Annales de la Société entomologique de France (N.S.): International Journal of Entomology
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tase20

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Alex Franc [a] & Jean-François Duranton [a]
[a] CIRAD, UPR Acridologie , Montpellier , F-34398 , France
Published online: 31 May 2013.

To cite this article: Alex Franc & Jean-Franois Duranton (2012) Red locust Nomadacris septemfasciata (Serville) upsurges in northern Madagascar between 1998 and 2004, Annales de la Société entomologique de France (N.S.): International Journal of Entomology, 48:1-2, 97-105, DOI: 10.1080/00379271.2012.10697756

To link to this article: http://dx.doi.org/10.1080/00379271.2012.10697756

Red locust *Nomadacris septemfasciata* (Serville) upsurges in northern Madagascar between 1998 and 2004

Alex Franc & Jean-François Duranton
CIRAD, UPR Acridologie, Montpellier, F-34398 France

Abstract. The Red locust (*Nomadacris septemfasciata* Serville) is commonly found in southern Africa and the Indian Ocean islands. In Madagascar until 1998, only infested crop fields were controlled. However, since 1998 the Red locust has caused considerable crop damage in northern Madagascar, where gregarious individuals were identified for the first time in Madagascar in 2002. In this study, an accurate history of the outbreaks which occurred between 1998 and 2004 is drawn up on the basis of field surveys and anecdotal data. A total area of more than 60,000 ha was infested between 2001 and 2003, at the peak of the outbreak. With these results, we can make out a first biogeographical synthesis for this locust.

Résumé. Pullulations et invasion du criquet nomade *Nomadacris septemfasciata* (Serville) au nord de Madagascar de 1998 à 2004. Le Criquet nomade *Nomadacris septemfasciata* (Serville 1838) est distribué en Afrique australe et dans les Iles de l'Océan Indien. A Madagascar depuis 1998, seules les cultures attaquées étaient protégées. Cependant depuis 1998, le Criquet nomade a causé de sévères dégâts aux cultures dans le nord de l'île, où des individus grégaires ont été décrit pour la première fois à Madagascar en 2002. Dans cette étude, les pullulations entre 1998 et 2004 sont précisément décrites grâce à des prospections et des enquêtes de terrain. Au total, plus de 60 000 ha ont été infestés entre 2001 et 2003 à l'acmé de l'invasion. Ces résultats permettent de dresser une première biogéographie pour ce ravageur majeur.

Keywords: Crop damage, Outbreak area, Biogeographical unit.

The Red locust *Nomadacris septemfasciata* (Audinet-Serville 1838) is common and distributed throughout Africa and the islands of the Indian Ocean, It is known to have initiated widespread locust plagues from a few, relatively small, floodplain areas on the African continent (Bahana & Byaruhanga 1999). These outbreaks are controlled by an old and efficient international organisation, using a wide range of pesticides (Price *et al.* 1999). Also widely distributed over the western half Madagascar, the Red locust has, until recently, rarely formed swarms there and was so far considered as a localised crop pest.

In Madagascar, this locust was first studied during surveys carried out by Zolotarevsky (1929) and then by Frappa (1935; 1936) during investigations on the Malagasy migratory locust, *Locusta migratoria capito* (Saussure, 1884), which is of greater economic importance and therefore considered as a national pest. Most observations on the Red locust have consequently been focused on south-western Madagascar, which corresponds to the Migratory locust outbreak area.

Studies on the Red locust conducted by Frappa (1935; 1936), Têtefort & Wintrebert (1963; 1967), Randrianasolo (1978), Franc *et al.* (2005) and Lecoq *et al.* (2006) have revealed that it has broad bio-ecological requirements in southern Madagascar. It is an univoltine semi-arboreal polyphagous species. The breeding and hopper development takes place during the rainy season, in summer (December–March). Adults remain immature in diapause throughout the dry season and until the first rains, when they mature, mate and lay eggs (Franc & Luong-Skovmand 2009). To start gregarizing, this locust requires high densities (threshold varying from 5,000 to 10,000 adults/ha depending on the habitat); both swarms and solitary individuals can migrate over long distances (Franc *et al.* 2005).

