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A simple diet for the rearing success of the Desert Locust, *Schistocerca gregaria* (Forskål, 1775) (Orthoptera, Acrididae)

Nabil AZIZI*, Lahsen EL GHADRAOUI*, Daniel PETIT**,
Fatima FADIL* & Ahmed MOHIM***

* Faculté des Sciences et Techniques, Université Sidi Mohamed Ben Abdellah, Laboratoire de biotechnologie microbienne, BP 2202, Fès, Maroc <azizi1958@yahoo.fr>, <fatimafadil66@gmail.com>, <lahelghadraoui@yahoo.fr>
** UMR INRA 1061, Unité de Génétique moléculaire animale, Faculté des Sciences et Techniques, 123 avenue Albert Thomas, F – 87060 Limoges <daniel.petit@unilim.fr>
*** Centre National de la lutte antiacridienne, Aït-Melloul, Inezgan, Agadir, Maroc <mouhimahmed@yahoo.fr>

Summary. – The Desert Locust, *Schistocerca gregaria* (Forskål, 1775) (Orthoptera, Acrididae) is known as a very important insect pest in many countries including Morocco. As a result, it is regarded as one of the most used biological models for studying various physiology domains. In this work, we studied the effect of three types of food on nymphal development and maturation of the ovaries in adults in order to assess the most adequate trophic sources for the rearing of the locusts. The results obtained showed that a mixed diet or a monospecific diet based on turnip could be suitable as nutritive elements: they confer a fast development to nymphal life and a satisfactory oocyte maturation compared to the other studied diet types.

Résumé. – **Un régime alimentaire simple pour la réussite de l'élevage du Criquet pèlerin *Schistocerca gregaria* (Forskål, 1775) (Orthoptera, Acrididae).** Le Criquet pèlerin *Schistocerca gregaria* (Forskål, 1775) (Orthoptera, Acrididae) est un ravageur polyphage récurrent des productions agricoles et pastorales dans de nombreux pays y compris le Maroc. Vu son importance économique, il est le sujet de nombreuses recherches acridologiques. Il est considéré comme l'un des modèles biologiques les plus utilisés au laboratoire. Cependant, on ne peut réussir son élevage que par la mise en place des besoins nécessaires et de conditions bien contrôlées. Dans le présent travail, nous avons étudié l'effet de trois types du régime alimentaire sur le développement des juvéniles et la maturation des ovaires afin de chercher le régime trophique le plus adéquat pour l'élevage. Les résultats obtenus ont montré que le régime mixte et le régime monospécifique à base de navet semblent être les éléments nutritifs les plus convenables pour l'élevage du Criquet pèlerin. Ils confèrent un développement des juvéniles et une maturation des ovocytes accélérés par rapport aux autres types de régime alimentaire étudiés.

Keywords. – *Schistocerca gregaria*, food mode, nymphal development, oocytes.

The Desert Locust, *Schistocerca gregaria* (Forskål, 1775), is known as a very important insect pest in North Africa (DURANTON *et al*., 1982; SANCHEZ-ZAPATA *et al*., 2007; AMMAR *et al*., 2009). It is characterized by a phase polymorphism (UVAROV, 1921, 1966) enabling the transition from an inoffensive solitary phase to an extremely dangerous gregarious phase for the agricultural productions and pastures. The Desert Locust is perhaps the most dramatic and potentially devastating species, and can devastate the cultures of a whole continent (LECOQ & MESTRE, 1988). The expression of this behaviour, mainly due to the effect of densation, seems to be influenced by many factors including temperature, dryness, salinity of the ground, carbonic gas content, as well as the quality and the availability of the nutrients (APPERT & DEUSE, 1982; DESPLAND, 2005).

By its geographical location and its favourable climatic conditions, Morocco is regarded as one of the most exposed countries to the permanent attacks of this devastating insect that migrated from Mauritanian populations. Thus, in the last few years, thousands of hectares of cultures had been devoured and enormous quantities of pesticides were poured to fight against this acridian (CNLAA, 2005).

The food mode of Desert Locust was largely approached (TAIL, 1998; YOUSSEF, 1999; OULD EL HADJ *et al*., 2004; ABBASSI *et al*., 2005; GUENDOUZ-BENRIMA *et al*., 2010). It is

polyphagous and its food mode is much diversified, including a high number of vegetable plants (up to 400 species) belonging to numerous families (STCHERBINOVSKY, 1952). This food diversity seems to influence the physiology, fecundity, longevity as well as the duration of the development (DAJOZ, 1982; HAHN, 2005); this confers a plasticity of increased adaptation, enabling the colonization of various habitats.

