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***Eudicella trimeni* Janson, 1884 (Coleoptera: Scarabaeidae: Cetoniinae: Goliathini): Description of larva with notes on conservation status, biology and taxonomy**

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ABSTRACT

Eudicella trimeni is reportedly one of the most endangered species of the genus, having been declared virtually extinct until recently. Present research has shown that the species occurs in an area wider than previously known. However, its habitat is disappearing at a fast rate and the Eastern Cape and KwaZulu-Natal populations appear to be sufficiently different from each other to warrant at least subspecies status and further investigation. Third instar larvae of the northern population were collected recently in the Karkloof Nature Reserve, KwaZulu-Natal. They were reared to adulthood under environmentally controlled conditions and are here described.

KEY WORDS: South Africa, Goliathini, *Eudicella trimeni*, fruit chafers, scarab beetles, third instar larva, extinction, intraspecific variation.

INTRODUCTION

Eudicella trimeni is a prominent goliathine endemic to the eastern part of South Africa, specifically Eastern Cape and KwaZulu-Natal provinces, where it occurs only in a few relict rainforests. At the beginning of the 20th century, Péringuey (1907) already reported on the rarity of this species, suggesting that this may be ‘due to it being a struggler from the north’. This was, however, based on his conviction that the species was ‘identical’ to *Eudicella chloe* Raffray described earlier from the Horn of Africa. Allard (1985) noted that the species was extremely rare and ‘would no longer be found except on a few farms in Natal’. A similar assessment was provided by Holm and Marais (1992), who stated: ‘This rare species was described from Umvoti in Natal, and was long regarded as extinct. Recently it was collected in several inland forests in Natal and in the coastal forests of Transkei’.

Allard (1991) described the population from the former Transkei region of the Eastern Cape as a distinct subspecies, *E. trimeni transkeiensis*. The distinction was based on: (a) a ‘more elongated appearance’ in *E. t. transkeiensis*, compared to the nominal subspecies; (b) its ‘dark olive pronotum’; (c) the background sepia colour of the elytra, ‘with the angular dots smaller’ than in the nominal subspecies; and (d) a narrow sutural ‘band not reaching the humeral calli’ (Allard 1991). Unfortunately, his description was based on characters that are known to vary intraspecifically and was promptly dismissed by Holm and Marais (1992), who argued that the ‘slight colour variation described by Allard as a subspecies is unjustified: a long series from the Port St Johns area (recently collected by Mr P. Stobbia) contains all intermediates’. This was echoed more recently by De Palma (2009), who stated that ‘The subspecies described by Allard (“*transkeiensis*”) is a mere

colour form', despite Sakai and Nagai (1998) having earlier effectively recognised the distinction proposed by Allard in the statement 'Figured specimens from Transkei are treated as ssp. *transkeiensis* Allard 1991'.

The conflict appears largely related to the lack of sufficient study material available until recently, particularly regarding the population from the KwaZulu-Natal Midlands. New collections made during the past 12 years in this region now allow a more suitable comparison, using substantial series for both populations. During this process, third instar larvae of the KwaZulu-Natal population have also been obtained and successfully bred, thus making it possible to provide the first description of an immature stage for the species.

MATERIAL AND METHODS

Between 2001 and 2011, 18 larvae of *Eudicella trimeni* were obtained from Karkloof and six from Entumeni. Three third instar specimens from Karkloof were immediately fixed in 75% ethanol, while the others were brought back in their natural decomposing wood to the laboratory for rearing. They were kept in an environmental-control room at the University of KwaZulu-Natal at an average temperature of 22 °C (ranging from 16 °C in midwinter and gradually increased to 28 °C by midsummer) or 15 °C (ranging from 10 °C in midwinter and gradually increased to 20 °C by midsummer). Larvae were kept in 20-litre buckets filled to approximately half capacity with the original substrate. The surface layer of each bucket was sprayed with water at regular weekly intervals until pupation, but left to dry out thereafter. The success rate was about 80% in both cases, with adults emerging in good conditions over a period of about three months, from December to February.

Two larvae were studied between 10–40× of magnification using a stereo microscope. Mouthparts were dissected using a scalpel and observed under light or electron microscopes. Material for electron microscopy was critical point-dried and gold coated at Rhodes University. The terminology follows Hayes (1929), Böving (1936) and Ritcher (1966).

