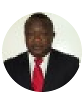
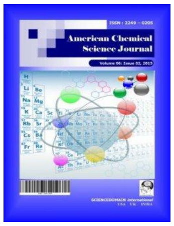
An Assessment of the Impact of Chemical Insecticides Used to Control Desert Locust (Schistocerca gregaria) (Orthoptera, Acrididae) on Lacertid Lizard Acanthodactylus spp (Sauria, L...

ARTICLE · JANUARY 2015

DOI: 10.9734/ACSJ/2015/16556



Abdou Mamadou
National Center of desert locust Control, Nia...



American Chemical Science Journal
7(4): 193-200, 2015, Article no.ACSj.2015.074
ISSN: 2249-0205

SCIENCEDOMAIN *international*
www.sciencedomain.org

An Assessment of the Impact of Chemical Insecticides Used to Control Desert Locust (*Schistocerca gregaria*) (*Orthoptera*, *Acrididae*) on Lacertid Lizard *Acanthodactylus* spp (Sauria, *Lacertidae*) in Niger

Mamadou Abdou[1*]

[1]National Center of Desert Locust Control, P.O.Box 2219, Niamey, Niger.

Author's contribution

The sole author designed, analyzed and interpreted and prepared the manuscript.

Article Information

DOI: 10.9734/ACSj/2015/16556
Editor(s):
(1) Dimitrios P. Nikolelis, Chemistry Department, Athens University, Greece.
(2) Sang Hak LEE, Department of Chemistry, Kyungpook National University, Daegu, 702-701, Korea.
Reviewers:
(1) Anonymous, Morocco.
(2) Ghulam Abbas, Pest Warning and Quality Control of Pesticides, Lahore, Pakistan.
(3) Anonymous, Spain.
(4) Anonymous, Egypt.
(5) Anonymous, Turkey.
Complete Peer review History: http://www.sciencedomain.org/review-history.php?iid=1048&id=16&aid=9206

Original Research Article

Received 6th February 2015
Accepted 10th April 2015
Published 8th May 2015

ABSTRACT

Chemical treatments still constitute the main method used to control desert locust during the invasion phases. In addition to their relatively high costs, these pesticides are not target specific in the majority of the cases; they can have negative effects on the biotic and abiotic components of the ecosystem. The goal of our study, conducted under natural conditions, was the assessment of the ecological effect of ethyl chlorpyrifos and fenitrothion, the most widely used organophosphate pesticides in desert locust control in Niger. To assess the impact of pesticides on the relative abundance of lacertid lizard *Acanthodactylus boskianus* and *Acanthodactylus* sp before and after treatments, we used the method of pedestrian transect. The analysis of the variance was used to carry out a statistical comparison based on BACI (Before-After-Control-Impact) method. The experiments were carried out in a randomized complete block design with three replications. The

---

**Corresponding author: E-mail: abdoumamadou@yahoo.fr;*

experimental plots had an area of 16 ha each, the treatments consisted of ethyl chlorpyrifos at the rate of 225 ga.i./ha; fenitrothion at the rate of 450 ga.i./ha. Unsprayed plots were used as controls. These rates are those recommended by the Food and Agriculture Organisation of the United Nations (FAO) to control desert locust. Chemical treatments were carried out in total cover using a battery driven hand-held spinning disk sprayer (Micro-Ulva®), in accordance with the technical directives of the FAO for ultra-low volume applications. The field trial was carried out in the valley of Tafidet located in the eastern side of Aïr Mountains in Niger, from June to December of the years 2004 to 2006. Ineach experimental plot, two lines of 300 m length and 10 m width were used as area of counting. These lines of counting skirted one of the diagonals of each plot. The results demonstrate the noxious effect of ethyl chlorpyrifos and fenitrothion (organophosphate pesticides) on lizard. We recorded the first decrease of population at 9 days after treatment. The first decrease of the lizard populations was noted in the phase I (1-12 DAT). We also recorded the first dead or moribund lizards between 9 and 21 days after chemical treatment. The number of death or moribund lizards ranged from 0, 33±0.57 to 4±1 in the plots treated with chlorpyrifos and fenitrothion respectively. The optimum of the efficacy of the pesticides was noted in phase II (15-30 DAT) it was decreased from 76% to 98% with chlorpyrifos and fenitrothion. It was also observed; the chemicals had a delayed effect on the lizard. In the last phase (45-60 days after the treatment) no death or moribund lizards is noted in all plots (treated and untreated).

