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COMPARATIVE LIFE HISTORY, FECUNDITY, AND SURVIVAL OF *Spodoptera exigua* (Hübner) (LEPIDOPTERA: NOCTUIDAE) ON *Allium cepa* L. AND OTHER HOST PLANTS IN THE PHILIPPINES[1]

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ABSTRACT

The life history, development, and post development traits of *Spodoptera exigua* (Hübner) were studied on different host plants (*Allium cepa* L., *A. fistulosum* L., *Ricinus communis* L., *Trianthema portulacastrum* L., and *Zea mays* L.) in the laboratory. Significant differences were observed in the life history, larval development, total development time, post developmental period, and fecundity among the host plants tested for both sexes of *S. exigua*. Suitability for feeding and development in decreasing order are as follows: *T. portulacastrum*, *R. communis*, *A. fistulosum*, *A. cepa,* and *Z. mays*. Based on proximate analysis, levels of crude fiber and percent moisture rather than crude protein, crude fat, and total sugar of host plants had influence on feeding suitability and development for *S. exigua*.

Key words: development time, effect of host plants, life history, onion armyworm, post developmental period, *Spodoptera exigua*

INTRODUCTION

In 2016, the first outbreak of *Spodoptera exigua* (Hübner) was reported in the provinces of Nueva Ecija, Tarlac, and Pangasinan. This alarmed farmers, consumers, and local government units (LGU), the Department of Agriculture-Regional Crop Protection Center III, and the former Crop Protection Cluster under the then College of Agriculture, and the Office of the Chancellor, University of the Philippines Los Baños (UPLB). LGU officials of some towns which were devastated by said pest declared a state of calamity. In the province of Nueva Ecija alone, about 1.6 billion pesos worth of loss in production was recorded due to *S. exigua* damage on onion. The total damage reached nearly

600 hectares affecting more than 5,000 onion farmers (Nueva Ecija Provincial Agriculture, 2016). Chemical control against this pest failed to stop the outbreaks leading to huge losses and abandonment of onion fields of some farmers.

S. exigua is a polyphagous pest infesting vegetables, field crops as well as ornamentals. It is commonly known as asparagus fern caterpillar, berseem armyworm, cottonworm, inchworm, lesser armyworm, lesser cottonworm, onion armyworm, pigweed caterpillar, small mottled willow moth, and sugarbeet armyworm (CABI, 2016). It originated from Southeast Asia and became cosmopolitan in distribution. It attacks more than 90 plant species in at least 18 families throughout North America (Pearson, 1982; Greenberg et al., 2001).

Larvae of *S. exigua* feed on both foliage and fruit structures of host plants. The outbreaks of *S. exigua,* although not regular, develop quickly and since older larval instars are difficult to manage with synthetic insecticides, early cautioning of population build-up is necessary to effectively manage the pest (Mardani-Talaei et al., 2012).

The life history traits of *S. exigua* have been studied on different host plants by several foreign researchers. These include Greenberg et al. (2001) on five host plants (cabbage, cotton, bell pepper, pigweed, and sunflower); Azidah & Sofian-Azirun (2006) on four host plants (cabbage, shallot, string beans, and lady's finger); Saeed et al. (2009) on various host plants including cotton, cauliflower, peas, and wheat; Mehrkhou et al. (2010) on nine soybean cultivars; Karimi-Malati et al. (2010) on four sugar beet cultivars; Farahani et al. (2011) on host plants including *Zea mays* L., *Brassica napus* L., *Glycine max* (L.) Merr. and *Chenopodium album* L.; and Mardani-Talaei et al. (2012, 2016) on 10 corn hybrid varieties. Other information are available in Arizona (Fye & McAda, 1972), California (Atkins, 1960; Berdegue et al., 1998; Griswold & Trumble, 1985; Meade & Hare, 1991; Yoshida & Parrella, 1992), Egypt (Afify et al., 1970), Florida (Wilson, 1932), Pakistan (Idris & Emelia, 2001), Japan (Kawana, 1994), India (Khalid Ahmed et al., 1997), Texas (Huffman et al., 1996), and Malaysia (Azidah & Sofin-Azirum, 2006).