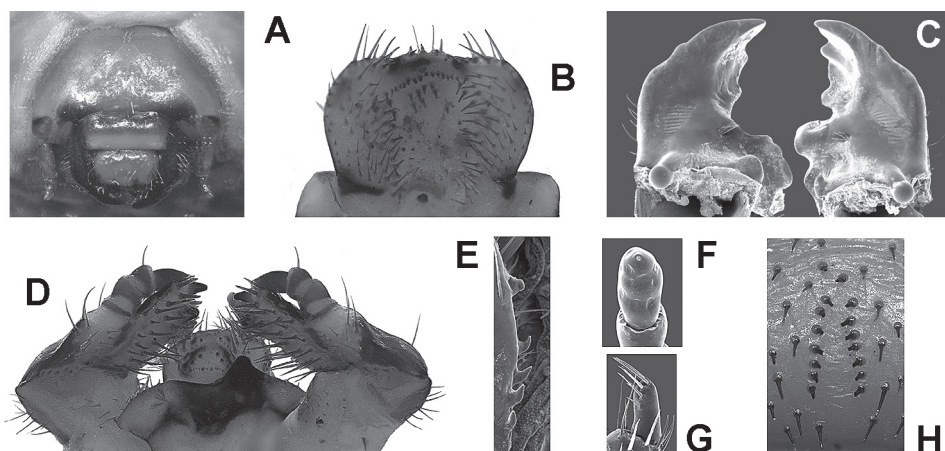


Fig. 1. Third instar larvae: (A) head, (B) epipharynx, (C) mandibles, (D) labium and maxillae, (E) stridulatory areas of mala, (F) dorsal view of last antennomere, (G) lateral view of tarsungulus, (H) raster.

Adult specimen length was measured from the tip of the clypeal horns to the apex of the pygidium. Specimen width represents the maximum width of the elytra, at the level of the humeral callus.

Material was examined from the following public and private collections:

- BMPC – Ball & Marais Private Collection, Cape Town;
- DMSA – Durban Museum of Natural Sciences, Durban;
- EPPC – Ernest Pringle Private Collection, Bedford;
- SAMC – Iziko South African Museum, Cape Town;
- PCPC – Perissinotto & Clennell Private Collection, Port Elizabeth;
- TMSA – Ditsong (formerly Transvaal) National Museum of Natural History, Pretoria.

RESULTS AND DISCUSSION

Genus *Eudicella* White, 1839
Eudicella trimeni Janson, 1884

Figs 1–4

Description of larva

Diagnosis: Including *Eudicella trimeni*, only four species in the genus have their third larval instar described. The others are: *E. aethiopica* Müller (described as *E. daphnis aethiopica*) by Lumaret (1985); *E. ducalis* Kolbe by Kühbandner and Carl (1994); and *E. morgani* White (described as *Eudicella woermanni* Kraatz, 1890), also by Kühbandner and Carl (1994). Larval characters of a fifth species, *E. tetraspilota euthalia* (Bates) were included (as *E. euthalia*) in the phylogenetic analysis of Micó *et al.* (2008) and Šípek *et al.* (2009), but the species still lacks a formal description with illustrations. *Eudicella trimeni* can be separated from the other known species of the genus on the basis of a clearly V-shaped raster. The raster of the other species described so far is never composed of regular rows of diverging palidia, but instead of irregular rows of pali. The known larval instars of *Eudicella* are difficult to separate and exhibit a high degree of similarity in the characters examined so far. For example, according to Kühbandner and Carl (1994), the only way to separate *E. morgani* from *E. ducalis* is based on the number of stridulatory teeth on the maxilla.

Description:

Third instar larva.

