

Host preferences of some acridids (Insecta: Orthoptera) in relation to some biochemical parameters

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MS received 9 October 1986

Abstract. Biochemical analysis of host plants of 6 species of acridids for their total protein, carbohydrates, phenols, free aminoacids, water and nitrogen content revealed significant correlation in regard to their host preferences, wherein the leaf water-nitrogen index as well as the total phenol composition appeared to play an important role.

Keywords. Biochemical parameters; host preferences; acridids.

1. Introduction

The presence or absence of phagostimulants/deterrents in the right proportion to facilitate optimal food utilization is of significance in host selection in acridids (Mulkern 1967). Less preferred/non-host plants exhibit varied resistance mechanisms in terms of such chemical parameters as their total nitrogen, protein, aminoacids and phenols (Chapman and Bernays 1977; Miller and Strickler 1984). Specialist and generalist feeders are equally common among acridids, some exclusively graminaceous feeders, others only on dicots and yet others on both (mixed feeders). In terms of the quantitative intake of leaves which influences the biotic potential of the insect (Ananthakrishnan *et al* 1985a, b), an analysis of the chemical factors of the host plants appear relevant for a basic understanding of the nature of host preferences of such acridids as *Oxya nitidula* (Walker) (Oxyinae), *Truxalis indica* Boliver (Truxallinae), *Orthacris maindroni* Boliver (Pyrgomorphidae), *Atractomorpha crenulata* (Fabricius) (Pyrgomorphidae), *Aiolopus thalassinus* (Fabricius) (Oedipodinae) and *Cyrtacanthacris ranacea* Stoll (Cyrtacanthacridinae).

2. Materials and methods

Different species of acridids were collected from the fields of *Oryza sativa*, *Panicum maximum* and *Gossypium hirsutum* and mass reared in the laboratory on the various host plants in wooden cages measuring 25 × 25 × 30 cm. The duration of development of the acridids on the various host plants was observed and this was taken as an index for the host preferences of the species.

The host leaves were subjected to biochemical estimation for the total proteins (Lowry *et al* 1951), carbohydrates (Dubois *et al* 1965), nitrogen (Vogel 1963), phenol (Hori 1974) and total free amino acids (Moore and Stein 1948). The moisture content was estimated by weighing accurately 2 g of the sample and incubating at 37°C till a constant weight was obtained. The difference in weight was calculated and the moisture content represented as percentage.

3. Results

Food preference in terms of the rate of development on various host plants indicated faster development when reared on the preferred host, the quickest rate being that of *A. crenulata* when fed on *Ricinus communis* (37.7 ± 5.9 days), and the slowest when fed on *Solanum torvum* (99.4 ± 10.7 days). In the case of *O. maindroni* the longest nymphal duration was observed when fed on *Clerodendron* sp and shortest on *Dolichos lablab*. Faster post embryonic development of *C. ranacea* occurred when fed on *Gossypium hirsutum* (50.0 ± 0.94 days) as against the malvaceous weed *Abutilon indicum* (62.0 ± 1.66 days). *Panicum maximum* appeared to facilitate faster nymphal development of *Aiolopus thalassinus* and *T. indica* and *Cyperus rotundus* for *O. nitidula* (Ananthkrishnan *et al* 1985a,b).

O. nitidula feeds on poaceous and cyperaceous weeds and graminaceous crops avoiding dicotyledons. Likewise, *Truxalis indica* and *A. thalassinus* feed exclusively on graminaceous plants, whereas *A. crenulata* is a mixed feeder, feeding both on monocots and dicots. *C. ranacea* was observed to have a comparatively narrow feeding range, specifically confined to feeding on malvaceous plants thereby earning the 'specialist' status. Individuals of *O. maindroni* feed on a wide spectrum of dicots exhibiting greater preference towards *R. communis* and to a lesser extent on *D. lablab*.

