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Identification of Cystacanths and Adults of *Oligacanthorhynchus tortuosa*, *Macracanthorhynchus ingens*, and *Macracanthorhynchus hirudinaceus* Based on Proboscis and Hook Morphometrics

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Identification of cystacanths of certain acanthocephalans belonging to the family Oligacanthorhynchidae has been difficult due to discrepancies in the literature concerning proboscis and hook morphometrics (Meyer, 1933; Moore, 1946; Van Cleave, 1953; Schmidt, 1972; Elkins, 1981).

The purpose of this study was to conduct direct comparison of proboscis and hook morphometrics of *Oligacanthorhynchus tortuosa* (Leidy, 1850) Schmidt, 1972, *Macracanthorhynchus ingens* (Linstow, 1879) Meyer, 1932, and *Macracanthorhynchus hirudinaceus* (Pallas, 1781) Travassos, 1917. Recent acquisition of cystacanths of *O. tortuosa* and young juveniles of *M. ingens* provided material for comparison of cystacanths and adults of these 2 species. Resultant data make the identification of both cystacanths and adults of these acanthocephalans of North American mammals possible, greatly facilitating epizootiological investigations.

Adults and very young juveniles of *M. ingens* were acquired from raccoons utilized in a study of the population structure and dynamics of *M. ingens* from Ossabaw Island, Georgia (Richardson and Barger, 2005). Adult *M. hirudinaceus* from domestic swine were acquired from a biological supply company. Adult *O. tortuosa* were acquired from Virginia opossums collected in Pope, Searcy, and Van Buren counties in Arkansas (Richardson, 1993; Richardson and Barnawell, 1995). Data for cystacanths of *O. tortuosa* were taken from Richardson (in press) who demonstrated the life cycle of *O. tortuosa* using cystacanths from millipedes (*Narceus americanus*) collected in St. Tammany Parish, Louisiana. Voucher specimens were deposited in the Harold W. Manter Laboratory, Lincoln, Nebraska, and assigned accession numbers as follows: proboscides of adult *M. ingens* HWML48143; proboscides of adult *M. hirudinaceus* HWML48144; proboscides of adult *O. tortuosa* HWML48145; juvenile *M. ingens* (HWML48146); cystacanths of *O. tortuosa* (HWML48149).

Proboscides were removed from adult worms. All specimens were treated and microscopically examined and drawn according to Richardson (in press). All measurements were made as prescribed by Van Cleave (1953) as follows. Hook numbers were ascribed considering hook arrangement of 6 diagonal rows of 6 hooks each or 3 circular rows of 6 hooks each. Either arrangement results

in the same numerical hook assignments (see Text Fig. C of Van Cleave (1953)). Measurements of hook length were conducted on hooks in full lateral view as shown in Fig. 1 being measured as a straight line connecting the free point of the thorn with the point where the thorn joins the root. Proboscis length was measured from the anterior end of the proboscis to the insertion of the hook blade of hook number 6. Proboscis width was measured at the widest point (Fig. 2). All measurements are given in μm with the range followed by the mean in parentheses. Statistical analyses were conducted using a Student's 2-tailed t-tests (Microsoft[®] Excel 2002). Significant differences assume $p < 0.05$.

Proboscides and hooks of *M. hirudinaceus* (Fig. 3) are larger than those of *M. ingens* (Fig. 4), which in turn are larger than those of *O. tortuosa* (Fig. 5). No significant differences were detected in proboscis length and hook length between cystacanths and adults of *M. ingens* and *O. tortuosa*. Barbs (Fig. 7) were observed inconsistently among hooks for all 3 species. Proboscis and hook morphometrics are summarized in Tables 1 and 2.

Both cystacanths and adults of *O. tortuosa*, *M. ingens*, and *M. hirudinaceus* may be easily identified based on proboscis and hook morphometrics. Differences in hook size among the 3 species are most dramatically exhibited by hook number 3 (Figs. 6-8).

