Records of the Western Australian Museum **19**: 187–200 (1998).

Ctenotus rimacola sp. nov. (Scincidae), a new species of lizard with two allopatric subspecies, from the Ord-Victoria region of northwestern Australia

Paul Horner[1] and Alaric Fisher[2]

[1]Museum and Art Gallery of the Northern Territory, GPO Box 4646, Darwin, NT 0801, Australia.
[2]Cooperative Research Centre for Sustainable Use of Tropical Savannas, Parks and Wildlife Commission of the Northern Territory, PO Box 496, Palmerston, NT 0831, Australia
and
Northern Territory University, Darwin, NT 0909, Australia

Abstract – A new species of *Ctenotus* Storr (Reptilia, Scincidae) with two allopatric subspecies, *C. rimacola rimacola* ssp. nov. and *C. rimacola camptris* ssp. nov., is described. A member of the *C. lesueurii* species-group, it is distinguished from congeners, notably *C. robustus*, *C. joanae* and *C. agrestis*, by a combination of body pattern and meristic characteristics. Two subspecies are recognised from geographic variation in colour and pattern within the taxon. This species is apparently endemic to areas of tussock grassland on black-soil (grey cracking clay) plains, which occur extensively in the Ord-Victoria region of northwestern Australia. Unlike the deserts of central Australian and the tropical savanna woodlands, black-soil grasslands in northern Australia support few *Ctenotus* species, although at least four species are endemic to this habitat.

INTRODUCTION

The genus *Ctenotus* Storr 1964 is the most speciose taxon of scincid lizard found in Australia. Containing more than 90 species (Wilson and Couper 1995), the genus is distributed throughout the continent, with one species occurring in southern New Guinea. *Ctenotus* species are found through a diverse array of habitats, ranging from arid deserts to tropical savanna woodland. Many species exhibit a high degree of habitat specificity and may have very restricted distributions (Horner 1995).

Mitchell Grass (*Astrebla* spp.) associations occur on heavy cracking-clay (black-soil) plains over a large area (c. 400 000 km^2) of inland northern Australia. Reptile species endemic to this habitat include several elapid snakes [*Pseudechis colletti* Boulenger 1902, *Pseudonaja guttata* (Parker 1926), *P. ingrami* (Boulenger 1908)], one varanid (*Varanus spenceri* Lucas and Frost 1903), one agamid (*Pogona henrylawsoni* Wells and Wellington 1985) and four skinks [*Proablepharus kinghorni* (Copland 1947), *Ctenotus agrestis* Wilson and Couper 1995, *C. joanae* Storr 1970 and *C. schevilli* (Loveridge 1933)]. During a study on fauna associated with Mitchell Grass communities, one of us (AF) collected a series of specimens of an unusual *Ctenotus* from black-soil habitats in the southern Victoria River District of the Northern Territory (Figure 1). These were recognised as being conspecific with a single damaged specimen collected by J. Woinarski from similar habitat on Victoria River Downs Station in 1994 (Woinarski and Fisher, unpubl. data). Further specimens, differing somewhat in colour and pattern to those from the Victoria River District, were collected by staff of Ecologia Environmental Consultants, Perth, WA, during the course of a biological survey of the alluvial black soil plains of the proposed Ord River Irrigation Area Stage II development (Figure 1).

The specimens share many features with *C. robustus* Storr 1970 and would be referred to that species by most identification keys. Additionally, the grey-brown ground colour and broad, dark vertebral stripe of the Victoria River District series, begs comparison to *C. agrestis* and *C. joanae*.

This paper describes the new species and its subspecies. A comparison is made with those species with which it could be confused and its known distribution and some features of its habitat are described.

METHODS

A detailed morphometric and meristic analysis was made of the 22 specimens available of the previously undescribed species of *Ctenotus*, 11 from each of the Victoria River District and Ord regions. The characters quantified for each specimen are listed in Table 1. Measurements were made with

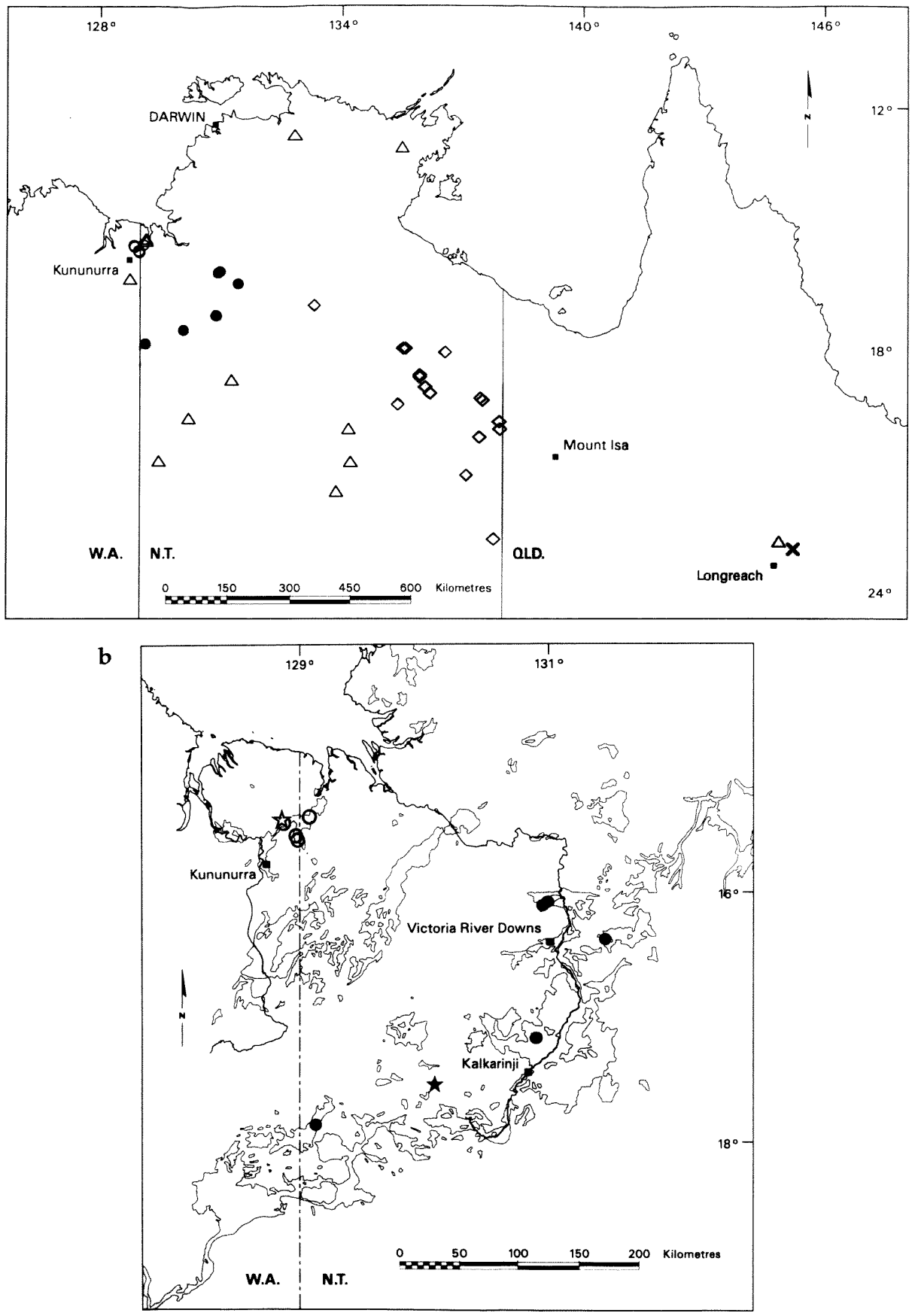

Figure 1 **(a)** Distribution of *Ctenotus rimacola* sp. nov. (*C. r. rimacola* – closed circles; *C. r. camptris* – open circles) and location of comparative specimens of *C. robustus* (triangles), *C. joanae* (diamonds) and *C. agrestis* (cross). Stippling shows the distribution of Mitchell grass communities in northern Australia. **(b)** Detail of the collection localities of *C. rimacola* sp. nov. (*C. r. rimacola* – closed circles; *C. r. camptris* – open circles; type localities – stars), showing the distribution of heavy clay soils (stippled) in the region.

electronic digital calipers and a steel rule. Counts of supraciliary, ciliary, and supralabial scales, subdigital lamellae and ear lobules were made on both sides of the body. The colouration and body pattern of each specimen was also recorded. Nomenclature for scalation and body pattern follows that of Horner (1992). Of the measurements and counts taken, the following require individual definition:

1. Head length: measured from the anterior margin of the ear orifice to the apex of the rostral scale;

2. Snout length: measured from the anterior margin of the orbit to the apex of the rostral scale;

3. Body length: measured between axilla and groin;

4. Forebody length: measured from the tip of the snout to the axilla;

5. Limb length: measured along the posterior edge, from the body wall to the tip of the longest toe (claw excluded);

6. Paravertebral scales: counted from first scale posterior to parietals to a point midway between the hindlimbs.

For analytical purposes all measurements of a specimen were expressed as a proportion of the snout-vent length of that specimen in order to minimise variation due to body size. A further nine variables were derived as ratios between various combinations of body measurements (Table 1).

