

## Effects of diet on longevity and fecundity of the spined stilt bug, *Jalysus wickhami*

D. Michael Jackson<sup>1</sup> & Karen M. Kester<sup>2</sup>

<sup>1</sup>USDA, ARS Crops Research Laboratory, Oxford, NC 27565

Present address: USDA, ARS, U.S. Vegetable Laboratory, 2875 Savannah Highway, Charleston, SC 29414, USA

<sup>2</sup>Department of Entomology, University of Maryland-College Park, Md.

Present address: Department of Ecology & Evolutionary Biology, Biological Sciences-West, Room 310, University of Arizona, Tucson, AZ 85721, USA

Accepted: January 11, 1996

**Key words:** Hemiptera, Berytidae, *Cotesia congregata*, Braconidae, tobacco hornworm, *Manduca sexta*, tobacco aphid, *Myzus nicotianae*, predation, nutritional ecology

### Abstract

We evaluated the suitability of selected food items for the adult spined stilt bug, *Jalysus wickhami* Van Duzee (Hemiptera: Berytidae), by providing one of seven diet treatments: (1) prepupae of the parasitoid, *Cotesia congregata* (Say) (Hymenoptera: Braconidae), on a leaf of tobacco (*Nicotiana tabacum* L., 'NC 2326') (Solanaceae); (2) *C. congregata* prepupae alone (i.e., no tobacco leaf); (3) eggs of the parasitoid's host, *Manduca sexta* (L.) (Lepidoptera: Sphingidae), on a tobacco leaf; (4) *M. sexta* eggs alone; (5) tobacco aphids, *Myzus nicotianae* Blackman (Homoptera: Aphididae), on a tobacco leaf; (6) a tobacco leaf alone; and (7) no prey and no tobacco. A tobacco leaf was necessary for the long-term survival of stilt bugs, but prey source did not affect longevity. Regardless of the prey type, stilt bugs with access to a tobacco leaf lived 21–23 days, while stilt bugs without access to tobacco lived less than 12 days. Animal prey provided a protein source required for egg deposition in *J. wickhami*, and prey species differed in their relative nutritive values. Female stilt bugs that fed on *M. sexta* eggs or on *C. congregata* prepupae were significantly more fecund (102 and 106 nymphs per female, respectively) than females that fed on tobacco aphids (24 nymphs per female). Results suggest that stilt bugs may feed on tobacco aphids and *C. congregata* prepupae when other prey are unavailable.

### Introduction

A typical feature of the nutritional ecology of hemipterans is the opportunistic feeding habit exhibited by both phytophagous and predatory species. Many phytophagous bugs are facultative predators, and some are reported to occasionally feed on carrion, bird droppings, dung, or even blood (Wheeler, 1976; Adler & Wheeler, 1984; Bryan et al., 1976). Likewise, plant feeding appears to be fairly common in predatory bugs and, at least for some species, supports optimal development, longevity, or fecundity (York, 1944; Stoner, 1970, 1972; Dunbar & Bacon, 1972).

The spined stilt bug, *Jalysus wickhami* Van Duzee (Hemiptera: Berytidae) (= *Jalysus spinosus* [Say] in

the eastern USA before 1981) feeds on plant sap and arthropods associated with its numerous host plants (Wheeler & Henry, 1981). Typical host plants are 'glandular hairy herbs' in the Solanaceae, Malvaceae, Scrophulariaceae, Oxalidaceae, and Onagraceae (Wheeler & Henry, 1981). The spined stilt bug was first reported as a phytophagous pest of tomato (Somes, 1916) and its predatory habits were first observed on tobacco (Gilmore, 1938). Although plant feeding is common, a prey source is required for proper development and fecundity (Elsey & Stinner, 1971). On tobacco, *Nicotiana tabacum* L., a common host plant, prey include tobacco aphids, *Myzus nicotianae* Blackman (Homoptera: Aphididae) (Kulash, 1949; Elsey & Stinner, 1971), and the eggs of several

lepidopterans, including *Manduca* spp. (Lepidoptera: Sphingidae) (Lawson, 1959; Elsey, 1972).

