BEET ARMYWORM FECUNDITY AND OVIPOSITION BEHAVIOR

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Abstract

Longevity, duration of the oviposition period, realized fecundity, and potential fecundity of the beet armyworm, *Spodoptera exigua* (Hubner), were examined in the laboratory under different feeding regimes. All parameters were significantly reduced for the water-only diet compared with 10% honey or sucrose diets. Oviposition was highest the night after mating and decreased in a logarithmic fashion thereafter. In the carbohydrate-fed moths, 92% of lifetime realized fecundity occurred by the fourth night of oviposition. Although our data indicate that carbohydrates in the adult diet can increase realized and potential fecundity, most of the lifetime complement of oocytes (91%) is present at the time of eclosion from the pupa. Pupal weight was significantly correlated with lifetime potential fecundity, explaining 37 - 66% of the variation among moths depending on adult diet. In cotton, most egg masses were deposited on the undersides of leaves within the upper 50% of the canopy and horizontally within the inner 50% of the plant. In pigweed, egg masses were commonly laid within the inner 50% of the canopy, but along the upper 80% of the vertical axis. This positional information will aid in further efforts to investigate, predict, and manage beet armyworm populations in cotton and non-cotton hosts.

Introduction

Beet armyworm, *Spodoptera exigua* (Hubner), is a highly polyphagous pest of many important crops worldwide (Hassanein et al. 1972, Aarvik 1981, Stewart et al. 1996). Some of its hosts which occur in the Lower Rio Grande Valley of Texas include pigweed (*Amaranthus* spp.), bell pepper (*Capsicum annuum*), cabbage (*Brassica oleracea*), sunflower (*Helianthus annuus*), and cotton (*Gossypium hirsutum*). The beet armyworm recently has become an increasingly damaging pest of cotton in the southern U. S. (Mascarenhas et al. 1998). Two of the most destructive recorded outbreaks on cotton occurred in the Lower Rio Grande Valley (Summy et al. 1996) and the Southern Rolling Plains of Texas (Huffman 1996) in 1995.

Because of the increasing importance of the beet armyworm as a secondary pest of cotton, its biology has become the subject of much interest. To date, only four studies have dealt with fecundity of the beet armyworm; two examined the effects of age at mating, one the effects of photoperiod, and one the effects of mating status (El-Sawaf et al. 1965, Ebeid 1981, Rogers and Marti 1996, 1997).

We are interested in determining where beet armyworm females prefer to lay their egg masses within the canopy of cotton, pigweed, and other hosts, because such information could improve scouting efforts, population forecasts, and treatment timing. Our objectives were to examine the relationships among pupal weight and potential and realized fecundity, to quantify temporal oviposition profiles, and define the spatial patterns of beet armyworm ovipostion within cotton and pigweed canopies.

Materials and Methods

Fecundity

Beet armyworm neonate larvae were obtained from a colony at the Kika de la Garza Subtropical Agriculture Research Center in Weslaco, Texas and reared on a soybean-wheat germ diet (Shaver and Raulston 1971). The insects were maintained in environmental chambers at 30ºC, 85% RH, and a 13:11 (L:D) photoperiod. At pupation the moths were sexed and placed in individual cups until adult emergence. Previous observations indicated that under our rearing conditions pupae lose weight continuously until adult emergence. Therefore, all pupae were weighed 4 d after pupation.

To determine initial potential fecundity, 50 females were dissected on the day of emergence. The ovaries were dissected by placing the female dorsum side down and applying pressure to the abdomen until the ovipositor protruded. The ovipositor was grasped with forceps and the entire ovary removed and placed in a drop of Ringer's solution on a glass slide. The ovarioles were teased apart up to the pedicel and the oocytes counted.

To determine realized fecundity, defined as the lifetime number of eggs oviposited, females and males were placed as pairs in 5.0-L cardboard containers on the day of emergence to allow mating. The pairs were separated the next day and the females were allowed to oviposit on following nights until death. The inside of each container was lined with waxed paper as oviposition substrate. All mated females were supplied with a water-soaked cotton ball. In addition, two groups of moths were supplied with a carbohydrate diet consisting either of a cotton ball soaked with 10% honey or with 10% sucrose. Containers were examined daily to record mortality and to remove eggs. Egg masses were cut from the liner, and the number of eggs in each mass counted. Moths were dissected after they died to determine the number of oocytes remaining. Lifetime potential fecundity was

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calculated as the realized fecundity plus oocytes remaining in the ovaries at the time of death. There was no evidence of disintegration of oocytes between the time of death and dissection.