Keywords: Desert locust; organophosphate pesticides; assessment; impact; lacertid; Acanthodactylus; Niger.

1. INTRODUCTION

Agricultural products intended for human or animal consumption need to be protected against pests, which are often likely to cause losses and irreversible damage. In parts of the world such as Africa, South America or Asia, the losses can amount to 48% of the crop produce [1]. In arid and semi-arid regions of Africa and Asia, locusts particularly Desert locust (*Schistocerca gregaria* Forskål, 1775) (*Orthoptera*: *Acrididae*) in invasion phase orrecrudescence, take an active part in the depredation of crops and grazing areas [2-5]. The problem of locusts, including invasion phase (presence of swarms and larval bands) is treated as a national priority in affected countries [6]. For example, agricultural production in 2004 was severely affected by the invasion of locusts and drought in the northern regions of Niger generating pockets of food insecurity [3]. To control the locusts, the most widely used control method is synthetic chemicals as pesticides. Since the banning of organochlorine pesticides in the early 1970s, due to their excessive persistence in the natural environment and risk of bioaccumulation in food chains [7]. Niger country uses annually about 130,000 liters (average for the phase 1994-2003) synthetic pesticides (organophosphates) to control grasshoppers and locust's [8-9]. In addition to their relatively high cost, synthetic pesticides are not safe for human health [10] and the environment [11-13]. Several studies highlighted their noxious effects on non-target fauna [14-18]. Since the Conference of the United Nations on the Human Environment (CNUEH) held in 1972 in Stockholm (Sweden) and especially the Conference of the United Nations on the environment and the development (UNCED) held in 1992 in Rio de Janeiro (Brazil), the environmental questions became a major component in the management of the Desert locust control. The FAO founded this study, which one of the aims was to assess the effect of the Desert locust control, on the lacertid lizard *Acanthodactylus*. This zoological group was selected because it is a predator of Desert locust [19] and it is registeredon the International Union of Conservation of Nature red list as threatened species

2. MATERIALS AND METHODS

2.1 Experimental Site and Design

The Field trial was carried out from 2004 to 2006 in the summer breeding area of desert locust about 300 km northeast of Agadez (18°09' 16N/09º30' 52E). This Valley is fedby the mountainous of Air (Takaloukouzet) whose summit is to 1295 meters. The eastern slope of the Air was the subject of several studies as floristically [20-23], but the data on ecological insects such a wild bees, the coleopteran predators and the hymenopterans parasitoids from this desert ecosystem is lacking. It is besides one of the points which underlay the choice of this zone to carry out this study. This desert ecosystem is part of the National Nature Reserve of the Air and Ténéré (NNRAT), classified as world heritage of UNESCO in 1991 [24]. The agro climatic zoning of Niger, classes our study site in the Saharan zone characterized by normal annual rainfall of less than 150 mm and a normal rainy season that lasts only a month, where rain fed agriculture is almost impossible [25]. During the field monitoring from 2004 to 2006, the rainfall ranged from 1±0.14 mm to 27.67±1.07 mm recorded from August to September (Fig. 1). The rainiest month is August with an average of 19±3 mm. Cumulative rainfall observed during July and August (2004 to 2006) in the study station is about 100% of the annual total, 42±3.60 mm. The relative humidity ranged from 15% to 28% and the Temperature ranged from 9.95±1.28ºC (day minimum recorded in December) to 41±7.13ºC (day maximum recorded in July). The floristic composition consists of annual and perennial species. In total, we identified in the Tafidet's Valley, 21 plant species belonging to 14 different families. Perennials (trees and shrubs) represent 47.82% and annual and biennial species represent 52.18%. The scattered woody vegetation was mainly composed of *Acacia erhenbergiana* (70%), *Balanites aegyptiaca* 18%) and *Salvadora persica* (12%). The density of three was low (7.75±1.19 threes).