A similar set of characters were quantified for 28 specimens of *C. robustus* from a broad geographic range, 19 specimens of *C. joanae* from the Barkly Tableland within the Northern Territory and two paratypes of *C. agrestis* from central Queensland (Figure 1; Appendix 1). Mensural and meristic

Table 1 Mensural and meristic variables for *Ctenotus r. rimacola* ssp. nov. and *C. r. camptris* ssp. nov. Probability associated with Mann-Whitney U-test or x^2 test between subspecies is given for each variable: 'ns' indicates P>0.1.

Characteristics	*Ctenotus rimacola rimacola* n=11			*Ctenotus rimacola camptris* n=11			prob.
	mean	SD	range	mean	SD	range	
No. of nuchal scales	6.8	0.8	6 – 8	6.7	0.7	6 – 8	ns
No. of supraciliary scales (n=22)	10.0	1.0	9 – 13	9.4	0.6	9 – 11	ns
No. of ciliary scales (n=22)	11.3	0.7	10 – 13	11.0	0.5	10 – 12	ns
No. of supralabial scales (n=22)	7.4	0.5	7 – 8	7.0	0.0		.07
No. of nuchal scales	6.8	0.8	6 – 8	6.7	0.7	6 – 8	ns
No. of ear lobules (n=22)	3.3	0.5	3 – 4	3.0	0.2	2 – 4	ns
No. of forefoot lamellae (n=22)	12.3	0.9	11 – 14	13.0	1.0	12 – 15	.09
No. of hindfoot lamellae (n=22)	19.5	1.6	17 – 22	19.4	1.7	17 – 22	ns
No. of midbody scale rows	28.1	1.0	26 – 30	27.8	0.6	26 – 28	ns
No. of paravertebral scales	55.0	1.5	52 – 57	55.4	1.6	53 – 58	ns
Nasals (% in contact)	63.6			27.3			ns
Prefrontals (% in contact)	90.9			81.8			ns
Presubocular present (%) (n=22)	54.5			100			.04
Snout-vent length (SVL)	78.6	10.83	59 – 94	81.4	5.1	72 – 88	ns
Percentages (of SVL)							
Body length	53.9	3.4	48.2 – 60.1	49.9	2.4	47.3 – 54.2	.01
Tail length	181.0	14.2	166.7–199.1	194.3	7.4	188.0–206.0	ns
Forelimb length	28.3	1.8	26.1 – 31.4	27.6	1.5	25.6 – 29.9	ns
Hindlimb length	41.6	2.6	38.1 – 46.3	42.0	1.9	38.5 – 46.1	ns
Forebody length	37.5	2.8	34.7 – 42.1	38.7	1.4	36.5 – 40.8	ns
Head length	18.7	1.0	17.2 – 20.3	19.1	0.7	17.8 – 20.2	ns
Head width	13.1	0.7	11.9 – 14.2	13.2	0.5	12.5 – 14.1	ns
Head height	10.6	0.9	9.3 – 12.2	11.1	0.7	10.3 – 12.6	ns
Snout length	8.2	0.4	7.6 – 8.7	8.3	0.4	7.6 – 8.9	ns
Ratios							
Hindlimb : forelimb	1.47	0.05	1.37 – 1.55	1.52	0.05	1.43 – 1.61	.04
Hindlimb : head length	2.22	0.09	2.07 – 2.35	2.20	0.07	2.09 – 2.32	ns
Forebody : forelimb	1.33	0.09	1.16 – 1.52	1.41	0.09	1.26 – 1.52	.07
Body : forebody	1.45	0.18	1.14 – 1.73	1.30	0.09	1.18 – 1.48	.04
Body : hindlimb	1.30	0.14	1.11 – 1.58	1.19	0.07	1.12 – 1.32	ns
Body : head length	2.89	0.31	2.47 – 3.43	2.62	0.18	2.45 – 3.04	.05
Body : snout length	6.60	0.64	5.53 – 7.40	6.04	0.46	5.58 – 7.08	.04
Head length: head height	1.77	0.11	1.59 – 1.95	1.72	0.07	1.60 – 1.85	ns
Head width : head height	1.24	0.08	1.11 – 1.37	1.19	0.08	1.00 – 1.30	ns

values for the holotype of *C. agrestis* were taken from Wilson and Couper (1995).

The mean, standard deviation and range of each variable were calculated for each taxon (Table 2). The following comparisons between taxa were made for each variable using Mann-Whitney U-tests, or x^2 tests for frequency data:

between Victoria River District and Ord region specimens of the new species;

between male and female specimens of the new species;

between all specimens of the new species and *C. robustus*, *C. joanae* and *C. agrestis*.

The similarity between all specimens in the latter comparison was also portrayed by ordination (semi-strong hybrid multidimensional scaling, Belbin 1994), using the variables measured for all specimens (Table 2). Variables showing a high degree of correlation (r>=0.9) with another variable were not included. In order to remove the overwhelming influence of body size on the ordination, snout-vent length (SVL) was excluded and body measurements expressed as a percentage of SVL.

The following abbreviations are used in the text: NTM, Museum and Art Gallery of the Northern Territory; WAM, Western Australian Museum; NMV, Museum of Victoria; AM, Australian Museum; QM, Queensland Museum.

RESULTS

Meristic and mensural characters for specimens from the Victoria River District and Ord River region are shown in Table 1.

While there are significant differences (P<0.05) between specimens from the two regions for five of the measured variables in Table 1 [mean body

Table 2 Mensural and meristic variables for *Ctenotus rimacola* sp. nov. and the three *Ctenotus* species with which it could be confused. Presented are means (± 1 SD) and ranges in parentheses. Variables for which there is a significant difference between *C. rimacola* sp. nov. and the other taxa are indicated: * P<0.05; **P<0.01; ***P<0.001.

