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ECOLOGY OF THE MEDUSA CASSIOPEA XAMACHANA IN CURAÇAO

by

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In the Netherlands Antilles *Cassiopea xamachana* Bigelow is found in many shallow, sheltered lagoons (WAGENAAR HUMMELINCK 1933, 1968). The medusae are lying on their umbrella with their arms upwards; they pulsate day and night. Mass mortality has repeatedly been observed, mainly in the wet season but also at other times, especially after a period of rain.

In order to get some insight into the environmental factors influencing the presence and the sudden mortality of the medusae some aspects have been investigated: such as wave action and currents, light intensity, temperature and salinity.

The investigations were carried out by the junior author during her stay in Curaçao during the second half of 1962. This half-year study was made possible thanks to a grant awarded by WOSUNA (Netherlands Foundation for the Advancement of Research in Surinam and the Netherlands Antilles). The senior author collected additional data during his stay from 1960 to 1964. Short preliminary accounts were presented by the junior author (1963) and by the senior author (1964) (both have been quoted verbatim by WAGENAAR HUMMELINCK 1968 p. 18–19).

WAVE ACTION AND CURRENTS

The medusae are never found in places exposed to wave action. In large lagoons, *Cassiopea* is always found in the most eastern part of the lagoon, in the lee of a coral bar or shrub growth, protected against trade-wind influence. We have observed that the medusae cannot exist in turbulent waters; apparently slight currents prevent settling. In aquarium experiments, currents of only two centimetres per second raised most of the medusae from the bottom. Active surf appears to kill the medusae in a short time as they become immobilized by repeated shocks. This fact was demonstrated by placing some medusae in a covered jar. If the jar was completely filled with sea water, shaking did not harm the medusae; however, if there was a layer of air between the water and the cover, continuous agitation of the jar immobilized the medusae in a quarter of an hour. Some of the immobile medusae resumed pulsations after some hours if the water was aerated constantly, but most of them remained motionless unless they were stimulated artificially, e.g. by an electric stimulus.[1]) Immobile animals succumbed during a period of darkness (i.e. during the night), probably because of a lack of oxygen, as in darkness the Zooxanthellae do not function.

LIGHT AND TRANSPARENCY

Cassiopea was always found in places of less than 1.50 m depth, in very clear water. [2]) Underwater light measurements were performed with the aid of a selenium cell, a technique described by Roos (1967, p. 41). By this technique the underwater light intensity is compared with that of the air; thus only relative values are obtained.

Only very small differences in light intensity could be found between pools inhabited by medusae and those without medusae (37 measurements at about 50 cm below the surface). These differences proved to be insignificant.

In the laboratory experiments the medusae were kept in satisfactory condition at a light intensity which was only 6–8% of their

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[1]) A sensivity toward surf or wave action is also known from other medusae. The senior author repeatedly observed that, in the North Sea along the Dutch coast, surface dwelling medusae like *Aurelia aurita* are found on the bottom after a gale. They will stay there for some days. Many of them do not recover but disintegrate in a week or so.

[2]) A few scattered specimens have been observed in the Lac, Bonaire, by HUMMELINCK and Roos (in litt.) as deep as 3 m, whilst WAGENAAR HUMMELINCK (1968, p. 16) refers to a publication of LEE BOONE, in which she mentions "a single specimen dredged in 6 fms., Dry Tortugas."

natural habitat. If, however, the light intensity was further reduced to 1–3%, a marked deterioration of the medusae's condition resulted. Thus, the critical light intensity appears to be about 5% of that of their habitat, an intensity which is found at depths of 5–7 metres – much deeper than the maximum depth (1.5 m) where the medusae are to be found. It may be concluded, therefore, that it is rather unlikely that light intensity plays any role, either in the horizontal or in the vertical distribution of *Cassiopea*. It may be possible, however, that the larvae prefer high light intensities when settling.

The fact that medusae are never found in turbid water suggests that the presence of silt or particulate matter is an important inhibiting factor. Experimental evidence on the effects of water transparency is absent.

TEMPERATURE

The temperatures of the lagoons inhabited by *Cassiopea* were found to be quite constant. Readings on 115 occasions indicated an average of 30.1°C and a range of 28.8° to 34.9°C with only a few deviations. On Feb. 1963 the temperature of one of the "Rifwater" lagoons was 26.4°C and in Sep. 1962 a reading of 27.0 degrees was obtained from a lagoon near Punta Caballo, Spaanse Water. In the laboratory temperatures of 23–24°C were endured for weeks, so that it is unlikely that in the Neth. Antilles too low temperatures ever play a role.

