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La Réunion and Mayotte cockroaches: impact of altitude and human activity

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Abstract

Competitive displacement is the outcome of interspecific competition between invading and native species. Alien insect species invade not only cultivated areas but also natural habitats. We prospected the cockroach fauna on two oceanic islands (Mayotte and La Réunion) to investigate the impact of altitude and anthropic disturbance on the distribution of these species. Most invading cockroach species seem to benefit from cultivation of land whereas endemic species occupy more specific and reduced habitats that are threatened by human impact. **To cite this article:** *S. Boyer, C. Rivault, C. R. Biologies 326 (2003).*

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Résumé

Les blattes de La Réunion et Mayotte : impact de l'altitude et de l'anthropisation. Les compétitions interspécifiques entre espèces envahissantes et espèces locales peuvent modifier leurs distributions. Les espèces introduites n'envahissent pas seulement les milieux cultivés, mais les habitats naturels. Nous avons étudié les blattes sur deux îles océaniques (Mayotte et La Réunion) pour estimer l'influence de l'altitude et de l'anthropisation sur la répartition de ces espèces. La plupart des espèces envahissantes semblent profiter des zones de culture alors que les espèces endémiques occupent des habitats plus spécifiques et de taille plus réduite, habitats qui sont menacés par les activités anthropiques. **Pour citer cet article :** *S. Boyer, C. Rivault, C. R. Biologies 326 (2003).*

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Keywords: cockroaches; human disturbance; La Réunion; Mayotte; invading species

Mots-clés : blattes ; perturbation humaine ; La Réunion ; Mayotte ; espèces invasives

1. Introduction

Both intentionally and unintentionally introduced species have invaded virtually all habitats from the sea level to the summits of the highest mountains and some of them have become pests and threaten native

species [1]. Competitive displacement is the outcome of interspecific competition between invading and native species. The major factors causing decline of native insect faunas are the impact of invasive alien organisms and the alteration of habitats and communities resulting from the impact of human use [2,3]. Alien species invade not only cultivated areas but also all suitable natural habitats to which they can disperse. Many of their effects and impacts may

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go unrecognized in natural areas and unmonitored habitats if not specifically sought. It may not be until an alien is well entrenched that attempts are made to deduce in hindsight what major factors were involved in the decline or disappearance of native species. Conservation biology focuses on islands because their fauna appear to be more sensitive to environmental changes and more prone to extinction than continental faunas [4,5].

Lack of taxonomic and ecological information concerning insects is important in tropical islands. The sub-order Blattaria (Insecta: Dictyoptera) is very poorly known, especially from the biodiversity and conservation points of view. We studied cockroaches because this group includes extreme examples, from world-wide to endemic or locally distributed species. Although lists of cockroach species have been established for many parts of the world, very few studies concern cockroaches in their natural environment and very little is known about their habitats.

We prospected two oceanic islands, Mayotte and La Réunion (DOM-TOM, France). They have never been attached to a continent, but were formed by submarine volcanoes. Emergence of La Réunion started 3 million years BP and that of Mayotte, 8 million years BP. Mayotte, in the Indian ocean, is one of the Comoro islands at the northern end of the Mozambican pass. It is part of a chain of sub-marine volcanoes several hundred kilometers long. La Réunion is part of the Mascarene archipelago. Respectively 300 km east and 700 km west of Madagascar, Mayotte and La Réunion are geographically very different. Mayotte, formed by two main islands: Petite Terre and Grande Terre, measures 374 km² and culminates at 600 m asl. La Réunion is larger (2512 km²) and is characterized by a more rugged surface, and culminates at 3096 m asl. The climate of these two islands is tropical, with one hot wet season from November to April (average temperature 28 °C) and one dry, cooler season from May to October (24 °C). Microclimates on these islands vary along an east-west axis and with altitude. These climatic variations are particularly important on La Réunion where a temperate zone can be found in altitude. Because of the volcanic origin of these islands, the animal and plant species present there have either immigrated or been introduced through maritime exchanges. The original vegetation has been modified by human activity on Mayotte, although a

relatively large forest cover remains on Grande Terre [6]. La Réunion still possesses a large old forest cover, protected by the higher altitude rugged surfaces, but the general plant profile is greatly marked by anthropic disturbance at low and medium altitudes.