Characteristics	*C. rimacola* sp. nov. **n = 22**	*C. robustus* **n = 28**	*C. joanae* **n = 19**	*C. agrestis* **n = 3**
No. of nuchal scales	6.8 ± 0.7 (6–8)	7.4 ± 1.1 (4–9) **	8.2 ± 0.7 (7–10) ***	8.0 ± 1.0 (7–9)
No. of supraciliary scales	9.7 ± 0.8 (9–13)	10.3 ± 1.0 (8–13) **	7.7 ± 0.5 (7–9) ***	8.3 ± 0.6 (8–9) *
No. of ciliary scales	11.2 ± 0.6 (10–13)	11.1 ± 0.5 (10–12)	10.6 ± 0.5 (10–11)	12.5 ± 0.7 (12–13) *
No. of supralabial scales	7.2 ± 0.4 (7–8)	7.3 ± 0.4 (7–8)	7.1 ± 0.3 (7–8)	7.5 ± 0.0 (7–8)
No. of ear lobules	3.2 ± 0.4 (2–4)	4.4 ± 0.6 (3–6) ***	2.7 ± 0.4 (2–3) *	3.2 ± 0.3 (3–4)
No. of hindfoot lamellae	19.5 ± 1.6 (17–22)	21.2 ± 1.1 (18–24) ***	19.3 ± 1.5 (17–22)	17.8 ± 1.0 (17–19)
No. of midbody scale rows	28.0 ± 0.8 (26–30)	29.7 ± 1.3 (26–32) ***	26.2 ± 0.7 (25–28) ***	30 ± 0.0 **
No. of paravertebral scales	55.2 ± 1.5 (52–58)	64.5 ± 3.3 (58–69) ***	54.6 ± 2.3 (51–59)	61.3 ± 1.5 (60–63) **
Nasals (% in contact)	45.5	51.8	100 ***	100
Prefrontals (% in contact)	86.4	100	0 ***	0 *
Presubocular present (%)	77.3	100	100	100
Snout-vent length (SVL)	80.0 ± 8.4 (59–94)	100 ± 17.1 (60–125) ***	70.8 ± 9.9 (55–86) **	72.8 ± 3.5 (69–76)
Percentages (of SVL)				
Body length	51.9 ± 3.5 (47.3–60.1)	54.0 ± 3.2 (46.3–60.5) *	54.2 ± 3.8 (46.9–62.1) *	52.2 ± 2.9 (49.2–55.1)
Tail length	187.6 ± 12.8 (167–206)	192.3 ± 30.0 (171–213)	182.6 ± 13.6 (169–196)	162 ± 9.1 (156–168)
Forelimb length	27.9 ± 1.7 (25.6–31.4)	23.6 ± 2.0 (20.9–28.1) ***	26.8 ± 2.0 (24.4–31.5)	26.2 ± 1.4 (24.8–27.7)
Hindlimb length	41.8 ± 2.2 (38.1–46.3)	40.0 ± 2.8 (33.8–46.0) *	41.8 ± 4.2 (34.0–49.3)	38.7 ± 1.1 (37.5–39.4) *
Forebody length	38.1 ± 2.2 (34.7–42.1)	38.0 ± 3.0 (33.5–40.8)	36.4 ± 2.1 (33.1–41.3) *	34.9 ± 1.7 (33.1–36.5)
Head length	18.9 ± 0.8 (17.2–20.3)	18.8 ± 1.3 (17.1–21.1)	18.5 ± 1.5 (16.0–21.6)	19.1 ± 0.3 (18.9–19.3)
Head width	13.1 ± 0.6 (11.9–14.2)	12.4 ± 1.0 (10.7–14.4) **	12.8 ± 1.0 (11.2–15.1) *	13.0 ± 0.1 (12.9–13.1)
Head height	10.9 ± 0.8 (9.3–12.6)	10.8 ± 0.9 (9.5–13.1)	10.2 ± 1.1 (8.3–12.7)	10.8 ± 0.3 (10.6–11.1)
Snout length	8.2 ± 0.4 (7.6–8.9)	8.2 ± 0.8 (6.9–10.1)	8.8 ± 0.9 (7.4–10.1) *	7.9 ± 0.5 (7.4–8.2)
Ratios				
Hindlimb : forelimb	1.50 ± 0.1 (1.37–1.61)	1.69 ± 0.1 (1.49–1.90) ***	1.56 ± 0.1 (1.35–1.69) *	1.48 ± 0.1 (1.43–1.51)
Hindlimb : head length	2.21 ± 0.1 (2.07–2.35)	2.13 ± 0.1 (1.95–2.39) *	2.26 ± 0.2 (1.74–2.47) *	2.06 ± 0.1 (2.04–2.08) *
Forebody : forelimb	1.37 ± 0.1 (1.16–1.52)	1.47 ± 0.1 (1.40–1.54)	1.36 ± 0.1 (1.25–1.55)	1.33 ± 0.1 (1.27–1.39)
Body : forebody	1.37 ± 0.2 (1.14–1.72)	1.42 ± 0.2 (1.26–1.68)	1.51 ± 0.2 (1.13–1.84) *	1.50 ± 0.1 (1.43–1.57)
Body : hindlimb	1.25 ± 0.1 (1.11–1.58)	1.36 ± 0.2 (1.06–1.66) **	1.31 ± 0.2 (1.02–1.57)	1.35 ± 0.1 (1.31–1.40)
Body : head length	2.76 ± 0.3 (2.45–3.43)	2.90 ± 0.3 (2.29–3.55)	2.96 ± 0.4 (2.26–3.67)	2.81 ± 0.1 (2.77–2.85)
Body : snout length	6.32 ± 0.6 (5.53–7.40)	6.66 ± 0.9 (5.12–8.44)	6.23 ± 1.0 (4.91–8.17)	6.59 ± 0.2 (6.38–6.72)
Head length: head height	1.75 ± 0.1 (1.59–1.95)	1.74 ± 0.1 (1.55–2.05)	1.82 ± 0.1 (1.52–2.18)	1.77 ± 0.1 (1.71–1.83)
Head width : head height	1.22 ± 0.1 (1.10–1.37)	1.15 ± 0.1 (1.06–1.30) ***	1.26 ± 0.1 (1.06–1.55)	1.20 ± 0.1 (1.18–1.22)

length (% of SVL); mean ratio of forelimb to hindlimb length; mean ratio of forebody to body length; mean ratio of head to body length; mean ratio of snout to body length], the ranges of each variable have considerable overlap.

Tests of sexual dimorphism revealed that males of *C. r. rimacola* ssp. nov. and *C. r. camptris* ssp. nov. have significantly shorter bodies and forebodies than do females. Additionally, male *C. r. rimacola* ssp. nov. have significantly wider heads and longer forelimbs than do females. To determine if this sexual dimorphism contributed to observed differences in body proportions between populations, those five variables which indicate significant differences were tested between populations for each sex separately. The results showed that body proportions do not differ significantly between males of the two populations, while females differed significantly only in the ratio of forelimb length to hindlimb length (*C. r. rimacola* ssp. nov.: mean = 1.46, sd = 0.06, n = 8; *C. r. camptris* ssp. nov.: mean = 1.57, sd = 0.04, n = 3; P = 0.024).

Greater differences between specimens from the two areas are found in body colour and pattern. The Ord population have an olive-brown ground colour (rather than grey-brown in Victoria River District populations), a noticeably narrower dark vertebral stripe (three quarters as wide as paravertebral scales) and absent to obscure dark laterodorsal and pale dorsolateral stripes vs distinct stripes. In colour and pattern, Victoria River District specimens more closely resemble *C. joanae* while Ord specimens are more similar to *C. robustus*.

Differences between the Victoria River District and Ord populations are not considered sufficient to warrant their description as separate species as they cannot be reliably diagnosed on any single character or combination of characters. The populations are therefore assigned to subspecies, but exact relationships cannot be resolved until further specimens of each population and from the intervening area become available. However, differences between the new taxa and other *Ctenotus* species are consistent for both type series.

SYSTEMATICS

Ctenotus rimacola rimacola ssp. nov.

Figures 2, 3, 4

Material Examined

Holotype

NTM R.22905, adult male, Lindermans Bore, Limbunya Station, 17°33'S 130°05'E, Northern Territory, Australia, collected by A. Fisher, 06 October 1996.

Paratypes

Northern Territory: NTM R.18344, NTM R.18346, Kidman Springs Station, 16°06'S 130°58'E, collected by A. Fisher, 25 May 1997; NTM R.20444, near Waterbag Bore, Victoria River Downs Station, 16°23'S 131°26'E, collected by J. Woinarski, 14 May 1994; NTM R.21537, Kirkimbie Station, 17°52'S 129°08'E, collected by A. Fisher, 08 June 1995; NTM R.22803–805, Kirkimbie Station, 17°52'S 129°08'E, collected by A. Fisher, 1–4 October 1996; NTM R.23242–244, near No. 5 Bore, Mount Sanford Station, 17°10'S 130°54'E, collected by A. Fisher, 06 December 1996.

Diagnosis

A moderately large and robust member of the *C. lesueurii* species-group, *C. r. rimacola* ssp. nov. differs from other members of this species-group by having prefrontals usually in contact, seven supralabials, prominent pale dorsolateral stripe, distinct dark, pale edged vertebral stripe and a maximum snout-vent length of 94 mm. It is distinguished from *C. r. camptris* ssp. nov. in having an grey-brown ground colour and more intense patterning, with a prominent dark vertebral stripe as wide as paravertebral scales, distinct dark laterodorsal and pale dorsolateral stripes and longitudinally striped pattern on hindlimbs.

Description

Head

Snout length 41–46% (mean = 43.8%) of head length. Prefrontal scales usually in broad contact (90.9%). Nasal scales usually in narrow contact (63.6%), or narrowly separated by rostral and frontonasal scales. Frontoparietal scales paired. Interparietal scale distinct. Loreal scales two, second larger than first. Upper and lower preocular scales present. Presubocular scale present (54.5%) or absent (45.5%), being fused with subocular scale. Nuchal scales six to eight (mean = 6.8). Supraciliary scales nine to thirteen (mean = 10.0), median five or six much smaller than first three and final scale in series. Ciliary scales ten to thirteen (mean = 11.3). Supralabial scales seven or eight (mean = 7.4), fifth or sixth under orbit. Ear lobules three or four (mean = 3.3).