Under normal conditions the water temperature in the *Cassiopea*-pools never exceeded 35°C, which is well tolerated by the medusae. After rainfall, however, a freshwater layer may cover the surface and then the underlying layer of seawater can become considerably warmer as a result of solar radiation. After a rainfall, in October 1963, the bottom water in one of the "Rifwater" pools had a temperature of 39.5°C and in the same month the bottom temperature in three pools near Santa Marta Baai rose to 40–41°C; both populations of *Cassiopea* succumbed. Under laboratory conditions the maximum temperature appears to be 35°C, a whole day of 35.5°C was usually lethal. On the other hand, temperatures up to 37.5°C could be endured for a limited period of about one and a half hours. MAYER (1914, p. 13) mentions still higher temperatures: in his experiments *Cassiopea* stopped pulsating at 38.5°C.

SALINITY

The normal salinity range (97 samplings) in *Cassiopea* lagoons varied from 36‰ (that of seawater) to 54‰. In periods of rain values were found as low as 33‰. Even at these extreme values the medusae were pulsating properly. It may be assumed that such variations will be harmless, at least, for only a limited period of, perhaps, some weeks. In a single instance – after a heavy rainfall (five hours in one day) at the end of August 1960 – the salinity near the bottom of a landlocked inlet of Santa Marta Baai was reduced to 14.5‰ which proved fatal to all the medusae.

In order to check the salinity influences on the viability of *Cassiopea* various parameters can be used: mortality, food conversion, growth rate etc. GOLDFARB (1914) used the regeneration rate of the arms as an index and we followed his techniques. Animals for testing were kept in aerated water and received natural sunlight from windows. The temperature varied generally from 27.5° to 32°C but occasionally reached 34.5°C. Each salinity group was composed of 20 to 25 animals. Of each animal one or two arms were

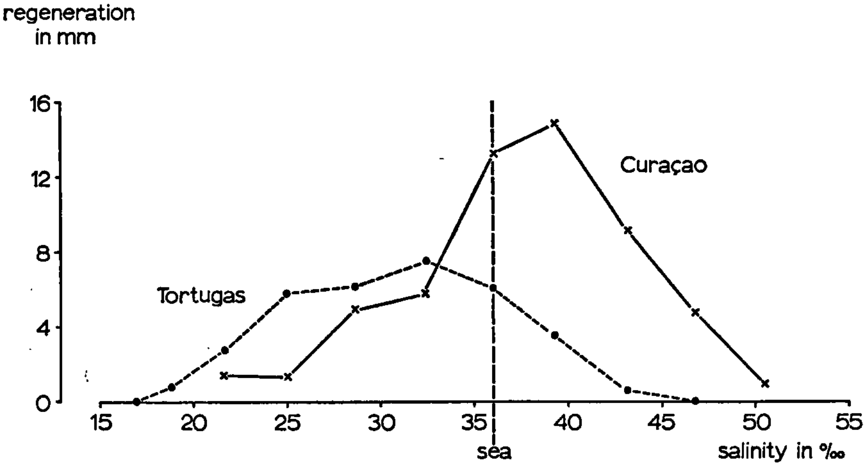

Fig. 64. Regeneration of the oral arms at various salinities, 24 days after the arms had been cut off. The Tortugas data have been derived from GOLDFARB, 1914.

amputated and regeneration was measured in millimetres. From Fig. 64 – in which regeneration after 24 days is shown – it is clear that the most rapid regeneration takes place at a salinity that is a little above that of normal seawater. This is in contrast with the results reported by GOLDFARB (1914), who used *Cassiopea xamachana* from the Dry Tortugas, Florida. In his experiments the regeneration rate was highest in diluted sea water.

GOLDFARB regrets not having determined the salinity of the sea water he used, but he assumes that his "normal" sea water was ocean water when he refers to CLARKE (1911) who gives salinity figures for "ocean water". According to DOLE (1914, p. 73–74) the salinity in the Tortugas area is about 36‰, ranging from 35.9 to 36.1‰. DOLE also gives values for the salinity in the moat where GOLDFARB collected his medusae, from 32‰ to 36.3‰, but as he explains his sampling was not always adequate. Nevertheless, the average salinity in the Dry Tortugas habitat seems to be somewhat lower than in Curaçao. This is not surprising as the average rainfall in the Dry Tortugas area is 96.7 cm (BOWMAN 1918, p. 113), and in Curaçao only 57.4 cm (BRUINENBERG 1969, p. 331).

