

BIBLIOGRAPHY

LOPEZ, LELYN K. OCTOBER 2007. Life Cycle of *Lygus hesperus* Kelson (Hemiptera: Lygaeidae) on Sweet Charlie Strawberry *Fragaria xananassa* Duchense. Benguet State University, La Trinidad, Benguet.

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ABSTRACT

The study was conducted at the Mites Predatory Rearing House in Balili, La Trinidad, Benguet from April to October 2007 to determined the durations and morphological descriptions of the different developmental stages of *L. hesperus*, compared the duration of life of the adult female and male, recorded the total number of eggs deposited by the female, discovered if the insect undergo parthenogenesis reproduction and observed how the insect feed and mate.

The insect pest underwent the paurometabolous type of metamorphosis with a five nymphal instar. Incubation period of egg had a mean of 8.98 ± 0.132 days. The duration of the nymphal stages had the following means: first instar was 6.07 ± 0.100 days; second instar was 4.31 ± 0.120 days; third instar was 5.28 ± 0.155 days; fourth instar was 5.89 ± 0.127 days; and the fifth instar was 9.15 ± 0.119 days. The duration of the adult female with food had a mean of 55.53 ± 1.760 days while the female without food was 5.85 ± 0.340 days. The adult male with food had a mean of 44.42 ± 1.945 days while the male without food was 4.96 ± 0.400 days. The average life span of the female *L. hesperus* was 96.35 days while the male was 85.17 days.

The egg was elongated, light yellow and turned reddish when about to hatch. Its body length was 0.59 ± 0.008 mm with a width of 0.19 ± 0.004 mm. The nymph was tear-shape and its wing pads become fully develop at the fifth instar. The body length and width of the different

nymphal instars were; first, 0.75 ± 0.011 mm length and 0.35 ± 0.011 mm width; second, 1.19 ± 0.019 mm length and 0.55 ± 0.021 mm width; third, 1.63 ± 0.024 mm length and 0.80 ± 0.018 mm width; fourth, 2.40 ± 0.019 mm length and 1.30 ± 0.021 mm width; fifth, 3.39 ± 0.020 mm length and 1.55 ± 0.011 mm width. The adult had a triangle mark on the thorax. The female adult had a length of 3.66 ± 0.044 mm and width of 1.21 ± 0.029 mm while the male had a length of 3.26 ± 0.025 mm and width of 0.91 ± 0.014 mm.

The mated females laid a ranged of 41 to 180 eggs with an average of 111.75 ± 8.996 eggs and the unmated female laid a ranged of 31 to 112 eggs with an average of 70.35 ± 5.047 eggs throughout their reproductive period.

The insect did not undergo the process of parthenogenetic reproduction.

The nymph feed on the seeds 4 to 8 times a day with an average of 1:03 hours per feeding while the adult feed 3 to 7 times a day with an average of 42:33 minutes per day.

The adult mates with a duration of 2:30 to 5:46 hours having an average of 3:71 hours per copulation. The female and male adults mate 3 to 6 times a day and female could be mated by different males.

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INTRODUCTION

The strawberry *Lygus hesperus* (kelson) belong to the order Hemiptera and family Lygaeidae commonly known as “Lygus bug” is one of the most destructive insect pest of strawberry plants in La-Trinidad, Benguet. The Adult and nymph stages have piercing sucking mouthparts that physically damage the strawberry flower buds as well as the developing fruits by puncturing the tissues when they suck on seeds juices. As this insect feed on developing reproductive organ of the plant buds, flower and developing seeds, they inject a toxin that kills plant nutrients (Gray et al., 2004).

L. hesperus are small insects, measuring about 5.7 mm long and 2.5 mm wide. The body color is brownish with yellow markings and generally shiny or brassy in appearance. A yellow V-shape or triangular mark is present on the middle back of the insect with a small head projecting in front (Mintenko, 2005).

The life cycle of *L. hesperus* is incomplete (Paurometabolous) type of metamorphosis while undergo the stages of an egg, nymph and adult. The adult female Lygus inserts their shiny eggs into the strawberry plants commonly into the stems, petioles, midribs of leaves, flower buds and fruits. The emerging nymph will begin to feed on the host plant and the adult female multiply very rapidly and repeat its life cycle during summer on same host plant.

Study on the life cycle of strawberry *L. hesperus* has not been fully established in La-Trinidad, Benguet. This indicates a closer attention to the insect pest because of the damage it can cause on strawberry plants. The information that were gathered on the study of the life cycle of *L. hesperus* will lead to understand the life processes of the insect.



Furthermore, it could also served as a bench mark data for future investigation of this insect on the different fields of Entomology.

The objectives of the study were to determined the durations (days), morphological descriptions of the different developmental stages of *L. hesperus*, compared the duration life of adult female and male, recorded the total number of eggs deposited by the female, discovered if the insect undergo parthenogenesis and observed how the insect feed and mate.

The study was conducted at Benguet State University Mites-Predatory Rearing House in Balili, La Trinidad, Benguet from April to October 2007.



REVIEW OF LITERATURE

Description and Characteristics

Egg. In 1999, Howitt describe that the Lygus egg is elongated and slightly curved in shape with a 0.95 to 1 mm long and 0.25 mm wide. As stated by Rao and Welter in 1997 the female insert eggs into strawberry plant tissue and often only the operculum is visible externally and hence the eggs are not easily detectable. These eggs are cylindrical or like barrels and are laid singly on the leaves but are difficult to find (Colting et al., 2003).