Head (Fig. 1A). Maximum width of head capsule 5.8–6.0 mm; cranium smooth, colour yellowish brown; frons with median longitudinal depression, single posterior frontal seta and single anterior angle seta; one round pigmented area medially at each side of frontal suture; dorsoepicranium with 2 widely separated, medium sized setae at each side; tentorial pits evident; stemmata evident; clypeus subtrapezoidal in shape, with 1 posterior clypeal seta and 1 or 2 exterior clypeal setae; preclypeus weakly sclerotized, without setae; labrum with anterior border trilobed and clithra present; epipharynx (Fig. 1B) without plegmata; corypha with 4 or 5 long stout setae; haptomeral region with cone-like process, with a curved row of 10–12 heli, 5–8 long and medium size setae irregularly placed behind row; acanthoparia with 5 or 6 small to medium setae; chaetoparia with 33–54 setae; dextortorma long, laetorma short and pternotorma small and rounded; nesia with sensorial cone; haptolachus without sensillae below cone.

Mandibles (Fig. 1C): Right mandible with 1 scissorial tooth anterior to scissorial notch and 2 scissorial teeth posterior to notch, stridulatory area elongate, narrow at base and wide at apex, length over $4\times$ its width, molar area trilobed, lateral edge with 10–12 setae, dorsal surface in apical half with 2 setae, brustia formed by 4–6 setae; left mandible with 1 scissorial tooth anterior to scissorial notch and 2 teeth posterior to notch, molar area trilobed, first lobe larger, lateral edge with 5–7 setae, dorsal surface in apical half with 2 setae, basomedian angle with brustia consisting of 3–5 setae.

Maxillae (Fig. 1D): Mala with 1 apical and 1 medial uncus, stridulatory area with row of 4 or 5 curved acute teeth and distal truncate process (Fig. 1E).

Labium (Fig. 1D): Hypopharyngeal scleroma asymmetrical, right side more prominent and sclerotized.

Antennae (Fig. 1F): First antennomere as long as or longer than 2 following segments combined; surface of last antennomere with 5–8 dorsal and 4–7 ventral sensory spots. *Thorax*. Spiracles with C-shaped respiratory plate, 0.8–0.9 mm high and 0.5–0.6 mm wide; dorsal area of thoracic segments with short, abundant setae.

Legs: Tarsungulus cylindrical (Fig. 1G), rounded apically, possessing 7 or 8 regularly distributed setae.

Abdomen. Spiracles of abdominal segments I–VIII similar in size; distance between the two lobes of respiratory plate of spiracles less than dorsoventral diameter of bulla; dorsal surface of segment I–VIII with a single row of short setae per annulet, some long setae interspersed between short setae; dorsum of segment VII with 2 annulets; segments IX and X fused, covered with irregular rows of short setae; spiracular area of abdominal segments I–VIII with 10–15 setae, frequently 11.

Raster (Fig. 1H): V-shaped, open posteriorly and closed anteriorly; palidia monostichous, with each palidium consisting of a row of 7 or 8 small size with flattened apex pali; septula elongate, length $3\times$ its width at posterior end; lower anal lip with moderate amount of short and medium size setae and few long setae proximal to anal aperture.

Adult material examined

In addition to the larvae, the following adult material has been examined, supplemented with previously published data.

Material examined: SOUTH AFRICA: *KwaZulu-Natal*: Entumeni (28°53'S 31°22'E), 1.ii.2004, 12.ii.2005 & 25.i.2009, R. Perissinotto & L. Clennell (PCPC); Entumeni, 25.i.2009, R. Perissinotto & L. Clennell (PCPC); Eshowe (28°54'S 31°28'E), xii.1906, H.W. Bell-Marley (TMSA CPH5655); Eshowe, 20.xi.1979, P. Reavell (TMSA CPH5646); Karkloof (29°23'S 30°16'E), 24.iii.1942, H.W. Bell-Marley (TMSA CPH5654); Karkloof, H.M. Millar (DMSA 10213); Karkloof, H.M. Millar, 'Don. H.B.W.M.' (DMSA 10214); Karkloof, H.M. Millar, E. Holm det. (DMSA 10215); Karkloof, H.W. Bell-Marley (DMSA 10216, 10217); Karkloof, 24–30.i.2000, 1–4.ii.2002, 16–22.ii.2002, 23.ii–2.iii.2002, 12.ii.2009, R. Perissinotto & L. Clennell (PCPC); Howick (29°29'S 30°14'E), iv.1943, H.M. Millar (TMSA CPH5650); Howick, iii.1943, H.M. Millar (TMSA CPH5651); Pietermaritzburg, Hilton (29°33'S 30°17'E), 18.ii.2012, M.J. Dyer (PCPC). *Eastern Cape*: Port St Johns (31°38'S 29°32'E), 26.x.1909 & iii.1911, H.H. Swinny (TMSA CPH5647, CPH5648); Port St Johns, ii.2002, O. Aschenborn (PCPC); The Haven (32°14'S 28°54'E), 23.i.1985, N.J. Duke, from larva (TMSA CPH5652); The Haven, 4.ii.1992, N.J. Duke (TMSA CPH5653); Embotyi Forest (32°49.5'S 28°07.0'E), v.1991 (TMSA CPH5649); Embotyi Forest, 29.iii.1991 & 12.iv.1992, A.P. Marais (BMPC, PCPC).