In Fig. 64 GOLDFARB's results and ours are combined; we assumed that GOLDFARB's "ocean water" had a salinity of 36‰. When comparing the curves it is clear that the optimum salinity for Tortugas *Cassiopea* is lower than for Curaçaon *Cassiopea.* Obviously, in accordance with the average salinity of their habitat, the Tortugas animals are adapted to lower salinities than are the Curaçao medusae. Whether these differences in regeneration rate are inherited or represent an adaptation cannot be ascertained without further experiments.

SUMMARY

1. *Cassiopea xamachana* is unable to tolerate any wave action, turbulence or currents.
2. Although the species is found only in shallow water where the light intensity is high, it could not be demonstrated that light intensity is an important factor.
3. Normal temperature fluctuations – at least in the Antilles – are of no significance as the range that *Cassiopea* under laboratory conditions proved to be able to withstand is wider than the

fluctuations occurring in their natural environment. On the other hand, after heavy rainfall when the pools are covered with fresh water the bottom water temperature may rise to deleterious levels.

4. The salinity range in the habitat of *Cassiopea* is from about 33‰ to 54‰. When the regeneration rate is used as a parameter for optimum salinity conditions, supersaline water of about 40‰ is optimal, which is about the average salinity in their natural habitat in Curaçao. In the Dry Tortugas, where the salinity is lower, optimum regeneration occurs at a lower salinity level, as reported by GOLDFARB, 1914.

