

Lordomyrma (Hymenoptera: Formicidae) of the Fiji Islands¹

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Abstract: This revision treats the members of the ant genus *Lordomyrma* (Formicidae: Myrmicinae) occurring in Fiji. Ten species are recognized, of which four are new: *L. curvata* **sp. n.**, *L. desupra* **sp. n.**, *L. levifrons* (Mann) **stat. n.**, *L. polita* (Mann) **stat. n.**, *L. rugosa* (Mann), *L. sukuna* **sp. n.**, *L. stoneri* (Mann) **stat. n.**, *L. striatella* (Mann), *L. tortuosa* (Mann), and *L. vuda* **sp. n.** Descriptions of each species are provided, along with distribution maps and a key for the identification of workers. Additional figures and identification tools are available on Antweb <<http://www.antweb.org/fiji.jsp>>. A preliminary comparison with *Lordomyrma* from Australia, New Guinea, and New Caledonia is followed by a discussion of the distribution of species within Fiji and an outline of future research directions pertaining to the taxonomy, biogeography and conservation of the Fijian species.

BACKGROUND

The genus *Lordomyrma* (Formicidae: Myrmicinae) Emery is comprised of relatively uncommon and often elegantly sculptured ants occurring in the Australian and Oriental regions. Species have been described from Japan, New Guinea, eastern Australia, New Caledonia, the Solomon Islands and Fiji (Bolton 1995), with additional undescribed species being reported from Borneo (Brühl *et al.* 1998). Of the 24 currently recognized species in the genus (including those described here), ten are endemic to the Fijian archipelago. Although museum holdings reveal many undescribed species from other areas, particularly New Guinea and New Caledonia (R.W. Taylor, pers. comm.) the diversity of *Lordomyrma* species in Fiji is substantial. Despite its remote location in the South Pacific and its small geographic area, the Fiji archipelago supports a diverse ant fauna. In a recent review of Fiji's ants, Ward & Wetterer (2006) listed 32 genera and 138 described species and subspecies, including 91 archipelago endemics, 22 Pacific-wide natives, and 25 exotics.

Within the Fiji archipelago, the genus has been collected from the two largest islands (Viti Levu and Vanua Levu) and from a handful of mid-sized islands, including Koro, Taveuni, Ovalau and Kadavu. Little is known about the biology of the Fijian *Lordomyrma* beyond their association with undisturbed mesic forests, maintenance of small inconspicuous colonies in soil and rotting logs, and their collection from the leaf litter and, to a lesser extent, the forest canopy.

The first Fijian *Lordomyrma* were described by Mann (1921) as three species (*L. rugosa*, *L. striatella*, *L. tortuosa*) and two subspecies (*L. tortuosa levifrons*, *L. tortuosa polita*) all belonging to the genus *Rogeria* Emery subgenus *Irogera* Emery. A third subspecies (*L. tortuosa stoneri*) was described several years later (Mann 1925). Brown (1953)

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suggested that all the aforementioned Fijian taxa were members of the genus *Lordomyrma*, and Kugler (1994) formalized the combination in *Lordomyrma* in his revision of *Rogeria*.

Lordomyrma can be differentiated from other myrmicines by the following characters: (1) 12-merous antennae; (2) simple sting with straight apex; (3) triangular mandibles; (4) seven or more teeth and denticles that decrease in size from the apex; (5) well-developed propodeal spines; (6) bicarinate median portion of clypeus; (7) and elongate frontal carinae.

A suite of characteristics common to all Fijian species of *Lordomyrma* includes: (1) the presence of short, subdecumbent hairs on the eyes; (2) a broadly and deeply impressed metanotal groove; (3) propodeal spines of moderate length; (4) petiole node and postpetiole dorsum without dorsal spikes or teeth; (5) scapes that fail to reach the posterior margin of the head; and (6) generally stout, robust bodies.

MATERIALS AND METHODS

Sources of Material

Museum specimens reviewed in this study are from the collections of the NMNH (National Museum of Natural History, Washington, DC, USA) and the MCZ (Museum of Comparative Zoology, Harvard University, Cambridge, MA, USA). Additional specimens were collected by standardized litter sifting conducted by the Wildlife Conservation Society during 2002–2005 with assistance from the NSF-Fiji Terrestrial Arthropod project and the Schlinger Fiji Bioinventory of Arthropods (FBA) (Evenhuis & Bickel 2005). The third significant source of material was hand collected by the author from January through August, 2006.

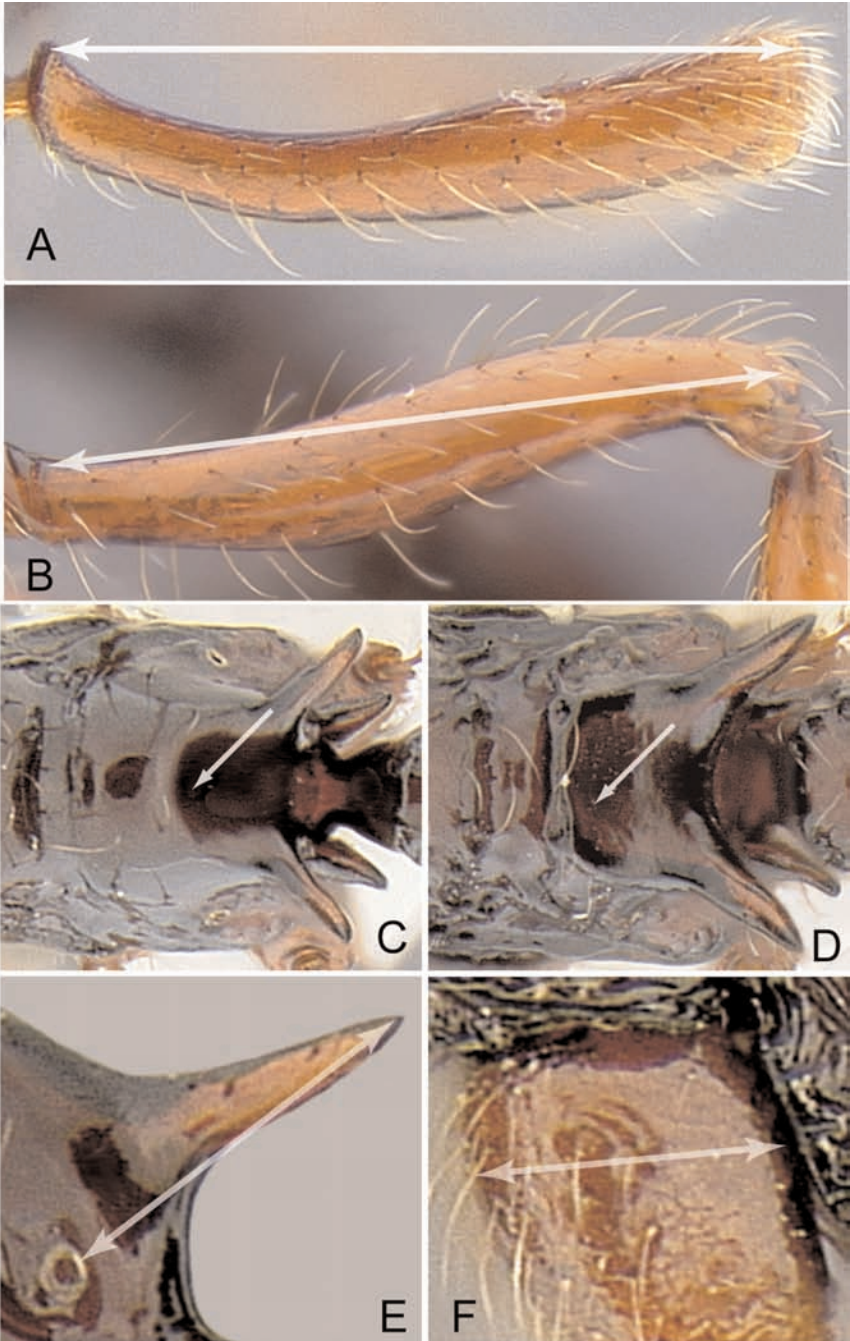
Holotypes and voucher specimens will be deposited in the Fiji National Insect Collection (FNIC), Suva. Where sufficient specimens allow, paratypes and positively identified specimens will be deposited in the ANIC (Australian National Insect Collection, CSIRO, Canberra, Australia), CAS (California Academy of Sciences, San Francisco, CA, USA), LACM (Natural History Museum of Los Angeles County, Los Angeles, CA, USA), BPBM (Bishop Museum, Honolulu, Hawai'i), MCZ and NMNH. Additional identification tools, including images of type specimens, queens and males are available at <http://www.antweb.org/fiji.jsp>

Analysis of Morphology

A total of 254 specimens (240 workers, 7 males, 7 queens) from 72 collection series were examined in order to examine intraspecific and interspecific variation. All specimens were studied with respect to relative shape and size using a Leica MZ7.5 dissecting microscope at magnifications ranging from 6.3–50.0 \times . Series of standardized measurements were recorded to the nearest 0.001 mm at magnifications of 70 \times for 82 workers using the Auto-Montage Pro[®] software package (Syncroscopy) in combination with a JVC KY-F75U digital camera mounted on a Leica MZ16 dissecting scope. A list of measurements taken and indices used is presented in Table 1, and a table of measurements for all species is given in the Appendix. Effort was made to capture a maximum range of morphological variation by measuring at least ten workers from as many collection series as possible for each species. If a given species was represented by fewer than ten workers, all available workers were measured.

Table 1. Measurements and indices used for morphological analysis.

Measurement	Description	View
HW	<i>Head width</i> : maximum width of head not including the eyes.	Full face
HL	<i>Head length</i> : maximum length of head from the posterior margin to the tip of the anterior clypeal margin measured along the midline.	Full face
EL	<i>Eye length</i> : maximum diameter of compound eye.	Oblique lateral
SL	<i>Scape length</i> : length of first antennal segment excluding the radicle.	Dorsal (Fig. 1A)
MFL	<i>Metafemur length</i> : length of metafemur measured along its long axis.	Posterior or anterior (Fig. 1B)
TL	<i>Total length</i> : maximum length of specimen measured from the tip of the mandibles to the tip of the gaster, not including sting.	Lateral
MH	<i>Metanotal hair length</i> : length of longest hair present on mesonotum.	Lateral
PSL	<i>Propodeal spine length</i> : maximum length of propodeal spine measured from the middle of propodeal spiracle to the tip of the spine.	Lateral (Fig. 1C)
PCW	<i>Procoxa width</i> : maximum width of procoxa measured parallel to dorsal margin.	Lateral (Fig. 1D)
PH	<i>Petiole height</i> : maximum height of petiole measured from base to summit of node at right angles to the petiole length.	Lateral
PW	<i>Pronotum width</i> : maximum width of pronotum measured at the dorsolateral margins.	Dorsal
DPW	<i>Dorsal petiole width</i> : maximum width of petiole.	Dorsal
CI	<i>Cephalic index</i> : HW/HL	
SI	<i>Scape index</i> : SI/HW	
MHI	<i>Metanotal hair length index</i> : MH/PCW	
REL	<i>Relative eye length index</i> : EL/HL	
PSLI	<i>Propodeal spine length index</i> : PSL/PCW	
MFLI	<i>Metafemur length index</i> : HFL/HW	
DPWI	<i>Dorsal petiole width index</i> : PW/PCW	



RESULTS

This study recognizes 10 species (four new) of *Lordomyrma* occurring on the Fiji Islands.