Nymph. The Lygus nymph stage undergo five instars, the first instar has a robust rear legs, they move rapidly in second instar, the wing pads are begin to develop in third instar and more pronounced earlier at fourth to fifth instars (Cermak and Welker, 1992). In 1997, Rao and Welter found that the first and second instars are pale green with a distinct red terminal antennal segment. The third through fifth instars are green and have five black dots on the back.

Rougoor (2006) describe that the first to the last instar nymph is a small in size range 1-5 mm in length. The green color comes darken as they mature and they were wingless.

Adult. The Lygus adult is a small, flattened bug about ¼ inch long, generally brown in color and mottled with splotches of white, yellow, and reddish-brown while feeded on plant tissues. The wings of the adult combine a hard cover wing that is similar to beetle with smoky-brown membranous tips which are common to all plant bugs and order hemiptera or true bugs in general. The adults can fly and will ready to run very rapidly and hide underneath the leaves of the plant (Nielsen, 2006).



Phillips et al., in 2006 describe that the adult are greenish or brownish in color having reddish brown markings on their wings. A yellow or pale green triangle located at the center back of the insect. While Colting et al., in 2003 record that the pest insect had malodorous smell.

Fecundity

Cermak and Walker in 1992 stated that the egg laying occurs at temperatures greater than or equal to 20 degrees Celsius. The female adult laid eggs from 10-31 days with approximately five eggs per day.

Life History

In the spring, the adult *Lygus* found one during winter which feed on host plant and laid eggs from May to July (Howitt, 1999). He further found that the first nymphs will be seen at the end of May while adults can be seen at the end of June in the South. In the Northern prairies, there is only one generation per year and in the Southern prairies there may be two generations per year. While Rougoor in 2006 cited that the *Lygus* adults emerge in the spring, feeding new buds and shoots and lay eggs on plant materials one the temperature becomes 20 degrees Celsius or higher. Depending on the temperature the nymphs will hatch in 7-10 days. Nymphs are usually seen on strawberries during bloom and generally emerge in mid May feeding on the developing fruit. Adults and nymphs can both be present in a crop at the same time as a result of overlapping generations that have three to five generations per year. From fall to winter only adults are present as they prepare to over winter in dead weeds, leaf litter and under the bark. Adults emerge in the spring when the temperature reaches 8 degrees Celsius to start the



life cycle over again.

Symptoms and Damage

The damaged fruits of strawberry shows dried and empty seeds and the berries are deformed. Many nymphal and adults *Lygus* can be seen feeding on the seeds of strawberry plant during sunny days (Colting et al., 2003). As stated by Howitt in 1999 the damage is done from the budding to the podding stage, damaged buds will turn white and fail to develop. The flower may fall without forming pods, or the pods can fall without maturing. The main economic damage usually occurs at the podding stage. *Lygus* bugs damage seeds by poking into the seed and sucking out its juice. The damage seeds collapse, shrink, darken, and lose quality and viability. The oldest nymph and adult do the most damaged like distortion of the berries known as cat facing, rendering the fruits unacceptable for fresh market sale and destroyed the developing embryos of seeds during early fruit development (Rao and Welter, 1997).

Rougoor (2006) reported that the pest insect feed on the reproductive organs of the plants, probing the tissue repeatedly causing mechanical damage. Nymphs take a test bite to determine whether the plant is a good food source, if it is suitable it will continue puncturing and release digestive enzymes into the tissue. Feeding causes a number of problems including; fruit malformation, abnormal growth, cell death, abscission of fruiting structures and damage to seeds. Both adults and nymphs feed on strawberry structure, but the nymphal stage causes the most economic damage, feeding on the achenes and tissue of the strawberry fruit *Lygus* damage can be identified by observing the shape of the achenes since they are of equal size while poor pollination is identified if



achenes are of varying size in the damaged area. The fruit malformation that caused by the insect can be confused with symptoms of poor pollination.

Management

Flint and Toseano (1990) stated that successful management of *Lygus* includes control of weeds host and adult on strawberries in summer. The timing of insecticide sprayer to control *Lygus* nymphs before they cause significant damage is necessary. Sprays must be timed to kill the earliest nymphs because most registered insecticides are not exceptionally effective on adults. It is important to limit the number of treatments for *Lygus*, because most of the materials that are effective against *Lygus* disrupt natural enemies of spider mites. Control actions for *Lygus* in strawberries generally are needed only in growing areas, and the management activities described below apply to these areas. Once flower development begins in strawberries, you can watch for the appearance of *Lygus* adults during other routine monitoring activities.

Parker et al. (2001) stated that insecticides that are available for use in strawberries are most effective against the early instars hence applications needed to be timed to period soon after egg hatch. *Lygus* adult migrate to strawberries from weeds when flowering commences hence plants needed to be monitored in summer to determine the first appearance of *Lygus* adult.

Knight (1989) stated that removal of adult *Lygus* have limited impact on the early instar. *Lygus* adult have mobile and rapidly migrate into strawberries after passage.

