Figure 231: *Iurus kraepelini*. **Top.** A juvenile after second ecdysis. **Bottom.** A juvenile after third ecdysis

Figure 232: *Iurus kraepelini*. **Top.** A juvenile shortly after the fourth ecdysis. **Bottom.** An immature specimen before the fifth ecdysis.

Figure 233: *Iurus asiaticus*. **Top.** An adult male shortly after the fifth ecdysis. **Bottom.** An adult male well after the fifth ecdysis.

Figure 234: *Iurus kraepelini*, an adult male immediately after the fourth ecdysis and its exuvium.

maturity, with the first female undergoing the fifth ecdysis at the age of 402 days and the last female undergoing the fifth ecdysis at the age of 800 days.

Observations on *Iurus* Embryos

Among a large collection of *Iurus dufoureius* from Peloponnese, Greece, given to the authors by Pierangelo Crucitti were two gravid females from Kalivia Sohas (Mystras District, Laconia Prefecture) with their embryos removed. We obtained 16 fully formed, late-stage embryos, contained in the vials with these two females (seven and nine embryos, respectively). Since *Iurus* embryos have not been previously observed and described in the literature, we offer here a pilot study of their morphology. Five embryos were prepared for SEM imaging (see Methods) with the kind help of David P. A. Neff. In the photographs and micrographs presented in Figures 235–246, we illustrate several of these embryos.

For the information on scorpion embryonic development, the reader is addressed to the most recent reviews by Farley (1999, 2001a) and to other important works by the same author (Farley, 2001b, 2005, 2008). The overall arrangement of the *Iurus* embryo and detail of structure development is similar to late-stage embryos of the apoikogenic *Smeringurus mesaensis* (Vaejovidae) and *Hadrurus arizonensis* (Caraboctonidae, the sister family of Iuridae) illustrated by Farley (1999, 2001a). The late-stage embryos of *Iurus* are formed in a typical "supine position" (such as depicted for *Hadrurus arizonensis* in Farley, 1999: fig. 23); i.e., the metasoma and telson as well as the legs and pedipalps are folded over the ventral aspect of the mesosoma (Fig. 235). The studied embryos were not the same size, some considerably smaller than others. The total length of a large embryo is 14.55 mm for the body (prosoma and mesosoma) and 7.65 for metasoma and telson.

As confirmed and discussed by Farley (2005), the so-called first stadium (= first instar, pronymph, newborn, pullus) in scorpions is a continuation and extension of embryological development. Its first ecdysis (molt) results in a drastic transformation of an embryo-like newborn to an adult-like second instar (= second stadium, nymph); see Farley (2005: figs. 9–10). The late-stage embryo in scorpions is generally very similar to the newborn animal. An interesting feature of this observed stage is a marked *heterochrony*: advanced embryonic development of some morphological features combined with the delayed development of others.

Mesosoma. The *carapace* is formed, exhibiting a wide anterior emargination, which is also found on adults; this emargination is much wider in the embryo. The lateral and median eye tubercles are developed and pigmented black, but no trace of median eyes are present. The developing three lateral eyes are definitely visible in Fig. 236 but are below the surface (as confirmed by SEM). The *chelicerae* are present; both movable and fixed fingers are developed, the movable finger slightly longer than the fixed; some setae are present. No cheliceral dentition is visible, but a beginning of the movable finger dorsal edge is visible due to a slight bifurcation distally (Fig. 237). The maxillary lobes are visible in Figs. 236 and 239, their distal portions extending somewhat outward. The sternum and genital operculum are well-developed and resemble what is seen in adults, except the sternum is considerably wider in the embryo (Fig. 236). The *pectines* are well-developed with their teeth, fulcra, and lamellae clearly formed, with visible setation. Even the sensorial areas are delineated, and a number of developing peg sensilla in various stages of development are well-visible (Figs. 237, 240). The elongated *stigmata* are developed (Fig. 241), located approximately at their adult position, not close to the posterior edge of the sternite.

