

PRELIMINARY OBSERVATIONS ON THE ECOLOGY AND BEHAVIOR OF  
*Aplexa fuliginea* (PULMONATA:PHYSIDAE) IN COSTA RICA

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ABSTRACT

The ecology and behavior of *Aplexa fuliginea* are studied for the first time. It can be cultured in pond water and fed with toilet paper, water lily, and chalk. In the aquarium, the snail spends most of the time underwater. Its maximum resistance to desiccation is estimated in 74 hours. This snail adjusts its buoyancy to move vertically in the water column and uses sudden-drop and emersion as scape mechanisms. Egg capsules are classified as capsula vera gibbosa and embryos and juveniles are illustrated. The snail hosts metacercariae and rediae. These liberate xiphidiocercariae within the same host. One oligochaete species was found inhabiting the surface of the snail body, where it may be protected from predators. Two other worm species are associated to egg capsules, which are laid mainly on *Eichhornia crassipes* (Pontederiaceae). No live snails were found in dry portions of the pool. It is hypothesized that snails survive only in the deeper sections during the dry season, and colonize the rest of the pool during the rainy months.

The studies about Costa Rican non-marine mollusks have stressed their systematics and role as hosts of parasites, while the ecology of all species remains poorly understood or is completely unknown. This is a first record on the behavior and ecology of the physid snail *Aplexa fuliginea*, and includes notes on the habitat it shares with the medically important *Biomphalaria straminea* and *Lymnaea* sp.

Though the commonly mentioned physid hosts of parasites are *Physa* spp., species of *Aplexa* are also reported (Wootton 1957; Agriculture Research Service 1968— 1982; Ditrich and Vojtek 1977; Leite, Costa and Costa 1979; the present). Generally, this genus has received little attention despite its wide distribution in America, Europe and Asia (Eames 1951; Hartog 1963; Malek and Cheng 1974). Some of its species were present in North American fluvial environments already in the Jurassic (Yen and Reeside 1946; Yen 1948), but the time of its arrival to Costa Rica (like that of most freshwater snails) is unknown for lack of fossil records. R. Fischer (1983, personal communication) believes this scarcity may be caused by the diatomite of our deposits, whose porosity allows the penetration of shell solvents.

**Material and Methods**

The habitat studied is a pool located in an abandoned coffee plantation at San Pedro de Pavas, San José (Fig. 1). *A. fuliginea* was also found nearby, in the San Pedro de Pavas Lagoon (Fig. 1—b). Annual mean temperature is 21.1°C and pluviosity of 1671.7 mm in the area, which thus corresponds to the Premontane Moist Forest (Tosi 1969).

Excepting section A (Fig. 1—c), the pool dried during the dry season. The water hyacinth *Eichhornia crassipes* (Pontederiaceae) covers section C. The water was contaminated with household refuse (see Acuña, Castaing and Flores 1983, for chemical data) and the bottom is organically rich mud. The site was visited 12 times in a year, during daytime (1982: Oct. 10; Nov. 6,9; Dec. 1. 1983: Jan. 4, 22; Mar. 5, 31; Jul. 8, 14; Aug. 6; Oct. 23).

For vertical distribution and substrate preference tests, specimens were carried to Sabanilla de Montes de Oca, and set in glass aquaria as follows: five tanks with 5 snails each (250 cc and microflora as food), and four with a total of forty newborns (100cc, microflora and decaying *E. crassipes* as food).

The number of individuals in each level and/or substrate was recorded at least daily. To test resistance to desiccation, snails were placed in open plastic containers without water, and deads counted 24 hours after

rewatering. Pool egg capsules and oligochaetes were placed together in three Petri dishes (plus two controls) for a preliminary test of their interactions. Squash preparation of live snails allowed observation of trematodes. Egg capsules were preserved in 70 percent alcohol and shell lengths measured according to Malek (1962). The following procedure to establish cultures was tested: egg capsules were changed to dechlorinated water to hatch free of worms, and snails were kept in original water in 10 x 6 x 5 cm plastic containers with no more than ten individuals each. They fed on toilet paper, decaying *E. crassipes* and chalk. Aquaria received continuous illumination (see Malek and Cheng 1974) and water level was restored with boiled tap-water at room temperature every third day. Voucher specimens are deposited in the Museo de Zoología, Universidad de Costa Rica.

