Observations on the morphology of *Australorbis nigricans*

W. Lobato Paraense and **Newton Deslandes**

Instituto Oswaldo Cruz, Rio de Janeiro, D.F.

Serviço Especial de Saúde Pública, Rio de Janeiro, D.F.

(With 11 text-figures and 3 plates)

In a previous paper (PARAENSE & DESLANDES, 1955) we published the results of our observations on the morphology of *Australorbis glabratus*, as a contribution to the systematics of that species. We will now present the results of a similar study dealing with another great planorbid from the neotropical region, *Australorbis nigricans* (Spix, 1827).

MATERIAL AND METHODS

On September, 1954, we collected 1 185 specimens of *A. nigricans* from a single breeding place in the city of Itajubá, southern State of Minas Gerais, Brazil, the shell diameter of which ranged from 5 to 27 mm. Identification was made on the basis of the shell characteristics, according to the descriptions and figures presented by LUTZ (1918) under the name *Planorbis nigricans* Spix, 1827. In order to render the results of the present study directly comparable with those of our before mentioned observations on *A. glabratus*, we selected 50 specimens with 18 mm in shell diameter. The methods referred to in our previous paper were employed again in the present work.

SHELL

The freshly emptied shell was horny, translucent in all but the deeply dark specimens, covered with a slender epidermis, with a fine, more or less distinct, oblique striation corresponding to the growth lines, and had six whorls in every specimen.

The prevailing colour was a ferruginous sepia, there occurring a minority of ochreous, olivaceous, nigrescent, and deeply black specimens. Corroded shells were frequently found, showing white, sometimes broad areas (pl. 1, fig. 3) owing to nacre exposure.

This work was done through co-operation between the Instituto Oswaldo Cruz and the Serviço Especial de Saúde Pública, Brasil.

The right side was either flattened or deeply concave, all intermediate degrees occurring between those extremes, the depth from the last whorl to the bottom of the umbilicus ranging from 1.5 to 3.5 mm. A carina runs parallel to and closely below the suture line, becoming quite distinct at the last whorl as a ridge near the rounded periphery (pl. 1, figs. 1a, 2a, 4). The carina varies in sharpness from poorly developed to bluntly angular. Almost always it becomes indistinct before reaching the margin of the aperture, nevertheless arriving at that point in some specimens. Since the whorls gradually increase along each side of a sagittal plane, a given whorl overlaps its predecessor by both sides (pl. 1, fig. 9b). The last whorl, however, tends to deviate to the left, the right surface of it becoming even with that of the preceding whorl (pl. 1, figs. 1b, 5, 7, 8). If the deflection is stronger, the fore portion of the penultimate whorl projects beyond the level of the last one.

The left side is more hollow than the right side, its depth varying between 1.5 and 3.5 mm. It is more conspicuously carinated than the right side (pl. 1, figs. 1c, 2c). The keel normally reaches the margin of the aperture, although in some specimens it somewhat dims shortly before arriving at that point. The conspicuousness of the left keel is due to its being sharper and less near the suture than the right one.

The right carina describes a spiral whose radius of curvature increases more rapidly than that of the spiral described by the left carina. Consequently, the area bounded by the right spiral is broader than that bounded on the opposing side, in spite of both spirals having the same number of whorls.

The shell aperture has a deltoid outline in most cases (pl. 1, figs. 1b, 5, 7, 8). The right wall runs nearly parallel to the sagittal plane up to the level of the carina. At this point the wall bends toward the medial line and then slopes about 45º to reach the left carina. Here it turns at an obtuse angle and attaches to the suture line. The width (transverse diameter) of the aperture predominated over its height (dorsoventral diameter). The commonest variations of the aperture were the projection (pl. 1, fig. 8) and blunting (pl. 1, fig. 7) of the angle formed by the left carina, the inclination of the right wall to the right (pl. 1, fig. 6), the increasing (pl. 1, fig. 2b) and decreasing (pl. 1, figs. 6, 8) in the curvature of the dorsal wall, the depression of the right wall (pl. 1, fig. 2b), the increasing (pl. 1, fig. 6) and decreasing (pl. 1, fig. 2b) in the mouth width.

The width of the shell, taken in the region of the aperture, was 6.37 ± 0.29 mm. In the previously studied sample of *A. glabratus* it was 5.59 ± 0.24 mm. The extremes of width variation in the present sample are shown in pl. 1, figs. 1b and 2b. The relatively large width and the existence of a keel on both sides are the most remarkable shell characteristics of *A. nigricans*. A section through the plane corresponding to the greatest shell diameter (pl. 1, fig. 9b) shows that the

whorls are rather low, their width being about twice the height, and have the lateral angulations corresponding to the keels. A similar section through a shell of *A. glabratus* (pl. 1, fig. 9a) shows that the whorls are comparatively higher and less wide, and have smooth lateral walls.

ANIMAL

The body is similar in appearance to that of *A. glabratus*. Some remarkable differences, however, were found as to pigmentation and body length. Pigmentation is less intense in *nigricans*, so that the external details of the organs caudally situated are clearly discerned through the enveloping mantle. The body length was 60.26 ± 3.62 mm, whereas in *glabratus* it was 47.06 ± 3.31 mm. The difference between these means is highly significant statistically, thus indicating that, the shell diameters being equal, the body is longer in *nigricans*.

RENAL TUBE

This organ is longer than in *glabratus*, being 30.68 ± 1.69 mm in length and 1.55 ± 0.37 mm in width. The ureter was 2.56 ± 0.30 mm long.

The renal region is devoid of longitudinal ridge, looking smooth and unpigmented (fig. 1 *tr*). The lack of a ridge is decisive in distinguishing *nigricans* from *glabratus*. In some larger specimens of the former the renal region may look somewhat crinkled, but a careful examination shows that there actually exists no longitudinal ridge, the crinkling being due to fixation artefact. In the small specimens up to about 10 mm in diameter the renal region has no ridge in either species (pl. 2, fig. 1; pl. 3, fig. 1), but one can easily distinguish a pigmented line along the path of the future ridge in *glabratus*, whereas such line does not develop in *nigricans* (pl. 2, fig. 2; pl. 3, fig. 2).

Owing to pigment shortage, the medial margins of the renal and pulmonary veins may be seen by transparency through the renal tube.

Fig. 3, pl. 2, and fig. 3, pl. 3, show the histological features of the renal regions in *glabratus* and *nigricans* having 18 mm in shell diameter, the other characteristics of the region being similar in both species.

GENITALIA

The histological and nearly all the anatomical features resemble those of *glabratus*. The differences, when existing, will be mentioned in the following description.

HERMAPHRODITE ORGANS

Ovotestis — Length 14.48 ± 1.93 mm, greatest width 1.70 ± 0.23 mm at the cephalic end (figs. 2, 6 *ot*, 7), thus being longer than in *glabratus*.

Ovisperm duct — Length 13.04 ± 1.60 mm, width about 0.10 mm (fig. 6 *co*). The seminal vesicle was 0.97 ± 0.21 mm in greatest width (fig. 6 *vs*).

