Chapter 4.5
Conservation of a Rare Malagasy Snake: The Case of *Pseudoxyrhopus kely* (Family Colubridae)

Jean-Baptiste Ramanamanjato[1], Richard K. B. Jenkins[2,3], and Christian J. Randrianantoandro[3]

Abstract

Pseudoxyrhopus kely is an endemic colubrid snake recently described from littoral forests near Tolagnaro. Surveys of 24 forest sites in the Anosy Region recorded this species at 18 sites, including five different forest areas that span the bioclimatic gradient of the zone from dry to humid. *Pseudoxyrhopus kely* is generally associated with low altitude (< 100 m), relatively intact forest, but can also tolerate areas of degraded vegetation. Pitfall trapping is the best method to capture this rare member of the snake community. Three populations survive in protected fragments (Réserve Privée de Berenty, 256 ha, Sainte Luce 240 ha, and Mandena 230 ha), but the larger forests at Marovony (2,127 ha) and Petriky (800 ha) are currently unprotected. The planned extraction of ilmenite at Petriky could result in a decrease in the remaining habitat of *P. kely* if preventative measures are not taken. Large gaps exist in our knowledge of the species, and we recommend additional surveys.

Résumé

Conservation d'un serpent malgache rare : le cas de *Pseudoxyrhopus kely* (Famille Colubridae). *Pseudoxyrhopus kely* est un serpent colubridé endémique qui a été décrit récemment des forêts littorales près de Tolagnaro. Des inventaires menés dans 24 stations forestières de la région de l'Anosy ont permis de dénombrer cette espèce dans 18 stations avec cinq zones forestières différentes couvrant le gradient bioclimatique sec à humide de la région. *Pseudoxyrhopus kely* est généralement lié à la forêt relativement intacte de basse altitude (< 100 m) mais peut aussi tolérer une végétation dégradée. Les trous-pièges ou 'pitfall' constituent la meilleure méthode pour capturer cette espèce rare de la communauté herpétologique. Trois populations survivent dans des fragments protégés (Réserve Privée de Berenty 256 ha, Sainte Luce 240 ha et Mandena 230 ha) mais les forêts plus étendues de Marovony (2 127 ha) et de Petriky (800 ha) ne bénéficient, pour le moment, d'aucune protection. L'extraction minière d'ilménite prévue à Petriky pourrait réduire l'habitat restant de *P. kely* si aucune mesure de protection n'est prise. Nos connaissances sur cette espèce souffrent de grandes lacunes et nous recommandons d'entreprendre davantage d'inventaires.

Introduction

The littoral forests of Madagascar are one of the most threatened habitats on the island, and most of the remaining vegetation is highly fragmented (de Gouvenain and Silander 2003, Bollen and Donati 2006). These forests are of considerable biodiversity importance and there are presumably endemic plant species restricted to them (Lowry and Faber-Langendoen 1991, Rabevohitra *et al.* 1996). The remaining littoral forests of the Anosy Region are threatened by charcoal production, slash and burn farming, logging, and the future extraction of minerals (Vincelette *et al*. 2003, Bollen and Donati 2006).

A series of biological inventories undertaken in the Anosy region since the late 1980's by QIT Madagascar Minerals (QMM) to assess the vertebrate populations in the project areas (Lewis Environmental Consultants 1992) uncovered a num-

[1] QIT Madagascar Minerals, BP 225, Tolagnaro 614, Madagascar. Email: jeanbaptiste.ramanamanjato@riotinto.com

[2] School of Biological Sciences, University of Aberdeen, Aberdeen, AB24 2TZ, United Kingdom. Email: r.jenkins@abdn.ac.uk

[3] Madagasikara Voakajy, BP 5181, Antananarivo 101, Madagascar. Email: christian_randrianatoandro@moov.mg

ber of reptile species new to science. These include *Paragehyra gabriellae* (Raxworthy and Nussbaum 1994), *Zonosaurus anelanalany* (Raselimanana *et al*. 2000), and *Uroplatus malama* (Nussbaum and Raxworthy 1995). Two other species new to science were also collected for the first time during the 1989-91 surveys: a day gecko, *Phelsuma antanosy* (Raxworthy and Nussbaum 1993, Nussbaum *et al*. 2000), and a colubrid snake, *Pseudoxyrhopus kely* (Raxworthy and Nussbaum 1994). Few details are known about *P. kely*, and herein we describe new information on the distribution and habitat preferences of this animal, which is considered "endangered" (CBSG 2002).

