamps and lakes, preferring the muddy bottoms. A carnivorous diet includes snails, molluscs, fish, frogs, snakes, etc. Nesting takes place from mid–March to July, with clutches of four to 24 eggs. This species is considered rare in many regions, mainly due to predation on its young, exploitation as food initially by colonists and more recently by Chinese markets, the drying of habitat, pollution and highway mortality (Bonin *et al.* 2006).

Pseudemys floredana (Common cooter) occurs in the south-eastern United States, and reaches 400mm, with a brown carapace and yellow markings on its limbs. The head is small with a projecting snout, and black skin. They live in slow-moving waters with muddy bottoms and dense aquatic vegetation, and can be gregarious, with as many as 20 to 30 individuals basking together. They can hibernate on the bottom of the water habitat, but are active from April to October, with an average of about 20 eggs in up to three nests per season. Being herbivorous, they forage on aquatic plants and algae. Although they are widely distributed, they are preyed upon by many predators, and their numbers are also dropping due to pollution (Bonin *et al.* 2006).

Species descriptions

Class: Monogenea Carus, 1863

Order: Polystomatidea Lebedev, 1988

Family: Polystomatidae Gamble, 1896

***Neopolystoma moleri* n. sp.**
(Figs. 1–3)

Specimens studied: Five sexually mature worms. Holotype (PL040621C3) and one paratype (PL040621C5) deposited in the Parasitic Worms Collection, National History Museum, Cromwell Road, London SW7 5BD, United Kingdom. Two paratypes (PL040621C2; PL040621C4) deposited in the Parasitic Worm Collection, National Museum, Aliwal Street, Bloemfontein, South Africa.

Type host: *Apalone ferox* (Schneider).

Type locality: Gainesville, Florida. Exact locality unknown. Road killed specimen collected by a member of the public and deposited at the office of the Florida Fish & Wildlife Conservation Commission, 4005 South Main Street, Gainesville FL 32601, Florida, USA.

Site: Conjunctival cavity of the eye.

Etymology: This parasite is named after Dr. Paul Moler of the Florida Fish & Wildlife Conservation Commission who provided the host specimens.

Description: The measurements, given in micrometers, are based on five egg–producing adults. The average measurement is followed by the range given in parenthesis. No larval measurements or characters are given, as no oncomiracidia were available.

Adult: General characteristics given of mature, egg-producing parasite (Figure 1). Body elongated, some stretched out, total length 5975 (3249–7944), greatest width 1269 (926–1694), width at vagina 984 (599-1426), haptor length 779 (601–983), haptor width 1027 (784–1426); haptor length to body length ratio 0.16 (0.11–0.21); haptoral suckers 6, mean diameter 280 (225–351). Mouth subterminal, ventral. Oral sucker 288 (180–358) wide; pharynx length 309 (243–415), width 331 (258–392). Intestine bifurcate with no diverticula, right caecum 3155 (1692–4101) in length, left caecum 3054 (1894–3863) in length. No anastomoses; caeca do not join posteriorly and do not extend into the haptor.

Testis compact, mid-ventral, medial, and posterior to ovary (Figure 1). Genital atrium median, ventral, posterior to intestinal bifurcation: 28 (19–37) in length with 12–13 spines, 9 (8–10) long. Ovary dextral, 15% from anterior end, ovary length 210 (124–312), width 92 (73–138). Short tubular uterus anterior to ovary, one of the five parasites containing a single egg, length 358, width 168. No intra-uterine development, egg operculated. Vitellaria diverticulated, situated in the first 75% of the body, forming no prehaptoral or haptoral anastomoses. Genito-intestinal canal prominent, on the same side as ovary, joining intestinal caecum posterior to ovary (Figure 1).

Remarks. *Neopolystoma moleri* n. sp. differs from other members of the genus by a combination of characters. This parasite was retrieved from the eye, distinguishing *Neopolystoma moleri* from most of the other members of the genus - all except *Neopolystoma cribbi*, *N. elizabethae*, *N. fentoni*, *N. liewi*, *N. palpebrae*, *N. queenslandensis*, *N. spratti*, and *N. tinsleyi*. However, only *N. elizabethae* and *N. fentoni* are known from the Nearctic region.

Neopolystoma moleri differs from *N. elizabethae* and *N. fentoni* regarding a number of diagnostic characteristics (Table 2). *Neopolystoma moleri* has an average body length of 5975 and a minimum length of 3249, notably larger than *N. elizabethae* and *N. fentoni*, with body lengths of 3125 and 1985 respectively. Furthermore, *N. moleri* is wider than *N. elizabethae* and *N. fentoni*, its minimum width, 926, being larger than the maximum width of *N. elizabethae* as well as the maximum width of *N. fentoni*. *Neopolystoma moleri* possesses a wider haptor and a slightly larger pharynx than that of the other two species. *Neopolystoma moleri* has an average haptor length to body length ratio of 0.16 that distinguishes it further from *N. elizabethae* (0.28) and *N. fentoni* (0.29). While its ovary, with an average length of 210, is slightly smaller than that of *N. elizabethae* (with an average length of 301), and slightly larger than *N. fentoni* (with an average length of 103) the testis of *N. moleri*, with an average size of 633 x 548, is much larger than that of *N. elizabethae* (with an average size of 208 x 155), and *N. fentoni* (with an average size of 225 x 181). With a maximum egg length of 332 and a maximum egg width of 146, *N. fentoni* possesses smaller eggs than that of *N. moleri* (with a length of 358 and 168), and the eggs are also wider than that of *N. elizabethae* (with an average width of 120). Furthermore *N. moleri* n. sp. can also be distinguished from *N. elizabethae* and *N. fentoni* since it has more genital spines (12–13) compared to eight for *N. elizabethae* and three to seven for *N. fentoni*.

