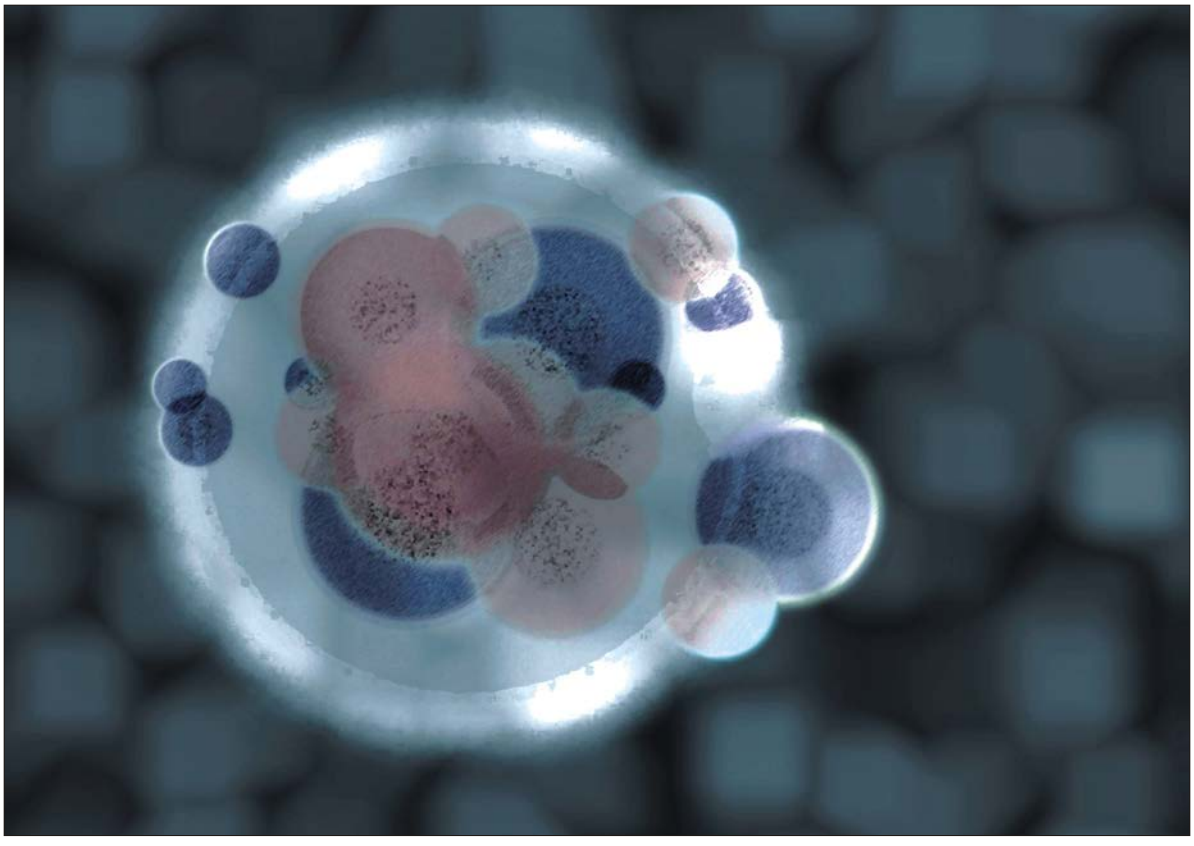

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The Effect of Food Plants on the Growth Rate, Fecundity and Survivability of Grasshopper *Hieroglyphus nigrorepletus* I. Bolivar (Orthoperta: Acrididae) a Major Paddy Pest in Pakistan

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Abstract: Present study was conducted to investigate the adaptability of the pest *H. nigrorepletus* to its host plants with reference to life history statistics under laboratory conditions. Nymphs and adults of *H. nigrorepletus* were reared on five selected host plants i.e., *Oryza sativa*, *Zea mays*, *Saccharum officinarum*, *Desmostachya bipinnata* and mixed diet. Feeding on *O. sativa* (29.85 days), *Z. mays* (30.48 days) and mixed diet (29.80 days) led to the faster development of nymphs compared to those fed on *S. officinarum* (41.85 days) and *D. bipinnata* (42.45 days). Adults laid greater number of egg-pods (3.30±1.82 and 3.30±1.50) per female and production of eggs was also high (78.30±46.19 and 78.40±33.23) on *O. sativa* and mixed diet, respectively, compared to other host plants tested. *H. nigrorepletus* showed significant differences in term of duration of life cycle, longevity and fecundity, when raised on various host plants. However, *O. sativa* and mixed diet proved to be the most suitable host compared to other host plants were tested.

