

New data on *Dierogekko* (Squamata: Gekkota: Diplodactylidae), with the description of a new species from Île Baaba, Province Nord, New Caledonia

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ABSTRACT

The diplodactylid gecko genus *Dierogekko* is endemic to the northern Grande Terre of New Caledonia and the adjacent ultramafic offshore islands. All species are allopatric except *D. poumensis* and *D. inexpectatus*, both of which occur on Sommet Poum. The validity of the latter species, described on the basis of a single female, is confirmed by a recently collected series of specimens from Paevala. *Dierogekko inexpectatus* appears limited to the northern portion of Sommet Poum, where it is restricted to closed forest remnants. Based on its tiny area of occurrence and existing threats from mining, wildfires, invasive weeds, and a diversity of invasive animals, it is assessed as Critically Endangered. A molecular phylogenetic analysis of *Dierogekko* confirms previously proposed relationships and reveals a new species level taxon from Île Baaba, off the northern tip of the Grande Terre. The specimen is known from a single female, but is distinguished from its congeners by its small size (<38 mm SVL) and narrow, divided subdigital scansors. It is separated from all other *Dierogekko* by an uncorrected ND2 divergence of 6-15% (Tajima-Nei distance 6-17%). It is vulnerable to wildfires, habitat degradation and introduced mammalian predators and fire ants and is considered to be Critically Endangered.

RÉSUMÉ

Nouvelles données sur *Dierogekko* (Squamate : Gekkota : Diplodactylidae), avec la description d'une nouvelle espèce de l'île Baaba, Province Nord, Nouvelle Calédonie.

Le genre de gecko diplodactylide *Dierogekko* est endémique du nord de la Grande Terre de Nouvelle-Calédonie et les îles adjacentes ultramaïques. Toutes les espèces sont allopatriques sauf *D. poumensis* et *D. inexpectatus*, qui tous deux se trouvent sur le sommet de Poum. La validité de cette dernière espèce, décrite sur la base d'une seule femelle, est confirmée par une série de spécimens récemment collectés à Paeva. *Dierogekko inexpectatus* semble limitée à la partie nord du Sommet de Poum, où elle est limitée aux restes de forêts denses. Sur la base de sa minuscule zone d'occurrence et les menaces actuelles de l'exploitation minière, les incendies de forêt, les mauvaises herbes envahissantes, et une diversité d'animaux exotiques, cette espèce est considérée en risque critique d'extinction. Une analyse phylogénétique moléculaire de *Dierogekko* confirme les relations proposées précédemment et dévoile un nouveau taxon de rang spécifique des espèces de l'Île Baaba, au large de la pointe nord de la Grande Terre. Le spécimen est connu à partir d'une seule femelle, mais se distingue de ses congénères par sa petite taille (<38 mm SVL) et ses lamelles subdigitales étroites et divisées. Il est séparé de tous les autres *Dierogekko* par une divergence ND2 non corrigée de 6-15% (Tajima-Nei distance 6-17%). Il est vulnérable aux incendies de forêt, à la dégradation de l'habitat et aux mammifères prédateurs introduits ainsi qu'aux fourmis électriques et il est considéré en danger critique.

INTRODUCTION

The genus *Dierogekko* was established (Bauer *et al.* 2006) to accommodate a clade of small, nimble New Caledonian diplodactylid geckos that had previously been allocated to the genus *Bavayia* Roux, 1913. It included the species originally described as *Bavayia validiclavis* Sadlier, 1989 from Mt. Panié and Mt. Mandjélia in the Panié Massif, as well as seven new



FIGURE 1

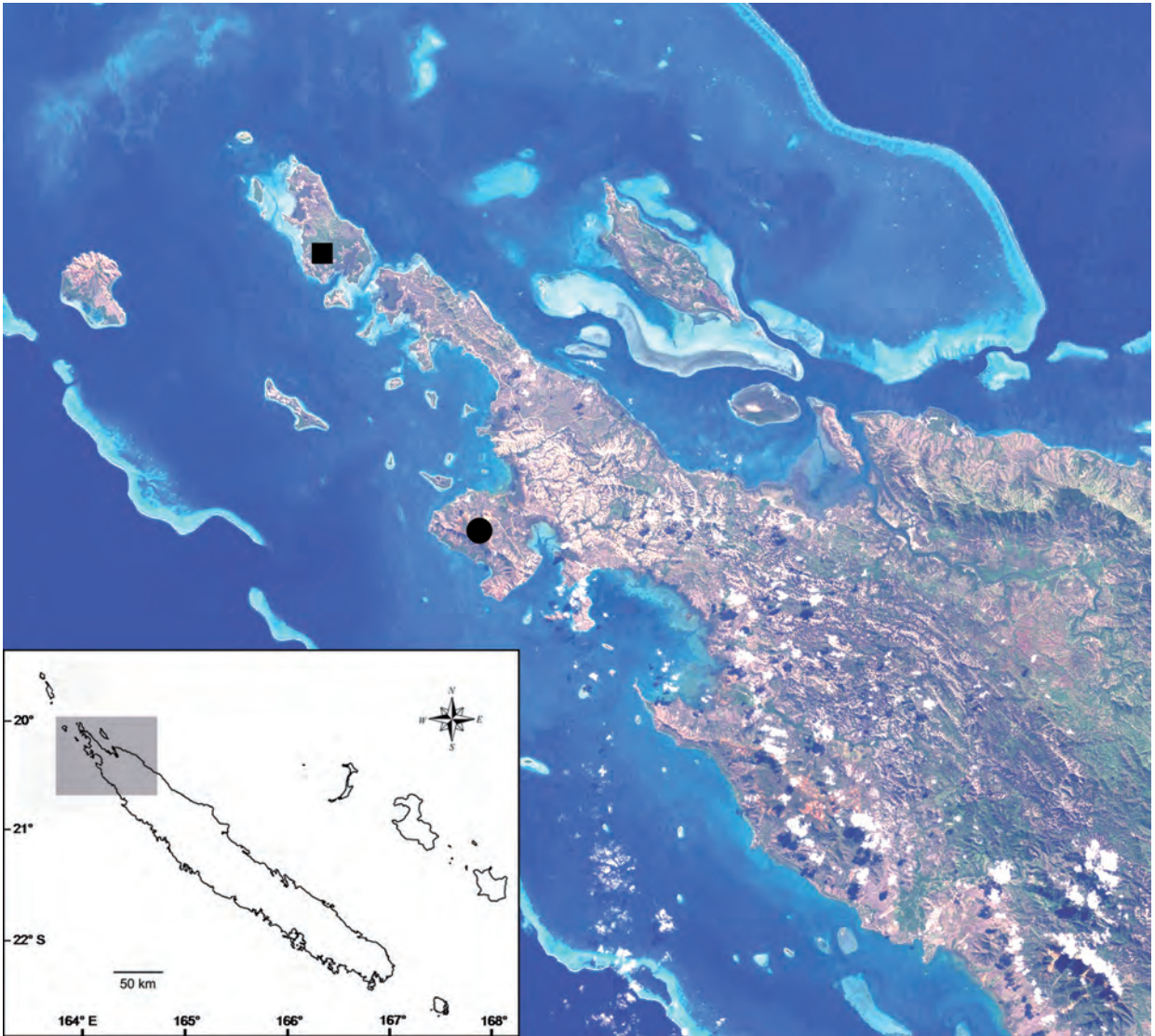
Comparison of the two species of *Dierogekko* occurring on Sommet Poum: Left, *D. inexpectatus*; Right, *D. poumensis*. Note the darker mid-dorsal stripe and bright white dorsolateral stripes over the tail base in the latter species.

species, each endemic to single areas on or near ultramafic peaks in the northwest of the Grande Terre (Whitaker *et al.* 2004; Bauer *et al.* 2006). At the time of the description of the new taxa and erection of the genus, phylogenetic evidence from the mitochondrial ND2 gene and the RAG-1 nuclear gene were presented to support the recognition of each taxon as a distinct lineage. Only in one case were two species found to occur on the same ultramafic massif; *D. poumensis* and *D. inexpectatus* (Figure 1) occur in strict sympatry on Sommet Poum (414 m a.s.l.) (Figure 2). At the time of description the latter species was known from only a single individual. This was a female lacking preloacal pores, an important diagnostic feature for species within this group and many other diplodactylid geckos.