Table 2. Comparison between the diagnostic measurements of *Neopolystoma moleri* n. sp., *N. grossi* n. sp., *N. elizabethae*, and *N. fentoni*. Measurements in micrometers.

CHARACTERISTICS	*Neopolystoma moleri* n. sp.	*Neopolystoma grossi* n. sp.	*N. elizabethae* Platt, 2000	*N. fentoni* Platt, 2000
Body length	5975 (3249–7944)	4018 (3298–4873)	3125 (2550–3675)	1985 (1500–2450)
Greatest width	1269 (926–1694)	988 (911–1130)	823 (640–990)	568 (426–760)
Haptor length	779 (601–983)	769 (707–819)	865 (790–970)	571 (449–690)
Haptor width	1027 (784–1522)	891 (709–989)	975 (880–1070)	683 (550–850)
Width at vagina	984 (599–1426)	983 (900–1125)	–	–
Right caecum length	3155 (1692–1426)	2453 (1877–3003)	–	–
Left caecum length	3054 (1894–4101)	2290 (1923–2804)	–	–
Oral width	288 (180–358)	403 (369–436)	271(251–292) x 473 (449–540)	230 (150–303) x 370 (240–496)
Pharynx length	309 (243–415)	222 (206–232)	255 (216–269)	216 (156–257)
Pharynx width	331 (258–392)	229 (209–246)	305 (268–320)	278 (185–367)
Ovary length	210 (124–312)	218 (210–222)	301 (218–350)	103 (80–245)
Ovary width	92 (73–138)	128 (118–135)	122 (100–146)	105 (55–169)
Testis length	633 (449–753)	235 (186–293)	208 (178–262)	225 (98–367)
Testis width	548 (328–719)	236 (149–245)	155 (140–192)	181 (78–251)
Genital bulb width	65 (36–79)	59 (58–60)	58 (50–63) x 57 (45–63)	55 (43–70) x 60 (30–83)
Number of genital spines	12–13	6–8	8	8
Genital spine length	9 (8–10)	8 (8–9)	10	11
Number of eggs *in utero*	1	1	3	3–7
Egg length	358	293 (288–301)	348 (322–367)	286 (245–332)
Egg width	168	139 (137–140)	120 (117–122)	136 (122–146)
Haptoral sucker width	280 (225–351)	241 (208–244)	372 (344–408)	265 (210–326)
Haptor length : body length ratio	0.16 (0.11–0.21)	0.20 (0.15–0.24)	0.28	0.29

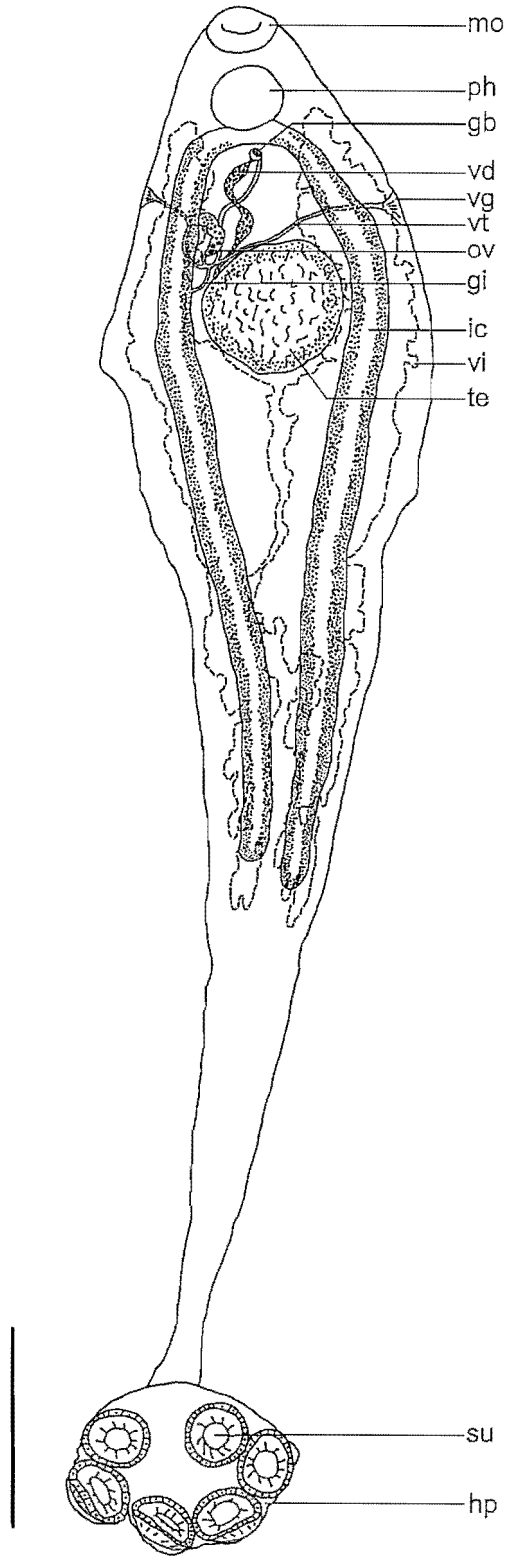

FIGURE 2: *Neopolystoma moleri* n. sp. Ventral view of holoype; the dotted line indicates the outline of the vitelline system. Abbreviations: gb, genital bulb; gi, genitointestinal canal; hp, haptor; ic, intestinal caecum; mo, mouth; ov, ovary; ph, pharynx; su, sucker; te, testis; vg, vagina; vd, vas deferens; vi, vitellaria; vt, vitelline duct. Scale bar: 1 mm.

