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Redescription of *Anoplocephaloides indicata* (Sawada et Papasarathorn, 1966) comb. nov. (Cestoda, Anoplocephalidae) from *Tapirus indicus*

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Abstract

This study includes a redescription of *Anoplocephaloides indicata* (Sawada et Papasarathorn, 1966) comb. nov. (Cestoda, Anoplocephalidae) based on museum material from the South-East Asian *Tapirus indicus*, comparison with *Flabelloskrjabinia tapirus* (Chin, 1938) from the South American *Tapirus terrestris*, as well as comments on the genus *Flabelloskrjabinia* Spasskii, 1951. The present analysis suggests that *A. indicata* and *F. tapirus* are independent species parasitizing *T. indicus* and *T. terrestris*, respectively, distinguished primarily by the size and morphology of the scolex and distribution of testes. However, new material from *T. terrestris* is needed for the evaluation of the generic status of anoplocephalid cestodes from tapirs.

Key words

Cestoda, Anoplocephalidae, *Anoplocephaloides*, *Flabelloskrjabinia*, tapirs

Introduction

Tapirs are perissodactyls (the mammalian order also including horses and rhinoceroses) with a disjunct extant distribution in South and Central America and parts of South-East Asia. In the Neotropics there are three species (*Tapirus terrestris*, *T. bairdii* and *T. pinchaque*) and in South-East Asia one species (*Tapirus indicus*) of tapirs. Due to overhunting and destruction of habitats, tapirs are presently listed as endangered, vulnerable or locally threatened by the IUCN (1996).

Three nominal species of anoplocephalid cestodes have been reported from tapirs. First, Diesing (1856, cited in Spasskii 1951) described superficially *Anoplocephala globiceps* Diesing, 1856 from *T. terrestris* in Brazil. Later, Chin (1938) described *Anoplocephala tapirus* Chin, 1938 from "*T. americanus*" (= junior synonym of *T. terrestris*) and Sawada and Papasarathorn (1966) described *Paranoplocephala indicata* Sawada et Papasarathorn, 1966 from *T. indicus* in Thailand. The latter authors did not consider *A. tapirus* or *A. globiceps* when describing *P. indicata*.

Due to incomplete descriptions and variable background information, the taxonomic status of these species has been controversial. Beveridge (1994) recognized only one species parasitizing tapirs, i.e. *A. tapirus*, which he assigned to the genus *Anoplocephaloides* Baer, 1923, as emended by Rausch (1976). *Paranoplocephala indicata* was regarded as a junior synonym of the former by Beveridge (1994). On the other hand, Rausch (1976) considered *A. tapirus* and *A. indicata* to be independent species, tentatively assigning both to *Flabelloskrjabinia* Spasskii, 1951, a genus erected for *A. tapirus* and, conditionally, for *A. globiceps* by Spasskii (1951). *Flabelloskrjabinia* was recognized by Yamaguti (1959), but it was listed as a synonym of *Paranoplocephala* Lühe, 1910 by Joyeux and Baer (1961). Due to the ambiguous taxonomic status of cestodes from tapirs, Rausch (1976) stated that "The study of additional material from *Tapirus indicus* would permit a more complete characterization of these cestodes".

This study includes a redescription of *Anoplocephaloides indicata* comb. nov. based on museum material from *T. indicus*, comparison with *Flabelloskrjabinia tapirus*, as well as comments on the genus *Flabelloskrjabinia*.

Materials and methods

The following museum specimens of *A. indicata* were examined in connection with the present study: (1) two pregravid specimens (whole-mounts) collected from *T. indicus* in Malaysia, deposited at the Parasite Collection, Royal Veterinary College, London (coll. no. CIP 4700); (2) a fragment of

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mature proglottids (whole-mount) from "saddle-backed tapir" (i.e. *T. indicus*) from San Diego Zoo, California, USA, deposited at the Lawrence R. Penner Parasitology Collection, University of Connecticut, Storrs, USA (no accession number specified). Other information lacking; (3) an alcohol-preserved entire gravid specimen and fragments (whole-mounts) of gravid proglottids collected from *T. indicus* in Thailand, deposited at the United States National Parasite Collection, Beltsville, Maryland, USA (coll. no. 47964).

