BIOLOGY AND ECOLOGY OF *PICROMERUS BIDENS* (HEMIPTERA: PENTATOMIDAE) IN SOUTHEASTERN CANADA[1]

M. Javahery[2]

ABSTRACT: Biology, ecology, and reproductive potential of the Palaearctic, predatory pentatomid *Picromerus bidens* were studied during 1983-85 in southwestern Quebec. Observations were made during three field seasons, and breeding and rearing were carried out in both the laboratory and the field. It is concluded that *P. bidens* was imported accidentally into North America (possibly in the egg stage and through Maine) more than fifty years ago. It has become well established in its new environment, both in the U.S. and in Canada. Both population and distribution are increasing in Quebec and adjacent regions. A comparison of data from a biological study made in an area where the insect is endemic (southern England) with results obtained in Quebec indicates many similarities between populations of both "new" and "old" environments. The preferred habitat, wide range of prey acceptance, and low rate of reproduction are among the disadvantages if this species is to be considered an important agent for biological control of insect pests.

This paper, the first of a series on the biology, ecology, and taxonomy of common Canadian Heteroptera, deals with a relatively unfamiliar species in North America, *Picromerus bidens* (L.). A common European predatory pentatomid of the subfamily Asopinae, it is widely distributed in the western Palaearctic Region and throughout Europe from 64°N latitude southward to North Africa. It occurs as far west as Ireland and as far east as Siberia (Mayné and Breny, 1948; Puchkov, 1961; Southwood and Leston, 1959; Javahery, 1967).

In the New World, *P. bidens* was first reported by Cooper (1967) from Union Village, Vermont. Research, however, reveals that the first known North American specimen, collected by J.C. Lutz, 22.VII.1932, in Lincoln County, Maine, was found among unsorted material at the U.S. National Museum by R.C. Froeschner and J.L. Herring. In Canada, it was first reported by Kelton (1972) from specimens collected by D. de Oliveira at Lennoxille, Quebec, 1968, and at Ascot Corner, Quebec, in 1969.

In 1983, another early Maine record was discovered during rough sorting of accumulated Hemiptera in the Lyman Entomological Museum; one male and two females among material collected by the late G.A. Moore, 28.VII.1945 at Peaks Island,* near Rockland, Maine. This seems

*This appears to be an English translation of Île Au Haut, which lies off the coast of Maine. The late G.A. Moore collected extensively on this island.

[1]Received April 4, 1985. Revision received September 12, 1985. Accepted February 7, 1986.

[2]Department of Entomology and Lyman Entomological Museum, Macdonald College of McGill University, Ste.Anne de Bellevue, Quebec, Canada H9X 1CO

to be the second earliest Nearctic record but more than a dozen years later than the first. Further specimens have been examined during 1983-85 among the collection of Heteroptera at the Department of Entomology of the Royal Ontario Museum, Toronto; in the University of Guelph's Department of Environmental Biology; and in the Canadian National Collection of Insects, Ottawa. As there is no record of the importation of *P. bidens* for evaluation as a potential biocontrol agent of insect pests by either the U.S. or the Canadian Departments of Agriculture, it is believed it was introduced accidentally with nursery stock or other horticultural plants (possibly in the egg stage, probably into Maine), some time before 1932.