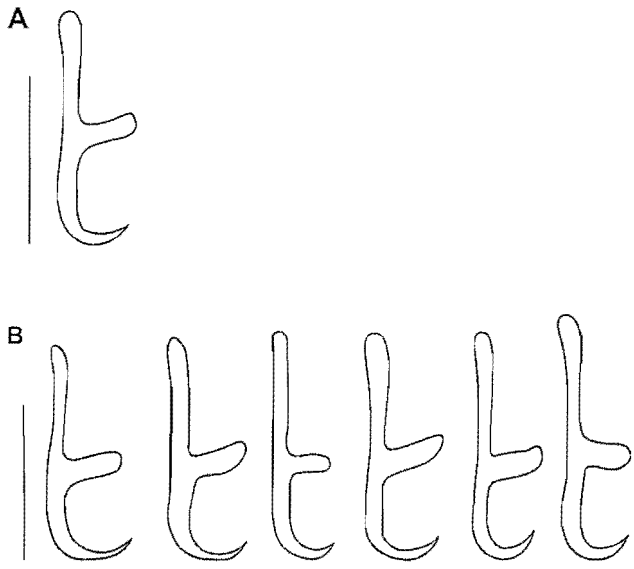

FIGURE 3: *Neopolystoma moleri* n. sp. **A**, marginal hooklet 1 from holotype and paratypes; **B**, marginal hooklets 2-8 from holotype and paratypes. Scale-bars: A & B: 10 µm.

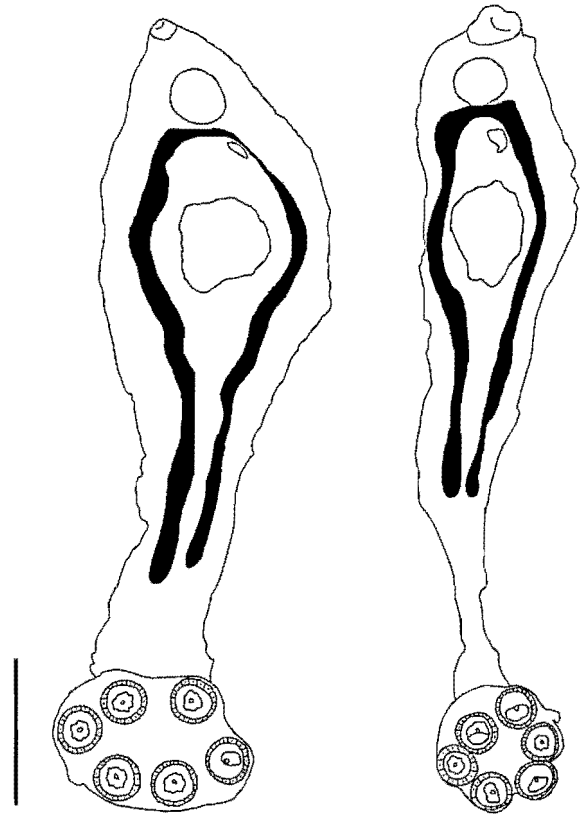

FIGURE 4: Paratypes of *Neopolystoma moleri* n. sp., demonstrating its ability to stretch its length in order to feed successfully without being dislodged. Scale bar: 1 mm.

Class: Monogenea Carus, 1863

Order: Polystomatidea Lebedev, 1988

Family: Polystomatidae Gamble, 1896

***Neopolystoma grossi* n. sp.**
(Figs. 5–7)

Specimens studied: Three sexually mature worms. The holotype (PL040612B1) and one paratype (PL040612B2) deposited in the Parasitic Worms Collection, National History Museum, Cromwell Road, London SW7 5BD, United Kingdom. Remaining paratype (PL040612B3) deposited in the Parasitic Worm Collection, National Museum, Aliwal Street, Bloemfontein, South Africa.

Type host: *Pseudemys floredana* (LeConte), sexually mature individual deposited in the Florida Museum of Natural History, Division of Herpetology, Museum Road, Dickinson Hall, University of Florida, Gainesville, Florida 32611 as a type host. Museum number: UF 141647.

Type locality: Pond at the United States Geological Survey USGS-BRD facility, Florida Integrated Science Centres, 7920 NW 71st Street, Gainesville FL 32653, Florida, USA. 29.725278°S 82.417778°W.

Site: Conjunctival cavity of the eye.

Etymology: This parasite is named after Dr. Timothy Gross who provided the research facilities.

Description: Based on three egg-producing adults; measurements are given in micrometers. The average measurement is followed by the range given in parenthesis. No larval measurements or characters are given, and although many eggs were harvested from the host, no development took place and no oncomiracidia hatched.

Adult: General characteristics given of mature, egg-producing parasites (Figure 5). Body elongated, some stretched out, total length 4018 (3298–4873), greatest width 988 (911–1130), width at vagina 983 (900–1125), haptor length 769 (707–819), haptor width 891 (709–989); haptor length to body length ratio 0.2 (0.15–0.24); haptoral suckers 6, mean diameter 241 (208–244). Mouth subterminal, ventral. Oral sucker 403 (369–436)

wide; pharynx length 222 (205–232), width 229 (209–246). Intestine bifurcate with no diverticula, right caecum 2453 (1877–3003) in length, left caecum 2290 (1923–2804) in length. No anastomoses; caeca do not join posteriorly and do not extend into the haptor.

