

New data on the distribution, status, and biology of the New Caledonian giant geckos (Squamata: Diplodactylidae: *Rhacodactylus* spp.)

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Abstract.—Recent collections and observations of the New Caledonian giant geckos (*Rhacodactylus*) result in range extensions and new information regarding the biology of these lizards. Significant range extensions are reported for the rough-snouted giant gecko (*R. trachyrhynchus*) and for the recently rediscovered Guichenot's giant gecko (*R. ciliatus*). Field observations confirm the association of the knob-headed giant gecko (*R. auriculatus*) with plants of the family Cunoniaceae and that Leach's giant gecko (*R. leachianus*) feeds on fruit. Range extension of some species, and data on local abundance allows a reassessment of their conservation status. Despite implied increases in giant gecko density and range, significant threats from habitat loss, introduced predators, and illegal trade leave all species at risk.

Key words. *Rhacodactylus*, *geckos*, *New Caledonia*, *distribution*, *diet*, *conservation status*

Introduction

Rhacodactylus is one of three carphodactyline^e gecko genera occurring in New Caledonia. The genus includes the largest living species of gecko, *R. leachianus* (>250 mm snout-vent length; Russell and Bauer 1986) and has attracted scientific attention because of unusual characteristics such as viviparity^f (in *R. trachyrhynchus*; Bartmann and Minuth 1979), the possession of and specialized dentition (in *R. auriculatus*; Bauer and Russell 1990; Bauer and Sadlier 1994b), and prehensile tails (all species; Bauer 1990; Bauer and Russell 1994). Species of this genus have also attracted much popular attention, especially among terrarium keepers, because most species thrive and reproduce well in captivity (Henkel 1987, 1991, 1993; Henkel and Schmidt 1991; Tytle 1992).

The systematics and morphology of *Rhacodactylus* have recently been the focus of significant investigation (Bauer 1990; Bauer and Russell 1990; Bauer et al. 1993; Seipp and Klemmer 1994; Good et al. 1997). However, knowledge of the distribution and biology of these geckos remains largely incomplete (Bauer and Sadlier 1993). Aside from brief reports of various aspects of natural history (e.g., Mertens 1964; Meier 1979; Sameit 1985; Bauer 1990; Bauer and Vindum 1990; Henkel 1991), field-based data are limited to a few investigations of diet (Bauer and DeVaney 1987; Bauer and Sadlier 1994b) and general accounts of behavior and ecology in nontechnical works (de Vosjoli 1995; de Vosjoli and Fast 1995). However, increasing awareness of the uniqueness of the flora and terrestrial fauna of New Caledonia (Myers 1988; Mittermeier et al. 1996) has given new impetus to the collection of basic distributional and biological data for all members of the New Caledonian herpetofauna, and previously understudied areas are being surveyed more systematically (e.g., Isle of Pines, Bauer and Sadlier 1994a). Observations made by the authors during several recent expeditions to

New Caledonia have yielded new distributional and/or dietary information for all six of the recognized species of *Rhacodactylus*. In addition, preliminary assessments of genetic variation within certain species (reported more fully in Good et al. 1997) were made on the basis of tissue samples accumulated over a series of trips since the mid-1980's. We present these data here as they help to provide a more accurate picture of the geographic ranges and biological requirements of the geckos and may be useful in establishing the conservation status of *Rhacodactylus* species.

Materials and methods

Herpetological collections and observations were made on mainland New Caledonia during trips in 1994 and 1995. Specimens were collected under a series of permits issued by the conservation authorities of the Province Sud (Marcel Boulet) and Province Nord (Christian Papineau) of New Caledonia to the authors. Preliminary estimates of genetic divergence between populations were based on results derived from allozymic^g data. Details of the electrophoretic methodology employed are presented in Good et al. 1997. Specimens cited are housed in the collections of the Australian Museum (Sydney)-AMS, the Natural History Museum (London)-BMNH, and the California Academy of Sciences (San Francisco)-CAS.

Results and discussion

Knob-headed giant gecko (*Rhacodactylus auriculatus*)

[Plate 1]. Böhme and Henkel (1985) reported a striped color phase of *R. auriculatus*, now known to be common. Although polymorphisms were noted within a single population of this species, there were no fixed differences among population samples from four different localities and no suggestion of significant intraspecific genetic variation. This tends to corroborate morphological observations that this species is generally polymorphic^h throughout its range but that there are no geographically related trends in character variation (Bauer 1990).