- L. curvata* Sarnat, **sp. n.**
L. desupra Sarnat, **sp. n.**
L. levifrons (Mann, 1921: 453) **stat. n.**
L. polita (Mann, 1921: 453) **stat. n.**
L. rugosa (Mann, 1921:456)
L. stoneri (Mann, 1925: 5) **stat. n.**
L. striatella (Mann, 1921: 454)
L. sukuna Sarnat, **sp. n.**
L. tortuosa (Mann, 1921:452)
L. vuda Sarnat, **sp. n.**

KEY TO SPECIES OF *LORDOMYRMA* OF THE FIJI ISLANDS BASED ON THE WORKER CASTE

1. In dorsal view, dorsal face of the propodeum gently sloping and continuously smooth, unbroken by a transverse carinate ridge or ridges between metanotal groove and insertion of propodeal spines (Fig. 1E); in larger workers promesonotum massive and spherical, produced well above the level of head and propodeum (Figs. 15, 21); moderate sized to large workers (HW 0.73–0.90); propodeal spines of moderate length (PSLI 0.90–1.26) 2
- . In dorsal view, dorsal face of the propodeum with a transverse carinate ridge or ridges between metanotal groove and insertion of propodeal spines (Fig. 1F); promesonotal shape, workers size and propodeal spines of variable length (HW 0.59–0.89, PSLI 0.76–1.31) 5
2. Frontal carinae becoming confluent with well developed, arcuate carinae posterior to the eye; carinae present mesad of, and paralleling, frontal carinae (Fig. 18); propodeal spines straight (Fig. 19); large species (HW 0.82–0.90) **tortuosa** (Mann)
- . Frontal carinae terminating before or just behind posterior level of eye; carinae posterior to eye short and poorly developed to absent; in full face view, carinae absent mesad of frontal carinae (Figs. 4, 12, 20); propodeal spines straight, downcurved or upcurved; medium to large species 3
3. Propodeal spines robust and strongly upcurved (Fig. 13); reddish brown species **stoneri** (Mann)
- . Propodeal spines downcurved to straight but never upcurved (Figs. 5, 21); reddish brown to dark brown 4

Figure 1. Worker morphology illustrating various measurements and characters of the worker caste. **A**, scape length (SL) in dorsal view; **B**, hind femur length (FL) in anterior view; **C**, propodeal spine length (PSL) in lateral view; **D**, procoxae width (PCW) in lateral view; **E**, dorsal face of the propodeum in dorsal view (transverse carina absent); **F**, dorsal face of the propodeum in dorsal view (transverse carina present).

4. Propodeal spines weakly produced, straight to downcurved (Fig. 5); propodeal dorsum steeply sloped; apical face of petiole sloping posteriorly with rounded apex; weak sculpturing present behind eye; smaller reddish brown species (HW 0.73–0.83; $n = 10$) **desupra** Sarnat, **n. sp.**
- . Propodeal spines strongly produced, downcurved (Fig. 21); propodeal dorsum shallowly sloped; apical face of petiole vertical with weakly peaked apex; sculpturing absent behind eye; larger dark brown species (HW 0.87–0.90; $n = 6$) **vuda** Sarnat, **n. sp.**
5. In profile, propodeal spines strongly produced, length greater than width of procoxa (PSLI > 1.10); petiole more robust (DPWI 0.90–1.10), with a gently sloping posterior face (Figs. 3, 7, 9, 11) and overlain by a coarse rugoreticulum; antennal scrobes broad and weakly defined, or if well defined, then also possessing upturned propodeal spines 6
- . In profile, propodeal spines weakly produced, straight to downcurved, shorter than or equal to width of procoxa (PSLI < 1.05); petiole more slender (DPWI 0.81–0.99), subtriangular with a steeply sloping posterior face and overlain by a fine rugoreticulum (Figs. 15, 17); antennal scrobes narrow and more deeply impressed 9
6. Entire face densely rugose between frontal carinae, rugoreticulate laterally and posteriorly (Fig. 10); procoxa with well defined transverse striae (Fig. 11); eyes small (REL 0.19–0.22; $n = 10$) **rugosa** (Mann)
- . Median portion of face smooth with scattered foveolae (Figs. 2, 6, 8), if carinae are present they are restricted to the area immediately mesad of the frontal carinae; procoxa without well developed transverse striae; eyes moderate to large (0.21–0.27) 7
7. Posterior corners of the head overlain by rugoreticulum (Fig. 2); frontal carinae becoming confluent with rugoreticulum posterior to the eye forming a broad, well defined antennal scrobe; propodeal spines upcurved (Fig. 3); small species (HW < 0.63; $n = 3$) **curvata** Sarnat, **n. sp.**
- . Posterior corners of the head either smooth or with a few weak carinae, but never overlain by rugoreticulum (Fig. 6, 8); frontal carinae terminating before reaching any carinae posterior to eye and never forming a well-defined antennal scrobe; propodeal spines straight (Fig. 7, 9); larger species (HW > 0.63, $n = 11$) 8
8. Longest hairs on promesonotum, petiole, postpetiole and gaster exceeding length of eye (MHI = 1.29; $n = 1$) (Fig. 7); series of strong carinae present between eyes and ventrolateral margin of face; large species (HW 0.89; $n = 1$) **levifrons** (Mann)
- . Hairs on promesonotum, petiole, postpetiole and gaster shorter than length of eye (MHI < 0.80, $n = 10$) (Fig. 9); strong carinae absent between eyes and ventrolateral margin of face; smaller species (HW 0.64–0.76, $n = 10$) **polita** (Mann)
9. In full face view, median region of head between frontal carinae filled with fine and tightly packed longitudinal striae (Fig. 14); sides and dorsum of pronotum rugose to rugulose (Fig. 15) **striatella** (Mann)
- . In full face view, median region of head between frontal carinae smooth and shining with scattered foveolae (Fig. 16); sides and dorsum of pronotum smooth, without striae or rugae (Fig. 17) **sukuna** Sarnat, **n. sp.**

SYNOPSIS OF THE GENUS *LORDOMYRMA* OF THE FIJI ISLANDS

The worker caste of all Fijian species of *Lordomyrma* can be recognized by the following features:

In full face view, head subquadrate, broadest width occurring just posterior to eyes. Mandibles triangular, with sparse setigerous foveolae; masticatory margin with four strong teeth apically and three to five denticles basally, all decreasing in size. Anterior margin of clypeus entire and evenly convex. Frontal lobes moderately broad and flat. Antenna 12-merous with terminal three segments forming a distinct club that is as long as the rest of the funiculi combined; scapes short and curved, not surpassing posterior margin of head. Eyes weakly convex with short curved hairs between ommatidia; situated in front of midline. In profile, ventrolateral margin of head delineated by a carina originating at posterior margin and terminating at level of eye. Promesonotum longer than broad; in profile round and convex; suture between the two segments absent; without projecting humeri. Metanotal groove broad and strongly impressed. In profile, propodeum with dorsal and declivitous faces concave; armed with one pair of spines. Petiole with a short peduncle and a high node. Gaster of moderate size, armed with a simple sting.

Lordomyrma curvata Sarnat, sp. n.

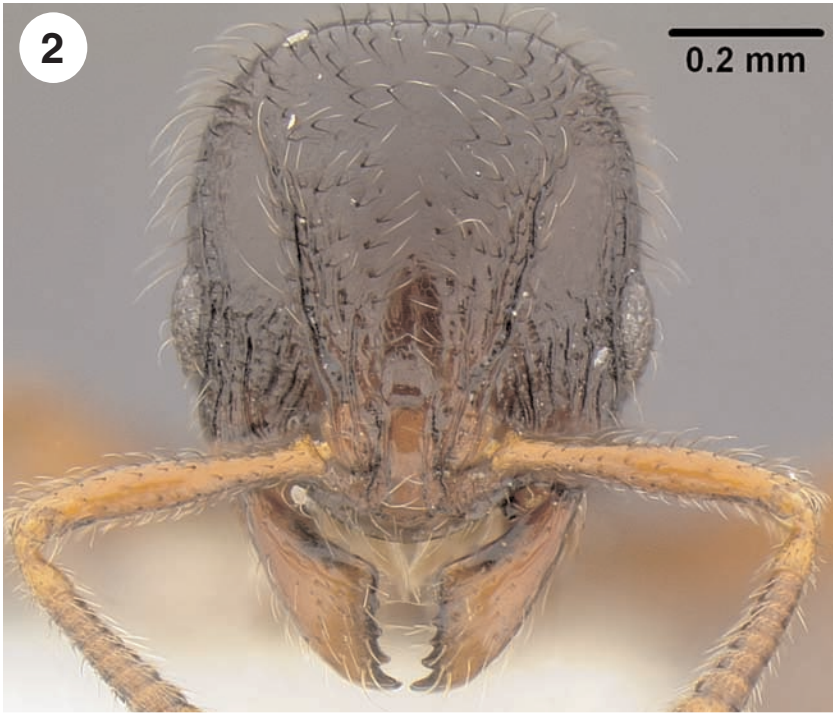
(Figs. 2, 3)

Description. *Worker.* TL 3.32–3.86, HL 0.72–0.73, HW 0.59–0.62, CI 0.83–0.86, SI 0.71–0.73, REL 0.22–0.25, PSLI 1.25–1.30, MFLI 0.93–0.97, DPWI 1.05–1.10 (3 measured). A small reddish brown species with long upcurved spines, long hair and a broad well-defined antennal scrobe. In full face view, posterior margin of head evenly convex with rounded corners. Clypeus with one pair of carinae extending from posterior margin to anterior margin. Frontal carinae distinct, extending posteriorly behind eyes and curving back anteriorly to form both the upper and lower margins of the antennal scrobes. Eyes relatively large. In lateral view promesonotum modestly sized, convex. Propodeal spines acute, upcurved and divergent, one and one third times as long as width of procoxa in lateral view as measured from propodeal spiracle. Propodeal lobes strong, long and upturned. Petiole robustly built; in lateral view anterior face of node concave and steeply sloped, posterior face convex and gently sloped. Postpetiole with anterior and dorsal faces both evenly convex, apex occurring near midline, anterodorsally compressed. Mandibles smooth and shining with sparse setigerous foveolae. Middorsum of head smooth and shining with scattered setigerous foveolae; carinae present mesad of frontal carinae. Frontal lobes with one pair of carinae in addition to the frontal carinae. In oblique lateral view, rugoreticulum behind, above and below the eye; posterior corners of head rugoreticulate. Promesonotum smooth and shining with a few weak rugae on sides; smooth and shining on dorsum with scattered smaller foveolae laterally and larger foveolae near apex. In dorsal view, propodeum smooth and shining with a distinct transverse carina proximal to the metanotal groove; declivitous face smooth and shining. Sides of mesonotum, metapleuron and propodeum overlain by coarse, widely spaced and occasionally intersecting rugae. Petiole and postpetiole coarsely rugoreticulate. All dorsal surfaces with acuminate yellowish hairs, the longest of which exceed the length of the eye. Head, mesosoma and gaster reddish brown, appendages lighter.

