ARCHIVES OF
Environmental
Contamination
and Toxicology

Vol. 32, No. 1, January 1997

Contents

Continued on next page

Springer

Arch. Environ. Contam. Toxicol. 32, 58–62 (1997)

ARCHIVES OF
Environmental
Contamination
and Toxicology

Impacts on Nontarget Insects of a New Insecticide Compound used Against the Desert Locust [*Schistocerca gregaria* (Forskål 1775)]

G. Balança, M.-N. de Visscher

Cirad-Gerdat-Prifas, BP 5035, 34032 Montpellier Cedex 1, France

Received: 1 April 1996/Revised: 21 July 1996

Abstract. In 1994, the effects of fipronil, a new insecticide compound of the phenyl-pyrazol chemical group, was tested against desert locusts during a field experiment in Mauritania. The impacts of these spray treatments on nontarget Coleoptera and Hymenoptera were also studied. In relation to organophosphorous insecticides usually used against grasshoppers and locusts, fipronil appeared more effective and persistent. Similar results were obtained for nontarget Carabidae and Tenebrionidae which were almost totally eliminated from the treated plot. The effects on Hymenoptera varied according the family; Scelionidae and Sphecidae seemed to be more affected than Apoidea. Positive and negative aspects of fipronil treatments are discussed. Appearing as one of the most convenient insecticides to successfully prevent locust outbreaks, at a very early stage of invasion under Saharan conditions, fipronil simultaneously induces heavy mortality in some nontarget insect groups.

In 1987, the use of dieldrin, the main tool of preventive control strategy against desert locust, was prohibited for environmental reasons. Dieldrin, because of its high efficacy and persistence, controlled desert locust upsurges at an early stage in remote Saharan areas. Barrier treatment with a succession of treated and untreated swaths was the usual way to spray this insecticide. This preventive control strategy was successfully applied for several decades; thus, avoiding outbreaks and chemical spraying on larger areas. Since then, no alternative insecticide (organophosphates, pyrethroids, carbamates) showed the required qualities to efficiently control desert locusts in remote desertic regions.

In 1994, fipronil (REGENT®), a new insecticide compound of the phenyl-pyrazol chemical group, was proposed to replace dieldrin. Efficacy of this insecticide against locusts was clearly demonstrated by first laboratory trials and long-term effects were suggested (Butler and Du Preez 1994; Kriel *et al.* 1994; Megenasa and Muinamia 1994).

At the end of 1994, the effects of fipronil were tested against desert locusts during a field experiment in Mauritania under Saharan conditions. The impacts of these spray treatments on nontarget Coleoptera and Hymenoptera were also studied (Rachadi *et al.* 1995). In 1993, similar data with organophosphorous treatments had already been collected in Burkina Faso, in Sahelian conditions (Balança and de Visscher 1994).

Methods

The experimental site in Mauritania was located in the African-Saharan zone in a frontal infiltration basin (19°47'N, 13°43'W; Figure 1). There was substantial vegetation cover because heavy rains had occurred two months earlier. The area was occupied by sparsely distributed short-cycle crop fields.

Three groups of plots were set up, the first was sprayed with fipronil (2 doses), the second with ethyl-chlorpyriphos as standard insecticide and the third was an unsprayed control area (Table 1).

The impacts of fipronil on locusts were assessed by visual counting. The methods and results were published elsewhere (Rachadi *et al.* 1995).

In Mauritania, population size variations of non-target insects before and after treatment were studied using three collecting methods: malaise traps and yellow plates for Hymenoptera and pitfall traps for Carabidae and Tenebrionidae.

In northern Burkina Faso, the impacts of two experimental spray treatments were studied in a savanna area in the southern part of the Sahelian zone (13°35'N, 2°25'W). The natural vegetation was almost dry and millet fields around almost ready to be harvested. Two doses of pyridaphention were used (Table 1). Coleoptera were collected with pitfall traps and Hymenoptera with sweep-nets.

According to the plot size, 6 to 16 groups of 5 pitfall traps and 4 groups of 3 to 5 yellow plates were installed at each plot of Mauritania and Burkina Faso. In Burkina Faso, three sweep-net samples were collected at each sampling date in each plot and two Malaise traps per plot were used in Mauritania. In both countries, insecticide treatments were carried out with ULV sprayers. The main characteristics of these treatments are given in Table 1.