Literature data: *KwaZulu-Natal*: Tugela River (Péringuey 1907); Karkloof (Péringuey 1907); Karkloof, Howick Falls (Allard 1985); Timiumbili, Umvoti (Holm & Marais 1992); Karkloof Nat. Res. (Bourquin 1993); Doreen Clark Nat. Res. (Bourquin 1993). *Eastern Cape*: Lusikisiki (Allard 1991); Port St Johns area (Holm & Marais 1992); Mbotyi Forest, v.1989 & iv.1992 (Sakai & Nagai 1998); Port St Johns, ii.2003 (De Palma 2009).

Taxonomic status

Although not well understood, the separation of the species into two subspecies proposed by Allard (1991) appears to be supported by the disjunct distribution of the two known populations and a number of morphological characters.

While the KwaZulu-Natal (KZN) population occurs in the area from Pietermaritzburg to Entumeni/Eshowe, the Eastern Cape (EC) population is restricted to a narrow coastal strip from The Haven to Mbotyi (Fig. 2). The two populations are thus separated by a discontinuity of about 300 km.

Regarding the size of the adults, Péringuey (1907) reported a range of 28.0–38.5 mm for total length and of 15.0–19.5 mm for width. Allard (1985, 1991) reported a length of 35 mm for the male of *E. trimeni* from KZN and 36 mm for the male of *E. t. transkeiensis* from EC. Sakai and Nagai (1998) provided separate length for male and female specimens of 32–40 mm and 29–31 mm, respectively. Data obtained in this study show the following for males and females of the two populations. KZN: male length ($n=26$): 29.0–46.0 mm (mean 38.9 ± 3.9 SD), width 15.0–19.0 mm (mean 17.1 ± 1.3 SD); female length ($n=18$): 27.0–33.5 mm (mean 30.5 ± 2.0 SD), width 13.5–16.5 mm (mean 15.4 ± 0.9 SD). EC: male length ($n=19$): 28.5–44.0 mm (mean 36.3 ± 3.7 SD), width 13.5–18.0 mm (mean 16.4 ± 1.5 SD); female length ($n=11$): 26.0–33.0 mm (mean 29.5 ± 3.9 SD), width 13.0–17.0 mm (mean 15.2 ± 2.8 SD).

Adults of these populations can be separated based on the shape and size of their humeral and apical spots, clypeal fork, mesometasternal process and parameres, as well as pronotal and ventral background colour. The humeral and apical black spots on elytra

