

***PICROMERUS BIDENS* (HETEROPTERA:
PENTATOMIDAE) IN NORTH AMERICA,
WITH A WORLD REVIEW OF DISTRIBUTION
AND BIONOMICS¹**

M.-C. Larivière², A. Larochelle³

ABSTRACT: The Palearctic, predatory pentatomid *Picromerus bidens* was introduced into North America about 50 years ago. Only recently, however, was this species recorded in the North American literature (1967). The introduction of the species on this continent is of particular interest since it has been shown, in Europe, to prey upon the larvae of many agricultural and forest insect pests. The species has been studied by the authors in 10 states or provinces of northeastern North America from 1978 to 1988. The establishment of the species in North America is discussed, and a world review of its distribution and bionomics (including habitat, associated plants, life cycle, seasonal activity, food, predators, and parasites) is given.

The introduction of the Palearctic, predatory pentatomid *Picromerus bidens* (L.) in North America occurred about 50 years ago. Cooper (1967) first reported the species in the North American literature. Since then, only a few papers have been published that dealt with the distribution, biology, and ecology of *P. bidens* in North America (Lattin and Donahue 1969; Oliveira and Juillet 1971; Kelton 1972; Larochelle 1979; Larochelle and Larivière 1980; McPherson 1982; Larochelle 1984; Javahery 1986; Froeschner 1988).

The European literature, on the other hand, has dealt extensively with this species since 1911. Many studies such as those of Schumacher (1911), Butler (1923), Strawinski (1927), Mayné and Breny (1947a,b; 1948a,b), Dupuis (1949), Southwood and Leston (1959), and Javahery (1967, 1968) have covered the morphology, biology, and ecology of *P. bidens*, and its potential use in biological control. The introduction of this species on this continent is of particular interest since European studies have shown this pentatomid preys upon the larvae of many agricultural and forest insect pests.

Until 1986, *P. bidens* was known in North America only from a few localities in Québec, New York, and northern New England. We have studied and collected this species from 1978 to 1988 in more than 10

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²Department of Entomology, Macdonald College of McGill University, Sainte-Anne-de-Bellevue, Québec H9X 1C0.

³Lyman Entomological Museum and Research Laboratory, Macdonald College of McGill University, Sainte-Anne-de-Bellevue, Québec H9X 1C0.

states or provinces in northeastern North America. The following account provides details of its habitat, biology, geographic distribution, and colonization speed in northeastern North America, and reports on the current state of knowledge of this species in Europe as well as in North America, as a reference for those wishing to study this pentatomid.

Picromerus bidens (L.)

Picromerus bidens belongs to the subfamily Asopinae and can be separated from all other North American asopines as follows: humeri prominent, ending in a spine; humeri, lateral margins of pronotum, and the head often shining deep-blue; inner apical third of anterior femora with a short spine and inner apical third of anterior tibia with a short, acute spur; dorsal and ventral surfaces of the body with fine or deep, dark punctures; length 11.0-14.0 mm.

A detailed description of the adult is found in Mayné and Breny (1948b), Dupuis (1949), and Kelton (1972); the latter also includes a color photo of the adult. The egg was described by Butler (1923), Mayné and Breny (1948b), Cooper (1967), and Southwood and Leston (1959). First to third instar nymphs were described by Mayné and Breny (1948b), the fourth instar by Butler (1923) and Mayné and Breny (1948b), and the fifth instar has been described in detail by Butler (1923), Mayné and Breny (1948b) and Dupuis (1949).

Geographic distribution

Paleartic distribution. In the Old World, *P. bidens* is widely distributed in the western Palearctic Region and throughout Europe, from 64°N latitude south to North Africa in the west and China in the east; it occurs as far west as Ireland, and as far east as Siberia and China (Mayné and Breny 1948b; Dupuis 1949; Puchkov 1961; Southwood and Leston 1959; Zheng 1980).