Subsequent surveys of the *D. inexpectatus* type locality, Paevala, and other areas of the Poum massif in 2003 and 2005 failed to locate additional material (Bauer *et al.* 2006). In 2006 the Poum massif was the target of an intensive lizard survey with particular emphasis on *Dierogekko* and *Oedodera* (Whitaker & Whitaker 2007a). No specimens of *Dierogekko inexpectatus* were found at the type locality, which was found to have become heavily infested with introduced fire ants (*Wasmannia auropunctata*), but a new population was found in a closed forest remnant ~270 m to the north. A more detailed survey in 2007, specifically targeting *Dierogekko inexpectatus*, failed to detect the species at any additional sites (Whitaker & Whitaker 2008).

Specimens and associated field data collected during the 2006 and 2007 surveys have provided crucial new data on the morphology, ecology and behaviour of *D. inexpectatus* and we take this opportunity to reevaluate its diagnostic features and report on variation and biology of this endangered taxon. Further, we reevaluate phylogenetic relationships within *Dierogekko* based on the mitochondrial marker ND2 and the relatively rapidly evolving nuclear gene, KIF24. A single individual from Île Baaba is identified as genetically distinct from all known species and is described as the ninth species in the genus.



**FIGURE 2**

Map of northern New Caledonia illustrating the position of Sommet Poum (*Dierogecko inexpectatus* - circle) and Île Baaba (*D. baaba* - square). Image from the Millennium Coral Reef Landsat Archive.

MATERIAL AND METHODS

MORPHOLOGY

The following measurements (to the nearest 0.1 mm) were taken with DigiCal digital calipers: snout-vent length (SVL; from tip of snout to vent), trunk length (TrunkL; distance from axilla to groin measured from posterior edge of forelimb insertion to anterior edge of hindlimb insertion), crus length (CrusL; from base of heel to knee); tail length (TailL; from vent to tip of tail), tail width (TailW; measured at widest point of tail); head length (HeadL; distance between retroarticular process of jaw and snout-tip), head width (HeadW; maximum width of head), head height (HeadH; maximum height of head, from occiput to underside of jaws), ear length (EarL; longest dimension of ear); forearm length (ForealL; from base of palm to elbow); orbital diameter (OrbD; greatest diameter of orbit), nares to eye distance (NarEye; distance between anteriormost point of eye and nostril), snout to eye distance (SnEye; distance between anteriormost point of eye and tip of snout), eye to ear distance (EyeEar; distance from anterior edge of ear opening to posterior corner of eye), internarial distance (Internar; distance between nares), and interorbital distance (Interorb; shortest distance between left and right supraciliary scale rows). Measurements and scale counts based on right side of animals unless otherwise noted.

Scale counts and external observations of morphology were made using a Nikon SMZ1000 stereo dissecting microscope. Photographs of preserved specimens were taken with a Canon G11 Powershot digital camera. Comparisons were made with museum material in the collections of the California Academy of Sciences (CAS), the Australian Museum (AMS), and the Muséum national d'Histoire naturelle, Paris (MNHN). See Bauer *et al.* (2006) for a complete list.

MOLECULAR PHYLOGENETICS

Sequences were acquired from 48 individuals representing all described species of *Dierogekko*, an increase of 23 from the previous analysis (Bauer *et al.* 2006). Representatives of each of the other New Caledonian diplodactylid genera were included as outgroups (Table 1). Sequences were analyzed for 1464 bp of the mitochondrial gene ND2 and five flanking tRNAs (NADH dehydrogenase subunit 2: 1049 bp protein coding, 415 bp tRNA) and 551 bp of the nuclear gene KIF24 (kinesin family member 24). Genomic DNA was obtained using the Qiagen DNAeasy Kit from whole tissues consisting of liver, tail tips, or skeletal muscle stored in 95% EtOH. The subsequent amplification of target loci was carried out in 25 µl PCR reactions on a Eppendorf Mastercycler gradient thermocycler. Primers were initially derived from the genomes of *Gallus* and *Anolis* before gecko specific primers were designed. PCR products were visualized on 1.5% agarose gels before being purified with AMPure magnetic bead solution kit (Agencourt Bioscience, Beverly, MA, USA). These were then sequenced using the BigDye Terminator v3.1 Cycle Sequencing Kit (Applied Biosystems, Foster City, CA, USA) and subjected to a final purification through the CleanSeq magnetic bead kit (Agencourt Bioscience, Beverly, MA, USA) protocol. Products were sequenced on a ABI 3730xl DNA analyzer before sequence quality was assessed using the program Geneious v4.7 (Drummond *et al.* 2006). Complete sequences were aligned by eye and manually corrected in MacClade (Maddison & Maddison 2008) after being translated into amino acid sequences.

Phylogenetic analysis included maximum parsimony (MP), maximum likelihood (ML), and Bayesian inference (BI). MP analysis was run in PAUP v4.0 (Swofford 2002) under a full heuristic search using tree bisection-reconnection (TBR). Nodal support was designated with 1,000 nonparametric bootstrap replicates. ML was run in the program RAxML v7.2.6 (Stamatakis *et al.* 2005, 2010, Stamatakis 2006) for 1,000 rapid nonparametric bootstrap replicates. MrBayes v3.1 (Huelsenbeck & Ronquist 2003) was used for BI analysis and run for 20,000,000 generations sampling every 1,000 generations. The first 5,000 trees from each of the two independent runs were discarded as burn-in and stationarity was assessed graphically with the online program AWTY (Are we there yet?) (Nylander *et al.* 2008). Bayesian runs that reached convergence were combined in PAUP to construct a 50% majority rule consensus tree. KIF24 and the protein coding region of ND2 were partitioned based on codon position while the five tRNAs immediately following ND2 were designated to a separate partition in all ML and BI runs. These segments were individually assigned nucleotide models of evolution in Modeltest v3.7 (Posada & Crandall 1998) using Akaike Information Criterion (AIC) (Table 2).

TABLE 1

Specimens used in the molecular study and their corresponding GenBank accession numbers.

