THE BEETLE ACROBATS

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Introduction

Beetles, Family: Coleoptera, are among the most species-rich families of animals. Because of this diversity there is likely no single basic description that would cover all the species. However, familiar beetles have a body divided in 3 obvious parts - (1) a head (Fig. 1, h) with antennae, eyes and mouthparts; (2) a thorax consisting of 3 segments, the first (Fig. 1, t1) separated by a somewhat flexible joint (Fig. 1, j) from the fused 2nd and 3rd , the three segments are obvious ventrally as each segment bears a pair of legs; (3) an abdomen of several segments but hidden, dorsally, by the large fore wings (Fig. 1, e) from thoracic segment 2 that have been modified into shields that also hide (and protect) the 2nd pair of wings, from thoracic segment 3, used in flight.

Fig. 1. A Ground Beetle, *Chalenius sericeus*, showing the basic beetle morphology.
h: head; t1: pronotum, 1st thoracic segment; j: joint between 1st and 2nd thoracic segments; e: elytra, modified fore wings

The Flea Beetles (Family: Chrysomelidae)

These small beetles are aptly named as they can 'disappear' almost instantaneously in one giant leap. The 3rd segments (femora) of the hind legs are greatly enlarged to accommodate the large jumping muscles. They are more athletes than gymnasts.

The Click Beetles (Family: Elateridae)

These are the true acrobats. They are small to large beetles with a characteristic body shape – narrowly elongate with parallel sided elytra (Fig. 2, e); hind angles of the dorsal surface of the 1st thoracic segment (pronotum) extending backwards and often pointed (Fig. 2, t1), and a very loose connection between the 1st and 2nd thoracic segments forming a flexible hinge (Fig. 2, h).

Although Click Beetles are recognizable from the dorsal surface it is the underneath (ventral) that is drastically different from other beetles.

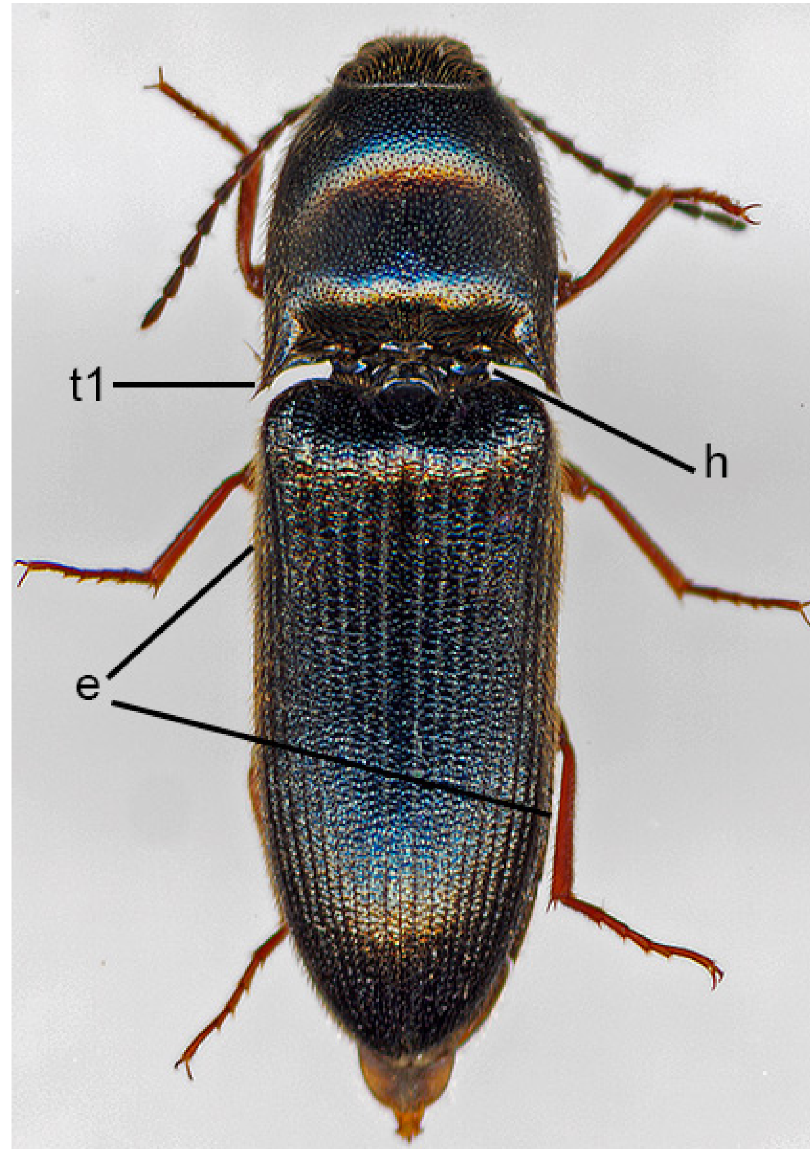

Fig. 2 . Click Beetle, dorsal view
t1: pointed hind angle of the pronotum, 1st thoracic segment;
h: flexible hinge between 1st and 2nd thoracic segments;
e: elytra, modified fore wings

The Morphology

Figure 3 shows the ventral surface of a click beetle from the back of the head to close to the end of the 2nd thoracic segment.

It is this part of the Click Beetle morphology that is modified to allow the beetle to perform its acrobatic stunts.

