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Development, survival, and fecundity of *Helicoverpa zea* (Lepidoptera: Noctuidae) on five weedy host plants common across the mid-south USA

James P. Glover[1,], Maribel Portilla[1], and Gadi V.P. Reddy[1]*

Abstract

Helicoverpa zea (Boddie) (Lepidoptera: Noctuidae) is a highly mobile and polyphagous pest known to feed on over 300 cultivated and wild host plant species. Larvae cause significant economic damage to several commercial row crops over multiple generations each growing season. The objective of this study was to compare biological fitness of *H. zea* on 5 weedy host plants commonly found across the mid-south US. Crimson clover (*Trifolium incarnatum* L.), white clover (*Trifolium repens* L.), hairy vetch (*Vicia villosa* Roth), kudzu (*Pueraria montana* [Lour.] Merr. (all Fabaceae), and honeysuckle (*Lonicera japonica* Thunb.; Caprifoliaceae) were evaluated as primary food sources for *H. zea* under laboratory conditions at 27 ± 0.5 °C, a relative humidity of 60 ± 5%, and a 14:10 h (L:D) photoperiod. This study measures the development, biomass, survival, and fecundity of *H. zea* when reared on the reproductive tissues of 5 common weeds. Larvae of *H. zea* successfully developed on all 5 weeds to adulthood, but significant mortality (> 50%) was observed for larvae reared on hairy vetch, honeysuckle, and kudzu. Larval developmental periods ranged from 30 d to 39 d for *H. zea* reared on honeysuckle and white clover, respectively. Pupal biomass ranged 158.1 mg to 161.2 mg for individuals reared on hairy vetch, followed by 196.2 mg to 202.8 mg on crimson clover, and 204.6 to 217.4 mg for individuals on white clover, honeysuckle, and kudzu collectively. Pupal emergence varied from 92.1% to 61.8% for crimson clover and hairy vetch, respectively. Larval mortality varied from 25.3% on crimson clover to 68.9% for hairy vetch. Average adult longevity ranged from 10 d to 11 d for females and males reared on crimson clover to 4 d on kudzu and 4 d on white clover for female and male, respectively. The average number of eggs laid by females reared on crimson clover, white clover, hairy vetch, honeysuckle, and kudzu were 553.5, 512.3, 288.2, 194.7, and 142.2, respectively. Our findings indicate crimson and white clover were among the most suitable hosts, and kudzu the most unsuitable based on larval mortality and reproductive capability.

Key Words: cotton bollworm; fitness; crimson clover; kudzu; honeysuckle; hairy vetch; development time; survival; fecundity; weedy hosts

Resumen

El objetivo de este estudio fue comparar los parámetros biológicos de *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae) en cinco plantas hospederas comunes de mid-south: trébol carmesí (*Trifolium incarnatum* L.), trébol blanco (*Trifolium repens* L.), arveja vellosa (*Vicia villosa* Roth), kudzu (*Pueraria montana* (Lour.) Merr.) (todos Fabaceae) y madreselva *Lonicera japonica* Thunb. (Caprifoliaceae) evaluadas bajo condiciones de laboratorio a 27 ± 0.5 °C, 60 ± 5% de humedad relativa y un fotoperíodo de 14:10 (L:O). Se midió el tiempo de desarrollo de huevo, larva y pupa, peso pupal, longevidad y fecundidad del adulto de *H. zea*. La larva se desarrolló con excito hasta adulto sobre las cinco plantas hospederas, sin embargo, se observo una diferencia significativa de > 50% in larvas criadas en arveja vellosa, madreselva y kudzu. El rango del periodo de desarrollo larval vario de 30 d a 39 d en madreselva y trébol blanco, respectivamente. El rango de biomasa de pupa vario de 217.4 mg para hembras criadas en trébol blanco y 213.6 mg para machos criados en madreselva a 161.2 y 158.1 mg para hembras y machos criados en arveja vellosa. La emergencia de pupa vario de 92.1% a 61.8% para trébol carmesí y arveja vellosa, respectivamente. La mortalidad de larva vario de 25.3% en trébol carmesí a 68.9% en arveja vellosa. El rango promedio de longevidad del adulto vario de 10.3 d a 11.2 d para hembras y machos criados en trébol carmesí a 4 d en kudzu y 4 d en trébol blanco, respectivamente. El promedio de huevos ovipositados por hembras criadas en trébol carmesí, trébol blanco, arveja vellosa, madreselva y kudzu fueron de 553.5, 512.3, 288.2, 194.7 y 142.2, respectivamente. Nuestros resultados indican que los tréboles blanco y carmesí fueron los mas susceptibles comparados con el resto de las plantas hospederas y con base en mortalidad de larva y capacidad reproductiva de adultos, kudzu fue el mas resistente.