TAXON	CATAL OGUe NUMBeR	LOCALITY	GeNBANK ACceSSION NOS.	
OUTGROUP			ND2	kIF24
<i>Bavayia aff. robusta</i>	AMS R138591	Île des Pins (22°38'S, 167°25'E)	JF972431	JF972395
<i>Bavayia geitaina</i>	AMS R148084	Mt. Koghis (22°10'18"S, 166°30'58"E)	–	JF972396
<i>Bavayia geitaina</i>	CAS 202733	Mt. Koghis (22°10'18"S, 166°30'58"E)	JF972423	–
<i>Paniegekko madjo</i>	AMS R149329	Mt. Panié (20°34'04"S, 164°46'25"E)	JF972430	JF972397
<i>Eurydactyloides symmetricus</i>	CAS 232006	Pic Ningua (21°44'36"S, 166°09'02"E)	JF972428	JF972393
<i>Oedodera marmorata</i>	AMS R161249	Paagoumène (20°29'21"S, 164°11'49"E)	JF972427	JF972392
<i>Rhacodactylus auriculatus</i>	AMS R161252	Dôme de Tiébaghi (20°27'38"S, 164°11'11"E)	JF972429	JF972394
INGROUP				
<i>Dierogekko inexpectatus</i>	CAS 248152	Sommet Poum (20°14'54.6"S, 164°01'21.9"E)	JF972442	–
<i>Dierogekko inexpectatus</i>	CAS 248153	Sommet Poum (20°14'54.6"S, 164°01'21.9"E)	–	JF972405
<i>Dierogekko inexpectatus</i>	CAS 248154	Sommet Poum (20°14'54.6"S, 164°01'21.9"E)	JF972440	JF972406
<i>Dierogekko inexpectatus</i>	AMS R175527	Sommet Poum (20°14'54.6"S, 164°01'21.9"E)	JF972439	JF972407
<i>Dierogekko inexpectatus</i>	AMS R175529	Sommet Poum (20°14'54.6"S, 164°01'21.9"E)	–	JF972408
<i>Dierogekko inexpectatus</i>	AMS R175531	Sommet Poum (20°14'54.6"S, 164°01'21.9"E)	–	JF972404
<i>Dierogekko inexpectatus</i>	AMS R161222	Sommet Poum (20°15'44"S, 164°02'07"E)	JF972441	JF972403
<i>Dierogekko insularis</i>	AMS R166974	Mariri, Île Yandé (20°02'39.4"S, 163°47'43.4"E)	JF972435	–
<i>Dierogekko insularis</i>	CAS 231857	Mariri, Île Yandé (20°02'39.4"S, 163°47'43.4"E)	JF972436	JF972411
<i>Dierogekko insularis</i>	AMS R166972	Mariri, Île Yandé (20°02'39.4"S, 163°47'43.4"E)	JF972434	–
<i>Dierogekko insularis</i>	CAS 231858	Mariri, Île Yandé (20°02'39.4"S, 163°47'43.4"E)	JF972433	–
<i>Dierogekko insularis</i>	AMS R161066	Pânan, Île Pott (19°35'06"S, 163°35'07"E)	JF972459	JF972410
<i>Dierogekko insularis</i>	AMS R161067	Pânan, Île Pott (19°35'06"S, 163°35'07"E)	KF366667	KF366658
<i>Dierogekko insularis</i>	AMS R161069	Île Art (19°42'53"S, 163°39'38"E)	JF972458	–
<i>Dierogekko insularis</i>	AMS R161070	Île Art (19°42'53"S, 163°39'38"E)	KF366666	–
<i>Dierogekko kaalaensis</i>	AMS R161095	Mt. Kaala (20°37'03"S, 164°22'49"E)	JF972455	JF972412
<i>Dierogekko kaalaensis</i>	AMS R161096	Mt. Kaala (20°37'03"S, 164°22'49"E)	JF972456	JF972413
<i>Dierogekko kaalaensis</i>	AMS R161101	Piton de Pandop (164°22'05"E, 20°35'16"S, 164°22'49"E)	JF972454	JF972414
<i>Dierogekko koniambo</i>	AMS R161114	Mt. Koniambo (20°59'51"S, 164°48'47"E)	–	JF972421
<i>Dierogekko koniambo</i>	AMS R161128	Mt. Koniambo (20°59'42"S, 164°48'56"E)	–	JF972423
<i>Dierogekko koniambo</i>	AMS R161129	Mt. Koniambo (20°59'51"S, 164°48'47"E)	JF972451	JF972422
<i>Dierogekko koniambo</i>	AMS R168036	Taavao, Pointe de Vavouto (21°00'49"S, 164°40'39"E)	JF972452	KF366659
<i>Dierogekko koniambo</i>	AMS R168037	Taavao, Pointe de Vavouto (21°00'49"S, 164°40'39"E)	JF972453	KF366660
<i>Dierogekko nehoueensis</i>	AMS R166970	Rivière Néhoué (20°25'12.3"S, 164°13'04.5"E)	KF366663	JF972426
<i>Dierogekko nehoueensis</i>	CAS 231835	Rivière Néhoué (20°25'03"S, 164°13'15"E)	JF972438	KF366661
<i>Dierogekko nehoueensis</i>	CAS 231855	Rivière Néhoué (20°24'27.0"S, 164°12'09.3"E)	KF366664	KF366662
<i>Dierogekko nehoueensis</i>	AMS R162976	Rivière Néhoué (21°25'03"S, 164°13'15"E)	JF972437	JF972425
<i>Dierogekko nehoueensis</i>	AMS R161242	Dôme de Tiébaghi (20°27'38"S, 164°11'11"E)	KF366665	JF972424
<i>Dierogekko poumensis</i>	AMS R166981	Sommet Poum (20°14'19"S, 164°01'56"E)	–	JF972398
<i>Dierogekko poumensis</i>	MCZ R184132	Sommet Poum (20°14'19"S, 164°01'56"E)	–	JF972399
<i>Dierogekko poumensis</i>	AMS R175535	Sommet Poum (20°15'0.8"S, 164°01'24.2"E)	JF972446	–
<i>Dierogekko poumensis</i>	AMS R175536	Sommet Poum (20°15'0.8"S, 164°01'24.2"E)	JF972443	JF972401
<i>Dierogekko poumensis</i>	AMS R175537	Sommet Poum (20°14'52.6"S, 164°01'23.3"E)	JF972447	JF972402
<i>Dierogekko poumensis</i>	AMS R161203	Sommet Poum (20°15'44"S, 164°02'07"E)	JF972444	JF972400
<i>Dierogekko poumensis</i>	AMS R161204	Sommet Poum (20°15'44"S, 164°02'07"E)	JF972445	–
<i>Dierogekko poumensis</i>	AMS R161205	Sommet Poum (20°15'44"S, 164°02'07"E)	JX024375	–
<i>Dierogekko baaba</i> , n. sp.	MNHN 2010.0621	Île Baaba (20°04'22"S, 163°57'05"E)	JF972457	JF972409
<i>Dierogekko thomaswhitei</i>	AMS R161153	Gomen Mine, Mt. Taom (20°46'36"S, 164°33'45"E)	JX024376	JF972420
<i>Dierogekko thomaswhitei</i>	AMS R161154	Gomen Mine, Mt. Taom (20°46'36"S, 164°33'45"E)	JF972450	JF972417
<i>Dierogekko thomaswhitei</i>	AMS R161178	Mt. Taom (20°46'36"S, 164°33'45"E)	–	JF972419
<i>Dierogekko thomaswhitei</i>	AMS R164183	Massif d'Ouazangou-Taom (20°46'55"S, 164°34'53"E)	JF972448	–
<i>Dierogekko thomaswhitei</i>	AMS R164186	Massif d'Ouazangou-Taom (20°46'50"S, 164°35'00"E)	JF972449	–
<i>Dierogekko thomaswhitei</i>	MNHN 2004.0018	Massif d'Ouazangou-Taom (20°46'40"S, 164°34'38"E)	–	JF972418
<i>Dierogekko validiclavis</i>	AMS R144230	Mt. Panié (20°33'35"S, 164°47'03"E)	JF972461	JF972415
<i>Dierogekko validiclavis</i>	AMS R149305	Mt. Panié (20°33'35"S, 164°47'03"E)	KF366668	JF972416
<i>Dierogekko validiclavis</i>	AMS R153695	Mt. Mandjéla (20°33'35"S, 164°31'06"E)	KF366669	–
<i>Dierogekko validiclavis</i>	AMS R153696	Mt. Mandjéla (20°33'35"S, 164°31'06"E)	JF972460	–