Metasoma and telson. All five segments of the metasoma are present, but their proportions are considerably different than those found in post-embryonic stages. Typical of adult *Iurus*, we see that the metasomal segments are the widest basally on segment I and then narrowing successively through segments II–V. However, the segments of the embryo do not exhibit the successive lengthening as in post-embryonic stages; on the contrary, segment I in the embryo is by far the longest, II is longer than III, and so forth. Slight indications of dorsal carinae are visible on segments III–V, presented as wide longitudinal raised areas on the segment surface (Fig. 238). Large setae are present on metasoma (Fig. 242). The telson is present, formed as a short triangular-shaped segment with a blunt tip. There is no indication of a vesicle-aculeus juncture or a formed aculeus, although setae are definitely visible (Fig. 243).

Pedipalps. All five segments, as well as the chelal movable finger, are developed in the embryo (Fig. 235). The relative proportions of these segments are not abnormally different from post-embryonic stage, as seen in the metasoma. However, carinae are not developed, and finger dentition is not present. *No trichobothria* are found on any of examined aspects of all three pedipalp segments (confirmed by SEM imaging of five embryos). Definitely socketed, large setae (but *not* trichobothria) are present on the fixed finger. Farley (2005, for *Centruroides vittatus*) commented on the fact that trichobothria and other sensory organs appear *en masse* after the first ecdysis (molt) to the second instar.

An interesting find is a somewhat well-developed *constellation array* (Fet et al., 2006), which is easily recognizable, with as many as five of its characteristic sensilla visible (Figs. 244–245). The adult *Iurus dufoureius* has six sensilla (see Fig. 21). This is the first time that the *constellation array* is documented for an embryonic stage.

Figure 235: Embryo of *Iurus dufoureius*, Kalivia Sohas, Mystras, Greece. **Top**. Embryo, ventral view, showing typical "fetal position", metasoma, legs, and pedipalps folded tightly against the mesosoma. **Bottom**. Close-up, ventral view, showing chelicerae, pedipalps, and legs.

Figure 236: Embryo of *Iurus dufoureius*, Kalivia Sohas, Mystras, Greece. **Top**. Close-up, ventral view, showing pectines, basal piece, genital operculum, and an enlarged sternum. At the top, coxosternal lobes appear as protruding plugs (some leg portions were removed for this picture). **Bottom**. Close-up, chelicerae and anterior edge of carapace showing darkened eye tubercles. Three lateral eye positions are visible.