Data are presented in two ways: mean numbers of individuals collected by traps per day and percentage of individuals collected relative to control data. The results are thus expressed according to relative abundance while taking into account natural population size variations in unsprayed plots and data obtained before spray treatment in all plots. This relative abundance (RA) is defined as the ratio between numbers of individuals collected, the same day, in treated (Tr) and in control (C) plots:

$$RA = Tr/C$$

Correspondence to: G. Balança

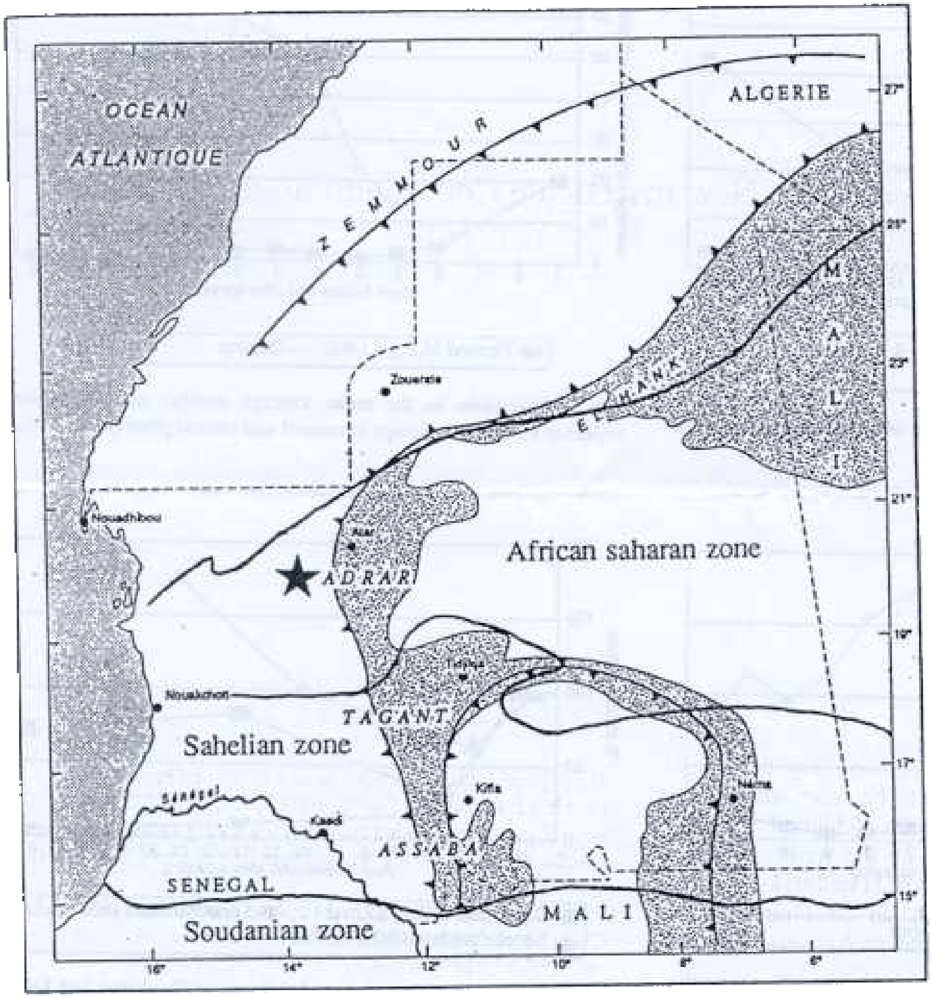

Fig. 1. Location of the experimental site in Mauritania

Table 1. Main characteristics of experimental treated plots

Country	Date	Insecticide	Dose	Treated area
Mauritania	21 nov 94	fipronil	13.4 g a.i./ha	28 ha
	21 nov 94	ethyl-chlorpyriphos	210 g a.i./ha	27 ha
	9 dec 94	fipronil	4.2 g a.i./ha	8 ha
Burkina Faso	28 sep 93	pyridaphention	500 g a.i./ha	15 ha
	20 oct 93	pyridaphention	250 g a.i./ha[a]	20 ha

[a]Recommended dose for grasshoppers

Insecticide impact on population size, the n days after spray treatment is expressed as a ratio between the relative abundance (RA) obtained on day n and that obtained just before spray treatment (d − 1):

$$\text{Insecticide impact} = RA_{d+n}/RA_{d-1}.$$

For the treatment at 4.2 g a.i./ha of fipronil, there was no available data before spray treatment for the control plots.