CODON POSITION	MODEL
ND2 1st	TVM + G
ND2 2nd	HKY + I + G
ND2 3rd	GTR + G
tRNAs	TVM + G
KIF24 1st	TrN + I
KIF24 2nd	TrN + I
KIF24 3rd	K81uf + I

TABLE 2

Codon positions and evolutionary models for the gene fragments used in this study.

SYSTeMATIC PART

RESULTS

Family DIPLODACTYLIDAE Underwood, 1954

Genus *Dierogekko* o Bauer, Jackman, Sadlier & Whitaker, 2006

Type species. *Dierogekko validiclavis* (Sadlier, 1989).

Dierogekko inexpectatus Bauer, Jackman, Sadlier & Whitaker, 2006

MORPHOLOGY — Eighteen specimens of *Dierogekko inexpectatus* were captured at Paevala, Sommet Poum (20°14'55.0" S, 164°01'21.9" E) by A.H. Whitaker and V.A. Whitaker on 23 and 27 September, 2006. Of these, eight specimens were preserved (AMS R045135-39, 23.IX.2006, AMS R045144-46, 27.IX.2006), providing additional morphological data on the species. The new specimens agree well in most aspects of morphology to the holotype (MNHN 2004.0025) and range in size from 31.7 to 39.5 mm (Table 3). Two specimens, CAS 248153 and AMS R175531, have only a single internasal, but the remaining specimens have two. This contrasts with three, as recorded in the holotype. There were four males among the sample, of which pore data could be collected for three. All have two uninterrupted rows of precloacal pores, with a longer anterior row (11-13 pores) and a shorter posterior row (7-8 pores). There is also variation in dorsal pattern. Although CAS 248154 and AMS R175527-30 are similar to the holotype, with a distinct striped pattern, CAS 248152-53 and AMS R175531 lack paired whitish stripes and instead exhibit two parallel rows of 11 small, pale cream-colored dots with irregular thin dark brown ventral and posterior borders running from the occiput to the sacrum (Figure 3). The vertebral area enclosed by these rows of dots is similar to the remaining dorsal coloration. The striped and spotted color morphs occur in roughly equal proportion and are not correlated with age or sex.

DISTRIBUTION AND NATURAL HISTORY — The habitat at the new site for *D. inexpectatus* is generally similar to the type locality, comprising a dense, closed-canopy forest (Figure 4) growing on a cuirasse surface with deep boulder beds (Figure 5), although the canopy is somewhat lower (~5-6 m *versus* >10 m) and trunk diameters smaller (to ~30 cm *versus* ~45 cm). Both the type locality and the new site for *D. inexpectatus* are on the northern end of the Sommet Poum plateau at 300-330 m elevation. Both sites are in tiny remnants of closed forest (approximately 0.9 ha and 0.5 ha, respectively). Four additional remnants of similar forest habitat occur in the same vicinity, together totalling just over 0.5 ha (0.06-0.18 ha), but surveys in these —and in less comparable forest remnants elsewhere on the Poum massif— have failed to detect *D. inexpectatus*, although *D. poumensis* was

TABLE 3

Mensural data specimens of *Dierogecko inexpectatus*. Abbreviations as in Materials and methods. All measurements in mm.

	MNhN 2004.0025	CAS 248152	CAS 248153	CAS 248154	AMS R175527	AMS R175528	AMS R175529	AMS R175530	AMS R175531	AMS R167252
hOIOTyPe										
Sex	female	Male	Female	Female	Male	Male	Male	Female	Female	Female
SVL	39.5	38.2	38.3	38.8	38.3	38.2	36.4	39.5	31.7	37.2
Foreal	4.9	4.9	4.8	4.6	4.7	4.7	4.9	4.8	4.2	4.3
CrusL	5.7	5.7	5.5	5.7	5.6	5.8	5.8	5.6	5.1	5.4
TailL	36.2	21.7	24.6	4.4 (br)	4.4 (br)	3.9 (br)	25.6	3.7 (br)	33.8	23.9
(regen.)	(25.8)	(12.4)	(4.2)	—	—	—	(20.4)	—	—	(19.5)
TailW	4.8	4.4	4.6	—	—	—	4.4	—	3.4	3.3
TrunkL	17.4	17.3	16.1	18.1	17.0	17.7	16.7	17.4	14.4	16.7
HeadL	10.5	10.1	9.9	9.7	10.0	9.8	10.1	9.8	9.1	9.3
HeadW	7.2	7.4	7.1	7.4	7.4	7.0	7.2	7.3	6.6	6.0
HeadH	4.1	4.1	4.5	4.5	4.6	4.4	4.5	4.7	3.3	3.3
OrbD	2.5	2.7	2.5	2.4	2.5	2.9	2.5	2.6	2.2	2.4
EyeEar	3.0	2.9	2.6	2.6	2.9	3.1	3.0	2.9	2.5	2.5
SnEye	4.6	4.7	4.7	4.1	4.8	4.5	4.3	4.1	3.0	3.5
NarEye	3.0	2.8	2.9	2.9	2.9	3.0	3.0	2.8	2.4	2.5
Interorb	3.5	3.6	3.4	3.7	3.4	3.8	3.8	3.6	2.9	3.0
EarL	1.4	1.5	1.3	1.4	1.4	1.6	1.4	1.1	1.0	1.1
Internar	1.3	1.3	1.6	1.2	1.3	1.6	1.4	1.5	1.2	1.3
Internasals	3	2	1	2	2	1-2	2	2	1	1
PreClPores	—	11/7	—	—	13/7	?	11/8	—	—	—
Pattern	stripes	dots	dots	stripes	stripes	stripes	stripes	stripes	dots	dots

present in all but one of them (Whitaker & Whitaker 2007a 2008). The presence of ancient stumps and logs and the unmistakably seral nature of much of the present maquis vegetation clearly indicate that the forest remnants are the last surviving fragments of what had presumably been a more or less continuous forest cover across on the entire cuirasse plateau (ca. 76 ha) before being destroyed, primarily by wildfires. The remaining forest remnants have been damaged by prospecting activities (cut by bulldozed tracks) and are subject to on-going degradation from browsing by deer (*Cervus timorensis*).