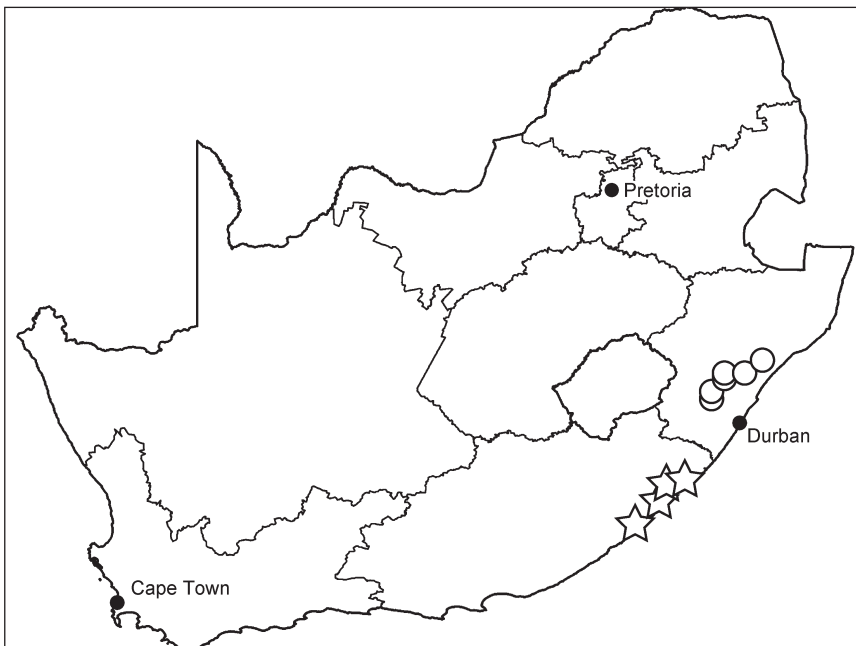


Fig. 2. Distribution of *Eudicella trimeni* populations in KwaZulu-Natal (circles) and in the Eastern Cape (stars).

are much larger, normally twice as large, in the KZN than in the EC populations. The sutural band on the elytra is basally convergent and always merging with the humeral spots in the KZN populations, but is narrower and at times not reaching the humeral spots in the EC material, leaving the latter areas isolated in the light brown background.

The mesometasternal process is generally longer and more acuminate in the EC than in the KZN populations. The clypeal fork angle is also significantly wider in EC specimens, while the pronotal and ventral colour is predominantly olive to bright green in EC specimens, but golden green in KZN ones (Fig. 3). The parameres are short in both populations, but the dorsomedial groove on each lobe in EC specimens is noticeably longer and deeper than in KZN specimens, reaching almost to the base. This

