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NESOBASIS SPECIES DIVERSITY AND ABUNDANCE: NOTES ON AN ENDEMIC GENUS OF THE ISLAND GROUP OF FIJI (ZYGOPTERA: COENAGRIONIDAE)

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Compared to other regions in the world, the islands scattered over the south-western Pacific Ocean remain largely unstudied with respect to damselfly biology. Only a few studies have been undertaken and these have been mainly of a taxonomic nature. Here, an overview is presented of the diversity, abundance, distribution and field diagnostic characteristics of spp. within the Fijian genus *Nesobasis*, one of the most speciose odonate genera found in any oceanic island group in the world. 24 spp. (2 undescribed) were encountered during a 2-month visit in the dry season of 2005, collected from Viti Levu and Vanua Levu. This brings the total number of spp. currently known for the genus to 31 (of which only 21 are at present formally described). Information is provided on species diversity and abundances at the major collecting sites. For both islands the most speciose location harboured 8 spp. Abundant spp. tended to be widespread, while less abundant spp. were usually restricted in occurrence to a few sites. Included are basic species descriptions and observations on reproductive activities.

INTRODUCTION

Oceanic islands have long provided important exemplars in evolutionary ecology (DARWIN, 1859; MACARTHUR & WILSON, 1967). Freedom from predators, coupled with the difficulty of finding mates can generate unique selection pressures, culminating in adaptations that include gigantism, flightlessness and even reproduction without sex. As an example, recent work in the Azores Islands has led to the discovery of a female-only population of the damselfly *Ischnura hasta-*

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ta, in which adults reproduce parthenogenetically (CORDERO-RIVERA et al., 2005; SHERRATT & BEATTY, 2005*)*. This result has recently been described as "One of the all-time most interesting and important discoveries in odonate biology" (DONNELLY, 2005).

Despite these facts, many regions of the tropics, especially the islands of the Southwest Pacific, remain largely unexplored from the standpoint of odonate diversity and biology. Here we describe some first results of our study of the genus *Nesobasis*, a group endemic to the Fijian Archipelago (DONNELLY, 1990). Earlier research on the genus focussed appropriately on taxonomic work (SELYS-LONGCHAMPS, 1891; TILLYARD, 1924; DONNELLY, 1990) as even now species remain to be described. However, this particular island group provides fascinating research opportunities on ecology, behaviour and evolution (see DONNELLY, 1990; and below).

Research on this genus is of interest for several reasons. First, *Nesobasis* is the most speciose genus of Odonata found in any oceanic island group in the world (DONNELLY, 1990) providing opportunities for multi-species comparative studies. Second, Fiji consists of many islands; the present distribution of known *Nesobasis* species shows that individual islands have a unique suite of species, and thus offers the possibility for new species to be found and zoogeographic work to be undertaken. Third, the larger Fijian islands are characterised by a complex topography, with several mountain ranges and significant variation in altitude. This topography seems to explain some of the species distributions in *Nesobasis*, and together with rainfall may explain some of the variation in colour, structure and size within and between species (see also DONNELLY, 1990). Fourth, it has been suggested that in some *Nesobasis* species the females may present examples of sex-role reversal, with females effectively establishing and defending territories, which is otherwise typically a male activity (DONNELLY, 1990).

Our aims are to provide information on basic characteristics that were useful for us while identifying species in the field. At present 21 species within the genus have been formally described (TILLYARD, 1924; DONNELLY, 1990), while ten additional species are the subject of a forthcoming paper (T.W. Donnelly, unpubl. ms.). Here we give specific details on the reproductive behaviour (tandem, copulation wheel, and oviposition) observed in the field for those species we encountered. We also provide a first quantitative perspective on *Nesobasis* species diversity at 16 localities, including indications of species abundances. More details on the sex-ratios and behaviour, based on an independent data set, are provided in a companion paper (VAN GOSSUM et al., submitted).

METHODS

The Fiji Islands in the eastern Melanesian region of the southwestern Pacific consist of several hundred islands and occupy an area of approximately 650,000 km² of which the land area is less than 3 percent. There are two large islands (which we surveyed for odonates): Viti Levu (10,388 km²) and Vanua

Levu (5,535 km²) (see also EVENHUIS & BICKEL, 2005). The major islands are rugged, and landforms include volcanic plugs, eroded calderas, deep gorges, and ravines carved by mountain streams, flat-bottomed valleys with extensive food plains, and mangrove dominated deltas (EVENHUIS & BICKEL, 2005). Fiji has a warm, humid tropical maritime climate with mean monthly temperatures from 23°C in July to 27°C in January (RYAN, 2000). Because Fiji is subequatorial, there is weak seasonality, with heavier rainfall between November and April, especially on the low islands and the leeward sides of the large islands (EVENHUIS & BICKEL, 2005). Our study period took place during the dry season from August 4 to October 1, 2005.