Body

Snout-vent length to 94 mm (mean = 78.6 mm). Body length 48–60% (mean = 53.9%) of snout-vent length. Tail length 167–199% (mean = 181%) of snout-vent length. Paravertebral scales 52-57 (mean = 55). Midbody scale rows 26–30 (mean = 28.1)

Limbs

Forelimb length 26–31% (mean = 28.3%) of snout-vent length. Hindlimb length 38–46% (mean =

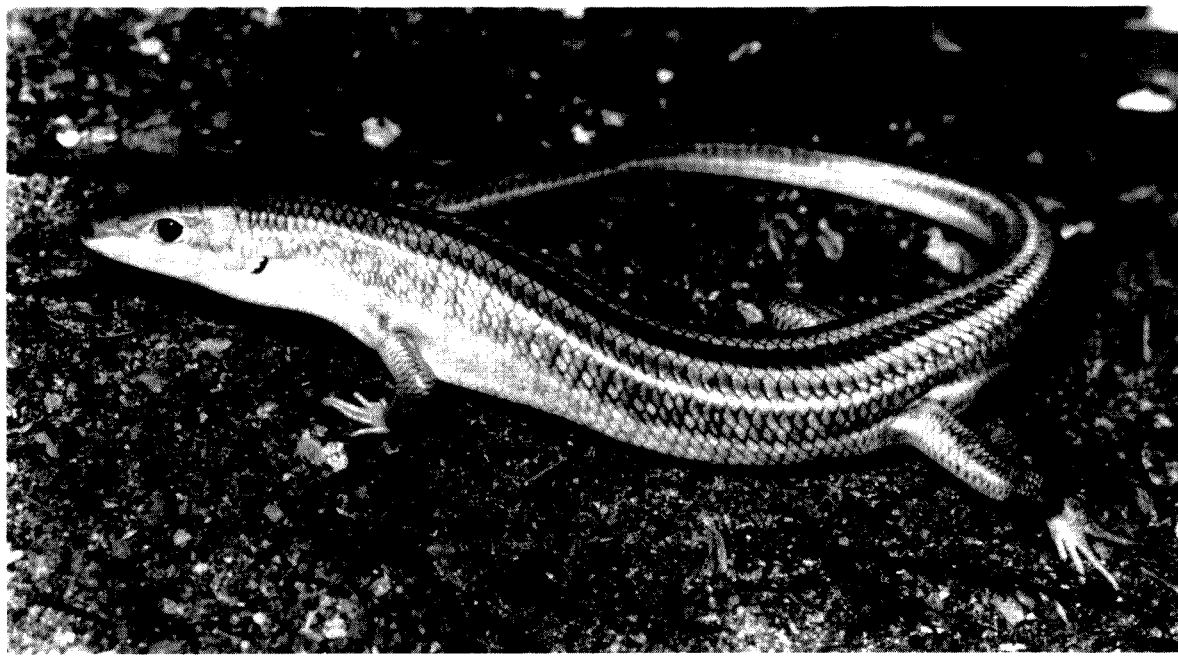

Figure 2 Holotype of *Ctenotus rimacola rimacola* ssp. nov. (NTM R.22905) in life.

41.6%) of snout-vent length. Subdigital lamellae under fourth toe 17–22 (mean = 19.5).

Colour and pattern (in spirit)

Holotype

Body pattern consists of a complex arrangement of smooth-edged, longitudinal stripes, zones of ground colour and pale blotches (Figure 2).

Body

Dorsal surface pale grey-brown, patterned with smooth edged stripes. Prominent, broad, blackish-brown vertebral stripe, as wide as paravertebral scales, extends from anterior nuchal scales to base of tail. Vertebral stripe margined by obscure, white paravertebral stripes which are about one quarter as wide as vertebral stripe. Paravertebral stripes bordered by zones of grey-brown background colour, about as wide as paravertebral scales, which extend from parietal scales onto tail. Outer margins of background colour zones bordered by prominent, blackish-brown laterodorsal stripes, about half as wide as vertebral stripe, which extend from outer edge of parietal scales onto tail. Outer margins of laterodorsal stripes bordered by distinct, white dorsolateral stripes, about a third as wide as vertebral stripe, which extend from outer edge of fourth supraciliary scales onto tail. Lateral surface of body light grey-brown, patterned with pale blotches and pale mid-lateral stripe. Broad light grey-brown upper lateral zone extends from above auricular opening onto tail and is patterned with single, regular series of 19–20 large pale blotches. White mid-lateral stripe most prominent posteriorly, about one third as wide as upper lateral zone, extends from upper posterior margin of auricular opening, above limbs onto tail. Between midbody and auricular opening, mid-lateral stripe broken into series of elongate pale blotches. Grey lower lateral zone, about three quarters as wide as upper lateral zone, extends from below auricular opening to hindlimb, zone patterned by a series of about ten obscure pale blotches. Lower lateral zone coalesces into immaculate whitish ventral surface.

Head

Immaculate light brown dorsally. Temporal region brown, patterned with a single pale blotch. Obscure, white subocular stripe extends from first loreal scale to auricular opening. Supralabials pale grey. Infralabials off-white. Ventral surface white, changing to cream on mental scale.

Limbs

Immaculate light brown ground colour on dorsal surface of forelimbs. Off-white on ventral surface. Hindlimbs similar but patterned with three or four obscure brown stripes.

Tail

Light grey-brown on dorsal surface. Basal portion has remnants of dark vertebral stripe. Laterally, continuations of dark laterodorsal stripes, pale dorsolateral stripes, upper lateral zone and pale mid-lateral stripes extend along anterior two thirds of tail. Off-white on ventral surface.

Variation in paratypes

Variation in meristic and mensural variables of

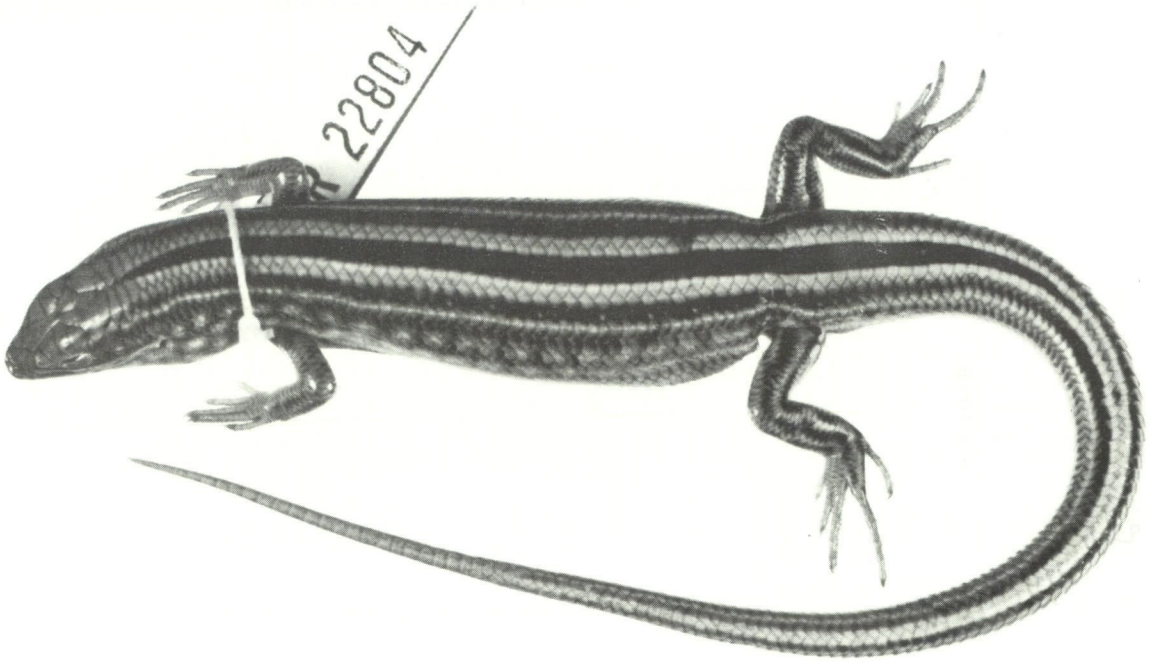

Figure 3 Paratype of *Ctenotus rimacola rimacola* ssp. nov. (NTM R.22804), showing typical body pattern.

paratypes is summarised in Table 1. Most specimens conform to the holotype's body pattern and colour, differing only in intensity (Figure 3) (eg. vertebral and laterodorsal stripes black in 50% of specimens) and continuity of pale mid-lateral stripe (varies from continuous for length of body to a prominent longitudinal series of elongate blotches and dashes). Two specimens (NTM R.20444, NTM R.23242) have the pale dorsolateral stripes broken, on the anterior third of body, into a series of pale elongate dashes. Pattern and colour become increasingly drab as specimens age.