## Results and Discussion

Laboratory: The culture method proved satisfactory. Distribution records were homogeneous in all aquaria, despite the limited number of individuals involved. The time spent at or above water surface is short (Table 1), though *A. fuliginea* does not show the complete return to water of *Physa*, which rarely or never emerge to breath (Pennak 1953). Juveniles (adults were not tested) stayed and fed more on water hyacinth than on microflora. Pedal feeding (plankton) was uncommon, though it was seen often in the pool and might be a significant source of energy (Summers 1966).

During desiccation, most snails sealed shell aperture to substrate with mucous matter (mucous veil or epiphragm ?) and did not expose a pneumostome for respiration, in contrast with *Stagnicola elodes* (Romach 1971). Mortality increases with desiccation time (Table 2) and would reach 100 percent in 74 hou. (Fig. 2). Potentially, *A. fuliginea* could be dispersed by birds, and suffer low mortality from dryness. But its resistance is considerably lower than in marine, operculate and planorbid snails (see Mattox 1949; Imlay 1968; Camacho 1979). Thus its control may be effected by draining of its habitats.

Like most snails, *A. fuliginea* normally creeps over a slime track, but it also hunches (see Pennak 1953) and swims at the surface by "shell-hanging." When disturbed, snails lose pallial bubble and drop rapidly (if close to the surface) or detach from substrate and the bubble causes a quick rise. Like Snyder (1966) I interpret both actions as escaping mechanisms. There is a controversy on whether the pallial bubble has a hydrostatic function or not (Russell-Hunter 1964). While it may not in other snails (Henderson 1963), it does in *A. fuliginea*, which adjusts its buoyancy to move vertically in the water column. At least in small pools, this mechanism may be physiologically (energetically) "cheaper." When an individual of *A. fuliginea* approaches another one, it is usually rejected by repeated shell blows; a behavior that potentially allows intraspecific competence for feeding areas (see Rogers 1951).

Five pairs were found in copula and carried to the laboratory, where only one snail survived. It layed two capsules with 6 and 74 eggs, seventeen days after matting. In aquaria, most capsules were layed at night, as was previously observed in *Physa fontana* (Duncan 1959). The length of 66 pool egg capsules is  $X = 16.4 \pm (SD = 9.6 \text{ mm})$ . I classify them as capsula vera gibbosa following the structural criteria of Nekrasov (1927) (Fig. 3—1). A vitelline membrane should be present (Hess 1971), but optical limitations prevented its positive identification as well as that of a rotating embryo as trochophorae larvae (Fig. 3—b). After 8 days (Fig. 3—c) the embryo fills one pole of the egg (eye-spots recognizable) and after 15 (about two before eclosion) the protoconch is complete (Fig. 3—d). Easy rearing and translucent body of juveniles (Fig. 4) make *A. fuliginea* suitable to study the influence of physical factors on pallial bubbles and heartbeat (see Weber 1929 and Jacobs 1941). Growth rate was not recorded, but length of 474 pool snails was  $X = 12.2 \text{ mm} (\pm SD = 5.4)$ .

Three trematode stages (redia, cercaria and metacercaria) were found, and perhaps as an adaptation that decreases niche overlap, they were concentrated in opposite tissues of the snail (Fig. 5). The rediae (Fig. 6) produce xiphidiocercariae within the same snail. Cheng (1973) considers that most, if not all, xiphidiocercariae belong to the Lecithodendriidae Odhner 1910. If we accept his opinion, the expected vertebrate hosts are birds and mammals, especially bats (Malek and Cheng 1974). But Erasmus (1972) considers that they may belong to at least ten families. Identity and life-cycle of the metacercarial trematode are known to a lesser extent (Fig. 6), but it necessarily infests some snail predator. The three stages could also belong to the one single species.