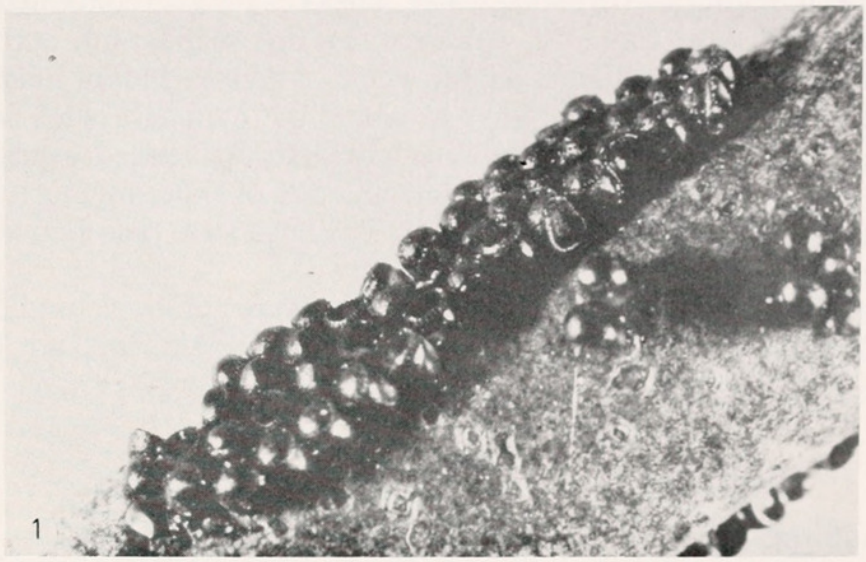
Little has been published on this species in its North American environment (Cooper, 1967; Kelton, 1972; Larochelle and Larivière, 1980; Larochelle, 1984). The objective of the present work was to study the biology, ecology, reproductive potential, predatory-prey relationships, and the possible role of *P. bidens* in depressing populations of its prey in southwestern Quebec.

MATERIALS AND METHODS

All stages of *P. bidens,* eggs, nymphs, and adults, (Figs. 1-3) dealt with in this paper were collected in southern Quebec and to a lesser extent, in eastern Ontario. Immature and adult bugs were collected by sweeping or beating vegetation from May 1983 to August 1985. A sweep-net thirty cm in diameter and a beating cloth of 1 m^2 were used. Breeding and rearing experiments were undertaken in the field and in the laboratory under two temperature regimes (23.0° ± 1C and 28.0°C) at 70-80% R.H. under LD 10.5:13.5.

From these experiments, data on fertility, fecundity, incubation period and egg hatching, as well as on embryonic and nymphal development were obtained. Females were dissected for a study of ovarian development and eggs for determination of embryonic development. Eggs were held in constant darkness (at 2.0° ± 1C) in a petri dish placed in a jar of moist sand prior to use.

Laboratory breeding and rearing were maintained in polystyrene containers (11x11x6cm) ventilated by screened holes (each 2.5 cm diam) on each side.) A tube (2.5 cm in diam) containing water and plugged with cottonwool was introduced through a hole to provide humidity and drinking water for the bugs. The bases of containers were covered with paper toweling and roof-shaped strips (5x4cm) of cardboard, and paper toweling was placed in each container for oviposition and walking. The insect was also cultured in rectangular glass cages (30x40x45cm) covered by a screened lid. Petri dishes (15cm in diam) with saturated cottonwool



Figs. 1-3. Different stages of *Picromerus bidens* (L.). 1. A batch of eggs on twigs. 2. (left to right) first; second; third; fourth and fifth nymphal instars. 3. A pair of *Picromerus* (male on right) Female length 12-14 mm.

provided humidity and drinking water. These cages also contained toweling and strips of cardboard, as well as twigs for oviposition and walking. Celluloid cylinders (20cm in length, 10cm in diam) used for field breeding and rearing enveloped live twigs to which the cylinders were secured at either end by sleeves. Each cylinder also had 4 screened windows (3cm diam) and a stoppered hole for the introduction of experimental insects and food and for the removal of dead prey. The bugs were provided with insect larvae (see "Food").

Data collected during the three seasons were combined and compared with those obtained in a similar study made in southern England (Javahery, 1967).

RESULTS

The habitat

P. bidens favors damp, shrubby habitats such as those occurring on riverbanks, isolated bushes growing in meadows, the margins of woods, and tall sedges. Less frequently it is found in orchards or on coniferous trees. It is generally found on warm, sunny days, on vegetation usually about one meter above the ground. In southwestern Quebec and eastern Ontario, it was found on *Ambrosia, Polygonum, Rubus, Solidago, Vaccinium,* apple trees, grasses, and forage legumes.