The genus *Nesobasis* is abundant and widespread in the Fijian islands and are the dominant Zygoptera in all stream habitats but are absent from large rivers and from ponds (DONNELLY, 1990, 1994). Preliminary communication with T.W. Donnelly and D. Polhemus allowed us to select specific regions both on Viti Levu and Vanua Levu, which could be expected to harbour *Nesobasis* damselflies. For Viti Levu, sites included in our study are located mainly in the northwest, while for Vanua Levu sites were located mainly directly west of Savusavu (Fig. 1).

Sites for Viti Levu were (see Fig. 1A): Abaca Road 2 (17°39.99'S; 177°31.65'E, elev. 380 m), 1-2 km before entering Abaca Village

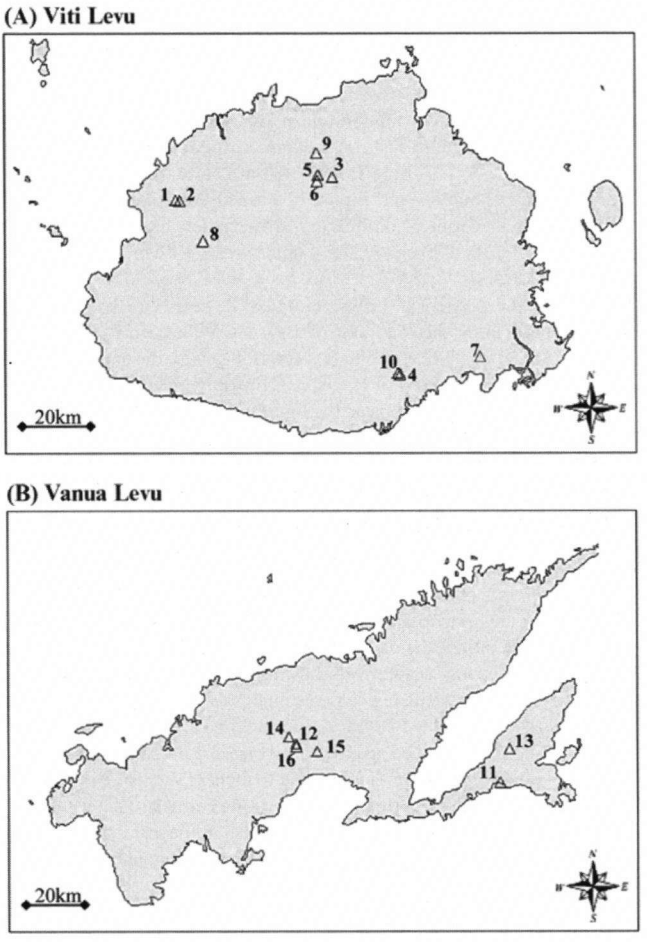

Fig. 1. Island maps, showing site locations. (A) Viti Levu: (1) Abaca Road 2, – (2) Abaca Road 3, – (3) Korowaiwai, – (4) Namosi Road, – (5) Nukunuku, – (6) Qualiwana Tributary, – (7) Vaqo Creek, – (8) Vaturu Dam Road, – (9) Waikubukubu, – (10) Wainikovu; – (B) Vanua Levu: (11) Bagasau Creek, – (12) Lomaloma Falls, – (13) Niuwauvudi Creek, – (14) Raviravi Creek, – (15) Sauvuqoro Creek, – (16) Volivoli Creek. – [See Methods section for site lat/long coordinates, elevations and descriptions]