As a polyphagous pest, *S. exigua* eats almost any plant parts and its development is greatly affected by the host plant. For example, Greenberg et al. (2001) conducted feeding and life history studies of *S. exigua* on different host plants in Texas, USA. They investigated larval consumption rates on five common host plants and their separate effects on pupal weights and fecundity, and the effects of host plant on life table parameters. They found that consumption peaked at six days in pigweed, cotton, and cabbage, and eight days in pepper and sunflower. Pupal weight was significantly related to the amount of leaf tissue consumed for each host plant. Mean pupal weight was highest on pigweed, followed by cabbage, cotton, and pepper. Azidah & Sofin-Azirun (2006) expanded the experiments of Greenberg et al. (2001) and also conducted life history studies of *S. exigua* on various host plants in Malaysia. The authors noted that there was no significant variation in the incubation period of the eggs reared on cabbage, shallot, string beans, lady's finger, and chilli, although there was significant difference in the development time of larval instars. Generally, larval development time was longest when fed on shallot and lady's finger, followed by cabbage. On the other hand, larval development time was shortest

when fed on string beans. Larvae fed on lady's finger had longer pupation period, compared with those on cabbage, shallot, and string beans. There was no significant difference in adult longevity but survival rates were higher on string beans and lady's finger.

This paper presents information on the biological relationship of *S. exigua* with various host plants, development time, fecundity, hatchability, and longevity that may contribute in formulating effective and efficient control tactics for the management of the pest on onion in the Philippines.

MATERIALS AND METHODS

Test Insects

Egg-masses and larvae of *S. exigua* on onion (*Allium cepa* L.) leaves were collected from farmers' field in San Jose, Nueva Ecija. These were brought to the laboratory for sorting, rearing, and holding. Eggs were held in plastic plates lined with moistened filter paper until they were about to hatch or at black head stage. Ensuing larvae were placed on plastic vats for rearing until pupation. Pupae were kept in emergence cages where adults mated and females laid eggs. These served as parental stock for mass rearing *S. exigua*. The stock culture was the source of insects for various experiments in the laboratory.

Life history study

Fifty neonate larvae were individually transferred to fresh onion leaves and reared in plastic plates until the adult stage. The duration of the different larval instars and pupal period, and their morphological features were observed and recorded. The same set-up was done using leek (*A. fistulosum* L.), castor (*Ricinus communis* L.), horse purselane (*Trianthema portulacastrum* L.) and corn (*Z. mays*) as larval hosts.

Ten males and females (reared separately on the abovementioned host plants during the larval stages) were caged separately in oviposition cages. They were provided with cotton soaked in 10% sugar solution as food source.

The following data were gathered: (1) Development period (in days) from the first instar to the fifth/sixth instar before pupation time; (2) Pupal period in days, reckoned from the time the fifth or sixth instar molted into the pupal stage until it emerges into adult; (3) Post-developmental periods: a. Pre-oviposition period - in days, reckoned from the time the adult female emerged to the time the first mass of eggs is laid, b. Oviposition period - in days, reckoned from the time the female starts laying eggs to the time it stopped laying, at which time all the eggs expected of her in her lifetime are laid, c. Post-oviposition period - in days, reckoned from the time female stopped laying till death; d) Hatchability of eggs - determined by taking the number of neonates that hatched from all egg-masses laid by a female in her lifetime; e) Fecundity - number of egg-masses and number of eggs per egg-mass laid in the lifetime of adult females, gathered from emerged females in the set-up; f) Longevity of male and female adults - in days, reckoned from the time the adult emerged till death. The number of eggs per cluster was counted using a binocular microscope.

Samples of the different host plants used in the study were submitted to the Central Analytical Services Laboratory, National Institute of Molecular Biology and Biotechnology, UPLB, for proximate analyses.