The basic beetle parts are labeled.:
a- antenna
e – eye
t1 – 1st thoracic segment
t2 – 2nd thoracic segment

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Figure 4, next page, is a close up of the parts involved in the jumping behaviour

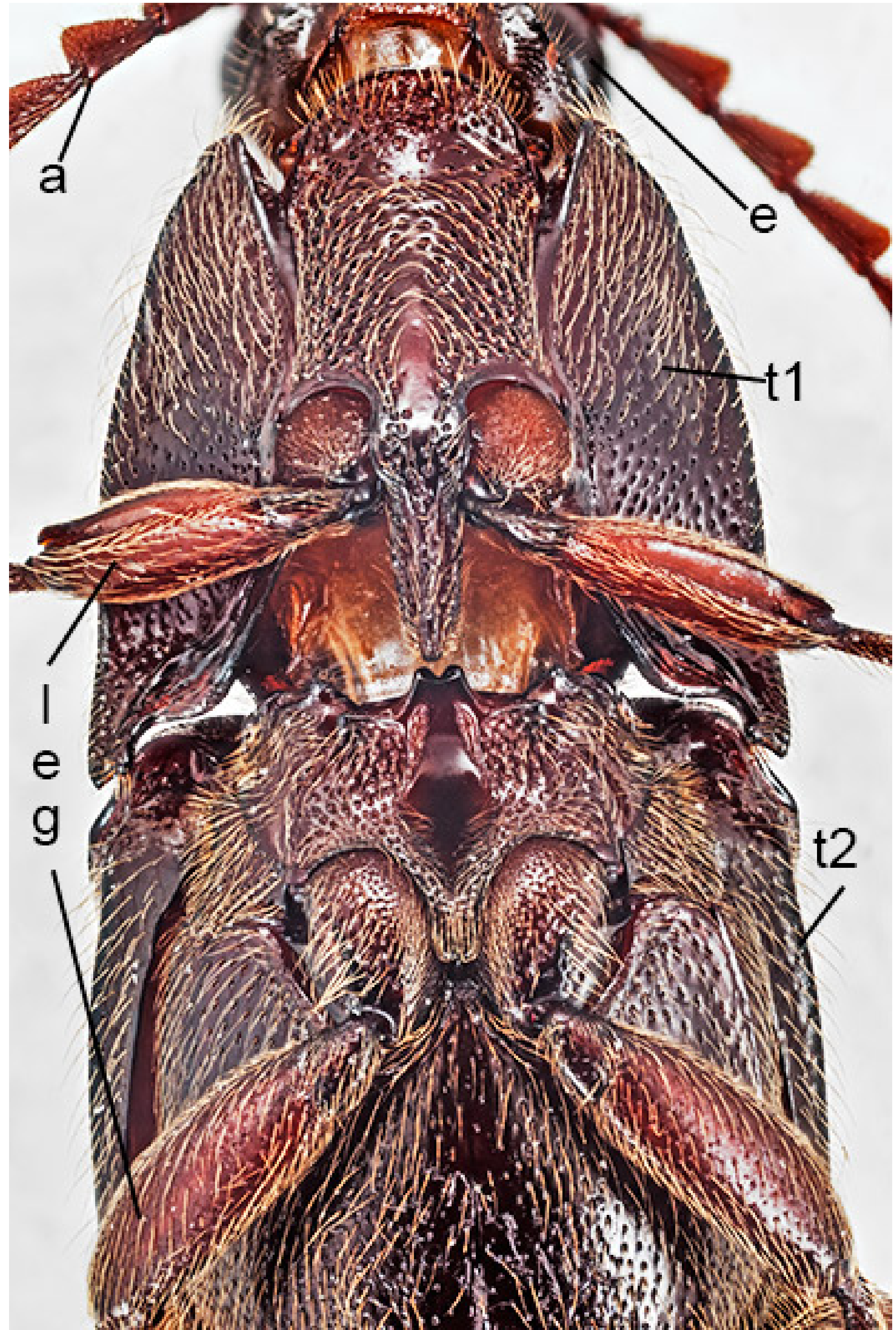

Fig. 3. Ventral view of thorax of click beetle

Figure 4, a close up of the parts involved in the jumping behaviour.

Figure 5, next page, is a lateral view of these parts.