Key words: *Hieroglyphus nigorepletus*, Acrididae, major pest, fecundity, survivability, host plant, life history statistics

INTRODUCTION

The acridid grasshopper *Hieroglyphus nigroreletus* I. Bolivar is reported as a major pest of rice, sugarcane, wheat, maize and as a minor pest of millets and fodder crops in Pakistan and India (Roonwal, 1978; Riffat *et al*., 2007). It was in 1949 that, this pest was reported by Bhatia (1950) to be causing extensive damage to millets in Ajmer Marwara state and in the adjoining areas of Rajastan about 75% of the village covering an area of 112.707 acres of maize and jowar in Ajmer-Marwara state was reported to be infested with this grasshopper and the loss caused by this pest was reported to be six million rupees.

Food plants are known to affect the biology and behaviour of insects including rate of growth and development, survival and fecundity and fertility (Pickford, 1962; Banjerjeet and Haque, 1985; Aslam and Whitworth, 1988). Since grasshoppers are largely phytophagous insects, there have been extensive studies on food selection in grasshoppers and these have been adequately reviewed by Uvarov (1977) and Chapman (1990). It has been reported that plant availability in a habitat is very important in establishing the diet breadth of grasshopper species. However, diet breadth is determined not only by the relative abundance of individual plant species, but also by individual plant species nutritional and pathological condition (Chapman, 1990).

According to Bailey and Mukerji (1976), an insect ability to consume a variety of food plants indicates little with regard to the ability of plants to support growth. Low digestibility of a plant may result in most of the ingested materials being voided in faeces rather than being assimilated. In other words, while a plant must be ingested before growth of the insects is possible, ingestion of the plant does not ensure growth (Fraenkel and Soo Hoo, 1966).

Therefore, the present study is an attempt to record the effects of various host plants on the life history statistics of *H. nigroreletus*. The results of such studies will be instrumental in understanding and devising population management strategies, which could help avoiding or preventing any possible future outbreak.

MATERIALS AND METHODS

Stock culture: Present study was designed to investigate the effects of various host plants on the nymphal development, fecundity and fertility of *H. nigrorepletus*. The stock culture consisted of adult specimens mostly collected from cultivated fields having rice, maize, sugarcane and other surrounding vegetation of grasses from different climatic zoon of Sindh province during months of July-September in the year 2005. It was only established to provide regular sources of nymphs and adults for the actual experiment, which was carried out

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only one generation. The insects were mass-reared in cage measuring (length 16½, width 13 ½ cm) on one selected host plant *Zea mays*. Green shoots of fresh leaves cuttings were clipped and placed into 50 mL conical flask filled with water.

The cage was kept under laboratory conditions (25°-23′N 68°-24′ E), where temperature fluctuated between the ranged of 28±2°C-39±2°C at morning 9 O'clock but, by the late afternoon the room temperature reached 30±2-41±2°C with the relative humidity ranged from about 26-51 to 28-61% during July to September. These temperature and relative humidity regimes are similar to field conditions. Eggs trays filled with fine sand then water added in ratio of 100:15 sand: water by volume to achieve humidity of 70-80% for optimum oviposition. Nymphs and adults from the egg-pods laid were also used for the subsequent experiments.

Statistics of the nymphal development: Newly emerged (vermiform larva) first instar nymphs were obtained from the stock culture and transferred into glass jars and they were introduced on different host plants such as *Oryza sativa*, *Zea mays*, *Saccharum officinarum*, *Desmostachya bipinnata*, (as single host plant with ratio of 4.64 g) and Mixed diet (combination of these all host plants with equally ratio of 0.77 g). Thus for each developmental stage at least ten specimens held individually for every host plant. Insects were reared to adult, host plant were obtained from laboratory cultivation, 3-4 weeks old leaves were used for the experiment, these immersed in water and changed daily. Developmental periods were recorded for every instar through to the adult.