Statistical Analysis

Analysis of variance (ANOVA) for duration of different larval instars, larval development, pupal period and total development time of male and female *S. exigua* were performed using Proc GLM procedure for unbalanced data in SAS (SAS Institute, 2004). The experimental design was completely randomized in which the treatment factor (host plant) had different numbers of replicates. Type III sums of squares were used in testing the effects in this case since it tests a function of the underlying parameters that is independent of the number of observations per treatment. Tukey-Kramer method was used for mean separation test. Differences in means were determined using diffogram (called the mean-mean scatter plot by Hsu, 1996).

The data on corn was not included in the statistical analysis because the number of individuals that completed development was not sufficient, compared to those on other host plants. Likewise, the sixth instar was not included in the analysis because this was observed only for some individuals reared on *A. cepa* (13) and *A. fistulosum* (three).

Voucher Specimens

Voucher specimens have been deposited in the Entomology Section of the UPLB Museum of Natural History and in the Pest Collection of the National Crop Protection Center.

RESULTS AND DISCUSSION

Life cycle of *S. exigua*

The life history of *S. exigua* on onion is shown in Figure 1. The following descriptions of the different stages of *S. exigua* are based on specimens cultured in the laboratory and those observed from the field.

The eggs are laid in mass or cluster, in several layers, one on top of the others. On onion, females deposited eggs in clusters from as few as 15 to about 150 eggs and covered them with cottony white scales which give a cotton ball appearance to the cluster (Figure 2a). However, in confinement, female deposited eggs also in clusters but only sparsely covered with cottony white scales (Figure 2b). Eggs are spherical, white to pinkish turning dark when about to hatch.

Larvae molted up to five times when reared on onion and leek but only up to four molts when fed with *Z. mays*, *R. communis,* and *T. portulacastrum*. Larvae exhibit different color morphs ranging from bright green, purplish green, and brown to black (Figure 2c). The most common is greenish-brown with a darker stripe down the back and a paler stripe along each side. The fifth or sixth instar stopped feeding for a day or two (pre-pupa) before turning into a pupa.

In confined rearing in the laboratory, pupation occurs in between onion leaf cuttings, below the tissue paper lining, and sides of the plastic plate. In the field,

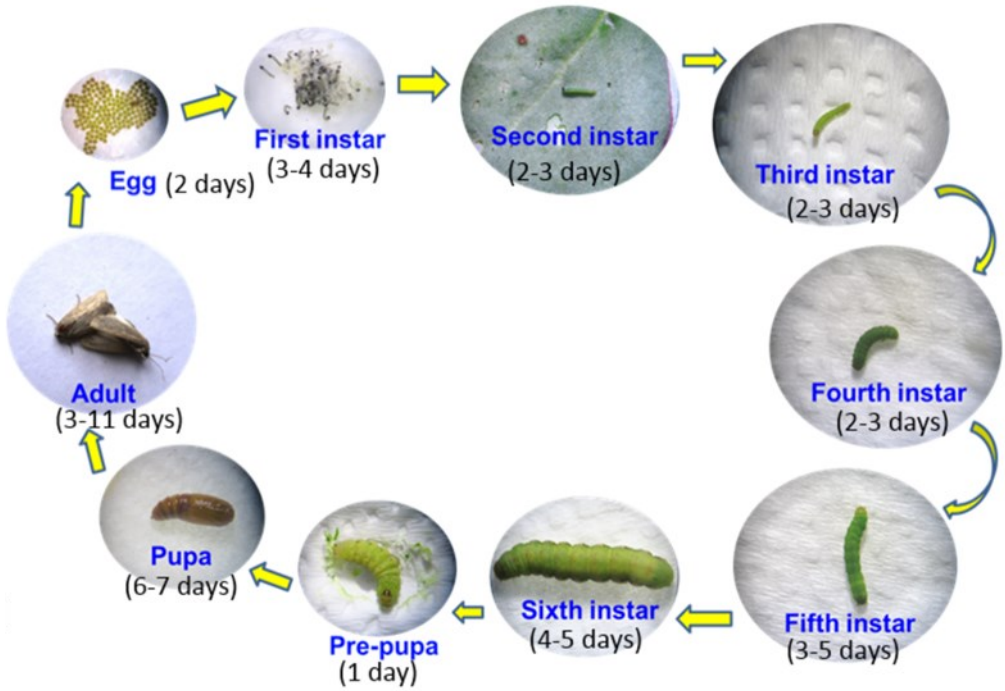

Figure 1. The life history of *Spodoptera exigua* reared on onion under laboratory conditions.