Hook size and proboscis length appear to remain stable through development from cystacanth to adult. The increase in proboscis width observed may reflect changes in musculature as opposed to true growth of the proboscis. These data support the assertion of Moore (1962) in regard to *Mediorhynchus grandis* that proboscis and hook morphometrics are fixed by the time worms become infective cystacanths. Van Cleave (1941) and Elkins

(1981) made the same observation in regard to hook morphometrics. Cystacanths of *M. ingens* and *O. tortuosa* are shown in Figs. 9 and 10.

It is well established that adult female acanthocephalans attain much greater sizes than adult males. Richardson (in press) found that female cystacanths of *O. tortuosa* are significantly more robust than males and have significantly larger proboscides and hooks. Thus, it appears that the size difference between sexes is apparent by the time worms become infective cystacanths.

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Table 1. Summary of proboscis morphometrics for adult *Macracanthorhynchus ingens*, *Macracanthorhynchus hirudinaceus*, and *Oligacanthorhynchus tortuosa* and cystacanths of *M. ingens* and *O. tortuosa*. All measurements are in μm . Range is followed by mean in parentheses.

Species and Ontogenetic Stage	Length	Width	Length:Width Ratio
<i>M. ingens</i> Adult	405-459 (437)	653-729 (683)	0.62-0.68 (0.64)
<i>M. ingens</i> Cystacanth	390-546 (467)	504-700 (590)	0.73-0.87 (0.79)
<i>M. hirudinaceus</i> Adult	716-952 (794)	873-1260 (1119)	0.62-0.88 (0.72)
<i>O. tortuosa</i> Adult	248-315 (282)	257-325 (291)	0.86-1.13 (0.97)
<i>O. tortuosa</i> Cystacanth	239-324 (282)	238-311 (277)	0.90-1.10 (1.00)

Table 2. Summary of hook lengths for adult *Macracanthorhynchus ingens*, *Macracanthorhynchus hirudinaceus*, and *Oligacanthorhynchus tortuosa* and cystacanths of *M. ingens* and *O. tortuosa*. All measurements are in μm . Range is followed by mean in parentheses.

Species and Ontogenetic Stage	Hook 1	Hook 2	Hook 3	Hook 4	Hook 5	Hook 6
<i>M. ingens</i> Adult	160-212 (185)	149-207 (182)	104-158 (135)	108-158 (123)	86-106 (96)	72-99 (86)
<i>M. ingens</i> Cystacanth	153-212 (182)	151-196 (173)	117-158 (137)	95-133 (114)	86-104 (95)	59-90 (82)
<i>M. hirudinaceus</i> Adult	185-325 (254)	196-291 (241)	225-302 (268)	160-218 (192)	131-221 (156)	95-162 (137)
<i>O. tortuosa</i> Adult	65-101 (89)	63-72 (67)	52-81 (61)	43-73 (57)	45-54 (50)	36-50 (42)
<i>O. tortuosa</i> Cystacanth	78-104 (90)	59-89 (74)	55-74 (62)	48-76 (57)	36-56 (47)	34-50 (41)

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Fig. 1. Proper measurement of hook length indicated by dotted line.