As with the discovery of the type specimen, at the new location *D. inexpectatus* was found during the day ($n = 11$) only beneath laterite boulders on the forest floor, generally deep down between the stones and the underlying soil. Examination of loose bark and holes and crevices in trees failed to find any *D. inexpectatus* in retreat sites above the ground. At night *D. inexpectatus* ($n = 7$) was found foraging on the foliage or fine terminal twigs of subcanopy shrubs, 0.8-1.6 m above ground.

Dierogecko inexpectatus has not been recorded at the type locality since the original specimen was collected in 2001 but it appears to be locally common at the new site. During daytime searches eight individuals were found in one boulder pile of ~6 m² and a further three at a similar site nearby that was ~9 m². The *D. inexpectatus* detected while active at night were found at an encounter rate of 2.7/person hour.

The boulder piles occupied by *Dierogecko inexpectatus* are also inhabited by *Kanakysaurus viviparus*. *Dierogecko poumensis* and *Eurydactylodes agricolae* are syntopic with *D. inexpectatus* in the foliage at night. Our limited data indicate that the smaller congener, *D. poumensis*, is less numerous but *E. agricolae* occurs in approximately equal numbers to *D. inexpectatus*. *Caledoniscincus atropunctatus* was the only other lizard species recorded within the forest remnants. *Dierogecko poumensis* and *E. agricolae* are abundant in the maquis shrublands that immediately surround the forest remnants inhabited by *D. inexpectatus*; other species present are *Hemidactylus frenatus*, *H. garnotii*, *Caledoniscincus haplorhinus*, *C. atropunctatus*, *C. austrocaledonicus*, *Kanakysaurus viviparus*, *Lioscincus nigrofasciolatus* and *Phoboscincus garnieri*. *Oedodera* aff. *marmorata* and *Cryptoblepharus novocaledonicus* occur elsewhere on the summit of the massif.



FIGURE 3

Striped and dotted color morphs of *Dierogecko inexpectatus*.

CONSeRvATION STATUS — The additional survey work and new data confirm that the provisional conservation status of Critically Endangered for *D. inexpectatus* (Bauer *et al.* 2006) is appropriate. The species has only ever been recorded at two sites which together give an extent of occurrence of approximately 5.0 ha and area of occupancy of 1.4 ha. Although it appeared to be relatively common at one of these sites in 2007, the small extent of the available habitat means the total population of *D. inexpectatus* is presumably very low. Its continued occurrence at the type locality is in doubt, as it has not been seen there since 2001. The habitat at both sites is vulnerable to the wildfires that frequently affect the Poux massif (the most recent on the plateau burnt ~11 ha of maquis shrubland in about 2002 pers. observ.) and is threatened with continued degradation by deer.

Trap data revealed that the introduced rats *Rattus exulans* and *R. rattus* are abundant on Sommet Poux, as are feral cats, and both rats and cats are serious predators of lizards. Although no direct evidence of predation on *D. inexpectatus* was obtained, cat droppings were found to contain lizard bones. Introduced little red fire ants (*Wasmannia auropunctata*) have invaded the type locality since 2001 and are now abundant in all forest remnants. It is not known if they are implicated in the apparent disappearance of *D. inexpectatus* from the type locality but there is no question that fire ants have a serious detrimental impact on lizard populations, including the local extirpation of some species (Jourdan *et al.* 2000, 2001). The introduced yellow crazy ant (*Anoplolepis gracilipes*) is also now widespread in maquis and forest remnants on the plateau and northern slopes of the Poux massif (Julien Le Breton, pers. comm., 9 June 2007) and it, too, is known to adversely impact lizard biodiversity and population density.

At some time between 2001 and 2006 *Hemidactylus frenatus* invaded the plateau area and is now common in the maquis shrublands and along the forest margins (it has not yet been recorded within the closed forest). This highly-invasive



FIGURE 4

View to the south across closed forest habitat at the type locality of *Dierogecko inexpectatus* at Paevala, Poux massif, Province Nord, New Caledonia.

and aggressive, introduced species is known to displace indigenous gecko taxa through competition for retreat sites and food resources, and by preying on small geckos, and in extreme cases has even resulted in local extinctions (e.g., Bolger & Case 1992; Case *et al.* 1994; Petren & Case 1996; Brown *et al.* 2002; Cole *et al.* 2005).

However, the overwhelming threat to the survival of *D. inexpectatus* is from the planned expansion of the nickel mine on Sommet Poom. Current proposals are that the entire plateau area will be mined over a 15-20 year period and this would see the removal of all vegetation from the cuirasse surface, including the closed forest remnants occupied by *D. inexpectatus*.

Although quantitative data on population size and trends are lacking for *D. inexpectatus*, the species' extremely restricted range (one location, <5 ha), the threats to its habitat (mining, wildfires, browsing ungulates, invasive weeds), the presence of mammalian predators (rats, cats), and the impacts of fire ants, yellow crazy ants and *Hemidactylus frenatus*, mean *Dierogekko inexpectatus* is assessed as Critically Endangered (A3c; B1a, b[iii, v]; B2a, b[iii, v]) (IUCN 2001), and the impact of these threats could drive the small population from which this species is known to extinction within the very near future.

MOle CUI AR Phyl OGeNeTICS — There were 399 variable and 343 parsimony informative sites for ND2, 118 variable and 88 parsimony informative sites for the tRNAs, and 72 variable and 37 parsimony informative sites for KIF24. The ND2 data for the expanded data set retrieves the same topology as reported by Bauer *et al.* (2006) for relationships within *Dierogekko*, again with generally high support values for some interspecific relationships (Figure 6). The additional *D. inexpectatus* sequences are nearly identical to that obtained from the single individual available in 2006 and as in the previous study, this species is part of a clade including *D. validiclavis* and *D. nehoueensis*. The single *Dierogekko* from Île Baaba (AMS R 167252)



FIGURE 5

Cuirasse boulder piles inhabited by *D. inexpectatus* at Paevala, Poom massif, Province Nord, New Caledonia.