Spatial Distribution of Egg Masses within the Plant Canopy

Beet armyworm were separated by sex as pupae. On the day of emergence, up to 20 males were placed together in a 0.5-L container, and females were individually placed in 0.5-L containers. Moths were provided with 5% sucrose and held overnight in an environmental chamber at 30°C, 85% RH, and a 13:11 (L:D) photoperiod. The following day one male was placed with each female. Females were allowed to oviposit for a single night before placement in field cages.

Eight rows of cotton or pigweed were treated with azinphosmethyl at 4 pt/ac to kill natural enemies. After 48 h, one row of plants was selected from near the center of the treated area and 1-m plots, spaced at least 10 m apart, were delimited. For each plot, the number of plants, the height of each plant, and maximum width of the canopy of each plant was recorded. Over the course of the study, cotton ranged in height from 40 to 67 cm, and pigweed averaged about 101 cm in height. The plots were covered with 1-m^3 mesh cages, and 4 females were placed in each cage. After two nights, the cage was removed and plants were inspected for egg masses. The height above the soil surface and the distance from the center of the canopy was recorded for each egg mass.

All statistical analyses were performed with Statistix software (Analytical Software 1998). The nonparametric Kruskal-Wallis test (Kruskal and Wallis 1952) was used to separate multiple means after an initial Kruskal-Wallis test indicated a significant treatment effect. Linear regressions were performed to elucidate the relationships of realized and potential fecundity to pupal weight.

Results and Discussion

Fecundity

Adult diet significantly affected beet armyworm female longevity, the duration of the oviposition period, and both realized and potential fecundity (Table 1). Carbohydrates in the diet significantly increased these parameters over a water-only diet. Only 6 of the 140 females examined in this study oviposited on the night of mating, while the rest first oviposited on the following night. The number of eggs oviposited was greatest on the first day of egg laying, and decreased logarithmically thereafter (Fig. 1). This pattern is similar to that of other noctuids including *Helicoverpa armigera* (Jallow and Zalucki 1998), *Sesamia nonagrioides* (Robert and Frerot 1998), and *Spodoptera pectinicornis* (Wheeler et al. 1998). Adult diet did not affect the number of eggs laid on the first two days of oviposition. However, the number of eggs laid by females on a water-only diet was significantly less than that of moths fed honey or sucrose diets on days 3-5. By day five of oviposition, water-fed females began to die in large numbers, but because the bulk of eggs were laid in the first four days (92% for honey and sucrose-fed females combined), the overall reduction in lifetime realized fecundity was small (12%) compared to carbohydrate-fed females (Table 1).

The number of oocytes present on the day of eclosion was positively related positively to pupal weight, but this relationship explained only 24% of the variation among moths (Fig. 2A). Potential fecundity was related positively to pupal weight (Fig. 2B-D), with the strongest observed relationship among water-fed females (Fig. 2D). For all diet treatments, the strength of the relationship of accumulated realized fecundity to pupal weight improved from the first through the third day of oviposition, and data from females of the water-fed treatment are presented as an example (Fig. 3). A similar tightening of the relationship through the first three days of oviposition was reported for the Mexican rice borer, *Eoreuma loftini* (Dyar) (Spurgeon et al. 1995).

Our data suggest the beet armyworm does not eclose with a full lifetime complement of oocytes. The number of oocytes present at eclosion (1285 $\pm$ 32.7, n = 50) was significantly less than lifetime potential fecundity for carbohydrate-fed moths (1469 $\pm$ 37.1, n = 96) (t = 3.25, df = 144, P = 0.0014). In contrast, lifetime potential fecundity of water-fed moths (1220 $\pm$ 59.5) was similar to that of moths dissected at eclosion (t = 1.00, df = 90, P = 0.3179), suggesting that carbohydrate in the adult diet can increase lifetime realized and potential fecundity. However, most of the lifetime egg complement in carbohydrate-fed moths (91%; Table 1) is present at eclosion. Because pupal weight has some influence on the initial complement (Fig. 2A), the quality of the larval diet likely affects adult fecundity. Ali and Gaylor (1992) found that pupal weights of larvae reared on cotton averaged roughly 90 mg, whereas those reared on pigweed averaged roughly 120 mg. Our data suggest that a difference in pupal weight of this magnitude would result in a decrease in the initial egg complement of about 200 eggs (Fig. 2A), or 15%.