Testis compact, mid-ventral, medial, and posterior to ovary (Figure 5). Seminal vesicle filled with sperm. Genital atrium median, ventral, posterior to intestinal bifurcation, 21 (12–24) in length with 6–8 spines, 8 (8–9) long. Ovary sinistral, ¼ from anterior end, ovary length 218 (210–222), width 128 (118–135). Short tubular uterus only anterior to ovary, containing only one egg; egg capsule length 293 (288–301), width 139 (137–140). No intrauterine development, eggs operculated. Vittelaria diverticulated, situated in the first 70% of the body, forming no prehaptoral or haptoral anastomoses. Genito-intestinal canal obscured by the testis, located on the same side as ovary, joining intestinal caecum posterior to ovary (Figure 4).

Remarks: *Neopolystoma grossi* n. sp. differs from other members of the genus in terms of a combination of characteristics. The most prominent difference is the location of the parasite: the eye, distinguishing *N. grossi* from most of the other members of the genus, all except *Neopolystoma cribbi*, *N. elizabethae*, *N. fentoni*, *N. liewi*, *N. palpebrae*, *N. queenslandensis*, *N. spratti*, and *N. tinsleyi*. However from these, only *N. elizabethae* and *N. fentoni* occur in the Nearctic realm.

Neopolystoma grossi differs from *N. elizabethae* and *N. fentoni* regarding a number of diagnostic characteristics (Table 2). With an average length of 4018 and a minimum length of 3298, *N. grossi* is significantly longer than *N. fentoni* (with a maximum length of 2450), and also longer than *N. elizabethae* (with a maximum length of 3675). *Neopolystoma grossi*, with an average width of 988, is also wider than *N. fentoni*, which has a maximum width of 760, and also possesses a slightly larger haptor. *Neopolystoma grossi*, with an average ovary size of 218 x 128, also differs from *N. fentoni* (with an average ovary size of 103 x 105), which is significantly smaller. *Neopolystoma grossi* can also be distinguished from *N. elizabethae* and *N. fentoni* by slightly smaller genital spines. *Neopolystoma elizabethae*, with a length of 322-367, have more elongated eggs than those of *N. grossi* (with a length of 288-301). *Neopolystoma grossi* can also be distinguished from *N. elizabethae* by a smaller haptoral sucker size of 241, as opposed to 372. Finally, *N. grossi* has a smaller maximum haptor length to body length ratio of 0.20 that distinguishes it further from *N. elizabethae* (0.28) and *N. fentoni* (0.29).

