Research Bulletin No. 80 May, 1971

Life History Studies on a Willow Leaf Beetle *Altica bimarginata* Say in North Idaho

(Coleoptera: Chrysomelidae)

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Contents

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ABSTRACT

Altica bimarginata Say (Coleoptera: Chrysomelidae) occurs on willow (Salix spp.) in many parts of western North America. In northern Idaho the species prefers as its host *Salix exigua* Nutt., a shrub-like plant found commonly along rivers and streams.

In the Clearwater River drainage of northern Idaho, *A. bimarginata* is univoltine, although a partial second generation may occur. Adults mate repeatedly and eggs are laid from late May through June. Incubation requires an average of seven days. Larvae are present during June and July and again generally in August and September. Larval development consists of three instars.

Larvae pupate in the soil during July and August. Adults emerge in large numbers during late July and early August. These adults may mate and produce a partial second generation in the fall. However, most mating and oviposition occurs in the spring. Overwintering commences during October and spring emergence of the overwintered adults occurs in early April.

INTRODUCTION

Altica bimarginata Say is a commonly-occurring, leaf-feeding flea beetle of the western United States. This insect has been observed feeding on foliage of *Salix exigua* Nutt. in northern Idaho and may occur in abundance on this stream-side inhabiting plant. The showy, metallic-blue adults often attract the attention of the public.

Like most of the 66 *Altica* species reported from North America, little is known about the biology of this species.

Confusion exists as to the name which is applied to Idaho populations. The authors follow Hatch (1966) in using the name of *A. bimarginata* for Idaho populations of the willow flea beetle.

LITERATURE REVIEW

The genus *Altica* was first erected by Geoffroy in 1762 as a distinct genus to include the flea beetles. Illiger 1802, and Hoffman 1803, both stated that the correct spelling should be *Haltica*, noting the Greek derivation, and this spelling was used by most authors until Woods (1917) declared the name *Altica* valid on rigid adherence to the rules of priority. Chevrolat, in 1834, described the genus *Graptodera*, a name later reduced to synonymy under *Altica* Geoffroy (Woods, 1917).

Say described *A. bimarginata* in 1824 from specimens collected in Missouri. Horn (1889) in his taxonomic treatment of the Alticini, Johannsen (1912), and Woods (1917) in their papers on the biology of this insect, all accepted Say's name for this species. Blake (1936), however, pointed out that what Say, Horn, Johannsen, and Woods referred to as *A. bimarginata* was a species complex and that the latter three authors, in their discussion of *A. bimarginata*, were actually referring to *A. ambiens* LeConte. Therefore Blake stated she was abandoning the name *A. bimarginata* Say because Say's type was not extant and there were two species occurring in the same area from which it was described that were indistinguishable by Say's description. She divided the species *bimarginata* Say, as interpreted by Horn, Johannsen, and Woods into four species: *A. plicipennis* (Mannerheim), *A. subplicata* (LeConte), *A. prasina* (LeConte), and *A. ambiens* (LeConte). Hatch (1966) agreed with Blake's interpretation that the species originally described by Say was a species complex but disagreed with Blake's decision to ignore nomenclatoral rules and therefore retained the name *A. bimarginata* Say for *A. plicipennis* Mannerheim, the name used by Blake.

Literature pertaining directly to biological studies of *Altica* species is scarce. Horn (1889), undoubtedly referring to *A. ambiens*, stated that larvae and adults of *A. bimarginata* feed on alder (*Alnus* spp.). Johannsen (1912) referred to *A. ambiens* as an alder feeder as did Woods (1917) and Brues (1924) in recording their observations on the biology of this species. Each of these three authors also referred to this species as being found occasionally feeding on poplar (*Populus* sp.) and willow (*Salix* sp.). However, since it was not until 1936 when Blake uncovered the existence of the species complex, statements concerning the biology of *A. bimarginata* Say (sens. str.) prior to that time remain in question. Woods (1918a) also studied *A. corni*, *A. rosae*, *A. ulmi* (all of which he described as new species) and *A. torquata* LeConte. Blake (1936) noted that *A. plicipennis*, *A. subplicata*, and *A. prasina* are primarily willow feeders and *A. ambiens* is an alder feeder. Hatch (1966) agrees that the host of *A. ambiens* is alder and refers to this insect as the alder flea beetle. Harris (1964) conducted life history studies on *A. carcuorum* Guerin. Dirks-Edmunds (1965) recorded the life history of *A. tombacina* (Mannerheim).

In 1891, Kunckel d'Herculais and C. Langlois (in Loan, 1963) reported a braconid parasite, *Microctonus brevicollis* (Haliday) from *A. ampelophaga* Guerin. Loan also stated that A. ambiens alni (Harris) is parasitized by *Microctonus nigritus* (Provancher) in Canada. Woods (1917) reared the tachinid *Amedoria* (= *Celatoria*) *spinosa* (Coquillet) from specimens of *A. bimarginata* (*A. ambiens*), *A. corni*, and *A. ulmi*. This parasite also attacks *A. chalybea* (Illiger) in Ontario, Canada, (Loan, 1963). Another tachinid, *Hyalomyodes triangularis* Loew, also was reared from the adults of *A. bimarginata* (= *A. ambiens*), (Woods, 1917). He also reported a parasitic fungus, *Sporotrichum globuliferum* Speng., which attached the larvae, pupae and adults of all the species he studied.

METHOD AND MATERIALS

STUDY SITES

Three major study sites were selected on the basis of accessibility, the presence of the host plant, and size of the beetle populations. These were located within five to fifteen miles east of Lewiston, Idaho, along the Clearwater River (Fig. 1). Site 1 was located 6.2 miles (9.98 km) east of Lewiston; site 2 was 7.8 miles (12.55 km) east of Lewiston; and site 3 was 5 miles (8.05 km) east of Spalding. Sites 1 and 2 were established on the north side of the river and site 3 on the south side. Supplemental observations and collections were made periodically at Arrow Junction, about 2.7 miles (4.34 km) east of Spalding, as well as several other areas along the Clearwater and Snake Rivers. Site elevations ranged from 750 to 850 feet (228.60 to 259.08 m).