Type Material. *Holotype.* Worker, FIJI: **Vanua Levu:** Kasavu Village, 16°42'S 179°39'E, 300 m, 28.viii.2003 (A. Rakabula) (FNIC). *Paratype.* 1 worker, same data as holotype (NMNH). Holotype will be deposited in FNIC.

Other Material Examined. FIJI: **Vanua Levu:** nr. Nakanakana Village, 16°37'S 179°50'E, 300 m, 28.viii.2003, from sifted litter (A. Rakabula); Ndreketi Village, 25.x.1977 (G. Kuschel).

Discussion. One of the smallest species of Fijian *Lordomyrma*, in general appear-



ance *L. curvata* is most similar to *L. levifrons* and *L. polita*. Like these species it has relatively large eyes, long propodeal spines and lobes, and a reddish brown integument. Two characters that separate *curvata* from the aforementioned species are the upturned shape of the propodeal spines and the well-developed rugoreticulum present posterior to the eyes. While *L. rugosa* and *L. striatella* both possess rugoreticulate occipital corners, only in *L. curvata* are the antennal scrobes and area between the frontal carinae covered by a smooth and shining surface. The only other species that possesses strongly upcurved spines is *L. stoneri*, from which *L. curvata* can be readily differentiated by the rugoreticulate posterior corners of the head and substantially smaller size.

Distribution and Biology. The three known collections of *L. curvata* are restricted to the island of Vanua Levu, two of which were taken by litter sifting. Thus far, *L. curvata* is the only species of *Lordomyrma* that is endemic to Vanua Levu.

Lordomyrma desupra, sp. n.

(Figs. 4, 5)

Description. *Worker.* TL 3.55–4.18, HL 0.81–0.93, HW 0.73–0.83, CI 0.87–0.92, SI 0.71–0.76, REL 0.21–0.25, PSLI 0.92–1.12, MFLI 0.99–1.08, DPWI 0.85–1.00 (10 measured).

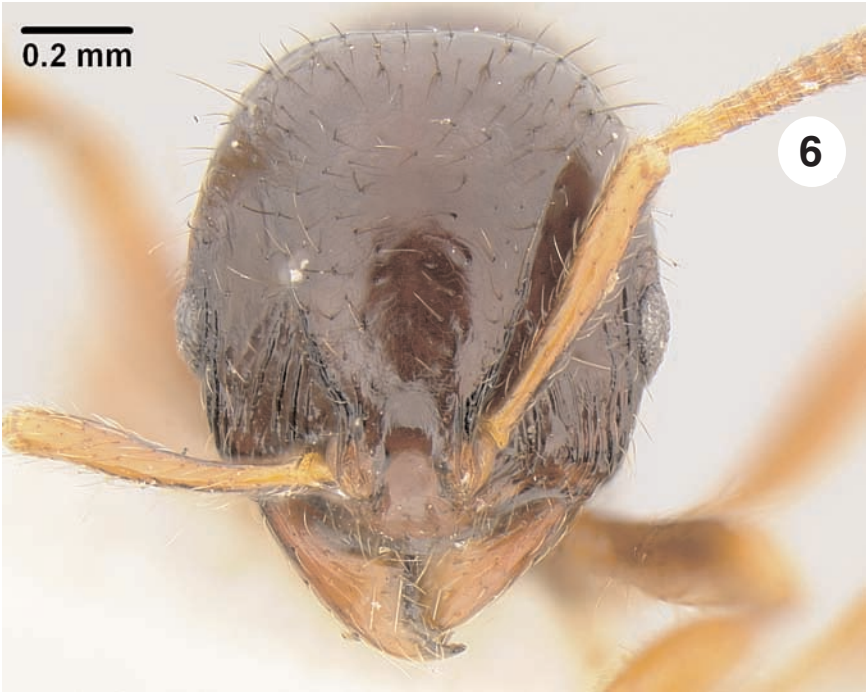
A medium to large reddish brown species with a large to massive promesonotum, straight to down-curved propodeal spines of modest length and reduced sculpturing on face and body. Posterior margin of head evenly convex with rounded corners. Clypeus bearing one pair of weak carinae. Frontal carinae weakly carinate, terminating just posterior to level of eye. Antennal scrobe weakly impressed. Eyes of moderate size. In lateral view (for larger workers), promesonotum massive, strongly convex, and bulging above the head and propodeum. Propodeal spines triangular, straight to slightly down-curved and of moderate length. Propodeal lobes triangular and of variable size. Petiole robustly built; anterior face strongly sloped and weakly concave; dorsal face more gently sloping and weakly convex; the rounded apex occurring at the anterior angle of node. Postpetiole with anterior and dorsal faces evenly convex, apex occurring at midline. Mandibles smooth and shining with sparse setigerous foveolae. Middorsum of head smooth and shining with scattered setigerous foveolae; several carinae mesad of and parallel to frontal carinae; terminating just after posterior level of eyes. Frontal lobes with one to two pairs of longitudinal carinae in addition to the frontal carinae. In oblique lateral view, scattered, weak and short carinae surrounding eyes. Promesonotum smooth and shining with scattered piligerous foveolae. Sides of mesonotum, metapleuron, and propodeum overlain by coarse, widely spaced and occasionally intersecting rugae. In dorsal view, propodeum smooth and shining, without a transverse carina proximal to the metanotal groove; declivitous face smooth and shining. Petiole with smooth and shining anterior face, banded by coarse transverse rugae that cross the ventral face. Postpetiole coarsely rugoreticulate. All shining surfaces laced with a delicate network of light etchings. All dorsal surfaces with an abundance of suberect to erect acuminate yellowish hairs, the longest of which equal or exceed the length of the eye. Head, mesosoma and gaster reddish brown, appendages lighter.

Type Material. *Holotype.* Worker, FIJI: **Viti Levu:** Monasavu Rd., 1.75 km SE Waimoque Settlement, 17°40'13"S 177°59'38"E, 850 m, 28.viii.2006 (E.M. Sarnat #2361) (FNIC). *Paratypes.* 15 workers, same data as holotype (ANIC, CASC, LACM, MCZC, BPBM, NMNH). Holotype will be deposited in FNIC.

Figures 2–3. *Lordomyrma curvata*. 2. head. 3. profile.



Figures 4–5. *Lordomyrma desupra*. 4. head. 5. profile.



Figures 6–7. *Lordomyrma levifrons*. 6. head. 7. profile.

Other Material Examined. FIJI: **Viti Levu:** 1.6 km NW Monasavu Dam 17°45'00"S 178°02'07"E, 800 m, 14.vii.2005, canopy fogging (H. Waqa); 4 km NE Monasavu Dam 17°44'05"S 178°04'46"E, 600 m, 13.vii.2005, canopy fogging (H. Waqa); 1 km NNE Vaturu Dam 17°44'36"S 177°40'09"E, 575 m, 27.vi.2005, on log (E.M. Sarnat #2190.02).

Discussion. *Lordomyrma desupra* lacks a transverse carina between the propodeal dorsum posterior to the metanotal groove and and possesses a robustly produced promesonotum that, in larger workers, bulges above the level of its head and propodeum. Of the three other species that share these characters, *L. desupra* can be distinguished from *L. tortuosa* by its weaker facial sculpture, from *L. stoneri* by its smaller, more slender appearance and straight propodeal spines, and from *L. vuda* by its facial sculpture, weaker propodeal spines, smaller size and lighter color.

Lordomyrma desupra shows a wider variation in the size of workers than normally encountered within the Fijian *Lordomyrma*. In smaller workers, the size of the promesonotum and propodeal spines is markedly smaller.

Distribution and Biology. Thus far, *L. desupra* has only been collected from the higher elevations of several mountain ranges in northern Viti Levu. Although the single small worker from the Vaturu Dam area was collected on a log, both large and small workers were abundant in the forest canopy of the Monasavu area where they were captured using fogging methods. The collection of the species from *Hydnophytum* ant-plants and from canopy fogging, together with its absence from sifted litter collections, suggests *L. desupra* is a component of Fiji's arboreal ant fauna.

***Lordomyrma levifrons* (Mann) stat. n.**

(Figs. 6, 7)

Rogeria tortuosa subsp. *levifrons* Mann, 1921: 453.

Description. Worker. TL 4.31, HL 0.99, HW 0.89, CI 0.90, SI 0.73, REL 0.21, PSLI 1.31, MFLI 1.01, DPWI 0.90 (1 measured).

A large reddish brown species with long straight spines and reduced sculpturing. In full face view, posterior margin of head evenly convex with rounded corners. Clypeus smooth and shining, only light traces of a pair of weak carinae terminating before reaching anterior border. Frontal carinae weakly carinate, terminating just after posterior level of eye. Antennal scrobe weakly impressed. Eyes of moderate size. In lateral view promesonotum large, moderately convex. Propodeal spines acute and straight, one and one third as long as width of procoxa in lateral view. Propodeal lobes strong, long and upturned. Petiole robustly built; in lateral view anterior face of node nearly vertical, posterior face more gently sloped, apex at anterior angle. Postpetiole with anterior and dorsal faces evenly convex, apex occurring at midline. Mandibles smooth and shining with sparse, setigerous foveolae. Middorsum of head smooth and shining with scattered setigerous foveolae; no carinae mesad of frontal carinae. Frontal lobes with one pair of strong carinae in addition to the frontal carinae. Arcuate carinae above and below eye, mostly smooth behind eye, longitudinal carinae between eye and mandibular insertion; posterior corners of head smooth and shining with a few punctures margined by elevated sides; carinae absent. Promesonotum smooth and shining with a few weak carinae on sides and a few striations on dorsum. In dorsal view, propodeum smooth and shining, with a distinct transverse carina proximal to the metanotal groove; declivitous face smooth and shining. Petiole and postpetiole coarsely rugoreticulate. Gaster smooth and shining. All dorsal surfaces with an abundance of suberect to erect acuminate yellowish hairs, the longest of which equal or exceed the length of the eye. Head and mesosoma reddish brown, gaster and appendages lighter.

Type Material Syntype, worker, Nadarivatu, Fiji (W.M. Mann) (NMNH) (examined).

Other Material Examined. FIJI: **Viti Levu:** Waiyanitu (W.M. Mann); Vesari (W.M. Mann.); Saiaro (W.M. Mann).

Discussion. This large, robust, long-spined ant is known only from Mann's collections and is the only species of *Lordomyrma* he described that has not been rediscovered since. Although the promesonotum is strongly produced in this species, and the petiole has a steep anterior face, it can be differentiated from *L. desupra*, *L. stoneri*, *L. tortuosa*, and *L. vuda* by the transverse carina posterior to the metanotal groove. *Lordomyrma levifrons* is distinguished from the other species with long propodeal spines, *L. polita*, by the long, fine-tipped hairs present on its face, mesosoma, petiole, and gaster.

