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

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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. nigrisriata, 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. nigrisriata, 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 Kruskal-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.
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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. pasteurii; PR: P. robertmertensi; PV: P. v. nigra. In brackets: given p-values without estimated perch heights data.

<table>
<thead>
<tr>
<th></th>
<th>PC</th>
<th>PD</th>
<th>PL</th>
<th>PN</th>
<th>PP</th>
<th>PR</th>
</tr>
</thead>
<tbody>
<tr>
<td>PD</td>
<td>P &lt; 0.001</td>
<td>(P &lt; 0.001)</td>
<td>–</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>PL</td>
<td>0.9230</td>
<td>P &lt; 0.001</td>
<td>(0.99912)</td>
<td>–</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>PN</td>
<td>0.9860</td>
<td>P &lt; 0.001</td>
<td>(0.99936)</td>
<td>0.9989</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>PP</td>
<td>P &lt; 0.05</td>
<td>0.4739</td>
<td>(0.95328)</td>
<td>P &lt; 0.05</td>
<td>(0.97786)</td>
<td>(0.62514)</td>
</tr>
<tr>
<td>PR</td>
<td>0.0589</td>
<td>P &lt; 0.05</td>
<td>(0.34261)</td>
<td>P &lt; 0.01</td>
<td>(0.06838)</td>
<td>(0.97305)</td>
</tr>
<tr>
<td>PV</td>
<td>0.4651</td>
<td>P &lt; 0.001</td>
<td>(0.46922)</td>
<td>0.9182</td>
<td>(0.11766)</td>
<td>(P &lt; 0.001)</td>
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(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. pasteurii, 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. pasteurii and P. nigristriata as well as between P. pasteurii 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. pasteurii 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 tendency shows in P. robertmertensi and possibly P. pasteurii. 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. pasteurii 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. pasteurii, 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. pasteurii; 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.
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. nigristrata (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.

References

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 Comoros Islands. – Zookeys, 144: 21–79.