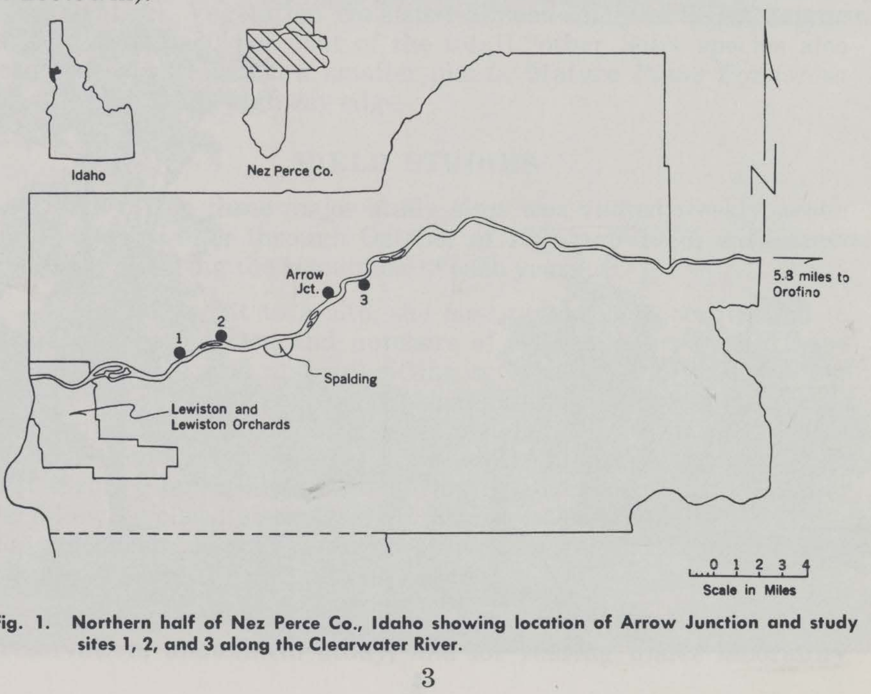


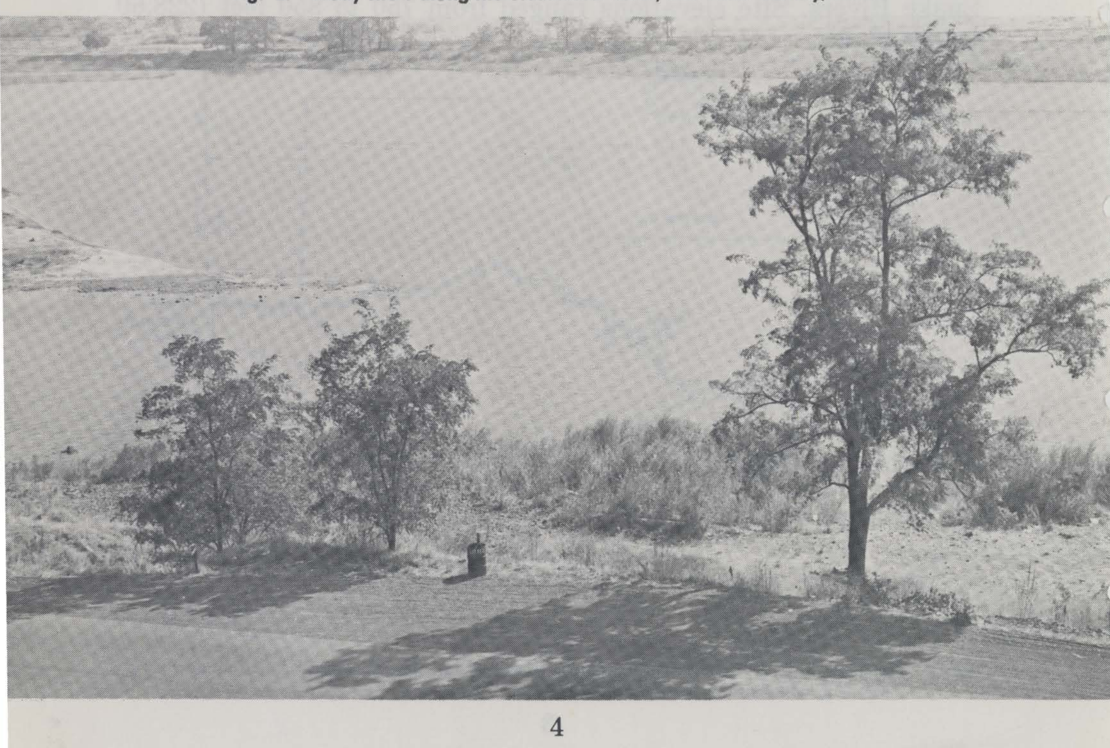
Fig. 1. Northern half of Nez Perce Co., Idaho showing location of Arrow Junction and study sites 1, 2, and 3 along the Clearwater River.

All of the study sites were located on the flat outwashes or banks of the Clearwater or Snake Rivers. The soil consisted of a sand topsoil above a clay-loam base. In many places the soil was very rocky. *Salix exigua*, other *Salix* spp. and *Populus trichocarpa* T. & G. were the dominant plant species.

Site 1 was the smallest of the three major sites, measuring approximately 25 x 100 feet (7.26 x 30.48 m), and located 10 feet (3.05) below Highway 95 (Fig. 2). A short, steep slope occurred at the river's edge. The soil was commonly rocky where the *S. exigua* grew and, except near the highway edge, there were very few other plant species present.

Site 2 measured approximately 200 x 400 feet (60.96 x 121.92 m) and was very flat except for slopes along the river's edge (Fig. 3). This site was about 30 feet (9.14 m) below Highway 95. The soil was very sandy; near the river's edge rocks were extremely numerous. Dominant vegetation was various *Salix* species (including *S. exigua*) and a few scattered bushes of *Populus trichocarpa*. These plants constituted 90 per cent of the observable vegetation. Other plants present included *Agropyron* spp., *Cichorium intybus, Gawia parviflora* Dougl., *Oenothera*, sp., *Verbascum Blattaria* L., and *Verbena bracteata* Lag. and Podr. These occurred in small numbers scattered throughout the site but were especially numerous near the bank at the highway edge.

Fig. 2. Study site 1 along the Clearwater River, Nez Perce County, Idaho.