The aim of this project was to determine the biological and ecological traits of invading cockroach species and to evaluate the consequences of their presence on the distribution and maintenance of local native species. First, we identified the cockroach species present on these two islands and mapped their distributions. Then we investigated environmental factors that could influence their distribution. The impacts of altitude and human activity were particularly emphasized.

2. Material and methods

Cockroaches are generally found in the leaf litter on the ground. 1 m² surface units were sampled by removing and examining the litter and scratching the ground. Ten surface units were used to estimate the population on one site. For each surface unit, the numbers of each species were recorded. This method allows rapid evaluation without damage and characterization of the specific richness of each site. Samples were taken for identification by L. Roth. 112 sites were prospected on Mayotte and 61 on La Réunion.

Human activity has established a mosaic of different types of environment. The different environments on these islands were divided into five types:

- (1) Natural and replanted forests (*Eucalyptus*, *Crypomeria*, *Terminalia*...).
- (2) Degraded forests, marked by human activities, with herbaceous and shrub zones that can be used as pasture.
- (3) Cultivated lands. On Mayotte, cultivated fields are small and close to natural or degraded forests. The main plants cultivated are manioc and banana and they are often intermingled. On La Réunion, the main crop, sugar-cane, is a monoculture on an industrial scale and fields cover large surfaces.
- (4) Very degraded dead trees with loose zones under the bark. Their fauna was sampled after disbark-

Table 1

List of species found on Mayotte and on La Réunion (2001). Comparison with previous records (Bruijning 1945 and Chopard 1957)

	Mayotte			La Réunion		
	1945	2001	<i>N</i>	1957	2001	<i>N</i>
<i>Balta contigua</i> (Walker)				X		
<i>Balta longicercata</i> (Bolivar)		X	12		X	19
<i>Blattella biligata</i> (Walker)		X	1		X	19
<i>Blattella germanica</i>		X			X	
<i>Blattella lituricollis</i> (Walker)		X	26		X	12
<i>Brachynauphoeta mayottensis</i> (Bruijning)*	X					
<i>Chorisoblatta chopardi</i> Princis*				X	X	1
<i>Chorisoblatta denticulara</i> (Roth)*		X	5			
<i>Euthyrrhapha pacifica</i> (Coquerel)				X		
<i>Leucophaea maderae</i> (Fabricius)				X		
<i>Loboptera dimidiatipes</i> (Bolivar)		X	54		X	18
<i>Margattea nimbata nimbata</i> (Selford)					X	14
<i>Mayottella dimorpha</i> (Roth)*		X	6			
<i>Neostylopyga rhombifolia</i> (Stoll)				X	X	4
<i>Pariplaneta americana</i> (Linné)		X		X	X	
<i>Periplaneta brunnea</i> (Linné)				X		
<i>Pycnoscelus</i> sp.		X	19	X	X	11
<i>Scalida latiusvittata</i> (Brunner)					X	10
<i>Symploce pallens</i> (Stephens)		X	1		X	1
<i>Temnopteryx abbreviata</i> (Saussure)*				X		
<i>Ylangella truncata</i> (Roth)*		X	8			

* Species is probably endemic; *N* = number of sites where each species was found, 112 sites were prospected on Mayotte and 61 on La Réunion.

ing. This closed habitat was investigated only on Mayotte.

- (5) Water edges, near ponds or rivers. This type of habitat was prospected only on La Réunion.

3. Results

3.1. Species present

Blattella germanica was observed only inside buildings and *Periplaneta americana* was peri-domestic. As these two species were never found outside built-up areas, they have not been included in the following analyses.