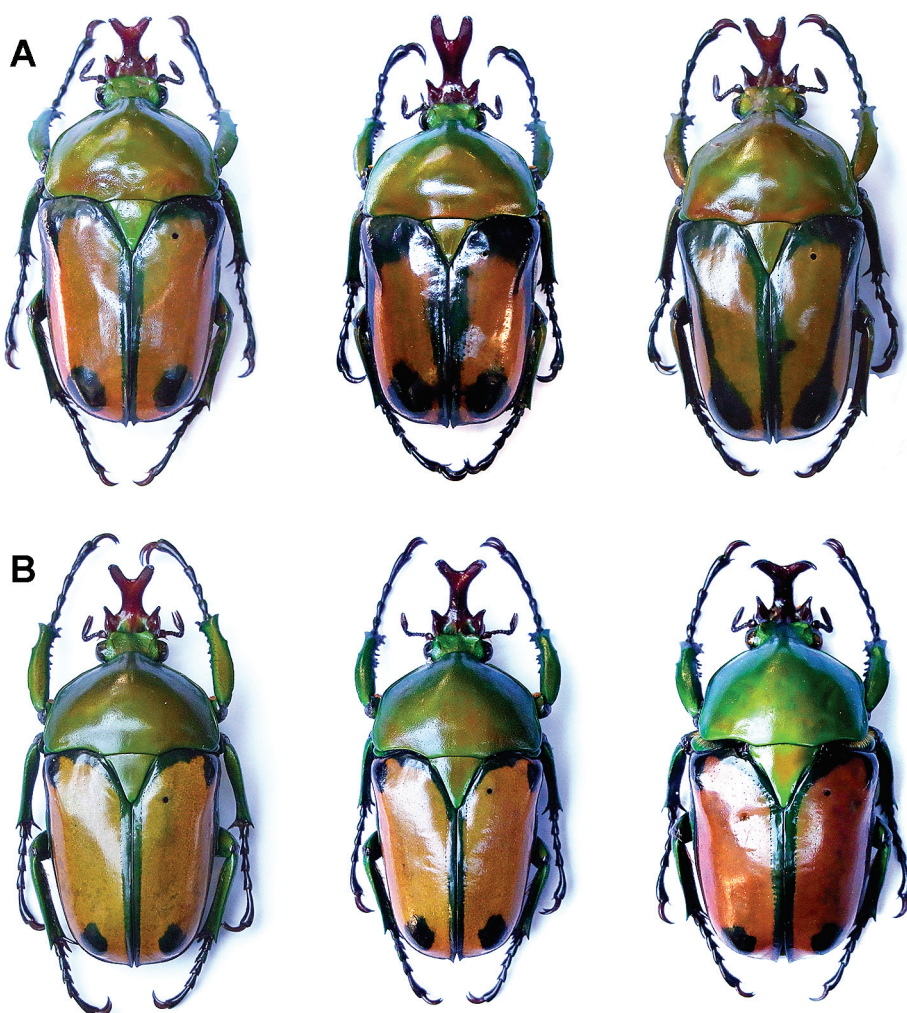


Fig. 3. Variation in male morphology and colour pattern of *Eudicella trimeni* populations from KwaZulu-Natal (A) and Eastern Cape (B).

is particularly evident in frontal view (Fig. 4A). Furthermore, in dorsal view the outer curvature at the departure point of the two lobes is more marked in the EC, compared to the KZN populations (Fig. 4B). Thus, there are differences in the two populations that support at least the earlier subdivision of the species into two subspecies and perhaps even the erection of a species group. Additional evidence from larval morphology and molecular studies will be required to conclusively resolve the taxonomic position of these populations.

Distribution, ecology and conservation

Collection records indicate that in KwaZulu-Natal *E. trimeni* is restricted to its north-eastern part, from just north of Pietermaritzburg in the west, to the Entumeni and Dlinza forests in the east. Recent collecting efforts have included the Midlands region to the west and southwest of Pietermaritzburg (e.g. Impendle, Bulwer, Weza, Umtamvuna), but have failed to produce any specimens. Baited traps were used in this region employing the same strategy used successfully in the other areas, involving deployment to the highest

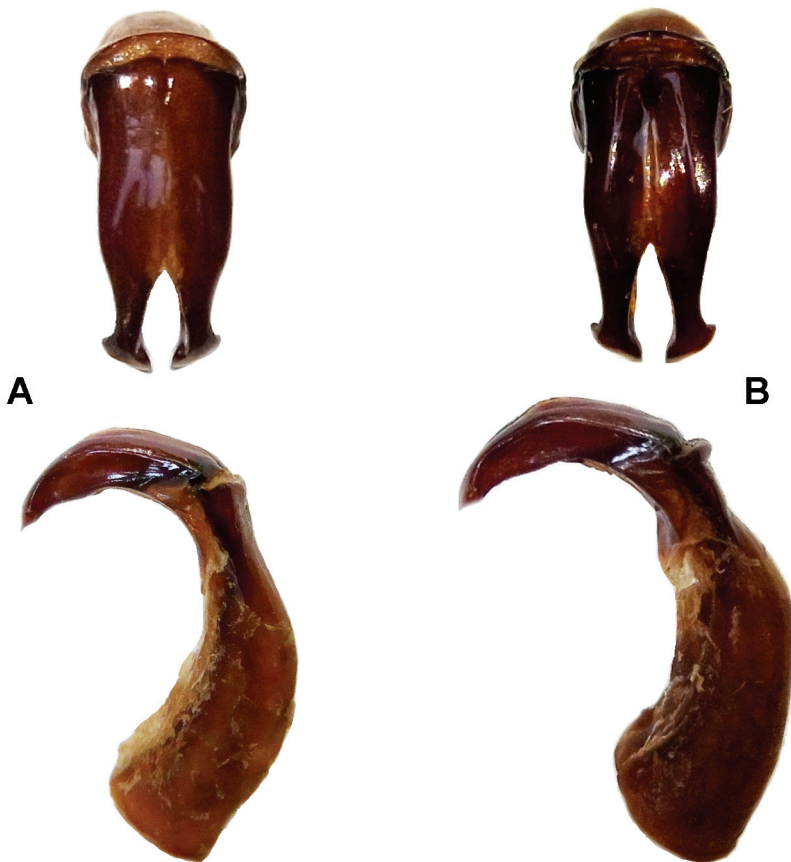


Fig. 4. Dorsal and lateral views of the aedeagus of *Eudicella trimeni* populations from KwaZulu-Natal (A) and Eastern Cape (B).

reachable levels of the forest canopy. Thus, discrepancies in collecting techniques and/or seasonality can be excluded as factors responsible for the disjunct distribution of the species. The KwaZulu-Natal populations are separated by a distance of approximately 300 km from their Eastern Cape counterparts, which seem to be restricted to a small area of scarp forest adjacent to the coast, between Port St Johns and The Haven to Mbotyi.