Sex ratio and sexual dimorphism

The sex ratio of the specimens examined favoured females (3:8). All meristic and mensural variables were tested for sexual dimorphism, with significant differences being found only for head width (% of SVL) (males: mean = 13.9, sd = 0.30, n = 3; females: mean = 12.8, sd = 0.64, n= 8; P = 0.014); ratio of forebody length to body length (males: mean = 1.28, sd = 0.15, n = 3; females: mean = 1.51, sd = 0.16, n= 8; P = 0.041); and, ratio of forelimb length to forebody length (males: mean = 1.43, sd = 0.09, n = 3; females: mean = 1.29, sd = 0.05, n= 8; P = 0.014). Mean body length (% of SVL) also differed between sexes, although probability was slightly greater than 0.05 (males: mean = 50.9, sd = 2.88, n = 3; females: mean = 55.0, sd = 3.01, n= 8; P = 0.066).

Details of holotype

(NTM R.22905). Adult male. Snout-vent length 82.5 mm; tail length 156 mm; body length 39.7 mm; forelimb length 22.8 mm; hindlimb length 33.3 mm; head width 11.7 mm; head depth 8.8 mm; snout length 7.2 mm; head length 16.1 mm; forelimb to snout length 34.7 mm; nasals in narrow contact; prefrontals in narrow contact; supraciliaries nine on both sides; ciliaries 12 on both sides; supralabials seven on both sides; nuchal scales eight; ear lobules four on both sides, second from top largest; subdigital lamellae under fourth toe 17 on both sides; midbody scale rows 27; paravertebral scales 55.

Heart and liver tissue samples were taken from the holotype at death. These are lodged in the South Australian Museum's tissue bank under the number SAM-EBU Z99.

Etymology

The epithet *rimacola* is a combination of the Latin *rima* (cleft or fissure) and *cola* (dwelling in) and refers to the distinctive, deeply cracking clay soils which this species inhabits.

Distribution and conservation status

The known distribution of *C. r. rimacola* ssp. nov. is in the Victoria River District of the northwestern Northern Territory (Figure 1). In this region it has been collected on Mount Sanford, Kirkimbie, Victoria River Downs, Limbunya and Kidman Springs Stations.

Using the quantitative ranking method adopted by Cogger *et al.* (1993) to assess conservation status, and conservatively extrapolating some variables from congeners, *C. r. rimacola* ssp. nov. is scored at 22.3. This score is within the range assigned to the "Rare or insufficiently known" category.

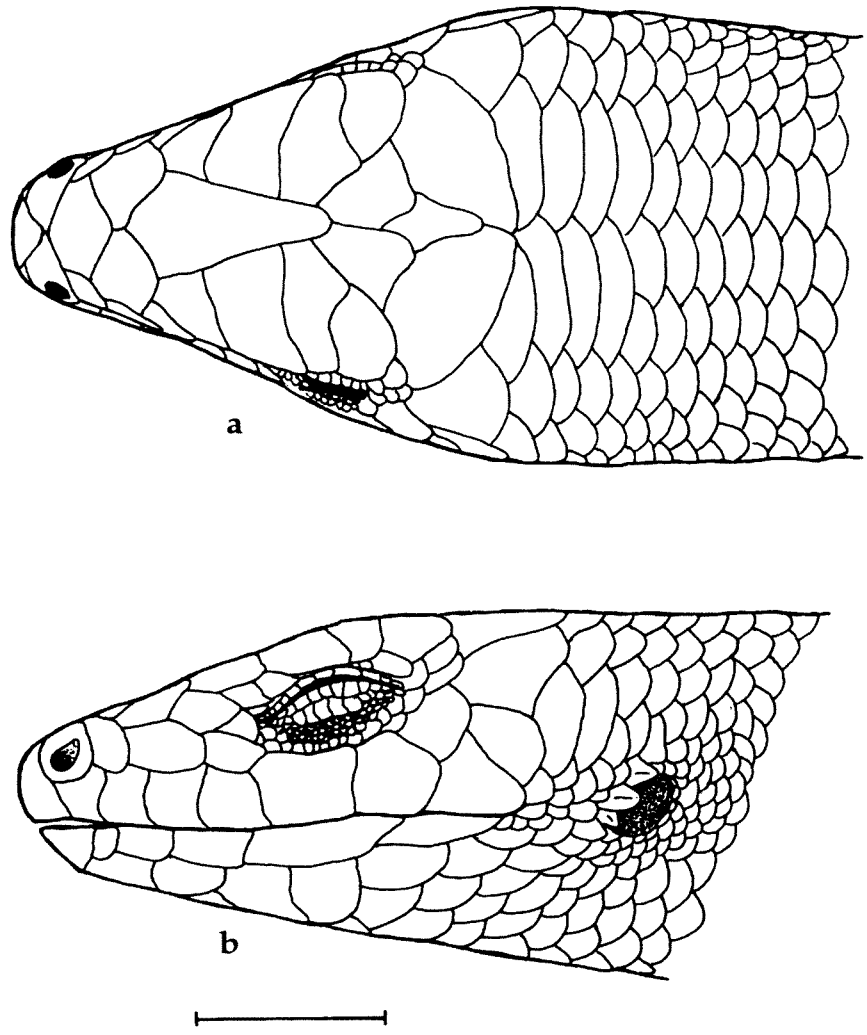

Figure 4 Holotype of *Ctenotus rimacola rimacola* ssp. nov. (NTM R.22905). Head scalation in a) dorsal and b) right lateral view. Scale bar = 5 mm

Habitat

All specimens were collected from areas of grey to grey-brown heavy clay soil, which is fissured by deep cracks for the majority of the year. Collection locations from Kirkimbie and Limbunya Stations were on treeless plains, while those on Mount Sanford, Victoria River Downs and Kidman Springs were plains or gently undulating rises with sparse woodland of *Terminalia arostrata* and *T. volucris*. In most cases the understorey was dominated by perennial grasses to 40 cm tall, including *Astrebla pectinata, A. elymoides, A. squarrosa, Chrysopogon fallax, Dicanthium fecundum* and *Aristida latifola*. At Victoria River Downs, the understorey was dominated by the annual grass *Brachyachne convergens* and the forbs *Sesbania simpliciuscula* and *Jacquemontia browniana*. At the time of collection, late in the Dry season, understorey cover ranged from 7% to 38%.

Ctenotus rimacola camptris **ssp. nov.**

Figures 5, 6

Material Examined

Holotype

WAM R.126064, adult male, c. 4 km south-west of Point Spring Yard, 15°25'S 128°51'E, Western Australia, Australia, collected by Ecologia Environmental Consultants, 14 October 1996.

Paratypes

Western Australia: WAM R.116456–457, WAM R.126012–013, WAM R.126065, 7 km south of Point Spring Yard, 15°27'S 128°52'E, collected by Ecologia Environmental Consultants, 14–17 October 1996; WAM R.125996, WAM R.126010, 20 km north of Mount Septimus, 15°33'S 128°58'E, collected by Ecologia Environmental Consultants, 18–19 October 1996; WAM R.125998, WAM

R.126015, 15 km north of Mount Septimus, 15°35'S 128°59'E, collected by Ecologia Environmental Consultants, 19 October 1996. **Northern Territory**: NTM R.22936, Spirit Hills Station, 15°23.52'S 129°05.3'E, collected by Ecologia Environmental Consultants, 12 October 1996.

Diagnosis

A moderately large and robust member of the *C. lesueurii* species-group, *C. r. camptris* ssp. nov. differs from other members of this species-group by having prefrontals usually in contact, seven supralabials, prominent pale dorsolateral stripe, distinct dark, pale edged vertebral stripe and a maximum snout-vent length of 88 mm. It is distinguished from *C. r. rimacola* ssp. nov. in having an olive-brown ground colour and less intense patterning, with a narrower dark vertebral stripe, obscure dark laterodorsal and pale dorsolateral stripes and dark mottling on hindlimbs.

Description

Head

Snout length 41–45% (mean = 43.5%) of head length. Prefrontal scales usually in broad contact (81.8%). Nasal scales usually narrowly separated (72.7%) by rostral and frontonasal scales, occasionally in narrow contact. Frontoparietal scales paired. Interparietal scale distinct. Loreal scales two, second larger than first. Upper and lower preocular scales present. Presubocular scale present. Nuchal scales six to eight (mean = 6.7). Supraciliary scales nine to eleven (mean = 9.4), median five or six much smaller than first three and final scale in series. Ciliary scales ten to twelve (mean = 11.0). Supralabial scales seven, fifth under orbit. Ear lobules two to four (mean = 3.0).

