Simplified Field Key to Identify Larvae of Some Rhinoceros Beetles and Associated Scarabs (Coleoptera: Scarabaeoidea) in Papua New Guinea Coconut Developments

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ABSTRACT In Papua New Guinea, Coleoptera associated with coconuts share or have similar larval breeding sites, which has led to some confusion with their identity. Conclusive identification of these larvae is important before deciding whether it is possible to use biological control measures against them. The available keys are complex and do not take into account simple observable characters that can be used in the field with live specimens. Specimens of the following species were examined: *Xylotrupes gideon* (L.), *Trichogomphus vicinus* Dechambre, *Oryctoderus latitarsis* Boisduval, *Oryctes centaurus* Sternberg, *Oryctes rhinoceros* (L.), *Scapanes australis* Boisduval (Coleoptera, Scarabaeidae, Dynastinae), *Dermolepida* sp. (Coleoptera, Scarabaeidae, Melolonthinae), Cetoniinae (Coleoptera, Scarabaeidae) and Lucanidae (Coleoptera Scarabaeoidea). A simple key to distinguish 2 important pest species, *O. rhinoceros* and *S. australis*, from allied Coleoptera directly in the field is presented, together with drawings and photographs to illustrate distinctive features to assist in using the key. The identifications presented in the paper were checked against existing taxonomic keys.

KEY WORDS Scarabaeoidea, third instar, identification key

A NUMBER OF beetles in the subfamily Dynastinae, commonly known as rhinoceros beetles, attack coconut palms throughout the world. *Scapanes australis* Boisduval, the Melanesian rhinoceros beetle, and *Oryctes rhinoceros* (L.), the Asiatic rhinoceros beetle, are the worst pests of coconut palms in Papua New Guinea and are particularly damaging during the first 10 yr after planting. These insects are common on the island regions of Papua New Guinea (East New Britain Province, New Ireland), where severe damage is continualy observed that reduces yield and prevents coconut rehabilitation. In either case, if attacks by the rhinoceros beetles are associated with damage by *Rhynchophorus bilineatus* Montrouzier (Coleoptera: Curculionidae), the death of the palm typically results. Search for the biological control of these pests was undertaken on the mainland of Papua New Guinea, where the level of *S. australis* damage is quite low, and also in East New Britain, a badly affected area. The purpose was to identify pathogenic agents found in the field and to establish or confirm the range of breeding sites. To collect this information, a means of identifying larvae of the pest species among other white larvae in the same or similar habitat was required.

Although the adult beetles are quite distinct, larvae of several different species were difficult to separate during field collection using existing taxonomic keys. Confusion could easily occur between at least 9 different white larvae belonging to the superfamily of Scarabaeoidea, which occupy similar feeding habitats (i.e., organic matter and decaying wood). The different larvae were identified as *S. australis*, *O. rhinoceros*, *Oryctes centaurus* Sternberg, *Xylotrupes gideon* (L.), *Trichogomphus vicinus* Dechambre, *Oryctoderus latitarsis* Boisduval (Coleoptera, Scarabaeidae, Dynastinae), *Dermolepida* sp. (Coleoptera, Scarabaeidae, Melolonthinae), Cetoniinae (Coleoptera, Scarabaeidae) and Lucanidae (Coleoptera, Scarabaeoidea).

The 1st 6 species are considered either as pests of coconut or associated with or occasionally attacking coconuts. These whitish larvae of all 9 species are known as curl grubs, typical of the family Scarabaeidae (Hurpin 1961, Ritcher 1966, Goddyer 1977, Waterhouse and Norris 1987).

During the past 30 yr, a number of scientific articles have been published to separate the larvae to family, subfamily, and genus (Ritcher 1966). Important taxonomic works based on chaetotaxy have been published to distinguish 6 of these Dynastinae species (Bedford 1974). However, these keys are difficult to use by inexperienced taxonomists and are not useful for field identification.

The crawling habit of some larvae had been observed by Hurpin (1961). The size of the larva and the head capsule aspect as punctuation was mentioned (O'Connor 1953, Hurpin and Fresneau 1970). Other

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morphological characters, such as the lateral sclerite on the 1st thoracic segment, were used to separate *Oryctes elegans* Prell from O. *rhinoceros*, *O. monoceros* Olivier, and *O. nasicornis* (L.) (Hurpin and Fresneau 1969 1970).