Palabras Clave: gusano del algodón; aptitud física; trébol carmesí; kudzu; madreselva; tiempo de desarrollo; de la veza peluda; supervivencia; fecundidad; anfitriones de maleza

The cotton bollworm, *Helicoverpa zea* (Boddie) (Lepidoptera: Noctuidae), is a cosmopolitan pest that feeds on numerous wild and cultivated crops. This insect pest causes economic damage on many vegetable and commercial row cropping systems across the Western Hemisphere (Cohen et al. 1988; Blanco & Houston 2005). *Helicoverpa zea* is documented to infest > 20 cultivated plant species and > 75 wild non-cultivated hosts (Stadelbacher 1980; Stadelbacher et al. 1986; King 1994; Hardwick 1996; Blanco et al. 2002). Larvae of *H. zea* feed on different parts of host plants such as flowers, buds, stems, and leaves (Garcia 2006). Infestations and outbreak populations of *H. zea* cause significant economic damage to 2 major crop hosts in the southern US: corn (*Zea mays* L.; Poaceae) and cotton (*Gossypium hirsutum* L.;

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Malvaceae). Corn is considered significantly more attractive to *H. zea* when compared to other widely grown row crops including sorghum (*Sorghum bicolor* L.; Poaceae), soybean (*Glycine max* L. Merr.; Fabaceae), and tobacco (*Nicotiana tobacum* L.; Solanaceae) (Hardwick 1965; Johnson et al. 1975; Luttrell 1994; Capinera 2001; Luttrell & Jackson 2012, Rhino et al. 2014). Host plants have been well documented to have significant effects on insect development, reproductive capability, and survivorship including many noctuid species (Ellsbury et al. 1989; Razmjou et al. 2014; Barbosa et al. 2016; Fathipour et al. 2020).

Many studies have investigated the larval developmental differences in *H. zea*, primarily for standardized moth diets commonly used in laboratories for mass rearing and on a variety of crops producing *Bacillus thuringiensis* Berliner (Bacillales: Bacillaceae) (*Bt*) toxin such as corn and cotton (Little et al. 2019). Life tables and demographic data have been collected for many cultivated crops such as chickpea (*Cicer arietinum* L.; Fabaceae), tomato (*Solanum lycopersicum* L.; Solanaceae), and tobacco (Blanco et al. 2007; Anderson et al. 2013; Barbosa et al. 2016). A considerable body of work describing the influence of abiotic factors including temperature, d length, and humidity have been studied for *H. zea* (Harrell et al. 1979; Pullen et al. 1992; Parajulee et al. 1998; Morey et al. 2012; Chen et al. 2014). Research investigating the factors regulating diapause induction and termination of *H. zea* and other related species within the heliothine complex also have been well studied (Phillips & Newsom 1966; Benschoter 1968).

However, few studies have compared biological parameters of *H. zea* when reared on common weedy hosts. Baseline biological data for *H. zea* on different weedy plants will help identify risk in agroecosystems and questions associated with *H. zea* survival and fecundity on hosts common across the mid-south. Crimson clover (*Trifolium incarnatum* L.; Fabaceae) and Japanese honeysuckle (*Lonicera japonica* Thunb.; Caprifoliaceae) are documented early season hosts of *H. zea* (Ellsbury et al. 1989; Pair 1994). Crimson clover is an early, cool season, annually grown cover crop throughout the southeastern US (Ellsbury et al. 1989). Historically, crimson clover has been cultivated across the southeastern US to control soil erosion and to stabilize highway rights of way (Power 1987). Across the mid-south, this practice continues and is actively managed by the state department of transportation providing an annual source of wild, first filial generation of field-collected *H. zea* (F_1) larvae. Japanese honeysuckle is a vining evergreen perennial weed that blooms twice a yr primarily from Apr to May and Sep to Nov across the mid-south. Japanese honeysuckle was introduced in about 1806 as an ornamental that escaped from cultivation around 1890, and subsequently has established throughout the eastern US (Hardt 1986; Pair 1994).

The availability and attractiveness of various non-cultivated hosts (i.e., weedy hosts) change through space and time across the landscape influencing local insect populations (Neunzig 1963; Sudbrink & Grant 1995; Kennedy & Storer 2000). Integrated pest management (IPM) programs require a detailed understanding of a pest's life cycle (Kogan 1998). These data may lead to identification of potential fitness costs associated with select host plants that may have detrimental impacts on *H. zea* in a given agroecosystem, such as increased developmental times and larval mortality, in addition to potential reductions in fecundity that may be exploited for decision making purposes (Cunningham & Zalucki 2014).

Therefore, the objectives of this study were to assess and compare biological parameters of *H. zea* when reared to pupation on crimson clover, white clover (*Trifolium repens* L.; Fabaceae), hairy vetch (*Vicia villosa* Roth; Fabaceae), kudzu (*Pueraria montana* (Lour.) Merr.; Fabaceae), and Japanese honeysuckle. In this study, we directly measured the average number of d until hatch, larval development, pupal development and biomass, percent adult emergence and survival, adult longevity, and fecundity for *H. zea* when reared to pupation (i.e., all life stages) on 5 different non-cultivated host plants commonly found across the mid-south.