Alford (1979) stated that the use of trap crops is now being evaluated in strawberries for the control of *Lygus*. Since *Lygus* adult sometimes don't prefer crops adjacent to the strawberries they can so it may be possibly be controlled by trapping.



Host Plant

Lygus bug feed in almost anything. They attack over 500 commercial crops. Their preferred vegetable hosts include bean, beet, cauliflower, cabbage, chard, celery, cucumber, potato, turnip, pechay, alfalfa, tomato, plum; Fruit include apple, peach, pear raspberries, strawberry, and most other deciduous and small fruits. It also attacks many flowers including dahlia, aster calendula, chrysanthemum, cosmos, gladiolus, poppy, salvia, daisy sunflower, verbena, and zinnia. The other host plants include weeds such as red root pigweed, stinkweed, wild mustard and lambs quarters. The insect is a very general feeder, attacking many kinds of trees and herbaceous plants. Lygus bug has a piercing sucking mouth parts as do all the true bugs (Howitt, 1999).

Natural Enemies

In 2003, Colting et al., found that the natural enemies of Lygus bug are Big-eyed bugs (*Geocoris* spp.), Damsel bugs (*Nabis* spp.), Minute pirate bugs (*Orius tristicolor*), Small beetles, Spiders, and Lacewings.



MATERIALS AND METHODS

Materials

The materials used in the study were sweet charlie strawberry, ripe strawberry fruits, plastic bags, Bio 3 in 1 fertilizer, urea, garden soil, multi-purpose plastic containers, tissue, foot-ruler, camel hair brush, insect pin, glass slide, vials, 80 percent ethyl alcohol, magnifying lens, dissecting microscope, monocular microscope with ocular (μm), digital camera, *Lygus hesperus* specimens, pen and notebook.

Methods

Maintenance of the host plant. 80 black plastic bags (8x8x14 centimeter) with Bio 3 in 1 (Processed chicken manure) mixed with soil were prepared to served as planting medium for sweet charlie variety of strawberry beside the greenhouse at the experimental field of Mites-Predatory Rearing House, Benguet State University (Figure 1). After planting the plants were watered and this is done every other day for the plants to develop its roots again. Weeds and dry leaves were removed upon observation and application of fertilizer (triple 14-14-14) is done after 15 days to supplement the necessary nutrients needed by the plant to grow well.





Figure 1. The sweet charlie strawberry

Maintenance of the host insect. *Lygus* population were maintained by collecting adults on the strawberry field at Balili and Swamp, La Trinidad, Benguet. Hands were used in collecting insect by picking during morning and afternoon for the insect not so active to catch on. The collected adults were cultured and placed in a multi-purpose plastic container (Cp-16) with piece of tissue and were supplied with ripe strawberry fruits to maintained the development of the host insects. These were allowed to reproduce and served as a source of sampled insect for the study of its life cycle.



Durations of the different development stages of *L. hesperus*. Gathering the information on the durations of the different development stages of *L. hesperus* began at the egg stage. The newly laid eggs on strawberry fruits that were supplied to the cultured insect were removed and collect the eggs individually using insect pin. These eggs are separately placed in pieces of tissue inside the multi-purpose plastic containers (Cp-10) by 20 replications. The containers were marked by the used of label tags to facilitate recording while the eggs are observed everyday at six o'clock in the morning and in the afternoon to determine the incubation period of the egg.

The newly hatch eggs to first instar nymph were reared supplied with fresh ripe strawberry fruits to maintained their growth and were changed when already rotten. The nymphal stage observed daily until emerging to adult stage while the duration takes after molting to next to last instars were recorded. The nymph instars were determined by the number of molts which were indicated by exuvia formed during molting while newly emerged adult were gathered and are prepared for the observation on the longevity of adult female and male insect.

The duration days of the different development stages of *L. hesperus* was conducted under laboratory conditions at Mites-Predatory Rearing House (Figure 2). The temperature recorded during conducting the study ranged from 16 degrees Celsius (minimum) to 30 degrees Celsius (maximum).





Figure 2. Mites-predatory rearing house

Longevity of the adult. The duration days of the life of adult female and male *L. hesperus* with food and without food were determined by placing a newly emerged adult female each in a Cp-10 containers (Figures 3 and 4) and another setup for adult male with and without food (Figures 5 and 6) with 20 replications. The sampled adults were taken from the cultured and the reared sample nymph.

With food and without food treatments were observed daily until the death of the adult. The longevity of the two sexes were recorded separately to served as the bases of comparison. The female and male adults were distinguished by its sizes generally the female is bigger in size with bright colored abdomen while the male is smaller in size with black abdomen.





