A redescription of *Trichosuroaelaps dixous* Domrow, 1972 (Acari: Laelapidae), from *Trichosurus cunninghami* (Marsupialia: Phalangeridae) from southern Australia

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Abstract. The adults of *Trichosuroaelaps dixous* Domrow, 1972 are redescribed from a population of *Trichosurus cunninghami* Lindenmayer, Dubach et Viggers, 2002 in south-eastern Australia. The nymphal stages are described for the first time. Morphologically, *T. dixous* is similar to *Trichosuroaelaps crassipes* Womersley, 1956. Morphological differences between the pre-female deutonymphs and adult females of the two mite species are the presence of a single large ventral spur on tibia I of *T. dixous*. Males of *T. dixous* could not be distinguished from *T. crassipes* morphologically and the idiosomal length of male *T. dixous* was variable (475–683 µm). Protonymphs of the two mite species differed only in size, with that of *T. dixous* being larger. Although *T. crassipes* was prevalent in a sympatric population of *Trichosurus vulpecula* and has been reported from other populations of *T. cunninghami* in southern Australia, it was never recovered from the population of *T. cunninghami* studied.

There are three species of brushtail possums: the common brushtail possum (*Trichosurus vulpecula* Kerr), the short-eared possum (*T. caninus* Ogilby) and the mountain brushtail possum (*T. cunninghami* Lindenmayer, Dubach et Viggers). *Trichosurus vulpecula* inhabits much of mainland Australia and Tasmania (Kerle et al. 1991), as well as New Zealand, where it is an introduced pest species (Pracy 1962). The more northern *T. caninus* and the more southern *T. cunninghami* have more restricted distributions at higher elevations along the east coast of Australia (Bennett et al. 1991, Van Der Ree et al. 2004).

Lumbo-sacral dermatitis (“rumpwear”), which is characterised by coat and skin damage in the rump region of affected animals, is a very common disease in brushtail possums (*Trichosurus* spp.) in Australia, possibly caused by a reaction to haematophagous ectoparasites, including *Trichosuroaelaps* spp. (Munday 1966, Presidente 1978, 1984, Hemsley and Canfield 1994). Skin-surface inhabiting *Trichosuroaelaps* spp. are among the most prevalent ectoparasites of *Trichosurus* spp. populations in Australia and New Zealand (Sweatman 1962, Presidente 1978, Clark 1993, Viggers and Lindenmayer 2004). The two congeneric mites *Trichosuroaelaps dixous* Domrow, 1972 and *Trichosuroaelaps crassipes* Womersley, 1956 are morphologically very similar, making differentiation of the two species difficult. In addition, the immature life-cycle stages of *T. dixous*, unlike those of *T. crassipes* (see Domrow 1979, Clark 1995), have not been described

previously. *Trichosuroaelaps dixous* has been reported from *T. caninus* (Domrow 1972) and *T. cunninghami* (Viggers and Lindenmayer 2004), with the prevalence of *T. dixous* in populations of possums varying from 23% to 91% for two populations of *T. cunninghami* at Cambarville and Bellbridge (Victoria) and 29% to 94% for five populations of *T. caninus* from New South Wales and Queensland (Viggers 1996).

In order to facilitate identification of *T. dixous* and to reduce possible confusion with *T. crassipes*, a redescription of *T. dixous*, based on scanning electron and light microscopy, was undertaken. A description of its nymphal stages and morphological features to distinguish the pre-female deutonymph and adult female of *T. dixous* from *T. crassipes* are included.

MATERIALS AND METHODS

Trichosurus cunninghami (n = 398) and *T. vulpecula* (n = 30) were captured on eight field trips over two years at Boho South, Victoria, south-eastern Australia (36°48'S, 145°45'E), using wire cage traps. Possums were sedated with zolazepam/tiletamine (Zoletil® Virbac, France) for collection of ectoparasites of the rump region. A 4 × 4 cm patch of fur was shaved from the rump region, and all mites found on the exposed skin area were removed with forceps and placed in 70% ethanol. Additionally, the removed fur was stored in 70% ethanol and was later examined under a stereomicroscope (Olympus™, Tokyo, Japan), at which time all mites encountered in the sample were collected. Ten specimens of immature, and 20 specimens of mature life-cycle stages of *T. dixous*

were measured; the mean size (in parentheses) and the range of measurements are given in micrometres (μm). No larval stages were recovered, although these were observed within the opisthosoma of some female mites. Identification of nymphs was based on comparison of morphological features with adult females. All specimens were cleared in Hoyer's medium or lactophenol for identification. Morphological terminology is based on Evans and Till (1965) and Domrow (1972, 1987).