pupation was observed within the onion leaf (Figure 2d), on or beneath the soil in earthen cells up to four cm deep in fields with standing crop, and beneath the soil or just under leaf cuttings from harvested onions. Pupae are obtect, initially whitish green turning brownish and darkened nearing adult eclosion.

Adults are small with body and wings silvery-gray to grayish-brown. Forewings have a lighter spot near the center while the hindwings are paler with darker borders and a light band present at the wing edges.

Larval development of *S. exigua* on onion and other host plants

Variations in the mean duration of each larval instar, total larval development, and total developmental period (egg to adult) in different host plants were statistically significant for both sexes of *S. exigua* (Figures 3 & 4).

On *A. cepa* and *A. fistulosum,* the larvae bore into the hollow, cylindrical leaves and feed on the internal tissues. On the other three host plants, larvae feed externally throughout larval development.

The first stadium is the longest in both *A. cepa* and *A. fistulosum.* It probably took the neonates longer time and spent lots of energy to bore through the leaves of the two *Allium* species before they get to feed. Extended larval development and occurrence of a sixth instar on these host plants is probably a way for the insect to compensate for the delay in the development of first instar.

Male *S. exigua* (Figure 3)**.** Mean development time of first instar larvae on

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Figure 2. Developmental stages of *Spodoptera exigua* (Hübner). **a.** Egg mass covered with white scales. **b.** same but with only sparse scale covering. **c.** different color forms of larvae. **d.** pupae inside onion leaf. **e.** pupae in earthen cells beneath soil surface.

portulacastrum (1.07 days) was significantly shorter than on *R. communis* (3.00 days), *A. fistulosum* (3.58 days), and *A. cepa* (3.85 days). Likewise, development time of first instar larva reared on *R. communis* was significantly shorter than on *A. fistulosum* and *A. cepa.* There were no significant differences in the durations of the first instar on the latter two hosts.

On the other hand, mean values of development time of second and third instar larvae on *A. fistolosum* (2.31 days and 2.42 days) were significantly longer than those on *A. cepa* (1.77 days and 2.08 days) and *T. portulacastrum* (1.79 days and 1.15 days).

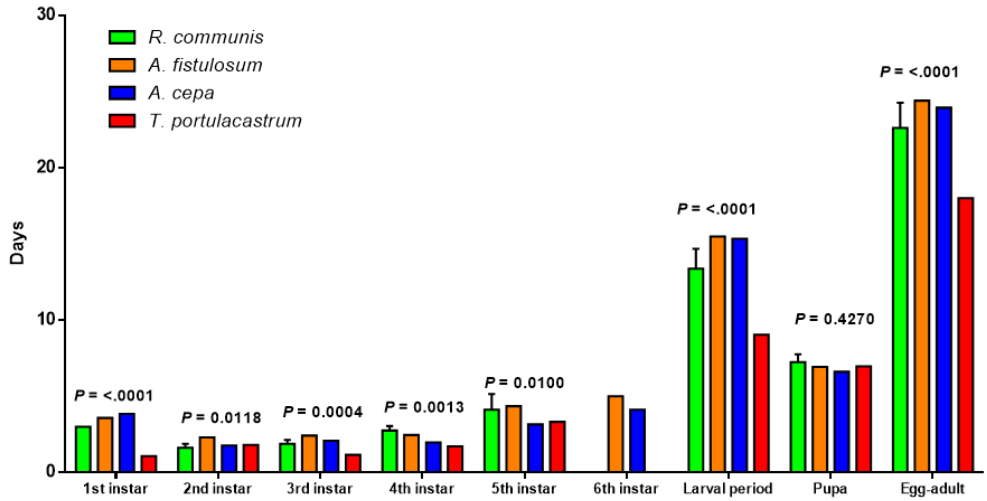

Figure 3. Development time of male *Spodoptera exigua* on different host plants. (Significant at 5% level if P-value < 0.05).