Distribution and Biology. Collected only from the mountains of Viti Levu, little is known about the biology of *L. levifrons*.

***Lordomyrma polita* (Mann), stat. n.**

(Figs. 8, 9)

Rogeria tortuosa subsp. *polita* Mann, 1921: 453.

Description. *Worker.* TL 3.32–3.86, HL 0.74–0.87, HW 0.64–0.76, CI 0.86–0.91, SI 0.75–0.79, REL 0.22–0.27, PSLI 1.13–1.46, MFLI 0.97–1.05, DPWI 0.91–1.09 (11 measured).

A medium-sized reddish brown species with long straight propodeal spines, short hair, shallowly impressed antennal scrobes, reduced facial sculpture and a robust petiole. In full face view, posterior margin of head evenly convex to slightly concave medially with rounded corners. Clypeus without strong carinae. Frontal carinae weakly carinate, terminating just posterior to level of eye. Antennal scrobe weakly impressed. Eyes relatively large. In profile, promesonotum modestly sized, convex. Propodeal spines acute, straight and divergent; when measured from spiracle in profile, one to one and a half times as long as width of procoxa. Propodeal lobes strong, long and upturned. Petiole robustly built; in profile anterior face of node concave and steeply sloped, posterior face convex and gently sloped, flat dorsally. Postpetiole with anterior and dorsal faces both evenly convex, apex occurring near midline. Mandibles triangular, smooth and shining with sparse setigerous foveolae. Middorsum of head smooth and shining with scattered setigerous foveolae; carinae mesad of frontal carinae. Frontal lobes with one to two pair of carinae in addition to the frontal carinae. In oblique lateral view, scattered punctures behind the eye, a few weak carinae above, below and in front of the eye; posterior corners of head with a few weak transverse carinae and punctures with elevated margins. Promesonotum varying from smooth and shining with a few weak carinae on sides and a few striations on dorsum to being overlain by thick, widely spaced rugae on sides and dorsum. In dorsal view, propodeum smooth and shining with a distinct transverse carina posterior to the metanotal groove; declivitous face smooth and shining. Sides of mesonotum, metapleuron, and propodeum overlain by coarse, widely spaced and occasionally intersecting rugae. Petiole and postpetiole coarsely rugoreticulate. Gaster smooth and shining. All dorsal surfaces with short and stout suberect to erect acuminate yellowish hairs, the longest of which are shorter than the length of the eye. Head and mesosoma reddish brown, gaster and appendages lighter.

Type Material. Syntypes, workers, 1 dealate queen, Nadarivatu, Fiji (W.M. Mann) (NMNH, MCZC) (examined).

Other Material Examined. FIJI: **Koro:** Mt. Nabukala, 5 km WSW Nasau Village, 17°18'45"S 179°23'17"E, 520 m, 15.iii.2005, nesting between epiphyte roots and tree trunk (E.M. Sarnat #1909, J. A. Schreiber). **Vanua Levu:** Mt. Vatudiri, 3km NW Waisali Village, 16°37'42"S 179°12'29"E, 641 m, 2.ix.2006, in dead tree fern (E.M. Sarnat #2389). **Viti Levu:** Navai forest, forestry camp, 11.vii.1997, in log (J. K. Wetterer #76, #94, #95); Koroyanitu National Park, Savione Falls, 2 km ESE Abaca Village, 17°40'34"S 177°33'01"E, 650 m,



Figures 8–9. *Lordomyrma polita*. 8. head. 9. profile.

25.viii.2006, in log (E.M. Sarnat #2341); 1 km NNE Vaturu Dam, 17°44'36"S 177°40'09"E, 575 m, on log (E.M. Sarnat #2190).

Discussion. *Lordomyrma polita* is readily discernable from the other long-spined Fijian species, *L. levifrons*, by its short hairs. There exists considerable variation with respect to sculpture of the promesonotum among specimens of *L. polita* as currently defined. Whereas the type specimens from Nadarivatu together with a series collected from nearby Navai tend towards a more sculptured promesonotum and face, and a flatter petiole node, the series collected from the islands of Koro and Vanua Levu tend a smoother promesonotum and face, and a more rounded petiole node. Additionally, a male specimen from the Navai series has a smooth and shining metapleuron while that of the Koro male specimen is finely punctate. The single specimen collected from the Vuda province of Viti Levu appears intermediate between the Nadarivatu/Navai series and the Koro/Vanua Levu series. The allopatric pattern of these morphological traits does not allow for confident separation of species, thus all of the aforementioned series are considered here as belonging to a single species.

Distribution and Biology. Thus far, *L. polita* is known from the highlands surrounding Mt. Tomaniivi, the drier western forest near Vaturu Dam, the interior of Vanua Levu, and the island of Koro. This species has been observed nesting in logs in the Navai area and Vanua Levu, and nesting between epiphyte roots and a tree trunk on the island of Koro.

Lordomyrma rugosa (Mann)

(Figs. 10, 11)

Rogeria rugosa Mann, 1921: 455.

Description. *Worker.* TL 3.36–3.77, HL 0.77–0.85, HW 0.71–0.76, CI 0.86–0.94, SI 0.68–0.72, REL 0.19–0.22, PSLI 1.28–1.48, MFLI 0.92–1.00, DPWI 0.98–1.10 (10 measured).

A medium-sized dark brown species with a rugose face and mesosoma, long upturned propodeal spines, small eyes and striated procoxae. In full face view, posterior margin of head evenly convex with rounded corners. Clypeus without strong carinae. Frontal carinae strongly produced, extending beyond posterior level of eye before integrating into dorsolateral rugoreticulum. Antennal scrobe lightly impressed, filled with dense arcuate rugoreticulum. Eyes relatively small. In profile promesonotum modestly sized, convex. Propodeal spines strong, slightly upturned distally and divergent; in profile when measuring from propodeal spiracle one and one third to one and one half times as long as width of procoxa. Propodeal lobes strong, long and upturned. Petiole robustly built; in lateral view anterior face of node weakly concave and gently sloped, posterior face convex and gently sloped, apex occurring at anterior angle of node. Postpetiole with anterior and dorsal faces evenly convex, apex occurring anterior to midline. Mandibles striate with sparse, setigerous foveolae. Middorsum of head overlain by a thick, widely spaced rugoreticulum. In oblique lateral view, face packed with dense rugoreticulum. Frontal lobes with one pair of carinae in addition to the frontal carinae. Promesonotum packed with dense rugoreticulum. In dorsal view, propodeum smooth and shining with a distinct transverse carina proximal to the metanotal groove; declivitous face with transverse carinae between propodeal spines. Procoxae transversely striate. Sides of mesonotum, metapleuron and propodeum overlain by coarse, widely spaced and intersecting rugae. Petiole and post-petiole coarsely rugoreticulate. Gaster smooth and shining. All dorsal surfaces with a suberect to erect acuminate yellowish hairs, the longest of which are longer than the length of the eye. Head, mesosoma and gaster dark reddish brown, appendages lighter.

Type Material. Syntypes, 1 dealate queen, workers, Nadarivatu, [Viti Levu] Fiji (W.M. Mann) (MCZC, NMNH) (examined).



Figures 10–11. *Lordomyrma rugosa*. 10. head. 11. profile.

Other Material Examined. FIJI: **Viti Levu:** Monasavu Rd., 1.75 km SE Waimoque Settlement, 17°40'13"S 177°59'38"E, 850 m, 28.viii.2006 (E.M. Sarnat #2367); Mt. Tomaniivi, 2.4 km E Navai Village, 17°37'06"S 178°00'30"E, 930 m, 1.ii.2005, secondary/primary forest ground foraging (E.M. Sarnat #1771, #1773, #1793); Mt. Tomaniivi, 2.4 km E Navai Village, 17°37'05"S 178°00'33"E, 930 m, 1.ii.2005, mid-elevation rainforest, nesting in soil (E.M. Sarnat #2147).

Discussion. *Lordomyrma rugosa* is one of the most distinctive species of *Lordomyrma* in Fiji. Like *L. levifrons*, *L. polita* and *L. curvata*, this species possesses long propodeal spines, well developed, upturned propodeal lobes, and a robust petiole. It differs from the general appearance of the aforementioned species in its small eyes, darker coloration, and the heavy rugoreticulum covering all surfaces of its face. The only other Fijian congener with such strong facial sculpturing is *L. striatella*, from which *L. rugosa* can be distinguished by its larger size, coarser sculpture, rugoreticulate antennal scrobes, longer propodeal spines and lobes, and more robust petiole. Additionally, *L. rugosa* is the only known species of all Fijian *Lordomyrma* to bear strong striations on its mandibles and procoxae.

Distribution and Biology. *Lordomyrma rugosa* is known only from the Nadarivatu, Mt. Tomaniivi area. Mann (1921) notes that the colonies are small and live beneath stones or in the ground, and that the workers are slow moving. I collected 66 workers and four males from a nest that was excavated in a clay soil with a 1mm entrance in the bare soil, and additional workers were observed on stones in another locality.

***Lordomyrma stoneri* (Mann), stat. n.**

(Figs. 12, 13)

Rogeria tortuosa subsp. *stoneri* Mann, 1925: 5.

Description. *Worker.* TL 4.21–5.52, HL 0.95–1.00, HW 0.82–0.89, CI 0.85–0.87, SI 0.72–0.76, REL 0.18–0.24, PSLI 0.96–1.11, MFLI 0.91–1.07, DPWI 1.00–1.07 (8 measured). A large shiny reddish brown species with a massive promesonotum, strong upcurved spines, and reduced sculpturing on face and body. In full face view, posterior margin of head evenly convex with rounded corners. Clypeus bearing one pair of weak carinae. Frontal carinae weakly carinate, terminating just after posterior level of eye. Antennal scrobe weakly impressed. Eyes of moderate size. In profile promesonotum massive, strongly convex, and bulging above the head and propodeum. Propodeal spines strong, triangular, divergent, and roughly as long as width of procoxae in profile when measured from, propodeal spiracle. Propodeal lobes of moderate size, triangular, stout. Petiole robustly built; anterior face strongly sloped and weakly concave; dorsal face more gently sloping and weakly convex; the rounded apex occurring at the anterior angle of node. Postpetiole with anterior and dorsal faces both evenly convex, apex occurring at midline. Mandibles smooth and shining with sparse, setigerous foveolae. Middorsum of head smooth and shining with scattered setigerous foveolae; several carinae mesad of frontal carinae; terminating just after posterior level of eyes. Frontal lobes with two pair of strong carinae in addition to the frontal carinae. In oblique lateral view, widely separated and weakly produced arcuate carinae above and below eye, mostly smooth and shining behind and in front of eyes. Promesonotum smooth and shining with scattered piligerous foveolae. Sides of mesonotum, metapleuron and propodeum overlain by coarse, widely spaced and occasionally intersecting rugae. In dorsal view, propodeum smooth and shining, without a transverse carina posterior to the metanotal groove; declivitous face smooth and shining. Petiole with smooth and shining anterior face, banded by coarse transverse rugae that cross the ventral face. Postpetiole coarsely rugoreticulate. Gaster smooth and shining. All shining surfaces laced with a delicate network of light etchings. All dorsal surfaces with an abundance of suberect to erect acuminate yellowish hairs, the



longest of which equal or exceed the longest diameter of the eye. Head and mesosoma reddish brown, gaster and appendages lighter.