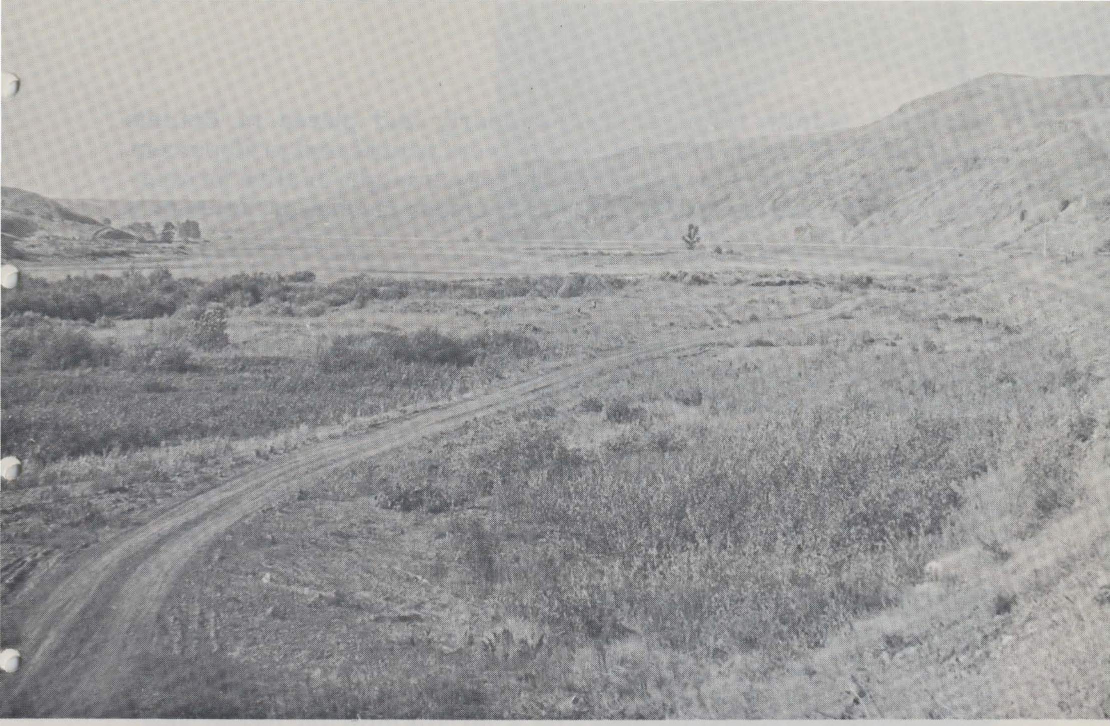


Fig. 3. Study site 2 along the Clearwater River, Nez Perce County, Idaho.

Site 3 measured 100 x 250 feet (30.48 x 76.20m) and was similar to site 2 in general topography. This site was about 10 feet (3.05 m) below Highway 12 and was flat except for a gentle sloping towards the river. Soil was very sandy except at the river edge where rocks were plentiful. Vegetation consisted almost solely of *Salix exigua* (approximately 80 per cent of the total); other *Salix* species also occurred as well as a few smaller plants. Mature *Pinus Ponderosa* Dougl. grew at the highway edge.

FIELD STUDIES

Each of the three major study sites was visited weekly, when possible, from May through October of 1965 and 1966, with occasional visits during the remainder of each year.

Upon each visit to a site, the host plants were scrutinized to determine the location and numbers of eggs and larvae. With the use of a hand trowel and soil-sifting screen, soil and ground litter was examined for life stages of the beetle. Additionally, small plants were pulled up and above ground and below ground parts were examined for the adults during the winter months. Damage to the host through larval and adult feeding was recorded on the basis of the following classifications: light damage — 0 to 15 percent defoliation; moderate damage — 15 to 60 percent defoliation; and heavy damage — 60 to 100 percent defoliation.

Representatives of all life stages were collected by hand for preservation, anatomical study, and for rearing under laboratory condition. Adults were sampled regularly and placed in Bouin's solution for 48 hours, after which they were transferred to 70 percent alcohol for storage. Larvae and pupae were brought in alive for rearing or killed and stored in either 70 percent alcohol or Peterson's fluid (KAAD).

LABORATORY STUDIES

Studies on the life cycle of *A. bimarginata* were conducted in the laboratory and correlated with field observations. Detailed observations on the behavior and duration of all life stages of populations maintained in the laboratory were made daily from August 5 to October 6, 1966. Constant records on temperature and humidity were obtained by means of a hygrothermograph located proximal to the rearing cages.

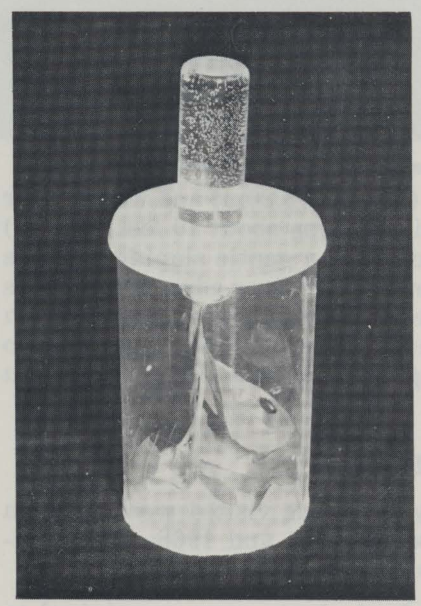


Fig. 4 Cylindrical plastic cage used for laboratory observations on adults of *A. bimarginata*.

Cylindrical plastic cages 2 x 3¼ inches (5.08 x 8.26 cm) were used to confine the beetles during laboratory studies on adult behavior (Fig. 4). The top of each cage was closed with a fitted, perforated plastic cap and the bottom covered with fine-mesh dacron cloth. The bottom of each cage was contructed evenly to allow for adequate air circulation through the cage when placed on a flat surface. A 2 dram (7.40 cc) glass vial was inserted upside down through a hole ⅝ inches (1.59 cm) in diameter drilled through the middle of the plastic cap. Before insertion the vial was filled with water and the cut end of a small sprig of new-growth willow was placed in it. A cotton plug was used to hold the willow in place and prevent water loss. The

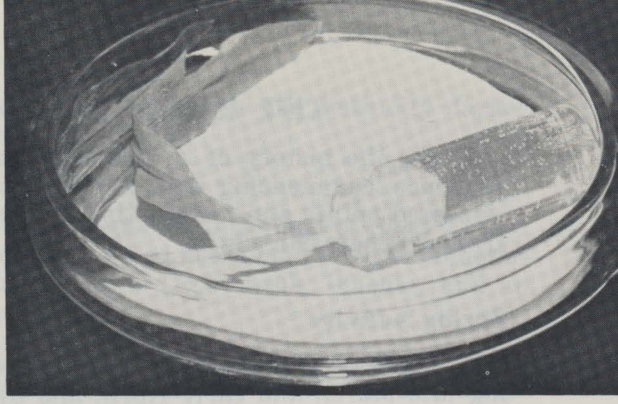


Fig. 5 **Rearing container used for laboratory observations of larvae of *A. bimarginata*.**

sprig was held under water while making the cut and placing it in the vial. This kept the sprig succulent longer, and replacement of sprigs was reduced to three-day intervals. One mating pair of beetles was placed in each of 11 cages.