The experimental device used is the Complete Random Block. We had three blocks, distant between them of 1000 m and 500 m between the experimental plots which are squares of 16 hectares.

Three treatments were made up: 1) plots treated with ethyl chlorpyrifos at the amount of 225 g a.i./ha; 2) fenitrothion at 450 g a.i./ha and 3) the untreated plots. The blocks were laid out perpendicular to the gradient of heterogeneity (vegetation) which decreases by northern southeast in the valley of Tafidet.

2.2 Treatments

The treatments of the pesticides (ultra-low-volume) in total cover were carried out according to the technical recommendations of FAO [26], with a rotary disc pelletizer carried to the hand Micro Ulva. The device is provided with five alkaline piles of 1.5 volts each one, this load would produce a number of revolutions/time from 6000 to 6400 according to the technical specifications of the manufacturer of the device. The ethyl chlorpyrifos 450 g/l (Dursban 450 UL) were sprayed at recommended volume application at the rate of 225 g a.i./ha and the fenitrothion 500 g/l (Fenitrothion 500 UL) at the dose of 450 g a.i./ha. All the treatments were carried out between 6:00 and 9:00 GMT, when the temperature was relatively low. Indeed, ascending current of convection can involve pulverization apart from the target zone when the temperature is higher than 35ºC [26]. The height of emission was of 1 m and the width of work (wind-row) was of 10 m.

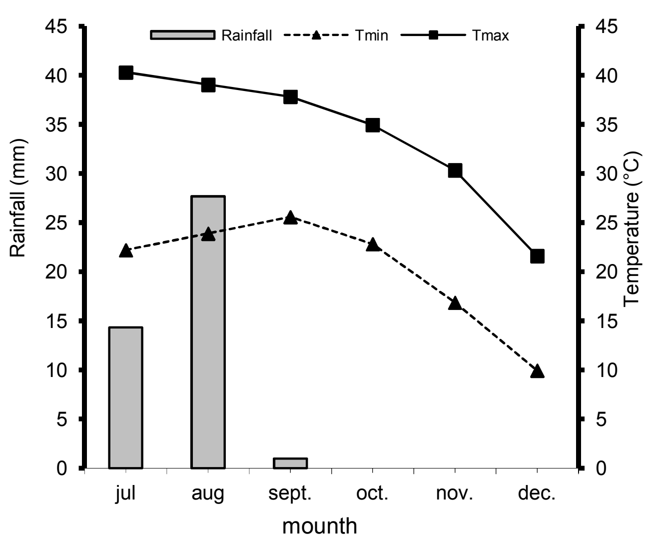


Fig. 1. Average rainfall and temperatures from 2004 to 2006 sampling phase in the Tafidet's Valley

2.3 Assessment of the Impact of Pesticides on Lacertid Lizard *Acanthodactylus* spp

The method of transects pedestrian was used to evaluate the activity of the lizards [20,27]. This method has the advantage of being able to be used under any condition and makes it possible to determine in a rather exact way the digital variation of lizards with various time intervals. Counting's were carried out at the hottest hours of the day (12-14), according to our observations, with their optimum time of activity in the valley of Tafidet. In each experimental plot, two lines of 300 m length and 10m width were used as area of counting. These lines of counting skirted one of the diagonals of each plot. The enumeration was done at sight. For that the operator placed himself in the middle of two lines and started to walk while counting all the lizards observed on his passage. The follow-up was carried out with various time intervals before (three day before treatment, one day before treatment: -3 DBT, 1 DBT) and after the treatments (3 DAT, 6 DAT, 9 DAT, 12 DAT, 15 DAT, 20 DAT, 30 DAT, 45 DAT, 60 DAT). The 60 day post-treatment phase was divided into three different time intervals: days 1 and 12 (I), 15 and 30 (II), 45 and 60 (III).