Food

P. bidens feeds on larvae of many insect species and, to a lesser extent, on pupae and softbodied, slow-moving adults. It is often found on plants that are attacked by leaf-eating larvae, particularly of Lepidoptera and Coleoptera (Strawinski, 1927; Mayné and Breny, 1948). In North America *P. bidens* is reported to feed on larvae of Lepidoptera and Hymenoptera (Cooper, 1967; Lattin and Donahue, 1969 and Kelton, 1972). During the present work in southwestern Quebec, particularly in the Morgan Arboretum of Macdonald College, Ste. Anne de Bellevue, *P. bidens* was observed to feed on larvae of Lepidoptera (mostly Pieridae, Geometridae, and Noctuidae), Coleoptera (Chrysomelidae), and Diptera (Calliphoridae). Small larvae were most frequently attacked.

P. bidens is attracted by the movement of its prey. The prey becomes inactive a few minutes after insertion of the predator's stylets into the softer parts of the body, such as ventral parts of abdominal segments and thorax (Fig. 4). With large prey, feeding continues for two or even three days, during which time, adults may occasionally mate. In the laboratory *P.*

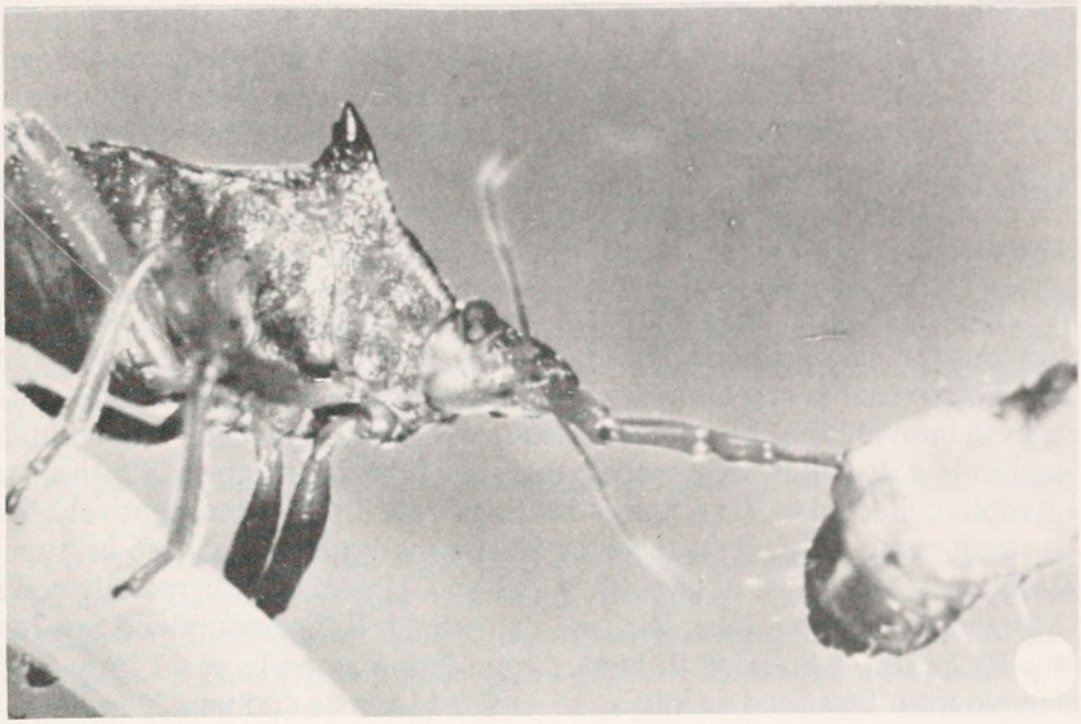


Fig. 4. *P. bidens* feeding on its prey of greater wax moth (*Galleria mellonella* (L.)) in the laboratory.

bidens was fed laboratory-cultured larvae of the Mediterranean flour moth, *Anagasta küehniella* (Zeller), and greater wax moth, *Galleria mellonella* (L.), when prey were not easily obtained in the field. *P. bidens* also demonstrated cannibalistic behavior when the food supply was low. Cannibalistic individuals were observed feeding on each other through the 8th and 9th abdominal segments. In the field *P. bidens* occasionally suck plant sap to obtain moisture. Under laboratory conditions, however, both the food and the water provided were sufficient for its culture.