As eggs in the adult cages hatched, two to eight newly emerged larvae were placed in each of numerous larval rearing cages. Each larval rearing cage consisted of a petri dish set that contained a ¾ dram (2.78 cc) shell vial with water, willow and cotton plug which was placed horizontally on a single piece of filter paper (Fig. 5). These cages were used in observing larval behavior and the number of instars and stadia.

When third instar larvae were three to four days old they were transferred to pupation cages identical in construction to adult rearing cages. Pupation cages were filled with sand to a depth of 1¾ inches (4.45 cm) to provide a pupation site similar to observed natural conditions. Two to eight nearly mature larvae were placed in each cage.

Four other laboratory rearing or observational methods were tested but all proved unsatisfactory. Glass jars were a problem because of excessive temperatures and lack of air movement. Screen cages made it difficult to observe closely the adults or larvae and escape of the adults was common when the cage was opened. Sleeve cages on living plants in the greenhouse were undesirable because of high temperatures and difficulty in preventing pesticide contamination when spraying in the greenhouse.

Insect parasites of *A. bimarginata* were mass reared from the late instar larvae in a large cardboard box 4 feet high x 2½ feet wide x 1½ feet deep (1.20 x 0.75 x 0.45 m) provided with a 4 inch (10.16 cm) layer of sand, two 3 gallon (11.37 L) cans containing live willow shoots, and a gauze-covered top. Just prior to pupation, the gauze was removed and the box completely sealed. Emerging adult *A. bimarginata* and their parasites were collected from vials inserted in holes along the sides.

Willow sprigs and shoots used as rearing media were cut from willows transplanted from the field and grown in the greenhouse.

LIFE HISTORY AND BIOLOGY

The life history of *A. bimarginata* is treated in chronological sequence, commencing with the early spring activities of the overwintered adults and terminating in the fall with the overwintering by new generation adults.

ADULT

Spring Activity

A. bimarginata adults begin to leave their hibernation sites during late March and early April, and by the end of April the great majority of overwintering beetles have become active. Activity of adults in the spring precedes bud-burst of the normal host plant, *Salix exigua* Nutt. The first active adult populations were observed in the field feeding on the well developed leaves of wild rose (*Rosa* prob. *Woodsi* (Lindl.). At that time, *S. exigua* in the immediate vicinity was still in a pre-anthesis stage, with leaf buds just beginning to open. A few adults could be found feeding on these opening buds, and some were observed congregating on bare willow stems. As leaves developed on the willow, adult beetles migrated to that host plant and by the end of April were seldom seen on the wild rose.

General Behavior

Adults are commonly gregarious and periodically migrate from one host plant to another a short distance away. However individual adults may also be found scattered on other host plants in the area. This scattering of the population was most pronounced in the early spring when adults were just beginning to emerge from their overwintering sites, and again in the late fall when they commenced their search for overwintering sites.

General adult activity varied greatly. Populations would be actively feeding and mating one day, and quite torpid the next. There was no apparent correlation between weather conditions and the activity (or lack of activity) observed, though it was supposed that the degree of adult movement within a population fluctuated during any given day. When active, as many as one-fourth of the adults from a given host plant would take flight at the same time and fly a short distance away, only to return to the same host. No reason for this behavior was ascertained, but it was not due to disturbance by the observer.

Overwintered adults were present in appreciable numbers until July 1, after which their populations declined. All overwintered adults had died by early August; however, during late July through August, new generation adults began to appear and become abundant. These "new" adults began to disperse in late September, presumably to search for overwintering sites.

An overlap of two generations of adults therefore occurred for about 30 days. Old generation and new generation adults, when together, are easily distinguishable. Old adults are distinctly darker and less brightly colored than new adults.

Feeding

Adult feeding is generally restricted to foliage of *Salix exigua* although some adults were seen to feed occasionally on an undetermined species of willow, a wild rose (*Rosa* prob. *Woodsi*) and an evening primrose (*Oenothera* sp.).

Initially, in the spring, adults feed on the developing buds of *S. exigua* but as the host leafs out they confine their feeding to leaves on the upper half of the host plant. Damage to young willow foliage by adult feeding during this spring was apparent. Some *S. exigua* plants showed evidence of 40 percent bud damage. Adults usually feed along the lateral edges of the leaves, leaving small, somewhat circular holes, and may eventually consume the whole leaf. Defoliation probably results in stunted growth, auxiliary branching, and sprouting, although this was not defintely ascertained. Heavy feeding during the summer months gave the plants a scorched appearance; however, no host mortality was observed.

Mating

Mating was initiated 10 to 12 days following emergence from overwintering sites. The mating incidence reached a peak on May 26, 1965, and May 24, 1966, or about 40 days after mating was first observed. Some mating of new generation adults occurred prior to overwintering.

Courtship behavior for *A. bimarginata* is almost nonexistent since males were commonly seen to approach females and immediately attempt copulation. Multiple mating throughout the active period of the adult life span was the normal behavior pattern for *A. bimarginata*.

In the basic mating position, the male positions himself on the posterior dorsum of the female at about a 45° angle with the first pair of legs near the base of the female's elytra (Fig. 6). The second pair of legs clasp the female about midway back on the lateral margin of the elytra, at the plical fold, and the third pair of legs hold the termi-

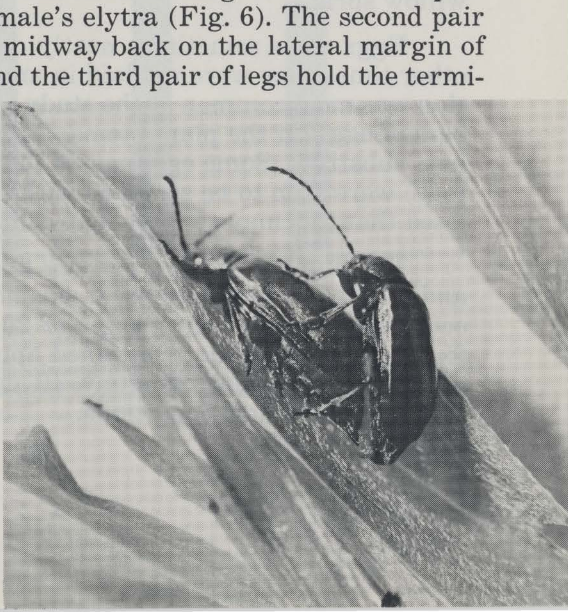


Fig. 6. Mating adults of *A. bimarginata*.

nal segments of the female's abdomen or rest on the host plant. The male bends the tip of his abdomen down and under, extends the aedeagus, and inserts it directly into the female's vagina. The insertion and subsequent copulating action of the male is accomplished by "dipping" the posterior portion of his body downward and forward. During copulation the male's antennae are spread and extended forward over the female's head, and he often touches the female's antennae with his own.