Spatial Distribution of Egg Masses within the Plant Canopy

About $^2/_3$ of the egg masses were deposited in the upper 50% of the cotton canopy, and within the inner 50% of the horizontal distance from the center to the edge of the canopy (Fig. 4). Of 145 egg masses deposited, all were found on the underside of leaves except one which was located on a square.

The pigweed in our study was taller, with a narrower, more open canopy than the cotton, and the spatial distribution of eggs laid by beet armyworms in the former was different in some respects (Fig. 5). As in cotton, most of the egg masses were found horizontally within the inner 50% of the pigweed canopy, but preference in the vertical dimension was less well defined. Egg masses were most commonly found on the undersides of leaves in the upper 80% of the plant.

Diawara et al. (1992) reported that beet armyworm eggs are usually deposited in the upper half of celery plants, and the same seems to be true for tomato (*Lycopersicon esculentum*) plants (Zalom et al. 1983). Thus, Diawara et al. (1992) suggested that scouting for egg masses in celery may be preferable to scouting for young larvae which tend to occur low in the celery canopy in relatively inaccessible positions. Our results should facilitate development of more effective and efficient egg scouting protocols in cotton. In addition, this information will allow proper placement of egg masses in planned studies of egg predation by natural enemies. The improved understanding of the dynamics of oviposition and fecundity obtained from the study reported here will be vital to further efforts to investigate, predict, and manage beet armyworm populations in cotton and non-cotton hosts.

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Table 1. Effects of adult diet on beet armyworm longevity, oviposition profiles and fecundity.

	10% Honey	10% Sucrose	Water
n	21	77	42
Longevity (days)	17.2 ± 1.2**a**	12.8 ± 0.5**b**	6.3 ± 0.2**c**
Days Ovipositing	9.2 ± 0.4**a**	7.7 ± 0.3**a**	3.8 ± 2.2**b**
Realized Fecundity	1507 ± 75**a**	1382 ± 48**a**	1236 ± 54**b**
Potential Fecundity	1546 ± 71**a**	1448 ± 43**a**	1219 ± 60**b**

Means followed by the same letter within a row are not significantly different, Kruskal-Wallis test, (α = 0.05). Potential fecundity was calculated as the total number of eggs oviposited plus any oocytes remaining in the ovaries at the time of death.

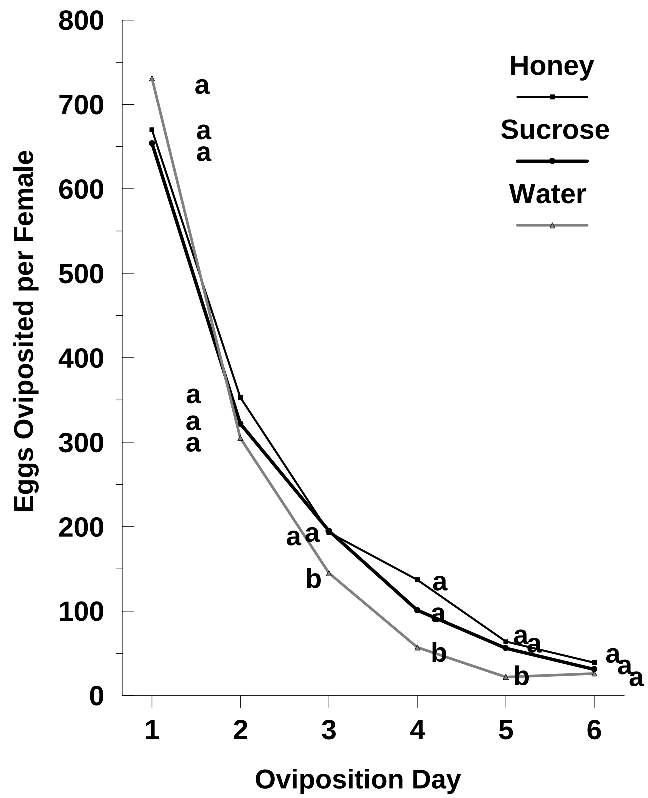
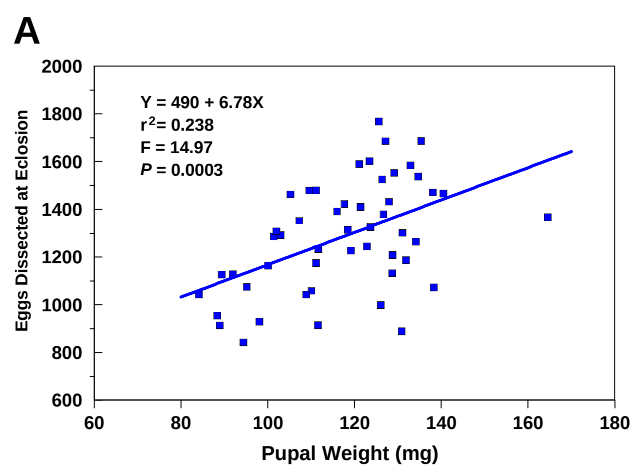