Occurrence and number of adults and nymphal instars

In Quebec and Ontario, *P. bidens* overwinters in the egg stage. Embryonic development begins with the rise in temperature during April and May. Of 300 eggs placed in cages in the field on 18 August 1983, 24 (8%) did not develop; 12 (4%) hatched between 16-28.IX.1983; and 264 (88%) overwintered and hatched the following year between 5-10 June, 1984. Eighteen field-collected first-instar, 24 second-instar, and 8 third-instar nymphs were collected during the first two weeks in June and over 100 fourth and fifth instars in July and early August in 1983, 1984, and 1985. Development of 48 bugs reared in field cages during 1984 are shown in Table 1.

Table 1. Time of occurrence and durations (days) for nymphal stadia I-V of *P. bidens* reared in field cages in 1984 (n=48)

	1st instars	2nd instars	3rd instars	4th instars	5th instars
Occurrence	9-16.VI	17-24.VI	25-VI. to 3-VII	4-12.VII	13-22.VII
Duration	(8)	(8)	(9)	(9)	(10)

During the first instars and 3-4 days of the second instars, nymphs did not feed but aggregated and lived close together in groups varying from 3 to 56. This variation in group size was due to the great variabilty in numbers of eggs in individual batches. Later instars were collected mainly individually and in low densities. The highest density of third-, fourth- and fifth-instar nymphs collected in 50 sweeps or beatings were 3, 6 and 2 respectively. The greatest numbers of adults taken by 50 sweeps or beatings were 6 in August 1984. A total of 158 adults (87 males and 71 females) were collected in Morgan Arboretum, Oka, Riguad, Valleyfield, Rougemount and Ste-Jean sur-Richelieu. Adults of *P. bidens* were found as early as 11 July 85 (a female from Oka) and as late as 15 Oct. 84 (a male and female in Baie D' Urfé).

Reproductive Biology:

Sexual maturation

Mating and oviposition of 18 pairs occurred in the field from fifteen to twenty days after the last molt. During this period adults of both sexes were often seen feeding upon their prey or walking. Six pairs kept in field cages without insect larvae died after 12 days. Twenty-five pairs reared in laboratory from egg to adult at 23° ± 1C showed a prematuration period of 14-18 days. Extensive feeding was observed during the prematuration and oviposition period. Neither sex was seen to fly, even in sunny weather or at high temperatures (up to 32°C) at any of the study areas. (In the laboratory, when disturbed, one female was observed several times to engage in short flights of approximately one meter.) It may be flight is not necessary for the initiation of sexual maturation and dispersal, whereas feeding and walking are.

Egg diapause

The oviposition period of *P. bidens* in southwestern Quebec occurred

from the second week of August until 15th October in 1983 and 1984. The eggs overwintered in a state of diapause. The results of holding 300 eggs in the field, as well as keeping 3000 under experimental conditions in the laboratory, indicate that eggs needed to be subjected to low temperatures (0-2°C) for approximately 30 days to have embryonic development begin. Without this chilling period 92% of the eggs did not hatch. Thus, there is an obligatory diapause that can be terminated only by exposure to low temperature. In the laboratory the eggs of *P. bidens* were kept at 2° ± 1C in a refrigerator for about six months. During this period, sufficient humidity (about 85%) was provided by keeping the egg-dish on sterile sand flooded with water in jars with wire mesh lids.