Of the ten cockroach species found on La Réunion and the nine on Mayotte, six were recorded on both islands (Table 1). Three of the species collected on Mayotte had never been identified (*Mayottella dimorpha* Roth, *Ylangella truncata* Roth and *Chorisoblatta denticulara* Roth and have now been described. These new species could be endemic on Mayotte. However, we did not find *Brachynauphoeta*

mayottensis, described by Bruijning in 1945 [7] as endemic on Mayotte. Chopard in 1957 [8] gave a list of nine species, including two endemic species, from La Réunion (Table 1). We added eight species to this list. We found one of the endemic species (*Chorisoblatta chopardi*), but not the other (*Temnopteryx abbreviata*) described without any precise localization. Four of the other species in Chopard's list were not found. Chopard's list included *Pycnoscelus surinamensis*. We collected two morphologically different types of females, one resembled *Pycnoscelus surinamensis* (parthenogenetic form) and the other could be *Pycnoscelus indicus* (sexual form). However, as no males were captured, precise identification was impossible. Therefore these species are referred to as *Pycnoscelus* sp. hereafter.

3.2. Effect of altitude

The number of species per site declined significantly when altitude increased on La Réunion (KW, $p = 0.0391$, $df = 2$) and on Mayotte (KW, $p = 0.0167$, $df = 2$). Altitude appeared to be a factor limit-

ing the presence of cockroaches. Temperature declines rapidly when altitude increases. On La Réunion temperature varies on average 0.7 °C every 100 m. Cockroaches can be found above 250 m, but usually one species was observed on a given site, whereas 2.6 species per site were recorded on average between 0 and 100 m (Fig. 1). The distribution in relation to

altitude varies with species. Some species, like *Pycnoscelus* sp., *Neostylopyga rhombifolia* and *Symploce pallens* were never found above 50 m, whereas *Loboptera dimidiatipes* and *Balta longicercata* can be found up to 900 m asl on La Réunion. On the other hand, *Chorisoblatta chopardi* was only found between 1300 and 1500 m asl (Fig. 2).

3.3. Level of environmental disturbance

Cultivated lands were significantly richer in cockroach numbers and species than degraded forests, and very few cockroaches were found in natural forests (Fig. 3), on Mayotte (KW, $p < 0.0001$, $df = 2$) and on La Réunion (KW, $p < 0.0001$, $df = 2$). Level of the impact of human activity on different environments and species abundance are related. The greater the influence of human activity on the environment, the higher the number of cockroach species present. Number of species did not vary significantly between

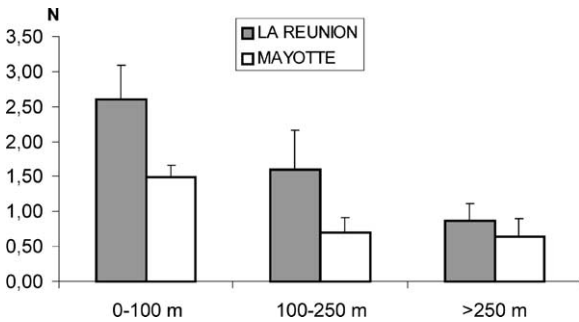


Fig. 1. Effect of altitude. Number (N, mean + s.e.) of species per site in relation to altitude, on Mayotte and La Réunion.