Life history statistics of the adult: Newly emerged adult from the stock culture were paired (one male and one female) in glass jars filled with moist sand to one- fifth of the sand capacity to serve as oviposition medium. Ten pairs were treated individually on single host plant and mixed diet (their feeding conditions were identical than that of numphs). Adults were maintained till their death. Pre-oviposition, oviposition period, longevity of insects, egg pods per female and number of eggs per-pod and total production of eggs was recorded.

Statistical analysis: Data obtained from experimental groups were subjected to one-way analysis of variance (ANOVA) (SPSS 10.0 Soft-ware) with repeated measures and significant means were determined using Duncan's New Multiple Range Test (DNMRT).

RESULTS

Nymphal development: It seems from the Table 1 that as in the first instars of *H. nigroreplretus*, while feeding on the *Z. mays* and mixed diet led to the fastest development and was comparable to the stadia of nymphs fed on *D. bipinnata* however, developmental period of numphs are almost similar when feeding was on *O. sativa* and *S. officinarum* as single host plant. In the second instar, developmental period of nymphs was prolonged when feeding was on *D. bipinnata* and *S. officinarum* but there was no significantly different in the nymphal duration of hoppers either reared on *O. sativa*, *Z. mays* and mixed diet it taken almost equal time to moult in next stage. In third instar, feeding on mixed diet led to a significantly shorter stadium followed by nymphs fed on *O. sativa*. There was no significant difference in the nymphal development of instars when feeding was on *D. bipinnata*, *S. officinarum* and *Z. mays*.

In the forth instar, feeding on *D. bipinnata* and *S. officinarum* led to prolonged developmental period than nymphs were reared on *O. sativa* and mixed diet followed by *Z. mays*. While in the fifth instar, nymphs complete their development earlier when fed on *O. sativa* which is high significant among the nymphs fed on *S. officinarum* and *D. bipinnata*. The developmental period also differ significantly among nymphs fed on mixed diet and *Z. mays*. In the sixth instar, the developmental period did not differ significantly among nymphs fed on either *O. sativa* or *Z. mays* than nymphs fed on mixed diet but, it was significantly longer in nymphs fed on *S. officinarum* and *D. bipinnata*.

Summing up these findings, it is suggested that in the mean total developmental period no significant differences were observed among nymphs that fed on *O. sativa*, *Z. mays*, *D. bipinnata* and mixed diet. Average duration for nymphal development was found similar on

Table 1: The effects of host plants on nymphal development period of *H. nigrorepletus*

	Mean developmental period of instar in days (Mean±SD)							
Treatments	I	II	III	IV	V	VI	Average duration	Total period
O. sativa	5.05±0.91^{a}	5.35±1.34^{a}	4.95±1.34^{a}	5.10±1.27^{a}	4.45±1.48^{a}	4.95±1.48^{a}	4.97±0.54^{b}	29.85^{a}
Z. mays	4.37±0.0^{b}	5.02±0.14^{a}	5.73±0.05^{b}	4.79±1.20^{b}	5.64±0.38^{c}	4.92±0.82^{a}	5.07±0.47^{b}	30.48^{b}
S. officinarum	4.85±0.77^{a}	7.35±1.34^{b}	6.10±0.84^{c}	6.05±1.20^{c}	8.55±1.90^{d}	8.95±2.19^{c}	6.97±1.71^{c}	41.85^{c}
D. bipinnata	6.00±0.70^{c}	8.50±1.41^{c}	6.25±0.91^{c}	6.20±0.70^{c}	7.7±1.27^{d}	7.8±1.27^{c}	4.96±0.89^{a}	42.45^{c}
Mixed diet	4.40±0.84^{b}	5.45±1.76^{a}	4.15±0.49^{a}	4.90±1.23^{a}	4.9±1.13^{b}	6.0±1.69^{b}	4.96±0.67^{a}	29.80^{a}
$F_{(0.05)}$	$_{(4.93)}$ 09.60*	$_{(6.33)}$ 11.34^{ns}	$_{(5.43)}$ 09.42^{ns}	$_{(5.40)}$ 09.42^{ns}	$_{(6.52)}$ 13.09^{ns}	$_{(5.80)}$ 11.34^{ns}	$_{(5.80)}$ 11.34^{ns}	$_{(34.88)}$61.96^{ns}