For the redescription, the scolex, neck and 2–3 mature proglottids from each individual were drawn on paper with the aid of camera lucida, and various organs were counted and measured from these drawings using a calibrated ruler. The cirrus sac was measured only if the cirrus was fully invaginated. Egg dimensions were obtained by disrupting a terminal gravid proglottid of an alcohol-preserved specimen, and measuring eggs in a mixture of ethanol and glycerine.

Results

Anoplocephaloides indicata (Sawada et Papasarathorn, 1966) comb. nov.

The following redescription is based on the four specimens (and fragments) listed in the Materials and methods. All measurements are in mm.

Description (Table I, Figs 1–3): Strobila 80–130 long, wide and robust. Scolex very large and muscular, almost quadratic in apical view, with large suckers directed anteriorly, partly or wholly embedded within scolex; suckers ellipsoidal in apical view. Neck (unsegmented region) absent, short constriction demarcates scolex from anterior strobila which widens rapidly. Proglottids craspedote, much wider than long; length/width ratio of mature proglottids 0.13–0.28 (mean 0.19).

Genital pores unilateral, opening in middle of proglottid margin in mature proglottids or slightly more posteriad. Genital atrium strongly developed, capable of forming prominent genital papilla.

Ventral longitudinal osmoregulatory canals of variable width (0.08–0.40, mean 0.20), arched. Distinct spur of variable length sometimes branching off laterally from ventral longitudinal canal in posterior part of proglottid. Ventral longitudinal canals connected by transverse anastomoses which may be twisted dorsoventrally. Dorsal longitudinal osmoregulatory canals thin (0.07–0.11), overlapping ventral trunks or positioned medial to them. Genital ducts passing longitudinal osmoregulatory canals dorsally.

Testes very numerous (221 on average), small (0.015–0.025), antiporal to ovary in 1–2 dorsoventral layers. Testicular field separated by distinct gap from antiporal longitudinal canal. Porally testes reaching level of antiporal margin or mid-

Table I. The main morphological features of anoplocephalid cestodes parasitizing tapirs

Cestode species	*Anoplocephaloides indicata*	*Anoplocephaloides indicata*	*Flabelloskrjabinia tapirus*	*Anoplocephala globiceps*
Host species	*Tapirus indicus*	*T. indicus*	*Tapirus terrestris*	*T. terrestris*
Origin	Thailand, Malaysia, USA (zoo)	Thailand	unknown, probably Brazil	Brazil
Source	present study	Sawada and Papasarathorn 1966	Chin 1938	Diesing 1856 (cited in Spasskii 1951)
Body length	80–130	135–198	80–112	25–40
Body max. width	9–10	10–12	8	ca. 3
Scolex width	4.3–5.4	8.7–9.0	0.67	0.8
Sucker width	1.8–1.9	1.8–2.1	0.3	–
"Neck" width	3.8	2.8–3.4	–	–
Number of testes	178–272 (221)*	350–358	"numerous"	–
Poral testis extent	antiporal margin of ovary	antiporal margin of ovary	poral and anteroporal to ovary	–
Cirrus sac length	2.1–2.5 (2.2)	1.4–1.8	0.6	1.0
Cirrus sac width	0.22–0.35 (0.268)	–	–	–
Ovary width	1.4–1.8 (1.51)	–	0.25	–
Ovary length	1.0–1.3 (0.91)	–	–	–
Vitellarium width	0.65–0.90	–	–	–
Vitellarium length	0.50–0.65	–		
Female gland position	poral	poral	median	–
Vagina length	2.3–2.7	–	–	–
Vagina width	0.05–0.09	–	–	–
Seminal receptacle length	0.5–0.9 (0.65)	–	–	–
Seminal receptacle width	0.3–0.6 (0.45)	–	–	–
Egg length	0.050–0.055 (0.0524)	0.053	0.048	0.043
Egg width	0.028–0.032 (0.0301)	0.030	0.028	–

All metric data in mm, *mean (in parentheses).