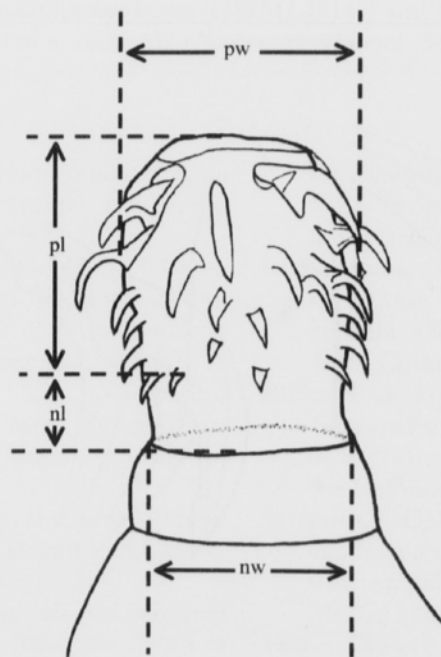
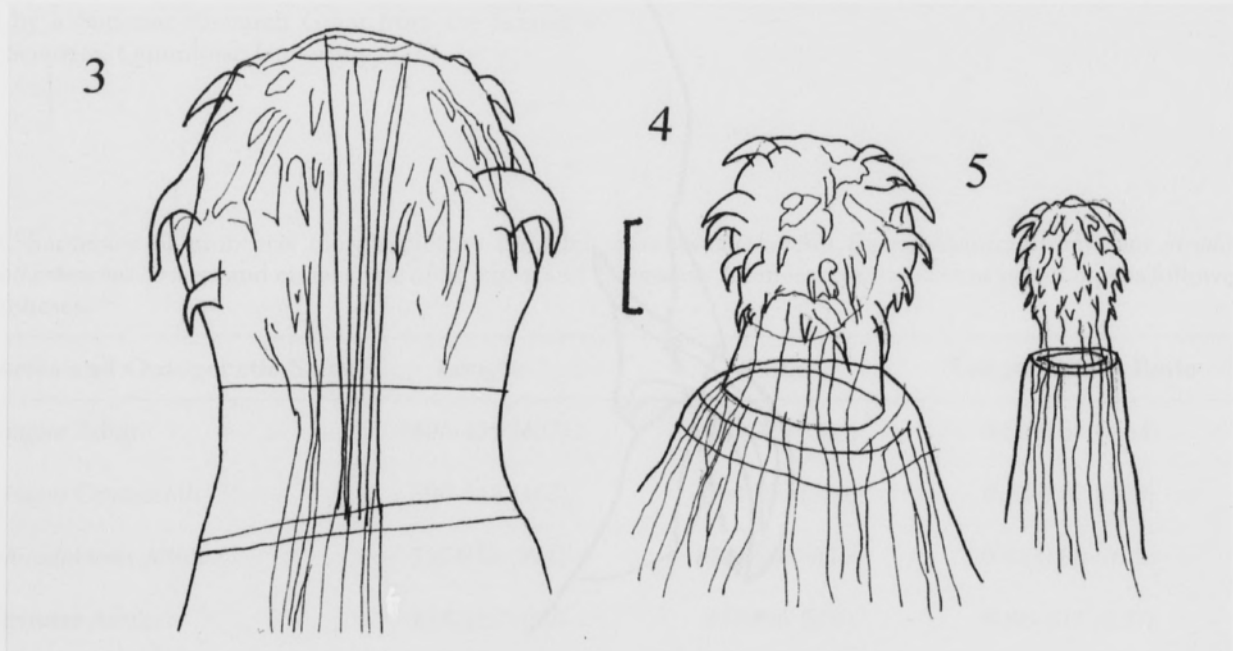
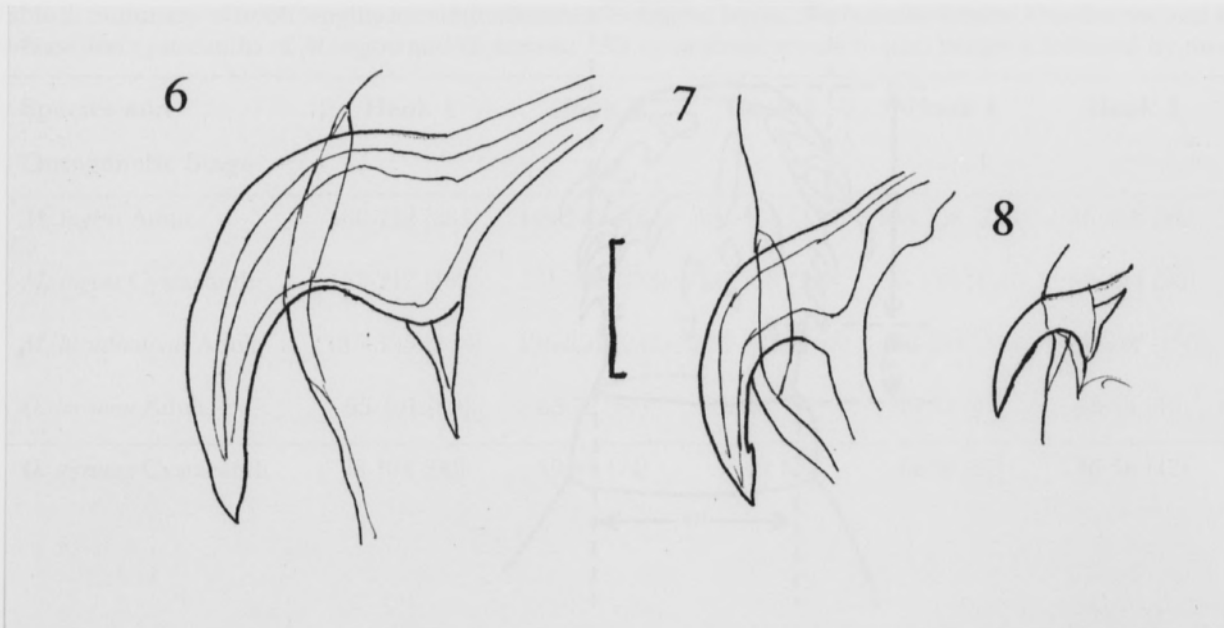