Change in weight, reproductive organs, numbers of eggs and color:

In maturation of both sexes of *P. bidens* weight increased and obvious changes took place in the reproductive organs. The weight fluctuated mostly with feeding and, in females, with oviposition. The mean weight of 20 pairs, 2-3 days after final molt, was 58.0 mg for males and 100.0 mg for females. The mean weight of females increased before first oviposition to 153.7 mg and decreased to 122.3 mg on postoviposition (at death). In females, changes were marked by the obvious development of ovarioles, which filled the abdominal cavity. Up to four eggs developed in each ovariole before a batch was laid. The eggs were attached by their sides by means of cementing substance in regular and parallel lines of 2-3 eggs each on twigs (Fig. 1), or in lines of 3 to 6 eggs each on or under paper toweling in the laboratory. The eggs were barrel-shaped and laid in batches varying from 2 to 73. Each egg (n=35) measured 0.8 to 1 mm high and 0.5 to 0.7 mm wide with a crown of 26-34 micropyles encircling the operculum. The egg is pale creamy-white in the ovarioles and common oviducts, remaining so for several hours after oviposition. Subsequently the color changes to a grayish hue and finally to almost black. Progressive color change after oviposition was observed both in the field and under laborabory conditions (1-2°C; 80% R.H.).

Ovariole development in relation to egg numbers:

The development of ovarioles and their relation to age, length of time after mating, and the number of eggs per batch in *P. bidens* were studied in 1983 and 1984. Female bugs collected in the field from mid-July until the end of October were dissected weekly. Morphological changes in the ovarioles during the life of the females, based upon regular dissection of 2-3 females per week, are indicated in Fig. 5. The changes have been classified into seven stages, with maximum fecundity during the fourth stage. During

that stage the female carries more than 50 eggs. Females mated once or twice before the first oviposition, and once before each subsequent one.

Stage I: Immature ovarioles. Females approximately 3 weeks old (1st-2nd week in August):

Ovary and oviducts slender; three chambers present in each ovariole, within which eggs will develop at a later stage.

Stage II: Beginning of development of one egg, one oocyte and differentiation of second oocyte. Females approximately four weeks old (2nd week in August):

The first creamy, barrel-shaped egg is distinguished, and one round, faintly creamy oocyte appears in each ovariole.

Stage III: Development of two eggs and one oocyte. Females approximately one month old (3rd or 4th week of August):