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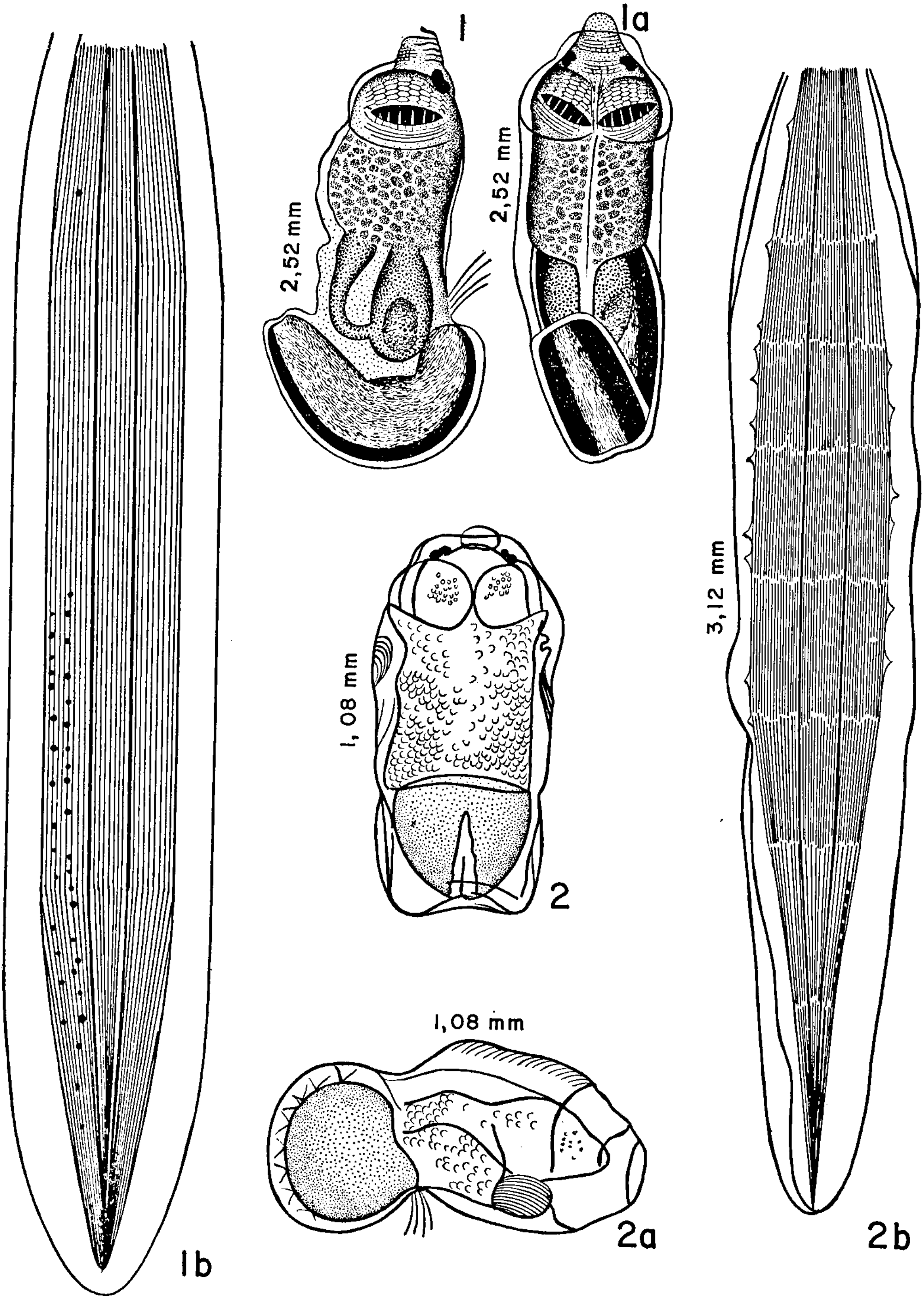
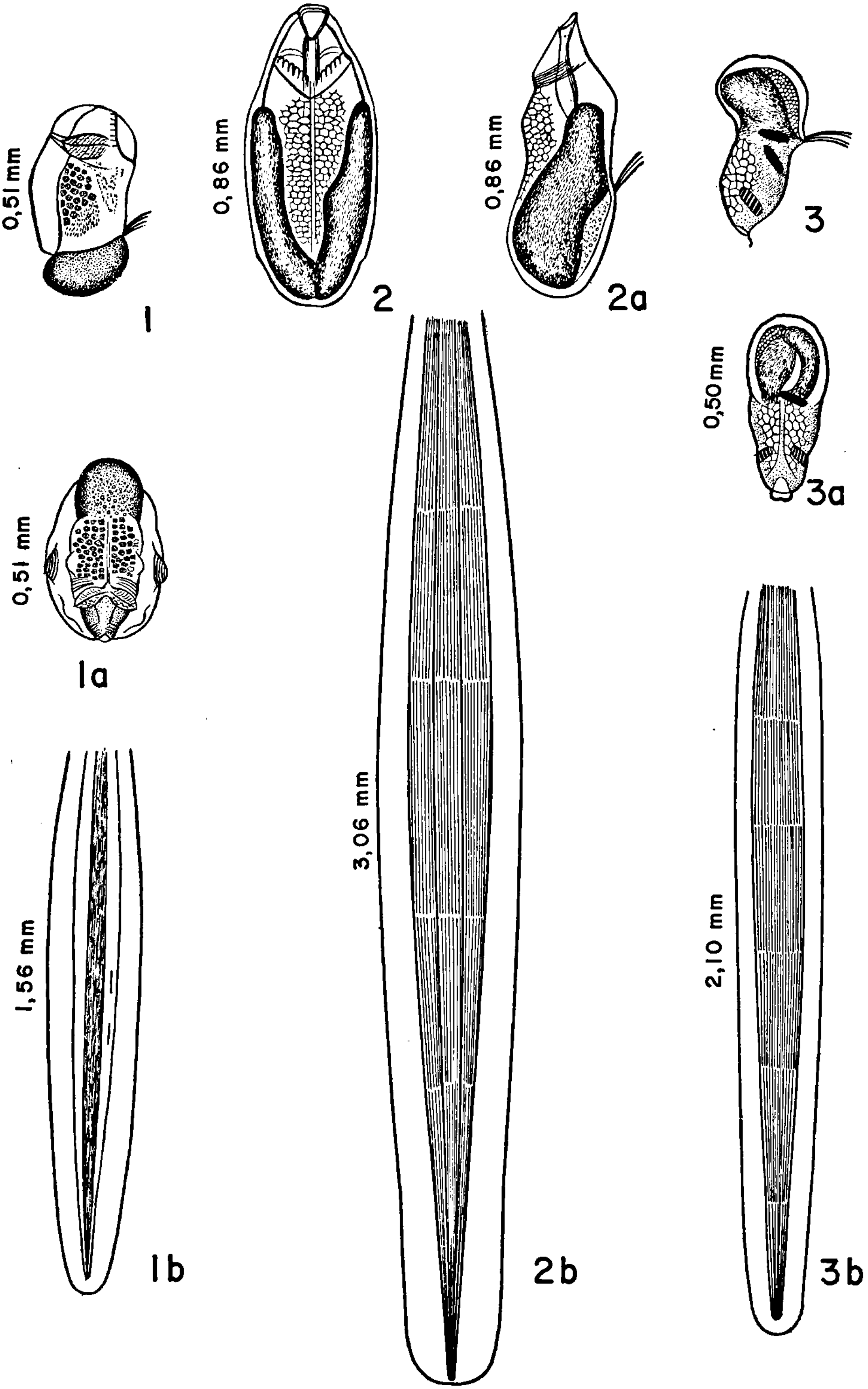
LÁMINA I



1. *Oikopleura albicans* (Leuckart), vista lateral del tronco; 1a, vista dorsal del tronco; 1b, cola.