one passes a narrow stream valley with dense vegetation on both sides, we sampled a small stream at the left-hand side of the road driving towards Abaca Village; Abaca Road 3 (17°40.11'S; 177°32.52'E, elev. 535 m), on Vereni Creek, a medium-sized stream which is located behind Abaca Village, in Abaca National Park, the stream is high gradient with cascades and waterfalls flowing over exposed rock and boulders, we sampled an area with water running over large patches of exposed rock; Korowaiwai (17°36.18'S; 177°56.83'E, elev. 700 m), where the road from Nadarivatu to Lewa crosses a second bridge, we sampled the river at both sides of the bridge; Namosi Road (18°06.74'S; 178°11.21'E, elev. 265 m), second small waterfall above Wainikovu Tributary at road post 8/10; Nukunuku (17°37.11'S, 177°56.71'E, elev. 660 m), road crossing just downstream of confluence between Vunikadanu Creek and Nukunuku Creek; Qualiwana Tributary (17°36.45'S; 177°59.34'E, elev. 725 m), a small tributary of Qualiwana Creek running out of the Forest Preserve north of the sub depot bridge; Vaqo Creek (18°04.89'S; 178°26.57'E, elev. 50 m), upstream of confluence with Savua River; Vaturu Dam Road 2 (17°46.23'S; 177°36.58'E, elev. 430 m), steep-gradient stream crossing Vaturu Dam Road, many very large boulders and exposed bedrock; Waikubukubu (17°32.84'S; 177°56.62'E, elev. 210 m), section 0.5 km from Waikubukubu Village at left-hand site coming from the village; Wainikovu (18°06.39'S; 178°10.82'E, elev. 230 m), small stream with open areas and sections shaded by overhanging vegetation.

For Vanua Levu (see Fig. 1B) we sampled: Bagasau Creek (16°42.90'S; 179°43.67'E, elev. 55 m), the stream adjoining the road east of Bagasau Village on the eastern peninsula; Lomaloma Falls (16°37.38'S; 179°10.00'E, elev. 300 m), waterfall next to the main road on the right-hand side between Lomoloma and Saivou west of Savusavu; Niuwauvudi Creek (16°38.12'S; 179°45.18'E, elev. 230 m), a deep stream (1-2 m depth) near the forestry station in the drainage upslope from Bagasau; Raviravi Creek (16°36.44'S; 179°08.87'E, elev. 90 m), a small stream entering the river at Saivou village; Sauvuqoro Creek (16°38.50'S; 179°13.50'E, elev. 250 m), a stream with pools in the Waisali Nature Preserve along the nature trail; Volivoli Creek (16°37.75'S; 179°10.08'E, elev. 135 m), a large stream with much fast flowing water (1-2 m deep in some places) on the left-hand side between Lomoloma and Saivou, to reach the stream one should follow a dirt track on the left after having passed Lomaloma coming from Savusavu, where the tracks crosses the river we obtained our samples.

Our sampling method consisted of netting all observed damselflies occurring at any of the studied rivers. For any individual belonging to the genus *Nesobasis* we undertook species identification. Additionally, we noted the date, latitude and longitude, details on stream width and length of the stream covered during sampling, and the approximate time our sampling took. The latter two estimates allowed us to calculate coarse estimates of species abundances. Stream width multiplied by stream length covered could be translated into area covered (number of individuals per unit of area), while sampling time provided an alternative measure for calculating species densities (number of individuals per unit of time). We decided only to include sites for which a visit lasted minimally an hour. While a one-hour sample period may not be long enough to detect all species present at a site (for example, those that are very rare or may be present at the water at different times of the day than those sampled), this level of sampling effort allowed us to characterize the common species at a particular site effectively. For sites that were sampled for shorter periods of time we considered sample effort too limited to include here. We have also chosen to exclude sites for which we sampled for an hour or greater, but where our sample efforts were focussed on the capture of particular species for our research; in these cases sampling effort would not provide an unbiased sample of species abundances at a site.

SPECIES DESCRIPTIONS

The following basic descriptions provide characteristics we used in the field for species identification. In some instances identification of species requires magnifying glasses (20 times) or a field-microscope, as a close look at the exact structure of genitalia and/or mesostigmal laminae is required

(see DONNELLY, 1990). More detailed descriptions can be found in TILLYARD (1924) and DONNELLY (1990) and will appear in Donnelly's publication. With respect to the latter and as agreed upon with T.W. Donnelly, in what follows we use the first letter(s) of the species names Donnelly will be using in his forthcoming manuscript to allow convenient comparison. We found two species new to science during our sampling, which are referred to simply as undescribed species (*Uds*). Here we also provide only basic field descriptions as they will be included in more detail in Donnelly's work.