Materials and Methods

HOST PLANT-SPECIFIC COLONIES

All studies were conducted during Apr 2021 at the USDA-ARS Southern Insect Management Research Unit, Stoneville, Mississippi, USA. Laboratory-reared research colonies were established from field collections made throughout late Apr and early May. Late instar larvae were collected from roadsides, embankments, and ditches using a 38.1 cm (15 in) diam sweep net from large contiguous patches of 5 different weedy host plants in Yazoo County, located south of the town of Yazoo City, Mississippi, USA. Larvae were reared individually in 42 mL clear plastic containers (Dart Container Corp., Mason, Michigan, USA) on the specific weedy host from which they were initially collected. The following 5 common weedy hosts found across the mid-south were used in this study: crimson clover, white clover, hairy vetch, Japanese honeysuckle, and kudzu collected from roadside embankments, ditches, and interstate medians. Plant tissues were collected opportunistically and approximately within a 16,093 m (10 mile) radius from the nearest agricultural fields to minimize the potential effects of agricultural spray application, drift, or run-off contamination. Larval diet consisted of plant tissues, the reproductive or flowering stage of the specific weed from which the caterpillar was initially collected (i.e., flower head). Fresh flowers were gathered and replenished every 2 d to ensure a constant food source with a consistent nutritive quality when offered to larvae.

Field-collected larvae were all reared to pupation in an environmental chamber with the following specifications: 85 cm × 85 cm × 196 cm, 80 µmol per m^2 of light irradiance measured at 15.24 cm (6 in) from the LEDs, with a temperature of 27 ± 0.5 °C, 60 ± 5% RH, and a 14:10 h (L:D) photoperiod to prevent winter diapause.

Individuals that developed successfully into pupae were sexed and weighed. Virgin females and unmated male moths from their respective host-plant colonies were mass mated in separate arenas at a 1:1 (F:M) ratio. Mating arenas consisted of 3.8 L white cylindrical paper ice-cream containers(18 cm high × 17.5 cm diam) (Rigid Paper Tube Corp., Wayne, New Jersey, USA) each supplied with a 42 mL plastic cup containing cotton balls saturated with a 10% sucrose solution as a food source (Little et al. 2019). Strips of organza cloth (25 cm × 25 cm, bridal white organza, part #4491676, Joann Fabric Stores, LLC, Hudson, Ohio, USA) were tightly fitted over the mouth of the containers as an oviposition substrate. Egg sheets were collected from each individual host plant colony and were placed in plastic bags and incubated in an environmental chamber (see above) until neonates hatched.

LARVAL DEVELOPMENT, PUPAL BIOMASS, AND PERCENTAGE SURVIVORSHIP

Groups of 500 eggs replicated 3 times per plant species were randomly selected from each of the 5-field collected and mass mated corn earworm colonies to observe the average number of d until egg hatch (hatching rate was not recorded). Newly hatched neonates (F_1) from each of the *H. zea* colonies were collected, a minimum of 500 for each host plant, and individually brushed with a fine tip paint brush into 42 mL plastic cups (Dart Container Corp., Mason, Michigan, USA). Treatments were replicated 15 times with 35 *H. zea* neonates, for a total of 525 individuals for each specific weedy host plant, and an overall total of 2,625 individual *H. zea* larvae. The host plant food source (i.e., flow-

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er heads) for each individual weedy host plant colony were provided to larvae and were replaced every 2 d until pupation. A single flower head was provided to all life stages as the food source. The average number of d for egg hatch, larval development, pupal duration, pupal weight (mg) 48 h after pupation, percentage larval mortality, and adult emergence were recorded. Data were subjected to analysis of variance (ANOVA) to investigate the effects of host-plant source on biological parameters of *H. zea*.

The total number of d from egg hatch to pupation was established as the larval development period and pupae were weighed 48 h after pupation. Larval mortality was established as the number of individuals that did not successfully molt to the fifth instar (i.e., accumulative mortality throughout instar development), and number of emerged adults from this cohort were recorded. Percentage data were transformed by arcsine square-root transformation of the proportion before analysis. Back transformed means are presented for ease of interpretation.

ADULT LONGEVITY AND FECUNDITY

Thirty pairs of virgin females and males, reared individually to pupation from each of the 5 host plant colonies were chosen randomly. One female and 1 male pupa were placed in mating arenas (see above), referred to as "single-pair" mating (Blanco et al. 2007), were supplemented with a 10% sucrose solution (see above), and allowed to mate for 48 h. Mated moths were then transferred individually to plastic oviposition cages (10.2 cm diam × 20.3 cm high) and covered with organza cloth. Treatments were replicated 3 times with 30 pairs of virgin male and female *H. zea* adults, for a total of 90 virgin mated pairs for each weedy host plant, and an overall total of 450 *H. zea* mated pairs. Numbers of eggs laid per female and mortality of mated pairs were recorded daily until all moths in the test had died.

