88

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FEEDING LOCUSTS ON FREEZE-DRIED PLANTS: A NEW REARING METHOD FOR HERBIVOROUS INSECTS

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The complete development and reproduction of *Locusta migratoria* was shown to occur using freeze-dried wheat seedlings as food; water being provided separately.

This method makes the rearing of locusts easier, and allows the control of water and food intake. It also makes it possible to experiment at the same time on the nutritional value of plants of different growth stages, or plants grown in different conditions.

In most laboratories, locusts are reared on fresh food, such as wheat seedlings grown on a seed-bed or with fresh cut Gramineae such as *Agropyron repens, Poa annua, Sasa japonica, Phragmites communis,* accepted by *Locusta migratoria,* or with foods such as *Brassica oleracea* and *Lactuca sativa* which may be preferred by *Schistocerca gregaria.*

For experimental purposes dry food has previously been provided for locusts, but generally for a limited time (Bernays, 1977). Powdered leaf material dried at 60°, has been added to artificial diets based on agar-agar medium (Aspirot, 1979), and completed with a balanced mixture of mineral salts, vitamins and proteins (Tira & Le Berre, 1976).

To study the nutritional value of different maize cultivars, Anglade (1962) used freeze-dried food, but soaked it before being given to caterpillars of *Sesamia nonagrioides.* In this way, complete development and reproduction were obtained.

In experiments with fresh plants, the nutrient and water contents are difficult to control since these factors change quickly in the plants and from one season to another. Moreover, the use of dried material as food is a way of knowing exactly the amount of food eaten day by day. Indeed, this method is more efficient and precise than others habitually used such as weighing fresh food and estimating the water content independently, or measuring the area missing on the leaf, (Gillon, 1970) or weighing the faeces (Louveaux, 1977).

The variation of food quality is of importance in the case of plants grown in natural conditions and the nutritional value can only be investigated if the food taken stays constant in quality during the whole period of an experiment, which can last over a month if larval and adult development are to be investigated.

For these reasons and because one of us observed African grasshoppers eating

dried material in the field, we attempted to use freeze-dried plants as food, the insects being supplied with water separately. The main point is to supply the insect with enough water. Normally, fresh food plants provide enough water for their requirements but in drought conditions some acridids have been seen, in nature, drinking free water; in laboratory rearing, locusts easily suck the wet cotton given to supply them with water. Locusts are known to drink in relation to their water requirements (Bernays, 1977).

MATERIALS AND METHODS

To test usefulness of lyophilised plants as food, we conducted experiments with *Locusta migratoria migratorioides* from Mali reared in the laboratory on their usual food, provided for 37 generations; this consists of 10 cm wheat seedlings grown on a seed-bed. Enough seedlings were lyophilised at the same time to feed 40 locusts for the whole period of the experiment. Freeze-dried wheat was kept in aluminium foil or in plastic bags in a vacuum desiccator.

Newly hatched hoppers were individually separated into two groups, one group fed on freeze-dried wheat and the other as a control, fed with young fresh wheat seedlings whose water content is about 87%. Each of these groups consisting of 15 males and 15 females was reared in a meshed cage of 3 dm^3; for fifth instars we have done individual rearings of five males and five females in meshed cages of 0,9 dm^3.

Mass and individual rearings on fresh and dry food were conducted together in the same thermoregulated cabinet at 30° with constant light and 60% r.h.

The locusts were observed from hatching to adulthood. Water was given on cotton to insects which had access to dried food. To supply enough water for a period of 24 hr, we made a watering device which consisted of a 25 ml tube filled with water, turned over to damp the cotton. The dry food was not in contact with water at any time. The control groups were supplied with freshly cut wheat seedlings which were kept fresh by watering in a tube. Fresh food, freeze-dried food and water were renewed daily.

RESULTS AND DISCUSSION

Complete development of hoppers and the reproduction of adults was possible using freeze-dried wheat seedlings as food.

To test the efficiency of such a food we controlled various parameters such as food intake, measured development length and fresh and dry weight gained, and we calculated the indices of digestibility and efficiencies from I.P.B. recommendations (Petrusewicz & MacFayden, 1970):

$$\text{Assimilation/consumption efficiency} = A/C,$$

$$\text{and Production/assimilation efficiency} = P/A.$$

These indices used also by the physiologists (Waldbauer, 1968) are then defined

TABLE I

Percentage mortality during hopper development.

		Instars					Total mortality
		I	II	III	IV	V	
Fresh wheat seedlings	15 ♂ 15 ♀	10	3	3	0	0	16.0 %
Freeze-dried wheat seedlings	15 ♂ 15 ♀	6.6	3	6.6	0	0	16.2 %

as approximate digestibility A.D. (= A/c) and efficiency of conversion of digested food to body substance E.C.D. (= P/a).