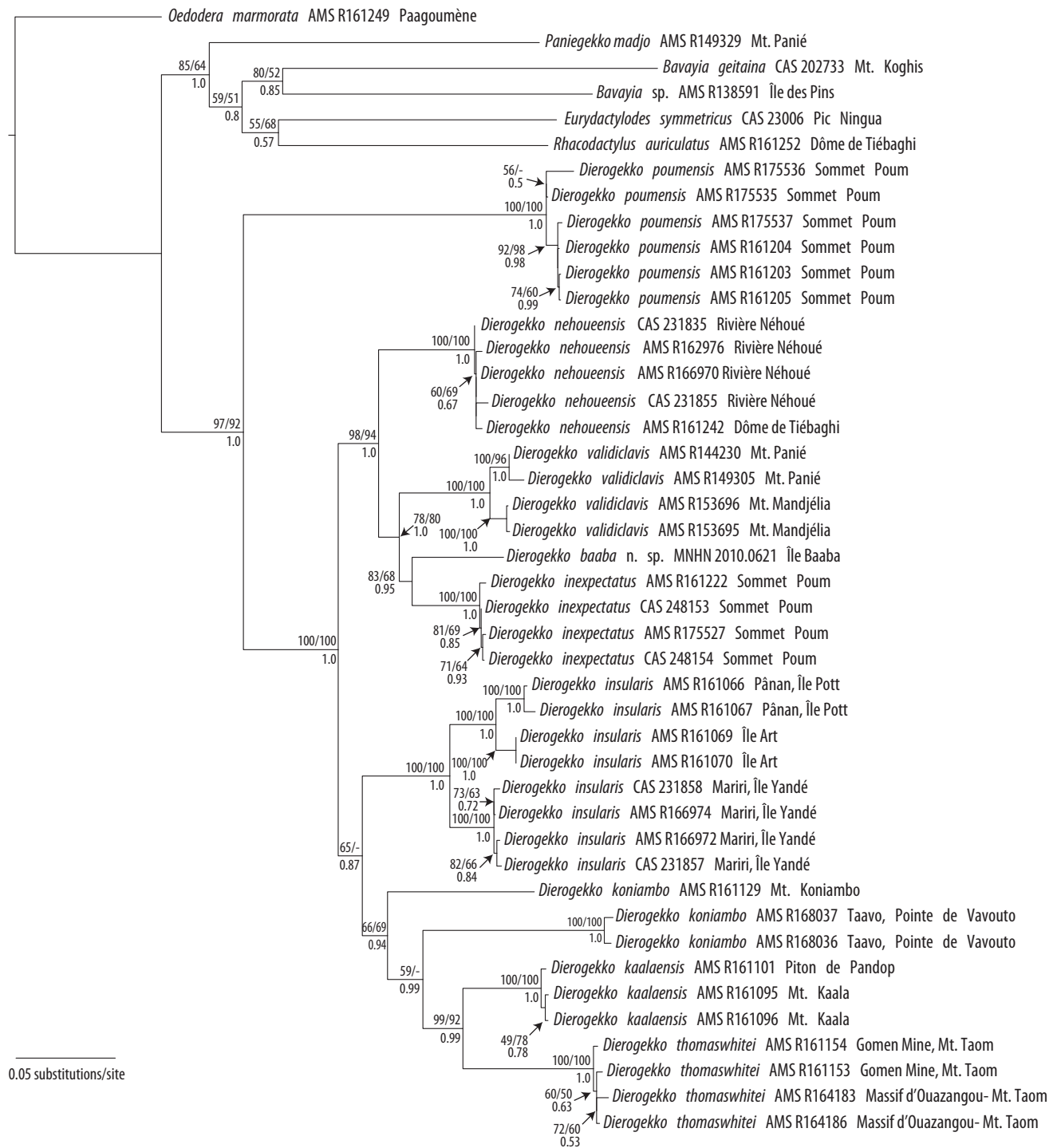


FIGURE 6

Maximum likelihood tree based on a fragment of the mitochondrial gene ND2 showing relationships among species of *Dierogekko*. Values subtending branches are maximum likelihood/maximum parsimony bootstrap values above the line and Bayesian posterior probabilities below the line.

is sister to *D. inexpectatus* within this clade, but without significant branch support. The clade comprising *D. insularis*, *D. thomaswhitei*, *D. kaalaensis*, and *D. koniambo* receives only moderate support, although the sister group relationship between *D. thomaswhitei* and *D. kaalaensis* is well-supported under all three analytical approaches. *Dierogekko koniambo* from Pointe de Vavouto do not cluster with those from Mt. Koniambo and this taxon is thus paraphyletic in both the likelihood and Bayesian analyses, although it receives some support as a natural group under parsimony; pending further investigation we regard the two populations as separate conservation units.

KIF24 (tree not shown), with its limited number of variable sites also retrieves a monophyletic *Dierogekko* and places *D. poumensis* as sister to the remaining taxa, although the latter with low support (ML bootstrap 70%; BI pP 0.90). Interspecific relationships among the remaining taxa are not generally well-supported and are based on only 35 variable sites, only 17 of which are informative, although a clade including *D. validiclavis*, *D. kaalaensis*, *D. thomaswhitei*, as well as the specimen from Baaba, had a posterior probability of 0.97.

The genetic distinctiveness of the Île Baaba specimen (ND2 uncorrected p-distance: 5.9708–14.8278 %, Tajima-Nei distance: 6.3411–17.016 % divergent from its congeners), along with several distinctive morphological features, support its recognition as a new species, which we describe here:

Dierogekko baaba Bauer, Whitaker & Sadlier, n. sp.

Figure 7

TYPe MATeRIAl — Holotype: MNHN 2010.0621 (formerly AMS R 167252): Adult female; New Caledonia, Province Nord, Île Baaba, 0.35 km SW Pucet Manaat, 20°04' 10.9"S, 163°57' 18.7"E (elevation 15 m a.s.l.), collected by A.H. Whitaker and V.A. Whitaker, 24 June 2006.

eTYMOl OGy — The species name *baaba* is a noun in apposition referring to the type locality of this form on Île Baaba.

TABLE 4

Comparison between species of *Dierogekko*.

TaxON	MAx. Svl (MM)	PReCl OACAI PORe ROWS	DISTAI SUBDIGITAL SCANSORS	DORSAL COI ORATION
<i>D. baaba</i> n. sp.	37.2	?	divided, narrow	pale vertebral region; thin dorsolateral stripes and pale dots weakly developed
<i>D. inexpectatus</i>	39.5	2 (11–13/7–8)	divided	dorsolateral stripes bold, or replaced with parallel rows of spots; no dark vertebral stripe; venter yellow
<i>D. insularis</i> (Yandé)	40.0	1 (12)	divided	vertebral region variably contrasting with flanks; dorsolateral stripes bold, or replaced with parallel rows of spots
<i>D. insularis</i> (Beleps)	41.4	2 (9–12/1–8)	divided	
<i>D. kaalaensis</i>	45.4	1 (12–15)	divided	pale vertebral region variably contrasting with flanks; thin dorsolateral stripes variably developed
<i>D. koniambo</i>	43.0	1 (10–12)	divided	pale vertebral region variably contrasting with flanks; dorsolateral stripes and dots absent on trunk
<i>D. nehoeensis</i>	40.3	2 (12/5–8)	divided	dorsolateral stripes bold or replaced with parallel rows of spots
<i>D. poumensis</i>	38.3	1 (8–11)	undivided	bright white dorsolateral stripes over sacrum and tail base, weakly contrasting on trunk; dark vertebral stripe present, sometimes indistinct; venter gray
<i>D. thomaswhitei</i>	44.9	2 (12–14/1–5)	divided	vertebral region weakly contrasting with flanks; dorsolateral stripes absent or vague
<i>D. validiclavis</i>	45.0	2 (12–16/8–11)	divided	pale vertebral region; thin dorsolateral stripes variably developed or replaced with parallel rows of spots

DIAGNOSIS — *Dierogecko baaba* can be distinguished from all congeners on the basis of the following combination of characters: size relatively small (37.2 mm in unique type), one internasal scale; subdigital lamellae relatively narrow, divided distally; [male preanal pore condition unknown]. Dorsum with a broad, pale vertebral stripe with edges weakly demarcated by vague pale dots and thin, broken dark borders. In addition to those features noted in Table 4, *D. baaba* can be distinguished from its congeners by its narrower digits (compare Figures 3 and 7).