Recently, we found that spined stilt bugs also feed on the prepupae of *Cotesia congregata* (Say) (Hymenoptera: Braconidae), a major parasitoid of the tobacco hornworm, *Manduca sexta* L. (Kester & Jackson, 1996). In order to assess the importance of *C. congregata* as a prey item for *J. wickhami*, we evaluated its nutritive value relative to tobacco hornworm eggs, tobacco aphids, and tobacco leaves.

## Materials and methods

Stilt bugs used in this study were removed from a laboratory colony of *J. wickhami* that was maintained on hornworm eggs and tobacco plants as described by Elsey & Stinner (1971) and Jackson & Lam (1989). This colony originated from stilt bugs collected from commercial tobacco varieties at the Tobacco Research Station, Oxford, N.C., USA in the summer of 1989. Cocoons containing prepupae of *C. congregata* were supplied from a laboratory colony that originated from field collections at Oxford in 1988. This colony was maintained on hornworm larvae using techniques modified from Postley & Thurston (1974) and Barbosa et al. (1991). Tobacco hornworm eggs were supplied from the Oxford laboratory colony, established in 1965 and maintained according to Baumhover (1985). Tobacco aphids were reared on tobacco in a greenhouse. This colony originated from a field collection from flue-cured tobacco in 1989 at Oxford. Tobacco for experiments was grown in a greenhouse without pesticides. All experiments were conducted in 1989.

*Experiment 1.* In this experiment, we tested the suitability of three diets for sustaining stilt bug adults. Diets were: (1) cocoons containing *C. congregata* prepupae on a tobacco leaf, (2) tobacco hornworm eggs on a tobacco leaf, and (3) a tobacco leaf alone. Equal numbers of unmated, teneral adult males and females of *J. wickhami* were randomly assigned to treatment groups and were held individually in plastic Petri dishes (5 cm diam.). Before adding prey items and bugs, a thin layer (ca. 1 cm thick) of wateragar (10 g carageenan in 1 liter of nearly boiling water) was poured into each dish and then cooled to provide moisture and maintain quality of the tobacco leaves. Dishes were held in a growth chamber at ca. 27 °C and L14:D10. Tobacco leaves were changed twice weekly; dead stilt bugs were counted and removed at that time. Ten repli-

cates were established for each of the three treatments, and the experiment was run twice. Data were analyzed by ANOVA (factorial treatment design) to test for main and interactive effects of gender, food, and experimental replication, using SAS (SAS Institute, 1989, 1993). All assumptions for parametric analyses were met.

*Experiment 2.* In this experiment, we tested the suitability of a larger selection of diets for sustaining stilt bug adults. Diets were: (1) parasitoid prepupae on a tobacco leaf, (2) parasitoid prepupae alone, (3) hornworm eggs on a tobacco leaf, (4) hornworm eggs alone, (5) apterous tobacco aphids on a tobacco leaf, (6) a tobacco leaf alone, and (7) no prey and no tobacco leaf. Prey in treatments without a tobacco leaf were placed on a slightly moistened filter paper. Procedures were the same as described for Experiment 1, except that five replicates were established for each treatment group and the experiment was run five times. Data were analyzed by ANOVA with orthogonal contrasts to test for main and interactive effects of food source and experimental replication, as described above (SAS Institute, 1989, 1993).

*Experiment 3.* In this experiment, we tested the suitability of three diets for supporting lifetime fecundity of *J. wickhami*. Previously mated, 2-day-old adult females were randomly assigned to the treatment groups and held individually in Petri dishes with water-agar, as described above. Diet treatments were an excess of: (1) parasitoid prepupae on a tobacco leaf, (2) hornworm eggs on a tobacco leaf, and (3) tobacco aphids on a tobacco leaf. Fresh prey and tobacco leaves were supplied three times weekly, at which time stilt bug eggs were counted and removed. Five replicates were established for each treatment group, and the experiment was conducted five times. Experiments were run until all of the stilt bugs had died. Data were analyzed by an analysis of covariance (ANCOVA) and orthogonal contrasts to test for main and interactive effects of diet treatments and experimental replication (SAS Institute, 1989, 1993). Because fecundity and longevity were correlated, longevity was entered as a covariate to control for any differences in fecundity that could be attributed to variability in adult life span only.