The current article contains descriptions of the 9 common Scarabaeoidea species found during extensive field surveys, and illustrations and drawings for the 3rd instar, which can be distinguished from live specimens by use of a hand lens in the field. This key does not work for the identification of dead or diseased larvae, which can be confirmed using Bedford's key (1974).

Materials and Methods

Field studies were carried out on the mainland of Papua New Guinea during 1996 and 1997 and in East New Britain Province between 1992 and 1997. On the mainland, surveys were carried out in Madang Province, including Karkar island, and East Sepik Province. In East New Britain, several areas including Kerevat and Sigute sites on the Gazelle peninsula were surveyed. Inspections were undertaken around cocoa and coconut plantations and inside the forest areas, where felled trees, decaying logs, rotten wood, and piles of organic matter are commonly found to contain Scarab larvae.

Third instars were hand-collected from the medium found in their feeding habitat. The mean of duration of the 3rd instar is much longer than the 1st or 2nd instar (Bedford 1976) and is more common in the field. The 3rd instar can be recognized by the size of the head capsule. In an attempt to separate and identify the larvae, we first eliminated all those that were not curled. If the specimen in question was a curled larva with 3 pairs of well-developed legs, white or creamy white, soft bodied, with hard, black, brown, yellowish brown, or reddish brown head capsule, and strong biting mouthparts, we interpreted it as belonging to the superfamily Scarabaeoidea.

In ambient laboratory conditions (28–30°C, 60–70% RH, natural photoperiod), a sample of 156 field-collected larvae was placed inside 5 different 15-liter plastic buckets with their respective organic feeding medium. The live immature stages were studied, and the dead specimens were used for confirmation of identification after additional observation and dissection.

At the time of collection and in the laboratory, the behavior of live larvae and their general aspect (e.g., color and hairiness) were observed by placing larvae of different species on flat ground to observe their movement.

Larvae were initially grouped according to their behavior, and from each group, 2 specimens were sampled to confirm their identity. Selected specimens were placed alive in KAA fixative and left for 12 h. Subsequently, they were stored in 80% ethanol (Norris and Upon 1974).

Microscopic characters of the head and mouthparts were observed after macerating the head capsule in 10% potash for 5 min in a gentle heat until it became transparent. After cooling and dipping in alcohol, the maxillae, labium, antennae, and mandibles were removed for verification of the characters described by Ritcher (1966) and Paulian and Baraud (1982). The identities of the Dynastinae species were confirmed using Bedford's key (1974). Other live specimens were reared to imago; we preserved ecdysed skins to confirm subsequent identification with existing keys.

Fig. 1. Cetoniinae. Third instar crawling on its back.

Results and Discussion

Observations on a sample of 156 mixed live larvae placed on a flat surface, either in the field or in the laboratory, clearly separated them into 3 types of crawling movement.

In the 1st group, 20 larvae moved on their dorsal surface (Fig. 1). In the 2nd group, 36 larvae progressed rapidly on their ventral surface using their legs (Fig. 2). In the 3rd group, 100 larvae remained still or moved only very slowly on their side (Figs. 3a–5).

The 1st group movement was recorded for the Cetoniinae (Hurpin 1961, Ritcher 1966). This character is sufficient to determine that this scarab does not belong to the subfamily Dynastinae. The larval head capsule, venter, and dorsum of the last abdominal

Fig. 2. *X. gideon.* Third instar crawling on its ventral side using the 3 pairs of legs.

Fig. 3. *T. vicinus.* (a) 3rd instar crawling on its side; (b) head capsule.

segment bear characters not easily observed directly in the field.

For the 2nd group of 36 larvae which proceeded to uncurl and walk rapidly on their ventral surface, using their 3 pairs of legs, 2 types could be easily separated. The 1st, and more abundant in the habitats studied, were covered in red hairs with a brown head capsule ($n = 6$) (Fig. 2), whereas the 2nd type shows a brown head capsule but did not have such distinctive body

Fig. 4. *O. rhinoceros.* Anal segment, dorsal surface. r, ring.