DATA ANALYSIS

All measures of larval developmental time, pupal weight, emergence, and fecundity data were used to examine host plant effects by using analysis of variance (ANOVA) (SAS Institute 2013) and used the *t*-test to evaluate differences in gender. A Tukey's mean separation test ($\alpha = 0.05$) was used to compare results among host plant species averaged across developmental measures when the host plant species was significant (Neter et al. 1985).

Results

HATCHING RATE AND LARVAL DEVELOPMENTAL STAGES

Significant differences were detected in each of the developmental measures accessed for each of the 5 host plants used to rear *H. zea*. However, no significant differences in sex or interactions were detected in any experimental measures during this study ($P > 0.17$).

The average number of d for egg hatch were significantly different across the 5 host plant species used in these experiments ($F = 12.36$; df = 4, 1256; $P < 0.001$) (Table 1). *Helicoverpa zea* reared on crimson clover took significantly longer to hatch than individuals reared on any other host, i.e., white clover, hairy vetch, honeysuckle, or kudzu ($P < 0.05$) Tukey's mean separation test ($\alpha = 0.05$). Host plant significantly affected larval developmental times ($F = 889.66$; df = 4, 1153; $P < 0.001$). Larvae reared on white clover had the longest developmental time observed to reach pupation when compared to the other 4 host plants (Table 1). Differences in the time *H. zea* spent in pupal development also were detected across host plants ($F = 248.51$; df = 4, 1056; $P < 0.001$). Pupal development ranged from 10 d to 6 d for *H. zea* when reared on hairy vetch and honeysuckle, respectively.

Similarly, combined developmental times (i.e., total duration in d from egg to adult emergence) also were affected significantly by host plant ($F = 932.43$; df = 4, 1259; $P < 0.001$). *Helicoverpa zea* reared on honeysuckle completed developed in the least amount of time ($P < 0.05$) (Table 1). Larvae reared on white clover took the longest time to complete development and emerge when compared to all other host plants ($P < 0.05$). Significant differences in pupal weights among insects reared on different host plants were detected ($F = 61.91$; df = 4, 1256; $P < 0.001$). Larvae reared on white clover, honeysuckle, and kudzu had the largest pupal biomass, when compared to crimson clover and hairy vetch ($P < 0.05$) (Table 1).

LARVAL MORTALITY AND ADULT EMERGENCE

The highest rates of larval mortality were observed in *H. zea* reared on hairy vetch and honeysuckle (> 60%), followed by kudzu at nearly 50% (proc TTEST; M = 3.93; SD = 0.72; $t = 12.27$; $P <$

Table 1. Mean (± SEM) of egg and larval developmental times (d), pupal weights (mg), and percentage survivorship of *Helicoverpa zea* reared on 5 different weedy hosts plants at 27 °C.

	Duration (d)						
Host plant type	Hatching rate[1]	Larva	Pupa male/female[2]	Combined stages	Pupal wt. (mg) female/male	Larval mortality (%)	Emergence (%)
Crimson clover	3.2 ± 0.15 a	27.17 ± 0.11 b	9.29 ± 0.08 F c 9.42 ± 0.11 M c	36.46 ± 0.16 b	196.21 ± 3.01 b 202.77 ± 3.36 b	25.3	92.1 a 85.3 a
White clover	2.7 ± 0.16 b	29.68 ± 0.18 a	9.95 ± 0.25 F ab 10.04 ± 0.14 M ab	39.63 ± 0.22 a	217.43 ± 1.56 a 210.46 ± 4.21 a	42.1	69.5 bc 72.1 bc
Hairy vetch	3 ± 0 b	25.48 ± 0.15 c	10.11 ± 0.23 F a 10.41 ± 0.25 M a	35.52 ± 0.26 c	161.23 ± 2.85 c 158.13 ± 3.07 c	68.9	61.8 c 65.4 c
Honeysuckle	3 ± 0 b	23.97 ± 0.18 d	6.31 ± 0.12 F d 6.28 ± 0.13 M d	30.27 ± 0.22 d	204.65 ± 3.59 a 213.65 ± 4.19 a	65.4	62.3 ab 61.1 ab
Kudzu	3 ± 0 b	25.48 ± 0.14 c	9.67 ± 0.08 F bc 9.51 ± 0.14 M bc	35.26 ± 0.16 c	214.86 ± 2.52 a 212.22 ± 3.81 a	57.4	71.6 bc 74.4 bc

[1]Means in a column followed by the same letter are not significantly different (Tukey's HSD test, $P < 0.05$) when comparing plant species.
[2]Denotes gender; F = Female, M = Male.

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0.0003). Larvae reared on crimson clover had the lowest mortality observed of all the host plants at 27% (Table 1). Adult emergence was influenced highly by host plant (F = 22.51; df = 4, 5; P < 0.002). *Helicoverpa zea* reared on crimson clover had the highest emergence rates of all the host plants, closely followed by kudzu and white clover (P < 0.05).