- *N. angulicollis* (TILLYARD, 1924): Viti Levu. – A medium-sized species, with the sides of the thorax almost entirely bright blue (variation in the thoracic markings led TILLYARD (1924) to recognize an additional species, *N. subhumeralis*, which DONNELLY (1990) considered a synonym of *N. angulicollis*). Abdominal segments eight to ten are bright blue dorsally, with this colour extending well down on the sides of segment eight distally, far down on the sides of segment nine and entirely around segment ten. This species also has a thin blue line along the mid-dorsal carina. The female is similar in colour to the male, but paler: specifically, the abdomen is mostly yellowish on the sides and underside, while dark bronze above, except for most of segment nine and the whole of segment ten, which are blue. We regularly observed tandem pairs, and also a few copulation wheels. Oviposition occurs while tandem-guarded by the male; we did not observe solitary oviposition by the female.
- *N. caerulecaudata* (DONNELLY, 1990): Viti Levu. – A dark species with bright blue-tipped abdomen, most of segment eight and all of segment nine and ten (except for thin lateral dark margins) are conspicuously coloured. For a description of the characteristic male appendages of this species see *N. longistyla*. This species is not reliably distinguished from *N. longistyla* by morphology, and the possibility should be considered that the two constitute only one species (T.W. Donnelly, pers. comm.). No females were observed during our study.
- *N. campioni* (TILLYARD, 1924): Viti Levu. – See description for *N. longistyla*. No males were observed during our study.
- *N. comosa* (TILLYARD, 1924): Viti Levu. – A very dark species with pale markings very much obscured by a dark grey pruinescence. It is found at higher altitudes in contrast to *N. heteroneura*, and the two species were never found syntopically. The superior and inferior appendages are about the same length and characteristically very hairy; while the superior appendages are blackish, the inferior ones are coloured reddish brown. *N. comosa* and *N. heteroneura* females are challenging to identify; usually the pale grey-green thoracic markings in *N. comosa* females are darker compared to *N. heteroneura* females, but since there is some overlap sometimes the only good diagnostic character is the association with the type of males present. The female oviposition behaviour is similar to that of *N. heteroneura* (see below).
- *N. erythrops* (SELYS, 1891): Viti Levu. – Males have bright red eyes and a predominantly red colour of the head and thorax and sides of the first two

abdominal segments. The black abdomen is relieved apically with segments nine and the basal half of ten being bright blue dorsally. The female body coloration varies from dominantly pale orange, to dark, and obscure bluish on the lateral sides of the thorax, however all individuals showed an orange face. It was observed mostly either as solitary males or tandem pairs. Copulation wheels were observed a few times. Female oviposition occurred mostly in tandem at the water surface, with only the female submerged, or both male and female submerged, but solitary oviposition of females was also observed.

- *N. flavifrons* (DONNELLY, 1990): Viti Levu. – A large, brightly marked species. Dark colour shining black to obscure brownish black, with greenish iridescence on the head; pale colour, chrome yellow on the face to pale yellow-orange on the thorax and the abdomen. The female is similar in appearance to the male, but the yellow colours are less intense and the dark is duller, also the dark colour is more limited. No mating associations were seen.
- *N. heteroneura* (TILLYARD, 1924): Viti Levu. – The species has a sturdy appearance with the thorax greenish black dorsally and blue laterally; the colour of the abdomen is greenish black above with segment nine and ten bright blue above and on the sides. It differs from *N. comosa* (see above) by the bright blue coloration on the thorax and at the tip of the abdomen; also *N. heteroneura* has the labrum coloured bluish-green. The female differs from the male in being shorter and stouter, with the bright blue of the thorax replaced by yellowish, greenish to a grey pruinose colouration, and the blue colour at the tip of the abdomen absent or sometimes represented by a small blue blotch on segment ten and the distal part of nine on an otherwise bronze black background. Females were observed ovipositing solitarily in cobbles and riffles.
- *N. longistyla* (SELYS, 1891): Viti Levu. – A medium-large species which together with *N. caerulecaudata* and *N. campioni* is easily recognised by the form of the male appendages, the superiors being straight and longer than segment ten, while the inferiors are very short and obtuse. *N. campioni* can be distinguished by its smaller dimensions and greenish iridescence. Compared to *N. caerulecaudata*, *N. longistyla* has limited blue at the tip of the abdomen varying from almost no blue to most of segment nine and ten being coloured blue. Identification of the female requires study of the mesostigmal laminae. No mating associations were observed during our study.
- *N. malcolmi* (DONNELLY, 1990): Viti Levu. – Male and female have similar body coloration and dimensions. A sturdy and beautifully coloured species characterised by a mixture of copper, yellow, greenish yellow to more orange on the abdomen. The only mating association that we observed was a flying duo of a female *N. malcolmi* that was taken in tandem by a male *N. comosa*. No *N. malcolmi* males were observed during our study. Females were seen commonly ovipositing in cobbles and riffles.
- *N. monticola* (DONNELLY, 1990): Viti Levu. – A dark species, with males

and females coloured similarly both showing limited pale blue and grey-green on the thorax. The abdomen is dark above grading into red-brown on the lateral margins; the sides of segment one and two are pale grey-green, grading into obscure red-brown on posterior segments. No males were observed during our study.