Figure 3. Multi-purpose plastic containers (Cp-10) with adult female and with strawberry fruit

Figure 4. Multi-purpose plastic containers (Cp-10) with adult female and without strawberry fruit

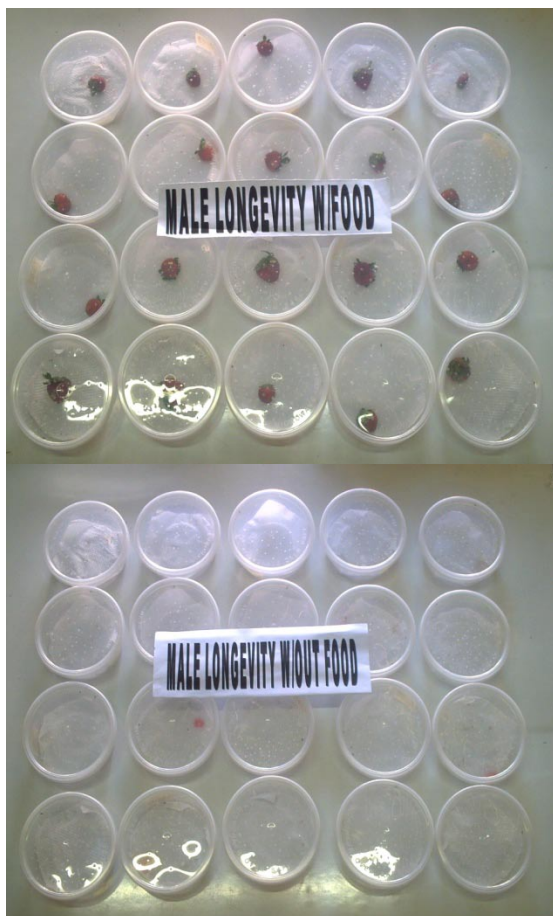


Figure 6. Multi-purpose plastic containers (Cp-10) with adult male and with strawberry fruit

Figure 5. Multi-purpose plastic containers

(Cp-10) with adult male and without strawberry fruit

Morphological descriptions of the different development stages of *L. hesperus*.

The morphological description of the different developmental stages of *L. hesperus* were taken from reared sampled insect. The newly deposited eggs, nymph until turned to adult were collected at every stages of development and were examined under magnifying lens and dissecting microscope. Observations were focused on the general shape and color of the different growth stages of the insect.

Size measurements of the different development stages. The size of the eggs were taken by measuring the body length and the body width by the used of monocular



microscope equipped with an ocular and micrometer calibration. Whereas, the length of the first to fifth instars were measured from the tip of head to tip of the abdomen and the width measured from both sides of third to fourth segment of the abdomen. The length of the adult measured from the tip of the head to tip of the abdomen while the width measured from the both sides of the first segment of abdomen. Measurement of the nymph and adult stage were measured in millimeter with the used of foot ruler and glass slide focused under microscope.

Micrometer (μm) measurements were converted into millimeters (mm) the conversion unit used were 1 millimeter = 0.001 micrometer. 20 sampled insect were measured in every development stages of the insect. The eggs measured alive while the nymphs and adults were measured after killed in 80 percent solutions of ethyl alcohol.

Fecundity of the adult female. The fecundity of the female *L. hesperus* were determined by placing a paired new emerged adult female and male each on a similar Cp-10 containers with an piece of tissue and ripe strawberry fruits served as a food as well as a laying site for the adult female insect (Figure 7). The eggs oviposited on the strawberry fruits were gathered and counted every day by removing the eggs individually using insect pin. The rotten strawberries were removed and supplied with frees ripe strawberries for the insect to feed and for the female to oviposites its eggs again.

The fecundity of single female *Lygus* without paired were gathered with in the adult longevity sampled insect with same procedure. The gathered eggs were observed





Figure 7. Adult female and male (Fecundity) inside the multi-purpose plastic containers (Cp-10) with strawberry fruit

everyday if the egg hatch and determined if the insect undergo parthenogenesis reproduction.

Feeding behavior. The feeding behavior of the nymph and adult Lygus were observed during rearing of the sampled insect. This was done by observing the feeding time of the insects with a three replications.

Mating behavior. The mating behavior of the adult Lygus were observed by pairing adult female and male inside the multipurpose plastic containers with strawberry fruit and five replications. The time of mating were recorded as well as the behavior of the insect during and after mating.

Oviposition. The oviposition sites of the adult female were determined after mating.

Documentation and preservation. Documentation on the different development stages of *L. hesperus* were taken with the used of digital camera and microscopes (digital

lens zoom was used in the documentation) while the specimens were preserved in vials with 80 percent ethyl alcohol.

Experimental design. The Completely Randomized Design (CRD) was used in analyzing data on the life cycle of *L. hesperus* on the strawberry.

The data gathered were as follows:

A. Duration and morphological description of the different development stages of *L. hesperus*

1. Egg. Color, size, shape and incubation period.
2. Nymph. Duration, color, shape, length and width.
3. Adult. Duration, color, length and width of the body and wingspan.

B. Longevity of the adult. Duration days of the adult female and male emergence to death

1. With food
2. Without food

C. Female fecundity. Total number of eggs laid by female.

1. With pair
2. Without pair

D. Behavioral Studies

1. Feeding behavior. The time of feeding by the nymphal and adult Lygus.
2. Mating. The time and manner of mating by the adults Lygus.
3. Oviposition. The preferred laying sites by the adult insect.



RESULTS AND DISCUSSION

Durations of the Different Growth Stages of *L. hesperus*

The duration days of the different developmental growth stages of *L. hesperus* reared under laboratory condition are shown in Table 1.

Egg. The incubation period of egg ranged from 8 to 10 days with a mean of 8.98 ± 0.132 days, a kind of observation similar with the findings of Rougoor (2006) that the incubation period of eggs were 7 to 10 days depending on the temperature.