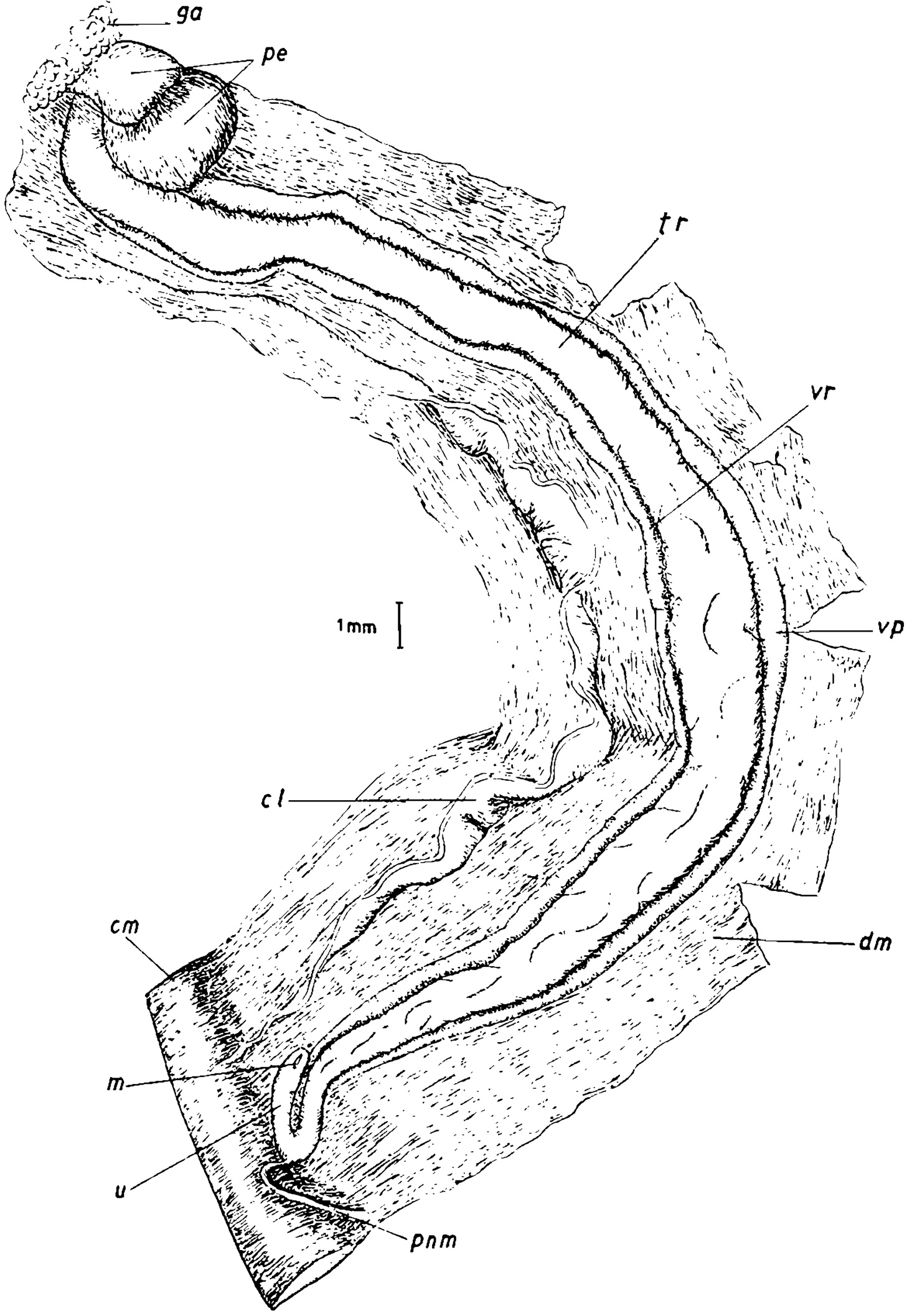

Fig. 1 — Ventral view of roof of respiratory cavity, showing smooth membrane covering renal tube. (cl = longitudinal lateral ridge; cm = mantle collar; dm = roof of respiratory cavity; ga = albumen gland; m = meatus of ureter; pe = pericardium, around heart; pnm = pneumostome; tr = renal tube; u = ureter; vp = pulmonary vein; vr = renal vein).

Carrefour — Resembling that of *glabratus* (fig. 6 *ca*).