Due to its economic importance, the Desert Locust remains one of the most studied locust species (DURANTON *et al*., 1982), and constitutes a choice model for experimental studies. However, the success of its rearing requires well controlled conditions, e.g. temperature, moisture, lighting. Moreover, the quality and the quantity of the nutritive needs remain one of the paramount elements for obtaining a good rearing. Indeed, the germinated corn is one of the basic elements in the maintenance of rearing at the laboratory of this insect; unfortunately, this plant presents problems of germination in summer. In this work, we searched to substitute germinated corn by an adequate food. With this intention, we studied the effect of several plants (lettuce, turnip and corn) on the nymphal development and ovary maturation of the Desert Locust.

MATERIAL AND METHODS

Species studied. – The Desert Locusts *Schistocerca gregaria* (Forskål, 1775) (Orthoptera: Acrididae: Cyrtacanthacridinae) come from a stock collected in Timzlit (22°50'N - 09°47'W). Rearing of the locusts was carried out in an insectarium regulated at 30°C, 65% relative humidity, under a 12h light / 12h dark photoperiod. A wood stick was placed under the bulb to permit the vertical movement of nymphs, to cling, moult and stand close to electric lamps to regularize their body temperature.

Plant species. – Three plants are used: lettuce (*Lactuca sativa* L., Asteraceae), turnip (*Brassica rapa* L., Brassicaceae) and germinated corn (*Triticum turgidum* L., Poaceae). These plants are cultivated in the CNLAA (Centre national de lutte anti-acridienne) in order to avoid the negative effect which could result from plants treated in the fields.

Nymphal development. – We followed the development, since the first nymphal stage until the imago, for each studied plant species. The food is given each day in limp out of plastic in complement with cereal bran. The laying resulting from massive rearing are collected and placed in a drying oven at a temperature of incubation of 33°C in order to hatch.

We put 480 nymphs of the first stage set in 12 cages at a rate of 40 individuals per cage. We have 3 cages for each of 4 food modes: germinated corn, lettuce, turnip and mixed mode (mixture of plants). The food is renewed daily, the nymphal duration and the number of deaths is recorded.

Ovarian development. – The females resulting from each food mode are taken at two different periods: 12 days after their imaginal moult and 20 days afterwards. They are dissected in order to count the ovariole number per ovary and to measure the length of primary oocytes. We used a dissection technique slightly modified from DURANTON *et al*. (1982). Briefly, it consists in killing the females by cyanide, and fixing them on Petri dishes with a parafilm solidified in the presence of physiological salt solution. The wings and the legs are cut down to facilitate handling; an abdominal opening is practised on the dorsal level, longitudinally, with fine scissors.

Statistical analyses of data were carried out using PAST vers. 1.96 (HAMMER *et al*., 2001). For variance analyses (ANOVA) and post-hoc tests of Tukey, the threshold of significance retained was 5%.

RESULTS

Nymphal development. – The duration of the nymphal development varies according to the food used (fig. 1). Thus, three types of diet, the mixed food, the food containing turnip and the food containing lettuce, allow development with intermediate duration which is respectively of 28, 29 and 33 days. In contrast, the insects consuming the germinated corns required 41 days to reach the imago stage.