Although the longest period of copulation observed in the field was one half hour, adults were observed in copula for periods in excess of one hour in the laboratory. When copulating, the male pumped an average of 53 times per minute. Field and laboratory observations showed that it was common for joined pairs to walk about during the actual copulation process.

Sex ratios of *A. bimarginata* are nearly equal. From randomly selected field samples of 2,188 adults, 1,173 were males and 1,015 were females.

Oviposition

Eggs were first observed on May 8, 1966 and were common at the study sites throughout May and June, the peak oviposition period. However, because of continued mating by adults and because of the presence of larvae in the field until September, it may be assumed that some eggs also were laid during July and August. Although they were not seen during these months, it should be pointed out that even during the weeks of peak oviposition, eggs were somewhat difficult to locate.

A. bimarginata adult females will oviposit in a variety of places on or near the host plant. In the field, the largest egg masses were found on the main stem of *S. exigua*, usually at the node or stem axis. Smaller egg clusters were seen on the leaves of this host. In the laboratory, eggs frequently were found in many places other than on the willow sprig.

Eggs were sometimes neatly deposited side by side on end; at other times they were not laid in any basic pattern. The latter situation was most common at the study sites when there were large numbers of eggs on the plant stems. Eggs were not well cemented to the host substrate. Some egg masses (both in the field and in the laboratory) were seen to be streaked with excrement; Woods (1917) postulated that this may serve to help camouflage the egg.

The number of eggs per egg mass varied greatly both for field and laboratory populations. It was not uncommon to find eggs either occurring singly or in groups of 20 to 30 or more. One mass was found in the field that contained approximately 90 eggs. There was an average of approximately 10 eggs per mass laid under both laboratory and field conditions.

Fecundity

Laboratory studies indicated that each female was capable of laying an excess of 400 eggs. Teneral female adults, brought in from study site 2 on August 5, 1966, laid an average of 384.8 eggs before they died two months later.

EGG STAGE AND HATCHING

Fig. 7 illustrates the oviposition rate of beetles caged in the laboratory. Because hatching was observed on a daily basis, there is reason to believe that many of the eggs recorded as hatching at 4 or 7 days could easily have hatched within the 5 to 6 day period. The mean, maximum and mean minimum incubation temperatures were 77° F, 83.3° F and 70.5° F, respectively.

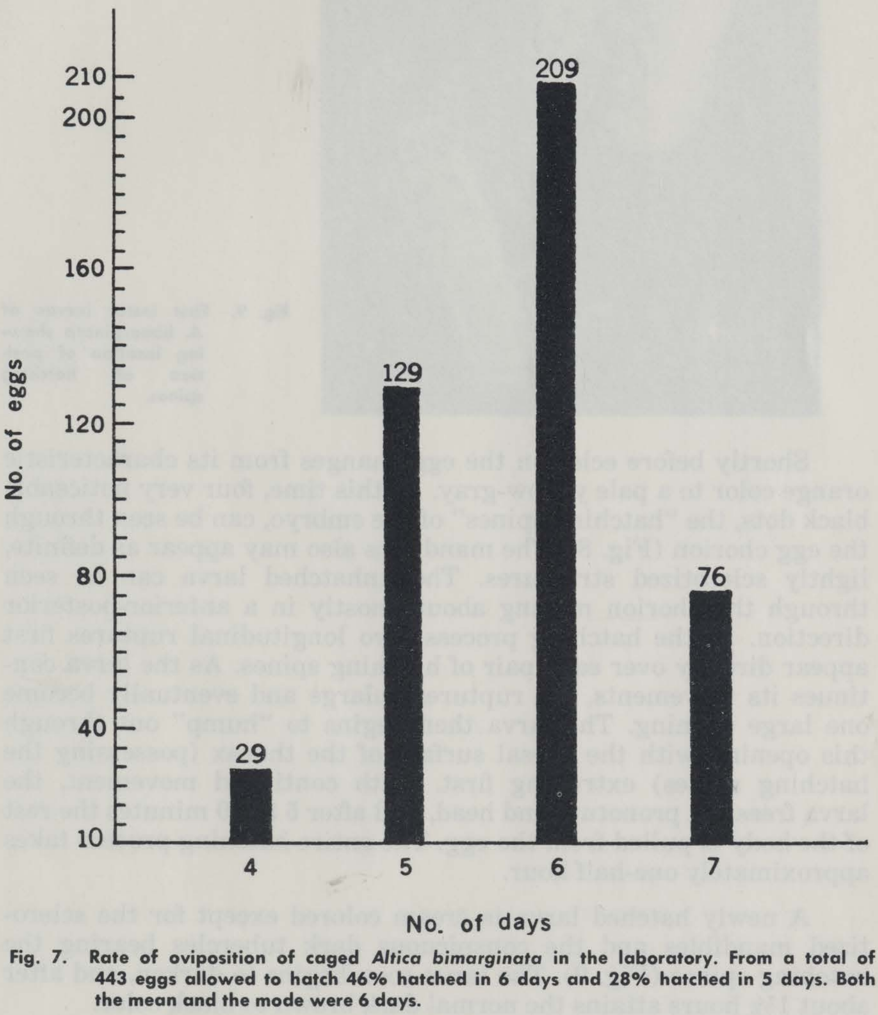


Fig. 7. Rate of oviposition of caged *Altica bimarginata* in the laboratory. From a total of 443 eggs allowed to hatch 46% hatched in 6 days and 28% hatched in 5 days. Both the mean and the mode were 6 days.

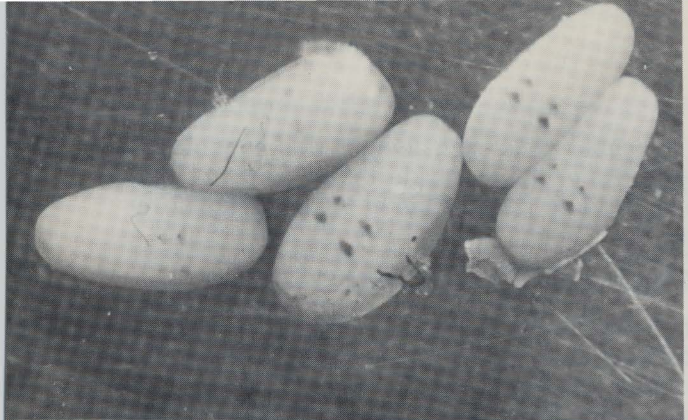


Fig. 8. Eggs of *A. bimarginata* with hatching spines evident through the chorion.