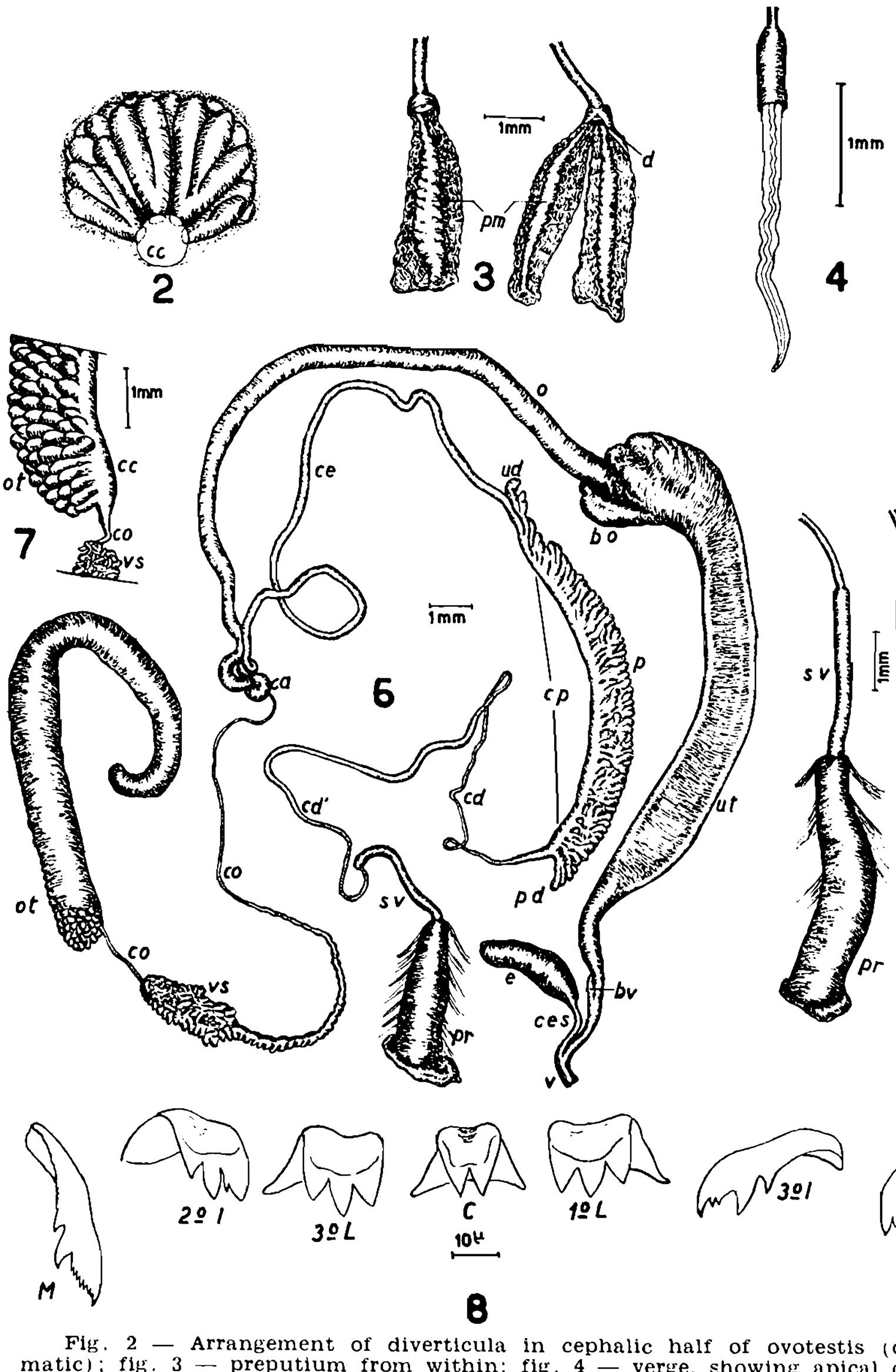

Fig. 2 — Arrangement of diverticula in cephalic half of ovotestis (diagrammatic); fig. 3 — preputium from within; fig. 4 — verge, showing apical outlet of sperm canal; fig. 5 — left: penial complex, right: verge within vergic sac partly removed; fig. 6 — whole genitalia dissected: ovotestis from dorsolateral side; fig. 7 — cephalic portion of ovotestis from left side; fig. 8 — radula teeth: central, lateral 1st and 3rd, intermediate 2nd and 3rd, marginal. (bo = pouch of the oviduct; bv = vaginal pouch; ca = carrefour; cc = collecting canal of ovotestis; cd = proximal segment of vas deferens; cd' = distal segment of vas deferens; ce = sperm duct; ces = spermathecal duct; co = ovisperm duct; cp = prostate duct; d = muscular diaphragm between vergic sac and preputium; dot = ovotestis diverticula; e = spermatheca; o = oviduct; ot = ovotestis; p = prostate; pd = foremost prostate diverticulum; pm = muscular pilaster in the wall of preputium; pn = verge; pr = preputium; sv = vergic sac; ud = hindermost prostate diverticulum; ut = uterus; v = vagina; vs = seminal vesicle).

MALE ORGANS

Sperm duct — Much longer than in *glabratus*, measuring 21.36 ± 1.53 mm in length and about 0.20 mm in width (fig. 6 *ce*).

Prostate — The prostate duct (fig. 6 *cp*) measured 7.14 ± 0.74 mm, thus being significantly longer than in *glabratus*, in which it measured 5.53 ± 0.74 mm (the difference between the means is 11 times its standard error).

The configuration of the diverticula did not differ from that described in *glabratus*. However, some differences were observed as to their number and disposition. The former ranged from 12 to 26, the mean being 19.6 ± 3.1 (in *glabratus* 15 to 30, mean 21.6 ± 3.5). The difference between the means is significant, thrice as great as its standard error. Therefore, the prostate of *nigricans* has fewer diverticula, in spite of showing a longer duct. This fact is due to the stalks of the diverticula tending to be more separate in *nigricans* (fig. 9).

The last diverticulum was simple in 8, bifurcate in 20, trifurcate in 2, arborescent in 20 cases. The penultimate one was simple in 3, bifurcate in 4, arborescent in 43 cases. The antepenultimate was ever arborescent, with the exception of one club-shaped anomaly. The first diverticulum was simple in 5, bifurcate in 1, arborescent in 44 cases. The intermediate were all arborescent; exceptionally a club-shaped or nodular intermediate diverticulum may occur. The aspects referred to are shown in figs. 9, 10, 11.

The prostate of *nigricans* tends to be more branched than that of *glabratus*, as may be seen if one compares the caudal diverticula of both species. In an average prostate of *glabratus* the last diverticulum is either simple or bifurcate, the penultimate one is arborescent, bifurcate or simple, the remaining ones are arborescent. In *nigricans* the last diverticulum is usually bifurcate or arborescent, the remaining ones being arborescent.

Vas deferens — Length 20.68 ± 1.38 mm, width about 0.15 mm (fig. 6 *cd*, *cd'*), being longer than in *glabratus*. The ratio *vas deferens/vergic sac* was 6.8 ± 0.8 (in *glabratus* 4.7 ± 0.6). The difference between these means is highly significant, 14 times its standard error. If this difference is confirmed in other samples, it will be useful as another distinguishing attribute.

Penial complex — The *verge* (figs. 4, 5 *pn*) was 3.08 ± 0.28 mm long and 0.11 ± 0.02 mm wide. In 40 of the 50 specimens examined the verge measured 3 mm.

The *vergic sac* (figs. 5, 6 *sv*) was 3.07 ± 0.28 mm long and about 0.20 mm wide.

The verge and vergic sac were longer in *glabratus*, in spite of the other organs being shorter in this species.

The ratio *vergic sac/preputium* was 0.84 ± 0.12.

The *preputium* (figs. 3, 5, 6 *pr*) was 3.69 ± 0.47 mm long and 0.85 ± 0.10 mm wide.

FEMALE ORGANS

Albumen gland — Resembling that of *glabratus* (fig. 1 *ga*).

Oviduct — Length 16.26 ± 1.41 mm, width 0.59 ± 0.11 mm (fig. 6 *o*), thus being longer and narrower than in *glabratus* (10.24 ± 1.29 and 0.81 ± 0.16 mm). The pouch at the cephalic end measured 1.85 ± 0.28 mm in greatest width (fig. 6 *bo*), whereas in *glabratus* it was 2.34 ± 0.39 mm.