Quantitative biochemical analysis of the leaves of the host plants in terms of water, nitrogen, proteins, carbohydrates, aminoacids, phenols and silica content revealed striking correlation with the food preference of these acridid species (table 1). Acridids feeding exclusively on monocots generally preferred host with low water content with the exception of *A. thalassinus*. The dicot as well as mixed feeders preferred hosts with high water content. An estimation of the water content of the host plants of *O. nitidula* indicated that *P. maximum*, one of the natural hosts with higher water content (77.29%) to be the least preferred. Though the water content of *C. rotundus* was less than that of *P. maximum*, the leaves of the former were readily consumed by all the stages of *O. nitidula*. Although the percentage of water in *O. sativa* (60.77%) and *C. dactylon* (61.97%) was nearly the same, *C. dactylon* was preferred to *O. sativa*, presumably due to the effect of the other chemical stimulants of the host. Similarly for *T. indica*, the most preferred host *C. dactylon* had a lesser water content. *A. crenulata* and *O. maindroni* preferred *D. lablab* with a higher water content (83%). For the specialist, *C. ranacea*, *Abelmoschus esculentus* with a higher water content (80.49%) was preferred less to *G. hirsutum*. Although the susceptibility of the host to insect attack is known to depend on the nitrogen content of the plant, the water-nitrogen ratio provided a better insight of the resistance of plants to acridids, showing a distinct correlation of their relative preference with the water-nitrogen index of the host, preferring the host with a low index. However, the mixed feeder, *A. crenulata* and *T. indica* preferred hosts with a high water-nitrogen index (figure 1).

As the total free amino acid content of the monocots is quantitatively lower than the dicots, an analysis of the comparative feeding preferences of the acridids indicated a preference for plants with higher amino acid content. The monocot feeding acridids generally showed a greater preference for feeding on higher amino acid content plants. All the acridids studied here appeared to show greater preference to leaves with high carbohydrate content, proteins being generally known to be essential for the growth and development of the insect. A comparative assessment of

Table 1. Chemical composition of different acridid host leaves.

Host	Proteins (mg/g)	Carbohydrates (mg/g)	Phenols (mg/g)	Amino acids (mg/g)	Nitrogen (%)	Water (%)	Water/N ₂
1. <i>Cyperus rotundus</i>	42.00	193.0	73.5	0.190	6.72	71.74	10.67
2. <i>Cynodon dactylon</i>	55.50	586.0	102.0	0.124	8.88	61.97	6.97
3. <i>Panicum maximum</i>	159.00	586.0	160.5	0.140	25.44	77.29	3.04
4. <i>Oryza sativa</i>	63.00	248.0	106.5	0.102	10.08	60.77	6.03
5. <i>Gossypium hirsutum</i>	55.00	440.0	232.5	0.152	8.80	73.16	8.31
6. <i>Abelmoschus esculentus</i>	12.50	515.0	245.0	0.240	2.00	80.49	40.24
7. <i>Abutilon indicum</i>	35.00	407.5	165.0	0.220	5.60	69.50	12.41
8. <i>Sida rhomboides</i>	97.50	302.5	245.0	0.092	15.60	46.36	2.97
9. <i>Ricinus communis</i>	68.00	200.0	38.0	0.464	10.88	75.00	6.89
10. <i>Arachis hypogaea</i>	92.39	17.0	24.0	0.365	14.78	72.00	4.87
11. <i>Solanum torrayi</i>	163.04	44.0	20.5	0.256	26.08	77.00	2.95
12. <i>Calotropis gigantea</i>	259.33	12.5	22.0	0.120	41.49	88.00	2.12
13. <i>Dolichos lablab</i>	189.53	275.0	55.0	0.345	31.76	83.00	2.61
14. <i>Clerodendron</i> sp.	80.00	425.0	85.0	0.158	12.80	80.00	6.25

1-4, Hosts of *O. nitidularis*; 5-8, Hosts of *C. ramaeae*; 1-3, Hosts of *T. indica*; 1-3, Hosts of *A. thalassinus*; 3, 9-11, Hosts of *A. crenulata*; 9, 12-14, Hosts of *O. maindromi*.