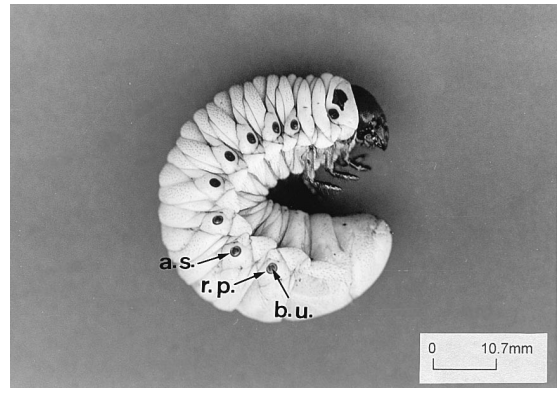

Fig. 5. *O. centaurus.* Third instar crawling on its side. a.s., abdominal spiracles; bu., bulla.; r.p., respiratory plate.

chaetotaxy ($n = 30$). The red hairs were previously recorded as being distinctive for *X. gideon* larvae (Bedford 1974, Morin 1991). Additional confirmation of *Xylotrupes* identity can be determined by counting the 13–32 long red setae on the 1st thoracic sclerite with the aid of a pocket lens or under a low-power microscope (Fig. 6a). The 30 other specimens in this group revealed only 1–2 medium-length setae plus 1–4 short setae (Fig. 6b) and were subsequently identified as *O. latitarsis.*

The larger remaining group of 100 larvae which moved only on their side did not have such clearly distinctive characters to further differentiate them. However, closer examination did enable the use of other reliable characters that form the basis of this field key.

Without the use of a hand lens, the larvae with a shiny black head capsule, observed in 5 specimens (Fig. 3b), could be separated from the rest. These specimens, with the use of a hand lens or binocular microscope, can be confirmed as *T. vicinus* if they have 2 long setae on the 1st thoracic sclerite (Fig. 6c).

Of the remaining specimens, a further distinctive feature is the presence (3 specimens) or absence (92 specimens) of an impressed line around the last abdominal segment (Fig. 4). Its presence, in conjunction with the larval movement on its side, is sufficient to identify *O. rhinoceros* specimens in the field. Bedford (1974) used this character in his taxonomic key. Additional characters are the 3–8 medium-length setae on the 1st thoracic sclerite, shorter than the width of the sclerite (Fig. 6d).

It is important to note that *O. rhinoceros* does not occur on the mainland of Papua New Guinea but only on the off-shore islands of the Bismarck Archipelago.

Among the remaining 32 specimens, apart from the head capsule being orange in color, a distinctive ventral transverse anal slit on the last abdominal segment (called raster) was observed in 7 specimens which were identified as Melolonthinae belonging to *Dermolepida* sp. The remaining 25 larvae with a distinctive Y-shaped anal opening were identified as belonging to the Lucanidae family.