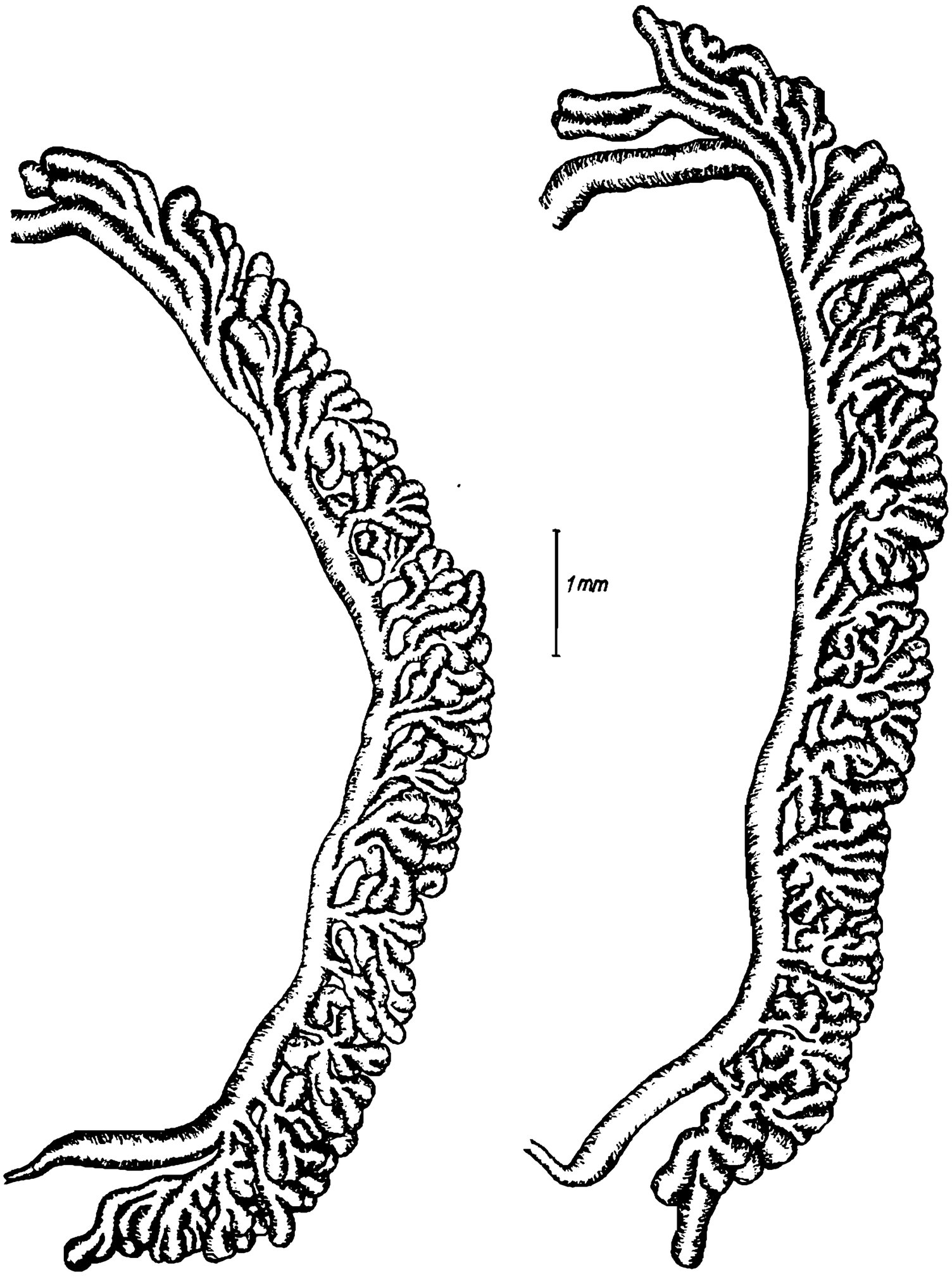

Fig. 9 — Prostates from two specimens. Left, with hindermost diverticulum arborescent. Right, with hindermost diverticulum bifurcate.

Uterus — Length 13.24 ± 1.19 mm, greatest width 1.52 ± 0.28 mm (fig. 6 *ut*), being also longer and narrower than in *glabratus* (10.58 ± 1.18 and 1.84 ± 0.32 mm).

Vagina — Length 1.70 ± 0.22 mm, width 0.28 ± 0.05 mm (fig. 6 *v*). The vagina of *nigricans*, as well as the verge, was shorter than in *glabratus* (2.06 ± 0.15 mm). At the level of its caudal swelling (vaginal pouch, fig. 6 *bv*) the organ measured 0.39 ± 0.07 mm in greatest width.

Spermatheca — Length 2.78 ± 0.40 mm, width 0.86 ± 0.16 mm (fig. 6 *e*), being about 1.5 times as long as in *glabratus* (1.57 ± 0.41 mm). The spermathecal duct was 1.11 ± 0.20 mm long and 0.10-0.15 mm wide (fig. 6 *ces*).

RADULA

Six out of the 50 specimens examined showed anomalous either central or lateral teeth. As it happens in such cases, a given anomaly reproduced along the whole vertical row of teeth in which it occurred.

The number of teeth rows varied from 125 to 168 (mean 153.9 ± 8.4). The radula formula ranged from 28-1-28 to 36-1-36 (mean 31.8 ± 1.9). The modal formula was 31-1-31.

The teeth resembled those of *glabratus*. Some aspects of them are shown in fig. 8.

DISCUSSION

At the outset of our investigations on the Brazilian *Planorbidae*, we admit true that all populations of carinate, wide-shelled specimens occurring in this country belong to the species *A. nigricans*. The original conchological literature on the subject being decidedly confusing and inconclusive, we consider as a waste of time and oftenest improductive mental exertion any attempt to judge the fitness of the earlier descriptions intended to institute a diversity of species within that group. If one examines a moderately large sample from a colonial population, it will become clear that at least some of the so-called species fall within the range of individual variation of the population. Therefore, intensive and extensive investigations are needed in order to ascertain the real status of such species. As a working hypothesis, we consider *A. nigricans*, as well as *A. glabratus*, to be polymorphic species (the polymorphism being either adaptive or nonadaptive), based on the fact that the populations which occupy many habitats in their territory of distribution should be genetically more diversified than populations restricted or specialized for occupation of only few habitats (DOBZHANSKY, 1953, p. 133).

The description just presented shows that *nigricans* and *glabratus* are closely related species from a morphological standpoint. However,

the ridge and melanic pigmentation along the ventral surface of the renal tube, that we have consistently observed to occur in *glabratus* and to be lacking in *nigricans*, and on a second plane the width and carination of the shell, give support to considering the latter a good species from a taxonomic standpoint (morphospecies).