Nymph. The nymphal stages of *L. hesperus* had five instars. The total duration days of the nymphal stages from first to fifth instars completed its development growth with in 29 to 34 days with a mean of 31.42 ± 0.318 days. The first instar nymph developed from 5.12 to 7.12 days with a mean of 6.07 ± 0.100 days; the second instar nymph was 4 to 6 days with a mean of 4.31 ± 0.120 days; the third instar nymph was 4 to 6.12 days with a mean of 5.28 ± 0.155 days; the fourth instar nymph was 5 to 7 days with a mean of 5.89 ± 0.127 days and the fifth instar nymph was 8.12 to 10.12 days with a mean of 9.15 ± 0.119 days. As pointed out by Cermak and Walker (1992) the duration of the nymph from first to fifth instars were 12 to 34 days depending on the temperature.

Adult. The longevity of the adult female ranged from 42 to 71.12 days with a mean of 55.53 ± 1.760 days while the adult male lived from 31 to 63 days with a mean of 44.42 ± 1.945 days. The pre-reproductive period of the female was 4.6 to 16.6 days with a mean of 10.24 ± 0.661 days; the reproductive period was 19 to 49 days with a mean of 37.7 ± 1.864 days and the post-reproductive was 4.6 to 20.6 with a mean of 8.29 ± 0.839 days.



The total life span of the female *L. hesperus* from egg to adult completed its development growth with in 81 to 111.12 days with a mean of 96.35 days while the male insect was 71 to 103.12 with a mean of 85.17 days. The female lived longer than the male although some males lived as long as the female insect.

Table 1. Duration (days) of the different developmental growth stages of the *L. hesperus* under laboratory condition

STAGE OF DEVELOPMENT	DURATION (DAYS)	
	RANGE	MEAN
Egg incubation	8 – 10	8.98 ± 0.132
Nymph	29 – 34	31.42 ± 0.318
1 st instar	5.12 – 7.12	6.07 ± 0.100
2 nd instar	4 – 6	4.31 ± 0.120
3 rd instar	4 – 6.12	5.28 ± 0.155
4 th instar	5 – 7	5.89 ± 0.127
5 th instar	8.12 – 10.12	9.15 ± 0.119
Adult		
Female	42 – 71.12	55.53 ± 1.760
Pre-reproductive	4.6 – 16.6	10.24 ± 0.661
Reproductive	19 – 49	37.7 ± 1.864
Post-reproductive	4.6 – 20.6	8.29 ± 0.839
Male	31 – 63	44.42 ± 1.945
TOTAL LIFE SPAN		
Female	81 – 111.12	96.35
Male	71 – 103.12	85.17

Longevity of the Adult *L. hesperus*

The longevity of the adult *L. hesperus* is indicated in Table 2. As observed, the longevity of the adult female provided with food lived from 42 to 71.12 days with a mean



of 55.53 ± 1.760 days and the adult male was 31 to 63 days with a mean of 44.42 ± 1.945 days while the without food adult female lived from 4 to 9 days with a mean of 5.85 ± 0.340 days and the adult male was 3 to 8 days with a mean of 4.96 ± 0.400 days.

The insect provided with food lived longer than the without food. The nutrients and proteins that the insect suck during feeding on seeds of the strawberry fruit gives and provides energy to developed and maintained the growth which is needed by the body of the insect to lived. Without the presences of the food the insect cannot lived and died for a few days.

Table 2. Longevity of the adult *L. hesperus*

ADULTS	WITH FOOD		WITHOUT FOOD	
	RANGE	MEAN	RANGE	MEAN
Female	42 – 7.12	55.53 ± 1.760	4 – 9	5.85 ± 0.340
Male	31 – 63	44.42 ± 1.945	3 – 8	4.96 ± 0.400

Morphological Descriptions and Body Size of *L. hesperus*

The body length and width of the different growth stages of *L. hesperus* reared under laboratory condition are presented in Table 3.

Egg

The egg of the *L. hesperus* are very small elongated and cylindrical in shape but same eggs are slightly curved. The body are smooth and shiny while color were light yellow with two red spotted on the both sides (Figure 1). The eggs turned reddish if its nearly hatched. The body length measures from 0.49 to 0.065 mm with a mean of $0.59 \pm$



0.008 mm long and the width was 0.16 to 0.22 mm with a mean of 0.19 ± 0.004 mm wide. This finding runs counter to the finding of Howitt (1999) that the length measured of the egg was 0.95 to 1 mm long and the width was 0.25 mm wide.

Nymph

The first to fifth instar nymph are tears like in shape or look like an aphids in appearance and wingless. The head are opisthognathous with piercing sucking mouthparts. The antennae and legs were relatively long. The compound eye is located beside the head near the prothorax. The segment of the abdomen is obviously seen.

First instar. The new hatched nymph were whitish in color and as it matured the color of the abdomen turned light yellow with reddish on its segments, the head and thorax are shaded in color (Figure 3). The thorax has a light yellow triangle on the center and a V shape line on the head that separate the two compound eyes. The antennae and legs are yellowish but the last segments of the antennae are maroon in color. The body length (from tip of head to tip of the abdomen) measured from 0.7 to 0.8 mm with a mean of 0.75 ± 0.011 mm long and the body width (both sides of third to fourth segment of the abdomen) was 0.3 to 0.4 mm with a mean of 0.35 ± 0.11 mm wide.