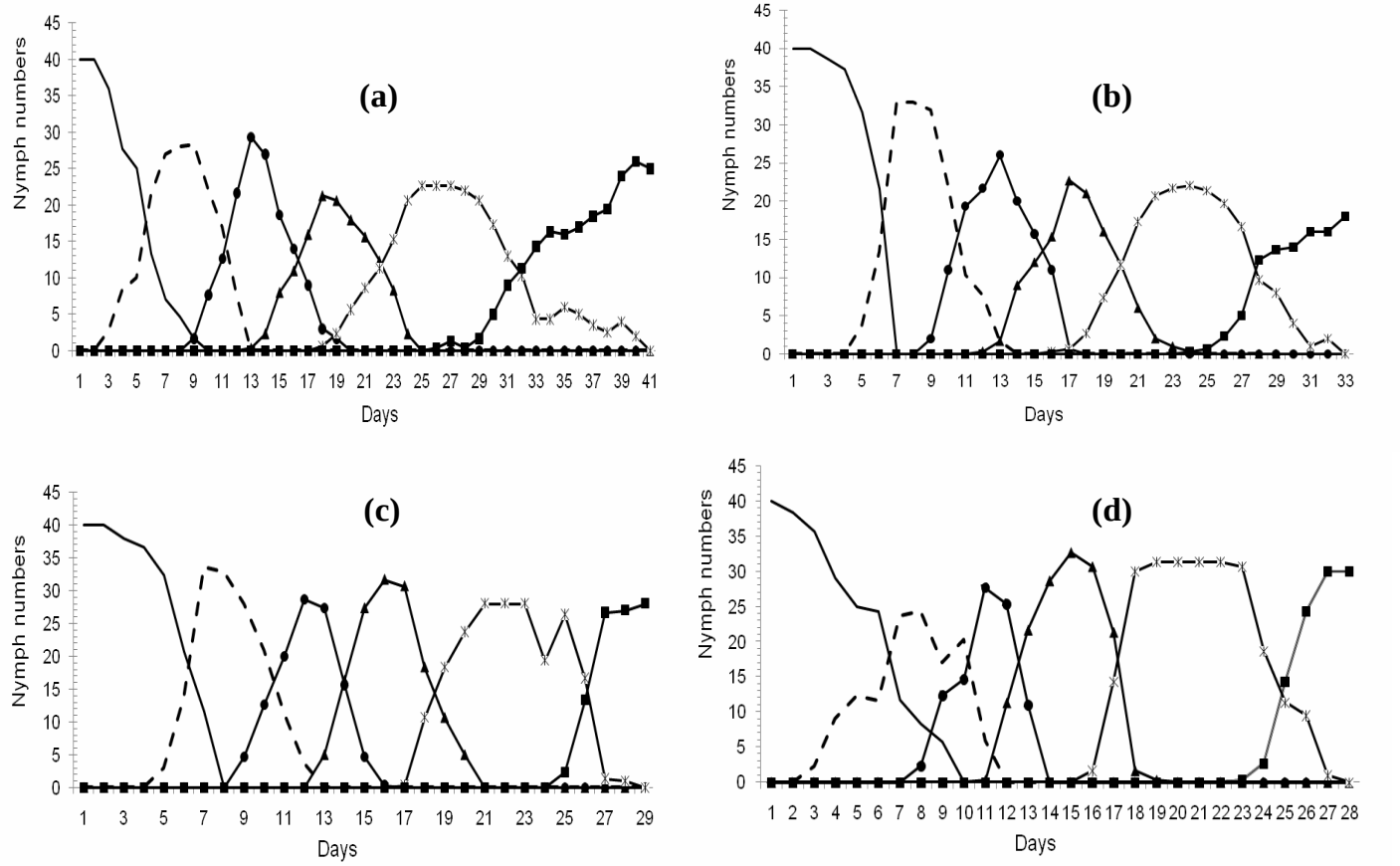

Fig. 1. – Nymphal development according to time (a: germinated corn; b: lettuce; c: turnip; d: mixed food).