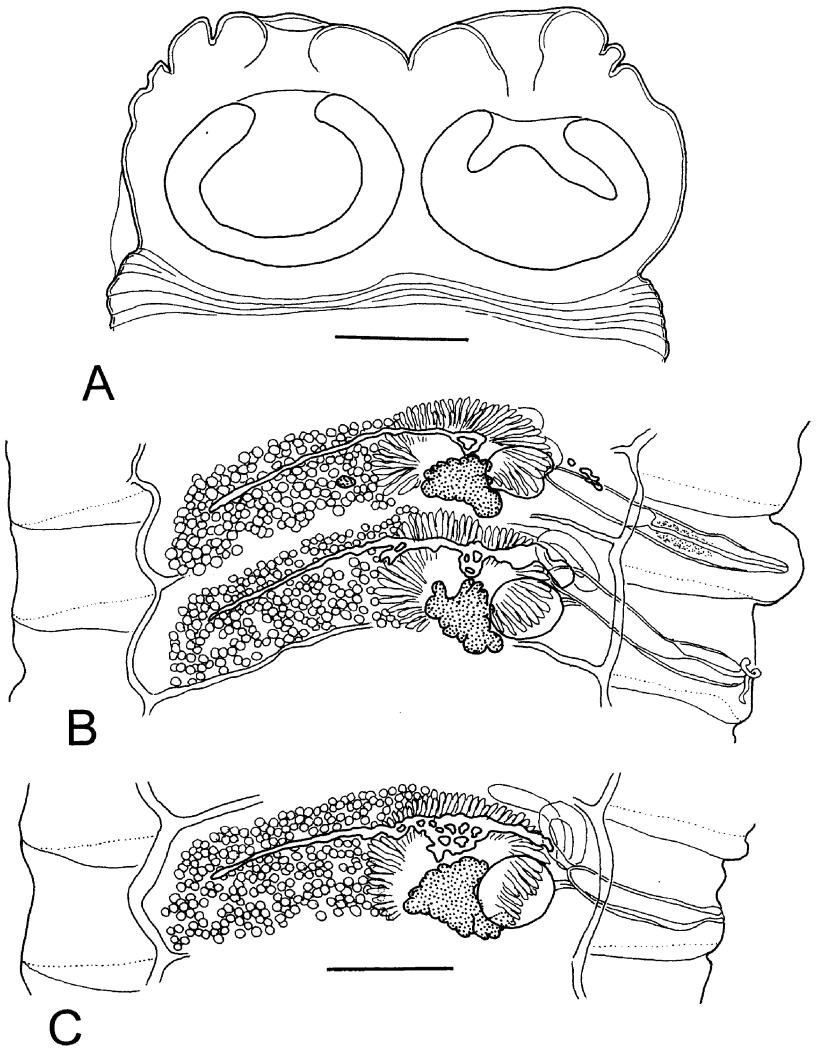

Fig. 1. *Anoplocephaloides indicata* from *Tapirus indicus*. **A** – scolex (Malaysia). **B** and **C** – three consecutive mature proglottids (San Diego Zoo). Scale bars = 1.0 mm

dle of vitellarium. Testes do not usually overlap ovary. Cirrus sac very long and slender, slightly curved anteriorly, extending markedly across longitudinal canals when not contracted; contracted cirrus sac barely reaching longitudinal canals. Distal cirrus armed with long spines. Vesicula seminalis interna ca. 1/3 of length of uncontracted cirrus sac, expands and covers almost whole length of contracted cirrus sac. Vesicula seminalis externa long, usually looped, covered by loose cell layer. Well developed retractor muscle attached to proximal cirrus sac.

Ovary highly lobed, semilunar or spherical, positioned slightly porally. Ovary not visible in early mature proglottids when male genitalia are already functional. Vitellarium asymmetrically bilobed or irregularly shaped, overlapping posterior part of ovary. Mehlis' gland not seen. Vagina formed by thin tube of uniform diameter, its proximal end curved posteriorly, on average slightly longer than cirrus sac, usually running ventral to it. Seminal receptacle thick-walled, ovoid or subspherical (even before being filled with sperm), distinctly set off from vagina, attains maximum size in mature proglottids. Uterus first seen in anterior part of early mature proglottids as transverse, undulating tube ventral to testes. Sparse, distinct reticulation present in median uterus overlapping ovary. Lateral ends of early uterus do not reach longitudinal canals or antiporal margin of testicular field. Poral branch of early uterus distinctly shorter than antiporal one, sometimes fragmented. Starting from poral branch, uterus develops discrete anterior and posterior sacculations branching off from median trunk. Fully developed uterus covers almost whole space between longitudinal canals, retaining sacculations and transverse trunk; anterior sacculations tend to be longer than posterior ones. Eggs distinctly ovoid. Pyriform apparatus present, provided with terminal bunch of fine threads.