LONGEVITY AND FECUNDITY

Significant differences in longevity and fecundity were detected for each of the 5 host plants. Consistent with previous measures of larval developmental, significant differences in sex were not detected (Satterthwaite; P > 0.05). The longevity of adult *H. zea* moths were influenced heavily by the host plant that larvae were reared to pupation on (F = 184.26; df = 4, 304; P < 0.001) (Table 2). Individuals reared on crimson clover (i.e., all life stages) lived longer significantly than larvae that fed on any other host plant (P < 0.05). *Helicoverpa zea* had the shortest life span observed when offered kudzu, compared to other host plant used in these experiments (Table 2). The total number of eggs laid for an individual female were affected significantly by host plant (F = 429.46; df = 4, 752; P < 0.001). Fecundity ranged from 553.53 ± 92.34 to 142.23 ± 28.16 for *H. zea* reared on crimson clover and kudzu, respectively (Table 2). When reared for all life stages on crimson clover and white clover, *H. zea* deposited significantly more eggs (> 500) over the duration of their adult life when compared to any other group (P < 0.05).

Discussion

In this study the biological performance of *H. zea* was influenced significantly by the host plant. Based on our results, host plant played a significant role in all developmental stages of *H. zea* larvae, longevity of adults, and reproductive capability. However, results from our study indicated no significant differences across sex for any of the biological parameters measured. These results are consistent with many previous studies on biological parameters of important noctuid species when reared on cultivated, non-cultivated (i.e., weedy hosts), and meridic diets (Nutri-Soy, Archer Daniels Midland Co., Decatur, Illinois, USA; and wheat germ, Anacon Foods, Atkinson, Kansas, USA) (Ellsbury et al. 1989; Liu et al. 2004; Barbosa et al. 2016).

The experimental data presented in this study have some limitations. The original cohort used to measure egg hatching rate was lost due to an equipment malfunction. As a result, only neonates were available from the host plant specific colonies and new groups of 500 individuals were selected randomly and used for determining larval development periods. Last, within-instar mortality was not recorded, and larval mortality was calculated as the number of individuals that were unable to successfully pupate.

Host plant suitability, measured in terms of mortality and fecundity are known to have significant variation on insects. Shorter developmental times and greater reproductive capability reflect the suitability of a given host (Tsai & Wang 2001). Larvae experienced significantly different developmental times when reared on each of the host plant species in this study (Table 1). When reared on hairy vetch and kudzu host plants, larvae took considerably less time to develop compared to all other hosts in this study. Similar variation was observed in the average time spent in the pupal stage. The combined developmental stages for larvae reared on honeysuckle had the shortest developmental period of 30 d, while larvae reared on other hosts took as long as 39 d to emerge (Table 1).

Pupal biomass of larvae that were reared on white clover, honeysuckle, and kudzu were among the heaviest observed (Table 1). *Helicoverpa zea* larvae reared on hairy vetch had among the lowest pupal weights observed of all host plant species. The developmental periods and pupal weights of *H. zea* observed in this study are comparable to those found in another study using the hosts crimson clover and wild honeysuckle (Gross & Young 1977; Ellsbury et al. 1989). Larval mortality was the lowest when reared on crimson and white clover with less than 42.1% and 27%, respectively. However, for all other host plant species larval mortality was in excess of 49% and reached 66% for *H. zea* when reared on hairy vetch. Emergence rates for larvae reared on crimson clover where the highest of all host plants (> 85%) (Table 1).

Longevity was highest for larvae reared on crimson clover and honeysuckle (> 8 d), and significantly limited when reared on kudzu (< 5 d) (Table 2). Significant differences in fecundity as measured by the total number of eggs laid per female were detected across each weedy host plant species (P < 0.05) (Table 2). The average number of eggs laid when reared on crimson clover, white clover, hairy vetch, honeysuckle, and kudzu were 553.5, 512.3, 288.2, 194.7, and 142.2, respectively.

Host plant antibiosis effects may have led to the reduced fitness and survival of *H. zea* observed in these studies and prolonged its developmental time frame. The increased larval development and pupal time may increase *H. zea* exposure to predation by natural enemies and other mortality factors (i.e., extreme temperatures or desiccation) (Sarfraz et al. 2006). Larval host plant experience has been shown to affect mate finding and oviposition substrate selection (Anderson et al. 2013). Variation observed across plant species may be explained by the nutritional quality of host plant tissue offered to insects (Awmack & Leather 2002). Previous research has shown that components of host plant quality such as nitrogen, free amino acids, and defensive metabolites are known to directly affect biological development and reproduction. Ellsbury et al. (1989) demonstrated the differences associated between crimson clover flowers and leaf tissue when offered to *H. zea*.

Larval development for *H. zea* reared on kudzu was among the shortest, pupal weights among the highest, and had the least number of eggs deposited (Table 2). This observation may be of particular importance given the vast geographic host range and aggressive nature

Table. 2. Mean (± SEM) longevity of females and males (d), and fecundity (total) of *Helicoverpa zea* reared on 5 different weedy host plants at 27 °C.