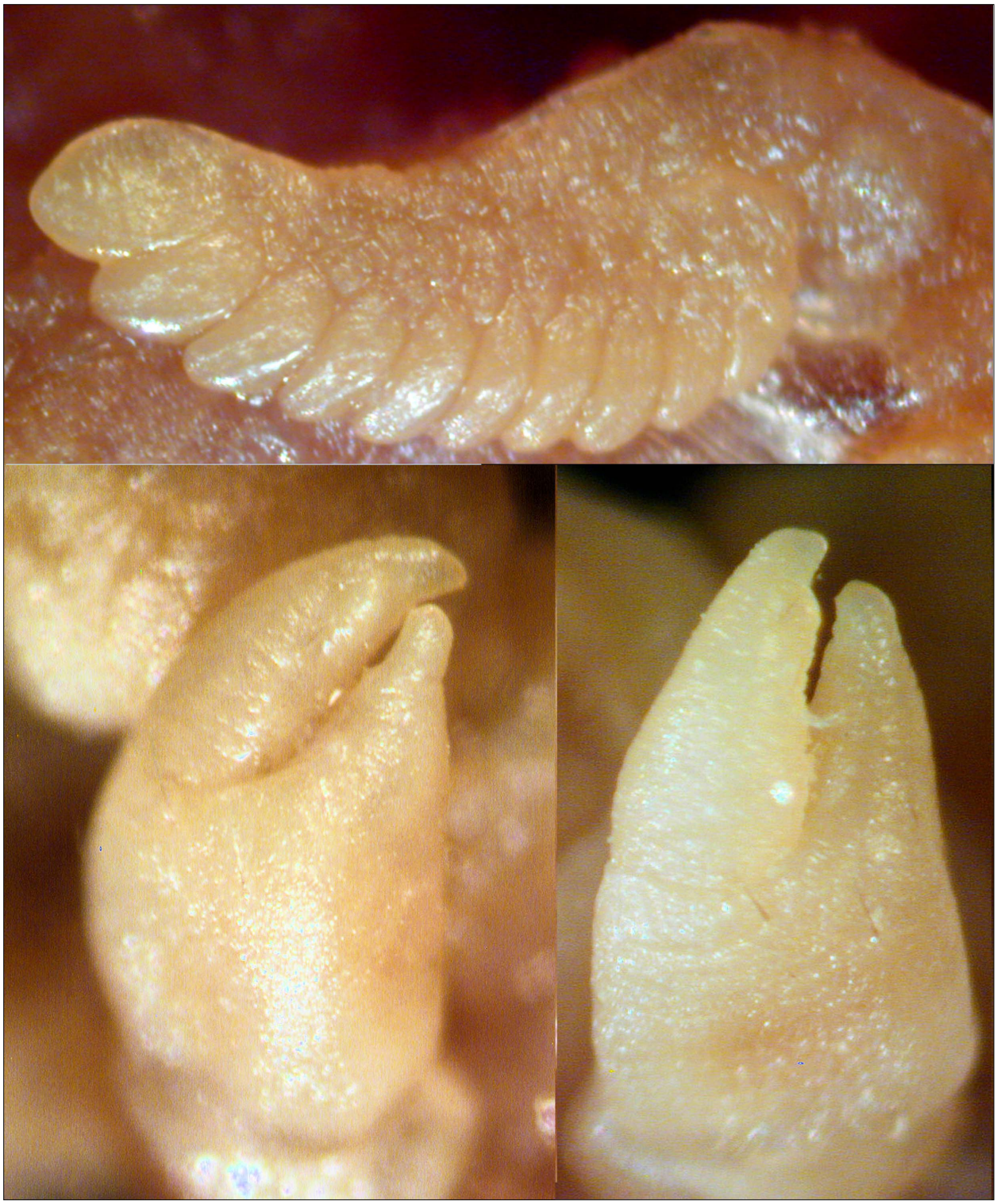

Figure 237: Embryo of *Iurus dufoureius*, Kalivia Sohas, Mystras, Greece. **Top**. Close-up, right pecten, showing anterior lamellae, fulcra, and teeth. **Bottom.** Close-up of left chelicera, dorsal view (left) and external view (right). In dorsal view, the movable finger connection to the palm is visible, and in the external view, a slight bifurcation is visible on movable finger terminus showing the initial development of the dorsal edge.

Legs. Seven of the eight segments are developed: coxa, trochanter, femur, patella, tibia, basitarsus, and a fused tarsus-epitarsus. The proportions of the leg segments are not as in adult specimens; in particular, the femur and patella are much shorter in the embryo. The characteristic *Iurus* leg spination (spinule tufts) is not

Figure 238: Embryo of *Iurus dufoureius*, Kalivia Sohas, Mystras, Greece. **Top**. Close-up of ventral view of metasoma and telson. **Middle.** Close-up of left chela, ventral view, showing connection of movable finger to palm. **Bottom.** Close-up of chelal fixed finger showing development of setae.