Specimens were examined under a LeicaTM (HC) DM 1000 compound microscope, and photographed using a NikonTM DS Camera Head DS-5M and a NikonTM Camera Control Unit DS-L1. Mites were prepared for scanning electron microscopy by dehydration with ethanol, followed by transfer to hexamethyldisilazane, which was allowed to evaporate. They were then mounted on stubs with double-sided adhesive tape and coated with gold in a PolaronTM E5000 sputter coater. Photographs were taken with a PhillipsTM 505 scanning electron microscope, using digitally acquired images in SpectrumTM.

Voucher specimens of protonymphs, deutonymphs, females and males, have been deposited in the Australian National Insect Collection, CSIRO Division of Entomology, Canberra.

RESULTS

A total of 4,642 specimens of *T. dixous* from *Trichosurus cunninghami*, consisting of 3,950 females, 439 males, 29 protonymphs and 224 deutonymphs, were collected and examined. Additionally, 96 specimens of *T. crassipes* from *T. vulpecula* were examined for comparison. *Trichosurolaelaps dixous* was the only species of *Trichosurolaelaps* identified from *T. cunninghami*, while *T. crassipes* was found only on *T. vulpecula*. The prevalence of *T. dixous* on *T. cunninghami* was greater than 90% (unpublished data J.H.).

Trichosurolaelaps dixous Domrow, 1972

Type host and locality: *Trichosurus caninus*, Upper Brookfield (Queensland), Australia (Domrow 1972).

Protonymph

Fig. 1

Poorly sclerotized. Cheliceral segments about three times length of first segment. Single row of 4 deutosternal denticles followed by 1 anterior row of paired denticles. Seta h_3 longest, with h_1 and h_2 about 1/3 its length; cs marginally longer than h_1 . Palpal trochanter with 1 ventral seta and palpal femur apparently lacking al ; apotele two-pronged.

Idiosoma 390–475 (403) long; podonotal shield 247–279 (268) long, posterior margin trilobed, pygidial shield 60–71 (67) long. Three pairs of mesonotal scutella present. Dorsal chaetotaxy based on that for protonymph of *T. crassipes* (Domrow 1979). Podonotum holotrichous for protonymph, with 16 pairs setae; j_{4-6} , z_{4-5} , s_4 very short. Opisthonotum hypotrichous for protonymph, lacking J_3 , Z_3 ; J_4 , J_5 , Z_4 very short. Some setae of J , s/S , r , Z series blade-like (Fig. 1A).

Tritosternum bifid. Sternal shield with 3 pairs of setae; stigmata without recognisable peritremes. Genital setae absent from opisthogaster; Jv_{1-2} and Zv_2 present. Jv_5 marginal. Para-anal setae shorter than post-anal seta.

Coxae II, IV with 1 short spur; 2 spurs on coxae I, III. Anterodistal margin of coxa I with fimbriated edge. Ad_1 on femur I very long, slender (about twice length of femur); pd_2 of genu I longer than other setae of that segment, about half length of Ad_1 . Some distal setae of tarsi I–III elongate, tapered; setae of tarsus IV quite long, stout, especially lateral ones.

Deutonymph

Figs. 1, 3

More heavily sclerotized than protonymph; but less than in adult. Chelicerae similar to those of protonymph. Deutosternal denticles and hypostomal setae arranged as in protonymph. Ventral seta (v_2) added to palpal trochanter, also third dorsal (d_3) and anterior lateral (al) seta. Genu apparently with single al . Apotele two-pronged.

Idiosoma 507–665 (567) long; dorsal shield entire, 468–539 (491) long and 227–279 (251) wide. Dorsal shield covering most of dorsal idiosoma with little or no lateral indentation. Dorsal chaetotaxy hypotrichous (33 pairs of setae), lacking j_3 , r_1 in podonotal portion; z_3 , s_{1-3} , r_4 added to protonymphal setation. J_3 , Z_3 missing in opisthonotal section, S_1 present. Some dorsal setae (j_{4-6} , z_{4-6} , s_4 ; J_{1-2} , J_{4-5} , Z_{1-2} , Z_4) very short, slender; other setae of marginal opisthonotal series (12–13 pairs) short, blade-like.