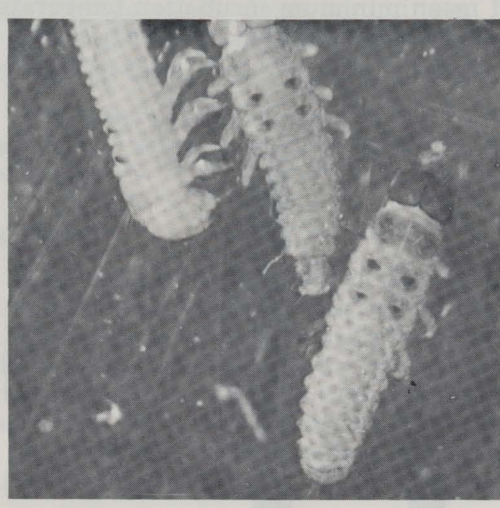


Fig. 9. First instar larvae of *A. bimarginata* showing location of position of hatching spines.

Shortly before eclosion the egg changes from its characteristic orange color to a pale yellow-gray. At this time, four very noticeable black dots, the "hatching spines" of the embryo, can be seen through the egg chorion (Fig. 8). The mandibles also may appear as definite, lightly sclerotized structures. The unhatched larva can be seen through the chorion moving about, mostly in a anterior-posterior direction. In the hatching process, two longitudinal ruptures first appear directly over each pair of hatching spines. As the larva continues its movements, the ruptures enlarge and eventually become one large opening. The larva then begins to "hump" out through this opening with the dorsal surface of the thorax (possessing the hatching spines) extruding first. With continued movement, the larva frees the pronotum and head, and after 5 to 10 minutes the rest of the body is pulled from the egg. The entire hatching process takes approximately one-half hour.

A newly hatched larva is cream colored except for the sclerotized mandibles and the conspicuous dark tubercles bearing the hatching spines (Fig. 9). The larva soon begins to darken, and after about 1½ hours attains the normal dark brown to black color.

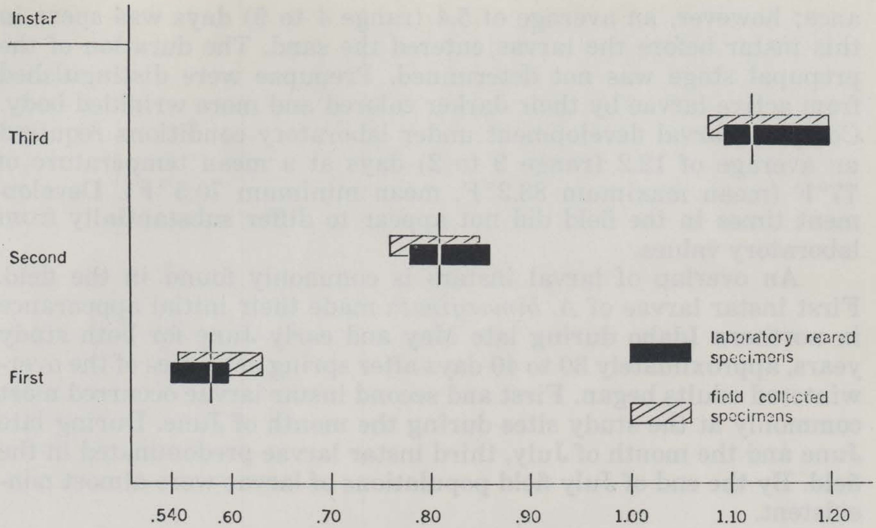


Fig. 10. Graphical presentation of *Altica bimarginata* Say head capsule width in mm. (vertical line indicates average overall head capsule width for each instar).

LARVA

Measurements of head capsules of 72 field-collected and laboratory-reared *A. bimarginata* larvae, together with daily observations on reared larvae, disclosed that there are three instars. Plotted head capsule measurements produced three distinct groups with no overlap (Fig. 10). Head width of each instar was approximately 1.38 times greater than that of the previous instar. Laboratory-reared larvae usually had slightly smaller head capsules than field-collected larvae; first instar head capsules averaged 0.02 mm smaller, second instar head capsules averaged 0.01 mm larger, and third instar head capsules averaged 0.01 mm smaller.

In the laboratory the first and second stadia averaged 3.9 (range 3 to 6) and 3.7 (range 2 to 6) days, respectively (Table 1). The third stadium could not be determined precisely because these larvae burrow into the sand to pupate during the last day or two of their exist-

Table 1. Summarization of larval stadia of *A. bimarginata* from specimens reared in the laboratory.

Number of days	Number of Specimens		
	1st Instar	2nd Instar	3rd Instar[a]
9			1
8			
7			2
6	1	1	1
5	3	2	4
4	12	6	4
3	7	8	
2		1	
1			

[a] stadia indicate number of days before entering pupation site in substrate.

ance; however, an average of 5.4 (range 4 to 9) days was spent in this instar before the larvae entered the sand. The duration of the prepupal stage was not determined. Prepupae were distinguished from active larvae by their darker colored and more wrinkled body. Complete larval development under laboratory conditions required an average of 12.2 (range 9 to 2) days at a mean temperature of 77°F (mean maximum 83.3°F, mean minimum 70.5°F). Development times in the field did not appear to differ substantially from laboratory values.

An overlap of larval instars is commonly found in the field. First instar larvae of *A. bimarginata* made their initial appearance in northern Idaho during late May and early June for both study years, approximately 30 to 40 days after spring activities of the overwintered adults began. First and second instar larvae occurred most commonly at the study sites during the month of June. During late June and the month of July, third instar larvae predominated in the field. By the end of July field populations of larvae were almost nonexistent.

Ecdysis

Larvae become somewhat lighter colored shortly before each molt due to the distension of their body wall which causes the darker tubercles and cuticular nodules to become more separated. As the molting process begins, a split appears first along the middorsal line of the thorax and rapidly extends forward to the vertex. By regular contraction and expansion, the larva slowly wriggles out of the old cuticle. The head, thorax (including legs), and first few abdominal segments are the first freed, and this occurs quite rapidly. The remaining abdominal segments are gradually freed by the contraction and expansion of the abdomen, a process which takes considerable time due to frequent pauses in these ecdysial movements. Ecdysis requires 45 to 65 minutes. At emergence larvae are noticeably orange colored, but within a few hours they darken and the typical brownish-black coloration is eventually achieved. In the field, larvae molted on the leaves and smaller stems in the top half of the host plants. Laboratory-reared larvae molted most commonly on filter paper that covered the bottom of their petri dish cages, rather than on the willow supplied as food. All larvae from any one egg mass molted at almost the same time.