In KwaZulu-Natal, *E. trimeni* occurs mainly in the southern mistbelt forests, at altitudes between 850–1600 m (Mucina & Rutherford 2006), in Karkloof, Howick, Hilton (Pietermaritzburg north) and Umvoti. It has also been recorded in the highest KwaZulu-Natal scarp forests of Entumeni and Dlinza, at altitudes over 600 m. In the Eastern Cape, on the other hand, the species occurs typically in the lower scarp forests of the eastern part, at altitudes of much less than 600 m and in the proximity of the coastline.

Eudicella trimeni has been reported consistently in the literature as one of the most rare Cetoniinae occurring in southern Africa, on occasions even been regarded as ‘extinct’ (Allard 1991; Holm & Marais 1992). The more recent of such reports may reflect the environmental crisis that the region of its typical habitat has undergone during the past 50 years, underpinned by deforestation, replacement of indigenous forests with commercial plantations and widespread alien plants encroachment (Mucina & Rutherford 2006). However, even Péringuey (1907) wrote in his assessment that the species was rare, believing that this was due to it being an occasional visitor from further north. While in hindsight it is obvious that he was confusing this South African endemic with the Eritrean *E. chloe*, described a few years earlier by Raffray (1885), the remark about its unusual rarity at a time when its habitat was virtually pristine is noteworthy.

Our research supports the hypothesis that the species may be more elusive, rather than truly extremely rare. Few specimens are known from museums and private collections. In the Karkloof Forest, several dozen specimens have been trapped during the past decade using fruit-baited funnel cylinders deployed at canopy heights during the hottest part of the day. Even richer collections have been made in the Port St Johns and Mbotyi areas of the Eastern Cape (Holm & Marais 1992; P. Stobbia pers. comm.). For instance, over 100 specimens were trapped in the Mbotyi Forest over a period of a week during April 1992 (A.P. Marais, pers. comm.).

Adult females have been observed flying close to the ground inside the forest, hovering over, and sometimes landing on, dead tree trunks. Males have only been seen on rare occasions, but are more often heard, flying high above the ground, at the top of the canopy (15–20 m). The species seems to be particularly sensitive to temperature changes, with most activity observed during hot and humid summer days, showing no activity at all during cooler days. Ideal temperature for adult activity has been estimated at above 27°C, from late November to late April in KwaZulu-Natal and from late October to May in the Eastern Cape (specimen data labels, RP pers. observ.).

The larvae of *E. trimeni* are saproxylic and can be found inside decomposing wood on large tree trunks or branches (diameter >25 cm) that are still standing or suspended in the air. No larvae appear to colonise wood that has fallen and is in contact with the ground, even when extraordinary large trunks are involved. This is presumably related to the increased risk of predation on the ground, particularly by ants and ground beetles. In KwaZulu-Natal, larvae have been found on a variety of large forest trees, including *Searsia chirindensis* (Baker), *Podocarpus latifolius* (Thunb.), *Combretum kraussii* Hochst. and others that could not be identified due to the advanced stage of

decomposition. In the laboratory, under controlled environmental conditions, larvae kept at an average temperature of 22 °C completed their growth to adults in one year, while their counterparts kept at 15 °C took two years to emerge as adults. However, while the former reached an average adult total length of 27.1 mm, the latter attained substantially larger size, with an average of 35.3 mm (RP pers. observ.).

Eudicella trimeni is entirely dependent for its larval growth and development on large, dead trees that are still standing while in advanced stage of decomposition. Unfortunately, both mistbelt and scarp forests are currently under unprecedented threat, both in KwaZulu-Natal and in the Eastern Cape. This is related to activities ranging from uncontrolled timber harvesting, collection of poles and firewood, as well as mismanagement of fire and burning regimes in surrounding grasslands (Mucina & Rutherford 2006). Along with other threatened invertebrates, *E. trimeni* is currently included in a list of species to be gazetted for statutory protection throughout the province of KwaZulu-Natal (A. Armstrong pers. comm.).

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