SALAMANDRA 54(1) | 71–74 | 15 February 2018 | ISSN 0036–3375

Correspondence

Comparative perch heights and habitat plant usage of day geckos (*Phelsuma*) in the Comoros Archipelago (Squamata: Gekkonidae)

Stéphane Augros[1], Mark D. Scherz[2], Cynthia Y. Wang-Claypool[3], Ludovic Montfort[2], Frank Glaw[2] & Oliver Hawlitschek[2, 4]

[1)] Eco-Med Océan Indien, 24 rue de la Lorraine, 97400 Saint-Denis, Ile de La Réunion, France
[2)] Zoologische Staatssammlung München (ZSM-SNSB), Münchhausenstr. 21, 81247 München, Germany
[3)] Museum of Vertebrate Zoology, 3101 Valley Life Sciences Building, University of California, Berkeley, California, U.S.A.
[4)] Institut de Biologia Evolutiva (CSIC-Universitat Pompeu Fabra), Passeig Marítim de la Barceloneta 37, 08003 Barcelona, Spain

Corresponding author: Stéphane Augros, e-mail: s.augros@ecomed.fr

Manuscript received: 27 February 2017
Accepted: 12 July 2017 by Alexander Kupfer

The Comoros Archipelago is a group of four major islands in the Western Indian Ocean. It is inhabited by five endemic species of day geckos of the genus *Phelsuma* (*P. robertmertensi, P. nigristriata, P. pasteuri, P. comorensis, P. v-nigra*) and another two introduced species (*P. dubia, P. laticauda*). The highest species richness is found on the island of Mayotte, where five species occur (*P. robertmertensi, P. nigristriata, P. pasteuri, P. dubia, P. laticauda*; Rocha et al. 2009). The results of earlier studies suggested that *Phelsuma* species avoid competition on an island by divergent preferences in macrohabitats, such as altitude zones, climate, and pristine vs. degraded habitats (Meirte 1999, Brückmann 2010, see also Hawlitschek et al. in press for the remarkably localized distribution of *P. comorensis* on Grand Comoro). Consequently, the perceived rareness of the otherwise abundant introduced *P. dubia* on Mayotte (four other species of *Phelsuma* present vs. one or two on other islands) and Anjouan (presence of the invasive *P. laticauda*) was attributed to strong competitive pressure for macrohabitats (Hawlitschek et al. 2011 and O. Hawlitschek, unpubl. data). However, several authors already speculated on a close association of this species with high palm trees and particularly with coconut trees (see Berghof 2001, Raxworthy et al. 2007). Furthermore, more recent studies reported observations of communities of up to five *Phelsuma* species in one site (Hawlitschek & Glaw 2014, Wang-Claypool et al. 2016, Augros et al. 2017). Therefore, we now test the hypothesis that sympatric species may shift their microhabitat preferences, specifically perch height and perch structure, in response to the presence of congeners.

Between 2002 and 2017, 953 observations on the seven species of *Phelsuma* occurring in the Comoros were recorded from the islands of Mohéli (n = 67 including 22 observations of *P. dubia*), Mayotte (n = 590 incl. 53 obs. of *P. dubia*), Anjouan (n = 223 incl. 34 obs. of *P. dubia*), and Grand Comoro (n = 73 incl. 24 obs. of *P. dubia*) (Hawlitschek et al. 2011, Hawlitschek & Glaw 2014, Wang-Claypool et al. 2016, Augros et al. 2017, S. Augros unpubl. data). Perch heights (n = 689) were systematically recorded by different observers in the field with an estimated accuracy of ± 0.5 m, and the perch structure (mostly type of plants) was noted. For some data points, perch height was not recorded (n = 215). In this case, the missing data were estimated from average perch heights of every type of perch structure observed in the field (*Musa*: 2.5 m; *Cocos nucifera*: 8 m; other Areaceae: 5 m; *Pandanus*: 2.5 m; Agavaceae: 0.5 m; *Litsea glutinosa*: 2.5 m; Bamboos: 8 m). Another 56 data points were excluded because of missing entries for perch height and perch structure. Statistics were computed with R version 3.2.2. As perch height data across all species for all four islands were not normally distributed (Shapiro-Wilk test, p-value < 2.2e-16), we chose to use a Kruskall-Wallis non-parametric test to infer whether different species of *Phelsuma* occupied different perch heights. The results indicate that the individual species did not follow the same distribution pattern (Kruskal-Wallis chi-squared = 92.85, df = 6, p-value < 2.2e-16). To assess pairwise differences, we applied a post-hoc multiple comparison Nemenyi test (Nemenyi 1963). In order to evaluate whether estimated heights changed the outcome of the analyses (n = 208), we ran the same tests excluding the approximated heights data