Nearctic distribution. Until now, the known North American distribution of *P. bidens* has been limited to Maine, Massachusetts, New Hampshire, New York, Vermont, and the Province of Québec (Froeschner 1988). The first North American specimens were collected on 22.VII.1932 in Lincoln Co., Maine, and on 28.VII.1945 at Ile-au-Haut (so called "Peaks Island") near Rockland, Maine (Javahery 1986). There seems to be no record of the voluntary importation of *P. bidens* for use as a biological control agent. Javahery (1986) suggests, and it is also our opinion, that the species may have been accidentally introduced from Europe, probably in the egg stage, with the importation of nursery stock or other horticultural plants.

The species has subsequently been collected at Union Village, Vermont, from 1962 to 1967 (Cooper 1967), at Durham, New Hampshire, in 1956 and 1967 (Lattin and Donahue 1969), and at Lennoxville and Ascot Corner in southern Québec in 1970 (Oliveira and Juillet 1971; Kelton 1972). In a previous paper (Larochelle and Larivière 1980), we reported *P. bidens* in Berkshire Co., Massachusetts and Franklin Co., New York as well as in about 40 localities in Québec.

We now have collected over 1,500 adults and 300 nymphs in more than 180 localities from 10 northeastern states or provinces from 1978 to 1988 (states, provinces, and counties in bold face):

MAINE: Franklin: Weld, Wilton, Oxford: Sumner.

MASSACHUSETTS: Worcester: W. Brookfield

NEW BRUNSWICK: Kent: Cap-Lumière, Pointe-Sapin. Restigouche: White Brook. Westmorland: Jolicure.

NEW YORK: Franklin: Duane, Fort Covington.

NOVA SCOTIA: Annapolis: Annapolis Royal. Cumberland: Middleboro.

Lunenburg: Canaan. Queens: W. Caledonia.

ONTARIO: Glengarry: Alexandria. Prescott: Carillon Prov. Park.

PRINCE EDWARD ISLAND: Kings: Brudenell River Prov. Park, East Baltic, Fortune. Prince: Ellerslie, Norboro. Queens: Surrey, Wood Islands Prov. Park.

QUEBEC: 136 localities; north to Etangs-des-Caps (*Ile-de-la-Madeleine*), in the following counties: Abitibi, Bagot, Beauce, Beauharnois, Berthier, Bonaventure, Brome, Champlain, Charlevoix-Est, Charlevoix-Ouest, Châcâteauguay, Chicoutimi, Compton, Dorchester, Drummond, Frontenac, Gaspé-Est, Gaspé-Ouest, Gatineau, Huntingdon, Ile-de-Montréal, Iles-de-la-Madeleine, Kamouraska, Lac-Saint-Jean-Est, Lac-Saint-Jean-Ouest, L'Assomption, Lévis, Lotbinière, Maskinongé, Matane, Matapédia, Missisquoi, Montcalm, Montmorency No. 2, Nicolet, Papineau, Pontiac, Richmond, Rimouski, Rivière-du-Loup, Rouville, Saguenay, Saint-Jean, Saint-Maurice, Shefford, Sherbrooke, Soulanges, Stanstead, Témiscouata, Terrebonne, Vaudreuil, Verchères Wolfe.

RHODE ISLAND: Providence: Chepachet.

VERMONT: Bennington: Mt. Equinox, Woodford. Essex: Bloomfield, E. Brighton. Grand Isle: E. Alburg, N. Hero. Lamoille: Belvidere Center, Belvidere Corners, Eden, Jeffersonville, Lake Elmore, N. Wolcott, Wolcott, Wolcott Pond. Orleans: Albany, Hazens Notch, Jay. Washington: E. Montpelier, Maple Corner Montpelier, Worcester. Windham: Townshend St. Park, Wilmington. Windsor: Mt. Ascutney.

The northern limit of distribution (Fig. 1) is now Iles-de-la-Madeleine (47°14' N latitude), Québec, and the southern limit, Chepachet, Rhode Island. The species is recorded for the first time from Prince Edward Island, Nova Scotia, New Brunswick, Ontario, and Rhode Island.