Figure 1. Daily oviposition profile of beet armyworm maintained on different diets. Day 1 indicates first day of oviposition, and was usually the day after mating. Means at a given day associated with the same letter are not significantly different (Kruskal-Wallis test, α = 0.05).



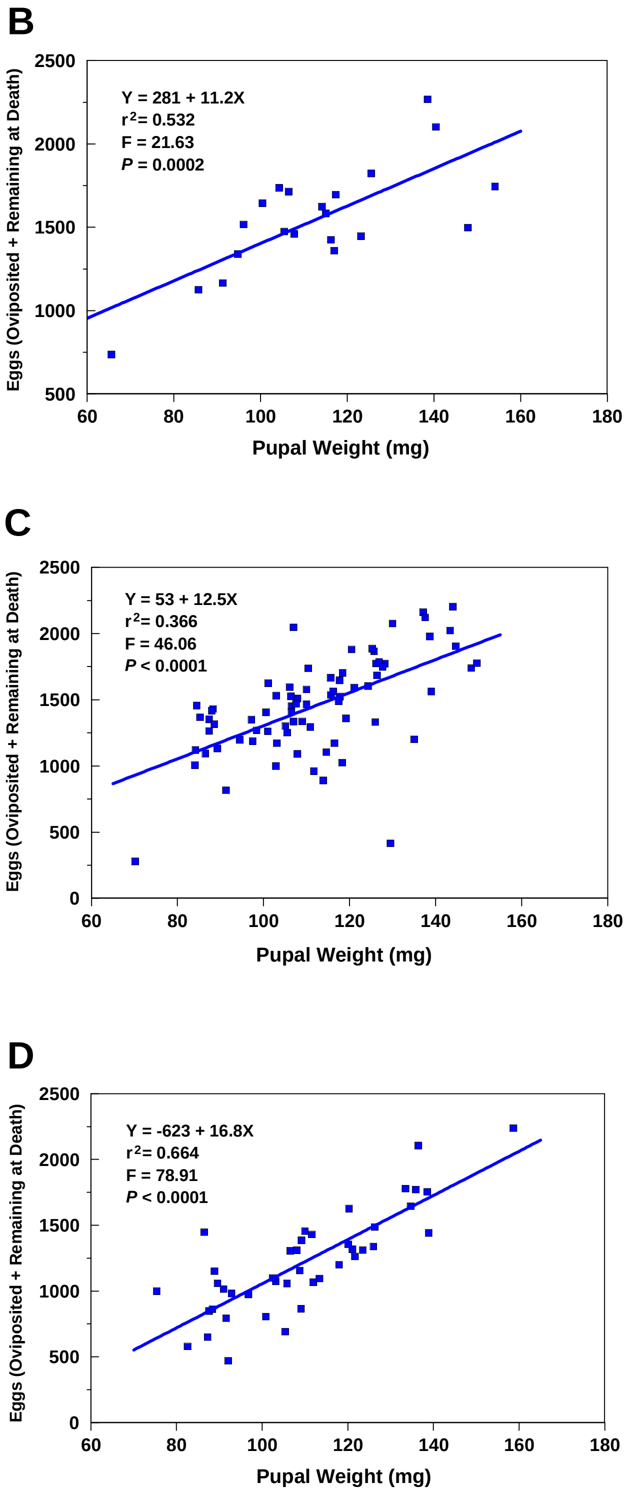


Figure 2. The relationship of potential fecundity and pupal weight for beet armyworm adults A) dissected the day of eclosion, B) fed with 10% honey and water, C) fed with 10% sucrose and water, or D) fed with water only.