During the Malagasy migratory locust plague in 1997–2000, when major locust control operations were undertaken throughout the Island (Duranton 2001), many small Red locust swarms also developed and were subsequently sprayed (Lecoq 2001). The number of Red locust infested areas increased between 1998 and 2003, especially in the North. Crop damage and upsurge reports continued to

E-mail: alex2021@laposte.net, alex2021@laposte.net, alex2021@laposte.net, alex2021@laposte.net, jfduranton2010@orange.fr
Accepté le 23 février 2012

increase despite chemical control operations carried out by the National Locust Centre (Centre National Antiacridien - CNA). Ground control operations against hopper infestations were conducted during the wet season in the Sofia basin (north-western Madagascar) to protect crops and also to avoid spread out of swarms into the two nearby, important rice-growing areas of the Marovoay Basin and Lake Alaotra (Franc *et al.* 2004).

Observations made on gregarious Red locusts in both southern and northern parts of the Island in 2002 (Franc *et al.* 2007) have shown that there were no well-delimited outbreak areas in Madagascar, which, as per Uvarov's definition (1977), contribute to produce Red locust outbreaks. Moreover, no archives or published observations on Red locust outbreak dynamics exist for Madagascar. Consequently, a study on the bio-ecology of *N.*

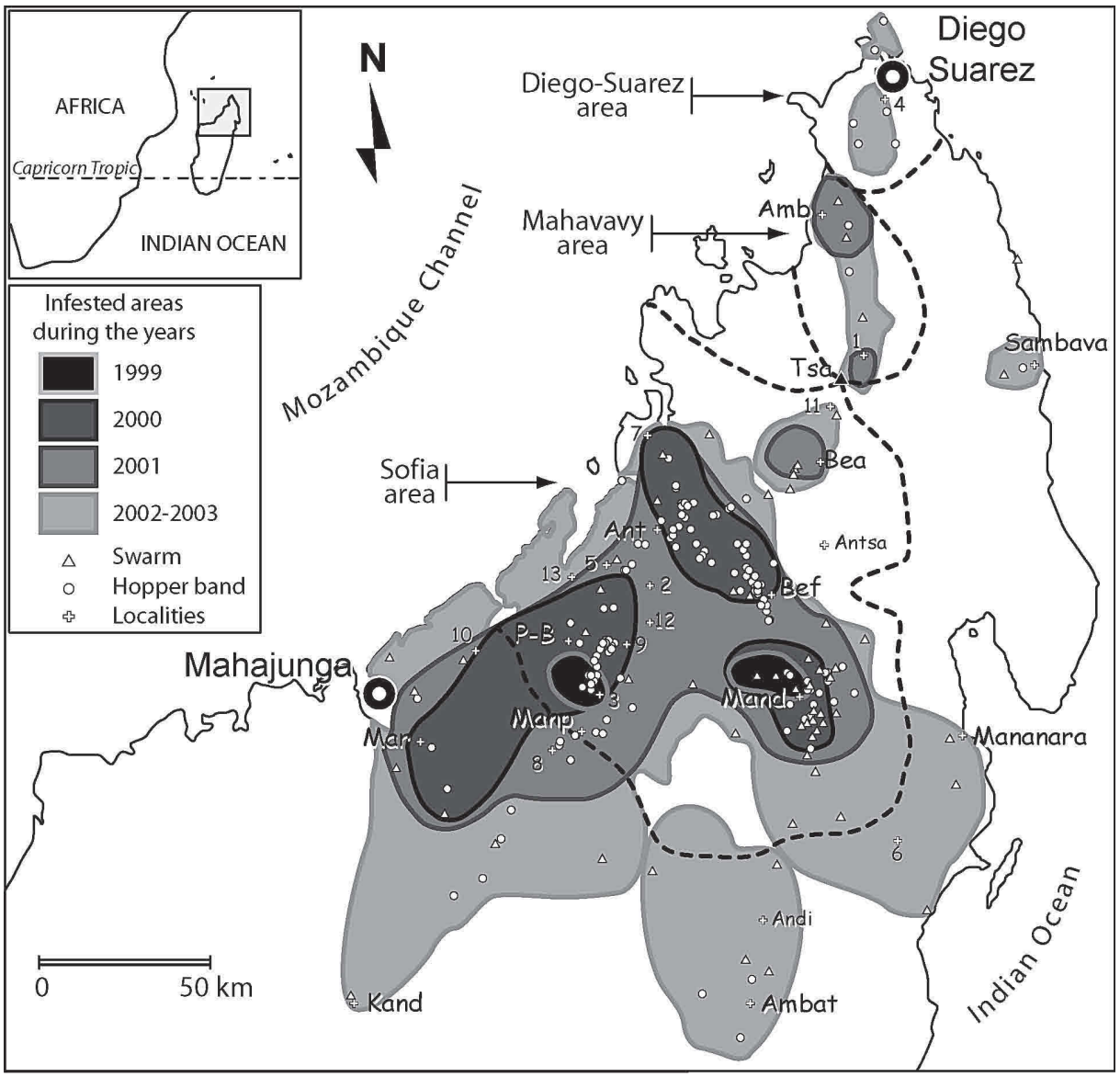

Figure 1
Extension of the Red locust (*Nomadacris septemfasciata* Serv.) outbreaks within the three geographical subunits from 1998 to 2004. From north to south, the Diego-Suarez region (Amber cape peninsula, Amber mountain slopes), Mahavavy river basin, Sofia catchment. Amb: Ambilobe, Bea: Bealanana, Ant, Antsohihy, Antsa: Antsakabary, Bef: Befandriana Nord, Mand: Mandritsara, P-B: Port-Bergé, Manp: Manpikony, Mar: Marovoay, Andi: Andilamena, Ambat: Ambatondrazaka, Kand: Kandreho, Tsa: Tsaratanana mountain (2876 m). 1: Ambilobekely, 2: Ambodimanary, 3: Andranomeva, 4: Anivorano, 5: Anjiamangirina, 6: Antenina, 7: Befotaka, 8: Bekoratsaka, 9: Leanja, 10: Mahajamba, 11: Mangindrano, 12: Maroala, 13: Marovatolena.

septemfasciata was initiated in 2001 to investigate the problem and recommend more effective crop protection measures (Franc 2007). A first approach in understanding this new phenomenon was to review the locust events, which occurred in northern Madagascar between 1998 and 2004.

Methods

There are no archives available on the Red locust in northern Madagascar. Crop protection services and farmers' organizations recorded the first dense populations in 1998. The data collected and used here cover the 1998–2004 period and come from three different sources: field records, surveys of rural inhabitants, and national agriculture services reports.

Field records