Type Material. Syntype, worker, Tamavua, Fiji (W.M. Mann) (NMNH) (examined).

Other Material Examined. FIJI: **Viti Levu:** Nakobalevu, 1.5 km NE Colo-i-Suva Village, 18°03'03"S 178°25'25"E, 340 m, 28.vii.2003, sifted litter (A. Rakabula); Tholo-I-Suva [= Colo-i-Suva], xii.1950 (N.L.H. Krauss); 4 km NE Monasavu Dam, 17°44'05"S 178°04'46"E, 600 m, 13.vii.2005, canopy fogging (Hilda Waqa); Waivudawa, 6 km NW Lami Town, 18°03'48"S 178°25'57"E, 300 m, 24.v.2002, sifted litter (M. Tokota'a).

Discussion. One of the larger species of *Lordomyrma* in Fiji, *L. stoneri* has an attractive and shining reddish brown integument and strong, upturned spines. The species lacks a carinate anterior margin on the dorsal face of its propodeum and all examined specimens possess a robustly produced promesonotum that bulges above the level of its head and propodeum. Of the other three Fijian species that possess these characters, *L. stoneri* can be distinguished from *L. tortuosa* by its weaker face sculpture, and from *L. desupra* and *L. vuda* by its strongly upturned propodeal spines. The only other species that has strongly upturned spines is *L. curvata*, which is almost half the size of *L. stoneri*, has a strongly carinate anterior margin of the dorsal face of its propodeum, and has a strong rugoreticulum on the posterolateral corners of its head.

Distribution and Biology. *Lordomyrma stoneri* appears to be constricted to a narrow range of mountains in southeastern Viti Levu, close to Suva. Little is known about the biology of this species, but it has been collected by litter sifting.

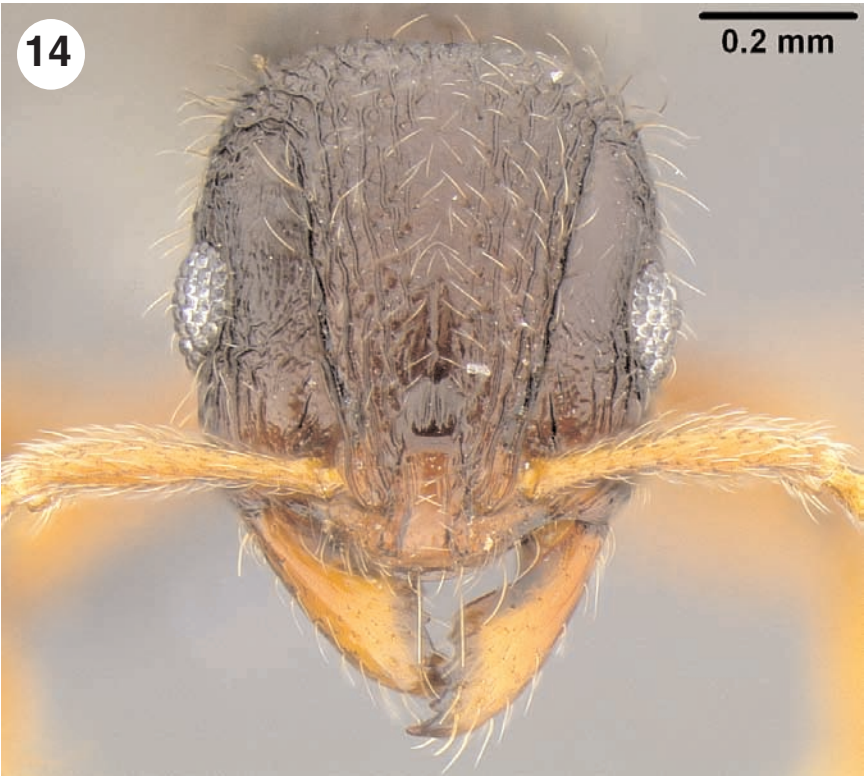
Lordomyrma striatella (Mann)

(Figs. 14, 15)

Rogeria striatella Mann, 1921: 454.

Description. *Worker.* TL 3.16–3.33, HL 0.71–0.75, HW 0.59–0.63, CI 0.83–0.88, SI 0.72–0.79, REL 0.21–0.26, PSLI 0.82–1.00, MFLI 0.93–0.99, DPWI 0.92–1.01 (10 measured). A small dark reddish brown species with fine rugulae overlaying nearly all surfaces of the head, mesosoma, petiole and postpetiole; strongly defined antennal scrobes, short weakly downcurved propodeal spines, long hair and subtriangular petiole. In full face view, posterior margin of head evenly convex with rounded corners. Clypeus with one pair of well-defined carinae. Frontal with one pair of carinae in addition to the frontal carinae. Frontal carinae strongly produced, extending beyond posterior level of eye before integrating with dorsolateral rugoreticulum. Antennal scrobe narrow and well defined; bordered above by frontal carinae and below by thin carinae above eye; smooth and shining with a fine rugoreticulum between eye and antenna insertion. Eyes of moderate size. In profile, promesonotum relatively low, convex. Propodeal spines acute, slightly downcurved and divergent, in profile when measured from propodeal spiracles equal or shorter than the width of procoxa. Propodeal lobes weak triangles. Petiole slender and subtriangular with steep anterior and dorsal faces. Postpetiole taller than long, smaller than petiole, apex occurring anterior to midline. Mandibles smooth and shining with sparse, setigerous foveolae. Middorsum of head with tightly packed rugulae between frontal carinae except for a thin smooth median strip. Posterior margin of head including corners finely rugoreticulate. In oblique lateral view, sculpture surrounding eye rugoreticulate above, behind, and below; longitudinal carinae in front. Pronotum with rugoreticulate sides and dorsum; mesonotum mostly smooth dorsally. In dorsal view, propodeum smooth and shining with a distinct transverse carina proximal to the metanotal groove

Figures 12–13. *Lordomyrma stoneri*. **12.** head. **13.** profile.



and transverse striations in between propodeal spines. Sides of mesonotum, metapleuron and propodeum overlain by fine, closely-spaced rugoreticulum. Procoxa with weak shallow impressions. Petiole and postpetiole finely rugoreticulate. Gaster smooth and shining dorsally and scalloped by shallow impressions basiventrally. All dorsal surfaces with long suberect to erect acuminate yellowish hairs, the longest of which are roughly equal to the length of the eye. Head, mesosoma and gaster dark reddish brown; appendages lighter.

Type Material. Syntypes, workers, Vanua Ava, Kadavu, Fiji (W.M. Mann) (NMNH) (examined).

Other Material Examined. FIJI: **Beqa:** Mt. Korovou, 1.5km WNW Dukuibeqa Village, 250–400 m, 23.v.2005, 18°24'32"S 178°07'10"E (E.P. Economo #93, #94); Mt. Korovou, 1.5 km WNW Dukuibeqa Village, 250–400 m, 23.v.2005, 18°24'32"S 178°07'10"E (E.P. Economo #93). **Ovalau:** 1.2 km NNW Draiba Village 17°41'S 178°49'E, 300 m, 24.vi.2003, sifted litter (A. Rakabula). **Viti Levu:** Nasoqo (W.M. Mann); 4.8 km NE Galoa Village 18°13'S 178°00'E, 300 m, 9.vi.2003, sifted litter (A. Rakabula); 7.5 km NE Vunisea Village 17°29'S 178°08'E, 300 m, 14.vii.2003, sifted litter (A. Rakabula).

Discussion. *Lordomyrma striatella* is a close relative of *L. sukuna*. Together, they are characterized by a narrow well developed antennal scrobe, a slender subtriangular petiole, striations on the propodeal declivity between the insertion of the spines, relatively short propodeal spines, weakly produced propodeal lobes, fine rugoreticulate sculpturing, long hairs on the dorsal surfaces, and dark coloration. *Lordomyrma striatella* can be easily separated from *L. sukuna* by the thin longitudinal striae running the length of its face within the bounds of the frontal carinae. While *L. rugosa* also has strong sculpturing between its frontal carinae, *L. striatella* can be distinguished by its more strongly developed and smooth antennal scrobe, more triangular petiole, smaller and more slender appearance, and weaker propodeal spines and lobes.

Distribution and biology. This species is recorded from collections scattered across Viti Levu, Ovalau, Beqa Island, and Kadavu. Many of the collections have been made from the leaf litter, and Mann reports them as being abundant from Kadavu where he found them nesting beneath stones. No collections of this species have been from above 400 m.

Lordomyrma sukuna Sarnat, sp. n.

(Figs. 16, 17)

Description. *Worker.* TL 3.48–4.14, HL 0.78–0.91, HW 0.65–0.75, CI 0.81–0.85, SI 0.78–0.87, REL 0.20–0.25, PSLI 0.76–1.02, MFLI 1.02–1.13, DPWI 0.81–0.95 (19 measured). A medium-sized black species with long hair, a slender petiole, short propodeal spines and reduced facial sculpture. In full face view, posterior margin of head evenly convex to slightly concave medially with rounded corners. Clypeus with one pair of carinae. Frontal carinae weakly carinate, terminating just after posterior level of eye. Antennal scrobe narrow and well defined; bordered above by frontal carinae and below by thin carinae above eye; smooth and shining with a few weak carinae near antenna insertion. Eyes of moderate size. In profile promesonotum modestly sized, convex. Propodeal spines acute, straight to slightly downcurved and divergent, in profile when measured from propodeal spiracles equal or shorter than the width of procoxa. Propodeal lobes variably sized and upturned. Petiole slender and subtriangular with steep anterior and dorsal faces. Postpetiole taller than long, smaller than petiole, apex occurring anterior to midline. Mandibles smooth and shining with sparse setigerous foveolae. Middorsum of head smooth and shining with scattered setigerous foveolae; varies from several carinae to no carinae mesad of the frontal carinae. Frontal lobes with

Figures 14–15. *Lordomyrma striatella*. 14. head. 15. profile.



Figures 16–17. *Lordomyrma sukuna*. 16. head. 17. profile.

one to two pair of carinae in addition to the frontal carinae. Sculpture surrounding eye varying from smooth and shining to patches of well developed rugoreticulum. Promesonotum smooth and shining, short longitudinal rugae present posteriorly and anteriorly. In dorsal view, propodeum smooth and shining, with a distinct transverse carina proximal to the metanotal groove. Sides of mesonotum, metapleuron, and propodeum overlain by fine, closely spaced, crenulate rugae. Petiole and postpetiole finely rugoreticulate. Gaster smooth and shining. All dorsal surfaces with very long suberect to erect acuminate yellowish hairs, the longest of which are longer than the length of the eye. Head, mesosoma and gaster black; appendages lighter.