Some pool snails carried oligochaetes which moved freely on the surface of the cephalopodal complex and pallial cavity. The association persisted several weeks until snails died presumably from improper culture conditions. It might be a symbiosis in which snails get some protection from miracidia (Fashuyi and Williams 1977) and worms escape from insect predators. Inside some pool egg capsules there were

worms of a second species, which may have entered through holes made by early hatchers, in search of shelter, or as parasites, or to predate on embryos. Two worms of a third species which normally builds mud tubes, appeared to be inside a couple of capsules found on floating twigs, but they were lost before examination and a test was set with fresh organisms. Instead of drilling them, the worms made tubes by cementing capsules to bottom (one worm under each capsule). Maybe the lost specimens had done likewise because mud was scarce. The discovering of these snail-oligochaete relationship increases the recorded geographic and systematic distribution of such associations (see Fashuyi and Williams 1977; Gilbertson, Kassim and Stumpf 1978).

**Field:** Polluted waters are usually unsuit for gastropods (Pennak 1953) but this species resists the organic pollution at Pavas. There are similar reports of *A. hypnorum* (Hartog 1963) and of other physids (Dudgeon 1983). The potentiality of *A. fuliginea* as a biological monitor of contamination deserves further attention (Camacho 1983, personal communication).

I found neither live snails or egg capsules in dry sections of the pool, and do not think were buried because their resistance to dryness is low. Furthermore, there was no burrowing in Experiment 2, and the related snails *Physa integra* (Clampitt 1970) and *A. hypnorum* (Hartog and Wolf 1962) suffer high mortality when their habitats dry out. The following hypothesis is now under research: as *Bulinus glabrum* does under similar conditions (Cantrell 1981), *A. fuliginea* snails move with receding water and finally concentrate in section A, where overcrowding increases mortality, especially of juveniles. Survivors then repopulate the pool during the rainy season.

All egg capsules were found under water, commonly on water-hyacinth, which many snails prefer for ovipositing (Camacho 1979; Pinter 1979; Cantrell 1981; Dudgeon 1983). When drought made the plant unavailable, floating twigs became the main substrate for capsules. They were found in all visits, and this supports the idea that *A. fuliginea* can not survive in dry sections of the pool, or any similar habitat, because year-round reproduction is associated to more stable habitats (see Russell Hunter 1964). It also indicates that, like most pulmonates (Dudgeon 1982), this species is an r-strategist.

Among invertebrate groups that prey on snails (Metteo 1946; Pennak 1953; Malek and Cheng 1974; Abercrombie and Berg 1975; Knutson and Abercrombie 1977; Beaver 1978), six were observed in the pool: ostracoda, coleoptera, hemiptera, diptera, odonates and hirudinea, but the only evidence on predation now available is from observation of an hemipter on that trapped a young *A. fuliginea* and submerged. Research on this topic is basic to understand the population dynamics of *A. fuliginea* and is strongly urged.

Biolley (1897) reported four species of *Physa* from San José, including the Torres and the Tiribí rivers. The taxonomy of physids is plagued with synonymy, so that one of his "*Physa*" could actually be *A. fuliginea*. Then, if this species inhabited the Torres River already in the XIX Century, I hypothesize that the founders of this population came from the Torres River via the San Pedro de Pavas Lagoon (Fig. 1-b). The Tiribí river is a less likely candidate because the connection is recent (about three years). The ability of *A. fuliginea* to move upstream is not known; so a combination of foretic displacement seems to account better for its distribution.

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#### **Resumen**

Se estudia por primera vez la ecología y comportamiento de *Aplexa fuliginea*, caracol pulmonado que puede mantenerse en el laboratorio (en el agua de charca) alimentándolo con papel higiénico, chorejas y tiza. En el acuario, *A. fuliginea* permanece la mayor parte del tiempo sumergido. Su resistencia máxima a la desecación se estima en 74 horas. El caracol se puede desplazar verticalmente modificando el tamaño de su burbuja palial, y utiliza inmersión y emersión súbitas como mecanismos de escape. Se clasifica la masa de huevos como capsula vera gibbosa y se ilustran embriones y estadios juveniles. Se encontraron metacercarias y redias que producen xifidiocercarias en el mismo caracol. Se halló una especie de oligoqueto que habita la superficie del cuerpo del caracol, donde probablemente obtiene protección de sus depredadores. Dos especies más se asocian a las cápsulas de huevos, las cuales son depositadas principalmente sobre *Eichhornia crassipes*. La ausencia de caracoles vivos en secciones secas de la poza,

origina la hipótesis de que *A. fuliginea*, durante la época seca, sólo sobrevive en la sección profunda, y coloniza el resto de la poza durante la estación lluviosa.