Table 1. P-values from the *post hoc* multiple comparison Nemenyi test between *Phelsuma* species perch height records (n=886). *PC: P. comorensis; PD: P. dubia; PL: P. laticauda; PN: P. nigristriata; PP: P. pasteuri; PR: P. robertmertensi; PV: P. v-nigra*. In brackets: given p-values without estimated perch heights data.

	PC	*PD*	*PL*	*PN*	*PP*	*PR*
PD	**P < 0.001**	–	–	–	–	–
	(P < 0.001)	–	–	–	–	–
PL	0.9230	**P < 0.001**	–	–	–	–
	(0.99912)	(P < 0.001)	–	–	–	–
PN	0.9860	**P < 0.001**	0.9989	–	–	–
	(0.99936)	(P < 0.001)	(0.72024)	–	–	–
PP	**P < 0.05**	0.4739	**P < 0.05**	**P < 0.05**	–	–
	(0.95328)	(P < 0.05)	(0.97786)	(0.62514)	–	–
PR	0.0589	**P < 0.05**	**P < 0.01**	**P < 0.05**	0.9974	–
	(0.34261)	(P < 0.05)	(0.06838)	(P < 0.01)	(0.97305)	–
PV	0.6551	**P < 0.001**	0.9182	0.8274	0.3801	0.4867
	(0.46922)	(P < 0.01)	(0.11766)	**(P < 0.001)**	(0.99460)	(0.99979)

(Table 1). With or without estimated perch heights, the results provided a significant difference in perch height between *P. dubia* and all other species except *P. pasteuri*, but this became significant when estimated heights were added to the analysis. Significant differences were also detected when comparing the Mayotte-endemic *P. robertmertensi* with the likewise endemic *P. nigristriata*, as was the case in the introduced *P. laticauda* and *P. dubia*. Significant differences were furthermore confirmed to exist between *P. pasteuri* and *P. nigristriata* as well as between *P. pasteuri* and *P. laticauda*, but only when the whole dataset including estimated perch heights was included in the analysis (Table 1, Fig. 1). In terms of perch preferences, native *Phelsuma* were found to use the same types of host plants as the introduced species (Table 2), specifically in disturbed areas whence syntopic occurrences have been reported (see Hawlitschek & Glaw 2014, Wang-Claypool et al. 2016, Augros et al. 2017). *Phelsuma robertmertensi* has an obvious preference for woody trees with 63% of all observations. This is significantly more than in all the other species, although 30 and 27% of *P. pasteuri* and *P. v-nigra* were respectively recorded from woody trees. *Cocos nucifera* represents 23% of all observations for *P. dubia*. A clear preference of the two introduced species for cultivated banana plants (*Musa* sp.) was detected, with 49 and 38% of all observations for *P. laticauda* and *P. dubia*, respectively. Banana plants also represent an attractive host plant for the two endemics *P. v-nigra* and *P. comorensis* and account for more than 10% in all other species (Table 2).

The use of significantly higher perches by *P. dubia* compared to the other species indicates that the abundance of this species might currently be underestimated, as the highest perches (coconut trees) reach up to 30 m, rendering observations difficult. The same tendency shows in *P. robertmertensi* and possibly *P. pasteuri*. The latter was observed more rarely (n = 50) than the two other endemics of Mayotte (n = 128 for *P. nigristriata,* n = 115 for *P. robertmertensi*), so that a bias in observation may also be expected. The surveys of 2002 through 2014 (but also of Wang-Claypool et al. 2016) were mostly based on slow walking transects, whereas surveys by S.A. since 2015 employed a new protocol consisting of one-hour stationary vantage point surveys with binoculars. This revealed that coconut crowns were commonly used by *P. dubia*, sometimes together with *P. laticauda*, and that *P. pasteuri* and *P. robertmertensi* also used higher perches than had been expected (i.e., bamboo plants and Arecaceae) even though very few observations to this effect exist at present (n = 5 for *P. pasteuri*, n = 13 for *P. robertmertensi*). The average observed perch height of *P. dubia* recently recorded through