	Longevity		
Host plant type	Female	Male	Fecundity (eggs laid per female)
Crimson clover	10.33 ± 0.25 (30) a	11.23 ± 0.33 (30) a	553.53 ± 92.34 (30) a
White clover	5.17 ± 0.23 (30) d	4.61 ± 0.24 (30) d	512.32 ± 49.80 (30) b
Hairy vetch	6.33 ± 0.34 (30) c	6.90 ± 0.30 (30) c	288.21 ± 52.76 (30) c
Honeysuckle	8.78 ± 0.24 (30) b	8.74 ± 0.18 (30) b	194.73 ± 62.43 (30) d
Kudzu	4.40 ± 0.31 (30) d	4.68 ± 0.29 (30) d	142.23 ± 28.16 (30) e

[1]Means in a column followed by the same letter are not significantly different (Tukey's HSD test, P < 0.05) when comparing plant species. Numerals in parentheses are the number of samples tested.

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of kudzu across the mid-south (Forseth & Innis 2004). Ellsbury et al. (1989) demonstrated that first to third instar *H. zea* readily bored into and fed upon crimson clover terminals and buds taking significantly more time to adult emergence, whereas larger instars who fed externally on flowers alone pupated and emerged faster. Conversely, our findings in this specific study indicate larvae reared from egg hatch exclusively on crimson clover flowers took significantly longer to hatch, having the longest larval and combined developmental periods across the study. A comparison of our crimson clover experiments with those of Ellsbury et al. (1989) suggest that the extended developmental duration observed in this study for early instars may be explained by a diet solely comprised of fresh crimson flowers and the absence of predators. However, when reared on either crimson or white clover flowers *H. zea* had the highest emergence and fecundity rates observed over the course of these experiments. When reared on honeysuckle, larvae had the shortest larval and combined developmental stages and the highest pupal biomass but suffered considerable mortality similar to kudzu and hairy vetch. Larvae reared on honeysuckle laid significantly more eggs than those reared on kudzu. *Helicoverpa zea* reared on hairy vetch were among the first to hatch and had the shortest developmental periods. However, this group had the smallest pupal weights observed across the study and experienced significant mortality (> 65%) (Table 1).

Implications from this study suggest that of the 5 weed species used in these experiments, white clover, hairy vetch, and honeysuckle may support *H. zea* populations in the wild. However, significant larval mortality, low adult emergence rates, and marked reductions in fecundity were repeatedly observed for individuals reared on these select weed species, suggesting the nominal role they play on *H. zea* field populations. Furthermore, the ephemeral nature of these select species complicate weed management and make selective weed suppression time consuming and impractical. Given the significant reductions in fitness associated with these candidate weed species, populations of larvae may build; however, it is unlikely that a significant proportion of these individuals will successfully pupate or emerge as an adult.

Individuals reared to adult emergence on white clover were among the most fecund second to larvae reared on crimson clover. However, these individuals took significantly more time to complete development and emerge while experiencing significant larval mortality (> 40%). These factors combined suggest crimson clover is among the most suitable of weedy hosts investigated in this study in terms of overall fitness. Crimson clover and kudzu are 2 of the most widespread and abundant weeds species commonly found across the mid-south that may significantly affect *H. zea* establishment.

When reared solely on kudzu, *H. zea* took on average 3 d to hatch similar to all treatments. However, these individuals had the shortest life span between 4 and 5 d and among the highest larval mortality (> 55%) observed across the study. Kudzu currently covers approximately 3,000,000 ha throughout the eastern US and continues to aggressively spread by 50,000 ha per yr (Forseth & Innis 2010). The ability to remove plant stands of kudzu for weed management is likely not feasible given the weed's aggressive growth habit colonizing large contiguous tracts of land. Large stands of kudzu also may play an indirect role in regional suppression of field populations. The aggressive growth of kudzu is known to displace other vegetation, ultimately decreasing plant richness and abundance. Plant competition from kudzu potentially may reduce suitable oviposition substrate in the field.

Results from this study strongly indicate crimson clover is among the most important species to be targeted for weed management. Annual plantings of crimson clover as a soil stabilizer have the potential to have a significant impact on *H. zea* field populations. Cultural integrated pest management strategies including planting date manipulation to disrupt *H. zea* populations may provide a useful management tool in addition to chemical control measures. Insect managers can use this information to make informed decisions concerning sampling and potential weed management efforts for species that are more advantageous to *H. zea* establishment.

The resulting fitness of *H. zea* on a given weedy host plant may help prioritize cultural and chemical integrated pest management strategies including the timely application of herbicides, biopesticides, and modulated planting date to desynchronize plant-insect phenological events. Increased understanding of *H. zea* host plant source-sink relationships may help to better explain the potential survival, outbreak, and migratory capability across a given landscape. Understanding the impact that different host plants have on a population's growth potential and biology are important tools used in integrated pest management programs. Future research should examine the quality of various host plant tissues such as vegetative growth compared to floral parts, because the nutritional quality may affect survival and fecundity.