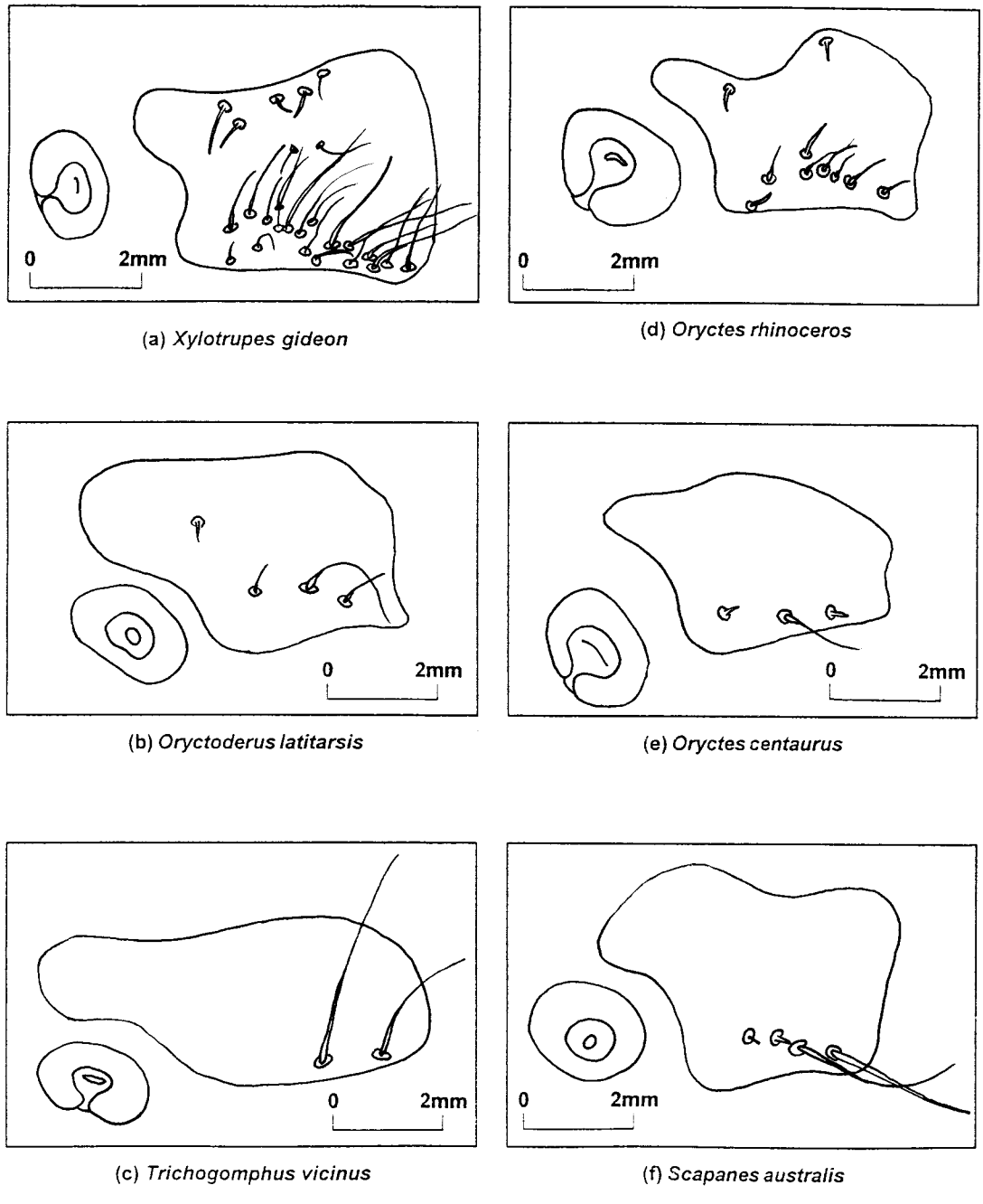

Fig. 6. First thoracic sclerite. (a) *X. gideon;* (b) *O. latitarsis;* (c) *T. vicinus;* (d) *O. rhinoceros;* (e) *O. centaurus;* (f) *S. australis.*

The 60 larvae with a brown head capsule and none of the distinctive characters described above required identification. These larvae had characters which required the use of a hand lens and a low-power binocular microscope to confirm their identity. Fifty specimens had a longitudinal depressed line on the

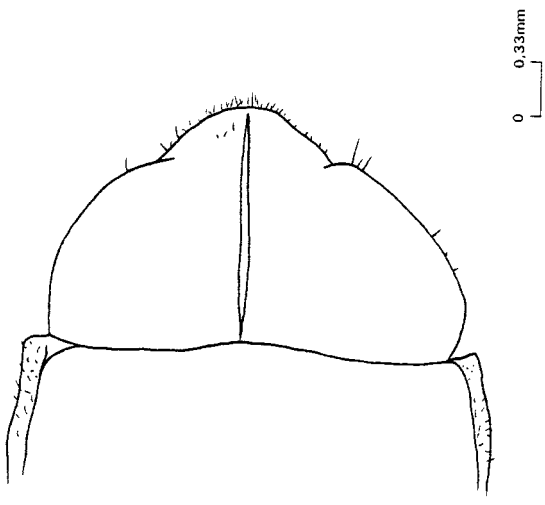

Fig. 7. *O. centaurus.* Longitudinal depressed line on dorsum of last abdominal segment.

dorsal surface of the last adominal segment which was absent on the 10 other specimens (Fig. 7). This line, combined with the slightly oval abdominal spiracles with a well-differentiated bulla (Fig. 5) and 1 prominent seta, longer than the width of the sclerite, plus 1 or 2 min setae (Fig. 6e), identified these 50 specimens as *O. centaurus.* Confirmation was obtained by rearing larvae through to the adult stage. This type of larva is found only on the mainland of Papua New Guinea.