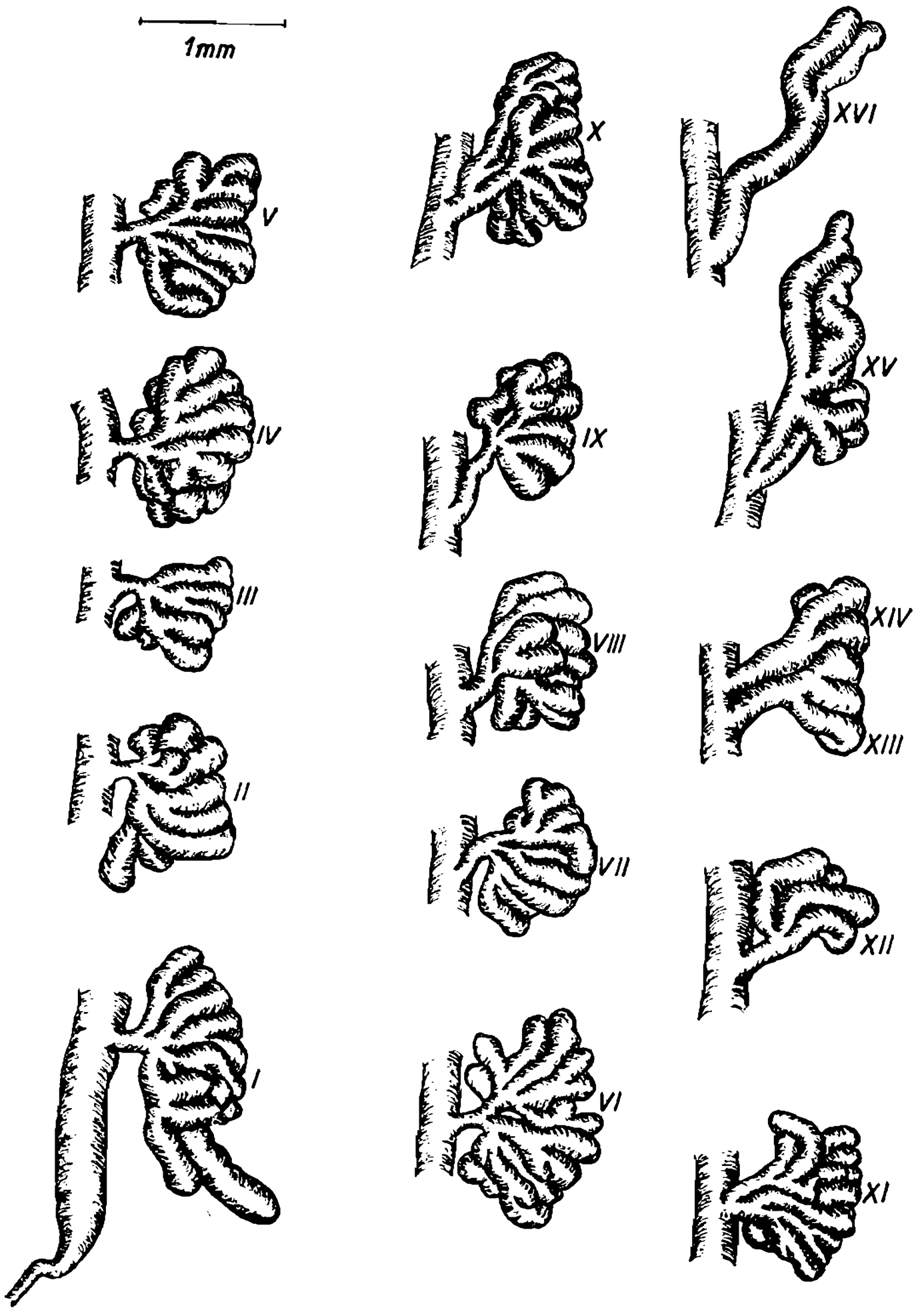

Fig. 10 — Isolated diverticula from prostate fig. 9 at right.

The shell width exhibits a range of variation in both species, there occurring wide-shelled populations of *glabratus*, as well as narrow-shelled specimens of *nigricans*. The carination is almost always clearly distinct in *nigricans*, even in the narrowest specimens, whereas the whorls are laterally smooth in *glabratus*. In doubtful cases the character of the renal region has till now proved a sure means of differentiation.

As doubtful cases we particularly refer to the specimens of some populations of *nigricans* which do not conform to the usual conchological pattern, showing a nearly indistinct carination resulting in an appearance that in many specimens may be mistaken for that of

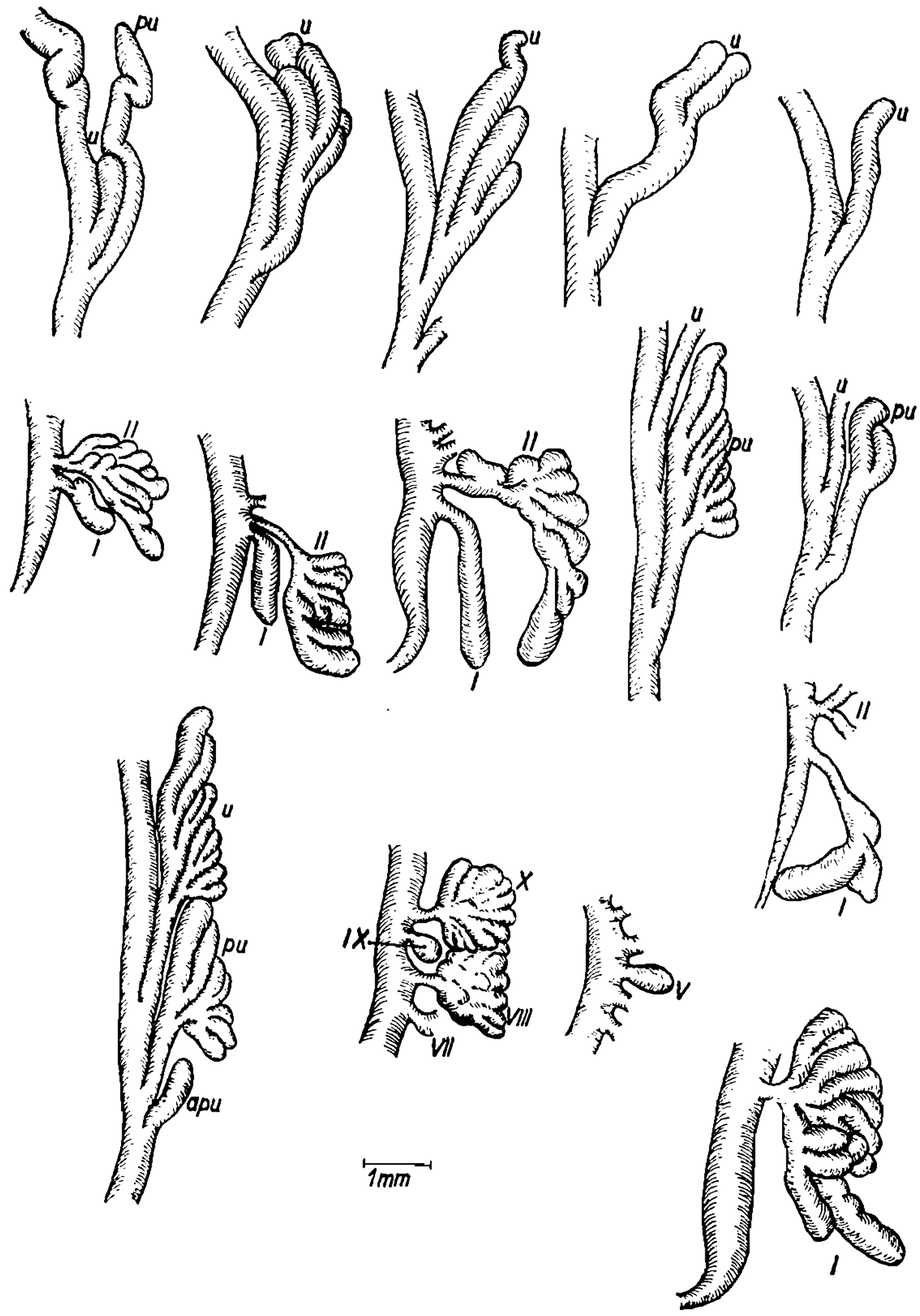

Fig. 11 — Variation in prostate diverticula (u = hindermost; pu = penultimate; apu = antepenultimate).

glabratus. We have met with such populations, in addition to other biotopes, in Jacarepaguá (Distrito Federal) and in Saboó (a district of Santos city).