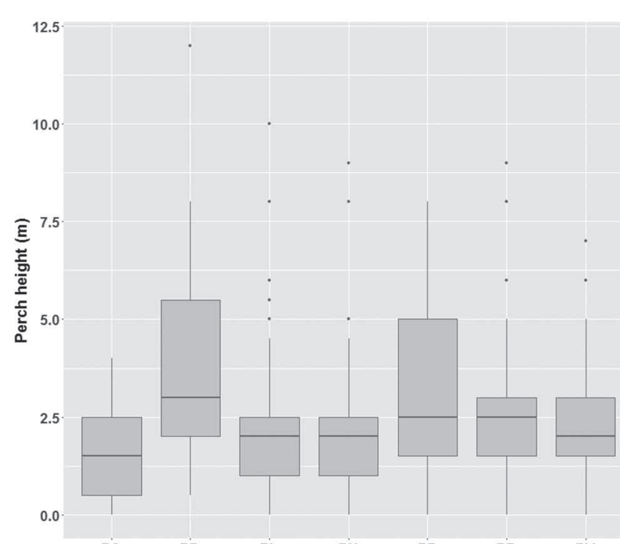

Figure 1. Boxplot of perch heights recorded for Comoran *Phelsuma* species. *PC: P. comorensis; PD: P. dubia; PL: P. laticauda; PN: P. nigristriata; PP: P. pasteuri; PR: P. robertmertensi; PV: P. v-nigra*. Boxes span the first quartile to the third quartile. Segment inside the box shows the median. Lines above and below the box show minima and maxima. Dots represent outliers.

Table 2. Estimated perch heights and usage of habitat plants (number of observations) of Comoran *Phelsuma* species. Perch heights are given as range followed by mean±standard deviation in parentheses. In brackets: percentage of total observations.

	PC	*PD*	*PL*	*PN*	*PP*	*PR*	*PV*	*Total*
Perch height (m)	0–4 m (1.7±1.2)	0.5–12 m (3.9±2.6)	0–10 m (2.1±1.8)	0–9 m (2±1.7)	0–8 m (3.3±2.6)	0–9 m (2.8±1.9)	0–7 m (2.2±1.4)	0–12 m (2.5±2)
Agavaceae	12 (38.7%)	9 (6.8%)	75 (21.1%)	27 (20.3%)		1 (0.8%)	13 (11.6%)	137 (14.4%)
Cocos nucifera		37 (27.8%)	23 (6.5%)		3 (5.1%)	7 (5.4%)	14 (12.5%)	84 (8.8%)
Other Arecaceae		1 (0.8%)	10 (2.8%)	12 (9.0%)	11 (18.6%)	7 (5.4%)	1 (0.9%)	42 (4.4%)
Bamboos			2 (0.6%)	10 (7.5%)	9 (15.3%)	5 (3.8%)		26 (2.7%)
Musa sp.	11 (35.5%)	65 (48.9%)	136 (38.3%)	15 (11.3%)	7 (11.9%)	14 (10.8%)	45 (40.2%)	293 (30.7%)
Pandanus sp.			19 (5.4%)	47 (35.3%)	4 (6.8%)			70 (7.3%)
Other woody trees	1 (3.2%)	3 (2.3%)	31 (8.7%)	7 (5.3%)	18 (30.5%)	82 (63.1%)	30 (26.8%)	172 (18.0%)
Artificial structures	6 (19.4%)	9 (6.8%)	45 (12.7%)	6 (4.5%)	1 (1.7%)	2 (1.5%)	7 (6.3%)	76 (8.0%)
Others	1 (3.2%)		11 (3.1%)	5 (3.8%)		1 (0.8%)	1 (0.9%)	19 (2.0%)
Not identified		9 (6.8%)	3 (0.8%)	4 (3.0%)	6 (10.2%)	11 (8.5%)	1 (0.9%)	34 (3.6%)
Total	31	133	355	133	59	130	112	953

vantage point surveys (n = 32) was 6.96 versus 2.84 m obtained from previous transects surveys (n = 92). As a consequence, despite clear statistical results, our results may still underestimate the trend of *P. dubia* for high perches, as the data from 2002 through 2014 were probably already biased. On Mayotte, our results also revealed significant differences in perch height preferences between *P. laticauda* and *P. robertmertensi* as well as *P. pasteuri*, with these latter two species using more woody trees and no Agavaceae as perches (Table 2). *Phelsuma robertmertensi* follows a distinct distribution pattern in terms of perch type (Table 2) and perch height compared to the two introduced geckos and *P. nigristriata* (Table 1). It has remarkably often been observed in disturbed lowland areas along with the two introduced species in four recent ecological assessments not taken into account in our results (S. Augros unpubl. data.). One hypothesis is that *P. robertmertensi* uses non-palm trees as a result of interspecific competition for palm trees and banana plants with the other native and introduced species. However, further studies are needed to understand the syntopic interactions between all five species from Mayotte in disturbed areas (see Augros et al. 2017).