Observations made in Québec indicate a rapid colonization of the territory. It is possible that Québec populations are the result of successive colonizations by Maine populations. We have noticed, however, while collecting in Maine (June, July and September 1985, and August

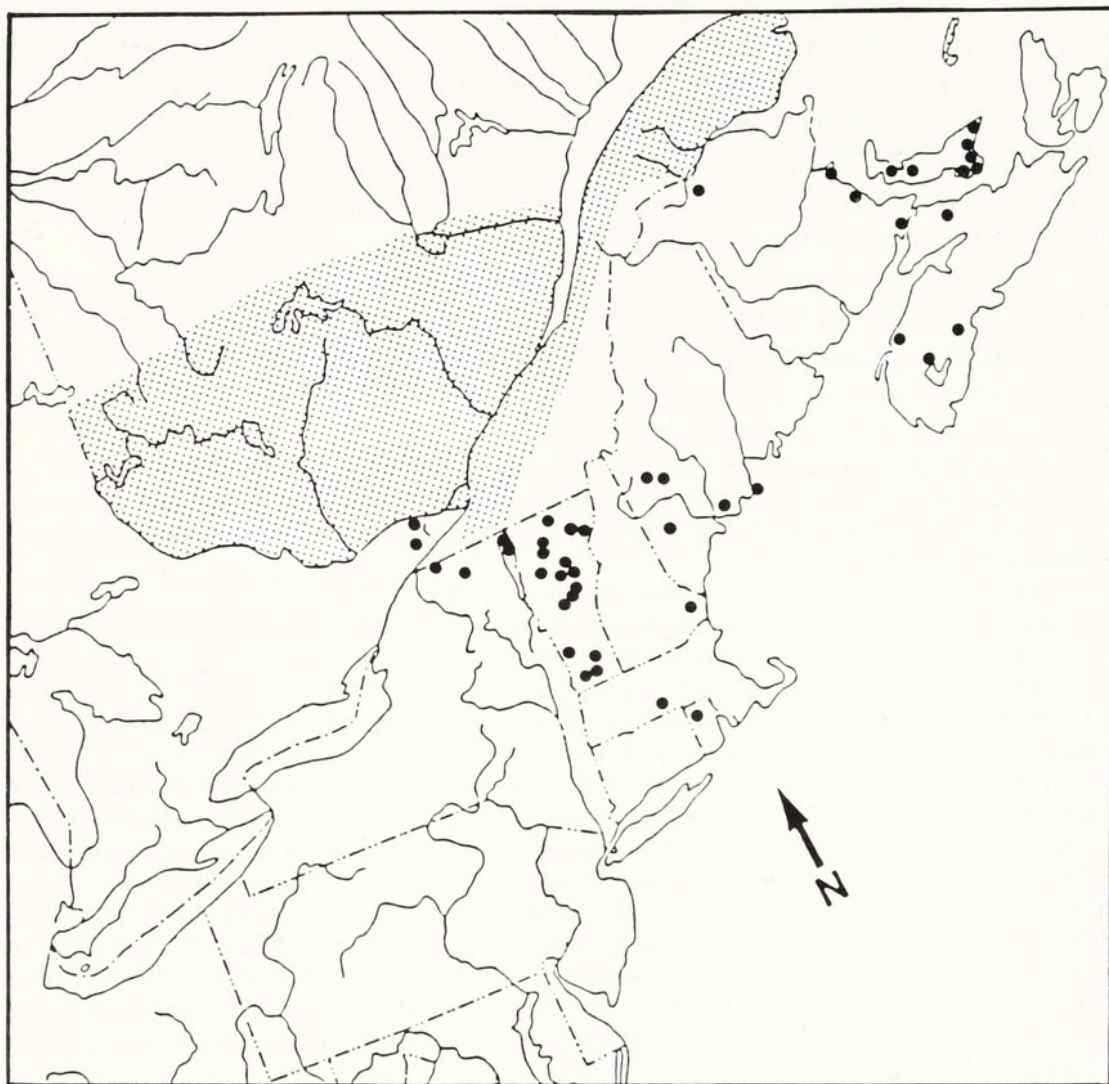


Fig. 1. Distribution of *Picromerus bidens* in northeastern North America.