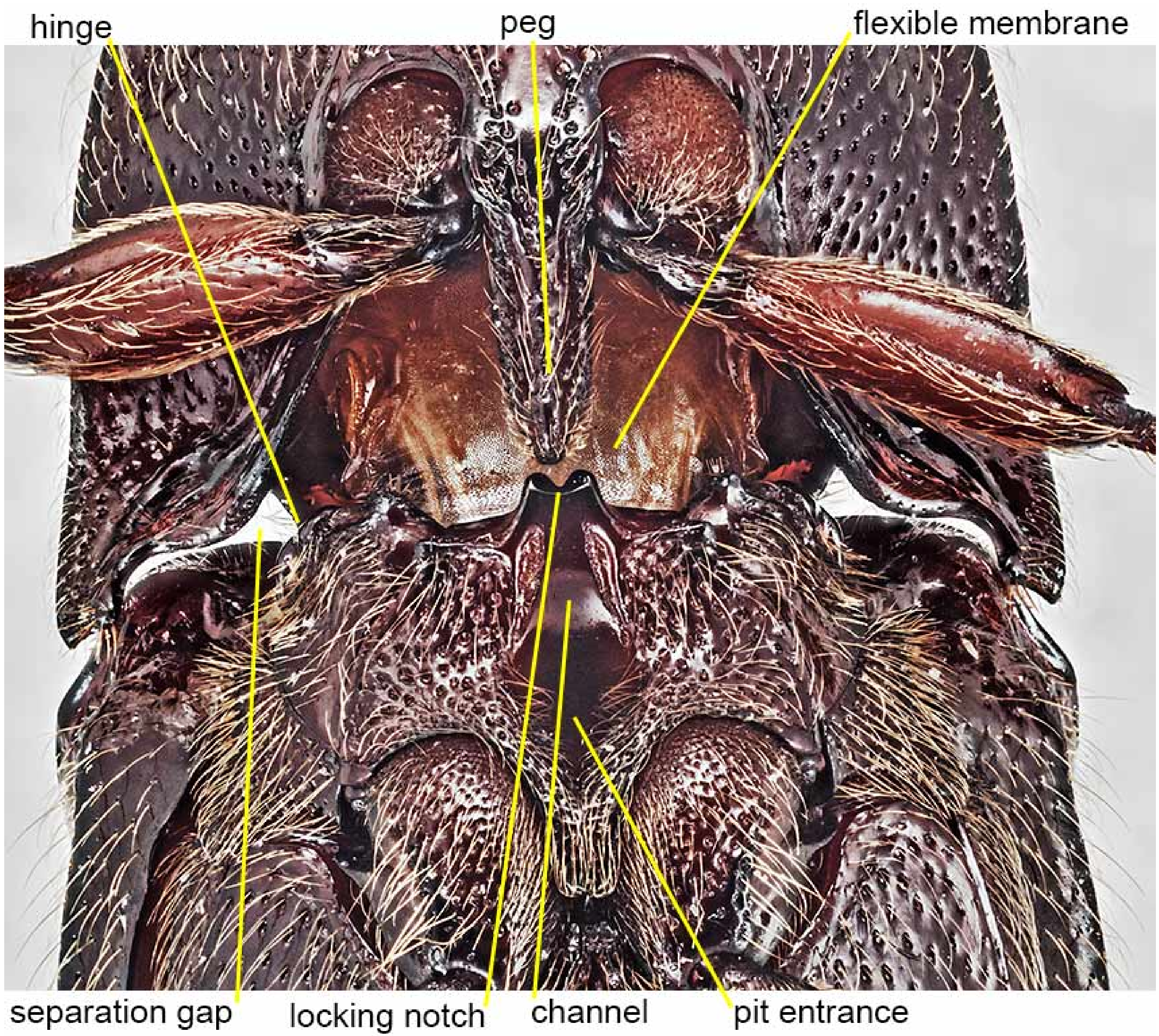

Fig. 4. Ventral

Figure 5 is a lateral view of the 1st and 2nd thoracic segments showing the parts involved in jumping.

Compare with Figure 4 previous page.