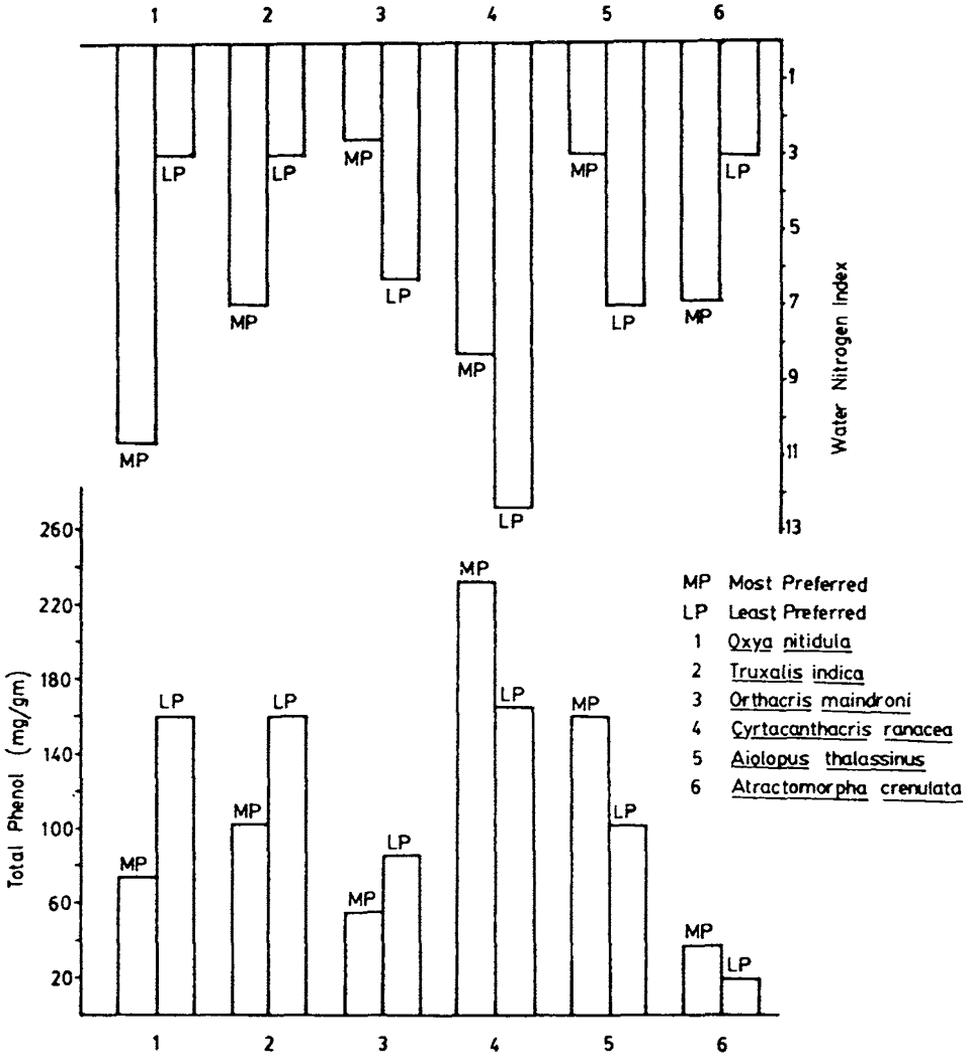


Figure 1. Comparative preference of different acridid species in relation to total phenols and water-nitrogen index of host plants.

the host plants for the total protein content indicated that the mixed as well as dicot feeders preferred hosts with high proteins, even though the monocots feeders were capable of thriving on plants with low protein content. The phenolic compounds are considered to act as deterrents to feeding in grasshoppers is evident in that the most preferred host plants of *O. nitidula*, *A. crenulata* and *O. maindroni* seemed to have a lesser phenol content as compared with the lesser preferred hosts (figure 1). *G. hirsutum*, the preferred host of *C. ranacea* has a less phenol content (232.5 mg/g) in comparison to *A. esculentus* (245.0 mg/g). However, a reverse trend was observed in the case of *A. thalassinus* and *T. indica*, which preferred hosts with higher phenol

content and this is presumably be due to their capacity to convert phenols into phenylalanine as proposed for *Schistocerca gregaria* by Bernays and Woodhead (1982).