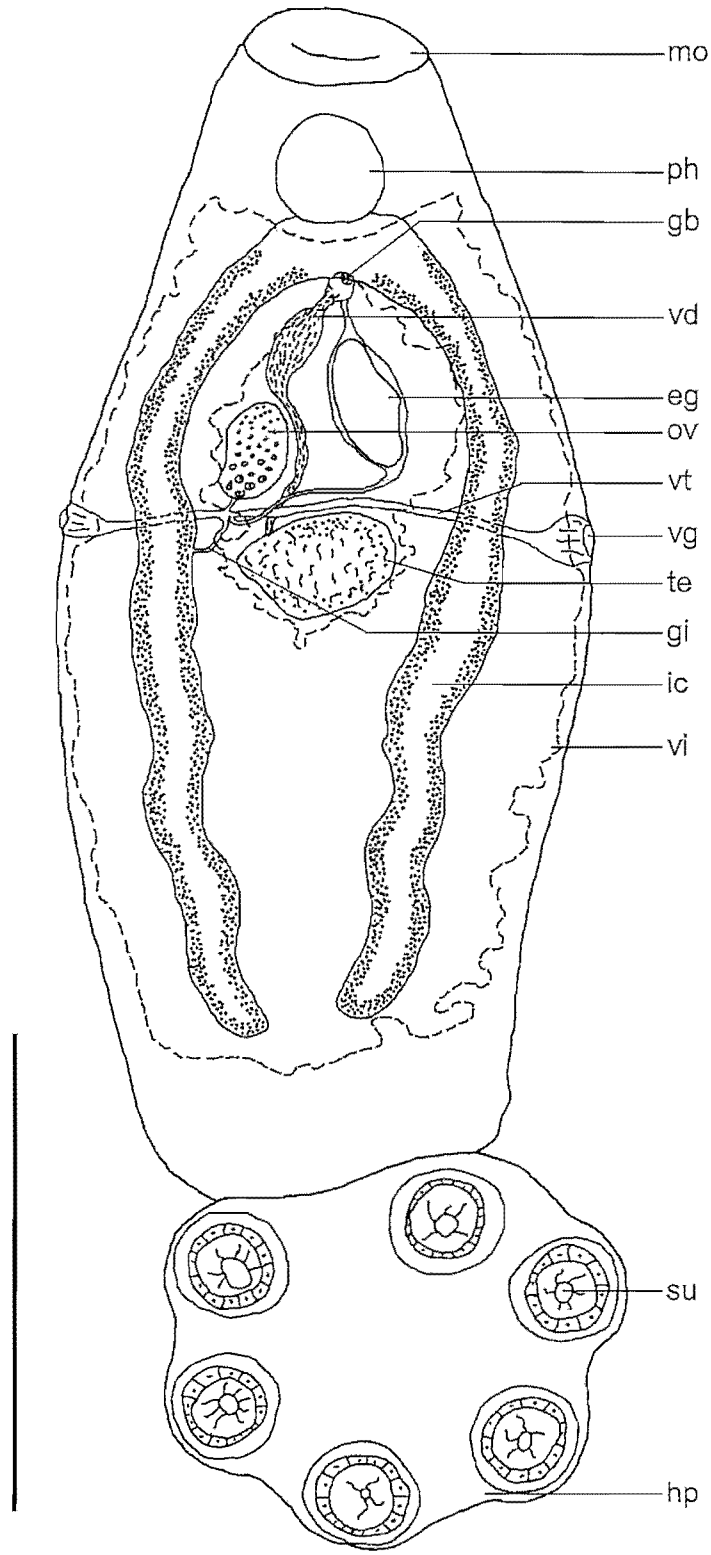

FIGURE 5: *Neopolystoma grossi* n. sp. Ventral view of holotype; the dotted line indicates the outline of the vitelline system. Abbreviations: eg, egg; gb, genital bulb; gi, genitointestinal canal; hp, haptor; ic, intestinal caecum; mo, mouth; ov, ovary; ph, pharynx; su, sucker; te, testis; vg, vagina; vd, vas deferens; vi, vitellaria; vt, vitelline duct. Scale bar: 1 mm.

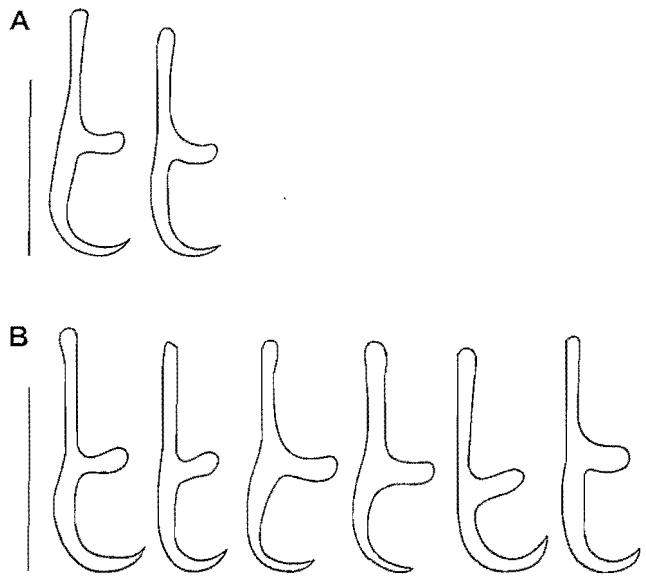

FIGURE 6: *Neopolystoma grossi* n. sp. **A**, marginal hooklets 1 from holotype and paratypes; **B**, marginal hooklets 2-8 from holotype and paratypes. Scale-bars: A & B, 10 µm.

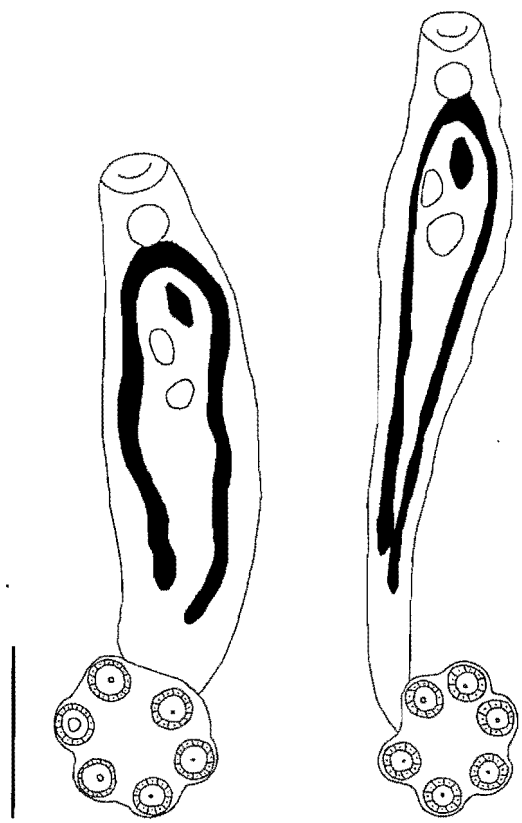

FIGURE 7: Paratypes of *Neopolystoma grossi* n. sp., demonstrating its ability to stretch. Scale bar: 1 mm.

The proposed new species, *Neopolystoma moleri* n. sp. and *Neopolystoma grossi* n. sp., differ from one another with regard to a number of key characteristics (Table 2): *N.*

moleri n. sp. is considerably larger than *N. grossi* n. sp., with a larger maximum length and width, and has a larger haptor. *N. grossi* n. sp., however, has a larger oral diameter, although its pharynx is much smaller than that of *N. moleri* n. sp. *Neopolystoma moleri* n. sp. has a larger testis than *N. grossi* n. sp., and although their genital bulb sizes are similar, *N. moleri* n. sp. possesses 12–13 genital spines, while *N. grossi* n. sp. possesses six to eight. Finally, *N. moleri* n. sp. has slightly larger haptoral suckers than *N. moleri* n. sp., but a smaller haptor length:body length ratio.

Comparison of marginal hooklet 1 measurements

Material of *Neopolystoma moleri* n. sp. and *N. grossi* n. sp. were studied in order to apply the protocol developed for chelonian polystomes (Chapter 4). A requirement for applying this protocol is that hooklets be in a flat orientation. Unfortunately, only a single hooklet could be measured for *N. moleri* and four for *N. grossi.* Attempts were made to obtain the type material of *N. elizabethae* and *N. fentoni*, but were unsuccessful. For these two species measurements were calculated from published drawings of the hooklets. Despite this, the plot yielded clear results: none of the data points overlap, supporting the species status for all four (Fig. 8).