- *N. rufostigma* (DONNELLY, 1990): Viti Levu. – A very small, brightly marked species. Dark colour of the body is iridescent red, while the pale colour is yellow. Wing venation is reddish-brown, with the pterostigma in the male being bright red, and pale red in the female. No mating associations were observed, but females were observed ovipositing solitarily in cobbles and riffles.
- *N. selysi* (TILLYARD, 1924): Viti Levu. – A very slender medium-sized species. The colours of the thorax vary from a bright blue with limited black markings, to rather dark individuals with a black thorax with obscure pale on the sides, to more greyish or brownish. Abdominal segments nine and ten are generally entirely black, but in some specimens each shows a narrow blue line around its distal border. A further characteristic of the species is its short anal appendages. Females are paler in colour, sometimes resembling those of *N. erythrops*, though lacking the yellow coloration of the face. Despite this species being very common and encountered in most locations visited on Viti Levu we never observed any mating associations.
- *N. telegastrum* (SELYS, 1891): Viti Levu. – A very large species with dark body colours: very limited pale blue or pearly grey on the thorax. The black labrum and postclypeus are separated by a yellow anteclypeus. Females were not observed during our study.
- *N. brachycerca* (TILLYARD, 1924): Vanua Levu. – A large damselfly, with equally sized males and females. The species shows a nice colour pallet with yellow, red ochre and dark bronze green. While the legs and ventral parts of the thorax are yellow-orange, the side of the thorax and the dorsal tip of the abdomen are reddish ochre and the dorsal parts of the thorax are dark bronze green in colour. The female shows either the lateral side of the thorax less conspicuous compared to the male with more a blue and brown colour mix, or is identical in colouration to the male. We are uncertain whether the colour variation in the female represents age-related colour changes or alternatively indicate female adult colour polymorphism. No mating associations were seen.

The following are the undescribed taxa:

- *N. al.*: Vanua Levu. – A small damselfly, which is similar in size to or slightly larger than *N. rufostigma* of Viti Levu. Males and females are similar in size, with the males being easily recognised by the white colour of the pterostigma in combination with adjacent black coloration over parts of the distal next two wing cells. The pale colours on the thorax in the male are green, while these are a more bright blue in the female. Also, the pterostigma in the females stands out less, with no adjacent black marking, and the colour of the pterostigma varying from white to more ochre. A few tandem pairs were observed flying.

- *N. au.*: Vanua Levu. – The female similar in coloration to the female of *N. a.*, though the pterostigma in this species is of a much darker brown. Males were not observed during our study.
- *N. c.*: Vanua Levu. – This species is easily identified because of its rather plain, stout body shape and greyish colouration. No males or mating associations were seen.
- *N. f.*: Vanua Levu. – A small damselfly, predominantly coloured green and black, but with the sternum of the abdomen red. The male has distinctive forked lobes of the genital pore on the venter of the tip of the abdomen. No females were seen.
- *N. l.*: Vanua Levu. – A slender medium-sized species that is reminiscent in appearance of *N. selysi*. The male and female are similar in size and body pattern, but while the pale colours in the male are blue in females these are usually less conspicuous and browner. Dorsally at the tip of the abdomen the species is blue in colour. Several tandem and copulation wheels were observed. We did not observe oviposition.
- *N. r.*: Vanua Levu. – A long and very slender species, almost entirely pale red, apart from two dark stripes dorsally on the thorax lining the red mid-dorsal carina. A single male was collected during our study, no females were observed.
- *N. t.*: Vanua Levu. – A large, dark species typified by some blue colour on the thorax, reminiscent of *N. longistyla* of Viti Levu. The male inferior appendages are obsolete. No mating associations were seen
- *N. v.*: Vanua Levu. – A slender medium-sized damselfly characterised by green pale body markings in both sexes. The superior appendages are long and forcipate, while the inferior appendages are only about half the size of the superior ones and pointy in shape. No mating associations were seen.
- *Uds1*: Viti Levu. – The female is similar to *N. longistyla* in that it has a postero-mesal rounded process on the mesostigmal laminae (DONNELLY, 1990). This character is not useful for naked-eye identification, but the different shape and size of this process distinguishes it from *N. longistyla* as well as from *N. campioni*, (which it more closely matches in size) and was our first indication that this may be a new species. The thoracic colour of the female is more blue-green, compared to the yellow of *N. longistyla* females. The ventral side of the abdomen is light in colour; the dorsal side of abdominal segments nine and ten have variable blue coloration. No males of this species were collected.
- *Uds2*: Vanua Levu. – The male and female possess a brown pterostigma. The male comes in two different colour morphs, which may represent age-variants or adult colour variations. One of the morphs is similar (but not identical) in appearance to the male of *N. heteroneura* as found on Viti Levu, with the sides of the thorax green to blue and the tip of the abdomen brightly blue (with variation in the extent of blue on segment eight which ranges from large dots posteriorly and dorsally placed accompanied by small dots anteriorly and dorsally, to almost a lack of blue on this segment; while nine and ten are mainly blue in colour). The other male colour variant is much more dark and obscured, lacking any conspicuous coloured markings. The superior and inferior appendages are of equal length and hairy. The females are smaller and sturdier than the male, having a vibrant coloration with metallic green on the dorsal parts of the thorax and abdomen, while the remaining of the thorax and the legs are coloured in a conspicuous red to shiny purple. The female eyes are a tricolour, dark dorsally, yellow-green anteriorly and reddish laterally. No mating associations were seen, but females were seen ovipositing in cobbles and slow streaming shallow sections of the river