2.4 Data Analysis

The analysis of the variance was selected to carry out a statistical comparison based on BACI principle (Before-After-Control-Impact) [28-29], followed by the multiple tests of comparisons of Student-Newman-Keuls if the H_0 hypothesis is rejected to the level α = 0.05. The BACI are commonly used to monitor for potential environmental impacts. The expressed values of absolute numbers were transformed by the relation y = Log (1+ x) and those expressed into percentage were transformed by $y = \arcsin\sqrt{x}$ in order to homogenize the variances and to ensure a normality of the eccentric distributions towards the line [30-31]. The value of 0% was replaced by ¼ n and the value100% by 100–1/4 n, where *n* represents the denominator used to calculate the percentage, i.e the size of reference population [16]. To distinguish early (I), delayed (II) and late (III) effect, the 60 day post-treatment phase was divided into three different time intervals. The total presence of lizards (TP) values was processed like binary lines transect counts. In the next step, the mean of two (phases I, II) or three (phase III) consecutive post-treatment sampling dates was calculated for each individual plot.

For example TP day 1 = 18 and TP day =27 on day 1 and 6 post-treatment yielded. TP phase I = (18+27)/2 = 22.5. These mean post-treatment value (TP after) as well as the single pretreatment value (TP before) were transformed into log (TP+1) to accomplish normality and homogeneity of variances and the change (C) in relative population density compared to the pre-spray levels was computed for each individual plot and treatment [16].

$$C = \text{Log}(TP_{after} + 1) - \log(TP_{before} + 1).$$

Negative value of C indicates a decrease and positive value an increase relative to pre-spray population densities.

The Effiacy (E) was calculated for each sampling phase and zoological group as the change in relative population density corrected for control fluctuation [16,32].

$$E(\%) = 100 - [1- (Cb.Ta) / Ca.Tb)]$$

Where Ca(Tb) = TP from all counts (treated) plots before treatments and Ca(Tb) = TP from all replicate plot after treatment during phase I, II and III.

Effects were evaluated according to the risk classification scheme for terrestrial invertebrate proposed by FAO (1998): low, <25%; medium, 25-75% and high, >75%.

3. RESULTS AND DISCUSSION

The first decreased lizard's population is noted, 9 days after treatment compared to the unsprayed plots where an increase is observed at the same phase (Fig. 2). During the timeI (1-12 days) post-treatment we noted a very significant difference between the treatments, F(2.6) = 28.76; *P* = 0.001. In the intervalII (15-30 days), the number of lizards observed fell in the treated plots compared to periodI. During this phase, the treatments were very significantly different to the untreated plots F(2.6) = 63.23; *P* = 0.004. We started to note the presence of death or moribund of lizards between the 9 and 21 day after chemical pulverizations respectively in treated plots with the ethyl chlorpyrifos and the fenitrothion. The number of dead or moribund of lizards varied from 0.33 ± 0.57 to 4 ± 1; in the fenitrothion and ethyl chlorpyrifos plots. In our study the efficacy of the insecticides ranged from 76% to 98% respectively with the chlorpyrifos and fenitrothion in the phase II (15-30 DAT). These results confirm the toxicity of chemical insecticides on *Acanthodactylus* spp.

The study of [17], carried out *in vitro* in Mauritania, made it possible to highlight the toxicity of fipronil (30 µg fipronil/g body weight) on *Acanthodactylus dumerili*, with 62.5% dead individuals or moribund in four weeks after ingestion of a contaminated food. During the phase III (45-60DAT), we noted a decrease of lizards in all the treated and untreated plots. No effect of the treatments was observed (P = 0.07). The visual analysis of their stomachic contents revealed the presence of the remains of locust and other insects; they are predatory of acridians and various other insects [27,33].