Surveys were carried out in all Red locust affected areas in northern Madagascar, i.e. Diégo-Suarez area, Mahavavy River basin and Sofia catchment basin (Figure 1) during six missions undertaken from June 2001 to early 2004. This involved personal visits to reported locust outbreak sites in order to observe and describe the locust populations present (size, density, phase and stage). Most of 50 stations were prospected according to survey itineraries in various parts of the North of Madagascar where occurs Red locust signalisations. On each station a standard fiche (Duranton *et al.* 2009). was completed and samples of Red locust were collected. The adult density was evaluated on 10 transects of 100 m long and nymph density on 50 places of 1 m².

Rural population surveys

A system was set up to interview rural inhabitants of Sofia catchment (Leblanc 2003) to determine the outbreak history and the importance of damage from 1998 to 2004. Most of 50 fiches chrono- and geo- referenced were completed in the Sofia catchment with indications on the environment, the damage on crop, the seasonal activity and the annual abundance of Red locust.

National services reports

Two main information sources were used: 1) records from the crop protection services in Mahajunga, Antsohihy (120 records) and Ambatondrazaka; 2) records of the NGO *Entretien et le Renouveau de la Terre* (FERT): 410 farmer records focused on Sofia catchment during the 1999/2000 season. Each record is chrono- and geo- referenced and inform on the presence of numerous populations of Red locust, (nymph or adults).

Results

Chronology of the gregarisation of Red locusts in Sofia catchment basin

Only anecdotal information is available to understand the origin of the outbreak: at the market in Mandritsara (east of Sofia catchment), women selling *N. septemfasciata* adult locusts for human consumption claimed that since 1998 they had noted high densities of locusts during the dry seasons in the highland wind-sheltered valleys. It seems that population densities have increased slowly between 1998 end 2000 in Mandritsara and Port-Berge areas (see Figure 1). At that time all the locust control efforts were focused on the Migratory locust on the south and the western slopes of the Island. This can explain why such density increase did go unnoticed. Andrianasolo (2000) is the first acridologist to report this situation in a FAO report.

2000/2001 – *Transiens* hopper populations

During the 2000/2001 rainy season, the humid lowland valleys in the rift valley extending from Manpikony to Antsohihy were settled by high densities of mature adults (more than 10,000 adults/ha) as of November, which massively oviposited in December. The hoppers then hatched and developed in these hot and humid areas and along marshes. In higher areas (northern Befandriana, Mandritsara, Antsakabary), hopper development was slightly delayed (hatching as of January and slower development) but progressed under suitable conditions, since hopper bands were reported.