1986) that the species is less abundant in fields and in general more difficult to find there than in Québec, where it was common to find 10 to 15 individuals in 3 to 4 sweeps from the third week of July to mid-September in almost any of the fields surveyed. It seems likely that the species has been more recently introduced directly into Québec (i.e., possible multiple introductions in North America), as is probably the case of certain Palearctic coccinellids (Coleoptera) such as *Propylea quatuordecimpunctata* (L.) (Gordon 1985) and *Hippodamia variegata* (Goeze) (Gordon 1987).

In 1975, *P. bidens* was known in Québec from only three localities in the southern part of the province. An intensive survey of the St. Lawrence Valley south of Tadoussac (Saguenay Co.) in 1978 showed that it occurred

in another three localities, which extended the known range more than 300 km north of Lennoxville (Sherbrooke Co.), the first record for the province. In 1979, a survey of the same region revealed its presence in more than 40 localities.

During July and August of 1980 to 1984, we surveyed the region from the southern part of the St. Lawrence Valley, north to Miquelon (Abitibi Co.), west to Abitibi-ouest and east around the Gaspé Peninsula; and from Sherbrooke (southeastern Québec) west through Montréal and the Ottawa Valley to Témiscamingue. *Picromerus bidens* has been collected in 87 localities, north to Miquelon (Abitibi Co.), western limit of its range in Québec at that time. A rapid survey of the same region in 1985 confirmed its presence in another three localities of Abitibi County. The known western limit of the range is now Manneville (Abitibi-Ouest Co.), about 30 km from the Ontario border. *Picromerus bidens* is now known from 136 localities in Québec.

Bionomics

Habitat

Europe. Fresh, humid, even marshy areas, although sometimes in drier places where a certain freshness persists; among abundant vegetation in sunny places; in areas in flower, in humid copses and bushes; especially near woods and waters; more rarely in orchards, gardens, or coniferous forests (Schumacher 1911; Strawinski 1927; Mayné and Breny 1948b; Dupuis 1949; Southwood and Leston 1959). In western Europe, the species is linked more to forests (Southwood and Leston 1959). It is found on the vegetation within two meters above the ground (Mayné and Breny 1948b).

North America. In Québec and also in the other states and provinces visited, *P. bidens* is found in wet and dry areas, but always in clear, sunny places; along hedges, in fields along the forest edge, along wooded roadsides, in openings of mixed, deciduous or coniferous forests, where it prefers shrubby areas rich in woody plants (trees or bushes, e.g., raspberry plants), but also on weeds such as goldenrods. The species is found on plants at a height of 1 to 2 m above the ground. It is found in flat open country as well as at altitudes of 1,000 to 1,200 m. We have found the species in Vermont on 7, 11, and 16.VIII.1987 at the summits of Mounts Jay Peak (1,251 m), Ascutney (1,019 m), and Equinox (1,236 m) respectively. Javahery (1986) reports that the species is rarely found in orchards.

Associated plants

The local distribution of *P. bidens* seems to be dictated by plant diver-

sity and the resulting variety of prey used for its feeding. The following is a list of plants on which various stages of the species can be found. These are not necessarily the hosts used for reproduction.

Europe: *Alnus glutinosa* (L.) Gaert., *Betula verrucosa* Ehrh., *B. pubescens* Ehrh., *Calluna* sp., *Carex* sp., *Corylus* sp., *Dipsacus* sp., *Fagus sylvestris* L., *Galeopsis* sp., *Galium* sp., *Genista* sp., *Juniperus* sp., *Myrica gale* L., *Pinus sylvestris* L., *Polygonum* sp., *Populus alba* L., *Primula elatior* (L.) Hill, *Prunus avium* L., *P. cerosus* L., *Pyrus malus* L., *Quercus* sp., *Q. pedunculata* Ehrh., *Ranunculus acris* L., *Rhamnus cathartica* L., *Ribes nigrum* L., *Rubus* sp., *R. idaeus* L., *Rumex* sp., *Salix nigricans* Sm., *S. repens* L., *S. caprea* L., *S. aurita* L., *Spiraea ulmaria* (L.), *Tilia* sp., and *Urtica* sp. (Butler 1923; Mayné and Breny 1948b; Dupuis 1949; Thomas 1954). According to Schumacher (1911), the following plants are visited less frequently: *Calluna* sp., *Genista* sp., *Polygonum* sp., *Salvia* sp., and *Urtica* sp.