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Plate 1



Plate 2



Plate 3A



Plate 3B



Plate 4



Plate 5A



Plate 5B



Plate 6

Plate captions: 1. Knob-headed giant gecko, *Rhacodactylus auriculatus*, from Rivière Bleue. 2. Bavay's giant gecko *Rhacodactylus chahoua*. Photo courtesy of R. D. Bartlett. 3A. Guichenot's giant gecko, *Rhacodactylus ciliatus*, from Rivière Bleue (adult with autotomized tail). 3B. *Rhacodactylus ciliatus*, from Rivière Bleue (subadult with complete original tail and complex body patterning). 4. Leach's giant gecko, *Rhacodactylus leachianus*, from Mt. Koghis. 5A. Roux's giant gecko, *Rhacodactylus sarasinorum*, from Kwa Nèie (adult retaining bold white dorsal markings). 5B. *Rhacodactylus sarasinorum*, from Rivière Bleue (adult with mottled dorsal pattern). 6. Rough-snouted giant gecko *Rhacodactylus trachyrhynchus*, from Mt. Aoupinie. Photos 1, 3A and B, 4, 5A and B, and 6: Ross A. Sadlier.



Plate 7. *Geissois* sp. from Mt. Do, southern New Caledonia. This plant is apparently utilized as a food source by *Rhacodactylus auriculatus*.

Bavay (1869) first reported on the diet of this species, indicating that it eats the flowers of *Geissois* (Cunoniaceae). This was verified by the recovery of anthers, stamens, and (possibly) pollen belonging to either a member of this family (or the Myrtaceae) from the stomach of one specimen (Bauer and Sadlier 1994b). On 9 January 1995 further evidence of the specific association between *R. auriculatus* and *Geissois* was obtained when geckos were found active on flowering specimens of *Geissois* spp. (Plate 7) 1.3-2.6 km from the summit of Mount (Mt.) Do (21°45' S, 166°00' E) in south central New Caledonia.

Bavay's giant gecko (*Rhacodactylus chahoua*) [Plate 2]. The known distribution of this species in central and southern mainland New Caledonia has been expanded by the capture of a specimen from Sarraméa (AMS R144171) and by specimens from unstated localities on the Isle of Pines (de Vosjoli 1995; de Vosjoli and Fast 1995) [Fig. 1]. This species is rather polymorphic with respect to coloration (Bavay 1869; Böhme and Henkel 1985; Bauer 1985), but the comparison of allozymes from individuals separated by more than 100 km suggests relative genetic uniformity.

Guichenot's giant gecko (*Rhacodactylus ciliatus*) [Plate 3A and 3B]. This species was numerous for the first 20 years after its description (e.g., Bavay 1869) and then was not seen again for over 100 years, despite extensive searches by several researchers. It was regarded as extinct (see Bauer and Sadlier 1993). In 1994, the species was rediscovered and has since been found at a variety of localities on the Isle of Pines (Seipp and

Klemmer 1994; Kullmann 1995) and several smaller offshore islands (de Vosjoli 1995). De Vosjoli (1995) and de Vosjoli and Fast (1995) recorded this species as common on the Isle of Pines but stated that it was not present on the mainland of New Caledonia. Despite their claims, Bavay (1869), whose data have proved to be very accurate (see Bauer and Sadlier 1994b), reported collecting seven specimens of this species at several (unspecified) localities on the mainland, and the type locality given by Guichenot (1866) was at Canala (21°35' S, 165°56' E), also on the mainland. The persistence of this species on the mainland was verified by two specimens (AMS 146594-5) collected by R. A. Sadlier near Pont German, Rivière Bleue (22°06' S, 166°38' E) in the extreme south of New Caledonia (Fig. 1). It has subsequently been taken at other localities on the mainland (Girard and Heuclin 1998; Bauer and Sadlier 2000), suggesting that it may be relatively widespread.

Leach's giant gecko (*Rhacodactylus leachianus*) [Plate 4]. This species has a broad distribution in the wetter areas of the New Caledonian mainland, especially along the east coast (Bauer 1990). Boulenger (1885) first recorded the species from the Isle of Pines (BMNH 53.8.16.13). Bauer and Sadlier (1994a) confirmed the presence of this species on the island with a 194 mm female (CAS 182197). Subsequently, the species has been recorded as fairly common on the Isle of Pines and nearby offshore islands (de Vosjoli 1995; de Vosjoli and Fast 1995). Although most known mainland New Caledonian localities are in low- to middle-elevation forests (Bauer 1990), specimens have been recorded from up to 1100 m (Mertens 1964). Sight observations in January 1995 at 540 m on Mt. Mandjéla (20°24'15" S, 164°31'18" E) extend the confirmed distribution of the species to the northwest, almost to the limit of the humid forest on the main island of New Caledonia.