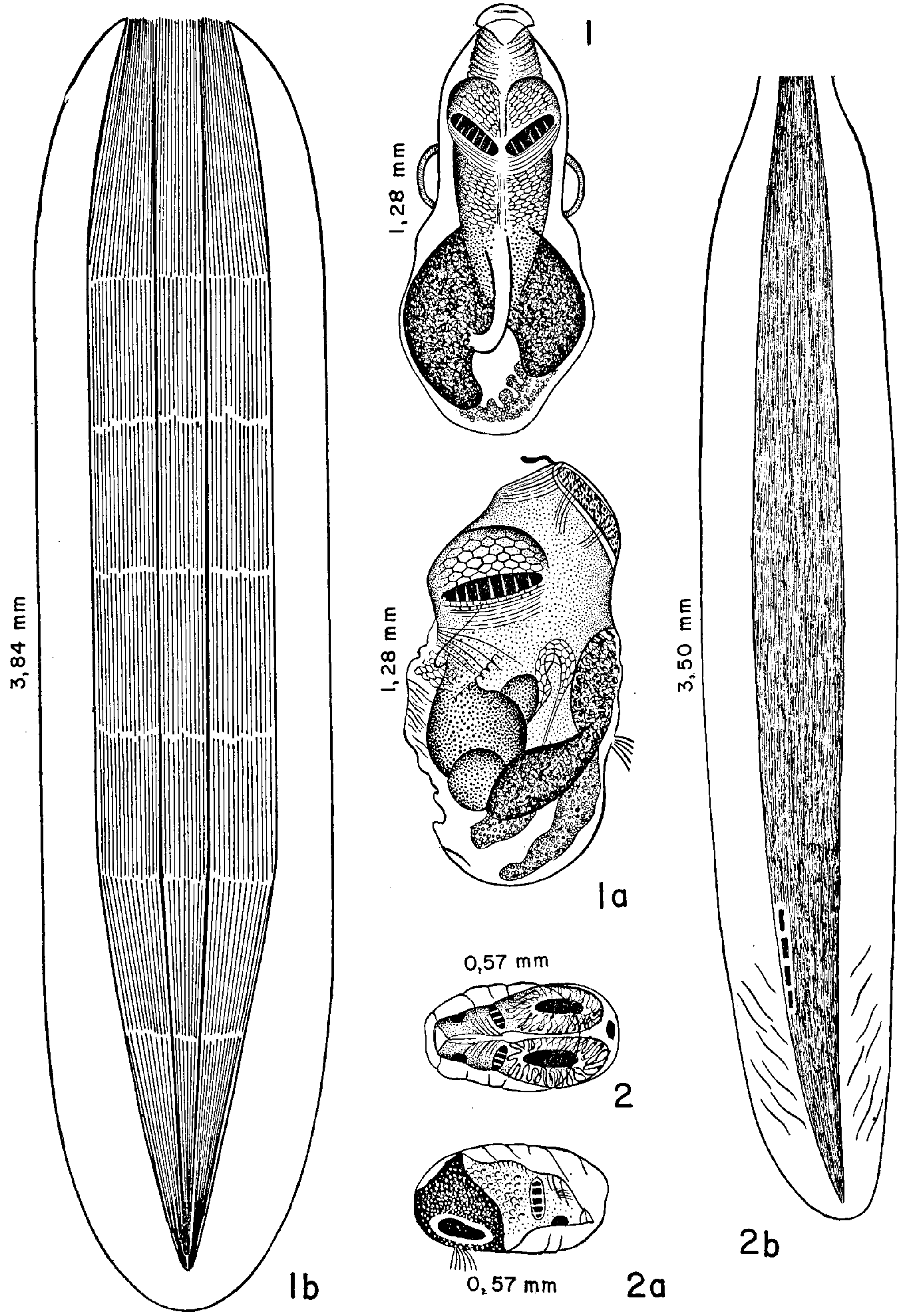
2. *Oikopleura cophocerca* (Gegenbaur), vista dorsal del tronco; 2a, vista lateral del tronco; 2b, cola.