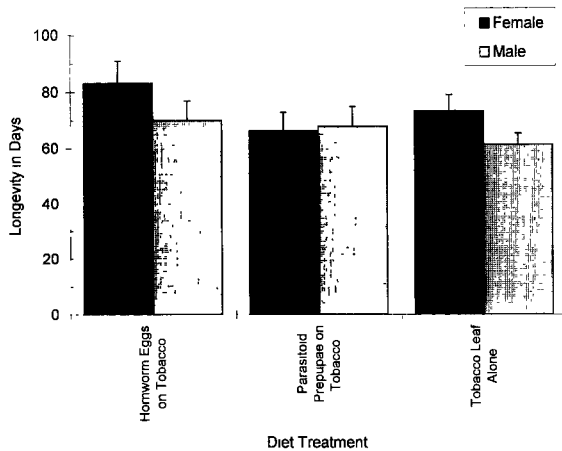


Figure 1 Effects of three diet treatments on the longevity of adult spined stilt bugs, *Jalysus wickhami*. Treatment means did not differ significantly ( $P > 0.05$ ) according to ANOVA (SAS Institute, 1989, 1993) ( $n = 20$ ). The vertical line above each histogram indicates the standard errors for that treatment mean.

## Results

Mean longevity of stilt bug adults was not affected by diet, as indicated by the nonsignificant ( $P > 0.05$ ) main effects of gender and food, or their interaction (Experiment 1, Figure 1). Main and interactive terms involving experimental replication were not significant ( $P > 0.05$ ). Interestingly, stilt bugs provided with only tobacco leaves (i.e., no insect prey) lived as long as those provided either with parasitoid prepupae on tobacco or with hornworm eggs on tobacco. These results demonstrate that the three diets do not vary in their suitability for maintaining optimal adult longevity. However, these results also may indicate that longevity is not influenced by adult diet, in that stilt bug nymphs were reared on the same optimal diet, hornworm eggs on tobacco leaves. Alternatively, because all three diet treatments included tobacco leaves, adult longevity may be influenced more by plant feeding than by predation.

In Experiment 2, ANOVA indicated that longevity of stilt bugs was affected by food source ( $P < 0.0001$ ), and orthogonal contrasts revealed that this result could best be explained by the presence or absence of tobacco leaves. Stilt bugs provided with a tobacco leaf lived significantly longer (21–23 days), even in the absence of prey, than those that were not provided with a tobacco leaf (less than 12 days) (Figure 2). Again, prey source had no effect on longevity. Results were consistent, as indicated by the nonsignificant ( $P > 0.05$ ) main and interactive effects involving experimental replication.

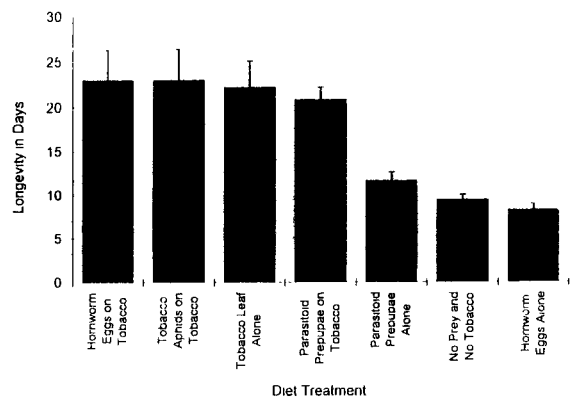


Figure 2. Effects of selected diets on the longevity of spined stilt bugs, *Jalysus wickhami*. Data were analyzed by ANOVA and orthogonal contrasts (SAS Institute, 1989, 1993) ( $n = 25$ ). The contrast between 'prey only' treatments vs all 'tobacco' treatments (with or without prey) was significant ( $P < 0.0001$ ). All other contrasts were not significant ( $P > 0.05$ ). The vertical line above each histogram indicates the standard errors for that treatment mean.