After completion of hopper development, adults whose cuticle had hardened flew away from crop areas and lowlands in April and May. They then moved into the highland valleys on foothills along the eastern edge of Sofia catchment (Mandritsara area). Red locusts were able to find suitable conditions to multiply and thus increase their population numbers most probably over several successive years until they reached the critical density threshold (phase transformation threshold of 7500 ± 1500 adults of Red locust, according to the phyto-biomass) , resulting in flights of loose and dense swarms as of 2001.

2001 – Grouped gregarious populations

Groups of adults were observed in dry medium-elevation valleys in the Mandritsara region at the onset of the dry season (June 2001). This dry season grouping phenomenon was new and unexpected. Rather than inducing dispersal, these dry season habitats promoted grouping or at least enabled populations that formed groups at diapause onset to maintain their coherence. The total area infested by diapausing adults was estimated at more than 5,000 ha in June 2001 in the Mandritsara region. In this region, populations survived the 2001 dry season in dry laterally-oriented valleys sheltered from the wind. Adults grouped in the central valleys in November after the first rain. They roosted in

the trees (density of more than 25,000 adults/ha) or in the high grasses on alluvial plains (density of 1,000 adults/ha). Gregarious flight behaviour was noted, which maintained the cohesion of grouped populations. The populations did not decline during the dry season as compared to the densities noted in June. Damage to banana, mango, raffia, sugarcane, cassava and high wild grasses was noted.

Early 2002 – Hopper bands in breeding habitats and E-W movement pattern

A survey carried out in the Antsohihy-Manpikony rift valley highlighted the diversity of cleared and mixed habitats. No Red locusts were observed in November 2001 when the environment was still dry. During the 2001–2002 rainy season, hopper patches were reported throughout Sofia catchment, from Mandritsara to Antsohihy. Unfortunately, no field surveys were possible because of socio-political events.

Late 2002 – Colonization by egg-laying swarms/ swarms disperse away from the Sofia area

In November 2002, a renewal of activity was again noted in Mandritsara region following the first heavy rain, with adults grouping in forsted valleys. The first rains at the onset of the season had a direct impact on the behaviour of sexually maturing female locusts (Franc & Luong-Skovmand 2009). For the first time, mature yellow adults were captured within swarms. Loose and dense swarms covering an area of around 10,000 ha were controlled (mortality higher than 95%) by aerial spraying in the vicinity of Mandritsara, but some sites were quickly reinfested. Despite these treatments, dense and loose swarms seeking for suitable areas to lay eggs were seen in November and December 2002. Morphometric measurements (E/F and F/C ratios) show clearly the gregariousness of these Red locust populations (Franc *et al.*, 2005 ; Duranton *et al.* 2009). These dense *transiens* and gregarious adult populations also dispersed beyond Sofia catchment: 1) south-western valleys (Mahajamba and Marovoay basin) toward Mahajunga: three swarms of more than 3 km long were reported in Mahajamba valley in late November. The most southern swarm was reported at Kandreho in December, which is likely the southern boundary of the gregarious Red locust distribution range. 2) Lake Alaotra: Andilamena region north of the lake was also infested by dense swarms from the Sofia catchment highland valleys. 3) East coast around Mananara: gregarious adult populations moved from Mandritsara to the east coast at the end of the previous dry season.

2002/2003 rainy season - Hopper bands in western breeding areas observed right to the Ocean

In the western valleys in Sofia catchment, rainfed crops and fallows were gradually colonized in late November and early December 2002. Habitats burnt at this time were initially infested by gravid females. The first hoppers were noted in January. From January to March 2003, many hopper bands of hundreds of metres long were observed in the western rift valley. This included, from north to south: Befotaka, Antsohihy area, Anjiamangirina region, the rift valley between Ambodimanary and Maroala, Leanja depression, Andranomeva and Bekoratsaka (see Fig. 1). Red locust hopper bands were also noted east of Antsohihy, in cleared parts of deciduous dry forest. Groups of hoppers (instars L4 to L6) marched in bands of several hundreds of metres wide, at densities of 300–500 hoppers/m^2 at the front of the band. In contrast to previous years, the coastal plains below the Bongolava and Manasamody mountains (Marovatolena, Mahajamba) were also colonized.

There was considerable crop damage, with entire crops sometimes destroyed, including maize, sugarcane, banana, rainfed rice and cassava (less commonly). Fruit trees were also damaged when crops were insufficient. Only irrigated rice crops were not attacked. East of Sofia catchment, the excessive rainfall recorded in January 2003 (500 mm at Mandritsara) has likely regulated embryonic populations due to high humidity levels in lowland areas (asphyxic conditions). The narrow alluvial plains, which are generally colonized by hoppers, were flooded for 2 weeks and no hoppers were observed in February 2003. However, slash-and-burn fields in mountainous areas east and south to Mandritsara were especially affected by hoppers. In some villages east of the Mandritsara sill (Antenina region), 100% of the slash-and-burn rice crops were destroyed.