Likewise, mean development time of the fourth instar larva on *T. portulacastrum* (1.71 days) was significantly shorter than on *R. communis* (2.75 days) and *A. fistulosum* (2.46 days). However, development time of the fourth instar was significantly longer on *R. communis* than on *A. cepa* (1.96 days).

Furthermore, mean development time of the fifth instar larva on *A. cepa* (3.15 days) and *T. portulacastrum* (3.33 days) was significantly shorter than on *A. cepa* (4.35 days) and *R. communis* (4.13 days).

In terms of mean total larval development time, those reared on *T. portulacastrum* (9.05 days) was significantly shorter than on *R. communis* (13.37 days), *A. fistulosum* (15.50 days), and *A. cepa* (15.35 days). Likewise, total larval development time on *R. communis* was significantly shorter compared with *A. fistulosum* and *A. cepa* but between the latter two hosts there was no significant difference.

In terms of mean total development time (egg to adult) those reared during the larval stages on *T. portulacastrum* (18.02 days) had significantly shorter duration than on *R. communis* (22.62 days), *A. fistulosum* (24.42 days), and *A. cepa* (23.96 days); all these having no significant differences among them.

Female *S.exigua* (Figure 4)**.** Mean development time of first instar larva on *T. portulacastrum* (1.07 days) was significantly shorter than on *R. communis* (3.00 days), *A. fistulosum* (3.81 days), and *A. cepa* (3.84 days). Likewise, development time of first instar larva reared on *R. communis* was significantly shorter than on *A. fistulosum* and *A. cepa*. Between *A. fistulosum* and *A. cepa*, development time was statistically the same.

Mean development time of second instar larva on *A. fistulosum* (2.41 days) was significantly longer than on *R. communis* (1.56 days) and *T. portulacastrum* (1.71 days) but not significantly different from *A. cepa* (2.16 days). That on *A. cepa* was significantly different from those on *R. communis* and *T. portulacastrum*.

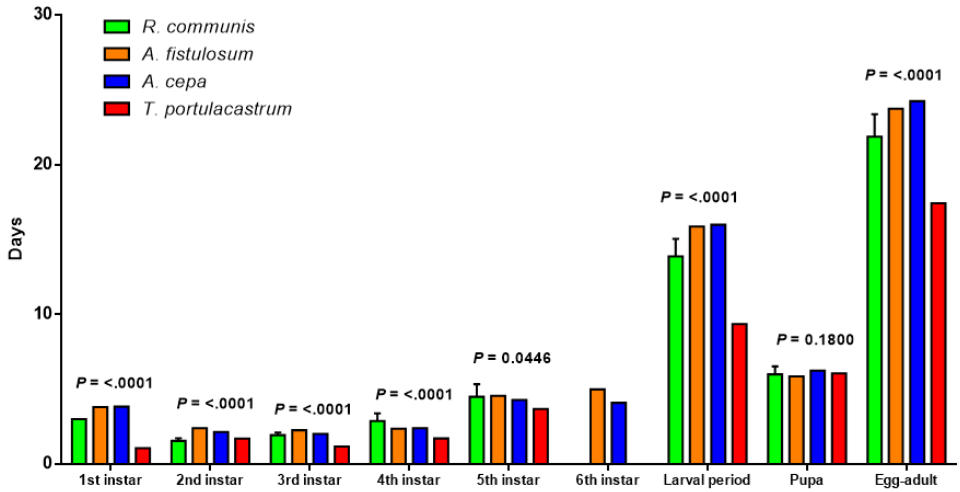

Figure 4. Development time of female *Spodoptera exigua* on different host plants (Significant at 5% level if P-value < 0.05).