Results

Locust and grasshopper populations were significantly reduced in all treatments.

- At 13.4 g a.i./ha, fipronil eliminated all desert locust hoppers and 80% of adults in one day. Five days after the treatment, the mortality of adults reached 93%. Imigrating adults obviously intoxicated by the product (behavioral disorders) were observed until the end of the survey period (29 days post-treatment).
- At 4.2 g a.i./ha of fipronil, the initial desert locust hopper population was reduced by 93% in five days, and it had completely disappeared in nine days.
- The mortality of desert locust hoppers introduced in a third area 23 days after a 11-g a.i./ha treatment with fipronil reached 86% in 12 days. For hoppers placed on the treated site 30 days post-treatment, mortality was as high as 59% in six days (end of the survey period).
- Spray treatments of ethyl-chlorpyriphos in Mauritania caused 92% mortality of desert locust adults in six days, but progressive recolonization was observed in the following days.
- In Burkina Faso, 70 or 93% of grasshopper populations were eliminated in two days depending on the dose of pyridaphention (250 or 500 g a.i./ha). Slow and continued recolonization was found to reach 30% of the initial population size in both treated areas, three to four weeks later.

In relation to organophosphorous insecticides for grasshoppers and locusts, fipronil was more effective and more persistent.

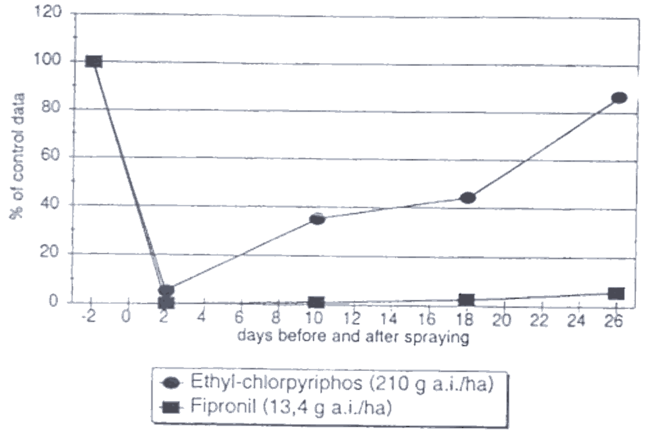

Fig. 2. Variations in the relative abundance of Carabidae collected in pitfall traps in treated plots (Mauritania)

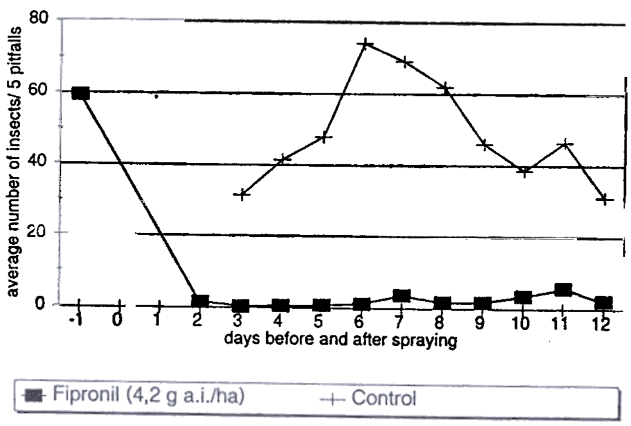

Fig. 3. Variations in the mean number of Carabidae collected in five pitfall traps in control and treated plots (Mauritania)

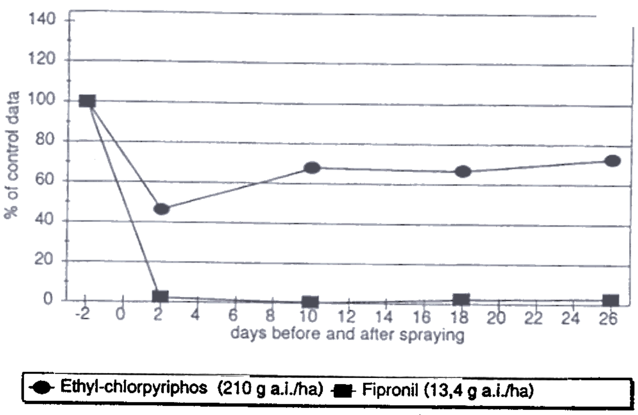

Fig. 4. Variations in the relative abundance of Tenebrionidae collected in pitfall traps in treated plots (Mauritania)

However, the lower the dose, the longer it took to obtain significant mortality.