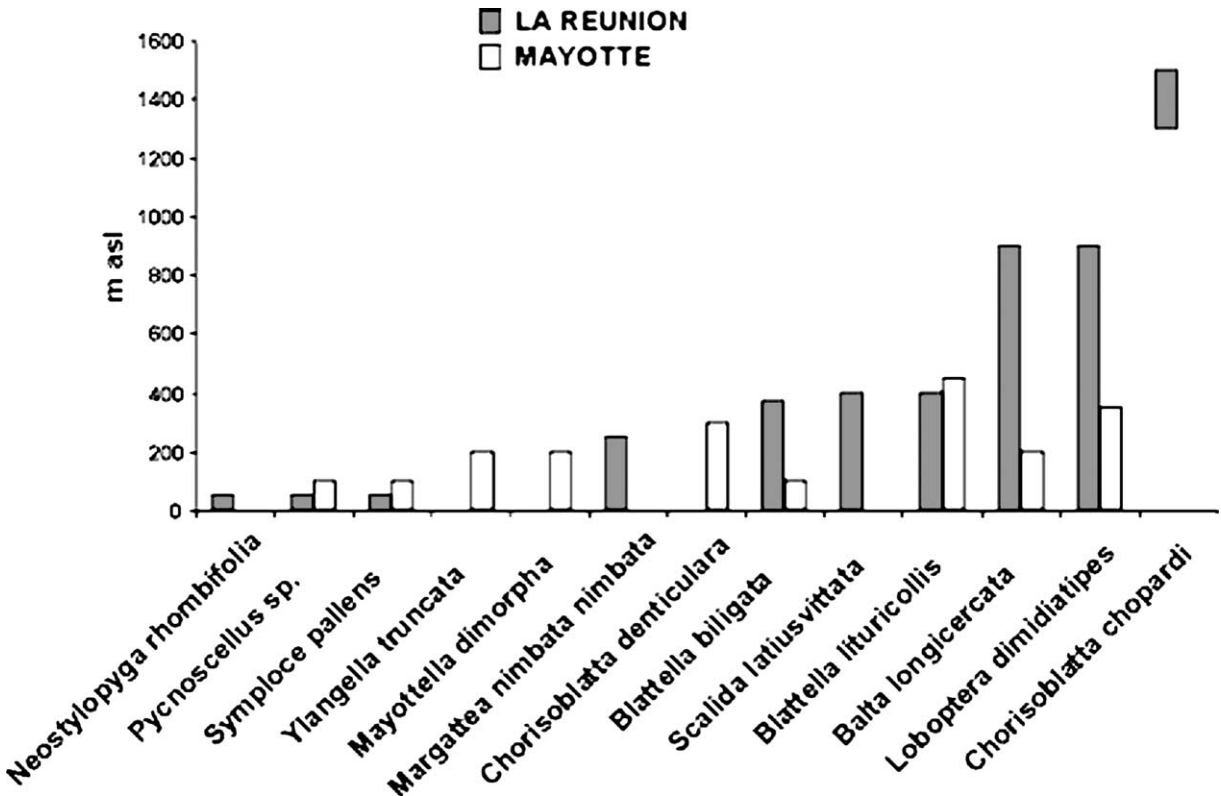


Fig. 2. Distribution of each species in relation to altitude.

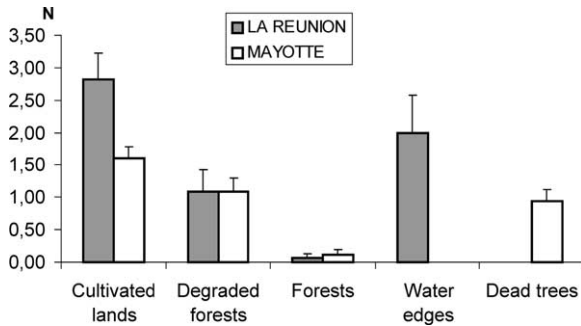


Fig. 3. Distribution of species in relation to type of environment. Legend: N: average number of species per site.

water edges and cultivated lands (MW, $p = 0.72$) (Fig. 2). However, species variety was greater in water edges than in forests (MW, $p = 0.0003$). Cultivated lands and water edges appear to favour establishment of several cockroach species. Cultivated lands on La Réunion allow a greater number of species to occupy the same site (MW, $p = 0.036$). Average number of cockroach species per site in cultivated areas was 2.8 on La Réunion but only 1.6 on Mayotte (MW, $p = 0.036$).