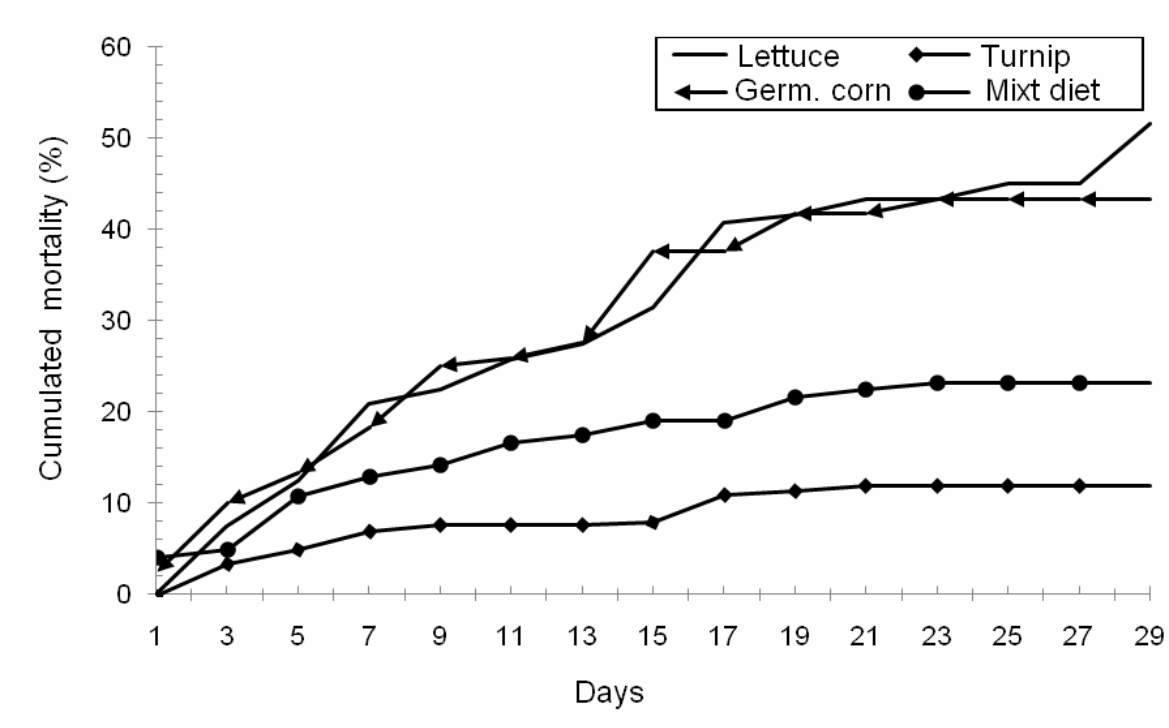

Fig. 2. – Cumulated mortality of the nymphs according to time.

Mortality of the nymphs. – The cumulated death of the individuals nourished with the various types of diet enabled us to record at the 29th day of the experiment the following values: 51.6%, 43.3%, 23.3% and 12% respectively for food containing lettuce, germinated corn, turnip and for mixed food (fig. 2). There are no significant differences between the two types of food containing lettuce or germinated corn ($p > 0.05$). In contrast, the difference is highly significant between these two diets, with that food containing turnip or mixed food ($p < 0.001$). The difference between food containing turnip or mixed food is also highly significant ($p < 0.001$). Globally, the mixed food has a cumulated death rate low compared to other types of food. It seems that the mixed food (mixture of plants) proves to be favourable for the survival of locusts in rearing in the laboratory conditions.