LÁMINA II



1. *Oikopleura dioica* Fol, vista lateral del tronco; 1a, vista dorsal del tronco; 1b, cola.
2. *Oikopleura fusiformis* Fol, vista dorsal del tronco; 2a, vista lateral del tronco; 2b, cola.
3. *Oikopleura fusiformis* f. *cornutogastra* (Aïda), vista lateral del tronco; 3a, vista dorsal del tronco; 3b, cola.

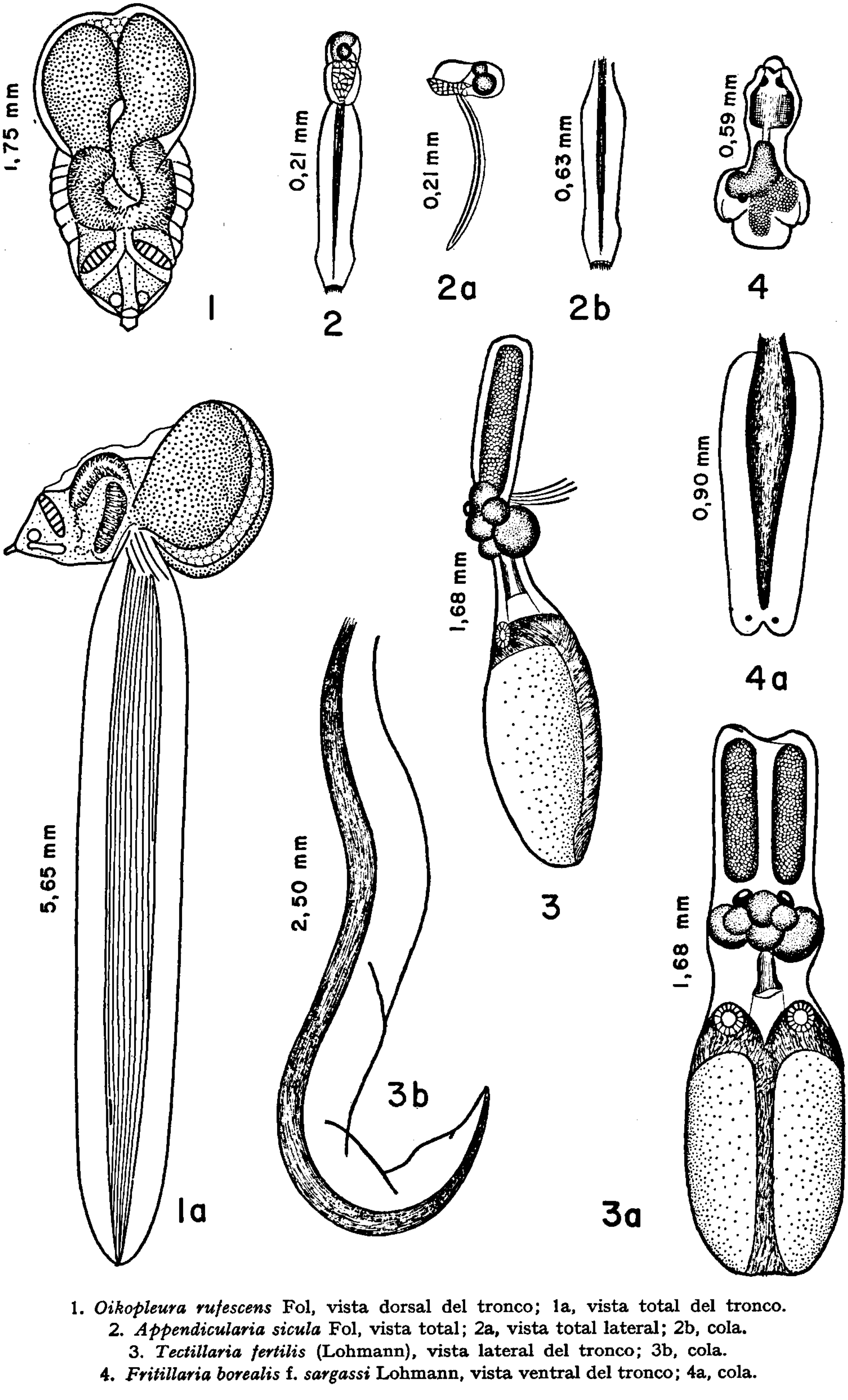
LÁMINA III



1. *Oikopleura longicauda* (Vogt), vista dorsal del tronco; 1a, vista lateral del tronco; 1b, cola.