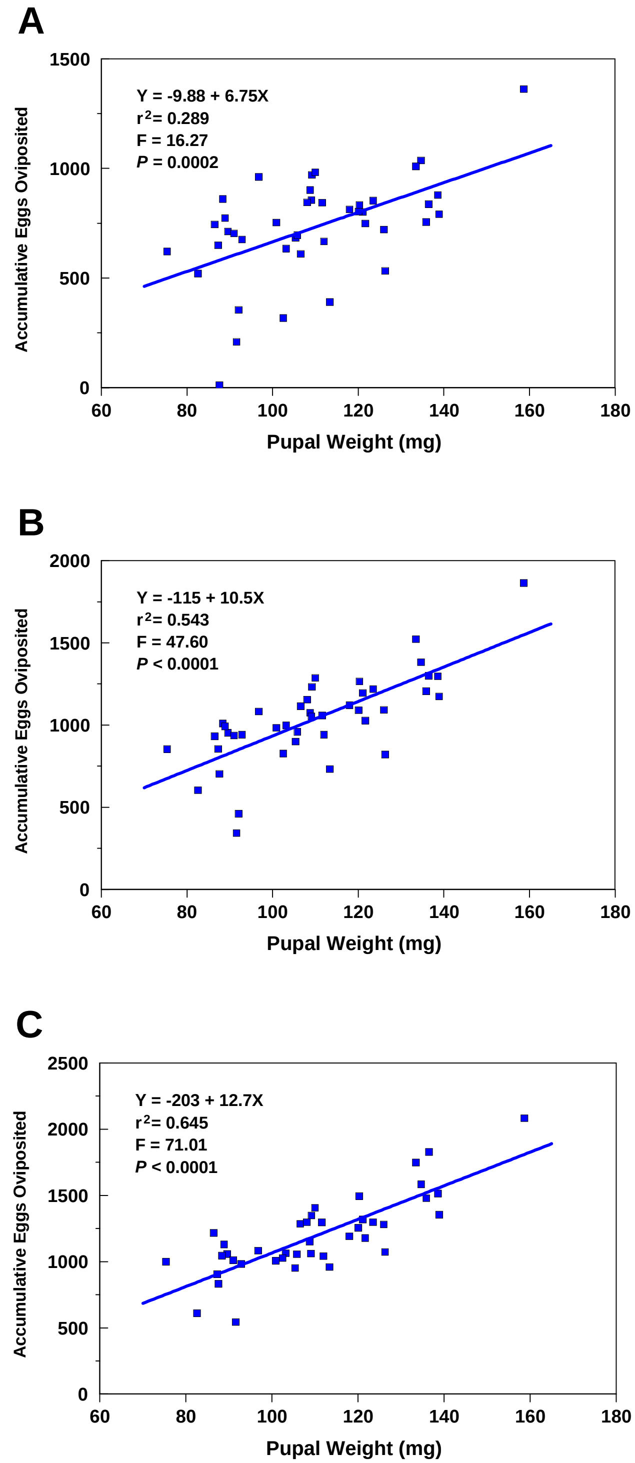


Figure 3. Regression of accumulated eggs oviposited on pupal weight on the A) first, B) second, and C) third day of ovipositional activity by beet armyworms maintained on a water-only diet.