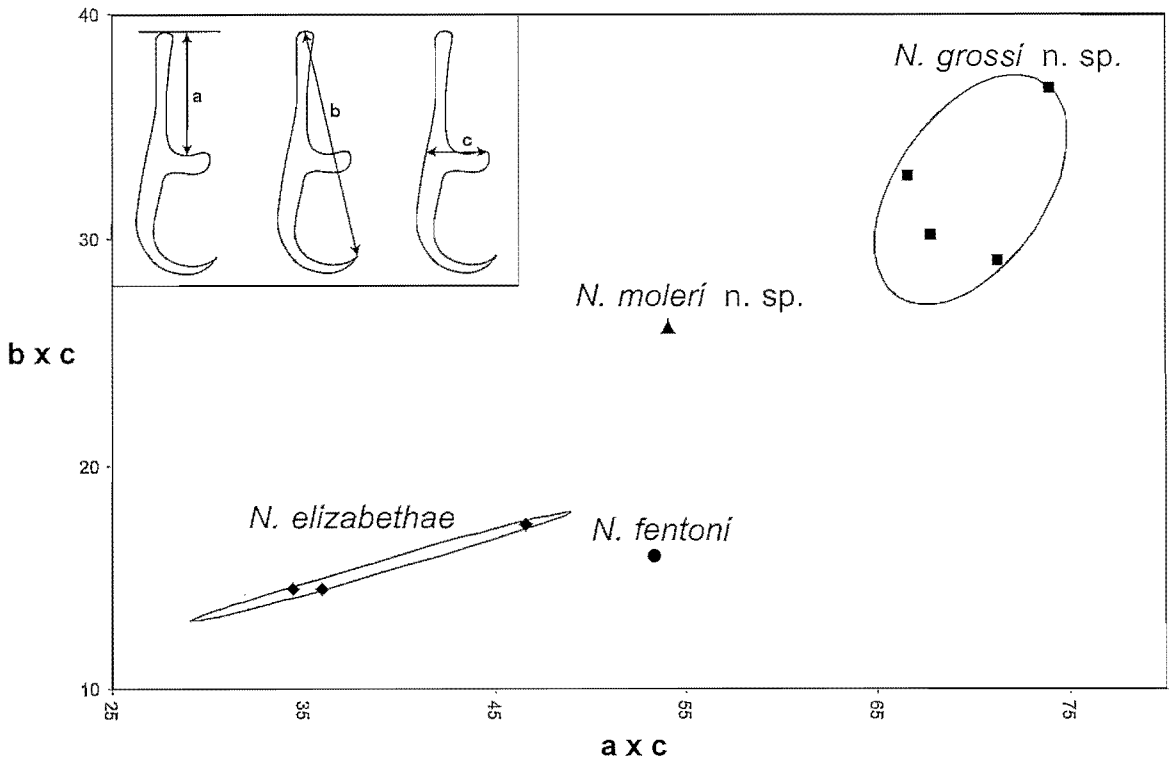

FIGURE 8: Scatter diagram of a x c plotted against b x c for the two known North-American eye polystomes as well as the new species.

Discussion

Chelonian polystomes have been well studied in the USA and 12 species are known from the area. Polystomes of the eye, however, have only recently been included in studies, with the first ocular polystome from a terrapin, namely *Neopolystoma palpebrae* Strelkov, 1950, being described only 59 years ago. Since then, new species were described very sporadically. The eye as a site for polystomes has often been overlooked in the past, with only eight out of 21 *Neopolystoma* species being described from the eye, seven of which were described after 1994. Apart from the eye, *Neopolystoma* species can be found in the cloaca, urinary and accessory bladders, oral, pharyngeal and nasal cavities (Pichelin 1995). The conjuctival sac provides the parasites with easy access as well as favourable living conditions (Stunkard 1924). Chelonian polystomes are known to be site-specific, allowing for speciation and thus more than one species in a single species of terrapin (Du Preez & Lim 2000). Littlewood *et al.* (1997) found that chelonian polystomes from different host species, but from the same site, are evolutionary closer together than parasites from different sites within a single host individual.

Chelonian polystomes are often semi-transparent since they do not feed on blood and are thus difficult to detect. This is especially true for ocular parasites as they tend to hide under the nictitating membrane and are often found right in the corner of the eye. The characteristic yellow spindle-shaped intrauterine egg is often observed before the rest of the parasite is seen. Keeping terrapins in water and screening the water after 24 hours by pouring the water through a plankton netting of about 120 µm reveals the spindle-shaped eggs. This is an indication that an ocular polystome is present. Spindle-shaped eggs have been reported for *N. liewi* (see Du Preez & Lim 2000), *N. elizabethae* (see Platt 2000a), *N. fentoni* (see Platt 2000b), and *N. tinsleyi* (see Pichelin 1995). It would thus appear as if spindle-shaped eggs are a characteristic of many ocular chelonian parasites. It could be the case that the elongated shape of the eggs renders them stronger so that they could better tolerate the pressure under the eyelids. *Oculotrema hippopotami* Stunkard, 1924, is found under the nictitating membrane of the hippopotamus eye. Unlike chelonian polystomes, the eggs of *O. hippopotami* are oval but they also have a mechanism for reinforcing their eggs to withstand the pressure of the eyelid and nictitating membrane, as well as reducing the chances of expelled eggs breaking during the blinking movement of the eye. *Oculatrema hippopotami* has a thicker eggshell - up to 3.3µm – and therefore the shell walls of these eggs are

exceptionally thick (Du Preez & Moeng 2004). Increasingly larger numbers of polystomes are discovered occupying the eye of terrapins, and it is highly likely that many new polystome species will be found when more studies are conducted on chelonian eye polystomes.