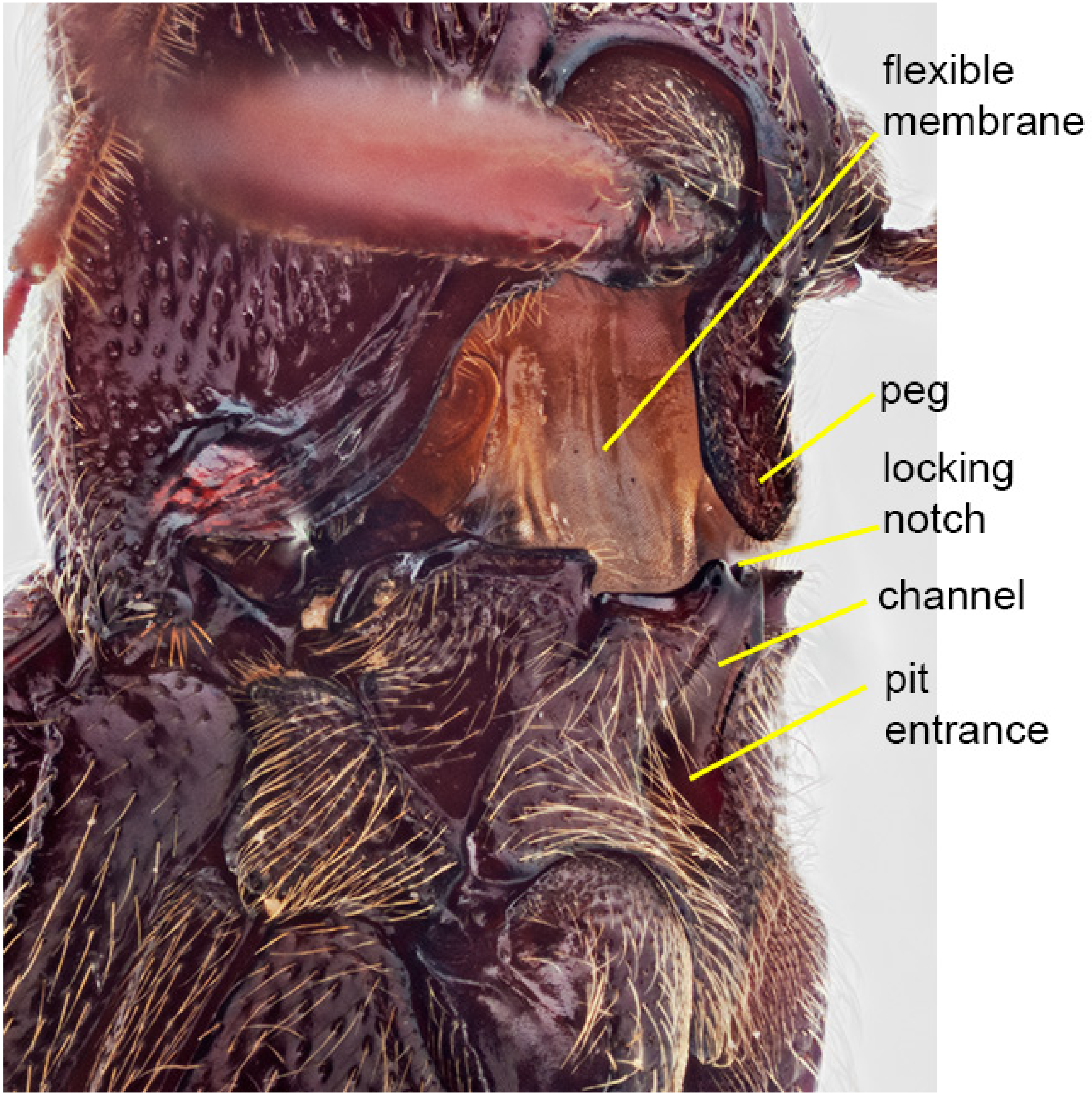

Fig. 5. Lateral view of thorax showing parts involved in jumping

Figure 6 is a ventral view in the vicinity of the connection between the 1st and 2nd thoracic segments.

The body of the beetle has been inclined at an angle of 45 degrees to allow the lens to look directly into the pit. The peg is hiding the channel that guides it into the pit.

Figure 7 shows the orientation of the beetle for Figure 5 image.

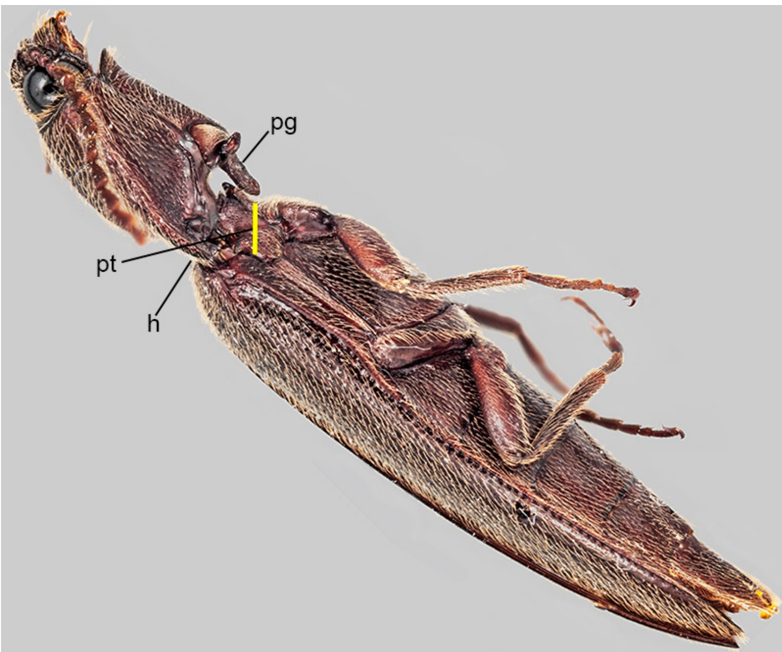

Fig. 7. Beetle orientation for Figure 5.
h - hinge between thoracic 1 and 2;
yellow line shows angle and depth of pit.
See also Fig. 8 (next page).