Second instar. The second instar nymph has more evident red color on its abdominal segment. The color of first segment of the abdomen were white to reddish while has a dark red color spotted on the fourth segment compared to the second segment to last segment that were orange to reddish in color. The thorax were brown dark while the head are dark with a brown lining color and had a thick horizontal line on the dorsal center part of the thorax and head. The body length having a size of 1.0 to 1.3 mm with a



Table 2. Length and width (mm) of the different growth stages of *L. hesperus* under laboratory condition

STAGE OF DEVELOPMENT	LENGTH (mm)		WIDTH (mm)	
	RANGE	MEAN	RANGE	MEAN
Egg	0.49 – 0.65	0.59 ± 0.008	0.16 – 0.22	0.19 ± 0.004
Nymph				
1 st instar	0.7 – 0.8	0.75 ± 0.011	0.3 – 0.4	0.35 ± 0.011
2 nd instar	1.0 – 1.3	1.19 ± 0.019	0.4 – 0.7	0.55 ± 0.021
3 rd instar	1.5 – 1.8	1.63 ± 0.024	0.7 – 0.9	0.80 ± 0.018
4 th instar	2.3 – 2.5	2.40 ± 0.019	1.1 – 1.4	1.30 ± 0.021
5 th instar	3.2 – 3.5	3.39 ± 0.020	1.5 – 1.6	1.55 ± 0.011
Adult				
Body				
Female	3.5 – 4.0	3.66 ± 0.044	1.0 – 1.4	1.21 ± 0.029
Male	3.1 – 3.4	3.26 ± 0.025	0.8 – 1.0	0.91 ± 0.014
Fore Wing				
Female	2.4 – 3.0	2.68 ± 0.042	0.9 – 1.0	0.93 ± 0.011
Male	2.4 – 2.7	2.49 ± 0.019	0.8 – 1.0	0.86 ± 0.015
Hind Wing				
Female	2.1 – 2.5	2.24 ± 0.037	0.9 – 1.0	0.93 ± 0.011
Male	1.8 – 2.0	1.91 ± 0.016	0.8 – 1.0	0.86 ± 0.015



mean of 1.19 ± 0.019 mm long and the body width was 0.4 to 0.7 mm with a mean of $0.55 + 0.021$ mm wide.

Third instar. The third instar nymph were similar within the second instar in terms of the body color with black hairs on the legs are developed. The fourth and sixth segments of abdomen are spotted with dark red surround by a white color. The body length measures from 1.5 to 1.8 mm with a mean of 1.63 ± 0.024 mm long while the body width was 0.7 to 0.9 mm with a mean of 0.80 ± 0.018 mm wide.

Fourth instar. The abdomen of fourth instar nymph were reddish-brown in color. The last segment of antennae comes brown while wing pads on the thorax were begin to developed. The dark red spotted on the fourth and sixth segment becomes black in color. The body length was 2.3 to 2.5 mm with mean of 2.40 ± 0.019 mm long and the body width was 1.1 to 1.4 mm with a mean of 1.30 ± 0.021 mm wide.

Fifth instar. The fifth instar nymph were almost similar in fourth instar nymph, it has a reddish lining on the thorax while brown lining on the head and a thin horizontal line that could be seen on the dorsal center part of the thorax and head. The body markings and wing pads are fully developed. The fifth instar abdomen are slender than the fourth instar. The body length measures from 3.2 to 3.5 mm with a mean of 3.39 ± 0.020 mm long while the width was 1.5 to 1.6 mm with a mean of 1.55 ± 0.011 mm wide.





Figure 1. The egg (10.5x)



Figure 2. First instar nymph (11.1x)





Figure 3. Second instar nymph (11.1x)

Figure 4. Third instar nymph (11.1x)





Figure 6. Fourth instar nymph (11.1x)

Figure 6. Fifth instar nymph (11.1x)



Figure 7. Adult female (11.1x)





Figure 8. Adult male (11.1x)

Adult

The adult *Lygus* are small bugs having two pairs of hemilytra wing. The hind wing and forewing lie flat over the dorsal abdomen. The basal portions of the front wing are thickened usually transparent or silvery in color. The scutellum were triangle or V mark shape located on the thorax region. The three segmented beak of labium arises from the front part of the head. The round, reddish-brown compound eyes are develop well near the prothorax with two present ocelli. The one pair clavated antennae are fairly long located dorsally on the head and closed to the compound eyes. The three segmented antennae were measured from 1.9 to 2.3 mm. The abdomen had a seven segment with spiracle on the both sides. The organ reproductive of the insect could be seen at the sixth



to last segment of the abdomen. The cursorial legs (Walking, running legs) were relatively long. The whole body were covered with fine hairs except the wings.

Adult female. The head, thorax and abdomen of adult female are dark to brown in color (Figure 7). The femur parts of the three pairs of legs are spotted with black color. The female has a bigger body and stout abdomen. The body length (from tip of head to tip of the abdomen) measures from 3.5 to 4.0 mm with a mean of 3.66 ± 0.044 mm long while the width (both sides of the first segment of abdomen) was 1.0 to 1.4 mm with a mean of 1.21 ± 0.029 mm wide. The length of the fore wingspan ranged from 2.4 to 3.0 mm with a mean of 2.68 ± 0.042 mm long and the width was 0.9 to 1.0 mm with a mean of 0.93 ± 0.011 mm wide while the length of the hind wingspan ranged from 2.1 to 2.5 mm with a mean of 2.24 ± 0.037 mm long and the width was 0.9 to 1.0 mm with a mean of 0.93 ± 0.11 mm wide.