The last 10 unidentified larvae in the collection have round abdominal spiracles, 2 prominent setae on the 1st thoracic sclerite, longer than the width of the sclerite, and 2 minute setae or empty setal sockets (Fig. 6f). There is no longitudinal depressed line on the dorsal side of the last abdominal segment. Larvae with these characters are *S. australis.* Of the 4 subspecies of *S. australis* in Papua New Guinea, these characters have been confirmed for *S. australis* subspecies *australis* and *S. australis* subspecies *grossepunctatus.*

Simple Field Key to Third-Instar White Larvae of Some Scarabaeoidea

1 Live larvae, when placed on a flat surface, uncurl and move on their dorsal surface (Fig. 1) . . . . . Cetoniinae
1′ Live larvae when placed on a flat surface, uncurl and move on their ventral side (Fig. 2) 2
1″ Live larvae when placed on a flat surface, uncurl and move on their side (Fig. 3a) 3
2 (1′) 1st thoracic sclerite with 13–32 medium to long red setae; body covered with abundant red setae (Figs. 2, 6a) . . . . *Xylotrupes gideon* L.
2′ 1st thoracic sclerite with 1 long seta, 1–2 medium setae plus 1–4 very short setae; body not covered with abundant red setae (Fig. 6b) . . . . . *Oryctoderus latitarsis* Boisduval
3 (1″) Head capsule black; first thoracic sclerite with 2 long setae (Figs. 3b and 6c) . . . . . *Trichogomphus vicinus* Dechambre
3′ Head capsule brown 4
3″ Head capsule orange 6
4(3′) Distinctive ring or saddle on anal segment; first thoracic segment with 1 long seta and 3–8 medium-length setae, shorter than width of sclerite (Figs. 4, 6d) . . . . . *Oryctes rhinoceros* L.
4′ No distinctive ring or saddle on anal segment 5
5(4′) Presence of a longitudinal depressive line in middle of dorsal anal segment (Fig. 7). Abdominal spiracles slightly oval in form; bulla and respiratory plate well differentiated (Fig. 5). First thoracic sclerite with 1 prominent seta, longer than width of sclerite, plus 1 or 2 short setae (Fig. 6e) . . . . . *Oryctes centaurus* Sternberg
5′ Absence of a longitudinal depressive line in the middle of the dorsal anal segment. Abdominal spiracles round in form; bulla and respiratory plate not clearly differentiated. First thoracic sclerite with 2 prominent setae, longer than width of sclerite, plus 2 min setae or empty setal sockets (Fig. 6f) . . . . . *Scapanes australis* Boisduval
6(3″) Venter of last abdominal segment with tranverse anal slit . . . . . *Dermolepida* sp.
6′ Venter of last abdominal segment with Y-shaped anal opening . . . . . Lucanidae

The results of our observations allow the use of simple characters to identify in the field the 3rd instars larvae that are morphologically similar and occupy similar breeding sites. This key does not require the use of complicated and sophisticated identification criteria as previously published. Apart from considering the known geographic distribution of the specimens collected before determination, the 1st character to observe, using live specimens, is the crawling movement of the larvae on a flat, solid surface. Then the easily visible characters are compared as follows: (1) color of the head capsule (black in *T. vicinus*); (2) particularly distinctive chaetotaxy (*X. gideon*), (3) presence of a specific ring on the last ventral abdominal segment (*O. rhinoceros*), (4) shape of the raster *(Dermolepida* sp., Melolonthinae, and Lucanidae), and (5) characteristic spiracles and sclerite chaetotaxy to separate *O. centaurus* and *S. australis.* It is important to note that the proportions of the different species presented in this article will vary from place to place.

To consider using biological control against certain coconut rhinoceros beetle pests, the number and distribution of the immature stages must be determined. This key enables both experienced entomologists and their staff to collect and identify the species being studied for biological control and to test pathogens against other related species before any rearing and introduction in the islands region. Although this key is not useful for dead or diseased specimens, the char-

acters of living material have been successfully used by students and school children who helped with the field collection of larvae.

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