North America. In Quebec and Ontario, *P. bidens* has been collected on *Ambrosia* sp., *Rubus idaeus*, *Malus* sp., *Polygonum* sp., *Rubus* sp., *Solidago* sp., *Vaccinium* sp., weeds, and forage legumes (Larochelle and Larivière 1980; Javahery 1986).

We have also found *P. bidens* on 46 additional associated plants in Quebec, Ontario, New York, and New England: *Abies balsamea* (L.), *Alnus* sp., *A. rugosa* (DuRoi) Spreng, *Amelanchier* sp., *Betula alleghaniensis* Britton, *B. glandulosa* Michx., *B. papyrifera* Marsh., *Clematis virginiana* L., *Comptonia peregrina* (L.), *Cornus stolonifera* Michx., *Corylus cornuta* Marsh., *Crataegus* sp., graminaceous plants, *Impatiens capensis* Meerb., *Juniperus communis* L., *Larix laricina* (DuRoi) Koch., *Osmunda claytoniana* L., *Ostrya virginiana* (Mill.) K. Koch., *Parthenocissus quinquefolia* (L.), *Picea* sp., *P. glauca* (Moench) Voss, *Pinus banksiana* Lamb., *P. resinosa* Art., *P. sylvestris* L., *Populus tremuloides* Michx., *Prunus serotina* Ehrh., *P. virginiana* L., *Quercus alba* L., *Q. macrocarpa* Michx., *Q. rubra* L., *Ribes* sp., *R. cynosbati* L., *Rubus idaeus* L., *Salix* sp., *S. fragilis* L., *Sambucus pubens* Michx., *Solidago* sp., *Spiraea latifolia* (Ait.), *Thuja occidentalis* L., *Tilia americana* L., *Urtica procera* Muhl., *Vaccinium* sp., *Viburnum lentago* L., *Vitis riparia* Michx., and various undetermined species of weeds.

Although it appears that *P. bidens* does not favor any particular plant species, we have observed that the density of individuals was higher on and around raspberry plants when these were present in the habitat. In Québec, the occurrence of raspberries almost always assured the collection of *P. bidens*. We have observed the same phenomenon on golden-rods, which are blooming in August. This is probably related to the fact that both plants, at certain times in the season, are inhabited by larvae and adults of species fed on by *P. bidens*. The presence of all nymphal

instars as well as adults was noted on goldenrods and raspberries.

Life cycle

The developmental cycle is regulated by ecological conditions and their influence on nymphal development and reproductive activity. Two cycles are thought to be possible: a primary cycle in which the species overwinters in the egg stage, and, less frequently, a secondary cycle in which some adults overwinter. Our observations on North American populations seem to indicate that the species follows the primary cycle described in the European literature.

Primary cycle. Adults oviposit from August into the fall. They die late in the season, after they have mated several times, and eggs overwinter (Strawinski 1927; Mayné and Breny 1948b; Dupuis 1949). Females may oviposit as many as 5 times (Strawinski 1927; Mayné and Breny 1948b). Adults that do not participate in reproductive activity do not seem to overwinter (Gulde 1919; Dupuis 1949). Eggs hatch in May and 40 to 60 days are required for the five nymphal instars to complete development; the first adults can be found in June (Strawinski 1927; Dupuis 1949; Southwood and Leston 1959). The first instar nymph takes about 5 days to develop, nymphs of instars II to IV take 12 to 14 days, and a little longer may be required by the fifth instar nymph (Dupuis 1948, Mayné and Breny 1948b; Thomas 1954; Groves 1956; Southwood and Leston 1959). The duration of the various stages varies according to ecological and meteorological conditions; it is not rare to find fifth instar nymphs in July and newly emerged adults in August (Strawinski 1927; Mayné and Breny 1948b).

Secondary cycle. This cycle is less common and probably involves adults that have not been reproductively active and that had sufficient energy to survive winter. These individuals overwinter, mate in May and June, lay eggs in July, and new adults emerge from mid-August to early September (Schumacher 1911; Dupuis 1949).