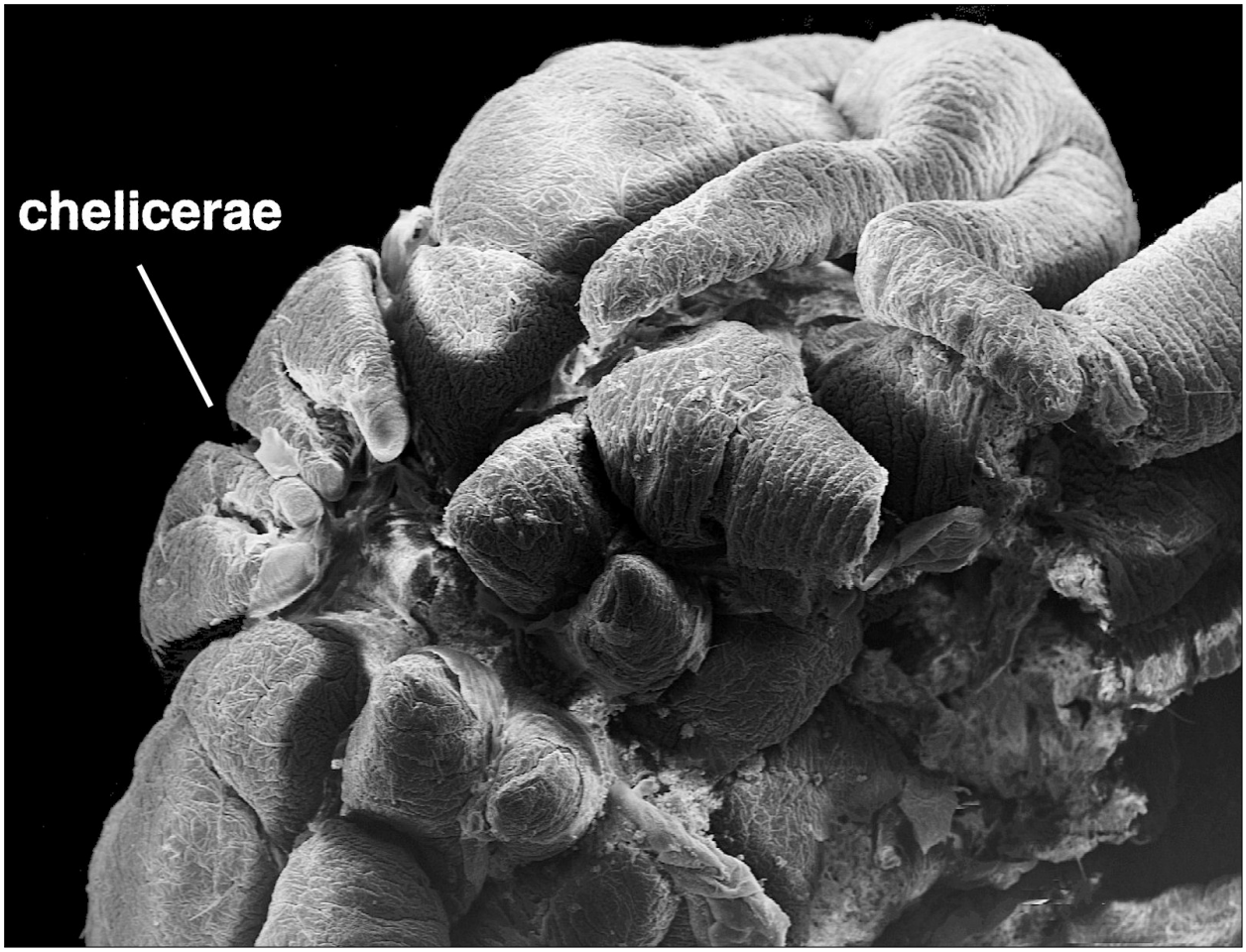

Figure 239: Embryo of *Iurus dufoureius*, Kalivia Sohas, Mystras, Greece. General ventroanterior view, coxae and chelicerae (35x).

developed in the embryo, and the fused tarsus-epitarsus does not exhibit pedal spurs, ungues or an unguicular spine (dactyl). However, strong, disproportionately long socketed setae are visible on the tarsus.

The distal aspect of the embryonic tarsus is quite interesting (Fig. 246). All surfaces are "tucked" into the tarsus tip, forming a pad-like structure, which does not become a developed distal epitarsus (= ungues + dactyl) until the first ecdysis. Millot & Vachon (1949: fig. 191) have a schematic illustration, for *Parabuthus capensis* (Buthidae), of an "adhesive organ" which newborn legs have instead of ungues, "resembling those in Thelyphonida pulli." Similar structures in other arachnids are discussed by Dunlop (2002). Farley (2005, figs. 11, 16) for the first time illustrated this structure in detail for the newborn of *Centruroides vittatus*, providing SEM micrographs. According to Farley (2005: 7), "The tip of the pronymphal leg may function like a suction cup, since pronymphs removed from the mother's dorsum are able to climb a vertical glass slide and cling to the underside of a glass slide on a microscope stage. When viewed in this position, the leg tips are somewhat spread out and pressed against the glass as though forming a seal. Second and subsequent instars with distal claws are unable to climb a vertical glass wall but usually have no difficulty with a roughened surface."

Ecology and Biogeography

Throughout the genus range, most of *Iurus* species are found from the sea level to high mountains. The highest altitudinal record for this genus (and also for the family Iuridae) is for *Iurus kraepelini*, 2130 m asl in Akdağ Mts (Muğla Province, Fethiye District; Yağmur, Koç & Akkaya, 2009). For *I. asiaticus*, the record altitude is 1600 m asl (Adana Province: Karaisalı District, Kızıldağ Plateau) (Karataş, 2001); *I. dufoureius* was found at 1200 m asl on Crete, Mt. Lefka Ori (Stathi & Mylonas, 2001). At the same time, *I. kinzelbachi* was so far found only at 84–92 m asl.