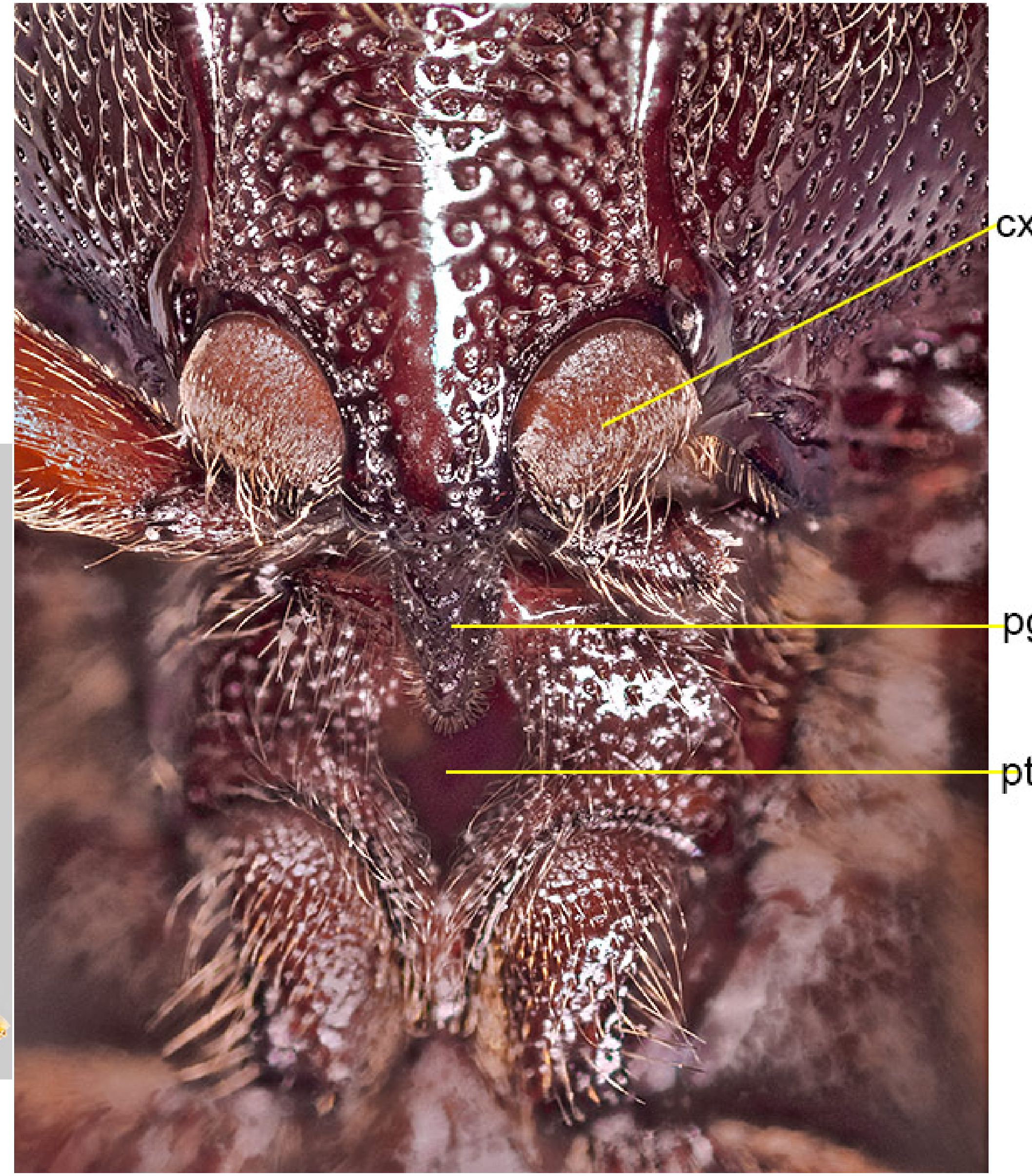

Fig. 6. A 45 degree angle view to show the deep pit: basal segment (coxa) of leg 1; pg peg; pt pit.

This pit slopes upwards and backwards at a 45 degree angle into the thorax (Fig. 8, pt). The peg (Fig. 8, pg) slides into the pit. The gap (Fig. 8, h) is the hinge area where the 1st thoracic segment flexes against the 2nd.
(note: front left leg removed so as to see the peg, cx (coxa) is the 1st joint of that leg).

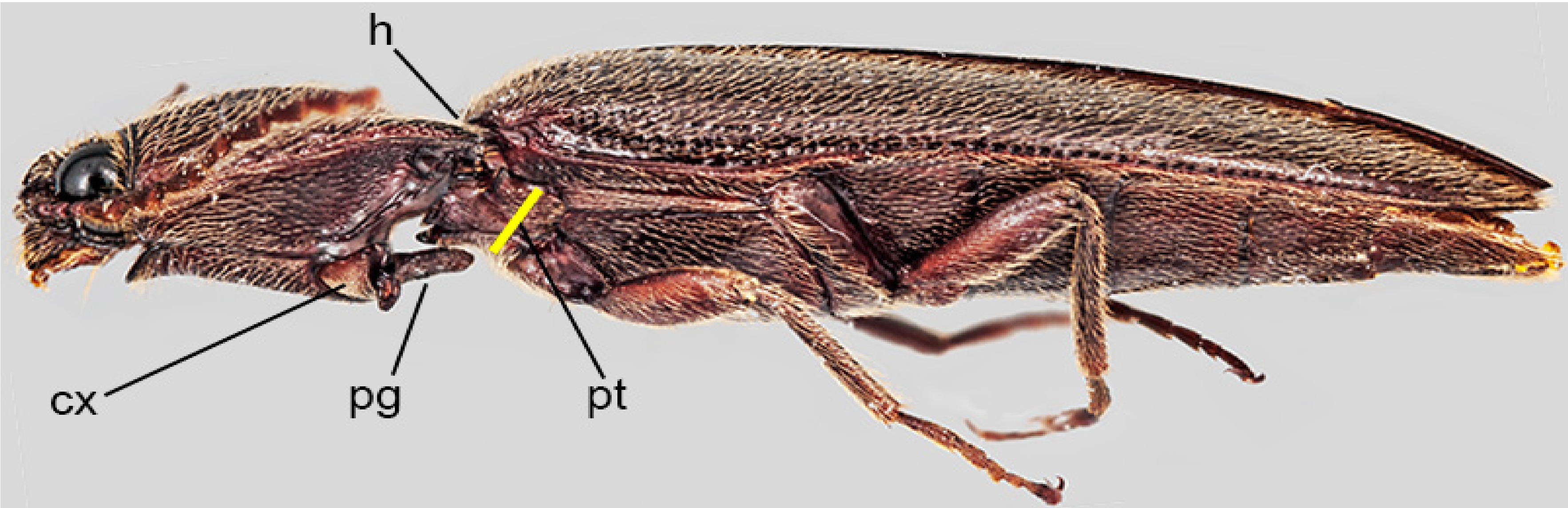

Fig. 8. Lateral view of beetle indicating the position and 45 degree angle of the pit originating on the ventral surface of the 2nd thoracic segment.
h – hinge area; cx – base segment (coxa) of 2nd left leg (leg removed); pg – peg; pt – pit position

The Jump

The loosely joined 1st and 2nd thoracic segments, the relatively large gap between them, the flexible membrane, the peg and socket apparatus, and the internal musculature , somehow all work together to give the beetle the unique ability, when lying on its back, to jump and inch or more vertically and perform one or more somersaults to land on its feet ready for a quick escape.