RESULTS AND DISCUSSION

In total we caught and identified 1857 *Nesobasis* specimens, of which 1429 were on Viti Levu and 428 on Vanua Levu. On Viti Levu we observed *Nesobasis*

at 24 sites, of which 11 complied with our data selection criteria (a minimum of 1 hour of unbiased sampling) and are presented here. For Vanua Levu we report on 6 out of 7 sites. The majority of our sampling was performed on Viti Levu (while our sampling occurred between August 4 and October 1 2005, our sampling on Vanua Levu was confined to the period between 17 and 20 September 2005). DONNELLY (1990) described 19 species for Viti Levu, of which we did not observe six: *N. leveri*, *N. ingens*, *N. flavostigma*, *N. aurantiaca*, *N. caerulescens* and *N. pedata*. The first two are restricted in occurrence to higher altitudes where we spent only a little of our collecting time; while for the other four species, only a few specimens have ever been collected. For *N. malcolmi* the total number of specimens collected prior to our visit was only three, whereas we made collections of 38 specimens at Abaca Road 3. Additionally, at Abaca Road 3 we collected a species (*Uds 1*) that was not previously observed or described (T.W. Donnelly, pers. comm.). For Vanua Levu we observed all nine species observed by Donnelly during a previous visit, and made additional observations of a new species (*Uds 2*). Considering we made only short visit to this island further visits will likely result in the discovery of more species.

DONNELLY (1990) reports for Viti Levu that even small and apparently unpromising streams commonly have at least four species, and encountered a maximal species richness of 12 species at a single locality (Waikubukubu). Our samples for species richness for Viti Levu ranged from 2-8 species; on Vanua Levu they ranged from 2-8 species as well. These numbers are slightly lower than the ones reported by DONNELLY (1990). One reason for this difference could be variation in species diversity between the dry and the wet season (T.W. Donnelly sampled many sites on different trips during different seasons). It would be interesting to evaluate whether species diversity changes throughout the year with adults of some species being confined in occurrence to certain environmental conditions. Also, the sites visited during our study will harbour much more water during the rainy season, thus species may then move habitat and be found on the smaller streams and tributaries. Alternatively, the lower species diversity we found may be attributed to our sampling being less intensive.

None of the *Nesobasis* species found on Viti Levu was found on Vanua Levu. DONNELLY (1990) provides information on distribution of species across Viti Levu and two of its neighbouring islands, Ovalau and Kadavu. For nearby islands species mainly appear to be shared, although *N. recava* was encountered only on Kadavu. Similarly, most species to be found on Taveuni may be those also present at Vanua Levu. Considering the Fiji Archipelago represents approximately 300 islands (RYAN, 2000), of which at least some islands have a surface and topography close to that of Ovalau, it is likely that several *Nesobasis* species remain to be discovered. Also, much of the interior of Vanua Levu is difficult to access, leaving ample possibility for exploration and observation of new species.