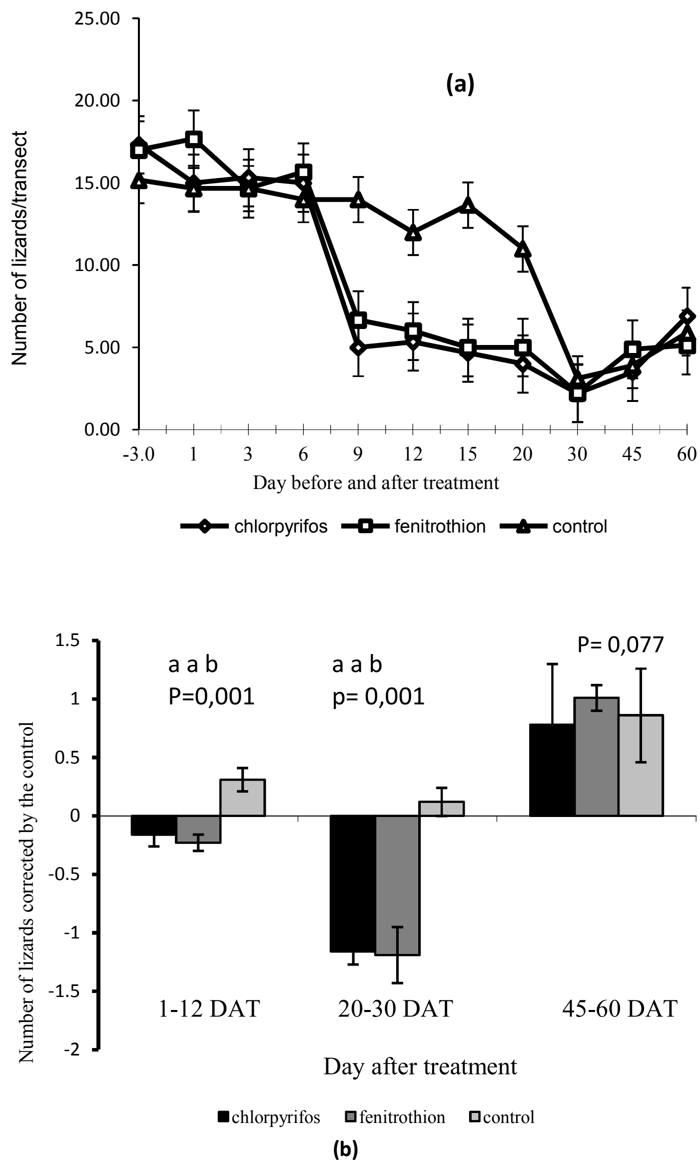


Fig. 2. Number of *Acanthodactylus* spp before and after treatment (a) and the number corrected to control (±SE) during the three post-treatment phases during 2004-2006. Values not sharing the same letter are significantly different at level *P*<0,05. The arrow indicates a day of treatment

4. CONCLUSION

In general, synthetic pesticides used in pest control are not specific only to locusts. They often have a reducing effect on the natural enemies of locusts, from birds and insects of agronomic utilities [15,34-36]. Indeed, ethyl chlorpyrifos and fenitrothion used at doses of 225 ga.i./ha and 450 g a.i./ha, respectively, had a negative effect on the relative abundance of the spiny footed lizard. This zoological group it is a predator of Desert locust and it is registered on the International Union of Conservation of Nature red list as threatened species.

The reduction of population of lizards was noted from 9 day to 21 after treatment with chlorpyrifos and fenitrothion. Both insecticides do not have an immediate effect on lizard, but a delayed effect of these pesticides on this zoological group was also observed. These results force us to explore some scientific investigation that lead to better understand the impact of repeated treatments would have on time for recovery of the populations of lizards. Indeed, in the context of this study, we performed a single treatment per year. Also, we propose to evaluate the impact that would have on non-target fauna, much lower doses than those recommended by FAO in desert locust control. Finally, the study on population dynamics of beneficial fauna (predators and pollinators) could be another line of inquiry in order to better control the natural population fluctuations outside the presence of a xenobiotic substance.

ACKNOWLEDGMENTS

The author thanks the Committee of Desert locust control and the FAO, which fully funded the study as part of a doctoral thesis. We express our gratitude to the FAO Commission of Desert locust control in the Western Region (CLCPRO) which awarded this scholarship in Niger. We thank the Directorate of Plant Protection of Niger for his help in logistics that allowed us to carry out this study. Finally, we thank all those who contributed to this study.

COMPETING INTERESTS

Author has declared that no competing interests exist.