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Table 1. Level and substratt preferences in the snail *Ap/ixa fuliginea* under aquarium conditions.

SUBJECT Variable	JUVENILE SNAILS							ADULT SNAILS		
	Vertical Distribution			Substrate Preference				Vertical Distribution		
Category	Above water level	At water level	Under water level	Bottom	Wall	Sur- face	Vegetation	Above water level	At water level	Under water level
Subtotal	78	479	2038	488	605	46	906	8	130	532
%	3.00	18.46	78.54	23.86	29.59	2.25	44.30	1.19	19.40	79.40
TOTAL	2595			2045				670		
Chi-Square	2478.95			746.43				673.21		
(Error<.01)	(2 D.F.)			(3 D.F.)				(2 D.F.)		
Conclusion	Significant			Significant				Significant		

Table 2. Resistance of the snail *Ap/ixa fuliginea* to experimental desiccation.

Experiment No.	Bottom substrate	Number of mails used	Snail length (mm) ± S.D.	exposed	Number of rehydrated snails	Number of survivors per group total %	Chi-Square (error<.01)
1	Plastic	9	11.9 ± 5.2	1	2	2 100	-
				2	2	0 0	
				3	2	0 0	
				4	2	0 0	
				5	1	0 0	
2	Decanted	25	11.4 ± 12.7	2	5	0 0	-
				Mud	3	5	
	4			5	0 0		
	5			5	0 0		
3	Plastic	50	10.7 ± 4.5	0	-	48 96	21.82
		50	118±4.7	1	50	45 90	(3D.F.)
		50	12.9 ± 5.6	2	50	29 58	Significant
		50	9.6 ± 4.8	3	50	14 28	
TOTAL		234					