As may be expected not all *Nesobasis* species are abundant and widespread.

Table I
Species diversity and abundance for locations visited on Viti Levu in 2005

Locality and date	Species	Number of individuals	Density (individuals/100m²)	Density (individuals/h)
Abaca Road 2 (23-IX)			*120m²*	*90min*
	N. angulicollis	8	6.7	5.3
	N. comosa	18	15	12
	N. erythrops	1	0.8	0.7
	N. flavifrons	1	0.8	0.7
	N. longistyla	3	2.5	2
	N. monticola	2	1.7	1.3
	N. selysi	14	11.7	9.3
	N. telegastrum	6	5	4
Abaca Road 3 (23-VIII)			*700m²*	*165min*
	N. angulicollis	33	4.7	12
	N. comosa	14	2	5
	N. erythrops	39	5.6	14.2
	N. flavifrons	1	0.1	0.4
	N. malcolmi	5	0.7	1.8
	N. rufostigma	2	0.3	0.7
Abaca Road 3 (23-IX)			*700m²*	*230min*
	N. angulicollis	63	9	1.4
	N. comosa	50	7.1	13
	N. erythrops	37	5.3	9.7
	N. longistyla	15	2.1	3.9
	N. malcolmi	33	4.7	8.6
	Uds 1	4	0.6	1
	N. rufostigma	3	0.4	0.8
Korawaiwai (14-VIII)			*600m²*	*110min*
	N. angulicollis	4	0.7	2.2
	N. comosa	5	0.8	2.7
	N. erythrops	17	208	9.3
	N. monticolla	2	0.3	1.1
	N. rufostigma	6	1	3.3
	N. selysi	4	0.7	2.2
Namosi Road (22-IX)			*30m²*	*100min*
	N. angulicollis	2	6.7	1.2
	N. campioni	4	13.3	2.4
	N. comosa	4	13.3	2.4
	N. erythrops	4	13.3	2.4
	N. longistyla	5	16.7	3
	N. rufostigma	7	23.3	4.2

Table I, continue

Nukunuku (14-VIII)			*700m²*	*95min*
	N. angulicollis	2	0.3	1.3
	N. erythrops	22	3.1	13.9
	N. heteroneura	10	1.4	6.3
	N. rufostigma	1	0.1	0.6
	N. selysi	11	1.6	6.9
Qualiwana (14-VIII)			*50m²*	*65min*
	N. erythrops	1	2	0.9
	N. selysi	10	20	9.2
Vaqo Creek (11-VIII)			*1500m²*	*100min*
	N. rufostigma	11	0.7	6.6
	N. selysi	2	0.1	1.2
Vaturu Dam Road (22-VIII)			*350m²*	*215min*
	N. angulicollis	4	1.1	1.1
	N. caerulecaudata	3	0.9	0.8
	N. comosa	19	5.4	5.3
	N. erythrops	16	4.6	4.5
	N. flavifrons	2	0.6	0.6
	N. longistyla	3	0.9	0.8
	N. rufostigma	30	8.6	8.4
	N. selysi	28	8	7.8
Waikubukubu (15-VIII)			*1800m²*	*160min*
	N. angulicollis	69	3.8	25.9
	N. erythrops	27	1.5	10.1
	N. heteroneura	23	1.3	8.6
	N. rufostigma	3	0.2	1.1
	N. selysi	7	0.4	2.6
Wainikovu (11-VIII)			*400m²*	*60min*
	N. comosa	13	3.3	13
	N. erythrops	19	4.8	19
	N. rufostigma	1	0.3	1
	N. selysi	3	0.8	3

Both on Viti Levu and Vanua Levu some species are present at nearly all sites where *Nesobasis* damselflies were found. These species were typically the more abundant species. Abundant and widespread species on Viti Levu were *N. angulicollis*, *N. erythrops*, *N. rufostigma* and *N. selysi* (see Tab. I). Additionally at low to mid elevations *N. heteroneura* was also commonly observed, while *N. comosa* replaced this species at higher altitudes (see also DONNELLY, 1990). Species restricted in occurrence to a few sites typically were less abundant, but could also be locally common. *N. malcolmi* is one such example (Tab. I). For Vanua Levu the more common species were *N. l*, *N. v*, *N. b* and *N. al* (Tab. II). For those species

that were not widespread on Vanua Levu they could again be locally abundant, e.g. *N. f.*, which was found only at Sauvuqoro Creek, was the most abudant species at this site.