Type Material. *Holotype.* Worker, FIJI: **Viti Levu:** Mt. Naqaranibuluti 1.3 km W Emperor Gold Mine Rest House, 17°34'10"S 177°58'20"E, 1050 m, 24.vi.2005, nesting under stone (E.M. Sarnat #2143) (FNIC). *Paratypes.* 15 workers, same data as holotype (ANIC, CASC, BPBM, LACM, MCZC, NMNH). Holotype will be deposited in FNIC.

Other Material Examined. FIJI: **Ovalau:** nr. Draiba Village 17°41'S 178°49'E, 300 m, 24.vi.2003, sifted litter (A. Rakabula). **Taveuni:** Qacavulo Point 16°53'S 179°57'E, 300 m, 26.ix.2003, sifted litter (M. Tokotaa & A. Caginitoba). **Viti Levu:** Mt. Tomaniivi, 2.4 km E Navai Village, 17°37'05"S 178°00'33"E, 950 m, 24.vi.2005, ground foraging (E.M. Sarnat #2148); Navai Forestry Camp, 11.vii.1997, in log (J.K. Wetterer #73).

Discussion. *Lordomyrma sukuna* can be distinguished from *L. striatella* by the lack of sculpturing on its face and pronotum. There is considerable variation within the material described here as *L. sukuna*. The most morphologically distinct specimens are the type series collected from Mt. Naqaranibuluti and a series collected from nearby Mt. Tomaniivi, both of which possess a larger size and a less sculptured face than specimens from other localities. This observation is counter to the general pattern in which sculpture tends to increase with size for individuals within a population.

Additionally, the geographic distribution of the morphological differences is counter to what one might expect. Despite being taken from the same mountain range as the two aforementioned series, the specimens from the Navai Forestry Camp share greater morphological similarity with the singletons collected from the islands of Ovalau and Taveuni. Furthermore, the Navai and Ovalau specimens exhibit sparse, short transverse carinae behind their eyes and no carinae mesad of the frontal carinae, whereas the Taveuni specimen exhibits a strongly developed network of carinae behind their eyes and posterior in addition to the presence of carinae immediately mesad of the frontal carinae. To further confuse matters, the Ovalau and Taveuni specimens were taken at a relatively low elevation of 300 m, whereas all of the Viti Levu series were taken from the tallest mountain range in the archipelago. Although no elevation is recorded for the Navai series, it is unlikely to be taken from below 700 m, and the other two series were collected from 950 m and 1050 m.

Considering the variability in facial sculpture observed among the Navai, Ovalau and Taveuni specimens, the unreliability of size as a discriminating character and the failure of morphometric bivariate regressions assign clear separations, I have decided to treat all of the series as belonging to a single species. Further elucidation of the morphological variability and its peculiar geographic distribution will depend upon additional evidence, such as future collections and genetic analysis.

Distribution and Biology. The Viti Levu specimens from the Navai region were taken from logs and under stones while the Ovalau and Taveuni specimens were collected from sifted litter, suggesting these ants are components of the ground fauna. The type series is from a colony collection of 30 workers that was made from a nest in soil beneath a stone, identifiable by excavated earth adjacent to the entrance.



Figures 18–19. *Lordomyrma tortuosa*. 18. head. 19. profile.

Lordomyrma tortuosa (Mann)

(Figs. 18, 19)

Rogeria tortuosa Mann, 1921: 452, fig 18.

Description. *Worker.* TL 4.15–4.53, HL 0.93–1.01, HW 0.82–0.90, CI 0.87–0.91, SI 0.69–0.76, REL 0.18–0.24, PSLI 0.96–1.11, MFLI 0.94–1.02, DPWI 1.00–1.11 (10 measured).

A large-sized shiny, reddish brown species with massive promesonotum, modestly-sized straight propodeal spines and strong arcuate carinae on face. In full face view, posterior margin of head evenly convex with gently rounded corners. Clypeus bearing one pair of weak carinae. Frontal carinae strong, becoming confluent with series of arcuate carinae present between eye and posterior corners of head, forming dorsal margin of a broad, poorly defined scrobe. Eyes of moderate size. In profile, shape of promesonotum massive, strongly convex, and bulging above the head and propodeum. Propodeal spines strong, triangular, straight, divergent; in profile when measured from propodeal spiracle roughly equal to the width of the procoxae. Propodeal lobes of moderate size, triangular, stout. Petiole robustly built; anterior face strongly sloped and weakly concave; dorsal face more gently sloping and weakly convex; the rounded apex occurring at the anterior angle. Postpetiole with anterior and dorsal faces evenly convex, apex occurring at midline. Mandibles smooth and shining with scattered setigerous foveolae. Middorsum of head smooth and shining with scattered foveolae; several carinae mesad of frontal carinae, extending continuously or with interruptions from frontal lobes posteriorly to behind the eyes. Frontal lobes with one pair of strong carinae in addition to the frontal carinae. In oblique lateral view, widely separated and strongly elevated arcuate carinae overlaying all dorsal surfaces of head from frontal carinae to ventrolateral carina and from posterior corners to antennal insertions. Promesonotum smooth and shining with scattered foveolae. Procoxae smooth and shining. Sides of mesonotum, metapleuron, and propodeum overlain by coarse, widely-spaced and occasionally intersecting rugae. In dorsal view, dorsal face of propodeum smooth and shining, the anterior margin without a transverse carina posterior to metanotal groove; declivitous face smooth and shining. Petiole with smooth and shining anterior face, banded by coarse transverse rugae that reach the ventral face. Postpetiole coarsely rugoreticulate. Gaster smooth and shining. All dorsal surfaces with an abundance of suberect to erect acuminate hairs, the longest of which equal or exceed the length of the eye. Head, mesosoma and gaster reddish brown with lighter appendages.

Type Material. Syntypes, workers, Ovalau, Fiji (W.M. Mann) (MCZC, NMNH).

Other Material Examined. FIJI: **Kadavu:** Mt. Washington, 1.4 km SSW Lomaji Village, 19°07'06"S 177°59'25"E, 700 m, 5.ix.2006, ground foraging (E.M. Sarnat #2406). **Koro:** Mt. Kuitarua, 2.7 km NW Nasau Village, 17°17'41"S 179°24'39"E, 465m, 12.iii.2005, in leaf litter (E.M. Sarnat #1861, #1862.08); Mt. Kuitarua, 3 km WNW Nasau Village, 17°17'42"S 179°24'30"E, 420 m, 13.iii.2005, nesting in large wet log (E.M. Sarnat #1885); Mt. Kuitarua, 3.1 km WNW Nasau Village, 17°17'43"S 179°26'11"E, 440 m, 20.vi.2005, in dead tree fern (E.M. Sarnat #2100); Mt. Kuitarua, 3.7km NW Nasau Village, 17°17'27"S 179°24'11"E, 470 m, 20.vi.2005, on log (E.M. Sarnat #2086.01, #2086.02); Mt. Nabukala, 4.7 km WSW Nasau Village, 17°18'44"S 179°23'26"E, 500 m, 15.iii.2005, foraging under bark of fallen tree (E.M. Sarnat #1897). **Taveuni:** Road to Des Voeux [Devo] Peak, 16°50'S 179°59'W, 700 m, 26.iv.1997 (L.S. Farley); Tavoro Falls, 1.4km WSW Korovou Village 16°49'47"S 179°53'23"W, 100 m, 18.vi.2005, foraging on stone (E.M. Sarnat #2053 & J.A. Schreiber); Tavoro Falls, 2 km WSW Korovou Village, 16°49'47"S 179°53'23"W, 160 m, 18.vi.2005 (E.M. Sarnat #2061, #2064.02, #2066.02). **Viti Levu:** 5.5 km NNW Nadakuni Village, 17°55'S 178°16'E, 300 m, 7.v.2003, sifted litter (A. Tabutabu & A. Caginitoba); Nakobalevu, 1.5 km NE Colo-i-Suva Village, 18°03'S 178°25'E, 340 m, 29.vi.2002, sifted litter (M. Tokota'a); Nakobalevu, 1.5 km NE Colo-i-Suva Village, 18°03'S 178°25'E, 340 m, 8.iv.2003 (M. Tokota'a); Nakobalevu, 1.5 km NE Colo-i-Suva Village,

18°03'S 178°25'E, 340 m, 24.iv.2003, sifted litter (M. Tokota'a & S. R. Prasad); Nakobalevu, 1.5 km NE Colo-i-Suva Village, 18°03'S 178°25'E, 340 m, 28.vii.2003, sifted litter (A. Rakabula); Nakobalevu, 1.5 km NE Colo-i-Suva Village, 18°03'S 178°25'E, 340 m, 28.vii.2003, sifted litter (A. Rakabula); Mt. Korobaba, near Lami Town, 18°01'S 178°21'E, 300 m, 10.ii.2003, sifted litter (A. Tabutabu); Mt. Korobaba, near Lami Town, 18°01'S 178°21'E, 300 m, 6.viii.2003, sifted litter (M. Tokota'a); 2.7 km NE Naikorokoro Village, 18°05'S 178°19'E, 300 m, 29.vii.2003, sifted litter (A. Rakabula); Abaca Village, 17°40'S 177°21'E, 704m, 7.vi.2004 (D. F. Ward); Vaturu Dam, 17°45'S 177°35'E, 484 m, 7.vii.2004 (D. F. Ward). **Vanua Levu:** 2 km NNW Kasavu Village, 16°42'S 179°39'E, 300 m, 28.viii.2003, sifted litter (A. Rakabula); Mt. Vatudiri, 3km NW Waisali Village, 16°37'42"S 179°12'29"E, 641m, 2.ix.2006, in dead tree fern (E.M. Sarnat #2393); 2 km NW Nakanakana Village, 16°37'S 179°50'E, 300 m, 27.viii.2003, sifted litter (A. Rakabula); 3.5 km NW Vuya Village 16°59'S 178°43'E, 300 m, 28.xi.2004, sifted litter (A. Rakabula); Lasema (W.M. Mann); Ndreketi 25.x.1977 (G. Kuschel); Suene (W.M. Mann).

Discussion. *Lordomyrma tortuosa*, together with *L. desupra*, *L. stoneri* and *L. vuda* lacks a transverse carina on the dorsal face of its propodeum posterior to the metanotal groove and possesses a robust promesonotum that bulges above the level of its head and propodeum. It can be readily distinguished from these three by the frontal carinae that join with the arcuate carinae posterior of the eye, and the presence of longitudinal carinae that run immediately inward from the frontal carinae. Although the number and strength of these carinae vary, the variation does not appear to follow a distinguishable geographic pattern.

Distribution and Biology. With many records from 8 of the archipelago's islands, *L. tortuosa* is far and away the most geographically widespread of *Lordomyrma* species occurring in Fiji. The species is often collected from leaf litter, and nests of small colonies have been found in logs and under stones. Additionally, *L. tortuosa* appears to be restricted to the lower elevations of the islands, with only two of the aforementioned 32 records being recorded from above 500 m. Mann (1921) notes that he often found workers of this species foraging on mossy stones in ravines, and I have also observed workers gleaning the surfaces of stones on the banks of rivers.