Finally, apart from the flooded areas, the entire Sofia catchment was colonized by *transiens* and gregarious Red locust hoppers from January to March 2003 (for color description of *transiens* and gregarious hopper, see Lecoq *et al., 2011)*. This was the peak of the locust outbreak, during which hoppers had infested a 50,000 ha area.

Onset of the 2003 dry season – Redistribution of adults

Late April 2003, hopper development came to an end in Port Bergé and Antsohihy regions – adult densities ranged from a few hundreds to several

thousands locusts per hectare. With the progressive drying-out of the environment, dispersal of adults was maximal, so there were no locusts left in these western habitats by June.

2003/2004 rainy season – The situation calms

In October 2003, a helicopter managed to treat loose and dense swarms at Mandritsara covering 8,000 ha over a 20-day period. The targets were small and dispersed. Only two swarms were subsequently reported in December 2003 north of Andilamena (Lake Alaotra), outside of Sofia catchment, while no egg-laying swarms were seen in this catchment. However, hopper groups were reported:

- Cleared parts of deciduous dry forest east of Antsohihy were colonized by young hoppers grouped in patches that were responsible for damaging maize crops.

- Antsohihy rift valley at Port Bergé where a single hopper band and some hopper patches were reported.

- Inland (northern Befandriana and Mandritsara), young hoppers sometimes formed high density groups covering small areas under *Sorghum* sp. and *Zea mais* L. plants. The greenish yellow colouring with black markings resembled *transiens* types (Lecoq *et al., 2011)*.

- Hoppers were reported in southern Mandritsara (slash-and-burn of the highland rainy forest). This area had not been surveyed, nor had it been controlled by air in October 2003.

Finally, during the 2003-2004 rainy season, hopper bands were quite limited. Less than 1,000 ha have been treated. This phenomenon could be explained by the series of heavy rains that fell during the egg-laying month. Small residual groups of *transiens* populations were observed beyond Sofia catchment. The crop protection service has treated 900 ha in Mahajamba valley and 210 ha north of Lake Alaotra.