Despite reading several accounts and actually watching beetles perform this acrobatic stunt I am still unclear how it is actually achieved. A description can be found here:
http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3116849/

What follows is my understanding of the process; IT MAY BE INCORRECT.
When first lying on its back the beetle has contact with a flat surface at just 2 places: the top of the pronotum of the 1st thoracic segment (Fig 9, p) and the convex surface of the elytra opposite the 2nd and 3rd legs (Fig. 9, e). The peg (Fig. 9, pg) extending from the true ventral surface but now in a dorsal position is just above the channel in the 2nd thoracic segment (Fig. 9, c).

This is the initial upside-down position.

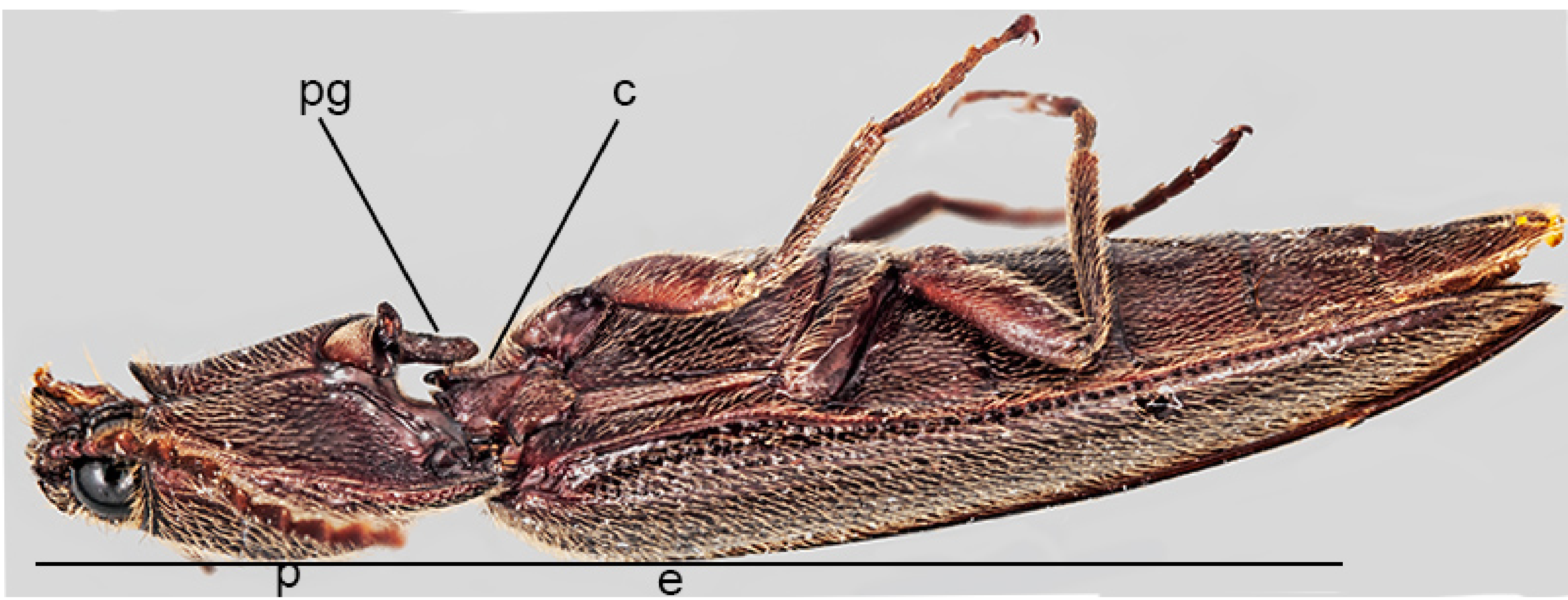

Fig. 9. A click beetle in the initial upside-down position, left front leg removed to show the prothoracic peg (pg). "p" (pronotum) and "e" (elytra) show the 2 points where the beetle contacts a surface.

The beetle changes the orientation of the 1st and 2nd thoracic segments, by muscle action in the thorax and enabled by the very flexible joint between the 1st and 2nd thoracic segments. This results in the centers of contact with the substrate changing significantly from the "initial upside-down position" (Fig. 10a) to the "pre-jump position" (Fig. 10b). Another consequence of this re-orientation is that the peg now comes to rest in the notch of the 2nd thoracic segment.