For sites that we visited only once we cannot infer whether we have obtained a complete assessment of total *Nesobasis* diversity. This is demonstrated from diversity estimates at sites that we visited multiple times. For example, during our first visit at Abaca Road 3 we observed *N. flavifrons*, a species that we did not sample a month later during a subsequent visit (Tab. I). This may not come as a surprise as we only observed 1 specimen during the first visit. The second visit, however, brought two new observations, *N. longistyla* and *Uds 1* (see Tab. I). For *N. longistyla* we made collection of 15 specimens, which makes one wonder why we did not collect this species during the first visit. Interestingly, during our second visit we stayed later in the afternoon, when the majority of *N. longistyla* were caught. Possibly, some species of *Nesobasis* are mainly active only during later hours in the day. At Waikubukubu our initial sampling rendered only 5 species. However, four additional species were observed (*N. caerulecaudata*, *N. flavifrons*, *N. longistyla*, *N. telegastrum*) when we did intensive research at this site on four full consecutive days (6-9 September). Most of these species were collected in few numbers in tiny dry tributaries to the main stream where damselflies were roosting in the vegetation. At Nukunuku, we also observed five species of *Nesobasis* during our first visit. Subsequent days of research (four full days), however, did not increase our appreciation of species diversity. At this location no small tributaries were present. Our goal in the present research was to broadly survey the distribution of species at a number of sites, which precluded our spending a great deal of time at any one site. For our purposes a 1-hour sampling seemed appropriate; in this time we were able to characterize the distribution and abundance of the more common species of *Nesobasis*. However, to achieve complete estimates of species richness for any location one should aim at spending at minimum an entire day collecting, including sampling tributaries of the main stream.

In conclusion, the genus *Nesobasis* clearly offers great research potential. In total 31 species of this genus have now been observed, with likely several more to be discovered. Also, that different islands harbour different species underlies the potential for comparative multi-species studies with focus on conservation, ecology, behaviour or evolution. The World Summit on Sustainable Development has recognized island communities as an essential component of global biodiversity (CICIN-SAIN et al., 2002). We hope that this research has expanded our knowledge of this unique island genus, and may promote further work on *Nesobasis*, as well as on other species groups of the Southwestern Pacific.

Table II
Species diversity and abundance for locations visited on Vanua Levu in 2005

Locality and date	Species	Number of individuals	Density (individuals/100m²)	Density (individuals/h)
Bagasau Creek (17-IX)			*1200m²*	*120min*
	N. l	4	± 0	2
	N. v	1	± 0	0.5
Lomaloma Falls (18-IX)			*200m²*	*215min*
	N. al	2	1	0.6
	N. au	4	2	1.1
	N. brachycerca	17	8.5	4.7
	N. c	5	2.5	1.4
	N. l	1	0.5	0.3
	Uds 2	2	1	0.6
	N. t	36	18	10
	N. v	23	11.5	6.4
Niuwauvudi Creek (17-IX)			*700m²*	*60min*
	N. b	19	2.7	19
	N. l	12	1.7	12
	N. t	1	0.1	1
Raviravi Creek (19-IX)			*600m²*	*115min*
	N. al	27	4.5	14.1
	N. au	2	0.3	1
	N. brachycerca	27	4.5	14.1
	N. l	76	12.7	39.7
	Uds 2	11	1.8	5.7
	N. v	2	0.3	1
Sauvuqoro Creek (20-IX)			*210m²*	*110min*
	N. al	1	0.5	0.5
	N. b	2	1.0	1.1
	N. f	7	3.3	3.8
	N. l	1	0.5	0.5
	N. r	1	0.5	0.5
	N. t	3	1.4	1.6
	N. v	3	1.4	1.6
Volivoli Creek (18-IX)			*1250m²*	*125min*
	N. al	6	0.5	2.9
	N. l	13	1.0	6.2
	Uds 2	101	8.1	48.5
	N.v	1	0.1	0.5

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We feel it appropriate to make a note on the cultural aspects that come with conducting field research on Fiji. Most of the land officially belongs to the Fijian people, with the lands surrounding a village under the control of the village chief. Accessing land for scientific research requires the permission of the chief. Requesting permission involves a ceremony in which visitors present a gift of kava (the roots of the plant *Piper methysticum*, which is used for making a ceremonial drink) and explain the purpose of the visit. Our project brought us in contact with many native Fijians; we always experienced very friendly and enthusiastic reactions to our research and often we benefited by a person of the village accompanying us during our field work.

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