In conclusion, our results suggest that microhabitat preferences play a significant role in the coexistence of *Phelsuma* species on Mayotte and, at least in the case of *P. dubia*, also on other islands of the Comoros Archipelago. Future studies on the introduced species in their native ranges might provide comparative data and hints on the degree of niche plasticity and the role of competition in microhabitat choice. Finally, we call for the application of specific field protocols in conservation management on Mayotte and also in the Comoros, at least for *P. dubia, P. robertmertensi*, and *P. pasteuri*. Our results suggest that elevated point surveys (Imlay et al. 2012) or one-hour stationary vantage point surveys using binoculars may be a necessary addition to walking transects to correctly reflect the distributions of the local *Phelsuma* species.

Acknowledgements

We thank Guillaume Decalf, DEAL Mayotte, for help with the management of the surveys and the obtaining of permits. We are also grateful for the critical comments of Katharina C. Wollenberg-Valero and Alexander Kupfer on an earlier version of this manuscript.

References

Augros, S., P.-Y. Fabulet & O. Hawlitschek (2017): First report of the co-existence of the three endemic *Phelsuma* species of Mayotte Island (Indian Ocean) in anthropogenic habitats. – Herpetological Bulletin, **140**: 20–22.

Berghof, H.-P. (2001): Neue Angaben zum Verbreitungsgebiet von *Phelsuma dubia* (Boettger, 1881) sowie einige Bemerkungen zu *Phelsuma hielscheri* Rösler, Obst and Seipp, 2001. – Herpetofauna, **23**: 11–18.

Brückmann, B. (2010): Ecological niche modelling of the genus *Phelsuma* with view on invasive species and climatic change. – Unpublished Masters Thesis, University of Munich, Faculty of Biology, Department II: Ecology, Munich, Germany, 158 pp.

Hawlitschek, O., B. Brückmann, J. Berger, K. Green & F. Glaw (2011): Integrating field surveys and remote sensing data to study distribution, habitat use and conservation status of the herpetofauna of the Comoro Islands. – Zookeys, **144**: 21–79.

Hawlitschek, O., B. Brückmann & F. Glaw (in press): Causal or spurious relationship? Climate and the distributions of *Phelsuma* geckos on Grand Comoro Island. – African Journal of Ecology, doi: 10.1111/aje.12380

Hawlitschek, O. & F. Glaw (2014): Determinant species of reptiles and amphibians for the delimitation of ZNIEFF zones in Mayotte. – Direction de l'Environnement de l'Aménagement et du Logement (DEAL), 48 pp.

Imlay, T., R. Dale, S. Buckland, C. Jones & N. Cole (2012): A novel approach to counting geckos : *Phelsuma* density in Mauritian forests. – Herpetological Review, **43**: 171–174.

Meirte, D. (1999): Reptiles et amphibiens. – pp. 114–135 in: Louette, M. (ed.): La faune terrestre de Mayotte. – Annales du Musée Royal d'Afrique Centrale, 284.

Nemenyi, P. (1963): Distribution-free Multiple Comparisons. – Ph.D. thesis, Princeton University, 254 pp.

Raxworthy, C., C. Ingram, N. Rabibisoa & R. Pearson (2007): Applications of ecological niche modeling for species delimitation: a review and empirical evaluation using Day Geckos (*Phelsuma*) from Madagascar. – Systematic Biology, **56**(6): 907–923.

Rocha, S., M. Vences, F. Glaw, D. Posada & D. J. Harris (2009): Multigene phylogeny of Malagasy day geckos of the genus *Phelsuma*. – Molecular Phylogenetics and Evolution, **43**: 685–692.

Wang-Claypool, C. Y., Scherz, M. D., L. Montfort & O. Hawlitschek (2016): Complementary herpetological surveys to complete the ZNIEFF database of Mayotte: results. – Direction de l'Environnement de l'Aménagement et du Logement (DEAL), 31 pp.