Most of the species recorded were present on cultivated sites (Table 2). Four species were never observed on cultivated lands. *Chorisoblatta chopardi* is strictly a forest species. It was found only in the high altitude moist Bébour forest on La Réunion, in holes in tree trunks and stumps. *Ylangella truncata* lives in large dead decaying trees on Mayotte. Although dead trees are more frequent in degraded forest zones,

this species seems also to be a forest species. *Symploce pallens* and *Neostylopyga* were found in degraded forest zones and near habitations. They also use decaying dead wood as shelters. The two other endemic species recorded on Mayotte (*Mayottella dimorpha* and *Chorisoblatta denticulara*) were found exclusively on cultivated sites, but on a very restricted number of sites (respectively 5% and 4%, $N = 112$). *Loboptera dimidiatipes* probably had the largest distribution. On Mayotte, it was found on cultivated land and in degraded forests (on 48% of the 112 sites). On La Réunion, it was found on cultivated land (on 28% of the 61 sites). *Balta longicercata* and *Blattella lituricollis* were found on cultivated land and on water edges on La Réunion, on cultivated land and in degraded forest on Mayotte. However, they were less frequent than *Loboptera dimidiatipes*. *Balta longicercata* was recorded on 11% of the Mayotte sites and on 31% of the La Réunion sites and *Blattella lituricollis* on 23% of the sites Mayotte and on 20% of the La Réunion sites. *Blattella biligata* was widely distributed on La Réunion, particularly on cultivated land where it was found on 53% of the sites. It was found only once on Mayotte, on a cultivated site. *Margathea nimbata* and *Scalida latiusvittata* were found on cultivated land and on water edges on La Réunion. *Pycnoscelus* sp. was found on cultivated land, in degraded forests, in dead trees and on areas near water. This species appears to be able to use a large variety of environments, as long as it can find loose substrate to burrow into.

Table 2

Distribution of species in relation to different types of environment, in numbers of sites where each species was recorded

	Mayotte				La Réunion			
	Cultivated lands	Degraded forests	Forests	Dead trees	Cultivated lands	Degraded forests	Forests	Water edges
<i>Balta longicercata</i>	10	2	0	0	18	0	0	1
<i>Blattella biligata</i>	1	0	0	0	17	2	0	0
<i>Blattella lituricollis</i>	20	6	0	0	11	0	0	1
<i>Loboptera dimidiatipes</i>	39	13	2	0	18	0	0	0
<i>Pycnoscelus</i> sp.	7	3	0	9	6	4	0	1
<i>Symploce pallens</i>	0	1	0	0	0	1	0	0
<i>Chorisoblatta denticulara</i> *	5	0	0	0				
<i>Mayottella dimorpha</i> *	6	0	0	0				
<i>Ylangella truncata</i> *	0	0	0	8				
<i>Chorisoblatta chopardi</i> *					0	0	1	0
<i>Margathea nimbata nimbata</i>					12	1	0	1
<i>Neostylopyga rhombifolia</i>					0	4	0	0
<i>Scalida latiusvittata</i>					8	0	0	2
Total number of sites	54	23	17	18	32	11	15	3

* Species is probably endemic.

4. Discussion

4.1. Effects of altitude and level of human impact

Altitude and temperature variations are related. Altitude influences cockroach distribution. Although some species, like *Loboptera dimidiatipes* and *Balta longicercata*, can be found at high altitudes, the general tendency of cockroach species is to remain near sea level, where the temperature is higher. Cultivated land constitutes a favourable environment where important populations of cockroaches can be found. The soil of cultivated areas has been ploughed and is loose enough for cockroaches to shelter in it. Another important aspect of this environment is the presence of abundant leaf litter offering shelter and food. Finally, these zones, particularly sugar-cane fields on La Réunion, are irrigated. Crops can also retain rain water with their leaves. The industrialisation of crops, particularly sugar-cane, on La Réunion appears to contribute to the presence of large cockroach populations. Altitude and cultivation are two factors which explain the distribution of cockroaches. Thus *Loboptera dimidiatipes* and *Balta longicercata* are found above 900 m asl due to the extension of cultivated land on La Réunion. On Mayotte, they were not present above 250 m asl because higher lands are rarely cultivated.