Mean in the same column followed by the same letter(s) are not significantly different from one another at 5% level of probability (DNMRT), ns = Not Significant p≥0.05

Table 2: The effect of various host plants on the life history in adults *H. nigrorepletus*

Treatments	Pre-oviposition period (Days) (Mean±SD)	Oviposition period (Days) (Mean±SD)	Longevity (Days) (Mean±SD)	Pods per female	Eggs per pod	Total eggs during enter life
O. sativa	4.30±1.33^{a}	26.10±7.97^{d}	36.90±10.37^{c}	3.30±1.82^{c}	24.84±7.14^{d}	78.30±46.19^{d}
Z. mays	6.30±1.23^{c}	21.06±8.50^{b}	35.93±16.48^{c}	3.60±1.40^{b}	23.64±7.71^{c}	58.23±1.22^{c}
S. officinarum	6.70±1.15^{d}	18.30±9.0^{a}	26.60±5.60^{a}	2.60±1.17^{a}	14.42±5.02^{a}	37.00±14.71^{a}
D. bipinnata	5.90±1.19^{c}	18.90±4.86^{a}	29.30±11.19^{b}	2.70±0.94^{a}	18.07±5.16^{b}	48.90±12.27^{b}
Mixed diet	4.80±1.54^{b}	24.30±6.53^{c}	46.80±7.08^{d}	3.30±1.56^{b}	23.84±8.62^{c}	78.40±33.23^{d}
$F_{(0.05)}$	$_{(5.6)}$ 11.34*	$_{(21.73)}$ 39.27*	$_{(35.10)}$ 61.96*	$_{(3.1)}$ 06.11^{ns}	$_{(20.96)}$ 37.52*	$_{(60.16)}$ 05.59^{ns}

Means in the same column followed by the same letter(s) are not significantly different from one another at 5% level of probability (DNMRT), ns = Not Significant p= 0.05

these four host plants but, *S. officinarum* led to prolonged developmental period. Total nymphal period showed that hoppers complete their development in significantly shorter period when feeding was on *O. sativa* and mixed diet as single host plant.

Life history statistics: Table 2 showed that shorter pre-oviposition period was recorded in the adults of *H. nigrorepletus* while fed on *O. sativa* followed by adults kept on mixed diet took (2 days) more. The prolonged pre-oviposition period was calculated in the adults fed on *S. officinarum* compared with the adults fed on *Z. mays* and *D. bipinnata*. Similarly feeding on the *O. sativa* led to the prolonged oviposition period about (26.10±7.97 days) followed by adults fed on *Z. mays* and mixed diet while it was significantly reduced when adults fed on *S. officinarum* and *D. bipinnata*. This suggested that adult females lived longer when fed on the mixed diet comparable with the adult females housed on the *O. sativa* and *Z. mays*. The longevity of females fed on the *D. bipinnata* was significantly different from those fed on *S. officinarum*. Adult fed on *Z. mays* laid the greater number of egg-pods (3.60±1.40) than adults fed on *O. sativa* and mixed diet. However, the least number of egg-pods laid by females fed on *S. officinarum* and *D. bipinnata*. The mean number of eggs per pod was maximum in the adults grow on *O. sativa*. Adults fed on *Z. mays* and mixed diet followed this. The least number of eggs per pod laid by female fed on *S. officinarum* than that of females fed on *D. bipinnata*. The total eggs production by per female during entire life was greater in the adults fed on *O. sativa* and mixed diet (78.30) and (78.40), respectively than that of adults fed on *Z. mays* (58.23) *S. officinarum* (37.0) and *D. bipinnata* (48.9).

DISCUSSION

The experiment involving rearing of *H. nigrorepletus* on various host plants presented singly or as mixed diet, clearly shows that the type of food plant can significantly affect the development of insect. For a single host plant, feeding on *O. sativa* resulted in the shortest nymphal development for the 5th nymphal instar, while feeding on *Z. mays* and mixed diet similarly gave the shortest nymphal development period for the 1st and 3rd instars. Contrary to this, *D. bipinnata* led to the prolonged nymphal development for 2nd, 5 and 6th instars. Thus, variable developmental period could occur in nature, depending on the preponderance of particular food plants in various localities (Nzekwu and Akingbohungbe, 2002). However, in localities where mixed population of food plants these can sever as complements to one another.