DeSCRIPTION — *Adult female*. (Holotype) SVL 37.2 mm; TailL 23.9 mm (distal 19.5 mm regenerated). Head short (HeadL/SVL ratio 0.25), wide (HeadW/HeadL ratio 0.65), depressed (HeadH/HeadL ratio 0.35), weakly set off from relatively thick neck. Loreal region without inflated canthal area; interorbital region neither concave nor convex. Snout relatively short (SnEye/HeadL ratio 0.38), blunt; longer than eye diameter (OrbD/SnEye ratio 0.66); scales on snout and forehead small, rounded, granular to weakly conical, homogeneous; scales on snout much larger than those on occipital region. Eye relatively large (OrbD/HeadL ratio 0.24); pupil vertical with crenelated margins; supraciliaries short, bearing three elongate spines near posterodorsal margin of orbit. Ear opening elliptical, angled posterodorsally at an angle of 45° from horizontal, large (EarL/HeadL ratio 0.12); eye to ear distance less than diameter of eyes (EyeEar/OrbD ratio 0.87). Rostral wider (1.6 mm) than deep (0.9 mm), incompletely divided dorsally. Two moderately enlarged supranasals separated by a single heptagonal internasal approximately same size as supranasals. Rostral in contact with first supralabials, nostrils, supranasals and internasal. Nostrils rounded, each surrounded by supranasal, rostral, first supralabial, nasal and 3 (right) or 4 (left) postnasals. At least four rows of small scales separate orbit from supralabials. Mental triangular, approximately as wide as deep (1.0 mm). A single enlarged (~8 times size of granular throat scales) hexagonal postmental, anterior apex narrowest, bordered by mental, first infralabials, and four enlarged chin shields, two posteriorly and one each posterolaterally. Two to three scale rows posterior to postmental and medial to infralabials enlarged relative to remainder of chin and throat scales. Supralabials to midorbital position 8/8; total enlarged supralabials 9/9; supralabial scales to angle of jaws 14/14. Enlarged infralabials 8/8; infralabials to angle of jaws 12/12. Interorbital scale rows across narrowest point of frontal bone 15, 31 scale rows between supraciliary scale rows of left and right sides.

Body slender, elongate (TrunkL/SVL ratio 0.45) no ventrolateral folds. Dorsal scales smooth, granular to conical, homogeneous. Ventral scales larger than dorsals, smooth, hexagonal to oval and subimbricate to imbricate, roughly uniform in size across venter, slightly larger on posteriormost abdomen. Approximately 124 scale rows around midbody. Gular region with homogeneous, smooth granular scales, slightly larger than dorsal granules. No enlarged precloacal or femoral scales; no precloacal or femoral pores. No enlarged cloacal spurs.

Scales on palm and sole smooth, rounded to oval or subrectangular. Scalation on dorsal surfaces of limbs similar to body dorsum. Fore and hindlimbs short and thick (ForeaL/SVL ratio 0.12; CrusL/SVL ratio 0.15). Digits relatively weakly dilated; claws well developed and recurved on digits II-V; claw much reduced and less strongly recurved on digit I, situated between asymmetrical distal pads (lateral pad approximately twice size of medial). Basal subdigital lamellae broad, rectangular, becoming bowed distally and angled and divided beneath distal phalanges (except for terminal scansor). Scansors (terminal scansors of digit I not included in counts): 4-9-10-11-10 manus; 6-8-10-10-10 pes. Relative length of digits: IV>III>V>II>I (manus); IV>III~V>II>I (pes); interdigital webbing moderately well developed between all digits of manus and digits I-IV of pes. Regenerated tail shorter than SVL (TailL/SVL ratio 0.64), thick, slightly constricted at base, tapering sharply along distal 1/3. No caudal tubercles; dorsal caudal scales rectangular, juxtaposed to subimbricate, eight rows per tail segment; subcaudal scales larger than dorsals.

Coloration (in preservative). Dorsal ground color mid-brown, with a wide, beige vertebral stripe, approximately 20-24 scale rows wide, along entire trunk. Lateral margins of stripe with some discontinuous darker edging scales and two parallel rows of 11 vague pale dots from occiput to tail base. Scattered darker scales within the vertebral stripe, some forming vague transverse marks, especially on posterior trunk. Lower flanks light brown with scattered darker scales. Sacral region mostly pale with dark irregular central markings.

Crown of head and dorsum of snout pale, continuous with broad vertebral stripe. An asymmetrical dark marking along length of nasal region. A broad dark band from nostril to front of orbit and from posteroventral rim of orbit, above

ear, to join darker lateral trunk coloration. Labial scales mid- to dark brown with cream gaps often bracketing sutures between scales. Iris blackish.

Limbs mottled; palms, soles and subdigital surfaces brown. Regenerated portion of tail midbrown with irregular darker markings, some longitudinally oriented, especially distally. Venter beige with scattered small, dark punctations on individual scales, especially in preloacal region and along length of thighs; chin mottled. Tail venter light brown, with relatively uniform brown pigment flecks across all scales; scattered larger dark brown markings irregularly distributed. Venter of regenerated portion of tail becoming darker distally.

Coloration (in life). Pattern as in preserved specimen. Body dorsum pale grayish-brown, lateral surfaces brown with scattered darker brown speckling, transitioning to yellowish-brown near ventrolateral margins of trunk (Figure 7). Paravertebral spots pale ashy gray. Venter milky yellow. Limbs mottled purplish-brown. Tail dorsum yellowish-brown proximally, becoming grayish-brown distally, with scattered darker markings. Crown grayish-brown, loreal stripe chocolate brown, labial scales yellowish with scattered dark speckling. Iris a bright coppery beige.

DISTRIBUTION AND NATURAL HISTORY — The only known specimen was collected at night as it foraged in the crown of a maquis shrub approximately 2 m above ground. The site was at the foot of a steep, south-facing slope with very sparse, low-growing woody maquis on a bouldery, peridotite surface. The animal was found at the margin of taller (to 3 m), denser maquis paraforestier that bordered closed coastal forest on the valley floor.

Pucet Manaat (134 m) is the highest point on Île Baaba (2,100 ha) and the vicinity of this peak is the only part of the island on an ultramafic surface. The vegetation in this area comprises a mosaic of maquis and maquis paraforestier on the slopes, interspersed with varying areas of outcropping peridotite and bare eroding soil surfaces. There are small remnants of closed forest near the peak and patches of savannah grassland. A narrow strip of closed coastal forest borders the coast. The vegetation in this area has been highly modified by wildfires and is degraded by introduced deer, cattle and horses.



FIGURE 7
Life photograph
of holotype of
Dierogekko baaba n. sp.
(MNHN 2010.0621)
illustrating color
pattern and the
relatively weakly
dilated toes.

It is highly likely that the range of *Dierogecko baaba* will be limited to the vicinity of Pucet Manaat (Figure 2). Six of the eight previously described *Dierogecko* species are confined to maquis shrubland and closed forest habitats on ultramafic surfaces, *D. nehoueensis* is almost entirely so (except for one population in adjacent gallery forest on alluvial river flats), and only *D. validiclavis* occurs in closed mesic forests on metamorphic surfaces (Bauer *et al.* 2006). If *D. baaba* is restricted to ultramafic habitats like most of its congeners the only part of Île Baaba with potential habitat is approximately 77 ha on Pucet Manaat and 23 ha on a hill 0.6 km to the south. The remainder of Île Baaba comprises sedimentary (schist) and alluvial surfaces covered almost entirely with savannah grassland and degraded secondary shrubland, with small, scattered, degraded remnants of closed forest and sclerophyll forest, mostly in the south. Surveys in some of these forest remnants, including one just 3.5 km E of Pucet Manaat, have failed to detect *Dierogecko* (Whitaker *et al.* 2004).