The species is generally recognized as univoltine. Schumacher (1911) indicated that when some authors have recognized two generations per year, it is probable that the two cycles have been cofounded.

Our observations and those of Cooper (1967) and Javahery (1986) indicate that *P. bidens* is univoltine and overwinters in the egg stage in eastern Canada, New York, and New England.

Seasonal activity

Eggs and oviposition. Mayné and Breny (1948b) observed that the number of eggs laid is often inversely proportional to the number of ovipositions per female, and suggested that an increased frequency of



mating favors the activity of the genital system. Egg-batch size varies from only 2 to 3 or as many as 70 to 75, and oviposition frequency is dependent on temperature (no oviposition under 14.5°C). Observed maximum fecundity is 300 eggs (Schumacher 1911; Mayné and Breny 1928b); mean fecundity is around 129 to 154 eggs (Javahery 1986). In Québec, we have seen gravid females from the end of August to the 15th of September in Charlevoix-Est County, and until October in the Montréal area.

Nymphs. First instars are gregarious and do not feed other than by occasionally sucking plant sap to obtain water; they remain sheltered in dark places, often on lower leaf surfaces near the ground (Mayné and Breny 1948b; Southwood and Leston 1959). Second instars are still quite gregarious, but start to disperse from time to time to find food; they become more carnivorous soon after the first molt (Mayné and Breny 1948b; Southwood and Leston 1959). Javahery (1986) observed that the two first instars in Québec populations last about 8 days, and the second instars do not feed during the first 3 or 4 days; they are gregarious at this time, forming groups of 3 to 56 individuals. Activity and mobility increase in instars III to V; the duration of each of these instars in Québec is 9 to 10 days (Javahery 1986). This author reported, from laboratory experiments, that fecundity decreases at 27°C and 28°C , suggesting that *P. bidens* is a species of cooler climates. Eggs are deposited on woody plants, in rows on stems and twigs or in batches on the lower surface of leaves (Strawinski 1927; Mayné and Breny 1948b). Javahery (1986) reported that the oviposition period in Québec is from mid-August to mid-October and that up to 4 eggs develop in the ovarioles prior to oviposition. He also observed that egg-batch size varies from 2 to 73 and that the eggs need to be subjected to low temperature ($0-2^{\circ}\text{C}$) for about 30 days for embryonic development to be initiated; without this chilling period, 92% of the eggs did not hatch. Javahery (1986) also studied in detail the maturation of the reproductive organs, diapause, and egg and ovariole development in Québec populations.

Adults. Adults of the new generation can be found in June. According to Mayné and Breny (1948b), peak adult activity is from mid-July to the first week of October. In the Lac-Saint-Jean region of Québec, we have seen teneral individuals from 5.VIII. to 22.IX, and about 15 days earlier in the Montréal area. Individuals can be found at the bases of plants in the morning, and climb upwards with increasing sunlight; they are active during daylight hours and return to the bases of the plants as soon as the temperature cools at sunset (Mayné and Breny 1948b; Dupuis 1949).

Mating. In the field, mating usually occurs from mid-August to October, with frequency varying according to temperature (no mating

under 14.5°C) (Strawinski 1927; Mayné and Breny 1948b). After the last molt, 15 days to a month is necessary for the reproductive organs to mature before mating (Mayné and Breny 1948b). We have observed mating pairs in mid-August in southern Québec on wild grape and red oak in the middle of the afternoon and at sunset.

Longevity. Observed maximum longevity in the laboratory was 114 days; it has been estimated to be 4 months in nature (Mayné and Breny 1948b). In the laboratory, longevity decreased at 27°C and 28°C, suggesting again that *P. bidens* is a species of cooler climates (Javahery 1986).

Flight. Javahery (1986) observed higher food consumption and greater mobility during the period of sexual maturation in Québec populations and reported that no flight tendencies were observed in either sex at that time. He also suggested that flight may not be necessary to initiate sexual maturation and dispersal, whereas feeding and walking are. Mayné and Breny's (1948b), and our observations seem to indicate that flight plays a role in dispersal. Mayné and Breny (1948b) reported that the species usually travels little and at very short distances except in the following cases: "After the last molt and after having eaten, the insect has an instinctive need for dispersal. The nymphal population was without any other traveling means than walking and when the winged adults emerge, these are crowded on the restricted area previously occupied by the nymphs. These new adults often fly long distances, probably to escape surpopulation but also by instinct of species propagation. In Belgium, such flights have been observed in July and August."