McFarlane and Thorsteinson (1980) reported that mixed plant diets are superior for *Melanoplus bivittatus* (Say), by promoting higher survival larger adults and higher growth indices than any single plant diet. Adams and Bernays (1978) had earlier shown that a range of chemicals having antifeedant properties of nymphs of *Locusta migratoria* (L.) is additive in its effects. However, Bernays and Bright (1991) provide evidence that individual polyphagous grasshoppers do switch more between dietary items and mix intake more on two different complementary foods, than when the two foods are nutritionally adequate and identical. Fanny *et al.* (1999) found that in *Orya nitidula* (Walker), the shortest nymphal periods were obtained when rearing was on *Panicum maximum*. Adequate diet is expected to reduce nymphal developmental period, which is very important for the fitness and survival of insects (Price *et al.*, 1980).

Experimental results showed that in adults, feeding on the single host plant i.e., *O. sativa* and Mixed diet led to a shorter pre-oviposition period than when feeding was on *S. officinarum*, *Z. mays* and *D. bipinnata*. This suggests that the former plants have qualities that enable them to promote faster maturation and oocyte development. The mean number of pods per female was highest when the adult females were fed on *Z. mays*. Lee and Wong (1978) demonstrated that food plants have significant effects on oocyte development in *Oxya japonica* Willemse, related to the nutritional requirements of the insect as well as the chemical composition and amount of food ingested.

Correct nutrient levels of food play a vital role which triggers the activity in endocrine system for oocyte development. It is generally supposed that the activity

with in the endocrine system is generated by the +stimulation of foregut stretch receptors during increased feeding (Hill *et al*., 1966) during somatic growth fairly large amount of food are ingested in order that fat may develop to a point at which vitellogenic protein synthesis can begin (Mordue and Hill, 1970). Therefore, the optimal amount and quality of food are necessary pre-requisites for the development and production of eggs. McCaffery (1975) reported that ingestion of less than 80 mg dry weight of grass per female per day is insufficient to initiate oocyte development in locusts whose somatic growth was normal.

The total number of eggs per female was greater when the grasshoppers were fed on *O. sativa* and mixed diet, indicating improved fertility on *O. sativa* and mixed diet. This shows that the overall nutritional value of the *O. sativa* and mixed diet in term of adult's fertility, is superior to that of single host plants.

Significant differences in pre-oviposition, oviposition and post-oviposition period observed in present study might be due to qualitative as well as quantitative differences of food plants used in this investigation. *H. nigrorepletus* feeding on host plants poor in nutritive value might have delayed the oocyte development resulting in prolongation of pre-oviposition period. The results of present study are correlated with the findings of McCaffery (1975), McCaffery and Hook (1978) and Ullah and Pfadt (1985).

It may be concluded that in *H. nigrorepletus*, while *O. sativa* and mixed diet are highly favored for optimum nymphal development and higher fertility certain single host plants could adequately promote adult maturation and egg-pod production. However, in nature, selection pressure may favor habitats with mixed host plants, since these will ensure adequate nutritional requirements for the development and survival of the nymph, a stage that is regarded as the most important with respect to population regulation among grasshoppers (Joern and Gaines, 1990; Lockwood, 1993).

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REFERENCES

Adams, C.M. and E.A. Bernays, 1978. The effects of combinations of deterrents on the feeding behaviour of *Locusta migratoria*. Entomol. Exp. Applic., 23: 101-102.

Aslam, M. and R.J. Whiteworth, 1988. Development of the southwestern corn borer *Diatraea grandiasella* Dyar on corn and Johnson grass. Southwest Entomol., 13: 191-198.

Bailey, C.G. and M.K. Mukerji, 1976. Consumption and utilization of various host plants by *Melanoplus bivittatus* (Say.) and *M. femurrubrum* (De Gree) (Orthoptera: Acrididae). Can. J. Zool., 54: 1044-1050.

Banjerjeet, C. and N. Haque, 1985. Influence of host plants on development, fecundity and egg hatchability of the arehitiid moth, *Diacrisia casignata*. Entomol. Exp. Applic., 37: 193-198.