Feeding

Larvae are leaf skeletonizers of their host plant, *S. exigua*. They normally congregated in large numbers; however, they also were found scattered individually on the host plant. This latter situation was most common during July and September when the larval population was decreasing. Feeding was commonly restricted to the leaves in the top half of the host plant.

Heavy populations (10 larvae/12 inch (30.48 cm) branch) resulted in 70 percent defoliation. However, the willow was not seen to be permanently affected and eventually attained its normal vigor once the larval population departed.

PUPATION AND ADULT EMERGENCE

Pupation in northern Idaho occurred from early July to August 8, 1966, and took place 1½ to 3½ inches (3.81 to 8.89 cm) beneath the surface of the soil in small oval chambers hollowed out of moist sand. Moist sand appeared necessary for successful pupation. Most pupal chambers were found directly under infested bushes on the side nearest the river. Laboratory rearings indicated that adults emerged from the soil 9 to 19 days after entering the soil as late third instar larvae, with the majority emerging after 14 days. In the field small exit holes of the adults may be extremely numerous in the moist sand under *S. exigua* plants.

New adults were present from late July and by mid-August were extremely numerous. These new adults mated and produced a partial second generation which was present as small to moderate numbers of first, second, and third instar larvae during August and September. It is not known whether this partial second generation succeeded in pupating.

OVERWINTERING

The overwintering period for *A. bimarginata*, at the study sites, extended from October to approximately mid-April during the winter of 1965-66. The first noticeable decrease in the size of the adult populations on the host plants occurred October 2 and September 25 in 1965 and 1966, respectively.

Overwintering sites included almost any place affording shelter — under various ground litter (including boards and driftwood), and around the bases of a wide variety of plants. Plants under which *A. bimarginata* adults were found included: *Agropyron* sp., *Cichorium intybus* L., *Gawia parviflora* Doug., *Verbascum Blattaria* L. and *Verbena bracteata* Lag. and Rdr. Adults usually were found in groups of 4 to 12 individuals, although 15 to 20 were not uncommon under some larger plants, and 50 to 75 were found once under a single piece of driftwood. Very few adults were found overwintering individually. The complete life cycle of *A. bimarginata* is summarized in Fig. 11.

PARASITES AND PREDATORS

A. bimarginata larvae apparently are not subject to a high incidence of parasitism. Laboratory rearings produced only two parasites and one of these is reportedly a parasite of Diptera. One parasite collected was placed in the Tribe Campoplegini (Family Ichneumonidae) by L. M. Walkley of the U.S. National Museum, though she stated the specimen had a combination of characters that fits no campoplegine genus known to her. The other parasite was determined by C. F. W. Muesebeck (also of the U.S. National Museum) as belong-

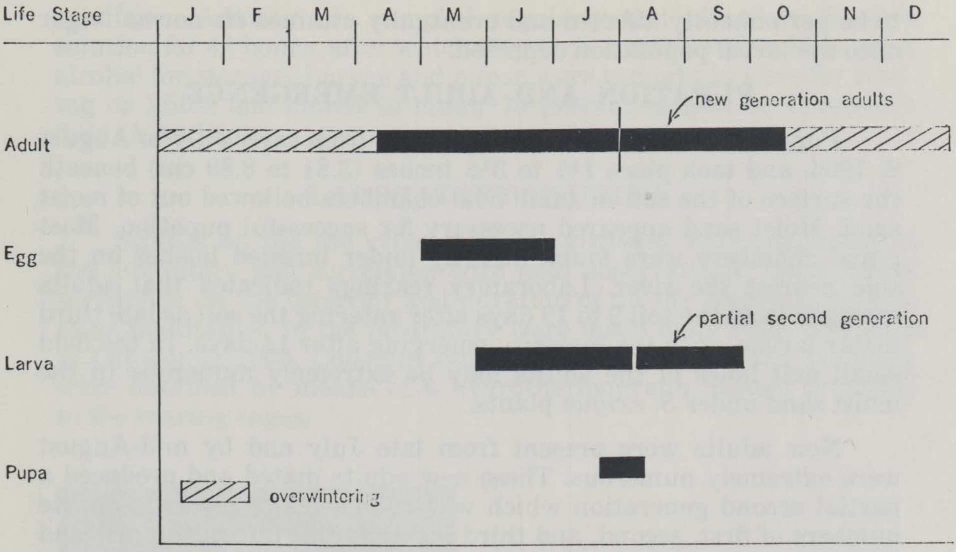


Fig. 11. Graphic presentation of field observed seasonal distributions of life stages of *Altica bimarginata* Say in northern Idaho.

ing to the Subfamily Alysiinae of the Family Braconidae. Muesebeck reports that as far as is known all Alysiinae are parasites of dipterous larvae or pupae.

Three different predators were found preying on *A. bimarginata* at the study sites. A carabid adult (*Lebia* prob. *perita* Casey) was observed very actively preying on the host larvae, and was present throughout the duration of the larval stage in the field. Carabid larvae (possibly the same species) were observed frequently feeding on pupae of *A. bimarginata.* A reduviid, *Sinea diadema* (Fabr.), was observed to be a common predator of adult *A. bimarginata.* This bug usually inserted its beak between the pronotum and the base of the elytra when feeding, although other areas of the beetle were also pierced. The seasonal occurrence of this predator in the field was not determined.

TEMPERATURE AND PRECIPITATION

Temperature and precipitation figures were obtained from records of official U.S. weather stations at Lewiston (Lewiston Orchards airport), Idaho, (elevation 1,400 ft. or 427 m) and Orofino, Idaho, (elevation 1,027 ft. or 313.2 m). Data from both stations was averaged and is summarized in Fig. 12 and 13. Because of the differences in both horizontal and vertical distances between the study sites and reporting stations, and the influence of temperature inversions, these temperature and precipitation values can only give an indication of the 1965 and 1966 conditions at the study sites.