Body

Snout-vent length to 88 mm (mean = 81.4 mm). Body length 47–54% (mean = 49.9%) of snout-vent length. Tail length 188–206% (mean = 194%) of snout-vent length. Paravertebral scales 53–58 (mean = 55.4). Midbody scale rows 26–28 (mean = 27.8)

Limbs

Forelimb length 25–30% (mean = 27.6%) of snout-vent length. Hindlimb length 38–46% (mean = 42%) of snout-vent length. Subdigital lamellae under fourth toe 17–22 (mean = 19.4).

Colour and pattern (in spirit)

Holotype

Body pattern consists of a complex arrangement of smooth-edged, longitudinal stripes, zones of ground colour and pale blotches (Figure 5).

Body

Dorsal surface light olive-brown, patterned with smooth edged stripes. Prominent, black vertebral stripe, three quarters as wide as paravertebral scales, extends from second nuchal scales to base of tail. Vertebral stripe margined by obscure, pale brown paravertebral stripes which are about one quarter as wide as vertebral stripe. Paravertebral stripes bordered by zones of light olive-brown background colour, about as wide as paravertebral scales, which extend from parietal scales onto tail. Outer margins of background colour zones bordered by narrow, discontinuous blackish-brown laterodorsal stripes, about a quarter as wide as vertebral stripe, which extend from just anterior of forelimb to hindlimb. Outer margins of laterodorsal stripes bordered by obscure, cream dorsolateral stripes, about a third as wide as

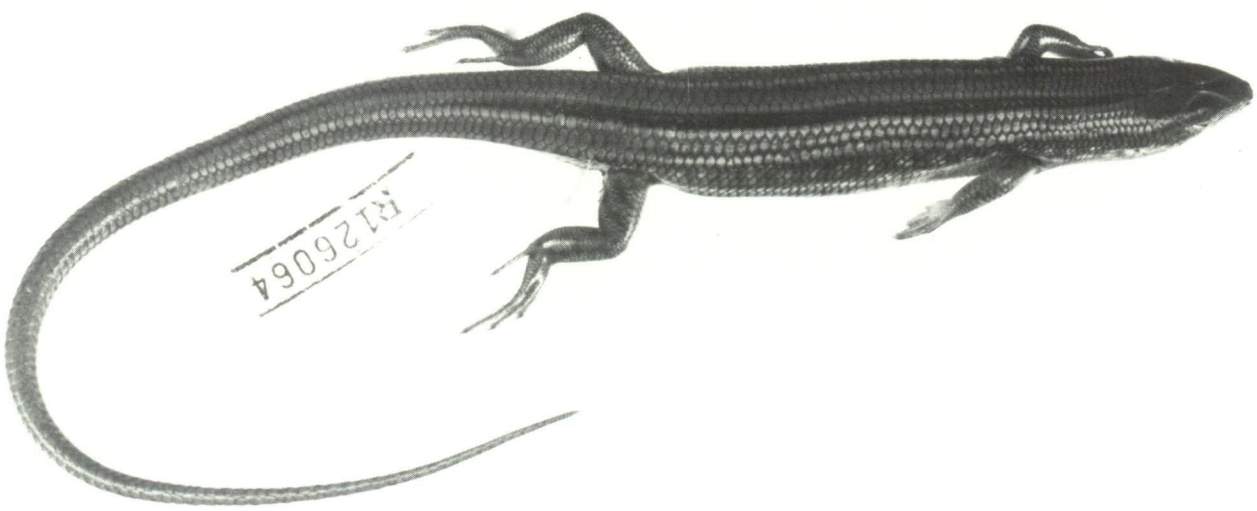

Figure 5 Holotype of *Ctenotus rimacola camptris* ssp. nov. (WAM R.126064).

vertebral stripe, which extend from outer edge of parietal scales to hindlimb. Lateral surface of body olive-brown, patterned with pale blotches and pale mid-lateral stripe. Broad olive-brown upper lateral zone extends from above auricular opening to hindlimb and is patterned with single, regular series of 18–19 large pale blotches. White mid-lateral stripe most prominent posteriorly, about one third as wide as upper lateral zone, extends from midpoint between auricular opening and forelimb, above limbs onto tail. On anterior third of body, mid-lateral stripe broken into series of elongate pale streaks and blotches. Light brown lower lateral zone, about three quarters as wide as upper lateral zone, extends from below auricular opening to hindlimb, zone patterned by a series of about 10–12 obscure pale blotches. Lower lateral zone coalesces into immaculate whitish ventral surface.

Head

Immaculate dark brown dorsally. Temporal region brown, patterned with a single pale fleck. Discontinuous white subocular stripe extends from second loreal scale to temporals. Supralabials pale brown. Infralabials off-white. Ventral surface white.

Limbs

Immaculate olive brown ground colour on dorsal surface of forelimbs. Off-white on ventral surface. Hindlimbs similar but obscurely patterned with brown flecks and variegations.

Tail

Olive-brown on dorsal surface. Basal portion has remnants of dark vertebral stripe. Laterally, vague discontinuous remnants of dark laterodorsal stripes, pale dorsolateral stripes, upper lateral zone and pale mid-lateral stripes extend along anterior two thirds of tail. Off-white on ventral surface.

Variation in paratypes

Variation in meristic and mensural variables of paratypes is summarised in Table 1. Most specimens conform to the holotype's body pattern and colour, differing only in intensity of pattern (eg. narrow dark laterodorsal and pale dorsolateral stripes prominent and continuous to virtually absent) and continuity of pale mid-lateral stripe (varies from continuous for length of body to broken anteriorly into a series of elongate blotches and dashes).

Sex ratio and sexual dimorphism

The sex ratio of the specimens examined favoured males (8:3). All meristic and mensural variables were tested for sexual dimorphism, with significant differences found only for body length (% of SVL) (males: mean = 48.7, sd = 1.11, n = 8; females: mean = 53.3, sd = 1.45, n= 3; P = 0.014); and ratio of forebody to body length (males: mean = 1.25, sd = 0.05, n = 8; females: mean = 1.42, sd = 0.06, n= 3; P = 0.014).

Details of holotype

(WAM R.126064). Adult male. Snout-vent length 81.0 mm; tail length 155 mm; body length 39.5 mm; forelimb length 22.6 mm; hindlimb length 33.6 mm; head width 10.9 mm; head depth 8.95 mm; snout length 6.53 mm; head length 15.3 mm; forelimb to snout length 30.1 mm; nasals broadly separated; prefrontals in narrow contact; supraciliaries nine on both sides; ciliaries 11 on right, 12 on left; supralabials seven on both sides; nuchal scales six; ear lobules three on left, four on right, upper largest; subdigital lamellae under fourth toe 21 on both sides; midbody scale rows 28; paravertebral scales 55.

Etymology

The epithet *rimacola* is a combination of the Latin *rima* (cleft or fissure) and *cola* (dwelling in) and refers to the distinctive, deeply cracking clay soils which this species inhabits. *Camptris* is derived from the Latin *campus* (field or plain) and *-tris* (where or place for) and also refers to the black-soil plains which this subspecies inhabits.

Distribution and conservation status

The known distribution of *C. r. camptris* ssp. nov. is on the northern floodplains of the Ord and Keep Rivers, adjacent to the Western Australia/ Northern Territory border (Figure 1). In this region it has been collected north of Kununurra, near Mount Septimus and Point Spring Yard in Western Australia, and on Spirit Hills Station in the Northern Territory.

Using the quantitative ranking method adopted by Cogger *et al.* (1993) to assess conservation status, and conservatively extrapolating some variables from congeners, *C. r. camptris* ssp. nov. is scored at 22.3. This score is within the range assigned to the "Rare or insufficiently known" category.

Habitat

All specimens were collected from alluvial plains of grey or brown cracking clays. These habitats typically have an understorey of *Chrysopogon, Dicanthium, Themeda* and *Sorghum* spp. and often a sparse overstorey of *Lysiphyllum cunninghamii.*

COMPARISON WITH SIMILAR SPECIES

As an aid to identification of *Ctenotus* in Western

Australia, Storr (Storr 1981; Storr *et al.* 1981) distributed the species from that region among ten species-groups. Based on characters in common, these species-groups are not necessarily natural but are useful in clustering similar species together. Wilson and Knowles (1988) tentatively recognised twelve species-groups incorporating all *Ctenotus* species. The following five character states in combination place the new taxa in the *C. lesueurii* species-group of Storr (Storr 1981; Storr *et al.* 1981). Digits slightly compressed, smooth or with moderately broad, dark calli on the subdigital lamellae. Usually four supraocular scales, first three contacting frontal, second larger than first, third and fourth. Supraciliary scales very disparate in size (a median series much smaller than outers). Ear lobules large and graded in size. Colour pattern includes a dark, pale-edged vertebral stripe.