Tritosternum bifid, stigmata with short peritremes (length up to twice diameter of stigmata). Para-anal and post-anal setae as in protonymph. Sternal shield with 3 pairs of setae; 1 pair of metasternal setae and 1 pair of genital setae present. Opisthogaster hypertrichous, adding Zv_{3-5} to holotrichous setation (Fig. 1D). Ventral body setae all relatively long, but more marginal opisthogastric setae shorter and blade-like (15 pairs of cuticular setae).

Coxae I–II with 2 spurs, coxa III with 3 spurs; coxa IV with 1 spur. Anterior margin of coxa I as in protonymph. On trochanters I–II, pv_1 stout spine; pv_2 elongate, tapered. Anterolateral setae of trochanters I–III thicker, shorter than other setae of segment. Elongate setae on femora I (av) and II (av , pv_2). Ad_1 (femur I) and pd_2 (femur II) long, thick, about 1.5 times femoral length. Av_1 of femur I short, stout spine, similar to ad_{1-3} on genua I–II. Ad_3 (genu I) almost as long as ad_1 (femur I); pd_2 (genu II) elongate. In pre-males, pv of tibia I long, setose (Figs. 1D, 3A); in pre-females spinous basally, with setiform elongation (Figs. 1E, 3B). Tarsus I with several long setae; setae of tarsus IV more spinous.

Female

Figs. 2, 3

Cheliceral proportions, deutosternal denticles as in nymphal stages. h_3 longest hypostomal seta; h_2 about 1/5 of h_3 , h_1 and cs about 1/3 length of h_3 . Palpal setation similar to deutonymph.

Fig. 1. *Trichosurolaelaps dixous*, nymphal stages. **A** – protonymph, dorsal view; **B** – protonymph, ventral view; **C** – deutonymph, dorsal view; **D** – pre-male deutonymph, ventral view; **E** – pre-female, tibia I, ventral view. *Abbreviations:* ap – anal plate; ds – dorsal shield; mn – mesonotal scutella; op – opisthonotal shield; pd – podonotal shield; st – sternal shield. Scale bars: 160 μ m.

Idiosoma 598–670 (635) long, dorsal shield large, 533–624 (575) long and 286–325 (307) wide, covering most of body. Dorsal chaetotaxy essentially that of deutonymph, missing j_3 , r_1 , J_3 , Z_3 . Dorsal cuticle with about 14 pairs of setae.

Tritosternum bifid. Sternal shield with 3 pairs of setae, 2 pairs of lyriform fissures; pair of metasternal setae

on metasternal shields, latter fused with endopodal shield of coxa III. Sternal shield not reticulate; subrectangular, anterior and posterior margins convex, latter about 2/3 along coxa III. Genital shield flask-shaped, with 1 pair of genital setae and well-developed hyaline flap, covering about 2/3 of sternal shield anteriorly. Para-anal and post-anal setae as for deutonymph, on

Fig. 2. A–D. *Trichosurolaelaps dixous*, adult. A – female, dorsal view; B – female, ventral view; C – male, dorsal view; D – male, ventral view. E–F. *Trichosurolaelaps crassipes*, female. E – peritreme; F – leg I, ventral view. Abbreviations: as – anal shield; co – coxa; fe – femur; ge – genu; gs – genital shield; hs – holovenal shield; ms – metasternal shield; st – sternal shield; ta – tarsus; ti – tibia; tr – trochanter. Setation of female dorsal shield and key leg setation is also labelled according to Evans and Till (1965) and Domrow (1972). Scale bars: 160 μ m.

Fig. 3. Light micrographs of *Trichosurolaelaps dixous* and *T. crassipes*. **A** – *T. dixous*, pre-male deutonymph, ventral view of leg I, note *pv* (arrow) of tibia; **B** – *T. dixous*, pre-female deutonymph, ventral view of leg I, note *pv* of tibia spinous basally with setiform elongation (arrow); **C** – *T. dixous*, female, ventral view of leg I, note *pv* (arrow) of tibia; **D** – *T. crassipes*, female, ventral view of leg I, note *pv* of tibia (fat arrow), genu and femur (thin arrows); **E** – *T. dixous*, female, dorsal view of peritreme, note peritreme does not extend beyond anterior margin of coxa III (arrow); **F** – *T. crassipes*, female, dorsal view of peritreme, note narrow elongation of peritreme to coxa I (arrow). Scale bars: 100 µm.

subtriangular anal shield. Metapodal shields not obvious; peritremes as in deutonymph, not extending beyond coxa III (Figs. 2B, 3E). Ventral cuticle with about 16 pairs of setae.