Methods

In this review, we used previously published accounts of the herpetofauna of the region (Lewis Environmental Consultants 1992, Nussbaum *et al*. 1999, Ramanamanjato 2000, QMM 2001, Ramanamanjato *et al*. 2002). All herpetological surveys used the same broad approach of a standardized pitfall trapping protocol and semi-quantitative searches by field biologists. Pitfall trapping consisted of 100 m lines of plastic buckets buried vertically in the soil at 10 m intervals, and linked by a low (0.5 m) drift fence made of plastic sheeting. Trapping effort varied both within and between different sites (Lewis Environmental Consultants 1992, Nussbaum *et al.* 1999, see Ramanamanjato Chapter 4.4), but usually consisted of three lines (33 buckets total) operated for seven days. Searches by herpetologists consisted of examining potential refuges, and looking for reptiles while walking trails during the day and night.

Results

Pseudoxyrhopus kely is a small, terrestrial nocturnal snake thought to live above ground in leaf litter and under fallen wood. It has a snout vent length of 170 to 228 mm, 19 dorsal, mid-body scale rows, eight supralabial scales, a bluntly rounded snout, pink venter, pale collar, and thin dark longitudinal lines on its body.

All recorded individuals were either trapped in pitfall devices or observed at night in leaf litter usually in areas of sandy or well-drained soils. Individuals of *P. kely* held temporarily in captivity at Mandena fed on termites and small frogs, but there is no information on its diet in the wild. An adult female caught in the Marovony Forest in December 2001 was gravid with four eggs, and thus, was presumably oviparous.

Table 1. Summary of the forest locations surveyed and sites where *Pseudoxyrhopus kely* was observed or captured between 1989 and 2006 in the Anosy Region.

Forest sites	Forest type	Survey site	Altitude (m)	Number of records of *P. kely*
Petriky	Littoral, dry	46°53'E, 25°04'S	0-40	10
Mandena	Littoral, humid	47°00'E, 25°58'S	0-20	6
Sainte Luce	Littoral, humid	47°11'E, 24°45'S	0-20	2
Tapera	Littoral, humid	47°07'E, 24°53'S	0-20	0
Ambatotsirongorongo	Dry/humid	46°46'E, 25°04'S	200-430	0
Manantantely	Humid	46°55'E, 24°59'S	50-600	0
Nahampoana	Humid	46°58'E, 24°58'S	100-300	0
Marovony	Humid	47°20'E, 24°05'S	50-100	2
Maromoky	Humid	47°09'E, 24°62'S	203	0
Ampasy	Humid	47°14'E, 24°58'S	36	0
Ivohibe	Humid	47°20'E, 24°56'S,	131	0
Farafara	Humid	47°00'E, 24°50'S	36-225	0
Ivorona	Humid	46°57'E, 24°49'S	100-400	0
PN d'Andohahela (Parcel 1)	Humid	46°11'E, 24°42'S	400-1950	0
PN d'Andohahela (Parcel 2)	Dry	46°36'E, 24°49'S	120	0
Manangotry	Humid	46°52'E, 24°45'S	200-650	0
Resérve Privé de Berenty	Gallery	46°17'E, 24°59'S	15-30	2
Amboasary	Dry	46°29'E, 25°00'S	70-120	0