Horner (1995) summarises the content of the *C. lesueurii* species-group as: *C. arcanus* Czechura and Wombey; *C. arnhemensis* Storr; *C. astictus* Horner; *C. borealis* Horner and King; *C. brachyonyx* Storr; *C. capricorni* Storr; *C. coggeri* Sadlier; *C. eurydice* Czechura and Wombey; *C. eutaenius* Storr; *C. fallens* Storr; *C. helenae* Storr; *C. hypatia* Ingram and Czechura; *C. ingrami* Czechura and Wombey; *C. inornatus* (Gray); *C. lateralis* Storr; *C. lesueurii* (Duméril and Bibron); *C. mastigura* Storr; *C. monticola* Storr; *C. nullum* Ingram and Czechura; *C. robustus* Storr; *C. saxatilis* Storr; *C. severus* Storr; *C. spaldingii* (Macleay); *C. stuarti* Horner; *C. taeniolatus* (White, *ex* Shaw); *C. terrareginae* Ingram and Czechura; and *C. vertebralis* Rankin and Gillam. To these can now be added *C. agrestis* Wilson and Couper and *C. rimacola*. Additionally, based on its narrowly callused subdigital lamellae, *C. joanae* is considered by Storr (1970) to be an aberrant member of the *C. leonhardii* species-group. However, it could equally be considered a member of the *C. lesueurii* species-group, as it agrees in most other respects with the criteria for that group.

The new taxa is distinguished from other members of the *C. lesueurii* species-group by the following eight character states in combination: four supraocular scales; body dorsal surface with

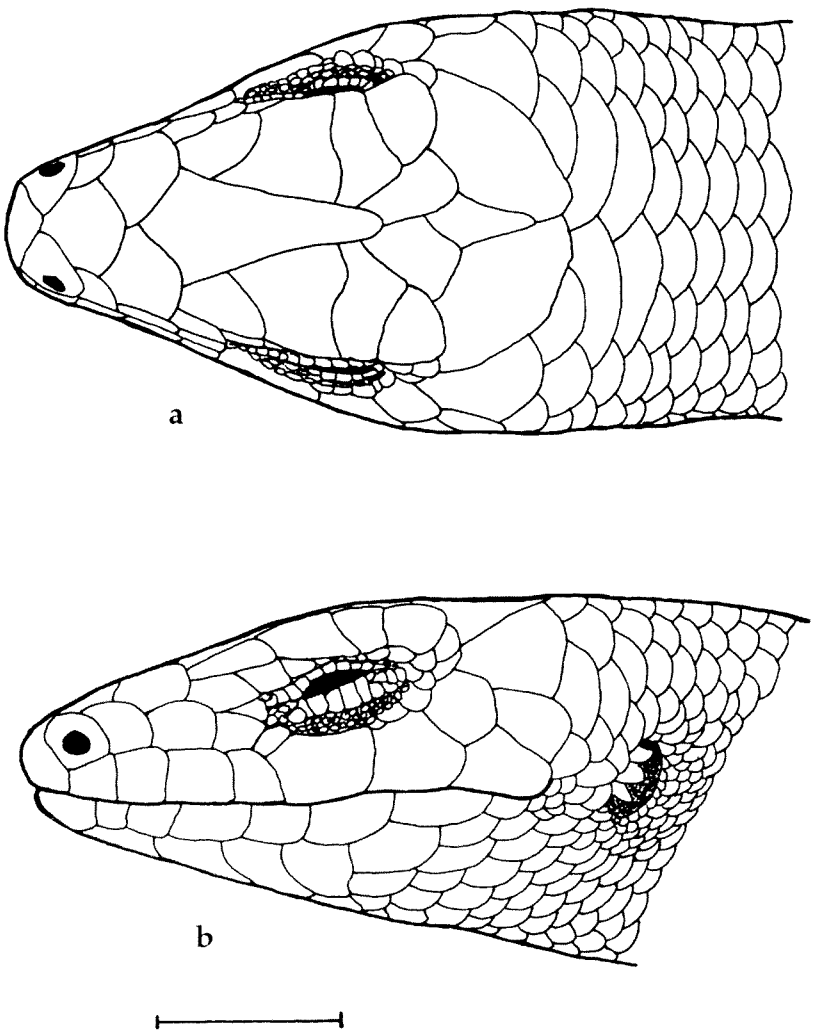

Figure 6 Holotype of *Ctenotus rimacola camptris* ssp. nov. (WAM R.126064). Head scalation in a) dorsal and b) right lateral view. Scale bar = 5 mm

three dark longitudinal stripes; prefrontal scales usually in broad contact; usually seven supralabial scales; pale subocular stripe present; white dorsolateral stripes present; maximum snout-vent length less than 100 mm; paravertebral scales less than 59.

Those species with which *C. rimacola* could be confused are *C. robustus*, *C. joanae* and *C. agrestis*. Table 2 summarises mensural and meristic variables of the four species.

Ctenotus rimacola can be distinguished from *C. robustus* by having fewer paravertebral scales (mean = 55.2 [range 52–58] vs 64.5 [58–69]). Although the ranges overlap for other variables, *C. rimacola* also has significantly fewer midbody scale rows (mean 27.9 vs 29.7), fewer ear lobules (mean 3.2 vs 4.4), fewer hindfoot lamellae (mean 19.5 vs 21.2), shorter hindlimbs (relative to body length), and narrower relative headwidth. *Ctenotus rimacola* also has a smaller recorded maximum size than *C. robustus* (SVL 94 vs 125 mm).

Ctenotus rimacola can usually be distinguished from *C. joanae* by having prefrontal scales in contact rather than separated. While ranges of the variables overlap, *C. rimacola* also has a significantly higher midbody scale count (mean 27.9 vs 26.2), fewer nuchal scales (mean 6.8 vs 8.2) and more supraciliary scales (mean 9.7 vs 7.7).

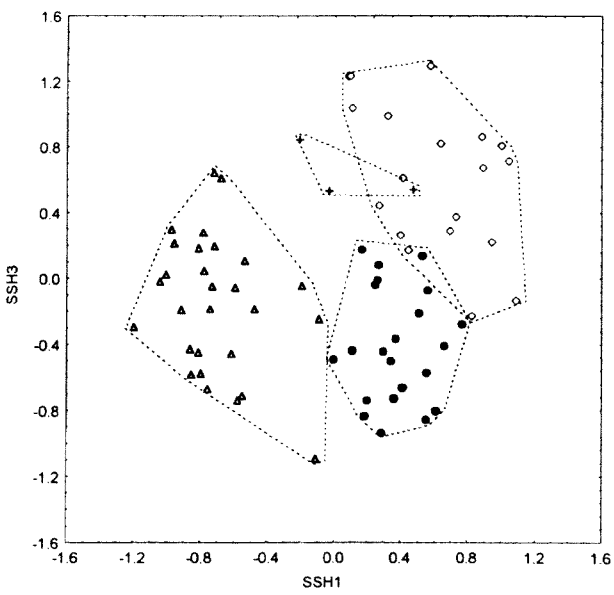

Figure 7 Ordination of specimens of four *Ctenotus* species according to mensural and meristic variables (*C. rimacola* sp. nov. – closed circles; *C. joanae* – diamonds, *C. robustus* – triangles; *C. agrestis* – crosses). All variables shown in Table 2 were used in the ordination with the exception of: snout-vent length; tail length; snout length; all ratios incorporating body length. The first and third dimensions of a three-dimensional ordination are illustrated, the second dimension not serving to separate the taxa.

Ctenotus rimacola has smooth subdigital lamellae, while they are bluntly keeled in *C. joanae*. Additionally, *C. rimacola* differs from *C. joanae* by the upper lateral pattern (series of pale blotches versus unpatterned, or occasionally a series of small pale dots). For the specimens measured, *C. joanae* had a slightly smaller maximum size than *C. rimacola* (86 vs 94mm).

Although measurements for only three specimens of *C. agrestis* are available, *C. rimacola* can be distinguished from this species by usually having prefrontal scales in contact rather than separated, fewer paravertebral scales (52–58 vs 60–63) and less midbody scale rows (mean 27.9 vs 30).