Similar results were obtained for nontarget Coleoptera and Hymenoptera. Figures 2 to 11 show how numbers of collected nontarget insects changed after fipronil or organophosphorous

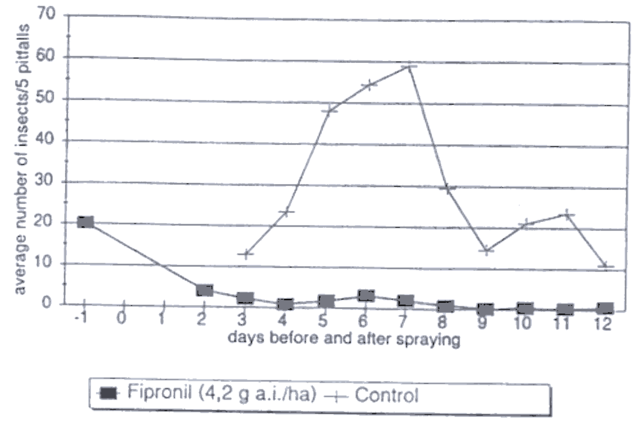

Fig. 5. Variations in the mean average number of Tenebrionidae collected in five pitfall traps in control and treated plots (Mauritania)

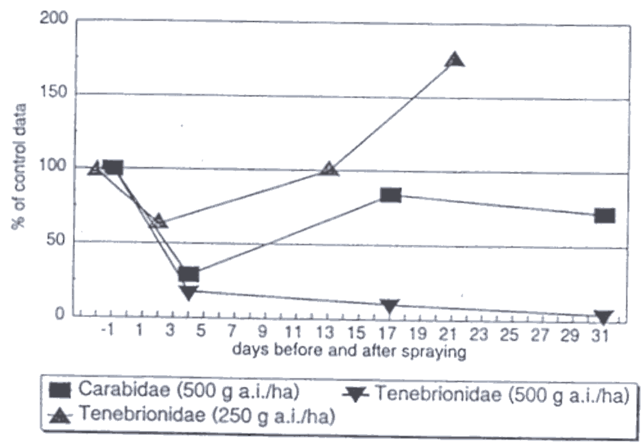

Fig. 6. Variations in the relative abundance of Carabidae and Tenebrionidae collected in pitfall traps in treated plots (Burkina Faso)

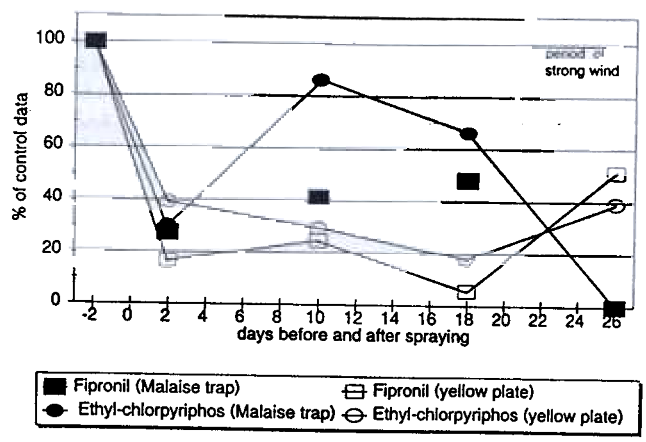

Fig. 7. Variations in the relative abundance of total Hymenoptera collected in Malaise traps and in yellow plates in treated plots (Mauritania)

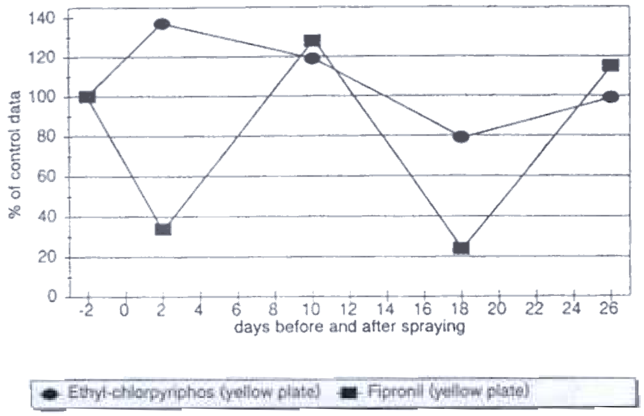

Fig. 8. Variations in the relative abundance of Apoidea collected in yellow plates in treated plots (Mauritania)