All coxae with strongly developed spurs: coxae I–II with 2 spurs, coxa III with 3 spurs, coxa IV with one robust and one less robust spur. Anterior spurs of coxae II–III directed posteriorly, somewhat longer, slimmer

than remainder. Anterodistal margin of coxa I as in nymphs. Trochanters I–II with stout spines (*pv*₁); at least one strong small spine (*pl*) on femur I, genu I, tibia I. Tibia I with large ventral, posteriorly-directed spur (*pv*), of similar length as tibial segment, about 1/3 its width (Figs. 2B, 3C). Dorsal setation on legs I–II same as deutonymphs, except *pd*₂ on genu II not elongated. Setae of tarsus IV long and spiniform.

Male

Figs. 2, 3

Capitulum as for female except for presence of spermatodactyl.

Idiosoma 475–683 (572) long, dorsal shield large, 462–663 (553) long and 254–410, (318) wide, covering most of body. Dorsal chaetotaxy as in female, but with about 12–13 pairs of setae on dorsal cuticle.

Tritosternum bifid. Holoventral shield narrowing to pass between coxae IV before expanding slightly upon reaching opisthogaster, then tapering before reaching anal shield (fused to holoventral shield). Holoventral shield with 8 pairs of elongate setae, extending past origin of next seta, anal portion of shield with 1 pair of para-anal setae and 1 post-anal seta, as in female. Anterior margin of shield convex; shield with reticulate pattern, extending posteriorly to about level of coxae IV. Peritremes as in female, ventral cuticle with about 12 pairs of setae, most marginal shorter.

Coxae as for female, except posterior spur on coxa IV much less pronounced. For leg I, pv_1 of trochanter, femur and genu spur-like; those of femur and genu especially long and tapered. Pv of tibia I elongate and tapered, about twice length of that in female, not robust and spur-like. Dorsal chaetotaxy of legs I–II similar to female, except pd_2 on genu II elongate as in deutonymph. Tarsal setae as in female.

DISCUSSION

Descriptions of all life-cycle stages of *Trichosurolaelaps crassipes* have been published (Womersley 1956, Domrow 1979). However, only the adult stages of *Trichosurolaelaps dixous* have been described previously (Domrow 1972, 1987). A comparison of the results presented here with existing descriptions of *T. crassipes* (Domrow 1979, Clark 1995) indicate that there are few, if any, morphological differences, other than size, between the protonymphal stages of *T. dixous* and *T. crassipes*. Idiosomal length of *T. dixous* protonymphs was 390–475 μm , compared to 310–340 μm (Domrow 1979) and 250–300 μm (Clark 1995) for *T. crassipes*. Size differences also exist between the deutonymphal stages of the two species: idiosomal length is 507–665 μm in *T. dixous*, compared to 450–460 μm (Domrow 1979) and approximately 470 μm (Clark 1995) in *T. crassipes*. In the deutonymphal stages of *T. crassipes*, pre-males can be differentiated from pre-females by variation in the shape of av_2 on genu I and tibia I (Domrow 1979). The same variation exists in *T. dixous*, described here for pv , but is present only on tibia I. Thus, while pre-female *T. crassipes* deutonymphs have a seta which is proximally spiniform but distally narrows with a short setose elongation on both genu I and tibia I; pre-female *T. dixous* deutonymphs have this feature only on tibia I. This mirrors the differences in leg I setation between the adult female mites of the two species and permits differentiation between pre-

female, but not male, deutonymphs of *T. dixous* and *T. crassipes*.