The Isle of Pines population has recently been described by Seipp and Obst (1994) as a distinctive subspecies, *Rhacodactylus leachianus henkeli*. The validity of this form is challenged on the basis of morphological and allozyme characters by Good et al. 1997. They found the *henkeli* color pattern to occur among geckos in at least two regions of the New Caledonian mainland and regarded behavioral differences as attributable to reduced predation pressure on the insular form. Because genetic distance data indicated no long separation of Isle of Pines *R. leachianus* from mainland populations Good et al. 1997 regarded the split of the insular population to be very recent. Indeed sea level minima of 100 m or more would have connected New Caledonia to the Isle of Pines as recently as 16,000-20,000 years ago (Stevens 1973; Holloway 1979).

Although the diet in captivity of *Rhacodactylus leachianus* has been well documented (Mertens 1964; Bauer and DeVaney 1987; Henkel and Schmidt 1991), and a few stomach contents have been reported (Roux 1913), the natural diet remains poorly documented. At Mt. Aoupinié, in January 1995, we observed individuals feeding on fruit in humid forest trees. Examination of feces of freshly captured individuals revealed only fig seeds and partially digested fig fruit. It appears likely that this, and perhaps other *Rhacodactylus* species, take advantage of seasonal and local availability of figs and may play a role in seed dispersal.

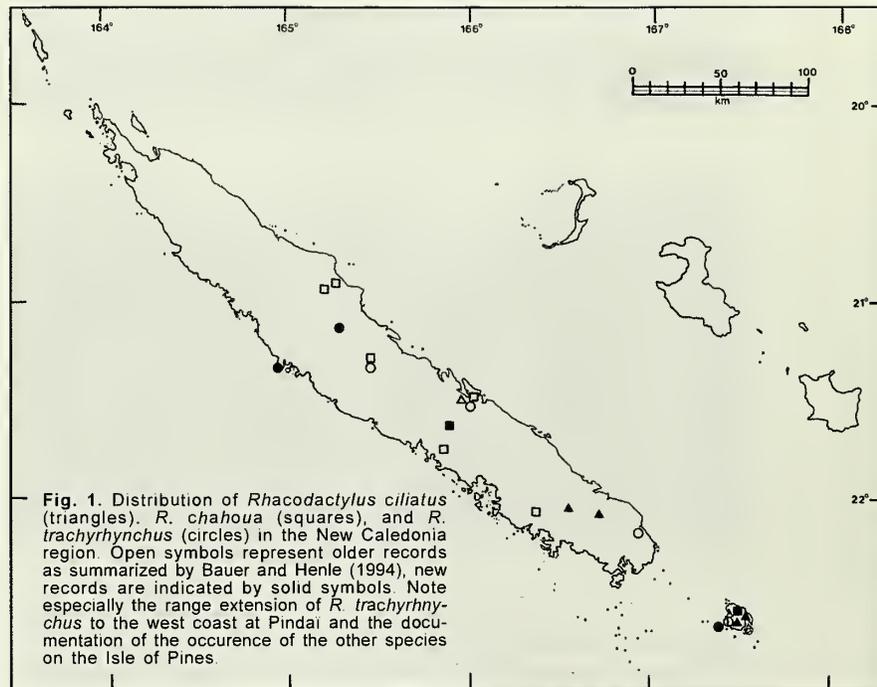
Roux's giant gecko (*Rhacodactylus sarasinorum*) [Plate 5A and 5B]. Bauer (1990) figured the type of *R. sarasinorum*