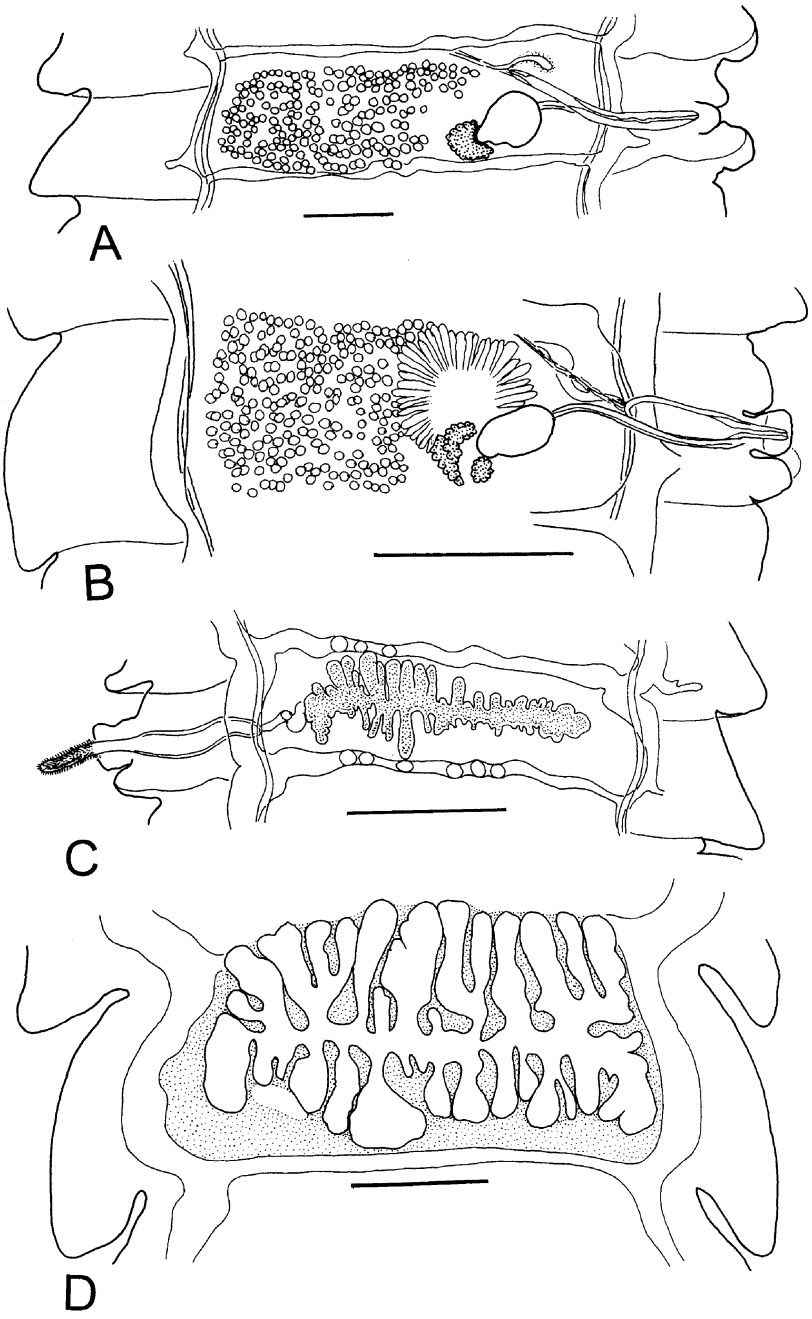

Fig. 2. *Anoplocephaloides indicata* from *Tapirus indicus*. **A** and **B** – mature proglottids (Malaysia). Scale bars = 1.0 mm for A; 2.0 mm for B. **C** – pregravid proglottid (Malaysia). Scale bar = 2.0 mm. **D** – fully gravid proglottid (Thailand). Scale bar = 1.0 mm

Discussion

The taxonomic status of anoplocephalid cestodes parasitizing tapirs has been highly controversial. Rausch (1976) regarded *F. tapirus* and *A. indicata* as independent species, but Beveridge (1994) assumed that the distribution of testes in *F. tapirus* was interpreted incorrectly by Chin (1938), and therefore synonymized *A. indicata* with the former, assigning it to *Anoplocephaloides*. However, Beveridge (1994) based his conclusion on specimens from the South-East Asian *T. indicus*, rather than the South American *T. terrestris*, the host of *F. tapirus* (below).