The ordination of specimens of the four species by 23 measured characters is shown in Figure 7. While *C. joanae* and *C. robustus* are clearly separated, specimens of *C. rimacola* occupy an intermediate position in the ordination space.

DISCUSSION

The *Ctenotus* fauna of the arid centre and monsoonal north of Australia is diverse, with a high number of sympatric, or even syntopic, species in both deserts and savanna woodland (Pianka 1969, Reid *et al* 1993, Sadlier *et al* 1985, Horner 1995). By contrast, few *Ctenotus* species are found on black-soil plains in northern Australia, reflecting the low diversity of the reptile fauna generally, and presumably arising from the very limited habitat variability. Many of the common reptile species of black-soil plains do however show a strong fidelity to this habitat. Recent biological survey of the Barkly Tableland of the Northern Territory (Fisher, unpubl. data) showed that *Ctenotus joanae* was widespread, occurring at 61 of 77 black-soil sample sites, and was the most abundant reptile recorded. However, this species was absent from sites in red loam soils immediately adjacent to the black soil plains. Conversely, while a number of *Ctenotus* species were recorded from loam sites, no other *Ctenotus* species was recorded from black soil sites, with the exception of *C. pulchellus* Storr 1978 which occurred only on low gravelly rises and *C. leonhardii* (Sternfeld 1919), which occurred patchily on the southern margin of the clay plains. The extensive black soil grasslands of central Queensland appear to contain a greater diversity of *Ctenotus* species, with at least four taxa reported to occur in this environment (*C. joanae*, *C. robustus*, *C. schevilli* and *C. agrestis*; Wilson and Knowles 1988, Ingram and Raven 1991, Cogger 1994, Wilson and Couper 1995). However, the distribution of reptile species in this region is very poorly known and systematic survey is required to determine whether these species are geographically or environmentally partitioned.

Ctenotus rimacola appears to be the ecological analogue of *C. joanae* in the black-soil grasslands of northwestern Australia. The limited systematic sampling in this area to date indicates that *C. r. rimacola* is moderately common, occurring in 11 of 25 sample sites (Fisher unpubl. data). It was also the only *Ctenotus* species recorded from these sites, although Horner (1992) reports that *C. militaris* Storr 1975 (which is very similar to *C. pulchellus*) is found in black soil grasslands in this region. *Ctenotus rimacola* has not been recorded from habitats other than black-soil grasslands, while *C. robustus* and *C. inornatus* Gray 1845 were present at loam woodland sites immediately adjacent to black soil plains where *C. rimacola* occurred (G. Connell pers. comm., Fisher unpubl data). The black-soil plains of the Victoria River District are isolated from those of the Barkly Tableland by the lateritic surface of the Sturt Plateau, which separates them by a minimum distance of approximately 200km. This barrier represents the westerly limit of a number of other black-soil-endemic reptile species which are common on the Barkly Tableland, such as *Varanus spenceri* and *Pseudonaja guttata*.

We postulate that *C. rimacola* and *C. joanae* are closely related taxa, that have either speciated following the isolation of previously more contiguous black-soil environments in northern Australia, or are commonly derived from a broadly distributed ancestor (such as *C. robustus*). *Ctenotus rimacola* does not however appear to merely represent the extreme end of a geographical cline in *C. joanae*, as the ordering of specimens of *C. joanae* in the ordination space (Figure 7) shows no relationship with their geographic ordering.

As their exact affinities remain unresolved by detailed meristic and mensural analysis (Table 1), further work (eg. allozyme electrophoresis) is needed to clarify the status of the two subspecies attributed here to *C. rimacola*. Frozen tissues are available for *C. r. camptris*, but only the holotype of *C. r. rimacola* has been tissue sampled. The two populations are apparently allopatric and may be geographically isolated, as the inland plains of the Victoria River Downs are separated from the coastal Ord and Keep River plains by the dissected Victoria River Plateau. This is a region of rocky skeletal soils, although it does contain scattered patches of clay soils (Stewart *et al* 1970). It remains for further biological survey to determine whether the distribution of *C. rimacola* also extends into the black-soil grasslands in the western and southern Kimberley region of Western Australia.

ACKNOWLEDGEMENTS

We are grateful to L. Smith of the Western Australian Museum for bringing the Ord River series of specimens to our attention, and for the loan of specimens in his care. Habitat details for the Ord River series were supplied by Ecologia Environmental Consultants. Comparative *C. robustus* material was loaned to us by John Coventry of the Museum of Victoria and by Ross Sadlier of the Australian Museum. *Ctenotus agrestis* specimens were loaned by Patrick Couper of the Queensland Museum. Biological survey of Mitchell Grass communities in the Northern Territory was funded by the grants to the Parks and Wildlife Commission NT from the National Reserve System Program (Environment Australia) and the National Estate Grant Program (Australian Heritage Commission). Maps were prepared by Damian Milne. Helpful comments on the manuscript were provided by John Woinarski. Rick Bawden photographed specimens for figures 4 and 6.

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Appendix 1. Comparative specimens examined.

Ctenotus agrestis

QUEENSLAND: PARATYPES, QMJ.46689, QMJ.46695, 22°57'S 145°14'E, Brendallan Station.

Ctenotus joanae

NORTHERN TERRITORY: NTM R.2579, 20°00'S 137°56'E, 25.5km W Qld border on Barkly Hwy; NTM R.3636, 17°59'S 135°36'E, Anthony Lagoon Stn; NTM R.5325, 17°59'S 135°32'E, Anthony Lagoon Stn.; NTM R.5232, NTM R.16424, 18°39'S 135°57'E, Brunette Downs Stn; NTM R.8446–47, 19°23'S 135°24'E, No.6 Bore Rockhampton Downs Stn; NTM R.8590, 18°42'S 135°57'E, Barkly Stock Route; NTM R.9573, 19°06'S 136°12'E, No.17 Bore Alroy Downs Stn; NTM R.14628, 19°49'S 137°55'E, Barwidgee Creek, Rocklands Stn; NTM R.21549, 19°13.7'S 137°28.1'E, Alexandria Stn; NTM R.21555, 19°16.9'S 137°31.4'E, Alexandria Stn; NTM R.22154, 22°43'S 137°47'E, Toko Ranges, Tobermorey Stn; NTM R.23221, NTM R.23225, 16°54'S 133°19'E, Hayfield Stn; NTM R.23236, 21°11'S 137°09'E, Georgina Downs Stn; NTM R.32016 (CAMR484), 20°12'S 137°27'E, Alroy Downs Stn; NTM R.32017 (NTM5337), 18°57'S 136°05'E, Alroy Downs Stn; NTM R.32021 (NTM5365), 18°05'S 136°34'E, Connells Lagoon Conservation Reserve.

Ctenotus robustus

NORTHERN TERRITORY: HOLOTYPE, NMV D.4957, 21°32'S 133°53'E, Barrow Creek, collected by Spencer-Gillen Expedition, 1901; PARATYPES – NMV D.40, NMV D.2912, NMV D.2918, NMV D.2922–23, NMV D.2939, 19°59'S 134°11'E, Tennant Creek, collected by Spencer-Gillen Expedition, 1901; NMV D.5616, NMV D.4958–60, NMV D.2925, 21°32'S 133°53'E, Barrow Creek, collected by Spencer-Gillen Expedition, 1901; NMV D.548, 21°32'S 133°53'E, Barrow Creek, collected by W.B. Spencer, 23 June 1916. NON-TYPE MATERIAL: NTM R.2246, 21°41'S 132°48'E, 4km SE Jabiru; NTM R.5744, 20°48'S 134°14'E, Whycliffe Well; NTM R.18560–62, 15°15.14'S 129°08.10'E; Keep River; NTM R.22934, NTM R.22935, 15°18.26'S 129°09.30'E, Spirit Hills Station; NTM R.32189 (NTM857), 20°47'S 129°28'E, Tanami Desert; NTM R.32186 (NTM869), 18°46'S 131°17'E, Merrina Waterhole; NTM R.32188 (NTM983), 19°44'S 130°13'E, near Lake Buck; NTM R.13088, 12°58'S 135°29'E, Donyoji.

QUEENSLAND: AM R.62271, AM R.62273, AM R.62275, 22°46'S 144°53'E, 38km S Muttaburra.

WESTERN AUSTRALIA: NTM R.13031, 16°15'S 128°45'E, Lake Argyle.

Manuscript received 9 December 1997; accepted 3 August 1998.