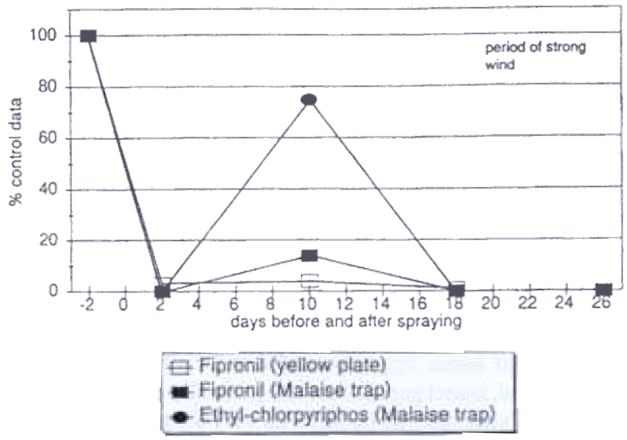

Fig. 10. Variations in the relative abundance of Scelionidae collected in Malaise traps in treated plots (Mauritania)

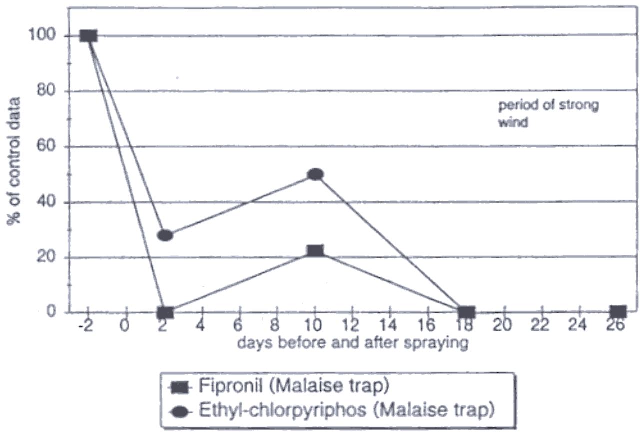

Fig. 9. Variations in the relative abundance of Sphecidae collected in Malaise traps in treated plots (Mauritania)

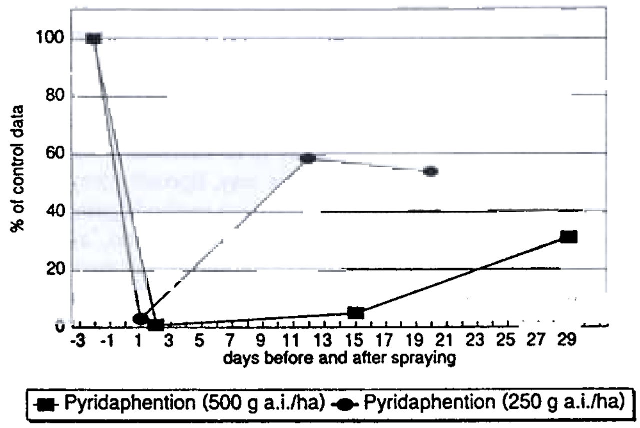

Fig. 11. Variations in the relative abundance of total Hymenoptera collected in sweep nets in treated plots (Burkina Faso)

treatments in relation to the situation before spray treatments and control data:

- For Carabidae and Tenebrionidae, regardless of the dose, fipronil caused more than 90% mortality in two days with very poor recolonization in at least four weeks (high dose, Figures 2, 4) or two weeks (low dose, Figures 3, 5). In the few cases where similar mortality was obtained with organophosphorous insecticides (Figures 2, 6), recolonization was only significantly delayed for Tenebrionidae when a very high dose of pyridaphention was used.
- Generally, for Hymenoptera the impacts of fipronil at 13.4 g a.i./ha seemed less severe and persistent than for Coleoptera (Figure 7) probably partially due to the higher mobility of the former. However, for the three studied families, this was only true for Apoidea (Figure 8).[1] Fipronil caused almost 100% mortality of Scelionidae and Sphecidae with very poor recolonization in four weeks (Figures 9, 10). The impacts of a high dose of pyridaphention in Sahelian conditions were also generally very severe for Hymenoptera (Figure 11).