I argue that *F. tapirus* and *A. indicata* are indeed closely related but distinct species parasitizing tapirs in South America and South-East Asia, respectively. The similarities between *F. tapirus* and *A. indicata* include the exceptionally high number of small-sized testes, highly lobed ovary, long vagina, distinct, (sub)spherical seminal receptacle, long and

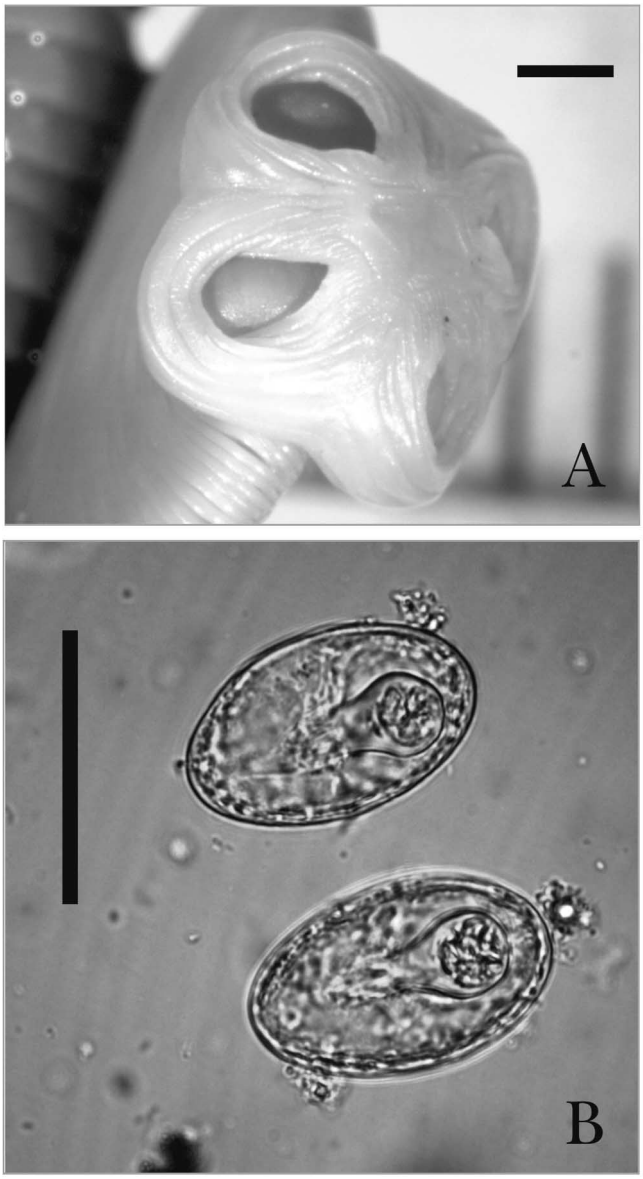

Fig. 3. *Anoplocephaloides indicata* from *Tapirus indicus*. **A** – scolex in apical view (Thailand). Scale bar = 1.0 mm. **B** – eggs (Thailand). Scale bar = 0.05 mm

slender cirrus sac (when not contracted), long, looped external seminal vesicle, strongly developed genital atrium and genital papilla, the structure of the fully developed uterus (discrete anterior and posterior sacculations branching from a transverse trunk, anterior sacculations being longer than the posterior ones) and distinctly ovoid eggs.

However, the dimensions of the scolex, suckers and neck are very different in these species, *A. indicata* having an enormous (4.3–5.4 in the present material) muscular scolex that is distinctly wider than the "neck" region, whereas *F. tapirus* has a small (0.67) scolex that is actually slightly narrower than the anterior strobila. The morphology of the scolex and neck region is one of the most informative features in anoplocephalid cestodes, strongly supporting the independent status of *F. tapirus* and *A. indicata*. It should be noticed that the extreme scolex size of *A. indicata* (8.7–9.0) reported by Sawada and Papasarathorn (1966) is probably an overestimate caused by the pressure applied during fixation.

Moreover, the distribution of testes in the poral part of the proglottid is basically different between *F. tapirus* and *A. indicata*. In the former species there is a separate, poral group of testes positioned anteroporally to the ovary (both anterior and posterior to the terminal genital ducts), whereas the testes of the latter species form a single group antiporal to ovary (no testes porally or anteroporally to ovary) (Figs 1 and 2). The difference in the position of female glands gives indirect support to the existence of a major difference in the distribution of testes; in *A. indicata* female glands are poral, but in *F. tapirus* they are medial, a feature which in various anoplocephalid cestodes is usually associated with the presence of testes in the anteroporal region of the proglottid. Additionally, the dorsal osmoregulatory canals are lateral to the ventral ones in *A. tapirus*, but overlapping or medial to the ventral canals in *A. indicata*.