Preference of humid environment seems to be constant in all species of *Iurus*, although they seem to

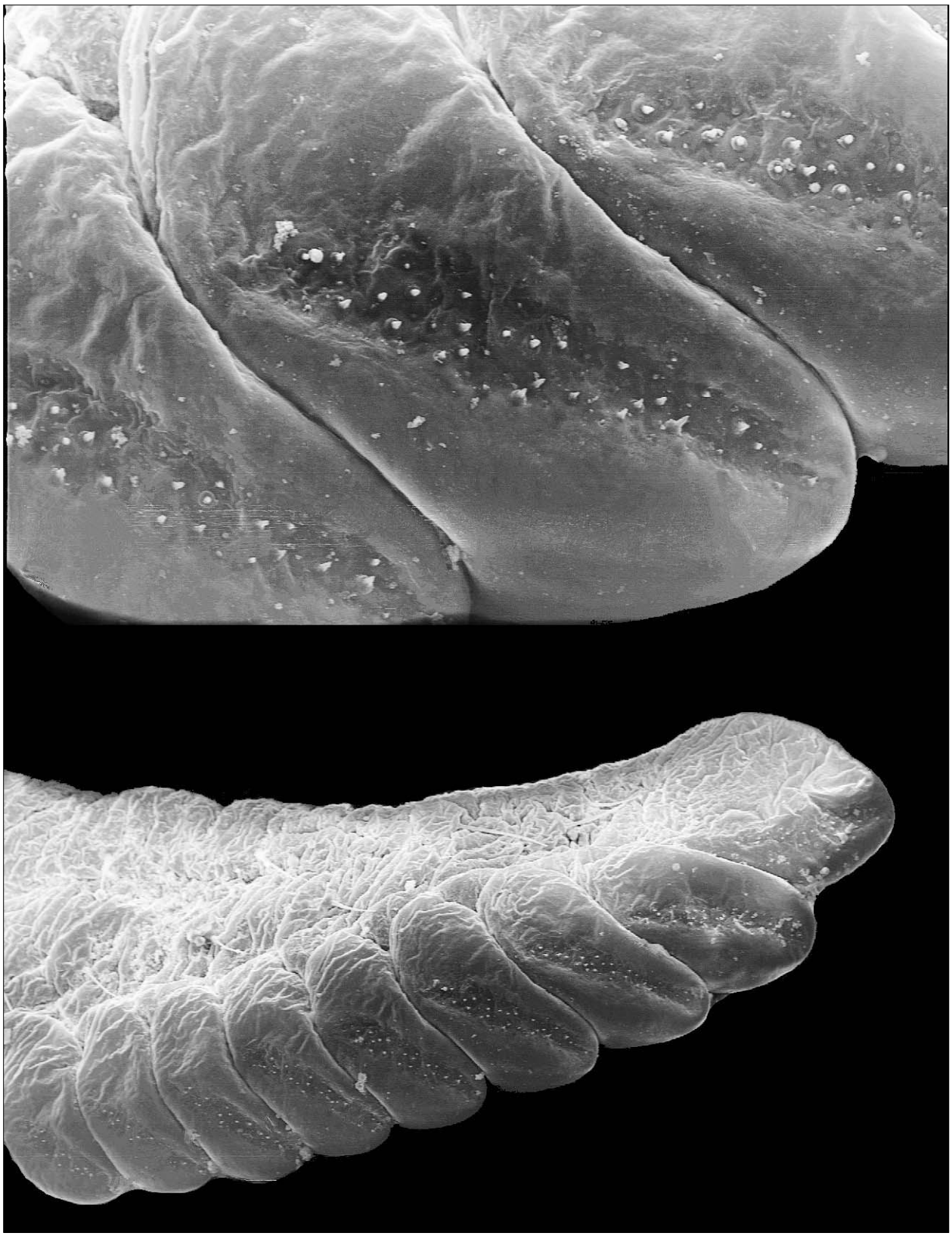

Figure 240: Embryo of *Iurus dufoureius*, Kalivia Sohas, Mystras, Greece. Left pecten, showing peg sensilla. Full view (bottom, 100x) and close-up of peg sensilla (top, 350x).