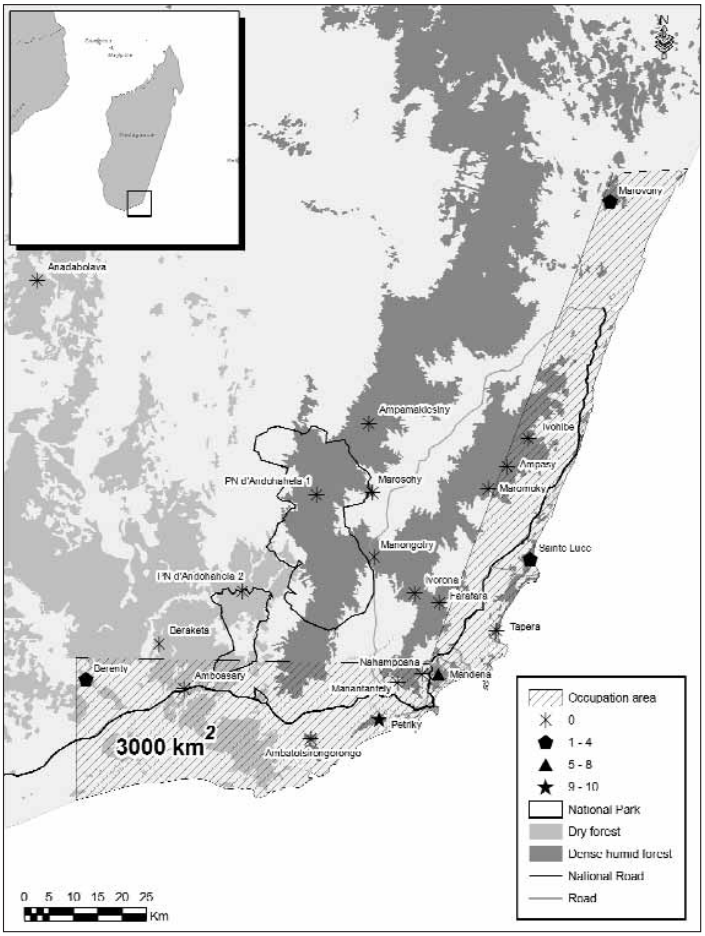

Figure 1. Study sites, distribution, and potential area of occurrence of *Pseudoxyrhopus kely*.

Thirteen of the 24 survey sites were in humid, five in dry, four in littoral and one in each gallery and transitional forests (Table 1). *Pseudoxyrhopus kely* was recorded in five of these sites - three littoral sites, one humid, and the gallery forest (Fig. 1, Table 1). Three of these occurrences were identified after the 1989-90 surveys, and the discovery of *P. kely* in the Marovony Forest and Réserve Privée (RP) de Berenty considerably extended its known distributional range. The Marovony Forest is 80 km to the north of the nearest *P. kely* population at Sainte Luce. The estimated extent of this species' occurrence encompasses 5,207 km^2 but, based on limited current data, the area occupied by this species is about 3.5 km^2.

The distribution data reveal a tolerance for a variety of environmental conditions and vegetation types. *Pseudoxyrhopus kely* was recorded in the Petriky littoral forest, which is distinctly drier than that of Madena and Sainte Luce, the gallery forest of the RP de Berenty, which is surrounded by spiny bush (Nussbaum *et al.* 1999), and littoral and lowland humid forests. All records are from < 100 m.

Levels of forest degradation at the five sites where *P. kely* was found span a gradient from low disturbance, which suggests a relatively intact forest with a closed canopy, such as that at Sainte Luce, to more open, degraded forest like Petriky. The Mandena and Sainte Luce forests are notably fragmented (Ramanamanjato 2000) and *P. kely* was recorded in four of these fragments: at Mandena in M15/16 (230 ha), M3 (221 ha), and M20 (6 ha), and at Sainte Luce in S17 (237 ha). Both Petriky (597 ha) and the RP de Berenty (256 ha) are also isolated fragments, while the Marovony Forest site (2,127 ha) potentially has larger remaining areas of suitable habitat.