Fig. 2. Proper measurement of proboscis length (pl), proboscis width (pw), neck length (nl), and neck width (nw).

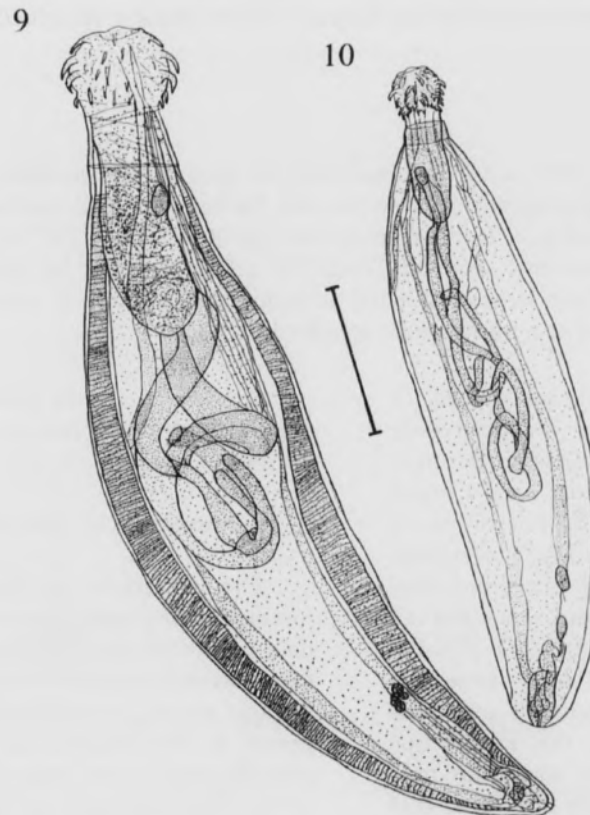
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Figs. 3-5. 3. Proboscis of *Macracanthorhynchus hirudinaceus*, 4. *Macracanthorhynchus ingens*, and 5. *Oligacanthorhynchus tortuosa*. Scale bar = 250 μ m.



Figs. 6-8. 6. Hook number 3 of *Macracanthorhynchus hirudinaceus*, 7. *Macracanthorhynchus ingens*, and 8. *Oligacanthorhynchus tortuosa*. Scale bar = 50 μ m.



Figs. 9 and 10. Cystacanths of 9. *Macracanthorhynchus ingens* (HWML48147) and 10. *Oligacanthorhynchus tortuosa* (HWML48148), respectively, removed from the hemocoel of a millipede (*Narceus americanus*) Scale bar = 1 mm.

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