The ambiguous origin of the type material has further obscured the status of anoplocephalid species parasitizing tapirs. According to the original description (Chin 1938), *F. tapirus* was found from "*Tapirus americanus*" (i.e. *T. terrestris*) that was "imported from the Philippines and died as a result of cold weather at Amoy…" (presently Xiamen, South China). However, Spasskii (1951) gives the host as "*Tapirus* sp." and the place of discovery as "Philippine Islands (?)", and Rausch (1976) states that *F. tapirus* was collected from "*Tapirus* sp. (evidently also *T. indicus*), geographic origin uncertain". It is, however, clear that the host specimen was not originally captured from the Philippines, since there are no tapirs on these islands. Also, it is unlikely that the host would have been misidentified as *T. indicus*, since its distinctive "saddle-backed" coloration separates it readily from all South American tapirs. Thus, the host of *F. tapirus* has probably been a captive specimen of *T. terrestris* originating from South America (or from a zoo) that was transported via the Philippines to China.

The present data agree closely with the description of *A. indicata* by Sawada and Papasarathorn (1966), with the only major exception concerning the number of testes (178–272 vs. 350–358). However, the testis number is known to be highly variable in anoplocephalid cestodes and, moreover, testis counts are usually approximate in species with a high number of testes arranged in multiple layers. *Anoplocephala globiceps*, described from *T. terrestris* in Brazil, is not identifiable and is therefore treated here as a *species inquirenda*. However, in its external dimensions it is more similar to *A. tapirus* (also from *T. terrestris*) than *A. indicata* (Table I).

Spasskii (1951) argued that *Anoplocephala tapirus* does not conform with the characteristics of *A. perfoliata*, the type species of the genus *Anoplocephala*, and consequently proposed the genus *Flabelloskrjabinia* for *A. tapirus*. The features that Spasskii (1951) used to differentiate *F. tapirus* from *A. perfoliata* are not, however, generally considered to be of

generic value; these are the complexity of the osmoregulatory system (two pairs vs. numerous longitudinal canals), direction in which the genital ducts are extended, shape and structure of the ovary and host species. Rausch (1976) accepted the genus *Flabelloskrjabinia* for *A. tapirus* (and conditionally for *P. indicata*), but noticed that in its basic morphology, *F. tapirus* resembles *Anoplocephaloides*, a genus resurrected and emended by Rausch (1976). The only major difference between *F. tapirus* and *Anoplocephaloides* seemed to be the distribution of testes; those of *F. tapirus* extend anteroporally to the ovary, whereas the testes of *Anoplocephaloides* are confined to the antiporal part of the proglottid, similar to *A. indicata*. The evidence presented here suggests that the difference in the distribution of testes is real, and therefore *A. indicata* and *F. tapirus* should be assigned to *Anoplocephaloides* and *Flabelloskrjabinia*, respectively, the morphological similarities notwithstanding. However, the genus *Anoplocephaloides*, as presently conceived, is a very heterogeneous, non-monophyletic assemblage of species (Rausch 1976, Genov and Georgiev 1988, Wickström *et al*. 2005), and a major taxonomic revision, including both species from tapirs, is clearly needed.

The presence of median uterine reticulations in *A. indicata* seems to be a unique feature among anoplocephalid species with a tubular early uterus. If *F. tapirus* is also found to exhibit corresponding reticulations, this character would provide a clear-cut diagnostic feature for *Flabelloskrjabinia*. If further morphological similarities between *A. indicata* and *F. tapirus* appear (such as the structure of the early uterus), an emended concept for *Flabelloskrjabinia* should include both species from tapirs.

Although the present analysis suggests that *A. indicata* and *F. tapirus* are distinct species, the status of anoplocephalid cestodes of tapirs can ultimately be resolved only by examining additional material from South American tapirs (especially *T. terrestris*). If *A. indicata* and *F. tapirus* are found to represent a monophyletic, congeneric pair of species, as here predicted, it would mean that their common ancestor has parasitized the ancestor of the Neotropic and Asian tapir lineages, with subsequent divergence in the two continents both in the host and the parasite.

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