4. Discussion

The choice of plants by the acridids seem to reveal that these may be based on the absence of feeding deterrents or their presence in smaller amounts in the host plants. For instance *O. nitidula* totally rejected all forbes, perhaps due to the presence of one or more compound deterrent to the graminivore (Bernays and Chapman 1977). General selection of food by an adult acridid appears to have a greater chemical basis (Bernays and Chapman 1970). *O. nitidula*, *T. indica* and *A. thalassinus* are found to select and feed constantly on the monocots only. This is possibly due to the favourable sensory inputs from the sensilla of the mouth parts and preoral cavity (Haskell and Schoonhoven 1969). Though the feeding activity could be initiated by the sensory receptors of the insect, the activation of these receptors requires a stimulatory factor to evoke normal feeding behaviour. The leaf surface chemicals play an important role in determining the feeding activity and acridids have been known to identify the phagostimulatory ones from the deterrents by palpation and recognise the leaf form from the leaf surface attributes (Chapman 1977).

Some hosts are rejected because of the presence of chemicals deterrent to feeding and such deterrent chemicals seem to play an important role in the feeding behaviour of acridids. Further, some secondary compounds that are deterrent for *Locusta* are ineffective for *Schistocerca* and some which are deterrent at high concentrations stimulate feeding at lower concentrations (Bernays and Chapman 1978). The substances which may stimulate feeding are specific and the occurrence of suitable phagostimulants may, in part, effect feeding. Some amino acids (proline and serine), hexose sugar and disaccharides are found to be phagostimulatory for *L. migratoria* (Cook 1977). Acridid species have evolved a diversity to recognise only small number of phagostimulants rather than a large number of feeding inhibitors. Hence feeding depends on the balance between the phagostimulants and the feeding deterrents and the response varies in different species so that a plant may be acceptable to some, but not to other species, or the rejection of hosts by these insects may be owing to the presence of one or more chemicals in amounts which inhibit feeding; some host plants are accepted only because of the absence of deterrent chemicals in sufficient quantities to limit feeding (Bernays and Chapman 1977; Bernays 1978).

Acridids are generally observed to take larger meal on lush grass with high water content (Chapman and Bernays 1977). Although Bernays and Chapman (1970) felt that moisture content may not play any part in the food selection of *Chortippus parallelus*, it cannot be ignored in the acridids studied here as the food plant provide water in excess of the requirements of the insect. Scriber (1984) suggested that the post ingestional growth performance in phytophagous insects is determined to a large extent by plant chemical quality and can be indexed by leaf water-nitrogen composition. All the acridids studied here appeared to show greater preference for host plants with low water-nitrogen index.

Total phenol content of the host plant appears to interfere with the food selection of the acridids. The high phenol content makes *D. lablab*, the least palatable, while

R. communis with least phenol content is most preferred for *A. crenulata*. The feeding preferences of *C. ranacea* only attest the fact that food selection depends not so much on specific phagostimulants in the acceptable plants as in the presence of inhibitory chemicals in the non-acceptable plants (Thorsteinson 1960). A very high concentration of sugar usually limits the amount of food taken (Cook 1977). However, *A. crenulata*, *O. maindroni* and *T. indica* appear to show greater preference for host with high sugar content. Hence, food selection of these acridids presumably involves, besides many physical and chemical factors, the balance between deterrent chemical and phagostimulants (Chapman and Bernays 1977), the inhibitory factors very often overriding the stimulatory ones.

Acknowledgement

This work was supported by a grant from the Department of Science and Technology, New Delhi.