Estimates of population size, whether relative or absolute, are difficult to make for *P. kely* because of the rarity of this taxon and variations in sampling frequency, effort, and methodology (Table 1). At Marovony, two individuals were trapped in 2001 with 77 pitfall days, but no captures were made in 1992 during 473 pitfall days (Lewis Environmental Consultants 1992). Between 1998 and 2005, six individuals were captured in Mandena during 4620 pitfall days, six individuals in Petriky during 3680 pitfall days, and four more individuals in Petriky were captured by direct observation.

Discussion

Pseudoxyrhopus is a genus endemic to Madagascar, and all of its 11 species (Raxworthy 2003) are secretive, ground-dwelling, and rarely observed or trapped during surveys (e.g., Raxworthy and Nussbaum 1994, Nussbaum *et al*. 1999, Cadle 1999). Notwithstanding the burrowing behavior of some species (Nussbaum *et al*. 1998), which may render them difficult to observe or trap, *Pseudoxyrhopus* appear to be rare members of the colubrid community.

Available information on the distribution of *P. kely* indicates that it is limited to southeastern Madagascar. Since its original description from the littoral forests of Mandena and Sainte Luce, the distributional range of *P. kely* has extended southwards to Petriky, westwards into the drier habitats of Berenty, and further north to the lowland humid forests of Marovony. Compared to the original description in 1994, the area occupied by *P. kely* has increased to 3.5 km^2. Even after extensive survey work, this species remains unknown in parcels I and II of the Parc National d'Andohahela (Nussbaum *et al*. 1999), and in the Vohimena Mountains (Ramanamanjato 1993, Randrianatoandro and Andriamazava, pers. comm.). Further, despite intense survey work throughout Madagascar by various researchers, *P. kely* has not been found outside the Anosy Region.

This species is well adapted to different types of habitat, from closed canopy vegetation to open dry forest, and from sandy to lateritic soils. It has been captured in open gallery forest dominated by large *Tamarindus* tree, whereas as well as in Sainte Luce and Marovony, where the sites are littoral and lowland humid forest, respectively. At Mandena and Petriky, it persists in degraded and fragmented forest blocks of less than 10 ha.

Pseudoxyrhopus kely was considered in the 1992 report to be among the rare and endemic species of the littoral forest (Lewis Environmental Consultants 1992, Raxworthy and Nussbaum 1994). The information collected between 1994 and 2004 (Table 1) confirms its rarity in littoral forest habitats, as well as other habitats in which it has been documented.

Threat and role of protected areas

The loss of habitat has undoubtedly caused a substantial population decline in this species. Charcoal producers deforested the M3 fragment in Mandena between 2000 and 2002, and there are now only nine ha of scrub vegetation remaining at this site. The six known populations of *P. kely* are all isolated from each other, and three of its five known forest localities are in protected areas. The QMM commitment in the 2001 Social and Environmental Impact Assessment (QMM 2001) to establish conservation zones in Mandena, Sainte Luce, and Petriky is directly linked to the success of this species. The S17 fragment in Sainte Luce and M15/16 in Mandena have recently been included within the network of national conservation sites (Système d'Aires Protégées de Madagascar). The gallery forest of RP de Berenty is also protected and deforestation is not a major threat, although the understory is thin because of tourist and cattle pressure. The Marovony Forest is currently without protection. The proposed conservation zone at Petriky should aim to protect a viable population of *P. kely*, from which post-mining restoration and translocation activities can be initiated.