Mean development time of third (1.17 days) and fourth (1.72 days) instar larva on *T. portulacastrum* was significantly shorter than on *R. communis* (3rd instar, 1.94 days; 4th instar, 2.87 days), *A. fistulosum* (3rd instar, 2.27 days; 4th instar, 2.36 days), and *A. cepa* (3rd instar, 2.03 days; 4th instar, 2.41 days).

Mean development time of the fifth instar larva on *T. portulacastrum* (3.69 days) was significantly shorter than on *A. fistulosum* (4.57 days).

Total larval development time on *T. portulacastrum* (9.36 days) was significantly shorter compared with *R. communis* (13.87 days), *A. fistulosum* (15.89 days), and *A. cepa* (16.00 days). Also, total larval development time on *R. communis* was significantly shorter compared with *A.fistulosum* and *A. cepa*. The total larval development time was not significantly different between *A. fistulosum* and *A. cepa*.

Total development from egg to adult on *T. portulacastrum* (17.43 days) was significantly shorter compared with *R. communis* (21.88 days), *A. fistulosum* (23.75 days), and *A. cepa* (24.25 days). Total development time on *R. communis* was significantly shorter than on *A. fistulosum* and *A. cepa*.

Examination of the nutritional composition of the different host plants used in this study showed remarkable differences based on the results of proximate analyses (Table 1). However, no relationship can be discerned between differences in development of *S. exigua* with those of differences in crude protein, crude fat, and total sugar among the host plants tested. Crude protein was highest but survival of larvae was lowest in *Z. mays*. *T. portulacastrum,* shown to be the most suitable host plant, has second lowest crude protein and crude fat, and lowest in total sugar. It is the striking high level of crude fiber in *Z. mays* that may have the most influence for its being the least suitable host. Succulent or less fibrous host plants appear more suitable, particularly, for larval feeding.

Post development on onion and other host plants

In terms of post development of adult female *S. exigua*, oviposition period varied significantly among the larval host plants but not on pre-oviposition and

Table 1. Proximate analyses of onion and other host plants of *Spodoptera exigua* (Central Analytical Services Laboratory, National Institute of Molecular Biology and Biotechnology).

Host Plant	Crude Protein	Crude Fat	% Total Sugar	Crude Fiber	% Moisture	% Ash
Allium cepa	0.96±0.01	0.22±0.01	3.24±0.00	0.73±0.04	89.78±0.30	0.83±0.03
Allium fistulosum	2.52±0.01	0.41±0.03	1.53±0.13	1.64±0.03	87.86±0.24	1.45±0.05
Ricinus communis	3.15±0.19	0.39±0.03	0.90±0.10	1.81±0.23	80.44±1.69	2.05±0.19
Trianthema portulacastrum	1.46±0.06	0.38±0.02	0.42±0.02	1.94±0.08	89.82±0.51	1.84±0.09
Zea mays	6.43±0.58	1.60±0.17	1.31±0.00	9.38±0.87	62.46±3.67	5.92±0.57

post-oviposition periods (Figure 5a). This means that these traits of adult female *S. exigua* are not easily affected by the host plant and, possibly, these are inherent to the species.

Fecundity and hatchability of eggs

Fecundity in terms of number of egg masses and number of eggs per egg mass of female *S. exigua* reared on *A. cepa* and other host plants showed significant differences (Figure 5b). Nevertheless, hatchability of eggs was highest on *A. cepa* and other host plants with *Z. mays* having the lowest.

Longevity

The lifespan of adult female *S. exigua* reared on *A. cepa* and other host plants in their larval stages showed significant differences but not on the adult males (Figure 5c).