In contrast, lifetime fecundity was affected by diet; optimal egg production required a protein-rich prey source (Experiment 3, Figure 3). Adult stilt bugs that fed on either hornworm eggs or parasitoid prepupae produced significantly more nymphs per female ( $101.5 \pm 13.4$  [ $\pm$  standard error] and  $106.1 \pm 14.0$ , respectively) than those that fed on tobacco aphids ( $24.3 \pm 13.1$ ). These means compare well with those reported for stilt bugs reared on hornworm eggs (137 eggs per female) by Elsey & Stinner (1971). These results demonstrate that parasitoid prepupae and hornworm eggs are nutritively equivalent in supporting fecundity of *J. wickhami* and that tobacco aphids are nutritively inferior.

## Discussion

Like many berytids, stilt bugs are omnivorous (Wheeler & Henry, 1981; Wheeler & Schaefer, 1982), and they can rapidly shift food sources in the field. Our results demonstrate that *J. wickhami* requires both a plant and an animal food source to support optimal adult longevity and fecundity. Further, our results demonstrate that for *J. wickhami*, prepupae of *C. congregata* are as nutritive as the eggs of *M. sexta*, and that both of these food sources are more nutritious than tobacco aphids.

The importance of plant feeding for adult longevity of *J. wickhami* may reflect an evolutionary shift from feeding exclusively on plants to the inclusion of sessile

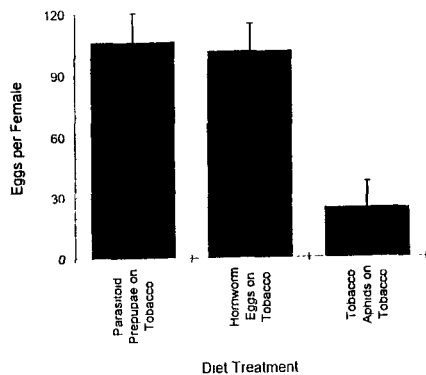


Figure 3. Effects of three diet treatments on the lifetime fecundity of spined stilt bugs, *Jalysus wickhami*. Data were transformed to  $\log_{10}(x + 10.0)$  before analysis by ANCOVA (SAS Institute, 1989, 1993) ( $n = 25$ ); means shown were back-transformed. Nonsignificant ( $P > 0.05$ ) interactions involving the covariate were dropped from the model. The vertical line above each histogram indicates the standard errors for that treatment mean.

prey in the diet of this species. Like other members of the subfamily Metacanthinae, *J. wickhami* is often found on sticky plants where they may feed on the glandular trichomes and, reportedly, on insects trapped by plant secretions (Wheeler & Schaefer, 1982). In any case, interesting analogies exist between omnivorous or predatory bugs that require a prey source and phytophagous hemipterans that require seeds for normal development. Seed-sucking hemipterans are differentially affected by seeds from different plant species (Slansky & Panizzi, 1987), they often feed on plant juices, they switch host plants as adults, and at least for some species, e.g., *Nezara viridula* (L.) (Pentatomidae), they require a green plant source for optimal fecundity and longevity (Kester & Smith, 1984).

The tendency towards omnivory in predatory bugs is well-documented and can result in complex trophic interactions of potential significance to biological control. For example, *Geocoris* spp. (Lygaeidae) require both a plant and an animal source for normal development (York, 1944), and at least some species can sustain adult longevity for months by feeding on seeds and water (Sweet, 1960, Stoner, 1970). The predatory anthocorid, *Orius insidiosus* (Say), can complete development on a diet of pollen and water (Kiman & Yeorgan, 1985). Although plant-feeding may sustain predatory bugs during periods when prey are unavailable or at low density (Stoner, 1970), it may also reduce predator numbers. For example, populations of predatory *Nabis* spp. and *Geocoris* spp. are reduced by applications of systemic insecticides on cotton (Ridgeway

et al., 1967), in part, because they feed substantially on cotton plants (Ridgeway & Jones 1968). Also, plant feeding may also explain why predatory bugs such as *Geocoris punctipes* (Say) are negatively affected by plant-resistant genotypes (Rogers & Sullivan, 1987). Given the importance of plant feeding suggested by our results, it is likely that *J. wickhami* may be similarly affected by host-plant based factors. Indeed, in an experiment where prey abundance was not a factor, Jackson et al. (1988) counted four times as many stilt bugs on a typical flue-cured tobacco cultivar (NC 2326) as they did on an insect-resistant tobacco introduction (TI 1112) in either solid plantings or in interplantings of the two plant types.