***Lordomyrma vuda* Sarnat, sp. n.**

(Figs. 20, 21)

Description. Worker. TL 4.65–4.84, HL 1.01–1.05, HW 0.87–0.90, CI 0.83–0.87, SI 0.84–0.89, REL 0.20–0.23, PSLI 1.19–1.26, MFLI 1.19–1.24, DPWI 0.94–1.02 (6 measured). A large dark brown species with sparse facial sculpture, long appendages, and strongly produced downcurved propodeal spines. In full face view, posterior margin of head evenly convex with gently rounded corners. Clypeus bearing one pair of weak carinae. Frontal carinae weak, terminating before to just after posterior level of eye. Antennal scrobe weakly impressed. Eyes of moderate size. In profile, shape of promesonotum massive, strongly convex, and bulging above the head and propodeum in larger workers; less robust in smaller workers. Propodeal spines strong, triangular, downcurved, divergent; in profile when measured from propodeal spiracle, surpassing width of the procoxae. Propodeal lobes of strongly produced, upturned. Petiole robustly built; anterior sloping steeply to a vertical face; dorsal face gently sloping and weakly convex; slightly peaked apex occurring at the anterior angle. Postpetiole with anterior dorsal faces evenly convex, apex occurring in front of midline. Mandibles smooth and shining with scattered setigerous foveolae. Middorsum of head smooth and shining with scattered fove-

olae; carinae absent mesad of frontal carinae. Frontal lobes with several pair of strong carinae in addition to the frontal carinae. In oblique lateral view, a few weak carinae above eye; smooth behind, below and in front of eye. Promesonotum smooth and shining with scattered foveolae. Procoxae smooth and shining. Sides of mesonotum, metapleuron, and propodeum overlain by coarse, widely spaced and occasionally intersecting rugae. In dorsal view, dorsal face of propodeum smooth and shining, the anterior margin without a transverse carina posterior to the metanotal groove; declivitous face smooth and shining. Petiole with smooth and shining anterior face, banded by coarse transverse rugae that reach the ventral face. Postpetiole coarsely rugoreticulate. Gaster smooth and shining. All dorsal surfaces with an abundance of suberect to erect acuminate hairs, the longest of which equal or exceed the length of the eye. Head, mesosoma and gaster reddish brown with lighter appendages.

Type Material. *Holotype.* Worker, FIJI: **Viti Levu:** Koroyanitu National Park, Savione Falls, 2 km ESE Abaca Village, 17°40'33.6"S 177°33'00.5"E, 650 m, 25.viii.2006, rainforest/river edge, on stone (E.M. Sarnat #2335) (FNIC). *Paratypes.* 5 workers, same data as holotype (ANIC, MCZC, BPBM, NMNH). Holotype will be deposited in FNIC.

Other Material Examined. FIJI: **Viti Levu:** Koroyanitu NP, Mt. Batilamu, 2 km SE Abaca Village, 17°40'45.8"S 177°32'34.2"E, 840 m, 24.viii.2006, on stone (E.M. Sarnat #2323).

Discussion. *Lordomyrma vuda*, is the largest species in the genus thus far collected from Fiji. Like *L. desupra*, *L. stoneri* and *L. tortuosa*, it lacks a transverse carinate margin posterior to the metanotal groove on the dorsal face of its propodeum. Like *L. desupra* and *L. stoneri*, it lacks a developed facial sculpture and the presence of longitudinal carinae that run inward from, and parallel to, the frontal carinae. The downcurved spines of *L. vuda* distinguish the species from *L. stoneri*. *Lordomyrma vuda* can be distinguished from *L. desupra* by the more vertical, peaked appearance of its petiole node, the more robust propodeal spines, the more shallowly sloped propodeal dorsum, its larger size and darker coloration.

The similar morphologies of *L. desupra*, *L. stoneri* and *L. tortuosa* suggest a closely related group of species into which *L. vuda* does not comfortably fit. The robust propodeal spines, shallow slope of propodeal dorsum, and dark color combine with the petiole shape and sculpture to give *L. vuda* a appearance distinct. It will be interesting to learn from future phylogenetic work the relationships between *L. vuda* and the other Fijian *Lordomyrma*.

Distribution and Biology. Thus far, *L. vuda* has only been collected from two nearby localities in western Viti Levu's Vuda Province. Both collections were made from workers foraging on stones, with one locality being adjacent to a river. So far, *L. vuda* is the only species of the genus that appears to be restricted to the drier, leeward mountain ranges of western Viti Levu.

DISCUSSION

Distribution of *Lordomyrma* in Fiji

Lordomyrma is a relatively rare and inconspicuous member of the Fijian ant fauna. Although litter sifting has proved an effective method for capturing *Lordomyrma* species, their small, dispersed and inconspicuous nests combine with a small, slow-moving and well-camouflaged worker caste to make detection of these ants difficult in the field. Despite the wide coverage of the litter sifting transects and hand collecting localities (Fig. 22), the low abundances of individuals captured suggest that the distributions reported in this study may represent a limited picture of actual species ranges. Of the ten islands and island groups sampled in the recent surveys, *Lordomyrma* species were found on eight



Figures 20–21. *Lordomyrma vuda*. 20. head. 21. profile.

Table 2. Distribution of *Lordomyrma* of the Fiji Islands

Species	VL	VN	TV	KV	KR	LA	BQ
<i>L. curvata</i>	—	x	—	—	—	—	—
<i>L. desupra</i>	x	—	—	—	—	—	—
<i>L. levifrons</i>	x	—	—	—	—	—	—
<i>L. longiseta</i>	x	—	x	—	—	x	—
<i>L. polita</i>	x	—	—	—	x	—	—
<i>L. rugosa</i>	x	—	—	—	—	—	—
<i>L. stoneri</i>	x	—	—	—	—	—	x
<i>L. striatella</i>	x	—	—	x	—	x	—
<i>L. sukuna</i>	x	—	—	—	—	—	x
<i>L. tortuosa</i>	x	x	x	x	x	x	—

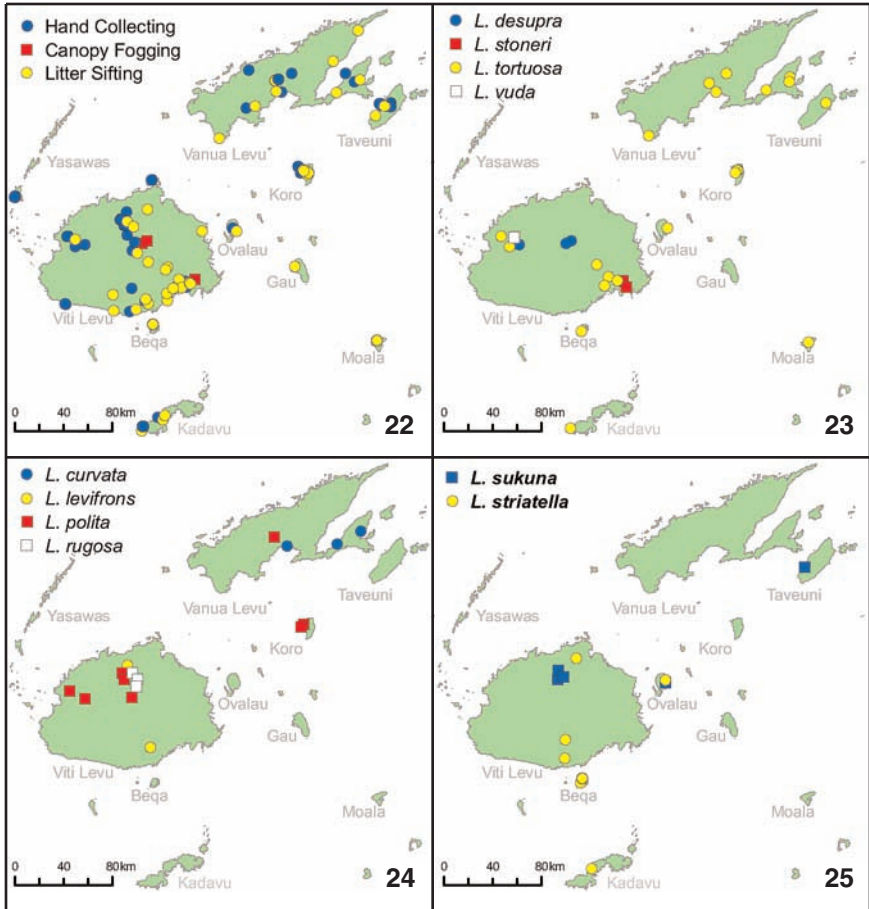
VL = Viti Levu, VN = Vanua Levu, TV = Taveuni, KV = Kadavu, KR = Koro, LA = Ovalau; BQ = Beqa

(Figs. 23–25). The recent collection of *L. tortuosa* from the island of Moala represents the most remote population of the genus in the archipelago. While it remains possible that *Lordomyrma* is also established on the Yasawa island chain in western Fiji and the Lau island group in eastern Fiji, the lack of sizeable, mesic and undisturbed forests in these regions limits the chances of their discovery. However, the larger island of Gau in the Lomaiviti province does appear to have suitable habitat for *Lordomyrma*, and the lack of records from that island is more likely the result of poor sampling than range limitation.

Although *L. tortuosa* is known from all eight islands on which *Lordomyrma* is recorded, the distributions of the other Fijian *Lordomyrma* tend to be more geographically restricted (Table 2, Figs. 23–25). For example, five species (*L. desupra*, *L. levifrons*, *L. rugosa*, *L. stoneri*, *L. vuda*) are recorded only from Viti Levu and one species (*L. curvata*) is known only from Vanua Levu. Another pattern revealed from the distribution records is that nine out of the ten species occur on Viti Levu. While Vanua Levu (5,535 km²) is approximately half the area of Viti Levu (10,388 km²), only three species have been recorded from the island. Although there may be compelling biogeographic explanations for this pattern, it must also be noted that Viti Levu is the better sampled of the two big islands.

Comparison with other Pacific Taxa

Lordomyrma material from Australia, Papua New Guinea and New Caledonia was examined to determine possible relationships with the Fijian fauna. Although preliminary comparisons of the Fijian taxa with that of neighbouring Pacific regions suggest that the archipelago may have been colonized by more than one lineage of *Lordomyrma*, a more thorough phylogenetic study is needed before conclusive results can be reported. Of the limited material examined, there exists a group of species, including *L. leae* Wheeler from Lord Howe Island, *L. punctiventris* Wheeler from eastern Australia, and *Lordomyrma azumai* Santschi from Japan, that bears close resemblance to the Fijian species *L. striatella* and *L. sukuna*. The most striking similarities among these species include (a) the presence of transverse striae crossing the dorsal face of the propodeum between the insertions of the propodeal spines, (b) a subtriangular shaped, slender petiole with straight and steep anterior and posterior faces in lateral view, (c) narrow, well-defined and strongly impressed antennal



Figures 22–25. Localities sampled from 2002–2006 and distribution of *Lordomyrma* species in the Fiji Islands. Overlapping symbols are offset where multiple species are recorded from identical localities.

scrobes, (*d*) sculpture marked by a fine and strongly produced rugoreticulum, and (*e*) long and abundant erect or suberect hairs on most surfaces of the body.