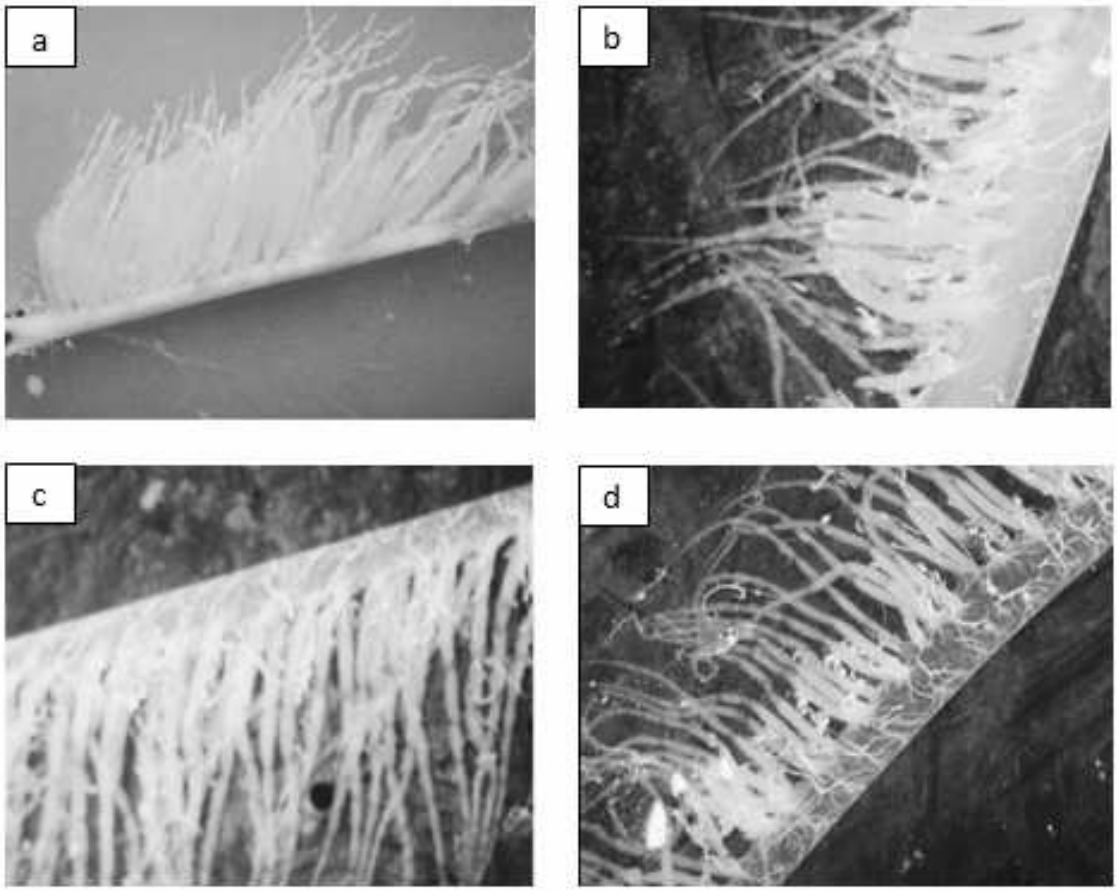

Fig. 3. – Ovaries of the females nourished with various types of food mode (a: mixed food; b: turnip; c: germinated corn; d: lettuce).

Ovarian development. – The females raised from mixed food containing three plants show a more significant development of their greasy substances compared to those nourished with other types of diet (containing turnip, lettuce or germinated corn) (fig. 3).

The number of ovarioles obtained does not show significant differences between the various food modes (table I), (ANOVA, $Fr_{(3.20)} = 2.496$, $p = 0.089$).

Table I. – Number of ovarioles according to the type of food mode (mean ± SEM).

Type of food mode	Lettuce	Turnip	Germinated corn	Mixed food
Number of ovarioles	114 ± 1.26	104.7 ± 4.27	111.3 ± 0.66	109 ± 2.17

The lengths (mean and standard deviation) of the primary oocytes in females resulting from experiment periods (12 days after imaginal moult and 20 days afterwards) are recorded in table II. These lengths vary according to the food mode. Females which are subjected to a mixed food present at the end of the 1st and 2nd period longer oocytes than individuals fed with a monospecific diet. During the second period, the females fed with turnip or mixed food have relatively comparable oocytes. In contrast, the ovariole lengths of females nourished

with lettuce or germinated corn remained lower than that measured in females fed with turnip or mixed food. It means that the accelerating effect of a mixed food is mainly pronounced during the first days after imaginal moult.

Table II. – Length of the oocytes according to the type of food mode (Tukey Test)

Type of food mode	Lettuce (N=30)	Turnip (N=30)	Germinated corn (N=30)	Mixed food (N=30)
1st Period	1.31 ± 0.03 a	1.23± 0.03 a	0.95 ± 0.02 a	2.75 ± 0.21 b***
2nd Period	2.39 ± 0.17 a	3.64 ± 0.56 ab	2.51 ± 0.14 a	4.14 ± 0.35 b**

***: significant difference with $p < 0.001$; **: significant difference with $p < 0.01$

CONCLUSION

The obtained biological cycle of studied nymphs seems similar to that noted by several authors like KARA (1997) and YOUSSEF (1999) working on Desert Locust under the same laboratory conditions. The diet type has a marked influence on the rate of nymphal survival. This effect varied according to type of food. Thus, the food containing lettuce or germinated corn allowed more than 50% nymphs to achieve the totality of their life cycle. This result is in agreement with that obtained by SEDDIK (1994) who nourished locusts with lettuce. In contrast, a food containing turnip or mixed food allowed 78% and 88% respectively of nymphs to reach adult stage.

The nymphal biological cycle lasts about 33, 29 and 28 days respectively when the studied individuals are fed with *Lactuca sativa* L., *Brassica rapa* L. or a mix containing the three species. In contrast, it requires 41 days for nymphs nourished on control food containing germinated corn. These results are close to those obtained by MEHENNI (1996) with *Schistocerca gregaria* nymphs nourished on food containing germinated corn, as they recorded a nymphal life cycle of about 49.3 days. Moreover, GHIDAOUI (1990) and OULD EL HADJ *et al*. (2004) showed that mixed food containing cabbage and grass accelerated the nymphal cycle (29.6 days) compared to food containing lemon tree (61.2 days).

In this study we also could show that the type diet of locusts seems to influence the ovarian development of females. Thus, during the first period of experiment (12 days after the imaginal moult), females subjected to mixed food present oocytes longer than those of females reared with other types of food. In the second period of experiment, females subjected to food containing turnip or mixed food (containing all studied plants), present relatively comparable sizes of oocytes.

Finally, we can conclude that a diet composed of mixed food or turnip confer a nymphal development and oocyte maturation more accelerated compared to other studied diet types. This would be explained by a high rate of water and nitrogen present in turnip, as this was shown by AZIZI *et al*. (2008). Thus, we can say that the rearing method developed in this study can lead to greater progress in the knowledge of the Desert Locust.

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