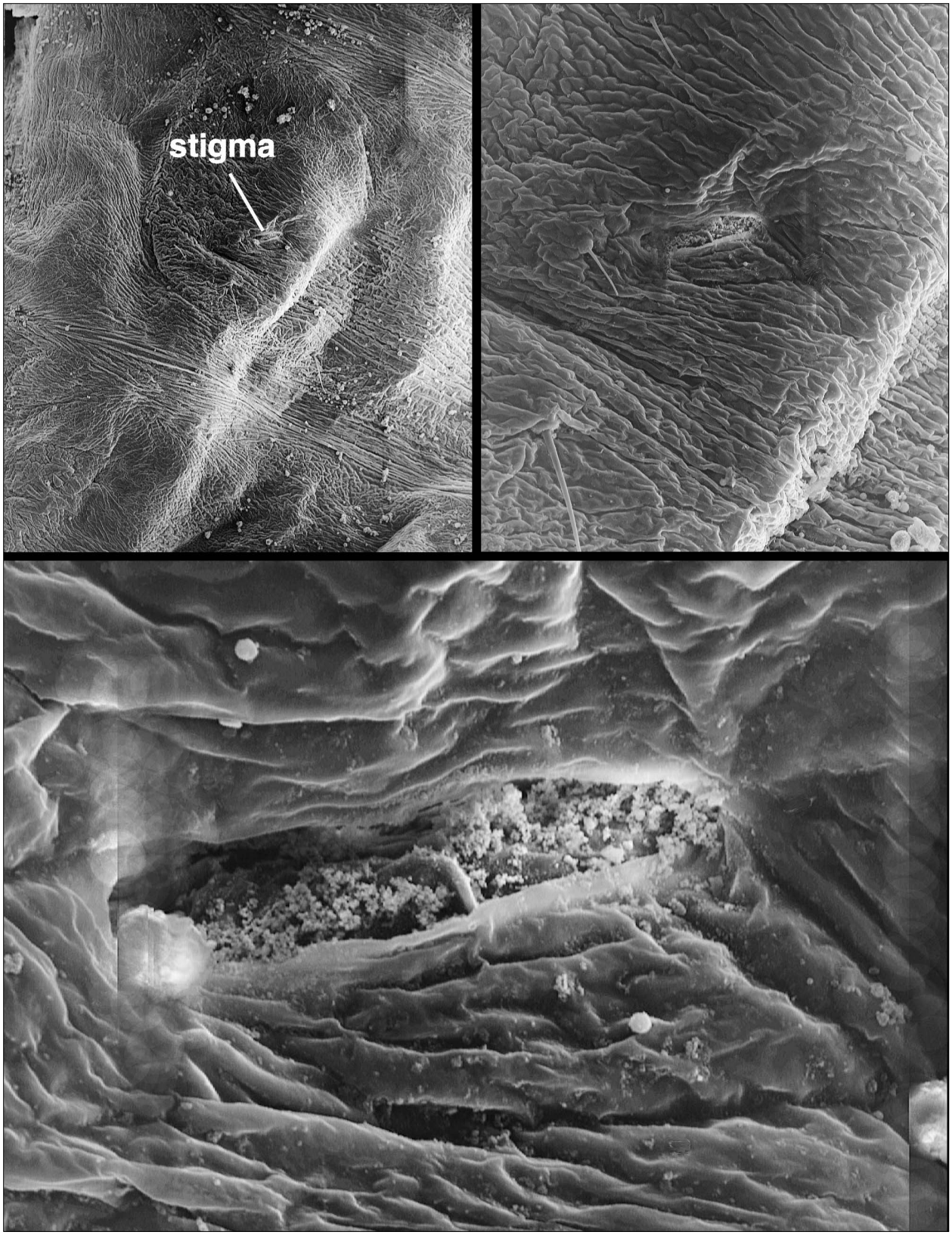

Figure 241: Embryo of *Iurus dufoureius*, Kalivia Sohas, Mystras, Greece. Right stigma IV; three successively magnified images (50x, 200x, 500x).