NEW CALEDONIA

New Caledonia is a French overseas territory, consisting of the large island of New Caledonia and the Loyalty Islands. Its location is approximately 1,200 km east of Australia (Geographic Coordinates 21°30' S, 165°30' E) in the South Pacific Ocean. These islands have an extraordinary diversity of fauna and flora with an extreme level of endemism in many taxa including birds and reptiles. Naturally occurring plant species number 3,380 (vascular plants), birds 116, mammals 9, and reptiles 87 (71 terrestrial and 16 marine). No naturally occurring amphibian species exist on New Caledonia though a nonnative species has been introduced from Australia (green and golden bell frog *Litoria aurea*). Total area is 19,060 square (sq) km (land 18,575 sq km and water 485 sq km) comparatively, slightly smaller than New Jersey. The terrain is west coastal plains with interior mountains (highest point Mont Panie 1,628 m) making up two-thirds of the island. The climate is subtropical (warm and humid) modified by southeast trade winds. There is little temperature change throughout the year, averaging between 71°F and 75°F (22°C and 24°C). The natural vegetation comprises tropical evergreen rain forest up to 1,000 m and tropical montane rain forest above 1,000 m. Mangroves occur along western coasts. The major vegetation types are dense evergreen forest (22.8% of total land area), Niaouli savanna woodland (13.8%), maquis vegetation in mining areas (25.1%), savanna grassland (21.7%), and scrub (8.3%). New Caledonia's human population numbers 191,003 (July 1997 estimate) with a 1.68% (1997 estimate) annual growth rate. New Caledonia's moderately developed economy is based on mining and has more than 20% of the world's known nickel resources as well as other natural resources as chrome, iron, cobalt, manganese, silver, gold, lead, and copper (thus mining is an important environmental issue). Only a negligible amount of the land is suitable for cultivation and food accounts for about 25% of imports. In addition to nickel, financial support from France and tourism are key to the health of the economy. The principal threats to the natural flora and fauna are mining, logging, and bushfires, reducing the forest cover from an estimated 90% cover to just 20%.¹

and noted variation in color pattern and body proportions in this species but did not elaborate. At least two color morphs have been illustrated and described by Henkel (Böhme and Henkel 1985; Henkel 1987, 1988), but there has been no suggestion of subspecific or specific distinction between these forms. Bauer's (1990) and Bauer and Vindum's (1990) concept of *R. sarasinorum* was based in part on typical specimens and in part on an individual from Touaourou that is larger, darker, and differs from other specimens in a number of scale counts. Allozyme analysis (Good et al. 1997) revealed that this specimen differed from a typical *R. sarasinorum* from Rivière Bleue (AMS R 146596) by four fixed differences. This is a greater genetic difference than that between *R. ciliatus* and *R. chahoua*. Both allozyme and morphological data thus suggest significant variation and are being analyzed separately, which may result in the recognition of a new *Rhacodactylus sarasinorum*-like species.

Rough-snouted giant gecko (*Rhacodactylus trachyrhynchus*) [Plate 6]. Bauer (1990) recorded five mainland New Caledonian localities for *R. trachyrhynchus*. Several of these, Coula-Borearé, Ciu, and Mt. Gouemba are in the eastern humid forest region of the island. The other two localities, La Foa and near Nouméa are imprecise but probably are also humid forest localities. All localities are at middle to low elevation. As briefly noted by Bauer (1995), recent censuses have expanded the known range of the species, both elevationally and geographically (Fig. 1). Five specimens (AMS R146417-9, CAS 200266-8) were found during rainstorms in humid forest (Fig. 2A) at approximately 520 m on Mt. Aoupinié in Central New Caledonia (21°09'19" S, 165°19'12" E), 27 km north and west of the previously documented range of the species. A single specimen, CAS 200269, was obtained in sclerophyll forest^t at Pindaï (21°20'02" S, 164°58'21" E) at approximately 20 m elevation (Fig. 2B). This locality is also somewhat further north than earlier records, but it is unique in that it is a west coastal locality in an area of low rainfall. The local vegetation is dominated by largely endemic dry forest plants and is regarded as the most threatened terrestrial habitat in New Caledonia (Jafré et al. 1993; Bouchet et al. 1995). The only other reptiles collected sympatrically with *R. trachyrhynchus* at Pindaï were Vieillard's prehensile-tailed gecko (*Eurydactylodes vieillardii*), Günther's New Caledonian gecko (*Bavayia cyclura*), sclerophyll forest gecko (*Bavayia exsuccida*), festive New Caledonian skink (*Caledoni-*