The great morphological resemblance, indicating a close relationship, between the species *nigricans* and *glabratus*, denotes that they either diverged from a common ancestor, or derived from one another.

A previous knowledge that we are far from attaining to is needed on the spatial distribution of both species, and chiefly on their vertical distribution along the geologic strata.

We do not certainly know whether both species may occur sympatrically, in spite of this fact having been mentioned by SPIX (1827). If sympatry actually occurs, it will be needful to verify whether it is ancient or recent, in which regions it is observed, and whether the two species hybridize in those regions.

SUMMARY

A morphological study was done on *A. nigricans*, based on the observation of shell, radula, renal region and genitalia of 50 specimens measuring 18 mm in diameter. The data obtained are to be compared with those recorded in our previous paper (PARAENSE & DESLANDES, 1955) on *A. glabratus*. The characteristics common to both species will not be mentioned here. The numerals refer to the means and their standard deviations; no special reference being done, they correspond to length measurements.

Shell — 18 mm in diameter, 6.37 ± 0.29 mm in greatest width, 6 whorls. Prevailing colour ferruginous sepia, a minority of olivaceous, ochreous, nigrescent and deeply black specimens being found. Right side variously depressed, umbilicated, 1.5 to 3.5 mm deep from the bottom of the umbilicus to the highest level of the last whorl. Left side more depressed than the right one, broadly concave, 1.5 to 3.5 mm deep. Both sides show a variously distinct keel, that looks sharper at the left. Aperture deltoid, varying in outline and width.

Body, extended — 60.26 ± 3.62 mm, less pigmented than in *glabratus*.

Renal tube — 30.68 ± 1.69 mm, showing neither ridge nor pigmented line along its ventral surface, this negative character affording a sure means of separation from *glabratus*.

Ovotestis — 14.48 ± 1.93 mm.

Ovisperm duct — 13.04 ± 1.60 mm, including the non-unwound seminal vesicle. The latter was 0.97 ± 0.21 mm in greatest width.

Carrefour — Resembling that of *glabratus*.

Sperm duct — 21.36 ± 1.53 mm.

Prostate — Prostate duct 7.14 ± 0.74 mm, collecting a row of long diverticula numbering 19.6 ± 3.1 and more separate than in *glabratus*. Last diverticulum generally bifurcate or arborescent, the remaining ones arborescent.

Vas deferens — 28.68 ± 1.38 mm. Ratio vas deferens/vergic sac = 6.8±0.8.

Verge — 3.08 ± 0.28 mm long, 0.11 ± 0.02 mm wide.

Vergic sac — 3.07 ± 0.28 mm long, about 0.20 mm wide. Ratio *vergic sac/preputium* = 0.84 ± 0.12.

Preputium — 3.69 ± 0.47 mm long, 0.85 ± 0.10 mm wide.

Albumen gland — Resembling that of *glabratus*.

Oviduct — 16.26 ± 1.41 mm, swollen at the cephalic end.

Uterus — 13.24 ± 1.19 mm.

Vagina — 1.70 ± 0.22 mm, swollen at the caudal portion.

Spermatheca — 2.78 ± 0.40 mm long, 0.86 ± 0.16 mm wide. Spermathecal duct 1.11 ± 0.20 mm.

Radula — 125 to 168 horizontal rows of teeth (mean 153.9 ± 8.4). Radula formula 28-1-28 to 36-1-36 (mean 31.8 ± 1.9). Mode formula 31-1-31.

The morphological characteristics of the renal region and shell, and the great body length in the same condition of shell diameter, distinguish *A. nigricans* from the most related species *A. glabratus*, giving support to considering it a good species from a taxonomic or phenotypic standpoint (morphospecies).

RESUMO

Foi feito um estudo morfológico do *Australorbis nigricans*, baseado na observação da concha, da rádula, da região renal e da genitália de 50 espécimes com 18 mm de diâmetro. Os dados apresentados a seguir devem ser confrontados com os obtidos, nas mesmas condições, de uma amostra de *A. glabratus* e que constam de trabalho anterior (Paraense & Deslandes, 1955). Não serão referidos os caracteres comuns às duas espécies. Os números exprimem as médias e seus desvios padrões; quando não acompanhados de referência especial, correspondem a medidas de comprimento.

Concha — 18 mm de diâmetro, 6,37 ± 0,29 mm de largura máxima, 6 giros. Côr sépia tendendo a ferrugínea, podendo ser ocrácea, olivácea, nigrescente e intensamente negra. Face direita deprimida, umbilicada, com 1,5 a 3,5 mm do fundo do umbigo ao nível mais alto do último giro. Face esquerda mais deprimida que a direita, amplamente côncava, com 1,5 a 3,5 mm de profundidade. Cada face é percorrida por uma carena, de nitidez variável, a esquerda mais saliente. Abertura deltóide, com variações na conformação e na amplitude.

Corpo distendido — 60,26 ± 3,62 mm, relativamente pouco pigmentado.

Tubo renal — 30,68 ± 1,69 mm, sem crista nem linha pigmentar ao longo da face ventral; êste carater negativo permite separar *nigricans* de *glabratus*.

Ovoteste — 14,48 ± 1,93 mm.

Canal ovispermático — 13,04 ± 1,60 mm, incluindo a vesícula seminal enovelada. Vesícula seminal 0,97 ± 0,21 mm de largura máxima.

Carrefour — Semelhante ao do *A. glabratus*.

Canal espermático — 21,36 ± 1,53 mm.

Próstata — Canal prostático 7,14 ± 0,74 mm, recebendo uma fileira de divertículos longos, em número de 19,6 ± 3,1 e implantados em pontos mais afastados que no *glabratus*. Em geral, o último divertículo é bifurcado ou arborescente e os restantes são arborescentes.

Canal deferente — 28,68 ± 1,38 mm. Relação *canal deferente/saco vérgico* igual a 6,8 ± 0,8.

Pênis — 3,08 ± 0,28 mm de comprimento e 0,11 ± 0,02 de diymetro.

Saco vérgico — 3,07 ± 0,28 mm de comprimento, cêrca de 0,20 mm de largura. Relação *saco vérgico/prepúcio* igual a 0,84 ± 0,12.

Prepúcio — 3,69 ± 0,47 mm de comprimento e 0,85 ± 0,10 mm de largura.

Glândula do albúmen — Semelhante à do *glabratus*.

Oviduto — 16,26 ± 1,41 mm, com dilatação em forma de bôlsa na extremidade cefálica.

Útero — 13,24 ± 1,19 mm.

Vagina — 1,70 ± 0,22 mm, com dilatação em forma de bôlsa na porção caudal.

Espermateca — 2,78 ± 0,40 mm de comprimento e 0,86 ± 0,16 mm de largura. Canal da espermateca 1,11 ± 0,20 mm.