REFERENCES

1. Thiollet-Scholtus M. Contribution d'un indicateur de qualité des eaux de surface vis-à-vis des produits phytosanitaire à l'échelle du bassin versant viticole. Thèse de doctorat. Institut National Polytechnique de Lorraine (France). 2004 ;206.
2. Bashir MO. El Rahim Sorkati IA, Hassanali A. The effect of desert locust, *Schistocerca gregaria* (Forskal), on the productivity of rangeland in Red Sea coast of the Sudan and its population management through environment-friendly control tactics. In: Squire VR, Sidahmed AE, (eds.). Drylands: Sustainable use of rangeland into the twenty-first century. IFAD SERIES. Technical Reports. 1998;321-328.
3. FAO/PAM. Mission FAO/PAM d'évaluation des récoltes et des disponibilités alimentaires au Niger. Rapport Spécial; 2004.
4. Kogo SA, Krall S. Yield losses on pearl millet panicles due to grasshoppers: A new assessment method. In: Krall S, Peveling R, Ba Diallo D, (Eds). New Strategies in Locust Control. Birkhäuser, Basle, Switzerland. 1997;415-423.
5. Krall S. Importance of locusts and grasshoppers for African agriculture and methods for determining crop losses. In Krall S, Wilps H, (Eds.). New Trends in Locust Control. Schriftenreihe der GTZ 245, TZ-Verlagsgeselschaft, Germany: Rossodorf. 1994;72.
6. Lecoq M. Recent progress in Desert and Migratory Locust management in Africa. Are preventative actions possible? Journal of Orthopteran Research. 2001;10(2):277-291.
7. Römbke J, Moltmann JF. Applied Ecotoxicology. Boca Raton: CRS Press. 1996;282.
8. FAO. Evaluation des essais de terrain relatif à l'efficacité des insecticides sur les criquets et les sautériaux. Rapport de la FAO du Groupe Consultatif sur les Pesticides. Sixième réunion, Rome du 10 au 12 décembre. 1997;1996:21.
9. FAO. Evaluation of field trial data on the efficacy and selectivity of insecticides on locust and grasshoppers. Report to FAO by the Pesticide Referee Group. 7th meeting, Rome. 1998;24.
10. Bell M, Hertz-Picciotto I, Beaumont JJ. A case control study of pesticides and foetal death due to congenital anomalies. Epidemiology. 2001;12:148-156.
11. Glotfelty DE, Taylor AW, Turner BC, Zoller WH. Volatilization of surface-applied