Both *Neopolystoma moleri* n. sp. and *N. grossi* n. sp. share quite a number of other characteristics with the mammalian eye polystome *O. hippopotami.* Ocular polystomes are rarely found on the cornea and rather occur on the conjuctiva covering the sclera, under the nictitating membrane, as well as under the eyelids. They have an exceptionally firm grip on the host's tissue and often form clusters on the eye with their haptors tightly arranged (Du Preez & Moeng 2004). Their haptoral suckers have clear skeletal elements that facilitate the firm grip on the host. *Neopolystoma* and *Oculotrema* do not possess hamuli, but both have a compact round testis and a small ovary. No intra-uterine development takes place, and while the eggs do not develop in saline conditions associated with the eye (Thurston 1968), the eye of the hippopotamus and terrapins are not constantly saline, because the hosts spend most of their time in the water and are also known to open their eyes when submerged. This can also lead to re-infections by larvae.

A characteristic that *O. hippopotami*, *Neopolystoma moleri* n. sp. and *N. grossi* n. sp. share is the ability to stretch. Du Preez and Moeng (2004) indicated that *O. hippopotami* has a flexible peduncle between the anterior body and haptor that enables the parasite to stretch out and double its length. In this region, they have well developed longitudinal and circular muscle fibres that enhance the flexibility and elasticity of the parasite (Moeng *et al.* 1998). Concomitantly, the parasites' reproductive and digestive organs are confined to the anterior third of the body. This same phenomenon, which probably enables the parasite to stretch out and feed on a larger area without detaching (Du Preez & Moeng 2004), was observed for both *Neopolystoma moleri* n. sp. and *N. grossi* n. sp. as well. An added advantage of this mechanism is that not having to move around while feeding minimises the risk of being dislodged when the host blinks. Monogeneans are known to have well developed attachment organs, but compared to other polystomes the eye polystomes have an exceptionally firm grip on the host's tissue, and after removal prominent bud-shaped attachment marks often remain.

Neopolystoma, *Polystomoides*, *Polystomoidella*, *Oculotrema*, *Concinnocotyla* species share some characteristics pointing to a possible common ancestry. They all abandoned a sanguiniforic diet and adopted a possible diet of epithelial cells and mucus, supported by the increased thickness and toughness found in the epithelial

lining of the parasites. Because their hosts share similar habits and habitats and may come into contact with each other, Du Preez and Moeng (2004) pointed out the possibility of a transfer of a terrapin polystome to the hippopotamus, which could have evolved and adapted in isolation to the environment of the hippopotamus eye. This could mean that the two species from different hosts are evolutionary closer to each other than terrapin species that occur on the same host, but different sites.

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CHAPTER 6

GENERAL DISCUSSION

Nature is endlessly dynamic, with species occurring in different forms, relationships, variations, and behaviours, creating an ever changing world. To organise all of this seems like an impossible task but this is where taxonomy and systematics come into play. In theoretical and applied biology, taxonomy characterises species, then arranges them in a hierarchy of higher categories. There are three stages: the analytical phase, synthetic phase, and biological phase. In the analytical phase, the species is characterised and named, in the synthetic phase, the species are arranged into a natural system of lower and higher categories, and finally, in the biological phase, the intraspecific and the biological phase variations and evolutionary speciation of the species are analysed (Kapoor, 2001).

A taxon is a taxonomic group which is sufficiently distinct to be given a name as well as ranking in a definite category (Kapoor, 2001). Examples of these are genera, or families. But what constitutes a species? Holmes (1982) defines a species as a group of interbreeding individuals not interbreeding with another such group, being a taxonomic unit including geographical races and varieties and having two names in binomial nomenclature. A species' members descend from common ancestral populations, have reproductive compatibility, and maintain genotypic and phenotypic cohesion (Hickman *et al.*, 2006). However, it is not this simple. Unfortunately, the term species has no simple and unambiguous meaning. Together with this, variation within species does exist with no two members being absolutely alike. Variation is the uniqueness of every individual within a species, and is present in morphological, as well as physiological traits (Mayr, 2003). The taxonomic groups studied in this study clearly demonstrate this, as it is apparent that any polystome species has differences in the morphological characters they posses. Furthermore, ranges of these characters between members of the same species also exist. This makes the identification of a new species more difficult, as the specimens under examination could simply be a variation of an already existing species.

The reference list also highlights several of the shortcomings that exist within chelonian polystome taxonomy. For example, modern species descriptions use certain characters to differentiate between species that were not used in earlier descriptions. General characteristics, such as hamulus length and shape, were most frequently used in the past to distinguish between species, while at present much more definitive morphometrics are used, such as the haptor length/body length ratio. New techniques are also being developed, such as marginal

hooklet morphometrics. These taxonomic characteristics are thus not known for many of the older species. A re-examination of the type specimens may help in some cases, but these are often deteriorated to the point that some characteristics may not be obtainable. This can lead to disputes on the validity of a species, or may create controversy in terms of species identities. Unfortunately, no one technique or characteristic is the most "useful", and each case of a new species description may be unique.