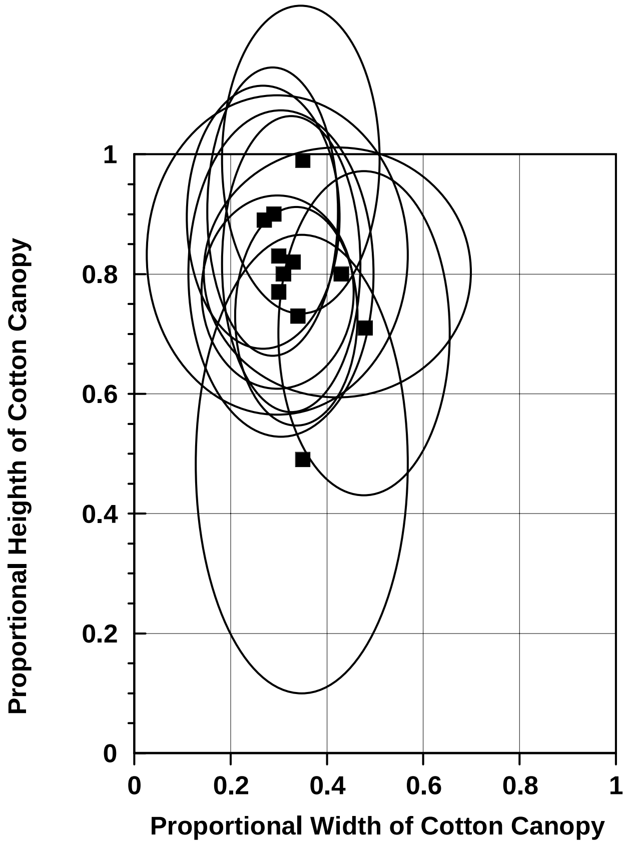


Figure 4. Relative position of oviposition sites within the cotton canopy. Squares indicate replicate means of at least 6 egg masses. Each mean is surrounded by a standard deviation ellipse. The X-axis is scaled to be 82% the length of the Y-axis, the average relationship of canopy width to plant height observed in this study.

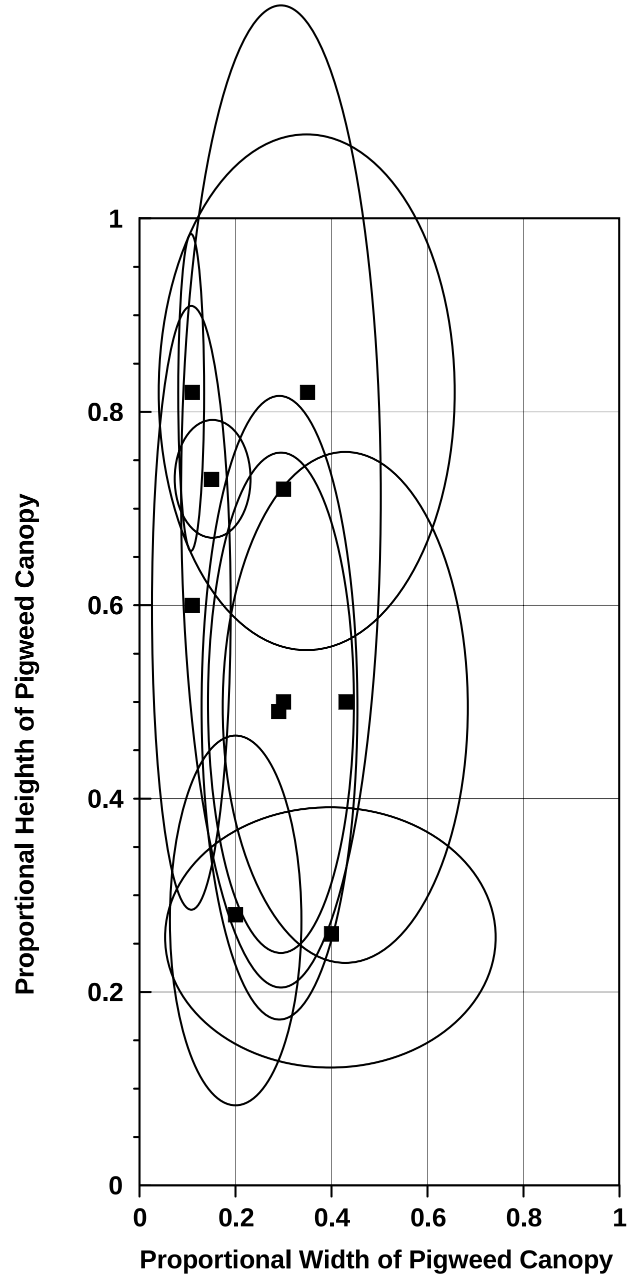


Figure 5. Relative position of oviposition sites within the pigweed canopy. Squares indicate replicate means of at least 7 egg masses. Each mean is surrounded by a standard deviation ellipse. The X-axis is scaled to be 48% the length of the Y-axis, the average relationship of canopy width to plant height observed in this study.