As with all *Pseudoxyrhopus* species, conservation assessments and plans are hampered by a lack of distributional and population data (Nussbaum *et al*. 1998). While we might expect future surveys to uncover other populations of *P. kely* in the larger fragments of Sainte Luce (S8 and S9) or the lowland forest near Marovony, its restriction to forests with elevations less than 100 m makes it a species of conservation concern. Given its rarity, a region-wide monitoring program is unlikely to provide substantial data on abundance or habitat use, but the regular capture of *P. kely* at Petriky in pitfalls demonstrates the potential of this type of monitoring. Regular pitfall trapping over the long-term at sites expected to undergo habitat loss (e.g., Petriky) are important, especially as other burrowing reptiles are sampled simultaneously. These efforts should continue both in the forest that is to be mined and at the proposed

conservation site. Further surveys of the forests around Marovony, the gallery forests on the Mandrare, and other rivers in the west of the region are also needed to better understand the distributional limits of *P. kely.*

Acknowledgements

We thank Manon Vincelette, Jörg U. Ganzhorn, Ronald A. Nussbaum, Christopher J. Raxworthy, and Achille Raselimanana for their advice and support throughout the work. We are also grateful to Laurent Randriahasipara, Johny Rabenantoandro, Faly Randriantafika, and Christian Rarivoson. Alain Andriamazava, Vola Romaine, Rivo Rajonson, Claude Hery Soanary, and Julson assisted in field activities. Lee Durrell, Joanna Durbin, Richard Gibbson, and Quentin Bloxam provided additional advice. Steven M. Goodman gave helpful comments to a draft. Funding was provided by QMM SA, the Rufford Small Grants Foundation, and the RioTinto Biodiversity Partnership.

References

Bollen, A. and G. Donati. 2006. Conservation status of the littoral forest of south-eastern Madagascar: a review. *Oryx* 40:57-66.

Cadle, J.E. 1999. The dentition, systematics, and phylogeny of *Pseudoxyrhopus* and related genera from Madagascar (Serpentes: Colubridae), with descriptions of a new species and a new genus. *Bulletin of the Museum of Comparative Zoology* 155:381-443.

CBSG. 2002. *Evaluation et Plans de Gestion pour la Conservation (CAMP) de la Faune de Madagascar. Lémuriens, Autres Mammifères, Reptiles et Amphibiens, Poissons d'eau douce et Evaluation de la Viabilité des Populations et des Habitats de* Hypogeomys antimena *(Vositse)*. SSC/IUCN, Apple Valley, Minnesota.

de Gouvenain, R.C. and J. A. Silander. 2003. Littoral forest. Pp. 103-111 *in*: Goodman, S.M. and J.P. Benstead, eds., *The Natural History of Madagascar*. The University of Chicago Press, Chicago.

Lewis Environmental Consultants. 1992. Madagascar Minerals Project. Environmental Impact Assessment Study. Part 1: Natural Environment. In Ilmenite Project. Social and Environmental Impact Assessment. Supporting Document no 5. Presented by QIT Madagascar Minerals S.A. to the Madagascar National Environment Office, May 2001.

Lowry, P.P. and D. Faber-Langendoen. 1991. Overall flora and vegetation study. In Ilmenite Project. Social and Environmental Impact Assessment. Supporting Document no 4. Presented by QIT Madagascar Minerals S.A. to the Madagascar National Environment Office, May 2001.

Nussbaum, R. A. and C. J. Raxworthy. 1995. New *Uroplatus* Duméril (Reptilia: Squamata: Gekkonidae) of the *ebenaui*-Group from the Anosy Mountains of southern Madagascar. *Copeia* 1995:118-124.

Nussbaum, R.A., F. Andreone and C.J. Raxworthy. 1998. New rain-forest species of *Pseudoxyrhopus* Günther (Squamata: Colubridae) from northern Madagascar. *Copeia* 1998:128-132.

Nussbaum, R.A., C.J. Raxworthy, A.P. Raselimanana and J.-B. Ramananjato. 1999. Amphibians and reptiles of the Réserve Naturelle Intégrale d'Andohahela, Madagascar. *In*: Goodman, S. M., ed., A floral and faunal inventory of the Réserve Naturelle Intégrale d'Andohahela, Madagascar: with reference to elevational variation. *Fieldiana: Zoology*, new series, 94:155-173.

Nussbaum, R.A., C. J. Raxworthy, A.P. Raselimanana and J.-B. Ramanamanjato. 2000. New species of day gecko, *Phelsuma* Gray (Reptilia: Squamata: Gekkonidae), from Réserve Naturelle Intégrale d'Andohahela, southern Madagascar. *Copeia* 2000:763-770.