Trophic interactions involving predatory bugs are further complicated when omnivory includes predation on potential competitors, i.e., 'intraguild predation' (Polis & Holt, 1992). Although intraguild predation has been rarely studied in agricultural systems, it is hypothesized to have important implications for biological control (Rosenheim et al., 1995). Intraguild predation by *J. wickhami* on the gregarious braconid *C. congregata* results in significant mortality to prepupae of this parasitoid (Kester & Jackson, 1996). Prepupae of *C. congregata* are as nutritious to stilt bugs as the eggs of the parasitoid's host, *M. sexta* (Figure 1), and aphids are less nutritious than either parasitoid prepupae or hornworm eggs (Figures 2 & 3). These results suggest that parasitoid prepupae could be an important food source for *J. wickhami* in the field, although the impact of this predation on both parasitoid and host population dynamics cannot be determined without additional field studies.

### Acknowledgments

We thank J. S. Cheatham, J. M. Hobgood, D. T. Hester, M. J. Weary, and E. B. Harris for their excellent technical and clerical assistance. We also thank two anonymous reviewers for their helpful suggestions for improving an earlier version of this manuscript. This study was a cooperative investigation between the USDA-ARS and the Departments of Entomology at the University of Maryland and North Carolina State University.

## References

- Adler, P. H. & A. G. Wheeler, Jr., 1984. Extra-phytophagous food sources of Hemiptera-Heteroptera. Bird droppings, dung and carrion. *Journal of the Kansas Entomological Society* 57: 21–27.
- Barbosa, P., P. Gross & J. Kemper, 1991. Influence of plant allelochemicals on the tobacco hornworm and its parasitoid, *Cotesia congregata*. *Ecology* 72: 1567–1575.
- Baumhover, A. H., 1985. *Manduca sexta*. In: P. Singh & R. F. Moore (eds). *Handbook of Insect Rearing*, Vol. 2. Elsevier Scientific Publications, Amsterdam, 387–400.
- Bryan, D. E., C. G. Jackson, R. L. Carranza & E. G. Neemann, 1976. *Lygus hesperus*: Production and development in the laboratory. *Journal of Economic Entomology* 69: 127–129.
- Dunbar, D. M. & O. G. Bacon, 1972. Feeding, development, and reproduction of *Geocoris punctipes* (Heteroptera: Lygaeidae) on eight diets. *Annals of the Entomological Society of America* 65: 892–895.
- Elsey, K. D., 1972. Predation of eggs of *Heliothis* spp. on tobacco. *Environmental Entomology* 1: 433–438.
- Elsey, K. D. & R. E. Stinner, 1971. Biology of *Jalysus spinosus*, an insect predator found on tobacco. *Annals of the Entomological Society of America* 2: 421–425.
- Gilmore, J. U., 1938. Observations on the hornworms attacking tobacco in Tennessee and Kentucky. *Journal of Economic Entomology* 31: 706–712.
- Jackson, D. M. & J. J. Lam, Jr., 1989. *Jalysus wickhami* (Hemiptera: Berytidae): Toxicity of pesticides applied to the soil or in the transplant water of flue-cured tobacco. *Journal of Economic Entomology* 82: 913–918.
- Jackson, D. M., R. F. Severson, A. W. Johnson, G. R. Gwynn, J. F. Chaplin, V. A. Sisson & G. A. Herzog, 1988. Host plant resistance in tobacco to *Heliothis* species. In: G. A. Herzog, S. Ramaswamy, G. Lentz, J. L. Goodenough & J. J. Hamm (eds), *Theory and Tactics of Heliothis population Management: III. Emerging Control Tactics and Techniques*. Southern Cooperative Series Bulletin Number 337, 31–49.
- Kester, K. M. & D. M. Jackson, 1996. When good bugs go bad: Intraguild predation by *Jalysus wickhami* on the parasitoid, *Cotesia congregata*. *Entomologia Experimentalis et Applicata* (in press).