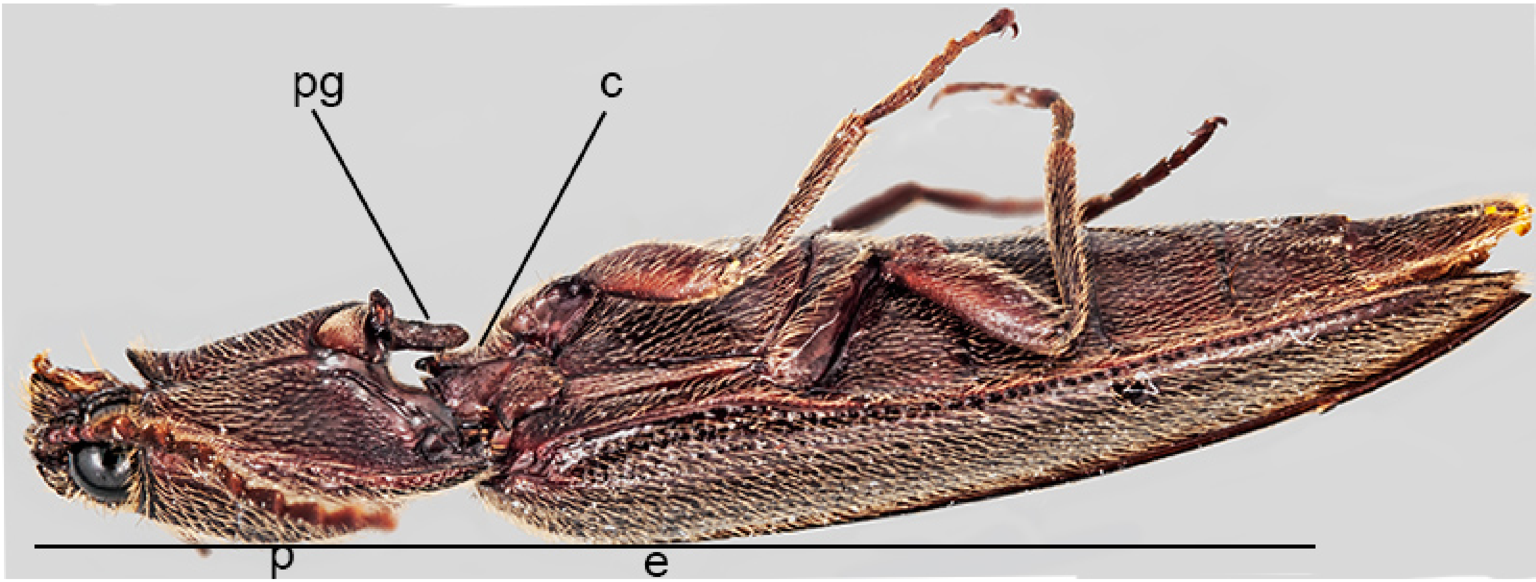

Fig. 10a. Beetle in the initial upside-down position


Fig. 10b. Beetle in the pre-jump position

Figure 11 is a close up of the connection between the peg and the notch in the “pre-jump” position.