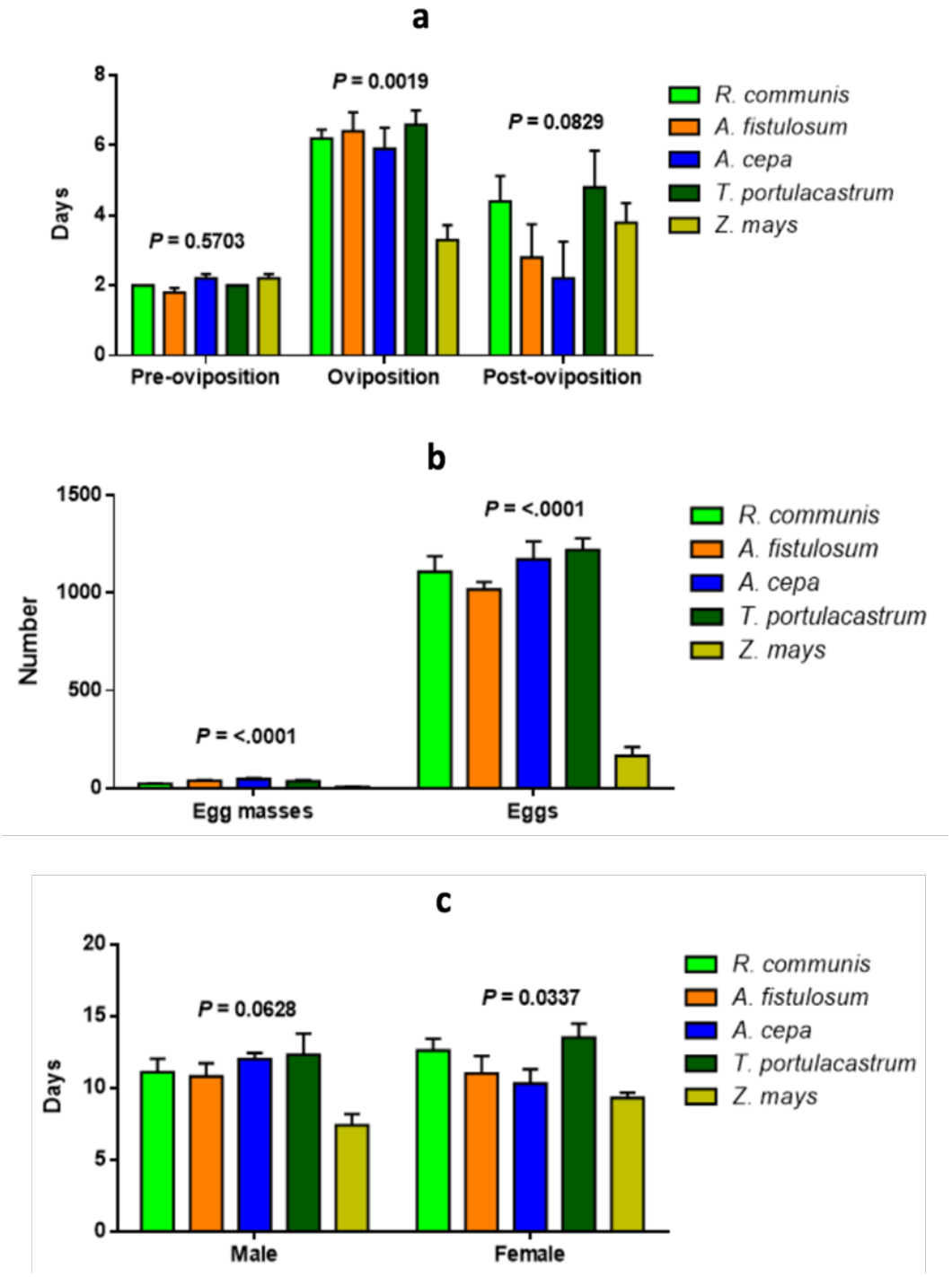

Figure 5. Post development features of *Spodoptera exigua* adults reared on onion and other host plants during the larval stages. **a.** pre-oviposition, oviposition, and post-oviposition. **b.** fecundity. **c.** survival. P-value < 0.05 is significant at 5% level of significance

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