The mean maximum and minimum temperatures averaged, respectively, 0.9° F and 0.6° F higher per month in 1966. Precipita-

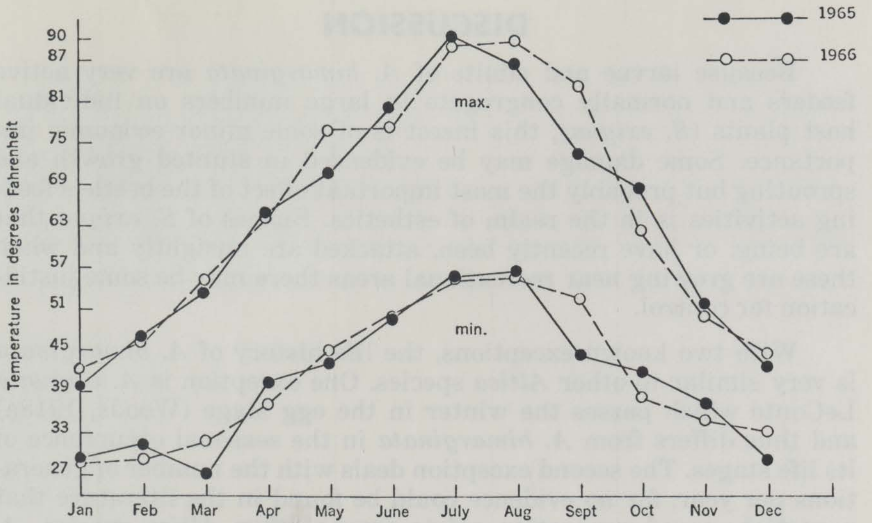


Fig. 12. Approximate average monthly mimimum and maximum temperatures at Clearwater River study sites for 1965 and 1966.

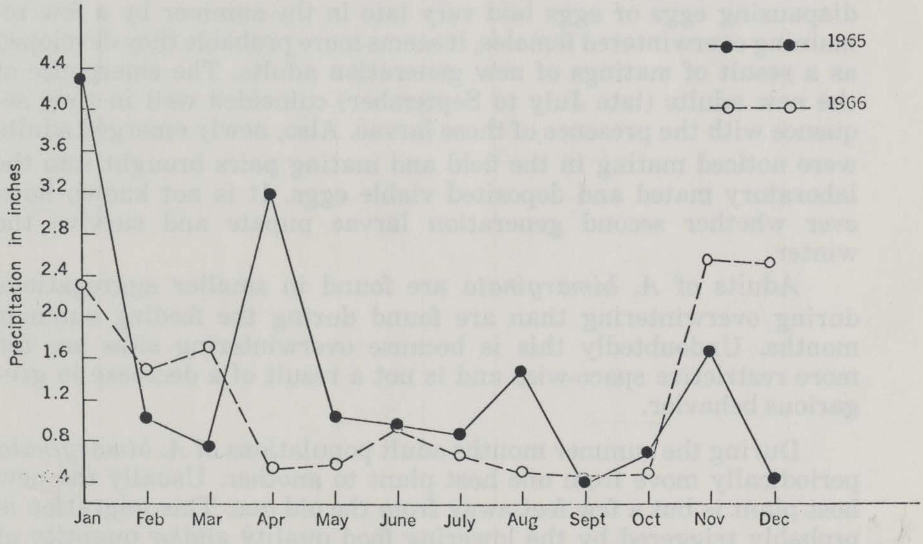


Fig. 13 Approximate total monthly precipitation at Clearwater River study sites for 1965 and 1966.

tion averaged 0.16 inches (3.1 mm) less per month in 1966. The small temperature differences, and the precipitation fluctuations between the two study years resulted in no observable differences in the life histories of *A. bimarginata* when field notes of the two years were compared.

DISCUSSION

Because larvae and adults of *A. bimarginata* are very active feeders and normally congregate in large numbers on individual host plants (*S. exigua*), this insect is of some minor economic importance. Some damage may be evidenced in stunted growth and sprouting but probably the most important effect of the beetle's feeding activities is in the realm of esthetics. Bushes of *S. exigua* that are being, or have recently been, attacked are unsightly and when these are growing near recreational areas there may be some justification for control.

With two known exceptions, the life history of *A. bimarginata* is very similar to other *Altica* species. One exception is *A. torquata* LeConte which passes the winter in the egg stage (Woods, 1918a) and thus differs from *A. bimarginata* in the seasonal occurrence of its life stages. The second exception deals with the number of generations per year, for no evidence could be found in the literature that a partial second generation exists among other *Altica* species. *A. bimarginata* has a partial second generation, at least in northern Idaho, since some larvae were seen in the field during August and September. Though it is possible these larvae came from summer diapausing eggs or eggs laid very late in the summer by a few remaining overwintered females, it seems more probable they developed as a result of matings of new generation adults. The emergence of the new adults (late July to September) coincided well in time sequence with the presence of these larvae. Also, newly emerged adults were noticed mating in the field and mating pairs brought into the laboratory mated and deposited viable eggs. It is not known however whether second generation larvae pupate and survive the winter.

Adults of *A. bimarginata* are found in smaller aggregations during overwintering than are found during the feeding summer months. Undoubtedly this is because overwintering sites are far more restrictive space-wise and is not a result of a decrease in gregarious behavior.

During the summer months adult populations of *A. bimarginata* periodically move from one host plant to another. Usually the new host plant is but a few feet away from the old one. This migration is probably triggered by the lowering food quality and/or quantity of the initial host plant.

Considerable overlapping of life stages occurs in the field during the summer. Eggs and first-through-third instar larvae may be found on the same host at the same time. This overlap appears to be a direct result of the lengthy period of time over which spring emergence, and subsequent continuous mating and oviposition of adults occurs.

The fecundity results mentioned previously need clarification. Because of two variables associated with the laboratory-kept adults, the figure of 400 eggs per female should only be considered an estimate of female fecundity in nature. These adults did not experience hibernation as did the field populations whose members generally mated and oviposited after they had overwintered.

Finally a few general statements can be made regarding correlations between observed seasonal distributions of life stages of *A. bimarginata* and temperatures that occurred at the study sites during the study period. This is most easily done by combining the information presented in Figs. 11 and 12. Overwintering ceases and commences when the average maximum temperature becomes approximately 66°F and the average minimum temperature becomes approximately 40°F. As the average maximum temperatures increase in the spring about 4°F, oviposition commences and when average temperatures have risen another 5° or so to approximately 75°F maximum and 46°F minimum larvae start emerging. Larval development is completed as summer temperatures reach their peak (87 to 92°F). Pupation then occurs in cool, moist sand during the hottest time of the year when average high temperatures range from 82 to 92°F. New generation adults make their appearance as the high summer temperatures start to drop.

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