Adult male. The head, thorax and abdomen of adult male are darker in color compared to the adult female (Figure 8). The femur parts of the hind legs were black in color. The fore and mid legs were just spotted with black color. The adult male has a slender pointed black abdomen and smaller to the adult female. In terms of body size, the body length (from tip of head to tip of the abdomen) ranged 3.1 to 3.4 mm with a mean of 3.26 ± 0.025 mm long and the width (from tip of head to tip of the abdomen) was 0.8 to 1.0 mm with a mean of 0.91 ± 0.014 mm wide. The fore wingspan was 2.4 to 2.7 mm with a mean of 2.49 ± 0.019 mm long and the width was 0.8 to 1.0 mm with a mean of 0.86 ± 0.015 mm wide while the hind wingspan was 1.8 to 2.0 mm with a mean of 1.91 ± 0.016 mm long and the width was 0.8 to 1.0 mm with a mean of 0.86 ± 0.015 mm wide.

Fecundity



The total number of eggs laid by the adult female *L. hesperus* with pair and without pair is shown in Table 4. It has been found out that the adult female mated (with pair) by adult male can lay as many as 41 to 180 eggs with a mean of 111.75 ± 8.996 eggs while the unmated (without pair) adult female lay 31 to 112 eggs with a mean of 70.35 ± 5.047 eggs. The mated females laid many eggs than the unmated female.

It has been found out that the female insect did not undergo the process of parthenogenesis in which the single female can lay eggs without the mating but the laid eggs were not hatch and come dry.

Table 4. Total number of eggs laid by the adult female *L. hesperus* (with pair and without pair)

SAMPLED NUMBER	TOTAL NUMBER OF EGG	
	WITH PAIR	WITHOUT PAIR
1	138	75
2	113	64
3	98	112
4	175	70
5	70	90
6	99	40
7	146	82
8	173	89
9	151	80
10	180	42
11	98	32



12	56	97
13	85	88
14	41	74
15	56	65
16	114	74
17	106	94
18	119	56
19	91	52
20	126	31
TOTAL	2,235	1,407
MEAN	111.75 \pm 8.996	70.35 \pm 5.047

Behavior Studies

Feeding behavior. The nymph and adult Lygus feed on seeds by using their piercing sucking mouth parts. The insect mouth had a long slender mandibular stylet and



Figure 9. Adult female sucking liquid from the strawberry seed

maxillary stylet that covered by a labrum and labium that they used in feeding and proving out the suitable portion of the seeds were they could inject their stylets to suck-



up the content liquid of the seeds (Figure 9). During feeding of the insect, salivary secretions are released down and liquid food is sucked-up (Facundo and Calilung, 1986). The nymph feed on the seeds for 49 minutes to 1:57 hours with a mean of 1:03 hours which were take 4 to 8 times a day while the adults feed for 23 to 58 minutes with a mean of 42:33 minutes and take 3 to 7 times a day. The newly hatch nymph begin to feed on the preferred seed at any time of the day as it matured to fourth and fifth instars the more seeds they suck.. Most of the adults feed after laying eggs and mating. The insect feed throughout its life time.

Meeting behavior. The mating of the adult *Lygus* was observed by placing one female and one male inside the container with strawberry fruits. It was observed, that no courtship when insect mate. When the male and female meet from different direction, the male actively go on the back of female in which female holds and embraced by the male using its three pair legs while insert his aedeagus to reproductive organ of the female for few minutes. After inserting, the male come down and mating occurs for 2:30 to 5:46 hours with a mean of 3.716 hours (Figure 10). Adults may mate 3 to 6 times a day but usually mating occurs when the temperature is high. The mating took place from 2 to 4 days old of the adult and female could be mated by several males. When mating disturbed, the male pulled the female and run to hide in the covered area. It is also observed, that during mating some of the male insect walking around carrying the female and they also feed on the seed while mating (Figure 11). After mating, the insect stay with each other for a few minutes and they moved to different direction to found food.