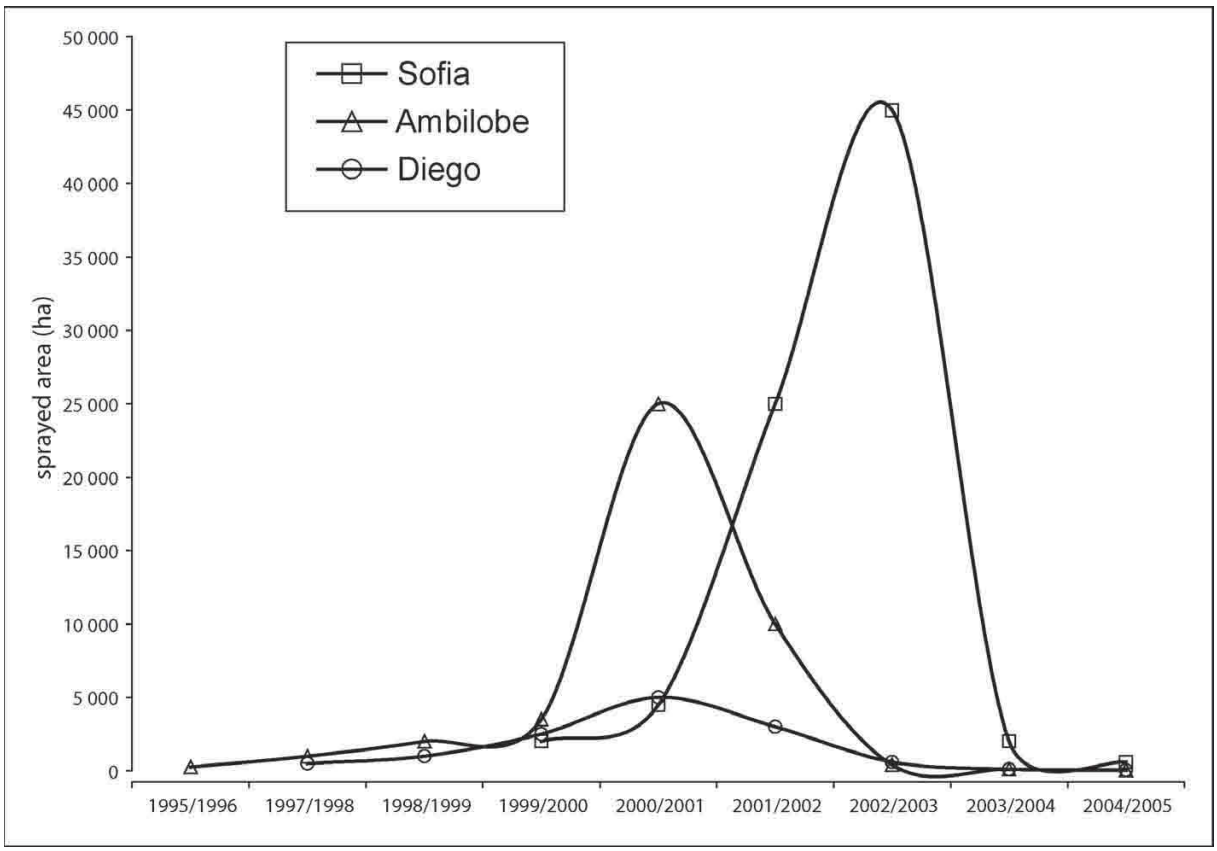

Figure 2
Sprayed area (ha) of outbreaks of Red locust, *Nomadacris septemfasciata* (Serv.), in three regional subunits of northern Madagascar (Sofia catchment, Mahavavy river valley and Diégo-Suarez region). Data for Sofia catchment were only available as of the 1999/2000 season.

2004 dry season – A new recession

No dense adult populations were reported during the 2004 dry season. Maximum densities south of Mandritsara did not exceed 250 adults/ha. Most of the locusts were solitary or *transiens degregans*, but their recent gregarious past still had morphometric and anatomic influence, and the number of oocytes was low, ranging from 95 to 150, versus the low density.

Finally, after 2 years of upsurge (1998 and 1999), there were 3 successive campaigns of Red locust outbreaks in the Sofia catchment region from 2000 to 2003. The Figure 2 estimates the size of the sprayed areas by the crop protection service. The outbreak peak occurred in 2002 and 2003 with a successful gregarisation, whereas degregarisation occurred between 2003 and 2004.

Two major events occurred simultaneously to stop the invasion process, first, control operations, and secondly weather conditions. Dense adult populations covering 20,000 ha were treated by two air sprayings at Mandritsara in November 2002 and then in October 2003. In addition, in April 2003, an area of 18,000 ha infested by hoppers was treated by air spraying in the Antsohihy region. These chemical treatments contributed to reduce infestations and locust gregariousness. Moreover, the rainfall level during the 2003–2004 rainy season was not suitable to egg laying and development. November 2003 was especially dry. The first substantial rainfall occurred during the last decade of December, inducing a wave of egg laying. January 2004, was twice as dry as normal (111 mm instead of 225 mm for the first two decades at Antsohihy). Finally, due to cyclone Elita, 479 mm of rain fell in 7 days (from 24 to 30 January 2004), thus flooding most young hoppers and eggs still in the ground and whose development had been previously hampered by the drought.

Outbreaks in the Mahavavy valley

Outside of the Sofia catchment basin, other smaller areas were infested by Red locust. In the Mahavavy valley (Ambilobe area), from 1998 to 2003, Red locusts threatened cash crops (sugarcane) in lowland areas and food crops and rangelands in medium-elevation valleys. On 2nd December 2000, a Red locust swarm flew over the town of Ambilobe for several hours.

This swarm then dispersed in sugarcane cropping area and laid eggs. Ten months later, in October 2001, farmers in the high valleys (Ambilobekely) reported seeing groups of not or sightly moving adults. A ground survey in November 2001 confirmed that around 1,000 ha were infested at densities ranging from a few thousands to several tens of thousands adults per ha. Heavy damage to raffia, coconut, jackfruit, mango, banana, vegetables, sugarcane, coffee and vanilla crops was noted. According to local farmers, the infestations have been worsening yearly since 1997. They were becoming chronic and a mass psychosis was developing, with fears that locust faeces will poison water. There was even a rumour that locusts could attack nursing infants! This highlights the incomprehension of this novel phenomenon by local people. Late 2001, a total area of around 3,000 ha had been infested. As a swarm had been reported at Mangindrano (north of Bealanana, in Sofia catchment) in December 2001, this indicates that locust movements are possible between the high Mahavavy valley and Sofia catchment through the southern slopes of Tsaratanana mountain. During the next rainy season (2002–2003), Ambilobe plain was completely flooded (800 mm of rainfall during the second decade of January) after cyclone Farihy, so the hopper infested area dropped drastically to just 250 ha. In December 2003, breeding adult densities were very low on Ambilobe plain. In January 2004, this plain was again flooded after receiving 916 mm of rain, and thus only 200 ha were infested by hoppers during this 2003-2004 rainy season. The only sites colonized were in non-flooded areas (edges of canals), which represent too small an area for the insect to build up a large population.