We have observed many individuals flying on sunny afternoons in July and August. We feel that this means of dispersal should not be overlooked, at least in relation to the rapid range expansion in Québec.

Food

Picromerus bidens is almost entirely carnivorous. It is a polyphagous species that preys on larvae of many Lepidoptera, Chrysomelidae (Coleoptera), Tenthredinidae and other leaf-eating Hymenoptera, and more rarely on pupae and adults of soft-bodied insects. It also sucks plant juices to satisfy its needs for water. Mayné and Breny (1948b) suggested that the proximity of fresh vegetation is indispensable to the successful development of nymphs and adults.

Ethology of food gathering. Prey are generally medium-sized, glabrous, soft-bodied, and slow-moving; *P. bidens* often goes from one prey to another, slightly piercing it without actually eating it, especially in cases in which the prey does not exactly suit its requirements. In any case, larvae pierced in such a manner will die, which makes *P. bidens* such a useful predator (Mayné and Breny 1948b).

Food in Europe. Coleoptera: larvae and adults of *Cassida viridis* L. (Manolache *et al.* 1939), larvae of *Melasoma populi* L. and *M. tremulae* F. (Vuillet 1919; Gabler 1937; Mayné and Breny 1948b), *Pyrrhalta viburni* (Payk.) and *Phyllobrotica quadrimaculata* L. (Schumacher 1911) (Chrysomelidae). Diptera: larvae (Gabler 1937). Heteroptera: *Cimex lectularius* L. (Dahlbom 1837; Clausen 1940) (Cimicidae). Hymenoptera: *Diprion* (*Microdiprion*) *pallipes* (Fall.) (Mallach 1974) (Diprionidae); larvae of Tenthredinidae (Schumacher 1911; Mayné and Breny 1948b); larvae, pupae and adults of Tenthredinidae (Gäbler 1937); *Cimbex connata* Schrank (Strawinski 1927), *Lophyrus pini* L. (Gabler 1937), *Lygaeonematus wesmaeli* Tischb. (Hsin 1935), *Phymatocera aterrima* Klug. (Butler 1923) (Tenthredinidae). Orthoptera: nymphs of *Leptophyes thelesine* (L.) (Javahery 1967) (Tettigoniidae). Lepidoptera: larvae and adults (Schumacher 1911; Mayné and Breny 1948b); *Euchelia jacobaeae* L. (Butler 1923), *Spilosoma lubricipeda* (L.) (Schumacher 1911) (Arctiidae); *Macrothylacia* (= *Bombyx*) *rubi* L. (Butler 1923; Mayné and Breny 1948b) (Bombycidae); *Ectropis* (*Boarmia*) *bistortata* Goeze (Schwenke 1976) (Geometridae); *Lymantria dispar* (L.) (Schaefer *et al.* 1984), *L. monacha* L. (Strawinski 1927; Mayné and Breny 1948b), *Orgyia antiqua* (L.) (Skatulla 1974) (Lymantriidae); *Acronicta psi* (L.) (Schumacher 1911), *A. rumicis* (L.) (Butler 1923; Mayné and Breny 1948b), *Bupalus pinaria* L. (Friederichs *et al.* 1941), *Dianthoecia capsicola* (W.V.) (Schumacher 1911), *Phytomera gamma* L. (Kanervo 1947), *Polia chi* (L.) (Schumacher 1911) (Noctuidae); *Phalera bucephala* (L.) (Schumacher 1911), *Ptilodon capucina* (L.) (Gninenko 1974) (Notodontidae); *Melitaea* sp., (Schumacher 1911) (Nymphalidae); *Aporia crataegi* L. (Krasnyuk 1928), *Pieris brassicae* L. (Schumacher 1911, Butler 1923), *P. rapae* L. (Butler 1923; Mayné and Breny 1948b) (Pieridae); *Laspeyresia* (*Cydia*) *funebrana* (Tr.) (Golubenko 1969) (Tortricidae). Neuroptera: larvae of Hemerobiidae (Butler 1923).