[1]The apparent decrease in samples size at the end of the experiment is mostly due to strong winds during the two last sampling periods.

Discussion and Conclusion

Fipronil presently appears to be one of the most effective insecticides for locust control because of its short and intermediate effects. For both target and nontarget insect species, equivalent short-term population reductions can be obtained with classical organophosphorous insecticides, but only very high doses caused the poor recolonization observed with very low doses of fipronil. For several weeks, newly hatched or immigrating individuals run the risk of being eliminated by residual fipronil.

On the one hand, fipronil is a very interesting insecticide, because persistence at low dose is a crucial feature to obtain efficient control of locusts on very large and remote areas of Sahara. The present results of fipronil tests show that this insecticide can be used to control locust upsurges in desertic zones. If this preventive control is successful, it would avoid locust outbreaks, and the whole sprayed areas would be reduced, especially in the cultivated regions.

On the other hand, although fipronil formulations are less toxic for mammals (WHO class III) than dieldrin and some other usual organophosphorous insecticides, their use seriously reduces important nontarget insect populations. This chemical locust control raises the more general problem of recolonization by nontarget insects in arid and semi arid ecosystems. Recovery of treated populations does not only depend on insecticide persistence but also on species mobility and distance of healthy populations. In the case of isolated treated areas (oases, wadis), it could be more difficult to find unaffected populations able to ensure recolonization. The poor flying abilities of some important taxa such as Tenebrionidae species (detritivores and predators of locust eggs) have also to be considered. In these arid regions, insect populations are generally adapted to survive highly irregular rainfall cycles with very long dry seasons but it is not known how these populations can stand up to further stress induced by insecticide spray treatments. Furthermore, the major role of Tenebrionidae, Carabidae and Hymenoptera as detritivores, predators, pollinators and parasitoids is generally known. However, additional data are necessary to assess actual impacts of populations reductions induced by insecticides on community persistence and, in more concrete terms, on production of short-cycle pastures and crop fields in arid zones.

As long-term consequences of these side effects in arid zones are poorly known, it is necessary to be cautious while ensuring an efficient locust control. In this way, fipronil spraying could be improved by using barrier treatment method against gregarious locust hopper bands. This control method, allowed by long-term activity of low doses of fipronil should partially spare nontarget insect populations: If less insecticide is sprayed per surface unit, complete destruction of local nontarget populations could be avoided. Field tests are necessary to prove and quantify this hypothesis. Finally, in order to find the lowest dose of fipronil still able to effectively control locusts and grasshoppers with the least impact for nontarget insect species in arid and semi-arid zones, antiacridian efficacy and ecotoxicological effects of very low doses of fipronil (1 and 2 g a.i./ha) should be tested.

References

Balança G, de Visscher MN (1994) Les effets sur les araignées et les insectes non-cibles des traitements chimiques contre les criquets ravageurs. Rapport annuel sur la deuxième campagne de relevés (Burkina Faso, juillet à novembre 1993). D. 494 Cirad-Gerdat-Prifas, Montpellier, France

Butler ET, Du Preez I (1994) Laboratory determination of the LD50 and LD90 values for fipronil against fifth instar nymphs of the Brown locust *Locustana pardalina* (Walker, 1870). Agricultural Research Council, Plant Protection Research Institute, Pretoria, South Africa

Kriel CF, Butler ET, Du Preez I (1994) Laboratory determination of the LD50 and LD90 values for fipronil against fifth instar african migratory locust nymphs, *Locusta migratoria migratorioides*. Agricultural Research Council, Plant Protection Research Institute, Pretoria, South Africa

Megenasa T, Muinania CK (1994) Evaluation of fipronil (exp. 60145 A) in the control and management of Desert locust (*Schistocerca gregaria*, Forskål) nymphs and adults. DLCO-EA, Nairobi, Kenya

Rachadi T, Balança G, Duranton JF, Foucart A (1995) Les effets du fipronil sur *Schistocerca gregaria* (Forskål, 1775), divers acridiens et la faune non-cible. D. 513 Cirad-Gerdat-Prifas, Montpellier, France