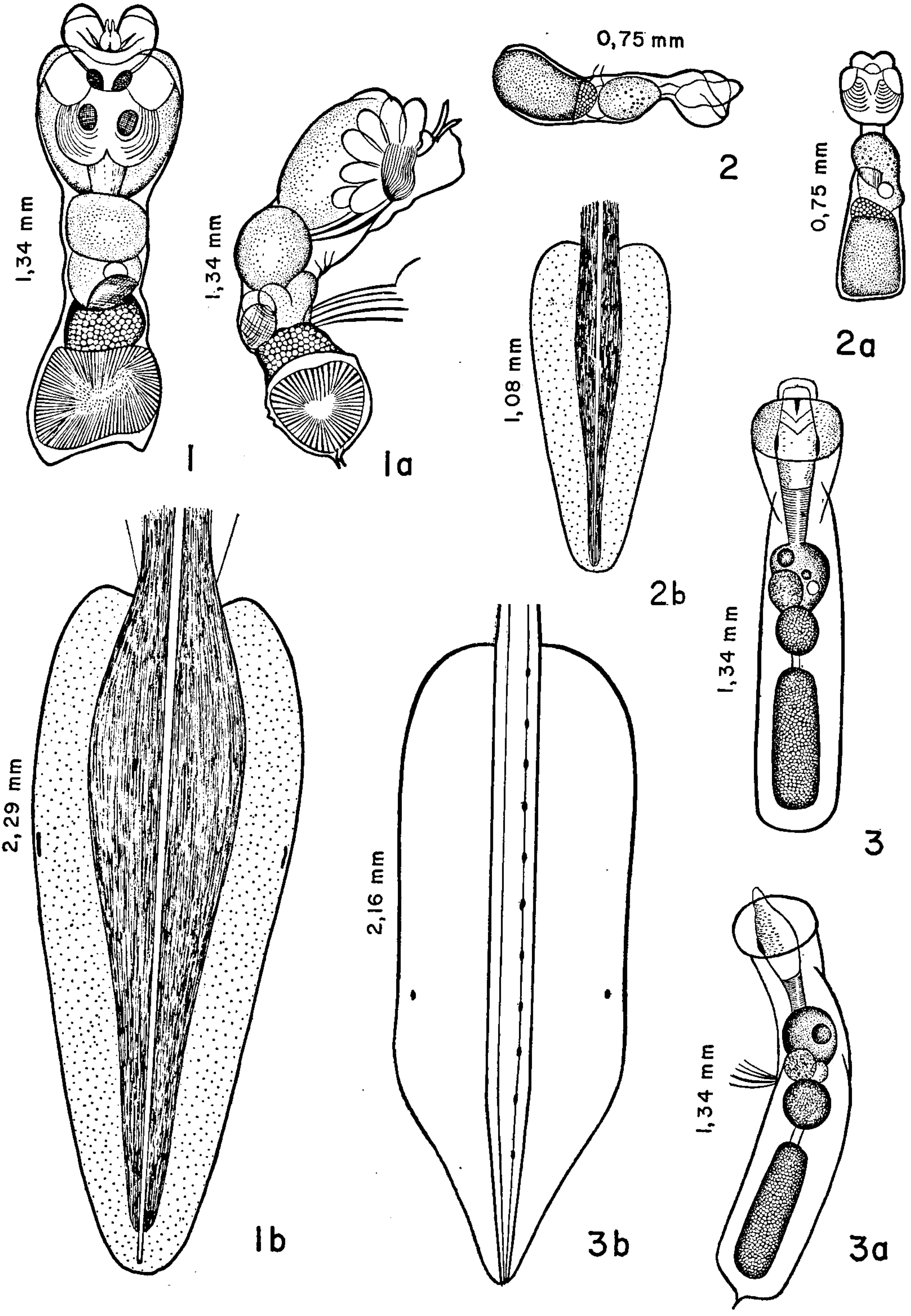
2. *Oikopleura parva* Lohmann, vista dorsal del tronco; 2a, vista lateral del tronco; 2b, cola.