Infestations in Diego-Suarez area

In the far North of the country, two areas were also colonised by Red locust dense populations. 1) Amber mountain slopes: The western slope of this mountain was regularly colonized by hoppers during the three 1998–2001 rainy seasons. Several reports of local outbreaks were recorded but the locust species were not always clearly identified (*L. m. capito* or *N. septemfasciata*). The eastern slope (Anivorano) was also invaded by hoppers during the 2000–2001 rainy season. According to farmers account, this phenomenon was less frequent. 2) Amber cape: This peninsula hosted abundant hopper populations during the 2000–2001 rainy season. This area is contaminated yearly by indigenous locust populations (present throughout the year) which are sometimes large enough to cause local damage to food crops. In June 2001, adult populations were dense (around 10,000/ha). These populations dispersed in the dry season. In November 2001, locust adult populations were

noted on lowland and medium-elevation shrubby savannas, where densities ranged from 10 to 3,000 adults/ha (average of about 500 adults/ha).

North-eastern coast

There were other reports of adults present along the humid north-eastern coast of Madagascar. In March 2001, high densities of adults were noted in coconut plantations in Sambava. Local infestations were also reported at Sambirano (Ambanja) under a humid tropical climate. Red locusts seem therefore able to breed some years in these very humid areas.

Discussion

Complementary ecological conditions

Suitable eco-meteorological conditions for *N. septemfasciata* populations are a prerequisite for the development of outbreaks. That also implies access to ecological complementary areas, including breeding habitats (used in the rainy season) and immature adult habitats (used mainly in the dry season). Moreover, the locust must be able to move from one area to another without major losses in population numbers (Franc *et al.* 2007; Franc & Luong-Skovmand 2009).

All of these complementary environments may be found in the three northern regions of Madagascar, called geographical subunits, i.e. Sofia catchment basin, Mahavavy valley and Diego-Suarez area. Within these 3 geographical subunits, we can define two main complementary environments as well as some highland areas that are still forested and hot humid lowland areas. Only a short distance separates these two complementary areas in the three subunits (tens to hundreds of kilometres at most) and are often connected by migrations pathways for the Red locust (Franc *et al.* 2008).

Each geographical subunit has nearly the same structure, i.e., relatively scattered habitats on the edge of humid areas and dry season diapause habitats located in the high valleys. Each subunit has its own dynamics, but populations could potentially spread out from one to another during serious outbreaks. No widespread Red locust outbreaks have been reported to date in Madagascar, but this might possibly occur if large locust populations develop simultaneously in these three subunits. The Mahavavy catchment is a small-scale version of the Sofia catchment which may have a more or less independent seasonal dynamic.

Biogeography of the Red locust in the Sofia catchment area

Within the subunit of the Sofia catchment, we have identified two areas corresponding to the two major periods of Red locust life cycle. These two areas are linked by the main river valleys, which are oriented in a SE-NW direction.

Breeding area

The entire Sofia catchment basin has been affected by Red locust breeding activities, except from highland zones above 2000 m elevation. However, reports of the densest hopper bands were concentrated in the Manpikony-Antsohihy rift valley whereas no locusts were noted in this valley during the dry season. It is a lowland area (0–100 m elevation) where streams flow up against the Manasamody and Bongolava reliefs, and temporary pools and swamps form as a result of the low drainage. There is a broad range of cleared and mixed habitats in this area. The tropical climate is hot (annual average temperature >25 °C) and humid (annual average rainfall >1500 mm) with marked contrasts between the seasons (6 to 8-month dry season without rainfall) (Jury 2003).