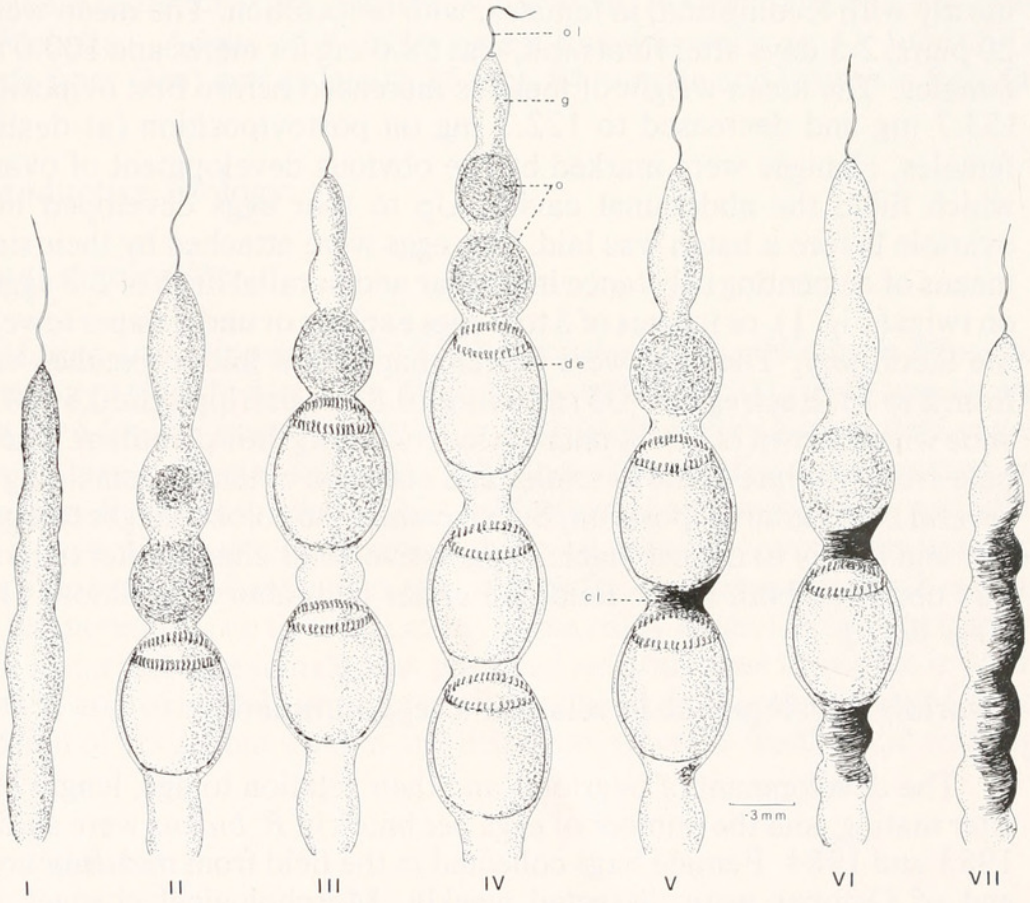


Fig. 5. Different stages of ovariole development in female *P. bidens* during preoviposition, oviposition, and postoviposition. ol-ovariole ligament; g-germarium; o-oocyte; de-third developed egg; cl-corpus luteum.

Two barrel-shaped, creamy eggs and one round, faintly creamy oocyte appear in each ovariole. Female becomes ready to oviposit and may lay its first batch of eggs.

Stage IV: Mature, three to (rarely) five eggs well developed. Females approximately six weeks old (late August to mid-September):

Usually three barrel-shaped, creamy eggs are developed in each ovariole. Two faintly creamy, round oocytes are also seen above the three eggs. Occasionally one of the three mature eggs can be seen in the lateral, or in the common oviduct. Corpora lutea are not visible. The female is ready to oviposit and will lay its greatest number of eggs in a single batch. Rarely the two top oocytes may develop to mature eggs, and the female may lay up to 70 or more eggs in one batch. Batches of 35 to 45 eggs were more common.

Stage V: Two mature eggs and one oocyte. Females approximately two months old (3rd week in September to early October):

Two developed, barrel-shaped, faintly creamy eggs are present in each ovariole. One oocyte is also seen below the germarium. This is similar to stage III, but corpora lutea are faintly visible and characteristic of this stage.

Stage VI: Period of declining oviposition. Females approximately three months old (October):

One rather small, creamy egg and one round, pale oocyte are present in each ovariole. Corpora lutea are clearly visible. The number of eggs in each batch is reduced to 14, 10, 7, or even 2 eggs. Females often die before depositing all their eggs.

Stage VII: Postoviposition period. Females more than three months old (late October and possibly early November):

All ovarioles are without eggs or oocytes, corpora lutea continue to be distinct, and females have laid all their eggs and die within a week.

Fecundity and longevity of *P. bidens:*

Schumacher (1911) in Germany and Mayné and Breny (1948) in Belgium reported, respectively, that a female of *P. bidens* could lay 300 and 200 eggs in an insectary. Javahery (1967), however, indicated that in southern England the mean fecundity of field-collected bugs fed on insect larvae was 129. Males lived for 83 days and females for 98. He further reported that mean fecundity per female was 217 eggs at 20°C, 257 at 23.5°C, but only 109 at 28.5°C in the laboratory. The mean longevity at 20°C was 93 and 122 days for males and females respectively. At 23.5°C it was 90 days for males and 91 for females. At 28.5°C, both males and females lived an average of only 73 days. All results were obtained at 75% R.H.

Fecundity and longevity of *P. bidens* were also studied in Ste. Anne de

Bellevue, Quebec, both at Morgan Arboretum and in the laboratory during 1983-84. Preliminary data indicated that the mean fecundity of 18 *P. bidens* was 154 eggs per female. Male bugs lived 78 days and females 87. In laboratory culture, however, the mean fecundity of 20 *P. bidens* was 224 eggs per female, and longevity 76 and 98 days for males and females, respectively, at 23° ± 1C. Two females did not lay eggs, though they had food and water and copulated several times. When dissected after death, the ovarioles were found to be filled with eggs. Fecundity and longevity decreased at 27°C and 28°C, suggesting the distribution of this pentatomid is limited to cooler climates.