Bhatia, G.H., 1950. Plant protection work in Ajmer-Merwara in 1948. Insect pests Plant Prot. Bull., New Delhi 1, 1: 19-20.

Bernays, E.A. and K.L. Bright, 1991. Dietary mixing in grasshoppers. Switching induced by dietary imbalances in foods. Entomol. Exp. Applic., 61: 247.

Chapman, R.F., 1990. Food Selection. In: Biology of Grasshopper. Chapman, R.F. and A. Joern (Eds.), John Wiley and Sons, New York, pp: 39-72.

Fanny, P., T. Ravikumar, M.C. Muralirangan and K.P. Sanjayan, 1999. Influence of host plants on the duration of post-embryologic development and food utilization of *Oxya nitidula* (Walker) (Orthoptera: Acrididae). J. Ortho. Res., 8: 119-124.

Fraenkel, G. and C.F. Soo Hoo, 1966. The selection of food plants in a polyphagous insect, *Prodenia eridania* (G.). J. Insect. Physiol., 12: 693-709.

Hill, L., W. Mordue and K.C. Highnam, 1966. The endocrine system, frontal ganglion and feeding during maturation in the female desert locust. J. Insect. Physiol., 12: 1197-1208.

Joern, A. and S.B. Gaines, 1990. Population Dynamics and Regulation in Grasshoppers. In: Biology of Grasshoppers. Chapman, R.F. and A. Joern (Eds.), John Wiley and Sons, New York, pp: 415-482.

Lee, S.S. and I.M. Wong, 1978. The relationship between food plants, haemolymph protein and ovarian development *Oxya japonica* Willemse (Orthoptera: Acrididae). Acrida, 8: 1-8.

Lockwood, J.A., 1993. Enviromental issue involved in biological control of rangeland grasshoppers (Orthoptera: Acrididae) with exotic agents. Environ. Entomol., 22: 503-518.

McCaffery, A.R., 1975. Food quality and quantity in relation to *Locusta migratoria migratorioidae*. J. Insect. Physiol., 21: 1551-1558.

McCaffery, A.R. and A.G. Cook, 1978. Utilization of food by *Zonocerus variegates* L. (Orthoptera: Pyrogomorphidae). Bull. Entomol. Res., 68: 589-606.

McFarlane, J.H. and A.J. Thorsteinson, 1980. Develompent survival of the two striped grasshopper *Melanoplus bivittatus* (Say) (Orthoptera: Acrididae) on various single and multiple plant diet. Acrida, 9: 63-76.

Mordue, A.J. and L. Hill, 1970. The utilization of food by the adult female desert locust, *Schistocerca gregaria*. Entomol. Exp. Applic., 13: 352-358.

Nzekwu, A.N. and A.E. Akingbohungbe, 2002. The effects of various host plants on nymphal development and egg production in *Oedaleus nigeriensis* Uvarov (Orthoptera: Acrididae) J. Ortho. Res., 11: 185-188.

Pickford, R., 1962.Develompent survival and reproductive of *Melanoplus bilituratus* (Wlk.) (Orthoptera: Acrodoidea) reared on various food plants. Can. J. Entomol., 94: 859-869.

Price, P.W., C.E. Bouton, P. Gross, B.A. Mcpherson, J.N. Thompson and A.E. Weis, 1980. Interaction among three tropical levels: Influence of plants on interaction between insect herbivores and natural enemies. Ann. Rev. Entomol. Syst., 11: 41-65.

Riffat, S., M.S. Wagan and S. Naheed, 2007. Distribution of *Hieroglyphus nigrorepletus* (Bolivar, 1912) (Hemiacridinae: Acrididae: Orthoptera) in various province of Pakistan. Int. J. Agric. Biol., 9: 199-201.

Roonwal, M.L., 1978. The phadka grasshopper and its control. Indian Farming, 27: 3-6.

Ullah, M. and R.E. Pfadt, 1985. Rearing of *Ageneotettix deorum* (Scudder) (Acrodoidea: Orthoptera) on diet of different combinations under laboratory conditions. Sarhad J. Agric., 1: 217-221.

Uvarov, B.P., 1977. Grasshoppers and Locust: A hand book of General Acridology Behaviour, Ecology, Biogeography and Population dynamics. Centre for Overseas Pest Research London, 2: 1-613.