The very limited information on the ecology of *Dierogecko baaba* indicates that—in common with the other *Dierogecko* species—it probably uses retreat sites on the ground beneath stones and litter, and forages in the outer canopy twigs of maquis shrubs at night.

Dierogecko baaba is syntopic with an undescribed member of the *Bavayia cyclura* clade and sympatric with *Caledoniscincus haplorhinus*; other lizard species recorded on Île Baaba are *Lepidodactylus lugubris*, *Caledoniscincus atropunctatus*, *C. austrocaledonicus*, *Cryptoblepharus novocaledonicus* and *Lioscincus nigrofasciolatum* (Whitaker & Whitaker 2007b).

CONSERVATION STATUS— Only a single *Dierogecko baaba* was found in 11 hours of night-searching in maquis shrubland and forest margins, and none were found by day (Whitaker & Whitaker 2007a), suggesting the population density of this species in the vicinity of Pucet Manaat is very low. The habitat at this site is vulnerable to wildfires, and ongoing degradation by deer, cattle and horses has a further negative impact on the remaining habitat. Trap data revealed introduced rats (*Rattus rattus*) are abundant at this site and feral cats were also observed. Although both rats and cats are serious predators of lizards, no direct evidence of predation on *D. baaba* was obtained, but studies elsewhere on their impact on small lizards indicate they are likely to have a significant negative effect on the *D. baaba* population. Introduced little red fire ants (*Wasmannia auropunctata*) are also present on Île Baaba and are known to impact severely on lizard populations (Jourdan *et al.* 2000, 2001). Although there are no quantitative data on population size and trends, the species' extremely restricted range (one location, <100 ha), the threats to its habitat (wildfires, browsing ungulates, invasive weeds), the presence of mammalian predators (rats, cats), and the impacts of fire ants, mean *Dierogecko baaba* is assessed as Critically Endangered (B1a, b[iii, v]; B2a, b[iii, v]) (IUCN 2001).

DISCUSSION

The initial finding of two genetically distinct *Dierogecko* sympatric on Sommet Poum was unexpected given nearly all other taxa in the genus have allopatric distributions. The level of genetic differentiation between the two taxa was supported to some extent (given *D. inexpectatus* was represented by a single specimen) by morphological differences, and on this basis (Bauer *et al.* 2006) recognised as two distinct species, *D. poumensis* and *D. inexpectatus*. Subsequent field studies on Sommet Poum have yielded additional specimens of *D. inexpectatus*, providing additional genetic and morphological data confirming the validity of the species. Further, extensive field surveys in northern Grande Terre (Whitaker & Whitaker 2007a,b, 2008), have failed to locate the species outside of Sommet Poum, and it appears to be restricted to the small remnant forest patches near Paeva on Sommet Poum. Examination of the additional specimens of *D. inexpectatus* show a level of variation in scalation and color pattern comparable to that seen in other species (Figure 3), even on the very limited spatial scale of Sommet Poum. Of particular significance is the confirmation of the male precloacal pore pattern. A double row of precloacal pores is shared by *D. inexpectatus*, *D. thomaswhitei*, *D. validiclavis*, and *D. nehoueensis*, whereas a single row characterizes *D. poumensis*, *D. kaalaensis*, and *D. koniambo*. *Dierogecko insularis* can have one or two rows of pores, and the newly described *D. baaba* is known only from a female, and thus the condition of this character is unknown.

Differences in body size, scensor morphology, and coloration pattern in combination will allow most specimens of *Dierogecko* (Table 4) to be assigned to a particular species, although given the allopatric distribution of most species location

information alone will determine all species except *D. poumensis* and *D. inexpectatus*. These two species are among the most morphologically divergent members of the genus and are readily differentiated by differences in body size, precloacal pore row number, and subdigital morphology, and several obvious color pattern differences. All *D. inexpectatus*, whether striped or spotted, lack a mid-dorsal stripe but a narrow, darker, mid-dorsal stripe is invariably present in *D. poumensis*, albeit often indistinctly (Figure 1). Further, in life all *D. inexpectatus* have yellow ventral surfaces (including the throat), clearly distinguishing them from *D. poumensis* which has a gray ventral surface (Figure 8).

The discovery of a new species in the genus from the far northern islands, *Dierogekko baaba*, is not surprising, given the extent of microendemism of *Dierogekko* spp. on ultramafic surfaces from the Koniambo Massif north to the Iles Belep. Nonetheless, the relatively deep divergence between this species and its congeners is perhaps unexpected, given the lesser divergence between the more distant island populations of *Dierogekko* on Yandé and the Beleps currently assigned to *D. insularis*. The extremely small distributions of most *Dierogekko* suggest both that additional species may yet be discovered in remnant habitats in the Province Nord. As a consequence of their restricted range and the diverse array of threats they face certain members of the genus must be considered among the most critically endangered of all New Caledonian vertebrates. The presence of introduced mammals and geckos, as well as invasive ants and non-native vegetation severely compromises many *Dierogekko*, especially *D. inexpectatus* and *D. baaba*, with ranges apparently restricted to just a few hectares. Combined with the threat of periodic fires and potential catastrophic habitat damage through mineral extraction, these species are truly at the brink of extinction. We strongly support proactive measures to stabilize the remaining habitat of both *D. inexpectatus* and *D. baaba* to decrease risk levels to these species. Possible mechanisms include limits on mining in critical habitats and eradication of feral and invasive organisms like those implemented successfully in New Zealand (Towns *et al.* 1997; Towns & Broome 2003). Whitaker *et al.* (2004) suggested such eradication programs for Île Yandé, Île Art, and Île Pott, where *D. insularis* occurs, but Île Baaba could also be a candidate, although its proximity to the New Caledonian mainland may make rat recolonization inevitable.



FIGURE 8
Comparison of series of freshly euthanized *D. poumensis* (left) and *D. inexpectatus* (right) illustrating the grayish venter in the former and yellowish venter in the latter.

ACKNOWLEDGMENTS

We are grateful to the Province Nord authorities for supporting our herpetological research in northwestern New Caledonia. Our fieldwork was carried out under Convention de Collaboration N^o. 80/2001 from the Direction du Développement Économique et de l'Environnement of the Assemblée de la Province Nord, and the majority of specimens of *Dierogecko* were collected under permits N^o. 31 and N^o. 49/02/SFE to Whitaker Consultants and permit N^o. 01/03/COLL-SCE to Aaron M. Bauer. We particularly thank Joseph Manauté, Christian Papineau, Jean-Jérôme Cassan and Van Duong Dang and the staff at the Antenne DDEE de Koumac. For permission to visit various massifs and island localities, and for assistance, we are grateful to Claude Paquet of Société Minière du Sud Pacifique. Logistical support and encouragement was provided by Hervé Jourdan of IRD Nouméa and Vivienne Whitaker participated in all the fieldwork. This research was supported by grants DEB 0108108 and DEB 0515909 from the National Science Foundation (U.S.A.) to A. M. Bauer and T. Jackman and by the project BIONEOCAL funded by the Agence Nationale de la Recherche (France).

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