Females were able to mature and to lay (infertile) eggs in the absence of males. The mean fecundity of 11 virgin females at 20°C was only about half that of mated ones (107 eggs in 8 batches), though their longevity was greater (191 days). Copulation increased fecundity and, under all conditions, females fed extensively and mated before eggs were laid. Each female mated 3 to 6 times. Only the eggs of mated females developed and produced progeny. During September of 1983 and 1984, only a few individual eggs (4% out of 300 eggs) from certain batches developed and hatched, but all resulting instars died without molting by late September or October.

In southeastern Canada *P. bidens* is a univoltine pentatomid that overwinters in the egg stage.

P. bidens and egg parasites

Eggs of laboratory-cultured *P. bidens* of both native (Javahery 1967, 1968) and immigrant populations placed in the field in June were parasitized by scelionid wasps. The percentage of parasitism of 136 eggs was 50% in southern England in 1965 and of 225 eggs was 17% in Quebec in 1984. In August, 1984, however, none of the 286 eggs of *P. bidens* placed in the Morgan Arboretum was parasitized. Moreover, the eggs of this predatory pentatomid were found suitable for culturing a number of species of scelionid egg parasites of the genera *Telenomus* and *Trissolcus*. The data on these parasitoids will be given in separate papers.

Biological and ecological similarities in Canadian and European populations of *P. bidens*

Biological and ecological data obtained in an area where *P. bidens* is native (southern England) (Javahery, 1967, 1968) and where it is immigrant (Quebec) agree in nearly all characteristics. In both regions, the bugs are univoltine, overwintering in the egg stage. Egg diapause is

terminated in early winter. Unless eggs are subjected to low temperature for about 30 days before development begins, the embryo does not develop successfully and the eggs do not hatch normally. Thus, there is an obligate diapause that must be broken by low temperature. Maturation and reproduction begin two to three weeks after the last molt in late July and August. Extensive feeding, walking, and multiple coupling ensure reproductive activity and egg laying. Fecundity of virgin females was about half that of the mated ones; unmated females did not produce fertile eggs. Observed dispersal was always by walking. The bugs therefore are regarded as nonmigratory pentatomids that have a wide range of prey. Cannibalism has been observed among nymphs and adults. Nymphs and adults have been observed to be preyed upon by other pentatomids: *Podisus maculiventris* Say and *P. modestus* Dallas. Eggs of laboratory-cultured *P. bidens* of both native and immigrant populations placed in the field were parasitized in June by scelionid wasps.

P. bidens is presently a useful predator in depressing the population of its prey species, especially larvae of Lepidoptera from June to October. Its activities, however, are concentrated in "preferred" habitats containing adequate prey. Eggs of *P. bidens* are a suitable host for culturing some scelionid wasps of genera *Telenomus* and *Trissolcus.*

The wide range of prey species, relatively low rate of reproduction, its slow locomotion, and difficulties of mass multiplications mitigate against *P. bidens* being considered a potentially exploitable biological agent for the reduction of insect pests.

ACKNOWLEDGMENTS

I am grateful to D.K. McE. Kevan and V.R. Vickery for reviewing the manuscript. The cooperation of Carl W. Schaefer, University of Connecticut, Storrs, and J.E. McPherson, Southern Illinois University, Carbondale, is sincerely appreciated. Also thanks to the authorities of the institutions mentioned in the text for allowing me to examine their specimens and to V.R. Vickery and D. Gordon for assisting in maintaining the culture of greater wax moth and Mediterranean flour moth, respectively. A.C. Sheppard assisted in finding the translated name of Peaks Island, Mrs. J.F. Alberti in preparation of the final draft, and P. Langlois in photography. This research was supported in part by grant A1378 to Dr. Kevan from the National Science and Engineering Council of Canada.

LITERATURE CITED

Cooper, K.W. 1967. *Picromerus bidens* (L.), a beneficial predatory European bug discovered in Vermont (Heteroptera: Pentatomidae). *Ent. News* 78: 36-40.