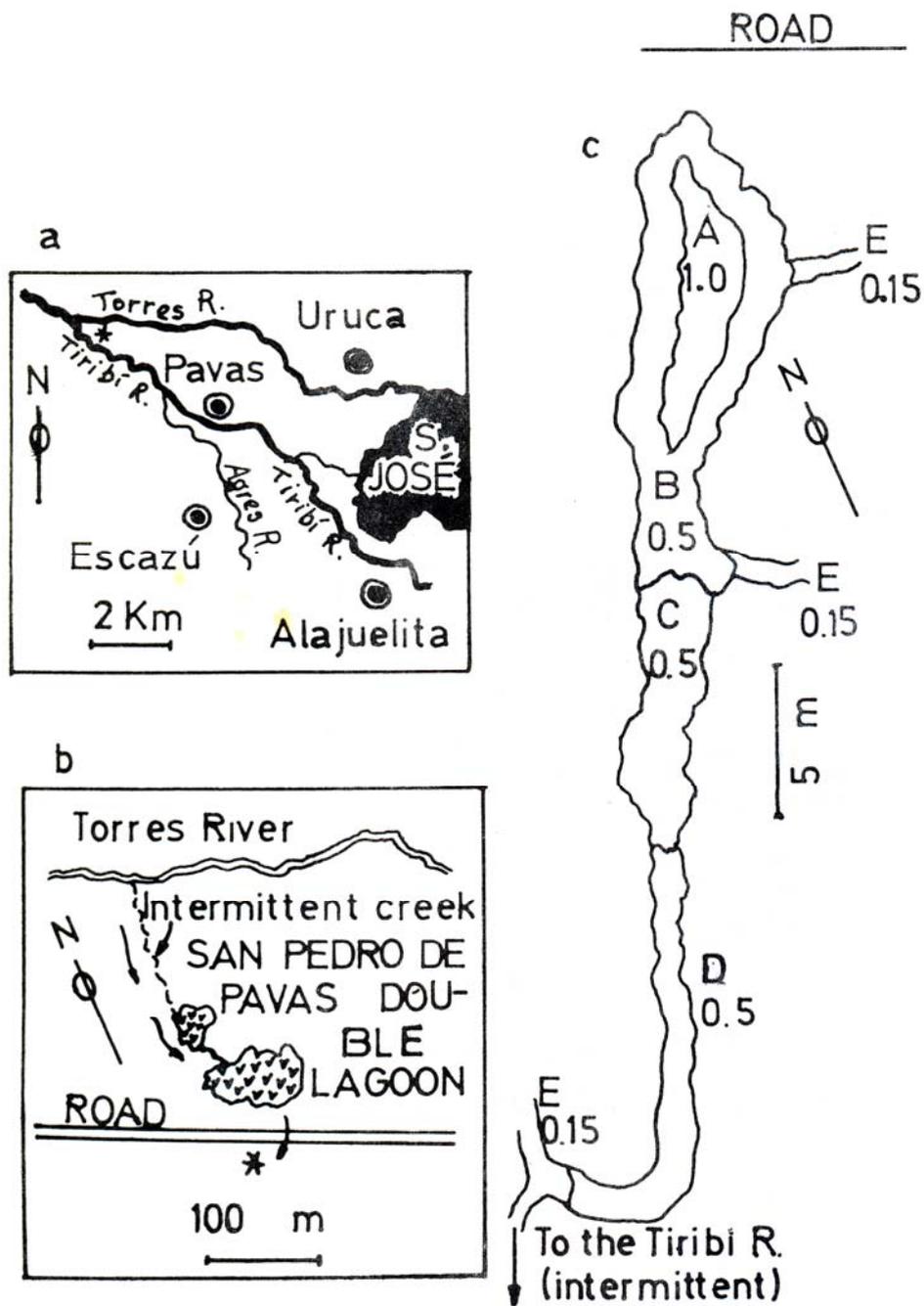


Fig. 1. a: Location of the study site (asterisk). b: Proposed route (arrows) followed by the founders of this population of *Aplexa fulginea*. C: The San Pedro de Pavas Pool. The numbers indicate depth (m) at peak of the rainy season.

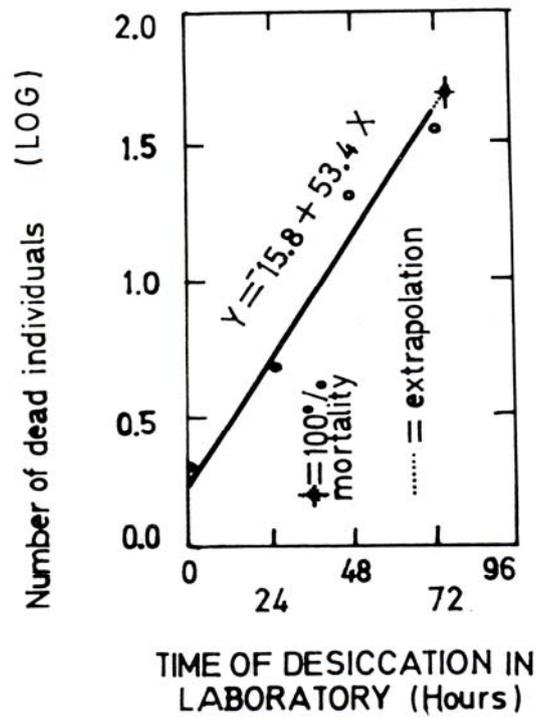


Fig. 2. Correlation between increasing desiccation time and mortality of the snail *Aplexa fuliginea* under experimental conditions (based on Experiment 3 of Table 2).

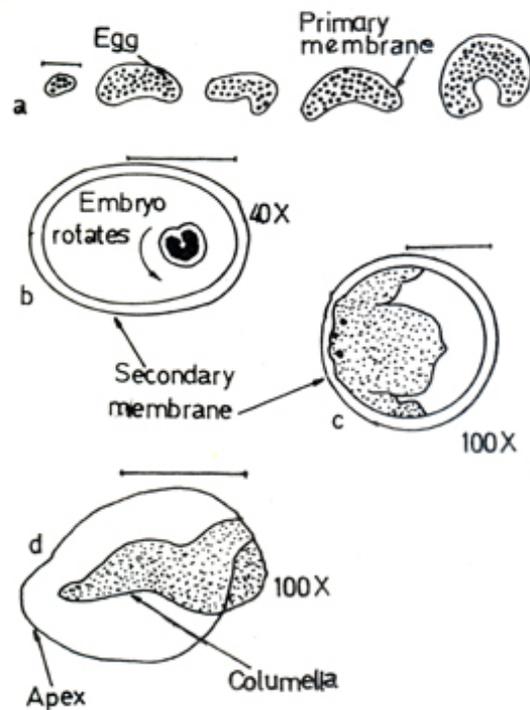


Fig. 3. Reproductive aspects of the snail *Aplexa fuliginea*. a: Typical egg capsules (bar: 1 cm). b: Five day old egg. The embryo rotates in the nutritive matter. c: Embryo in an eight day old egg (preserved). d: protoconch of a fifteen day old embryo (preserved). b—d: bar: 0.5 mm.