Differences in setation of leg I are also a reliable and easy means of differentiating adult female *T. dixous* and *T. crassipes*. While *T. dixous* females have one strong ventral tibial spur on each first leg (Figs. 2B, 3C), *T. crassipes* females, as observed on the specimens collected as part of this study, have a slightly smaller tibial spur, which is accompanied by a similar spur on the ventral aspect of genu I (Figs. 2F, 3D). Additionally, *T. crassipes* females have a stout, posteriorly-directed spine (pv) on femur I and trochanter I, whereas *T. dixous* females only have such a spine on trochanter I. Another distinguishing feature, but often more difficult to visualise, is the extension of the peritreme (with a much reduced diameter compared to its initial section) to near coxa I in female, but not male, *T. crassipes* (see Figs. 3E, 3F) (Domrow 1972, 1987).

The size differences between nymphs of the two species are similar to the trend seen in the adult life-cycle stages. Female *T. crassipes* range in idiosomal length 470–560 μm and males 380–500 μm (Domrow 1972, 1987). In the specimens measured, idiosomal length of female *T. dixous* varied 598–670 μm , slightly smaller than the 650–700 μm described for females of this species by Domrow (1972). There was great variation in idiosomal length of *T. dixous* males (475–683 μm), especially since the males described by Domrow (1972) showed much less variation (640–660 μm ; $n = 4$). No reliable morphological features to distinguish *T. dixous* males from those of *T. crassipes* could be found in the specimens collected here, and so it is possible that some of the smaller males were misidentified and were in fact *T. crassipes*. However, all male mites identified as *T. dixous* were collected from *Trichosurus cunninghami*. As all female specimens of *Trichosurolaelaps* found on *T. cunninghami* were identified unequivocally as *T. dixous*, it would be surprising to find male *T. crassipes*, but not females, on the same host.

Trichosurolaelaps crassipes has been reported at relatively high prevalences from *T. cunninghami* (Viggers 1996) and *Trichosurus caninus* (Domrow 1972, Presidente et al. 1982, Viggers 1996). However, in the population at Boho South, although commonly found on *Trichosurus vulpecula*, *T. crassipes* was never found to infest the sympatric population of *T. cunninghami*. While it is possible that the species was not collected from *T. cunninghami* despite it being present, given the large number of specimens of *Trichosurolaelaps* collected and examined from *T. cunninghami* as part of this study, it seems unlikely that *T. crassipes* was overlooked, had it occurred in significant numbers. It is possible that some *T. crassipes* mites were misidentified as *T. dixous*. However, this also seems unlikely as every single mite collected was examined carefully. There may be little opportunity for *T. crassipes* to be transmitted from *T. vulpecula* to *T. cunninghami* at our study

site. Although trapping data indicate that the two possum species are sympatric at Boho South, we have little knowledge of the degree to which they share resources, such as dens. Viggers (1996) did not examine *T. vulpecula* in her study, so it is not clear whether there was any overlap between the two possum species at her study sites. Finally, it is possible that *T. crassipes* recovered from *T. vulpecula* at Boho South is genetically different to *T. crassipes* identified from *T. cunninghami* at other locations (Viggers 1996, Viggers et al. 1998) and has different host preferences. This is supported by at least one morphological difference between *T. crassipes* collected from *T. caninus* and *T. vulpecula*. Domrow (1972) noted that *T. crassipes* from *T. caninus* had one fewer pair of setae on their dorsal shield (J_2 missing) than those from *T. vulpecula*. The specimens of *T. crassipes* collected from *T. vulpecula* at Boho South all had J_2 present. It is therefore possible that this form of *T. crassipes* is specific for *T. vulpecula* and does not infect *T. cunninghami*. The form which infects both *T. caninus* and *T. cunninghami* may not occur at Boho South.

There are many similarities between the life-cycle stages of the two congeneric species *T. dixous* and

T. crassipes. Generally speaking, specimens of *T. dixous* are larger than *T. crassipes*, but overlap in sizes may occur and size is therefore not always a reliable differentiating feature. Protonymphal and male life-cycle stages of the two species appear to differ only in size. However, variation in leg morphology allows reliable differentiation of pre-female deutonymphs and females. *Trichosuroaelaps dixous* was only recovered from *T. cunninghami* and never from *T. vulpecula*, which is consistent with other host records for this mite species (Viggers and Spratt 1995). However, in the present study, *T. crassipes* also appeared to be highly host specific, being found on *T. vulpecula*, but never recovered from *T. cunninghami*, a finding in contrast to previous studies (Viggers 1996, Viggers et al. 1998).

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