Further investigation of larval diet breadth and its effects on mating behavior, generational fitness, and host finding behavior may offer additional useful information when assessing the potential contribution of migrant individuals. Such information may help to increase our knowledge regarding its population dynamics and management in a given landscape. These findings improve our understanding and provide insights on the potential impact of 5 weedy host plants common across the mid-south and fill a gap by providing baseline biological data for *H. zea*.

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References Cited

Anderson P, Sadek MM, Larsson M, Hansson BS, Thöming G. 2013. Larval host plant experience modulates both mate finding and oviposition choice in a moth. Animal Behaviour 85: 1169–1175.

Awmack CS, Leather SR. 2002. Host plant quality and fecundity in herbivorous insects. Annual Review of Entomology 47: 817–844.

Barbosa TAN, Mendes SM, Rodrigues GT, de Aquino Ribeiro PE, dos Santos CA, Valicente FH, De Oliveira CM. 2016. Comparison of biology between *Helicoverpa zea* and *Helicoverpa armigera* (Lepidoptera: Noctuidae) reared on artificial diets. Florida Entomologist 99: 72–76.

Benschoter CA. 1968. Diapause and development of *Heliothis zea* and *H. virescens* in controlled environments. Annals of the Entomological Society of America 61: 953–956.

Blanco CA, Houston O. 2005. Manufacture and use of a trap to assess *Heliothis virescens* and *Helicoverpa zea* (Lepidoptera: Noctuidae) adult emergence. Florida Entomologist 88: 544–546.

Blanco CA, Lopez Jr JD, Latheef MA. 2002. Interplanting of alternative plants for enhancing Lepidoptera in cotton, pp. 1327–1331 *In* Proceedings of the Beltwide Cotton Conference, 8–12 Jan 2001. National Cotton Council of America, Memphis, Tennessee, USA.

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Blanco CA, Terán-Vargas AP, López Jr JD, Kauffman JV, Wei X. 2007. Densities of *Heliothis virescens* and *Helicoverpa zea* (Lepidoptera: Noctuidae) in three plant hosts. Florida Entomologist 90: 742–750.

Capinera JL. 2001. Corn earworm, *Helicoverpa zea* (Boddie), pp. 395–400 *In* Capinera J [Ed.], Handbook of Vegetable Pests. Academic Press, San Diego, California, USA.

Chen C, Xia QW, Fu S, Wu XF, Xue FS. 2014. Effect of photoperiod and temperature on the intensity of pupal diapause in the cotton bollworm, *Helicoverpa armigera* (Lepidoptera: Noctuidae). Bulletin of Entomological Research 104: 12–18.

Cohen RW, Waldbauer GP, Friedman S. 1988. Natural diets and self-selection: *Heliothis zea* larvae and maize. Entomologia Experimentalis et Applicata 46: 161–171.

Cunningham JP, Zalucki MP. 2014. Understanding heliothine (Lepidoptera: Heliothinae) pests: What is a host plant? Journal of Economic Entomology 107: 881–896.

Ellsbury MM, Burkett GA, Davis FM. 1989. Development and feeding behavior of *Heliothis zea* (Lepidoptera: Noctuidae) on leaves and flowers of crimson clover. Environmental Entomology 18: 323–327.

Fathipour Y, Baghery F, Bagheri A, Naseri B. 2020. Development, reproduction and life table parameters of *Helicoverpa armigera* (Lepidoptera: Noctuidae) on five main host plants. Journal of Crop Protection 9: 551–561.

Forseth IN, Innis AF. 2004. Kudzu (*Pueraria montana*): history, physiology, and ecology combine to make a major ecosystem threat. Critical Reviews in Plant Sciences 23: 401–413.

Garcia FJM. 2006. Analysis of the spatiotemporal distribution of *Helicoverpa armigera* Hb. in a tomato field using a stochastic approach. Biosystems Engineering 93: 253–259.

Gross HR, Young JR. 1977. Comparative development and fecundity of corn earworm reared on selected wild and cultivated early-season hosts common to the southeastern US. Annals of the Entomological Society of America 70: 63–65.

Hardt RA. 1986. Japanese honeysuckle: from 'one of the best' to ruthless pest. Arnoldia 46: 27–34.

Hardwick DF. 1965. The corn earworm complex. Memoirs of the Entomology Society of Canada 97: 5–247.

Hardwick DF. 1996. A Monograph to the North American *Heliothentinae* (Lepidoptera: Noctuidae). David F. Hardwick, Ottawa, Ontario, Canada.

Harrell EA, Perkins WD, Mullinix BG. 1979. Effects of temperature, relative humidity, and air velocities on development of *Heliothis zea*. Annals of the Entomological Society of America 72: 222–223.

Johnson MW, Stinner RE, Rabb RL. 1975. Ovipositional response of *Heliothis zea* (Boddie) to its major hosts in North Carolina. Environmental Entomology 4: 291–297.