- Kester, K. M. & D. Smith, 1984. Effects of diet on growth, fecundity and duration of tethered flight of *Nezara viridula* (L.). *Entomologia Experimentalis et Applicata* 13: 1208–1215.
- Kiman, Z. B. & K. V. Yeargan, 1985. Development and reproduction of the predator *Orus insidiosus* (Hemiptera: Anthocoridae) reared on diets of selected plant material and arthropod prey. *Annals of the Entomological Society of America* 78: 464–467.
- Kulash, E. M., 1949. The green peach aphid as a pest of tobacco. *Journal of Economic Entomology* 42: 677–680.
- Lawson, F. R., 1959. The natural enemies of the hornworm on tobacco [Lepidoptera: Sphingidae]. *Annals of the Entomological Society of America* 52: 741–755.
- Polis, G. A., C. Myers & R. D. Holt, 1989. The ecology and evolution of intraguild predation: Potential competitors that eat each other. *Annual Review of Ecology and Systematics* 20: 297–330.
- Postley, L. & R. Thurston, 1974. Rearing *Apanteles congregatus*, a parasite of the tobacco hornworm. *Journal of Economic Entomology* 67: 716–718.
- Ridgeway, R. L. & S. L. Jones, 1968. Plant feeding by *Geocoris pallens* and *Nabis americanoferus*. *Annals of the Entomological Society of America* 61: 232–233.
- Ridgeway, R. L., P. D. Lingren, C. B. Cowan, Jr. & J. W. Davis, 1967. Populations of arthropod predators and *Heliothis* spp. after applications of systemic insecticides to cotton. *Journal of Economic Entomology* 60: 1012–1016.
- Rogers, D. J. & M. J. Sullivan, 1987. Growth of *Geocoris punctipes* (Hemiptera: Lygaeidae) on attached and detached leaves of pest-resistant soybeans. *Journal of Entomological Science* 22: 282–285.
- Rosenheim, J. A., H. K. Kaya, L. E. Ehler, J. J. Marois & B. A. Jaffe, 1995. Intraguild predation among biological control agents: Theory and evidence. *Biological Control: Theory and Applications* 5: 303–335.
- SAS Institute, 1989. *SAS/STAT User's Guide*, Version 6, Fourth Edition, Volumes 1 & 2. SAS Institute, Inc., Cary, N.C.
- SAS Institute, 1993. *SAS Companion for the Microsoft Windows Environment*, Version 6, First Edition. SAS Institute, Inc., Cary, N.C.
- Slansky, F., Jr. & A. R. Panizzi, 1987. Nutritional ecology of seed-sucking insects. In: F. Slansky, Jr. & J. G. Rodriguez (eds), *Nutritional Ecology of Insects, Mites, Spiders and Related Invertebrates*. John Wiley & Sons, New York, 283–320.
- Somes, M. P., 1916. Some insects of *Solanum carolinense* L., and their economic relations. *Journal of Economic Entomology* 9: 39–44.
- Stoner, A., 1970. Plant feeding by a predaceous insect, *Geocoris punctipes*. *Journal of Economic Entomology* 63: 1911–1915.
- Stoner, A., 1972. Plant feeding by *Nabis*, a predaceous genus. *Environmental Entomology* 1: 557–558.
- Sweet, M. H., 1960. The seed bugs. a contribution to the feeding habits of the Lygaeidae (Hemiptera: Heteroptera). *Annals of the Entomological Society of America* 53: 317–321.
- Wheeler, A. G., Jr., 1976. *Lygus* bugs as facultative predators. In: D. R. Scott & L. E. O'Keefe (eds), *Lygus* bug: Host-plant Interactions. University Press of Idaho, Moscow, 38 pp.
- Wheeler, A. G. & T. J. Henry, 1981. *Jalysus spinosus* and *J. wickhami*. Taxonomic clarification, review of host plants and distribution, and keys to adults and 5th instars. *Annals of the Entomological Society of America* 74: 606–615.
- Wheeler, A. G. & C. W. Schaefer, 1982. Review of stilt bug (Hemiptera: Berytidae) host plants. *Annals of the Entomological Society of America* 75: 498–506.
- York, G. T., 1944. Food studies of *Geocoris* spp., predators of the beet leafhopper. *Journal of Economic Entomology* 37: 25–29.