The remaining Fijian species, however, have no close analogues to the species examined from Australia, and tend to share more characteristics with material examined from New Guinea. Shared characteristics include: (*a*) a more robustly produced promesonotum; (*b*) shallow, broader and more weakly defined antennal scrobes; and (*c*) a petiole with a more steeply sloping anterior face and more gently sloping posterior face in profile.

None of the material examined from New Caledonia closely resembled the Fijian fauna, however, there is reported to be a considerable amount of diversity that has yet to receive thorough examination (R.W. Taylor, pers. comm.). One unidentified species

examined from New Caledonia appears to be allied to a group of very small ants with representatives in Australia and New Guinea that is characterized by: (a) a dense pelt of short erect hairs; (b) a nearly flat mesosomal dorsum; (c) the absence or near absence of antennal scrobes; and (d) a dense rugoreticulum overlaying the face and much of the mesosoma. A greater diversity of the New Caledonia *Lordomyrma*, including *L. caledonica* Andrea, is unique to the island and appears to constitute an endemic radiation with the following characteristics in common: (a) the absence of dorsoventral carinae on the head; (b) relatively long scapes that reach or surpass the posterior corners of the head; and (c) a deeply impressed metanotal groove.

Future directions for the study of *Lordomyrma*

Taxonomy

While the present taxonomic treatment is limited to the Fijian species, a global revision is required to reassess the generic concept with respect to several genera that have been synonymized with *Lordomyrma* and a body of undescribed material that closely resembles *Lordomyrma*. *Promeranoplus* Emery and *Prodicroaspis* Emery were described by Emery (1914) from New Caledonia and stood as monotypic genera before Bolton (1994) synonymized them with *Lordomyrma*. Although the descriptions provided by Emery are insufficient to elucidate the relationships between these species and the other species of *Lordomyrma*, both possess features, such as the bilobed prominence produced between the expansively broad and flat frontal lobes of *Lordomyrma sarasini* (= *Promeranoplus sarasini*) and the bispinose petiole of *L. sarasini* (= *Prodicroaspis sarasini*), that are otherwise unique to the genus. There also exist a number of undescribed specimens from the Philippines, Borneo, Australia and New Guinea that possess characters diagnostic of *Lordomyrma*, but differ substantially from the described species. If the generic concept is expanded, other members of the tribe Stenammini, such as the New Guinean *Ancyridris* Wheeler and Afrotropical *Cyphoidris* Weber, will also deserve examination.

Biogeography

The rich diversity, species turnover and relatively restricted distributions of *Lordomyrma* in Fiji, and the Pacific in general, make the genus a strong candidate for elucidating biogeographic patterns and processes within the archipelago and between the archipelago and other Pacific regions. One pattern made clear by the collection records is the disproportionate number of species that occur on Viti Levu. In addition to being the largest and tallest of Fiji's islands, Viti Levu is also the oldest and most geologically unique. Viti Levu is believed to be a fragmented remnant of the ancient Vitiaz island arc, and may predate the other large Fijian islands by over 30 million years (Nakano *et al.* 1977; Rodda & Kroenke 1984; Whelan *et al.* 1985; Rodda 1994; Kroenke 1996; Stratford & Rodda 2000).

Another interesting pattern revealed by the distribution of *Lordomyrma* species in Fiji is the relatively rich diversity recorded from the island of Ovalau. Despite the relatively small size of Ovalau, it is tied with the much larger Vanua Levu as the second most diverse island with respect to *Lordomyrma*, hosting at least three species. However, all three of these species are also found on nearby Viti Levu. Although it is possible that individuals dispersed from Viti Levu to Ovalau over water, it is also believed that Viti Levu was connected to Ovalau by dry land during the last glacial maxima (Nakano, Silveira Neto, Batista, Yokoyama, Degaspari and Marichi 1977; Haq *et al.* 1987; Mestertongibbons & Dugatkin 1992; Rodda 1994), thus allowing for the potential of populations crossing from one island to the other.

Determining the biogeographic origins of the Fijian *Lordomyrma* may help to illuminate broader questions of the origins of the archipelago's other entomofauna. Little is known about the origin of Fiji's terrestrial arthropods. Although the islands boast high levels of endemism, the radiations appear to be older and more modest than the stunning lineage diversifications that have occurred relatively recently on other remote Polynesian archipelagos, such as Hawaii or the Marquesas. *Lordomyrma* is a distinctly western Pacific genus with strong representation in many of the major Pacific areas surrounding Fiji, and a biogeographic study of the genus has the potential to reveal interesting patterns concerning the colonization of the region.

More thorough sampling and a well-resolved phylogenetic tree will allow for rigorous testing of biogeographic hypotheses concerning the origin of the Fijian *Lordomyrma*. While Viti Levu, Taveuni and Koro have been relatively well collected, Kadavu and the interior of Vanua Levu have received less attention. Additionally, Gau and the islands of Moala and Matuku require at least a cursory sampling before a relatively complete census of the Fijian *Lordomyrma* can be expected. A well-resolved phylogenetic tree, incorporating relevant extralimital species, will allow for the analysis of biogeographic pattern using sister-group relationships. Clearer understanding of these relationships may be crucial for answering questions on the archipelago scale, such as the effects of sea level change on current distributions, as well as on the southwest Pacific scale, such as the origin or origins of the Fijian fauna.

Conservation

The conservation of the Fijian *Lordomyrma* is ultimately tied to the conservation of the mature, mesic and undisturbed forests of the archipelago. The high correlation between the distribution of these habitats and the presence of *Lordomyrma* suggests that these ants are restricted to Fiji's increasingly threatened native mesic forests. If *Lordomyrma* is to be used in conjunction with other taxa as a surrogate for conservation value it will be important to quantify the association between its presence and that of realistic correlates such as general ant diversity, ground arthropod diversity and forest characteristics. Furthermore, standardized and periodic censuses of the genus may help to monitor the effects that environmental changes, such as the spread of invasive species, habitat degradation and climate change, have on Fiji's native ground dwelling arthropods.

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APPENDIX

Measurements for each of the 10 species of *Lordomyrma* described from Fiji. (n) = number of individuals measured. Measurement abbreviations are described in Table 1.

	<i>L. curvata</i>	<i>L. desupra</i>	<i>L. levifrons</i>	<i>L. polita</i>	<i>L. rugosa</i>	<i>L. stoneri</i>	<i>L. striatella</i>	<i>L. sukuna</i>	<i>L. tortuosa</i>	<i>L. varda</i>
(n)	3	10	1	11	10	8	10	16	10	6
TL	3.12- 3.26	3.55- 4.18	4.31	3.32- 3.86	3.36- 3.77	4.21- 4.52	3.16- 3.33	3.48- 4.14	4.15- 4.53	4.65- 4.84
HL	0.72- 0.73	0.81- 0.93	0.99	0.74- 0.87	0.77- 0.85	0.95- 1.00	0.71- 0.75	0.78- 0.91	0.93- 1.01	1.01- 1.05
HW	0.59- 0.62	0.73- 0.83	0.89	0.64- 0.76	0.71- 0.76	0.82- 0.89	0.59- 0.63	0.65- 0.75	0.82- 0.90	0.87- 0.90
SL	0.42- 0.45	0.53- 0.62	0.65	0.50- 0.58	0.50- 0.54	0.61- 0.64	0.45- 0.49	0.51- 0.62	0.58- 0.64	0.75- 0.78
EL	0.16- 0.18	0.17- 0.23	0.21	0.17- 0.22	0.15- 0.18	0.20- 0.23	0.15- 0.19	0.17- 0.22	0.18- 0.23	0.20- 0.23
EW	0.09- 0.10	0.11- 0.15	0.13	0.10- 0.14	0.09- 0.12	0.12- 0.15	0.11- 0.12	0.11- 0.15	0.11- 0.16	0.14- 0.16
CW	0.19- 0.20	0.25- 0.28	0.29	0.22- 0.27	0.23- 0.26	0.26- 0.28	0.21- 0.23	0.23- 0.28	0.27- 0.28	0.29- 0.31
MFL	0.56- 0.60	0.75- 0.83	0.90	0.64- 0.80	0.68- 0.73	0.81- 0.92	0.56- 0.62	0.67- 0.83	0.79- 0.87	1.04- 1.08
PW	0.50- 0.54	0.57- 0.68	0.70	0.53- 0.69	0.57- 0.63	0.66- 0.74	0.46- 0.50	0.51- 0.59	0.68- 0.75	0.70- 0.71
DPW	0.21- 0.22	0.22- 0.26	0.26	0.20- 0.25	0.24- 0.26	0.27- 0.30	0.20- 0.22	0.21- 0.24	0.26- 0.30	0.28- 0.31
PH	0.25	0.28- 0.31	0.38	0.26- 0.31	0.30- 0.32	0.34- 0.37	0.28- 0.29	0.27- 0.31	0.28- 0.37	0.38- 0.41
MH	0.12- 0.14	0.16- 0.18	0.27	0.10- 0.15	0.17- 0.18	0.18- 0.21	0.18- 0.24	0.20- 0.26	-	0.19- 0.28
PSL	0.24- 0.26	0.23- 0.29	0.38	0.25- 0.35	0.29- 0.34	0.25- 0.31	0.19- 0.22	0.19- 0.26	0.21- 0.30	0.35- 0.38
CI	0.83- 0.86	0.87- 0.92	0.90	0.86- 0.91	0.86- 0.94	0.85- 0.87	0.83- 0.88	0.81- 0.85	0.87- 0.91	0.83- 0.87
SI	0.71- 0.73	0.71- 0.76	0.73	0.75- 0.79	0.68- 0.72	0.72- 0.76	0.72- 0.79	0.78- 0.87	0.69- 0.76	0.84- 0.89
MHI	0.75- 0.78	0.70- 1.00	1.29	0.48- 0.75	0.98- 1.12	0.86- 1.05	0.97- 1.05	1.20- 1.41	-	0.66- 0.93
REL	0.22- 0.25	0.21- 0.25	0.21	0.22- 0.27	0.19- 0.22	0.20- 0.23	0.21- 0.26	0.20- 0.25	0.18- 0.24	0.20- 0.23
PSLI	1.25- 1.30	0.92- 1.12	1.31	1.13- 1.46	1.28- 1.48	0.96- 1.11	0.82- 1.00	0.76- 1.02	0.96- 1.11	1.21- 1.26
MFLI	0.93- 0.97	0.99- 1.08	1.01	0.97- 1.05	0.92- 1.00	0.91- 1.07	0.93- 0.99	1.02- 1.13	0.94- 1.02	1.19- 1.24
DPWI	1.05- 1.10	0.85- 1.00	0.90	0.91- 1.09	0.98- 1.10	1.00- 1.07	0.92- 1.01	0.85- 0.92	1.00- 1.11	0.94- 1.02