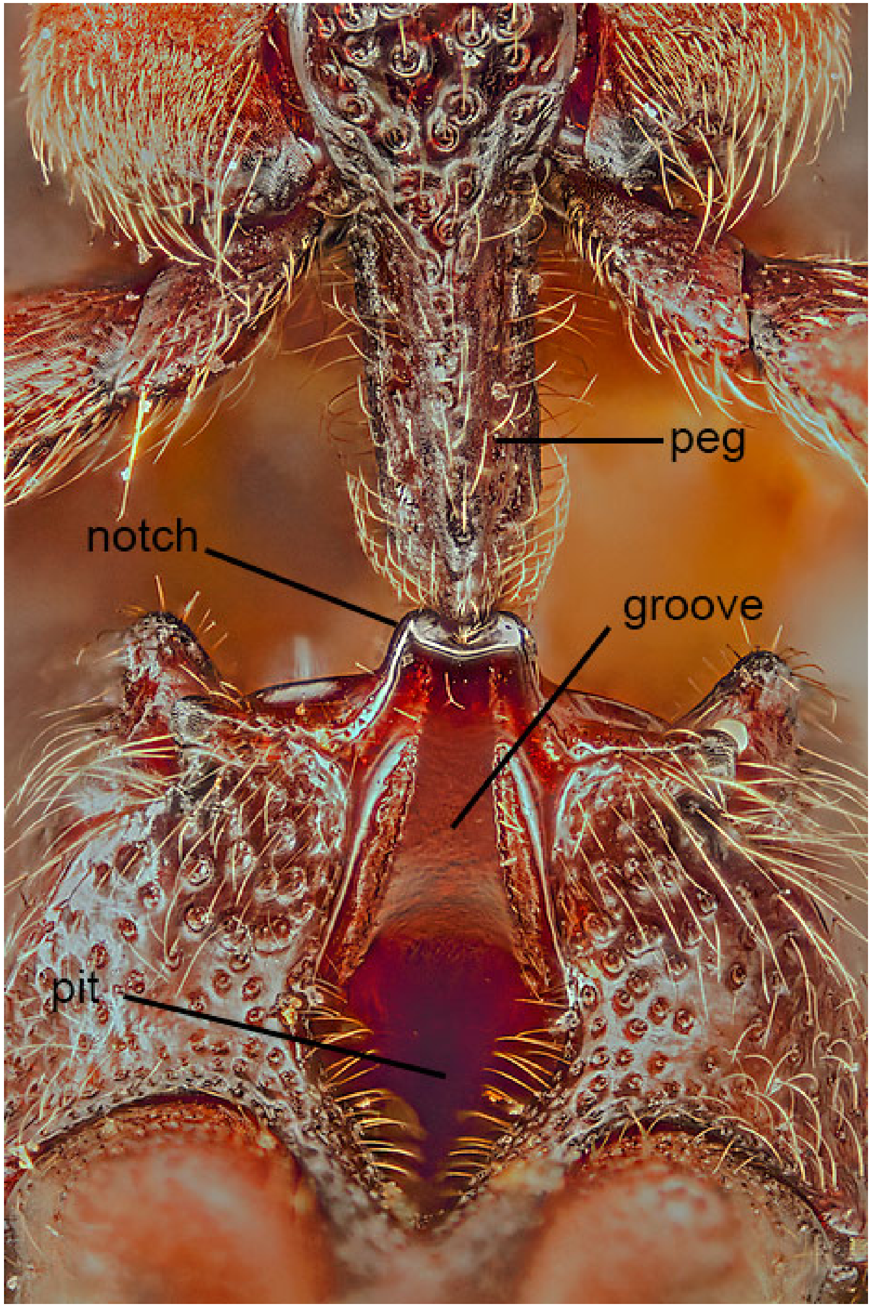

Fig. 11. Close up of the peg and notch when beetle is in the “pre-jump” position

Somehow the beetle releases the lock between the peg and the notch and the peg (Fig. 12, peg) slides into the groove in less than 1 ms. This sliding peg and its contact with the bottom of the pit is what causes the audible "click". The release of the energy and the sliding of the peg results in the flexing of the body at the hinge (Fig. 12, hinge) between the 1st and 2nd thoracic segments into the position shown in Fig. 12. The immediate result is the beetle being projected upwards and rotated around its longitudinal axis. Gravity takes over and the beetle falls to the ground with a 50:50 probability of it landing on its feet.

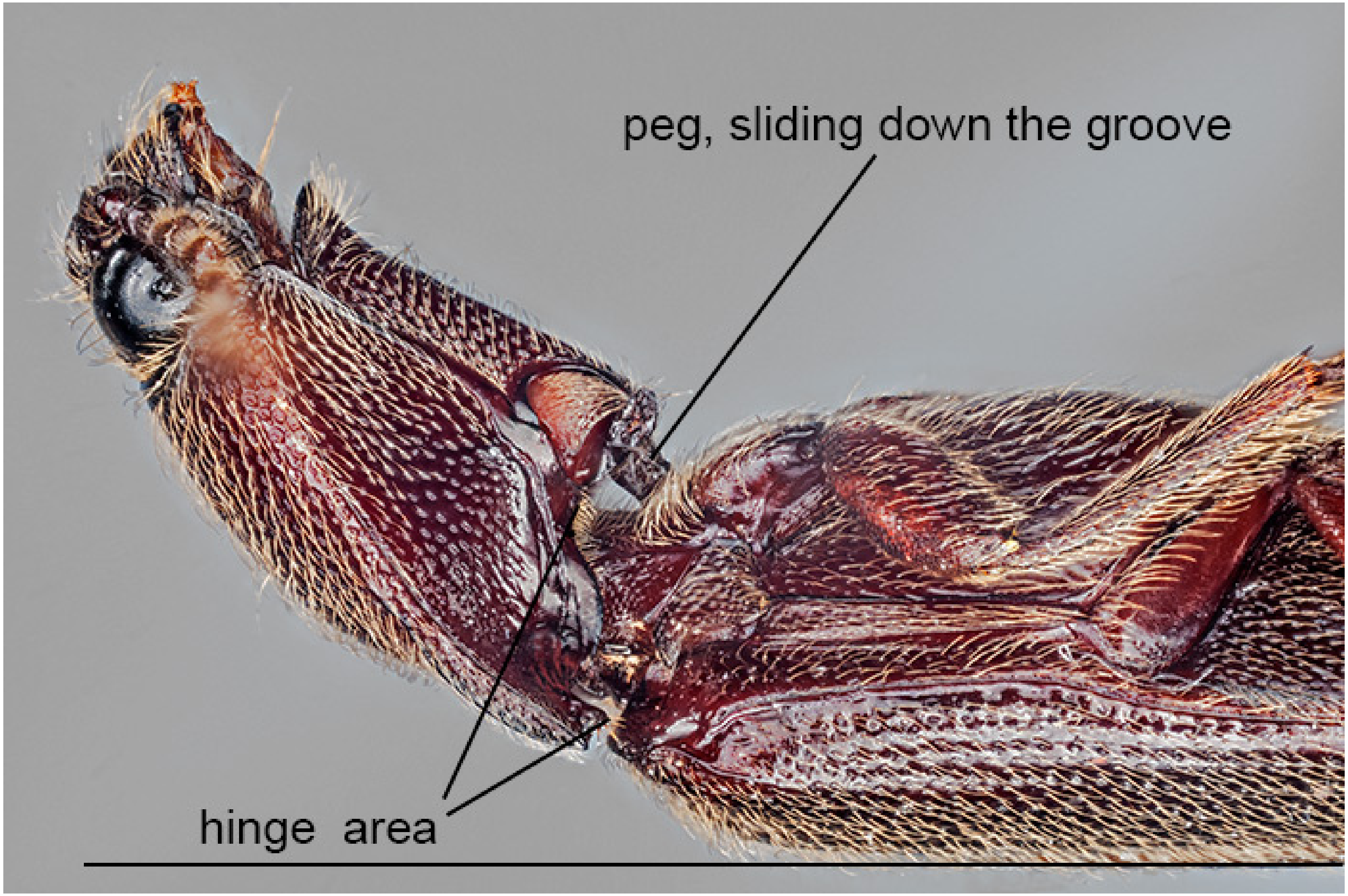

Fig. 12. Beetle in flexed position at the instant of being projected upward.

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