Javahery, M. 1967. The biology of some Pentatomoidea and their egg parasites. Unpublished. Ph.D. Thesis, University of London. 475 pp.

_____. 1968. The egg parasite complex of British Pentatomoidea (Hemiptera): Taxonomy of Telenominae (Hymenoptera: Scelionidae). *Trans. R. Ent. Soc. Lond.*, 120: 417-436.

Kelton, L.A. 1972. *Picromerus bidens* in Canada (Heteroptera: Pentatomidae). *Can. Ent.* 104: 1743-44.

Larochelle, A. 1984. Les Punaises Terrestres (Hemipteres: Géocorises) du Quebec. Fabreries Suppl. 3. 514 pp.

_____ et M.-C. Larivière. 1980. *Picromerus bidens* L. (Heteroptera: Pentatomidae) en Amérique du Nord: Réaparition géographique, habitat et biologie. *Bull. Invent. Ins.* Québ. 2: 10-18.

Lattin, J.D. and **J.P. Donahue.** 1969. The second record of *Picromerus bidens* (L.) in North America (Heteroptera: Pentatomidae: Asopinae). *Proc. Ent. Soc. Wash.* 71: 567-68.

Mayné, R. and **R. Breny.** 1948. *Picromerus bidens* L.: Morphologie. Biologie. Détermination de sa valeur d'utilisation dans la lutte biologique contre le doryphore de la pomme de terre. La valeur économique antidoryphorique des Asopines indigènes beleges. *Parasitica,* Gembloux 4: 189-224.

Puchkov, V.G. 1961. *Fauna of Ukraine.* Shieldbugs, 21. *Ac. Sci. UK.* SSR. Kiev. 338 pp.

Schumacher, F. 1911. Beiträge zur Kenntnis der Biologie der Asopiden *Z. Wiss. Insect. Biol.,* 7: 40-47.

Southwood, T.R.E. and **D. Leston.** 1959. Land and water bugs of the British Isles. Frederick Warne and Co., London and New York. 436 pp.

Strawinski, K. 1927. *Picromerus bidens* L. (Hemipt. Heteroptera, Pentatomidae). *Polsk. Pismo. Ent.* 6: 123-151.

SOCIETY MEETING - FEBRUARY 19, 1986

The third meeting of the 1985-86 year was held at the Academy of Natural Sciences in Philadelphia. Fourteen members and seven guests were present to hear Dr. Clifford Keil speak on "European Corn Borer: Mating Biology and Quality Control of Laboratory Rearing." Dr. Keil is an Assistant Professor in the Department of Entomology and Applied Ecology at the University of Delaware.

The European corn borer, *Ostrinia nubilalis,* was first recorded in North America in Massachusetts about 75 years ago. Since then this agricultural pest has spread from the Atlantic Coast to the Rocky Mountains, and Southern Canada to the Gulf Coast. The original population had one generation per year but since 1930 bivoltine and multivoltine races have appeared and spread over much of the geographic range where the growing season is longest. Dr. Keil has been interested in the genetic differentiation of various populations of the European corn borer and has worked on methods of laboratory rearing. Cytological examination of testes from larvae of four geographic locations indicated that obligate univoltine populations in the Red River Valley (Minnesota/North Dakota) have altered timing of spermatogenesis. The other three populations surveyed (Delaware, Georgia and Iowa) exhibited the usual timing of eupryene spermatogenesis preceding apryene spermatogenesis. Ninety percent of individuals from the Red River Valley produced apryene spermatocytes in large numbers in the 4th and 5th instars. The audience was particularly intrigued by the observation that inbred females bred to unrelated inbred males produce up to twice as many eggs as females in intrastrain matings. In contrast, classical hybrid vigor is expressed later in the offspring of interstrain matings. A considerable portion of the discussion following the talk focused on the mechanism of this effect.

Midwinter entomological notes of interest dealt with insects associated with man and his dwellings. There were reports of hibernating lady beetles and cluster flies and a stray mosquito. Only three of those in attendance had ever seen a live human head louse, a pest that appears every year on a few children in our local elementary schools.

Harold B. White
Corresponding Secretary