LÁMINA IV



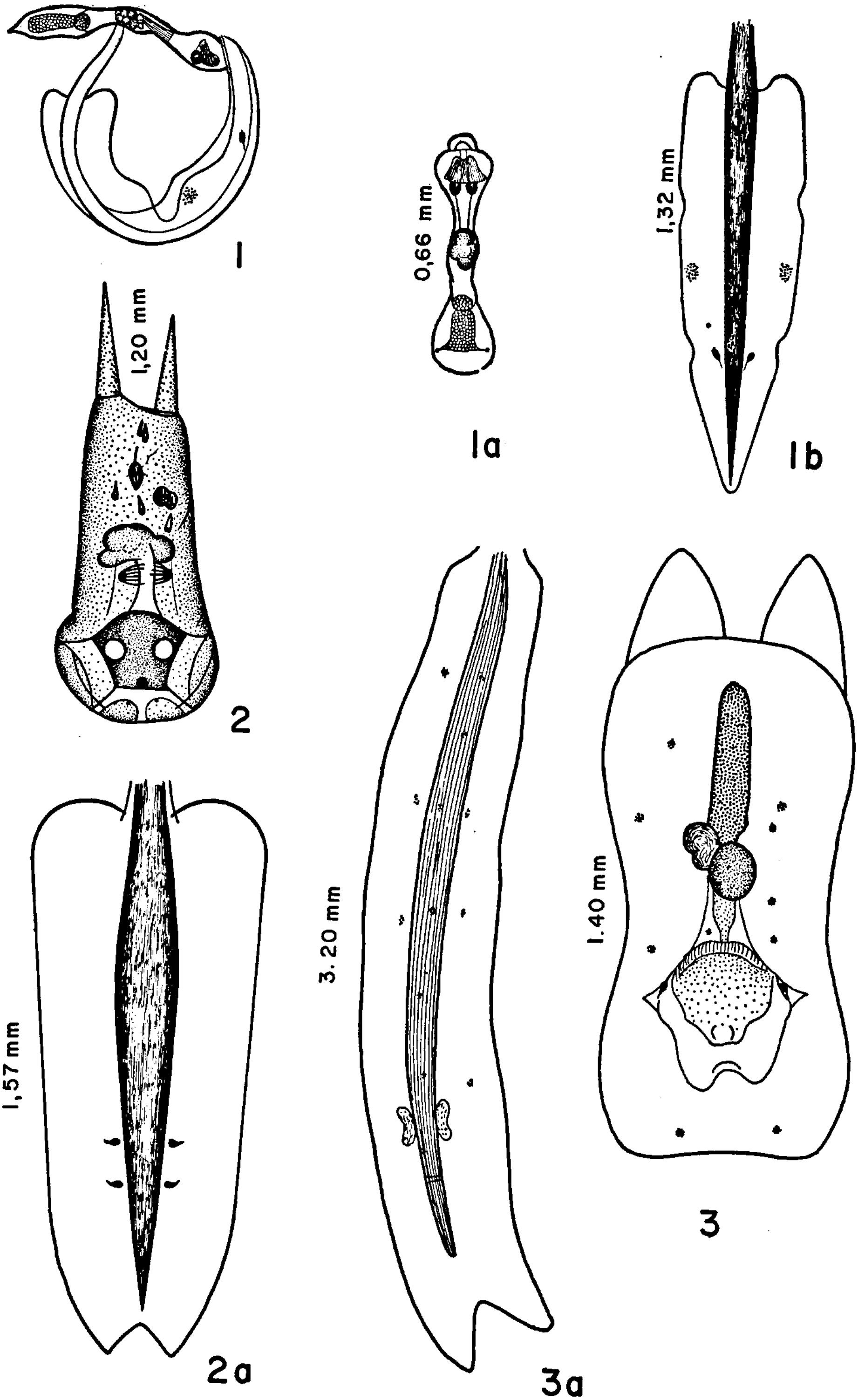
1. *Oikopleura rufescens* Fol, vista dorsal del tronco; 1a, vista total del tronco.
2. *Appendicularia sicula* Fol, vista total; 2a, vista total lateral; 2b, cola.
3. *Tectillaria fertilis* (Lohmann), vista lateral del tronco; 3b, cola.
4. *Fritillaria borealis* f. *sargassi* Lohmann, vista ventral del tronco; 4a, cola.

LÁMINA V



1. *Fritillaria formica* f. *digitata* Lohmann & Bückmann, vista ventral del tronco; 1a, vista lateral del tronco; 1b, cola.
2. *Fritillaria formica* f. *tuberculata* Lohmann & Bückmann, vista lateral del tronco; 2a, vista dorsal del tronco; 2b, cola.
3. *Fritillaria haplostoma* Fol, vista dorsal del tronco; 3a, vista lateral del tronco; 3b, cola.

LÁMINA VI



1. ***Fritillaria haplostoma*** f. ***abjörnseni*** Lohmann, vista total; 1a, vista lateral del tronco; 1b, cola.
2. ***Fritillaria pellucida*** (Busch), vista ventral del tronco; 2a, cola.
3. ***Fritillaria tenella*** Lohmann, vista dorsal del tronco; 3a, cola.