Kennedy GG, Storer NP. 2000. Life systems of polyphagous arthropod pests in temporally unstable cropping systems. Annual Review of Entomology 45: 467–493.

King ABS. 1994. *Heliothis*/*Helicoverpa* (Lepidoptera: Noctuidae), pp. 39–106 *In* Matthews GA, Turnstall JP [Eds.], Insect Pests of Cotton. CAB International, Wallingford, United Kingdom.

Kogan M. 1998. Integrated pest management: historical perspectives and contemporary developments. Annual Review of Entomology 43: 243–270.

Little NS, Elkins BH, Mullen RM, Perera OP, Parys KA, Allen KC, Boykin DL. 2019. Differences between two populations of bollworm, *Helicoverpa zea* (Lepidoptera: Noctuidae), with variable measurements of laboratory susceptibilities to Bt toxins exposed to non-Bt and Bt cottons in large field cages. PLoS One 14: e0212567. doi: 10.1371/journal.pone.0212567

Liu Z, Li D, Gong P, Wu K. 2004. Life table studies of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae), on different host plants. Environmental Entomology 33: 1570–1576.

Luttrell RG. 1994. Cotton pest management: Part 2. A US perspective. Annual Review of Entomology 39: 527–542.

Luttrell RG, Jackson RE. 2012. *Helicoverpa zea* and Bt cotton in the United States. GM Crops & Food 3: 213–227.

Morey AC, Hutchison WD, Venette RC, Burkness EC. 2012. Cold hardiness of *Helicoverpa zea* (Lepidoptera: Noctuidae) pupae. Environmental Entomology 41: 172–179.

Neter J, Wasserman W, Kutner MH. 1985. Applied Linear Statistical Models: Regression, Analysis of Variance, and Experimental Designs, second edition. Irwin Professional Publishing, Homewood, Illinois, USA.

Neunzig HH. 1963. Wild host plants of the corn earworm and the tobacco budworm in eastern North Carolina. Journal of Economic Entomology 56: 135–139.

Pair SD. 1994. Japanese honeysuckle (Caprifoliaceae): newly discovered host of *Heliothis virescens* and *Helicoverpa zea* (Lepidoptera: Noctuidae). Environmental Entomology 23: 906–911.

Parajulee M, Slosser JE, Boring E. 1998. Seasonal activity of *Helicoverpa zea* and *Heliothis virescens* (Lepidoptera: Noctuidae) detected by pheromone traps in the rolling plains of Texas. Environmental Entomology 27: 1203–1219.

Phillips JR, Newsom LD. 1966. Diapause in *Heliothis zea* and *Heliothis virescens* (Lepidoptera: Noctuidae). Annals of the Entomological Society of America 59: 154–159.

Power JF. 1987. The role of legumes in conservation tillage systems. American Journal of Alternative Agriculture 2: 48. https://doi.org/10.1017/S0889189300001545 (last accessed 12 Sep 2022).

Pullen SR, Meola RW, Lopez Jr JD. 1992. Temperature as a sole factor for diapause induction after pupation in *Helicoverpa* zea (Lepidoptera: Noctuidae). Environmental Entomology 21: 1404–1409.

Razmjou J, Naseri B, Hemati SA. 2014. Comparative performance of the cotton bollworm, *Helicoverpa armigera* (Hübner) (Lepidoptera: Noctuidae) on various host plants. Journal of Pest Science 87: 29–37.

Rhino B, Grechi I, Marliac G, Trebeau M, Thibaut C, Ratnadass A. 2014. Corn as trap crop to control *Helicoverpa zea* in tomato fields: importance of phenological synchronization and choice of cultivar. International Journal of Pest Management 60: 73–81.

Sarfraz M, Dosdall LM, Keddie BA. 2006. Diamondback moth-host plant interactions: implications for pest management. Crop Protection 25: 625–636.

SAS Institute. 2013. SAS Software version 9.3. SAS Institute, Cary, North Carolina, USA.

Stadelbacher EA. 1980. Oviposition preference of the bollworm for species of early-season host plants in the delta of Mississippi. Environmental Entomology 9: 542–545.

Stadelbacher EA, Graham HM, Harris VE, Lopez JD, Phillips JR, Roach SH. 1986. *Heliothis* populations and wild host plants in the southern US, pp. 54–74 *In* Johnson SJ, King EG, Bradley Jr JR [Eds.], Theory and Tactics of *Heliothis* Population Management. I. Cultural and Biological Control. Southern Cooperative Series Bulletin 316. Tifton, Georgia, USA.

Sudbrink Jr DL, Grant JF. 1995. Wild host plants of *Helicoverpa zea* and *Heliothis virescens* (Lepidoptera: Noctuidae) in eastern Tennessee. Environmental Entomology 24: 1080–1085.

Tsai JH, Wang JJ. 2001. Effects of host plants on biology and life table parameters of *Aphis spiraecola* (Homoptera: Aphididae). Environmental Entomology 30: 44–50.

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