Although this and other shortcomings and discrepancies in polystome taxonomy are pointed out and rectified in this dissertation, the aim of this study was not to ensure that none are left, but to shed light on the main problems as well as providing the means to ensure that these are not repeated in the future. Together with the reference list, the marginal hooklet protocol proposed in Chapter 4 will provide a valuable tool to characterise the species, and the description protocol might prove invaluable in the future description of species.

Chelonian polystomes have not been studied extensively, and for example, until 1974, the genus *Polystomoides*, which is now the largest genus of the chelonian polystome genera, was considered rare (Pandey, 1973). Today *Polystomoides* species have been studied more intensively than species of *Neopolystoma* and *Polystomoidella*, and can be seen as the representatives of the chelonian polystomes, although this is changing. Because polystomes are overdispersed and concentrated chelonian polystomes have been found in abundance in some well researched geographical areas while large gaps still remain in poorly studied areas. This has lead to a biased distribution pattern. As research patterns spread and intensify, it is highly likely that many more new species of chelonian polystomes will be described. More attention should be given to the biology and life cycle of this group. Although there are some similarities with the well studied life cycle of *Polystoma* several differences do exist. Chelonian polystomes' life cycles are simpler, and they do not synchronise with the breeding cycle of the host and no intermediary host is present (Smyth, 1994).

Some work has been done on the ancestry of chelonian polystomes, and many theories exist regarding their descent. It has been determined that parasites that occur in the bladder of different host species are closer related than those in different sites on the same host species or even host individual (Littlewood et al., 1997). Two hypotheses were proposed to explain this phenomenon: Hypothesis 1 stipulated that species occupying a particular site became adapted subsequently to different hosts, while hypothesis 2 stipulated that species occupying particular hosts or host lineages became adapted subsequently to different sites (Combes, 2001).

Furthermore, a theory rose out of this discovery concerning the heritage of chelonian polystomes and the hippopotamus eye polystome, *Oculotrema hippopotami*. Chelonian eye

polystomes and *Oculotrema* share certain characteristics that point to a common ancestry. Du Preez and Moeng (2004) proposed the theory that a terrapin polystome could have transferred to a hippopotamus, evolving and adapting in isolation to the environment of the eye, because the hosts share similar habitats and habits and may come into contact with each other. This seems to be supported by the fact that polystomes that occur on the same site on different hosts are more related than polystomes on different sites of the same host. Recent studies include cophylogenetic contributions to investigate the evolutionary trends within host-parasite associations (Verneau *et al.*, 2008).

When taking all of this into account, it is apparent that chelonian polystomes are very valuable as an evolutionary model, being an extremely old group of parasites (up to 425 million years). There is good evidence that the Polystomatidae has a very ancient origin, tracking the evolutionary history of the first aquatic tetrapods. Terrapin polystomes diversified together with their hosts, about 191 million years ago, and although amphibian polystomes diversified about 55 million years before that, both lineages are monophyletic and separated by very long branches when plotted on cladograms. Thus phylogenetic relationships within polystomatids suggest a sister relationship between amphibian and chelonian parasites, indicating that the two separated 353 million years ago (Verneau *et al.*, 2002). Chelonian polystomes are an excellent evolutionary model, providing a long and stable model, that can enable the study of biology, development, tendencies, and patterns of both host and parasite species. Platt (2000b) states that terrapins and their parasites may provide a valuable (but overlooked) resource for the study of host-parasite coevolution, biogeographic analysis, and speciation. Results of cophylogenetic studies recently conducted show that Polystomatidae may indeed track the evolutionary history of the first tetrapods in the Palaeozoic age, and the evolutionary lines of the major polystome lineages are also intimately related to the evolution of their hosts over hundreds of millions of years. Thus, the Polystomatidae has the potential to be an excellent model (Verneau *et al.*, 2008).

Morphometric data is still the most important strategy to separate polystome species, although new methods have been introduced. Until the 1960's, classification was based on genealogy, and could be summarised in a phylogram. Since then, classification has developed to include two new strategies: the appearance of organisms (phenetics), and the branching pattern in a phylogenetically related group of organisms (cladistics) (Price, 1996). Millions of species have been described today, emphasising the human need to organise and categorise. More and more methods are being developed to make this process easier, in order to understand the living world around us, but it is debatable if we will ever reach that goal.

CHAPTER 7

CONCLUSION

Members of the Polystomatidae are a fascinating group of parasites that represent unique as well as diverse parasitic strategies. Understanding these unique parasites holds great promise in the study of host-parasite co-evolution, interaction, and dynamics. The species count continues to grow, and new discoveries are made constantly. Today only a fraction of possible existing species is known.

This study attempts to address some of the problems existing within the species identity and species diversity of chelonian polystomes, simplifying the confusing tangle of information on them as well as exploring new methods of better distinguishing between species. It is becoming increasingly difficult to separate described species, and the arms race between classification methods and the increasing species count continues endlessly.

More research is needed to produce final solutions to the problems in chelonian terrapin polystome taxonomy, as well as understanding their biology, development, and host-parasite relationships. To aid in this, the aim of this study was to summarise the present knowledge on the 59 species of Polystomatidae parasitic on terrapins, to review the value of marginal hooklet measurement as taxonomic characteristic, and to describe two new eye polystomes. This study laid the foundation on which further studies on phylogenetic relationships between parasites, their hosts, and their biogeographic distributions, as well as a broader understanding of the extent of the parasites' speciation and biology should be built. Further studies will be invaluable to a better understanding of both host and parasite, improving the understanding of this unique and diverse group of parasites.

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