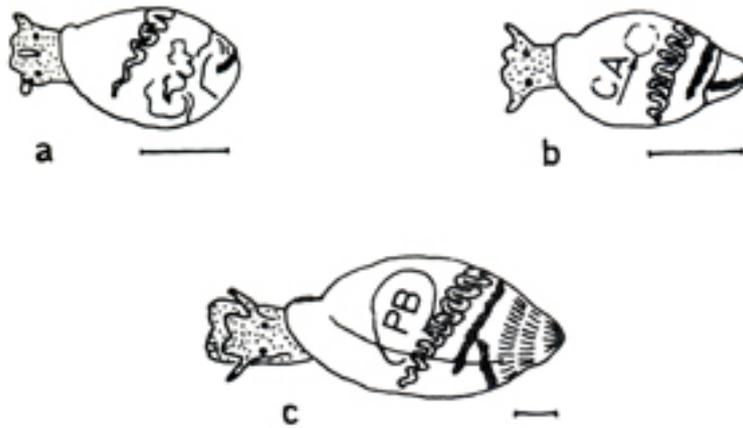


Fig. 4. *Aplexa fuliginea* one hour (a), 29 days (b) and 72 days (c) after birth. CA: cardiac area. PB: pallial bubble. All bars: 0.5 mm.

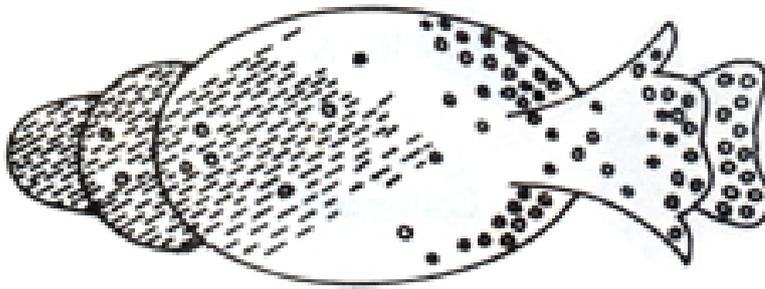


Fig. 5. Diagram of the distribution of rediae (bars) and metacercariae (circles) in the tissues of *Aplexa fuliginea*.

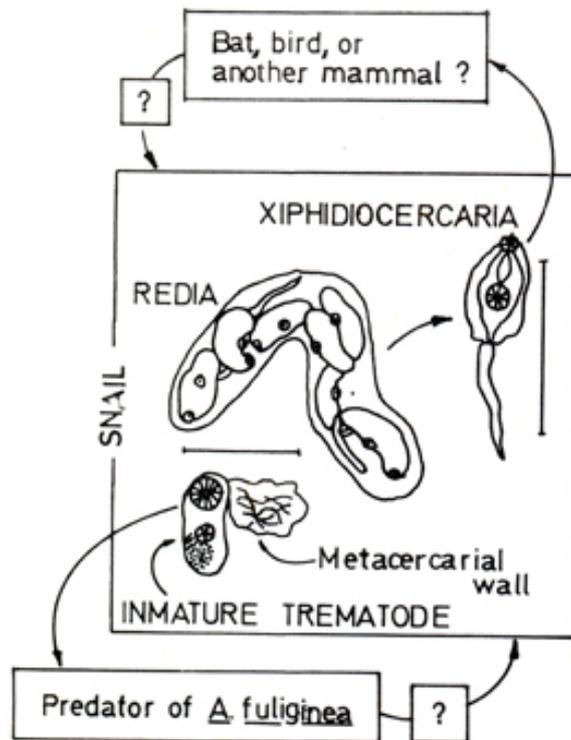


Fig. 6. The trematode stages found in *Aplexa fuliginea* and partial diagram of their life cycles. The immature trematode was pressed out of the metacercarial wall. Drawings made with the help of a *camara lucida*. Bars: 0.5 mm.