QMM (QIT Madagascar Minerals). 2001. QIT Madagascar Minerals: Ilmenite Project. Social and Environmental Impact Assessment, Vol. 1 and 2. Presented by QIT Madagascar Minerals S.A. to the Madagascar National Environment Office, May 2001.

Rabevohitra, R., P.P. Lowry, H. Randrianjafy and N. Razafindrianilana. 1996. Rapport sur le project 'Assessment of Plant Diversity and Conservation Importance of East Coast Low Elevation Malagasy Rain Forests'. Centre National de la Recherché Appliquée du Développement Rural, CENRADERU-FOFIFA, Missouri Botanical Gardens.

Ramanamanjato, J.-B. 1993. Contribution à l'étude des reptiles et amphibiens de la forêt ombrophile du Sud Est de Madagascar. Mémoire de DEA, Université d'Antananarivo, Antananarivo.

Ramanamanjato, J.-B. 2000. Fragmentation effects on reptile and amphibian diversity in the littoral forest of southeastern Madagascar. Pp. 297-308 *in:* Rheinwald, G., ed., Isolated Vertebrate

Communities in the Tropics. *Bonner Zoologische Monographien*. Vol. 46.

Ramanamanjato, J.-B., P.B. McIntyre and R.A. Nussbaum. 2002. Reptile, amphibian and lemur diversity of the Malahelo Forest, a biogeographical transition zone in southeastern Madagascar. *Biodiversity and Conservation* 11:1791-1807.

Raselimanana, A. P., C. J. Raxworthy and R. A. Nussbaum. 2000. A revision of the dwarf *Zonosaurus* Boulenger (Reptilia: Squamata: Cordylidae) from Madagascar, including descriptions of three new species. *Scientific Papers, The Natural History Museum, The University of Kansas* 18:1-16.

Raxworthy, C.J. 2003. Introduction to the Reptiles. Pp. 934-949 *in*: Goodman, S.M. and J.P. Benstead, eds., *The Natural History of Madagascar*. The University of Chicago Press, Chicago.

Raxworthy, C.J. and R.A. Nussbaum. 1993. A new Madagascan *Phelsuma*, with a review of *Phelsuma trilineata* and comments on *Phelsuma cepediana* in Madagascar (Squamata: Gekkonidae). *Herpetologica* 49:342-349.

Raxworthy, C.J. and R.A. Nussbaum. 1994. A review of the Madagascan snake genera *Pseudoxyrhopus, Parahadinea,* and *Heteroliodon* (Squamata: Colubridae). *Miscellaneous Publications of the Museum of Zoology, University of Michigan* 182:1-37.

Vincelette, M., L. Randrihasipara, J.-B. Ramanamanjato, P.P. Lowry and J.U. Ganzhorn. 2003. Mining and environmental conservation: the case of QIT Madagascar Minerals in the southeast. Pp. 1535-1537 *in*: Goodman, S.M. and J.P Benstead, eds., *The Natural History of Madagascar*. The University of Chicago Press, Chicago.

Captions for facing page:

1. *Fisherman going to the market to sell his products after successful captures (Rio Tinto)*
2. *The aquatic plant* Pandanus sp. *(QMM)*
3. *The fat tailed dwarf lemur (*Cheirogaleus medius*) hibernates for several months during the lean season (Kathrin Dausmann)*
4. *Dragonfly* Asciosoma ascalaphoides *(Kai Schuette)*
5. *The nocturnal, pair- living woolly lemurs (*Avahi meridionalis*) feed exclusively on leaves (Ivan Norscia)*
6. *The Tolagnaro Bay (QMM)*
7. *An example of the flora of the littoral forest* Symphonia fasciculata *(QMM)*
8. *Rivo at the entrance of the Ecological Center (QMM)*
9. Mantidactylus punctatus *from Sainte Luce (QMM)*