Food in North America. Coleoptera: larvae of Chrysomelidae (Javahery 1986). Diptera: larvae of Calliphoridae (Javahery 1986). Hymenoptera: *Diprion similis* (Hartig) (Lattin and Donahue 1969), *Gilpinia frutetorum* (Fab.) (Oliveira and Juillet 1971; Kelton 1972), two species of European sawflies (Diprionidae) noxious to Scotch pine (*Pinus sylvestris*) and white pine (*Pinus strobus*). Lepidoptera: specifically *Pyrrharctia isabella* (J.E. Smith) (Lattin and Donahue 1969), and also larvae of various Pieridae, Geometridae, and Noctuidae (Javahery 1986).

Cannibalism

Cannibalism has been observed among populations of *P. bidens*, especially when the food supply was low, or in periods of overpopulation (Mayné and Breny 1948b; Javahery 1967, 1986).

Predators and parasites

Nymphs and adults of *P. bidens* are sometimes preyed upon by *Podisus maculiventris* Say and *P. modestus* Dallas (Pentatomidae) (Javahery 1986), as well as by the sphecoid wasp *Astata boops* (Schrank) (Butler 1923). Javahery (1986) reported that eggs in southern England and Québec were parasitized by scelionid wasps. Moreover, he found that the eggs are suitable for culturing several Scelionidae, especially species of *Telenomus* and *Trissolcus*.

Karyotype

$2N = 12A + X + Y$ (Southwood and Leston 1959).

Rearing

Methods and materials used for rearing *P. bidens* have been described by Mayné and Breny (1948b) and Javahery (1986). Mayné and Breny (1948b) have successfully maintained laboratory cultures on larvae of *Melasoma populi* L. (Chrysomelidae), *Mamestra brassicae* L. (Noctuidae) and *Anagasta kuehniella* (Zell.) (Pyralidae), larvae of potato beetles, house flies, and pierids. Javahery (1986) used larvae of the pyralids *Galleria mellonella* (L.) and *Anagasta kuehniella* (Zell.). In the laboratory, the species seems to develop well on plants such as potato, cabbage, black nightshade, *Ligustrum* sp., *Weigelia* sp., birch, basswood, hornbeam, etc. (Mayné and Breny 1948b).

Biological control

Biological and ethological data suggest that *P. bidens* could be considered a useful predator against certain leaf-eating insects. The species seems to be able to establish itself well in the North American environment, it has a varied diet, occurs in diverse habitats, and has a relatively good egg-laying capacity. Oliveira and Juillet (1971) reported *P. bidens* as a biological control agent against larvae of *Diprion frutetorum* (Fab.) (Diprionidae) in pine forests in Québec.

Many authors have already pointed out the important role of this species in reducing insect pest populations in Europe. In Germany, Gäbler (1937) reported efficient control of the larvae of various sawfly species; Pschorn-Walcher and Zinnert (1971) observed the destruction of 5% of the larvae of *Pristiphora erichsonii* Htg. (Tenthredinidae) in Bavaria; and Mallach (1974) reported that the insect has been important in controlling the hymenopteran *Microdiprion pallipes* (Fall.) (Diprionidae). According to Clausen (1940), the use of *P. bidens* to control the hemipteran *Cimex lectularius* L. was recommended as early as 1776. The

method consisted of confining a few individuals of *P. bidens* in an infested room. In Sweden, *P. bidens* was found to be useful against mass appearance of the hymenopteran *Neodiprion sertifer* Geoffr. (Diprionidae) (Forsslund 1946). In Belgium, Mayné and Breny (1948b) described its action against the potato beetle. They concluded however, that even under optimal conditions (i.e., fields adjacent to its natural habitat or artificial dispersal of its eggs in spring), *P. bidens* does not effectively protect the plants. Two main factors mitigate against its systematic use in biological control: *P. bidens* is not a great traveller, traveling being mainly made by walking, and does not disperse easily in the field; it also seems far too general in the choice of its prey items.

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