Mortality was the same on dry and fresh seedlings and mainly affected young hoppers, as is usual in rearing locusts (Table I).

Development is slightly slower with dry food. Mean duration of development of the first instar was 5.4 days on fresh wheat and 6.3 days on freeze-dried seedlings but nymphs seemed to became adapted to the dry food since development of the fifth instar was almost the same as that observed on fresh food, respectively 9.2 and 9.0 days. The adults, reared on dry food were only 3 days late after 4 weeks rearing. The total duration of development of the larvae was 25.6 days on fresh food and 28.7 on the freeze-dried food.

TABLE II

Growth of nymphs, data from individual rearings, five males, five females weighed on the day of ecdysis. Weight in mg as mean ± S.E.

		Last instar	Newly ecdysed adult			Ingestion and assimilation of food during last instar		
		fresh weight	fresh weight	dry weight	% H_2O	dry weight ingested	P/A	A/C
Fresh wheat seedlings	♂	476 ± 28	922 ± 33	221 ± 5	76.1	773 ± 27	34.6	49.1
	♀	595 ± 17	1475 ± 26	351 ± 8	76.2	1206 ± 51	47.8	43.0
Freeze-dried wheat seedlings	♂	401 ± 9	904 ± 25	247 ± 11	72.7	729 ± 28	50.3	43.9
	♀	570 ± 27	1364 ± 58	361 ± 14	73.5	1206 ± 31	49.0	41.2

$$P/A = \frac{\text{Production due to body growth}}{\text{Assimilation}} \qquad A/C = \frac{\text{Assimilation}}{\text{Consumption}}$$

All terms are expressed in dry weights.

Females laid one to five egg pods with 50-80 eggs each in both cases. They were kept for a second generation. On dry food, fertility is less but no investigations have yet been done to find the reasons for this.

Food intake is similar to the control (Table II) in spite of the modification in phagostimulation:

— The lack of the water which is considered as phagostimulant (Sinoir, 1968, Barton-Browne & Van Gerwen, 1976).

— The eventual disappearence of leaf volatiles or "green odors" (Visser & Avé, 1978).

— The clamping of enzymatic mechanisms which may act as defense in plants (Aspirot, 1979).

Utilisation of the freeze-dried food noted by the ratio A/c is not different from the controls. The ratio P/a shows that conversion of the digested food, calculated from individual data was somewhat variable, results being dissimilar in males and females.

Feeding locusts with dry food over several weeks can greatly reduce body water content of the insects and their food intake, but as they have access to free water, they can regulate their water content (Lee, 1961). Our results showed that the body water content was only 3% less for the insects fed on freeze-dried food (Table II).

In a preliminary test, supplying drinking water was found to be insufficient and resulted in cannibalism. Since locusts habitually eat small quantities of dry parts of the leaves they feed on, it seems better to provide water *ad libitum* alongside the dry food and allow the insect to regulate its water requirements.

Our water supply appeared to be almost satisfactory since the whole of the life cycle is obtained and the differences between the treatments are not very important compared to the changes we had imposed on our locusts which adapted, and perhaps selected in our rearing conditions to food with a particularly high water content. Freeze drying is the best technique to preserve the nutritive quality of the plant and it allows a quantitative control of water since it is given separately. Yet we found that a small amount of water, 1.6%, is still provided with the freeze-dried wheat because it is slightly hygroscopic.

This method shows that it is possible with such lyophilised food to control the drinking water and food intake separately, and to experiment on the nutritional value of plants in different conditions or ages. It may be possible to extend this method not only to other acridids but also to other chewing insects.

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RÉSUMÉ

ALIMENTATION DU CRIQUET SUR PLANTES LYOPHILISEES, UNE NOUVELLE METHODE D'ELEVAGE POUR LES INSECTES HERBIVORES

Pour expérimenter conjointement sur la valeur nutritive de plantes à différents stades d'évolution, il a été tenté de réaliser des élevages de *Locusta migratoria* sur nourriture lyophilisée.

La comparaison d'individus élevés depuis l'éclosion sur blé germé lyophilisé avec des individus nourris de blé germé frais montre que le dessèchement de l'aliment n'affecte guère ni le développement, ni la reproduction dans la mesure où l'eau de boisson est fournie en quantité suffisante.

Cette méthode permet en outre de mesurer la consommation et l'efficacité de conversion de la nourriture ingérée avec bien plus de précision qu'il n'était possible jusqu'ici avec des aliments frais.

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