Rádula — 125 a 168 filas horizontais de dentes (média 153,9 ± 8,4). Fórmula radular 28-1-28 a 36-1-36 (média 31,8 ± 1,9). Fórmula modal 31-1-31.

Os caracteres morfológicos da região renal e da concha, e o maior comprimento do corpo em condições idênticas de diâmetro da concha, distinguem o *A. nigricans* da espécie mais próxima *A. glabratus*, permitindo considerá-lo como boa espécie do ponto de vista taxionômico ou fenotípico (morfoespécie).

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PLATE 1

Figs. 1, 2 — Widest (1) and narrowest (2) shells from the sample studied, a = right side, b = front, c = left side (2x); fig. 3 — corroded shell (2x); fig. 4 — black shell (2x); figs. 5, 6, 7, 8 — shells from front (2x); fig. 9 — section through shells of *A. glabratus* (a) and *A. nigricans* (b).

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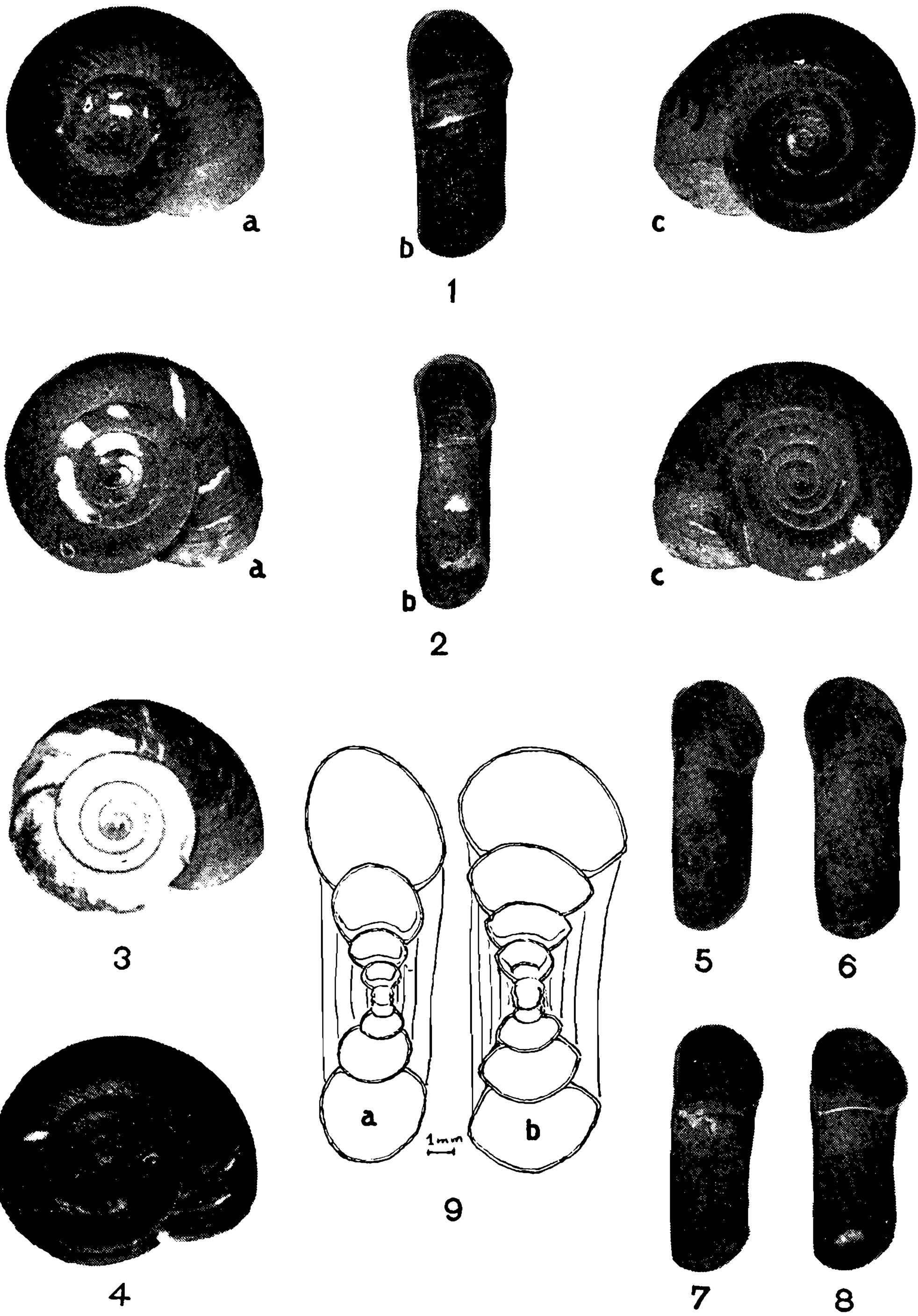
PLATE 1



Paraense & Deslandes: Morphology of Australorbis nigricans

PLATE 2

Fig. 1 — Cross section through middle of renal tube of *A. glabratus* 10 mm in diameter: no renal ridge, pigment in cells of lacunar reticulum (100x); fig. 2 — idem (200x)); fig. 3 — idem, *A. glabratus* 18 mm in diameter: renal ridge, pigment in cells of lacunar reticulum (100x). (car = respiratory cavity; cr = canal ridge; ll = layer of lacunar tissue between renal tube and ventral epithelium of dorsal membrane of mantle; ll' = layer of lacunar tissue between renal tube and dorsal epithelium of dorsal membrane of mantle; tr = renal tube; vp = pulmonary vein; vr = renal vein).