scincus festivus), New Caledonian skink (*Caledoniscincus austrocaledonicus*), and a new species of elf skink (*Nannoscincus* sp.). All previous records of *Rhacodactylus* spp. from the New Caledonian mainland have originated from the wetter eastern portions of the island, or from rainforest or maquis vegetation^k in the south (Bauer 1990; Henkel 1991, 1993; Bauer and Henle 1994). The occurrence of *R. trachyrhynchus* at this site is thus intriguing and suggests a much broader habitat tolerance range than previously suspected for this species. Although normally associated with large, mature rainforest trees (Meier 1979), at Pindaï, this gecko was collected less than five meters from the ground in the branches of a small tree. A very low genetic distance from this specimen to specimens from Mt. Gouemba and Mt. Aoupinié (Good et al. 1997) suggests no significant differentiation in the dry forest population, and the specimen is typical for the species in regard to morphology. Henkel (1991) suggested that there are two morphs in the species, one with a short, wide, robust snout, the other less so, but because these features were noted in captive born specimens of uncertain locality he did not imply any subspecific distinction. Our data, from three widely scattered localities, do not support the recognition of any specific or subspecific subdivisions within *R. trachyrhynchus*.

Fig. 2. Habitat of *Rhacodactylus trachyrhynchus*.

A. Overview of humid forest habitat at middle elevation on Mt. Aoupinié.



B. Sclerophyll forest habitat at Pindai on the west central coast of New Caledonia.

The presence of this species on the Isle of Pines remains problematic. Boulenger (1878) recorded the species (as *Chamaeleonurus trachycephalus*) from this locality. Subsequent collecting activity on this island, however (Bauer and Sadlier 1994a; de Vosjoli 1995) has not verified this occurrence. The unexpected findings of this and other *Rhacodactylus* after many years of extensive and intensive searching, however, argue against dismissal of this early record. Bauer and Sadlier (1994a) identified appropriate habitat for the species on the island.

Conclusions

The new dietary observations confirm earlier reports of herbivory by *Rhacodactylus* species. It is especially noteworthy that *R. auriculatus* was found active on flowering heads of plants of the same genus on which Bavay observed them over 130 years ago. The significance of reptiles as seed dispersers and as possible pollinators was recognized by Borzi (1911) but remains largely unexplored. Its recent documentation for the closely related carphodactyline geckos of New Zealand (Whitaker 1987) suggests that at least some species of giant geckos are important in this regard. The importance of plant material in the diets of *Rhacodactylus* sp. and the significance of geckos as dispersers of pollen or seeds, however, can only be adequately addressed by a seasonal dietary study at a single site.

Bauer and Sadlier (1993) reviewed the conservation status of all New Caledonian lizards on the basis of data then available. They summarized both the extent of the geographic range of the species and their apparent abundance within the appropriate

habitat types. The data reported on here necessitate a re-evaluation of that status report. *Rhacodactylus ciliatus*, previously considered possibly extinct, is now known to be common on islands of the south coast of New Caledonia and present, if somewhat less common, on the mainland. Using the terminology of Bauer and Sadlier (1993), its distribution is now regarded as restricted and its status as locally common. With the extension of its known range to the north and to the west coast sclerophyll forest, the distribution of *Rhacodactylus trachyrhynchus* can now be upgraded from restricted to moderately widespread and its status to locally common. The presence of this species, as well as a regionally endemic *Bavayia* (*B. exsuccida*) and a new, apparently endemic, *Nannoscincus* in the sclerophyll forest in west coastal New Caledonia (Bauer et al. 1998) adds impetus to efforts to protect the small remaining tracts of this habitat. *Rhacodactylus leachianus* was previously regarded as widespread and uncommon. The extension of the east coast range to the limit of humid forest underscores the fact that this is the most widely distributed of all *Rhacodactylus* species and observations of individuals under ideal weather conditions (warm and wet) suggest that the species may best be categorized as common in appropriate habitats. The status of the remaining species is unchanged by the new records.

Although at least several species of *Rhacodactylus* do appear to be locally abundant, even the most widely ranging species is endemic to the New Caledonian mainland and adjacent satellite islands, an area about the size of Connecticut. Further, no species is known to be present in all native habitat types and all are excluded from agricultural or urban environments (although they may be present at the periphery of human-modified areas). Habitat destruction and the impact of introduced predators were cited as the primary threats to the herpetofauna of New Caledonia by Bauer and Sadlier in 1993. These factors remain the most significant conservation concerns, but the illegal pet trade in *Rhacodactylus* has increased significantly in the 1990's and has become a potential threat to wild populations.

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Footnote

¹The research sources used in writing the country sidebar on page 10 (Madagascar), of this volume, and footnoted on page 14 (Juanate 2), were also used in writing the New Caledonia summary.

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