4.2. Endemic species

On La Réunion, *Chorisoblatta chopardi* did not appear to interfere with the other species as it occupies a very special habitat in the high altitude Bébou forest. The other species are simply not present in this habitat. The distribution of this species appears to have diminished since 1957 as it was then identified in the Bélouve forest, but we were unable to find it there again. Although nowadays the Bébou forest is protected by its status as a biological reserve, from all human disturbance, this habitat remains threatened by the invasion of plant pests like the giant bramble creeper (*Rubus alceaefolius*) [9]. The survival of *Chorisoblatta chopardi* is related to the protection of Bébou forest. Like other threatened and locally distributed insects, it is characterized by extreme ecological specialization.

On Mayotte, the three new species collected (*Mayottella dimorpha* Roth, *Ylangella truncata* Roth and *Chorisoblatta denticulara* Roth) could be endemic. *Mayottella dimorpha* and *Chorisoblatta denticulara* were found only on cultivated sites. They could come into competition with the other species present on cultivated sites. They were found only on few sites in the north-eastern part of Grande Terre and on Petite Terre, compared to *Loboptera dimidiatipes*, *Blattella lituricollis* and *Balta longicercata* that were distributed all over Mayotte. Crops on Mayotte are traditionally cultivated without pesticide use. Use of pesticides, if it develops, could present a threat for these species only found on cultivated land, their original habitat will probably remain unknown. *Ylangella truncata* occupies a special ecological niche: decaying trees form a limited closed microhabitat with few exchanges with outside. This species is not specific to a particular tree species, but to the level of decay of a large fallen tree trunk. Human activity is currently limited by law in the forests on Mayotte as deforestation contributes to erosion that could endanger the lagoon [6]. Deforestation would, at first, provide an important increase in potential habitats for *Ylangella truncata* and thereby a population increase. However, later this would lead to the destruction of its habitat and disappearance of the species. If the forest cover becomes too restricted, the number of available dead trees could drop below the level necessary for this species' survival.

4.3. Introduced species

Introduced species can be found in the wild, at least occasionally [10]. *Loboptera dimidiatipes*, *Blattella lituricollis* and *Balta longicercata* are widely distributed and well established on La Réunion and Mayotte. They are more frequent than the endemic species that use the same habitats. They appear to have succeeded colonisation and establishment, as their populations are self-sustaining. Although adult *Loboptera dimidiatipes* are apterous, this species has dispersed over Mayotte and La Réunion. Although *Blattella lituricollis* and *Balta longicercata* adults are winged and therefore present excellent adaptations for dispersal, they appear to be less frequent than *Loboptera dimidiatipes*, particularly on Mayotte. *Blattella bilingata* is very frequent on La Réunion but was found

only once on Mayotte, where it could be in the process of becoming established. As *Symploce pallens* was found only once on both islands, the species could also be in the process of becoming established. *Pycnoscelus* sp., considered to be an invading species [11], can be found on a great variety of sites, as long as the substrate is loose enough to burrow into. However, its population densities were generally low. Its density was higher in dead trees than in the other types of environment. It can be found in the same dead tree as *Ylangella truncata*, but the two species do not appear to mix. This microclimate formed by the tree trunk that provides a loose substrate also enables it to survive at higher altitudes. Species found on both islands (*Loboptera dimidiatipes*, *Blattella lituricollis*, *Balta longicercata* and *Blattella biligata Pycnoscelus* sp.) were found in different microhabitats indicating that they probably have less restricted ecological requirements than native species. These species are widely distributed over the Pacific and Indian Ocean islands [12–15]. Species with naturally small population sizes are more vulnerable to habitat modification simply because loss of even a small amount of habitat for a geographically restricted species could reduce numbers below sustainable levels [16].

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