References

- Ananthkrishnan T N, Dhileepan K and Padmanaban B 1985a Behavioural responses in terms of feeding and reproduction in some grasshoppers (Orthoptera: Insecta); *Proc. Indian Acad. Sci. (Anim. Sci.)* **94** 443-461
- Ananthkrishnan T N, Sanjayan K P and Suresh Kumar N 1985b Host plant preferences in *Cyrtacanthacris ranacea* Stoll in some malvaceous hosts in terms of food utilization; *Proc. Indian Natl. Sci. Acad.* (in press)
- Bernays E A 1978 Tanin—an alternative view point; *Entomol. Exp. Appl.* **24** 244-253
- Bernays E A and Chapman R F 1970 Food selection by *Chorthippus parallelus* (Zetterstedt) (Orthoptera: Acrididae) in the field; *J. Anim. Ecol.* **39** 383-394
- Bernays E A and Chapman R F 1977 Deterrent chemicals as a basis of oligophagy in *Locusta migratoria* (L); *Ecol. Entomol.* **2** 1-18
- Bernays E A and Chapman R F 1978 Plant chemistry and acridid feeding behaviour; in *Biochemical aspects of plant and animal co-evolution* (ed) Harbone (Academic Press) pp 99-141
- Bernays E A and Woodhead S 1982 Plant phenols utilized as nutrients by a phytophagous insect; *Science* **216** 201-203
- Chapman R F 1964 The structure and wear of the mandibles in some African grasshoppers; *Proc. Zool. Soc. London* **142** 107-121
- Chapman R F 1977 The role of the leaf surface in food selection by acridids and other insects; *Colloq. Int. C. N. R. S.* **265** 133-149
- Chapman R F and Bernays E A 1977 The chemical resistance of plants to insect attack; *Pontif. Acad. Sci. Script. Varia* **41** 603-643
- Cook A G 1977 Nutrient chemicals as phagostimulant for *Locusta migratoria* (L); *Ecol. Entomol.* **2** 113-121
- Dubois M, Gilles K A, Hamilton J K, Rebers P A and Smith F 1956 Colorimetric determination of sugars and related substances; *Anal. Chem.* **28** 351-356
- Haskell P T and Schoonhoven L M 1969 The function of certain mouthparts receptors in relation to feeding in *Schistocerca gregaria* and *Locusta migratoria migratoria*; *Entomol. Exp. Appl.* **12** 423-440
- Hori K 1974 Studies on the feeding habits of *Lygus disponsi* Linn (Hemiptera: Miridae) and the injury to its host plant. V. Phenolic compounds, acid phosphatase and oxidative enzymes in artificially infested tissues of sugar beet leaf; *Appl. Entomol. Zool.* **9** 225-230
- Lowry O H, Rosebrough N J, Farr A L and Randall R J 1951 Protein measurements with Folin Phenol reagent; *J. Biol. Chem.* **193** 265-275
- Miller J R and Strickler K L 1984 Finding and Accepting host plants; in *Chemical Ecology of Insects* (ed) W J Bell and R T Carde (London: Chapman and Hall Ltd) pp 127-157

- Moore S and Stein W H 1948 Photometric ninhydrin method for use in chromatography of amino acid; *J. Biol. Chem.* **176** 367–388
- Mulkern G B 1967 Food selection by grasshoppers; *Annu. Rev. Entomol.* **12** 509–523
- Scriber J M 1984 Plant-herbivore relationships: Host plant acceptability; in *The Chemical Ecology of Insects* (ed) W Bell and R Cardé (London: Chapman and Hall Ltd) pp 159–202
- Thorsteinson A J 1960 Host selection in phytophagous insects; *Annu. Rev. Entomol.* **5** 193–218
- Vogel I A 1963 Determination of nitrogen by Kjeldahl's method; in *A text book of quantitative inorganic analysis including elementary instrumental analysis*, (ed) I A Vogel (London: ELBS) pp 256–257