PLATE 2

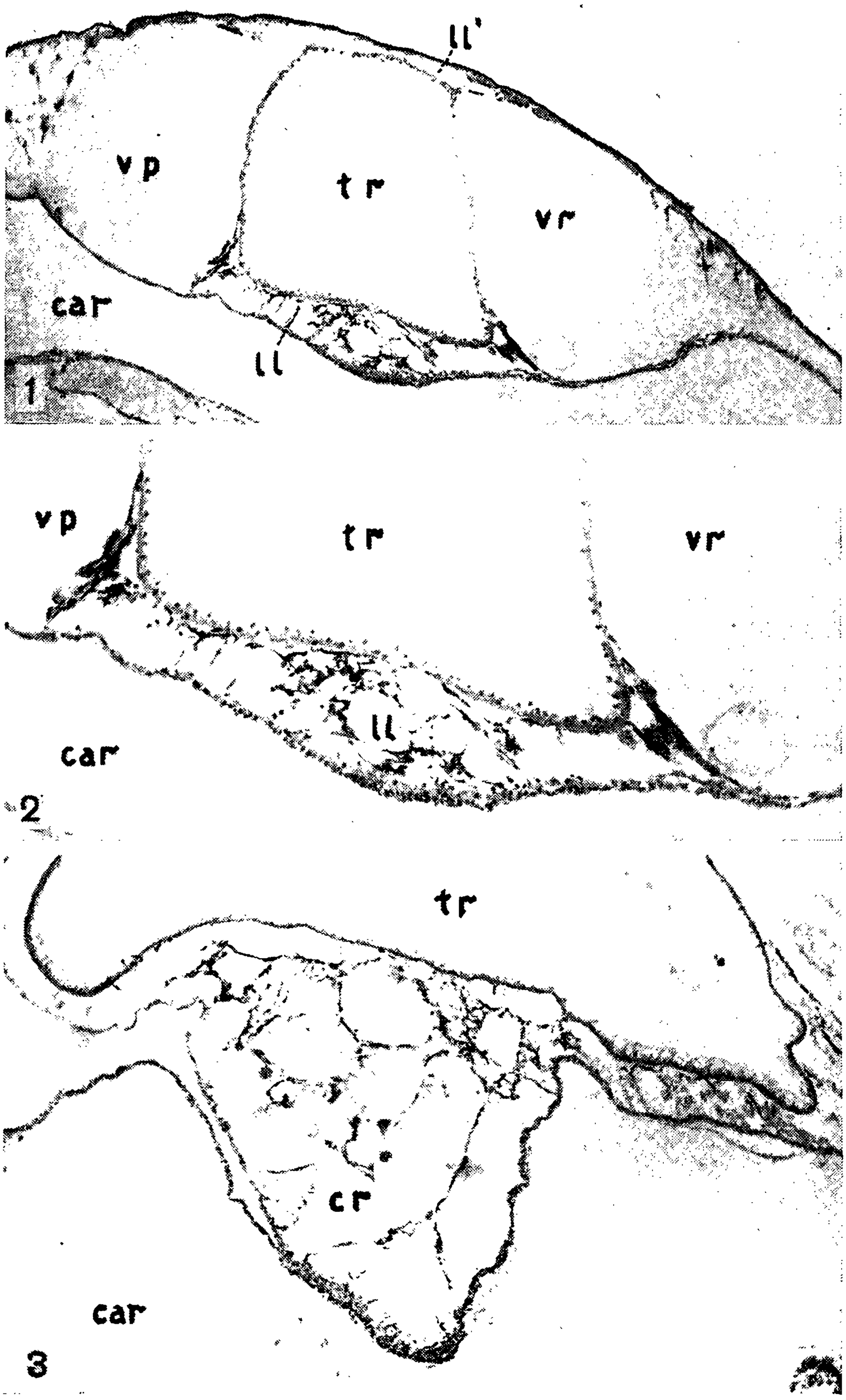


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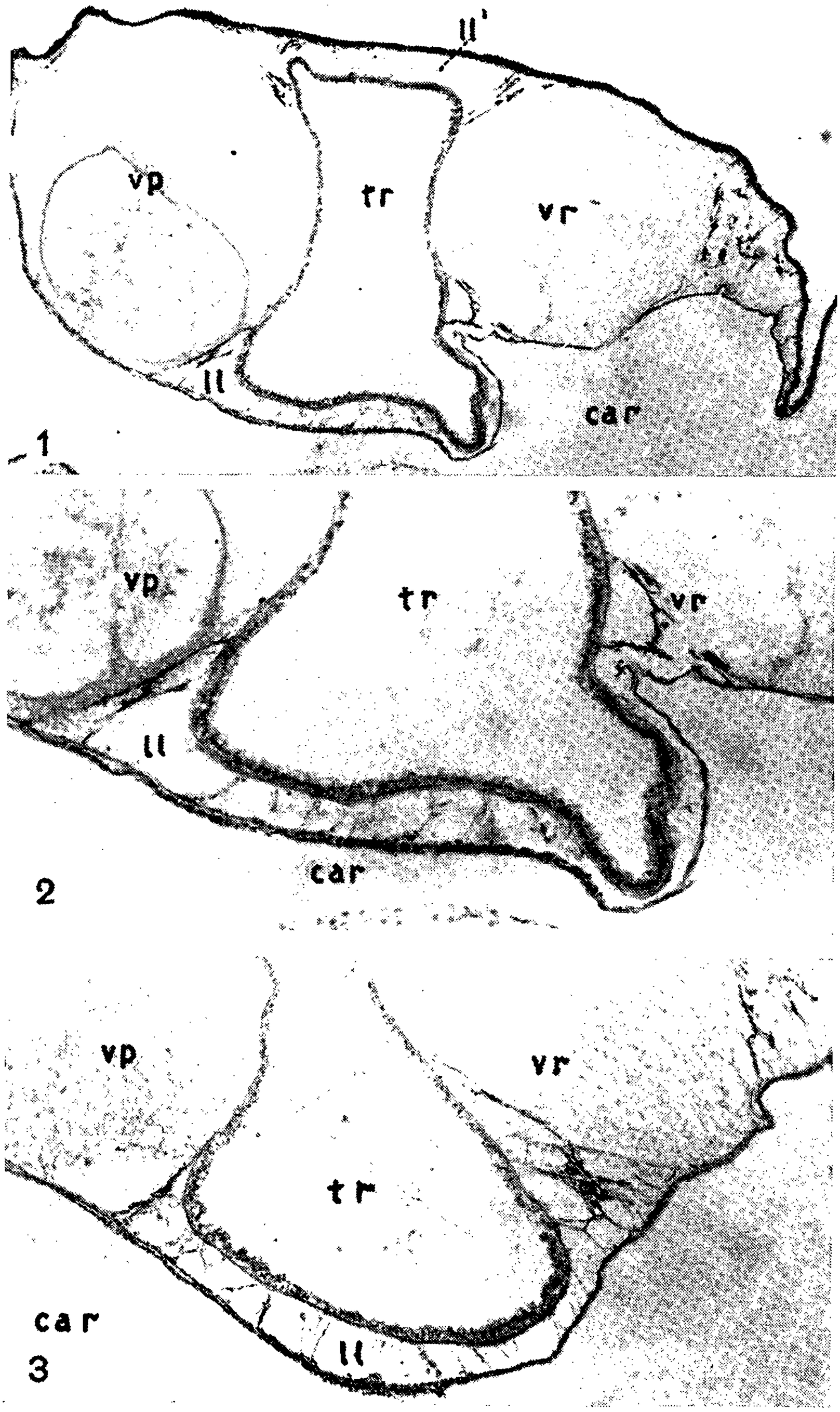
PLATE 3

Fig. 1 — Cross section through middle of renal tube of *A. nigricans* 10 mm in diameter: no renal ridge, very scarce pigment granules (100x); fig. 2 — idem (200x); fig. 3 — idem, *A. nigricans* 18 mm in diameter: no renal ridge, very scarce pigment granules (100x). (car = respiratoy cavity; cr = renal ridge; ll = layer of lacunar tissue between renal tube and ventral epithelium of dorsal membrane of mantle; ll' = layer of lacunar tissue between renal tube and dorsal epithelium of dorsal membrane of mantle; tr = renal tube; vp = pulmonary veins; vr = renal vein).

Mem. Inst. Oswaldo Cruz
Tomo 53 (1), 1955



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