pesticides from fallow soil. J. Agric. Food Chem. 1984;32:638-643.
12. Neueschwander P. Harnessing nature in Africa. Nature. 2004;432:801–802.
13. Taylor AW, Spencer WF. Volatilization and vapour transport processes. Pesticides in the soil environment. Soil Science Society of America Book Series, no 2, Madison, WI, USA. 1990;213-269.
14. Balança G, De Visscher M-N. Les effets des très faibles doses de fipronil sur diverses espèces de sauteriaux et d'insectes non-cibles. Résultats expérimentaux obtenus par CIRAD-GERDAT-PRIFAS au Niger (juillet à novembre 1995). Document 539. CIRAD-GERDAT-PRIFAS, France: Montpellier. 1996;71.
15. Mamadou A, Mazih A, Ghaout S, Hormatallah A. Etude de l'impact des pesticides utilisés en lutte contre le Criquet pèlerin (*Schistocerca gregaria* Forskål, 1775) (*Acrididae*: *Orthoptera*) sur deux espèces de *Prionyx* (*Hymenoptera*, *Sphecidae*) dans l'Aïr (Niger). Actes Institut Agronomique et Vétérinaire. 2005;25(1-2):59-65.
16. Peveling R, Attignon S, Langewald J, Ouambama Z. An assessment of the impact of biological and chemical grasshopper control agents on ground-dwelling arthropods in Niger based on presence/absence sampling. Crop Protection. 1999;18:323-339.
17. Peveling R, Demba SA. Toxicity and pathogenicity of *Metarhizium anisopliae* var. *acridum* (Deuteromycotina, Hyphomycetes) and fipronil to the fringe-toed lizard *Acanthodactylus dumerili* (Squamata: *Lacertidae*). Environmental Toxicology and Chimestry. *2003;*22(7):1437-1447.
18. Peveling R, McWilliam AN, Nagel P, Rasolomanana H, Raholijoana Rakotomianina L, Ravoninjatovo A, Dewhurst CF, Gibson G, Rafanomezana S, Tingle CCD. Impact of locust control on harvester termites and endemic vertebrate predators in Madagascar. Journal of Applied Ecology. 2003;40:729-741.
19. Duranton JF, Lecoq M. Le Criquet pèlerin au Sahel. Acridologie Opérationnelle nº6. 1990;83.
20. Anthelme F, Waziri-Mato M, de Boissieu D, Giazzi F. Dégradation des ressources végétales au contact des activités humaines et perspectives de conservation dans le massif de l'Aïr (Sahara, Niger). *Vertig O*. 2006;7(2):1-12.
21. Anthelme F, Michalet R, Saadou M. Positive associations involving the tussock grass *Panicum turgidum* Forssk. In the Aïr-Ténéré Réserve (Sahara, Niger). Journal of Arid Environment. 2007;68:348-362.
22. Giazzi F. Ressources Naturelles et aménagement du milieu dans le massif de l'Aïr (Niger). Actes du 6ème colloque Franco-japonais de géographie: «environnement et aménagements montagnards», Grenoble 16-20 septembre 1991, IGA. DRGA nº13. 1993;171-176.
23. Giazzi F. Etude initiale. La Réserve Naturelle Nationale de l'Aïr et du Ténéré (Niger). La connaissance des éléments du milieu naturel et humain dans le cadre d'orientations pour un aménagement et une conservation durables. Analyse Descriptive. MH/E, WWF, UICN. 1996;712.
24. UNESCO, 1996. Convention concernant la protection du Patrimoine Mondial Culturel et Naturel. Comité de Patrimoine Mondial. Dix-neuvième session, Berlin, Allemagne. 1995;124.
25. DMN. Climatologie du Niger ; 2005. [en ligne]. Available:http://www.meteo-niger.net/html/climatccl2.htm (Page consultée le 17 décembre 2006).
26. FAO. Directives sur le Criquet pèlerin. Lutte antiacridienne. 2è Edition. 2001;41.
27. Djellali H, Rouag R, Graiche H. Régime alimentaire et rythme d'activité de l'*Acanthodactylus erythrurus* (Shinz, 1835) (*Lacertidae*), au niveau du Parc National d'El Kala situé dans le nord-est algérien. *Mésogée*. 2006;62:65.
28. Stewart-Oaten A, Murdoch WW, Parker KR. Environmental impact assessment: Pseudoreplication in time? Ecology. 1986;67(4):929-940.
29. Underwood AJ. Beyond BACI: Experimental designs for detecting human environmental impacts on temporal variations in natural populations. Australian Journal of Marine and Fresh water Research. 1991;42:569-587.
30. Sokal RR, Rholf FJ. Biometry. The Principe and practice of statistics in biological research. 2nd edition. Freeman and Co. New York. 1981;859.
31. Sokal RR, Rohlf FJ. Biometry. 3rd edition. W. H. Freeman, San Francisco; 1995.
32. Henderson CF, Tilton EW. Test with acaricides against the brown wheat mite.

Journal of Economic Entomology. 1955;48:143-157.
33. Aljohany AMH, Spellerberg IF. Home range and vagility of lizards *Acanthodactylus schmidti* and *Acanthodactylus boskianus.* Saudi Arabia. Journal of Arid Environments. 1989;16:79-86.
34. Balança G. de Visscher MN. Impacts on Nontarget Insects of a New Insecticide Compound used Against Desert Locust (*Schistocerca gregaria* Forskal, 1775). Archives of Environmental Contamination and Toxicology. 1997;32:58-62.
35. Mullié WC, Keith JO. The effects of aerially applied fenitrothion and chlorpyrifos on birds in the savannah of northern Senegal. Journal of Applied Ecology. 1993;30:536-550.
36. Peveling R, Weyrich J, Müller P. Side-effects of botanicals insect growth regulators and entomopathogenic fungi on epigeal non-target arthropods in locust control. In: Krall S, Wilps H, (Eds.). New Trends in Locust Control. Schriftenreihe der GTZ 245, TZ-Verlagsgesellschaft; 1994.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sciencedomain.org/review-history.php?iid=1048&id=16&aid=9206