Dry season diapausing area

During the dry season, diapause adult populations withdrew from the eastern Sofia catchment area (Mandritsara). The elevation ranged from 300 to more than 1000 m. There are many valleys throughout the area. The dry season is relatively humid because it is affected by the humid climate of the close eastern coast. A temperature gradient extends from the low to the high valleys, with a tropical mountain climate prevailing in the Tsaratanana Mountains. The Mandritsara region is the driest part of the catchment area (annual average rainfall of 990 mm), but humidity is high throughout the year while temperatures are low (annual average temperature <21 °C) (Jury 2003). In southern Africa, Red locusts do not seem to undertake regular seasonal migrations, but instead exploit vast floodplains by following the water levels (Gunn & Symmons 1959; Gunn 1960). The bioecology of the Red locust is thus adapted to the environment encountered. The success of the migrations that are required on an island with a high bioclimatic diversity (Wilmé *et al.* 2006) may also prompt complete gregarisation. Slash-and-burn land clearing for rice cropping has accelerated since the late 1990s (Gautier *et al.* 1999, Gautier & Goodman 2003). The Red locust has now access to

areas with complementary habitats that are especially suitable for meeting the requirements of two of its development states, while also providing migration pathways linking the two regional complementary areas.

Red locust is a univoltine species, which means that several successive meteorologically favourable years are required before the build-up of population numbers is sufficient to reach its phase transformation threshold (±7500 adults/ha). Successful egg laying and hatching, hopper development and thus multiplication, seem to be associated with the rainfall patterns occurring at the onset of the rainy season. Moreover, wind conditions may also play a key role in determining migration patterns and should thus be investigated in future. Finally, studies should also be focused on the impact of deforestation in opening areas suitable for egg laying and creating locust migration pathways (Franc *et al., 2008)*.

The presence of a potential Red locust outbreak area in Sofia catchment is described. *Transiens* or gregarious populations from the Sofia catchment region can then colonize Mahajunga and Marovoay plains and also the Lake Alaotra catchment. These are the two most important rice-growing areas in Madagascar, and they fulfill food security needs of the whole country. It is essential in future to survey solitary Red locust populations and conduct preventive control operations once they begin forming groups.

Acknowledgements. We are grateful to the field scouts and agents of the crop protection service in northern Madagascar, especially: Ms. Angèle Rasoarisoa, Mr. Camille Dama and Mr. Tsimandany. We also thank everyone who read this article for their very helpful suggestions. The field missions were partly funded by the French Foreign Office and the FAO.

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C'est le troisième volume de cette splendide édition qui va rendre la faune entomologique des Emirats aussi bien connue que celle de l'Arabie Saoudite elle-même. C'est grâce à l'initiative de Son Excellence le Sheik Al Bahyan et l'érudition de mon vieil ami Van Harten que cette série a vu le jour et continue contre vents et marées. Cette fois ce seront les Araignées, les Hémiptères, 10 familles de Coléoptères, les Névroptères, les Hyménoptères, 7 familles de Lépidoptères, 8 familles de Diptères qui seront traitées. L'ouvrage est superbement illustré et dispose des index zoologiques habituels. Y aura-t-il un quatrième volume ? Il faut l'espérer, car une étude générale des fourmis des émirats s'impose et peut-être, comme Van Harten l'a déjà fait pour les îles du Cap Vert, un catalogue général et systématique. Il y a encore des choses à trouver dans les émirats et sur les montagnes d'Arabie et du Yémen. Rappelons-nous que le Sahara était encore vert, il y a cinq-mille ans, et que très probablement mes chers *Timarcha*, y ont promené leur démarche nonchalante ! Ils ont certainement pénétré dans la péninsule du Sinaï et au Moyen Orient. Sont-ils descendus en Arabie ? Cela reste une énigme difficile à résoudre, car cela daterait du Pléistocène et même d'avant. Des endogés, des cavernicoles, et toute une faune souterraine qui comprend non seulement des stygobiontes crustacés et autres, mais certainement aussi des Dytiques et autres Coléoptères aquatiques, doit persister en zone hypogée. Il y a une vie au dessous du sable et la nappe phréatique est partout grouillante avec une faune archaïque, comme on le voit si bien actuellement en Australie, où la colonisation semble dater du Miocène avec le début de la désertification. . La désalinisation de l'eau de la mer et l'irrigation des espaces désertiques a sans doute accru cette nappe phréatique potentielle.

Il est remarquable d'étudier une faune d'une région qui restait peu inventoriée, sauf par de vielles expéditions britanniques du siècle passé. La biogéographie de cette faune devra être réétudiée à la fin des volumes, en, fonction de la faune africaine, asiatique, voisine et même de Socotra, qui reste une énigme zoologique et botanique, au sud de l'Arabie Heureuse. Merci à Son Excellence le Sheik Al Bahyan et à Von Harten d'élargir nos connaissances dans un monde jusque là peu inventorié.

Pierre Jolivet