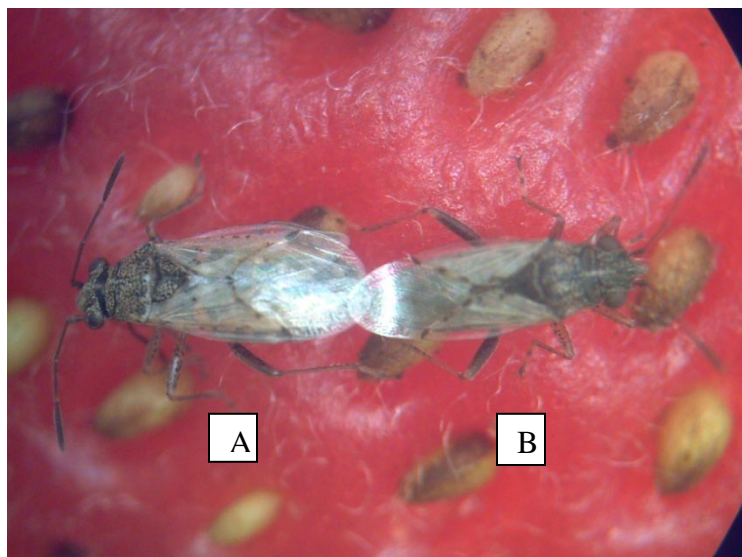


Figure 10. Adult female (A) and male (B) mating

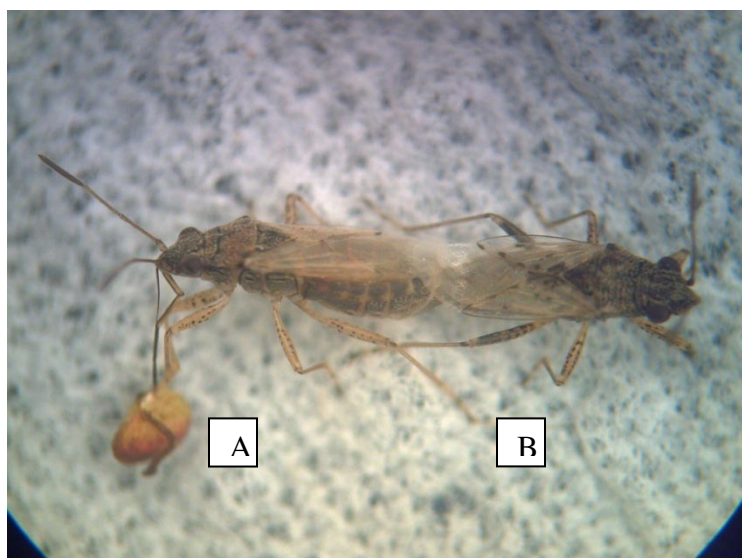


Figure 11. Female (A) adult feeding while mating

Oviposition. The oviposition occurred after the mating behavior. Oviposition can occur within the day and during nighttime. The preferred oviposition site of the adult female *Lygus* is in the strawberry fruits, tissue and in sides of the container but mostly inserted into the petiole (Figure 12) and on sides of seed of the strawberry (Figure 13). The eggs are deposited singly or scatteredly laid.

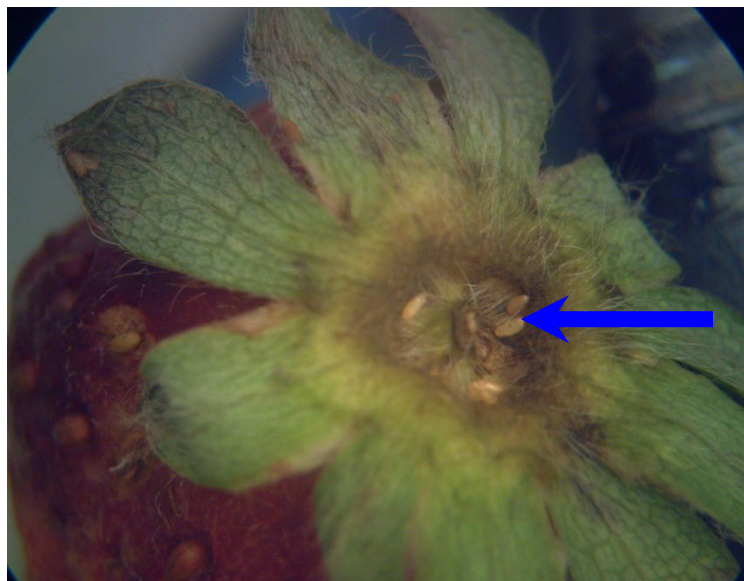


Figure 12. Eggs of *L. hesperus* inserted in the petiole of the strawberry fruit



Figure 13. Eggs of *L. hesperus* laid besides the seed of strawberry

SUMMARY, CONCLUSION AND RECOMMENDATIONS

Summary

The study was conducted at the Mites Predatory House in Balili La Trinidad, Benguet from April to October 2007 with the objectives of determined the durations, morphological descriptions of the different developmental stages of *L. hesperus*, compared the duration of life of adult female and male, recorded the total number of eggs deposited by the female, discovered if the insect undergo parthenogenesis and observed how the insect feed and mate.

The insect pest undergo three stages of development namely: egg, nymph and the adult. The incubation period of egg ranged from 8 to 10 days with a mean of 8.98 ± 0.132 days. The nymph undergo five instar of development. The duration of the first instar nymph was 5.12 to 4.12 days; second instar, 4 to 6 days; third instar, 4 to 6.12 days; fourth instar, 5 to 7 days; and fifth instar, 8.12 to 10.12 days. The duration of the adult female with food lasted from 42 to 71.12 days with a pre-reproductive of 4.6 to 16.6 days; reproductive, 19 to 49 days; post-reproductive, 4.6 to 20.6 days; while the male was 31 to 63 days. The adult female without food lives from 4 to 9 days while adult male was 3 to 8 days. The total life span of the female *L. hesperus* from egg to adult stage was 81 to 111.12 days with an average of 96.35 days while the male had a 71 to 103.12 with an average of 85.17 days.

The eggs were elongated, cylindrical-shape, light yellow and shiny color. It is light reddish in color when about to hatch. The nymph were tear-shape, wingless, as matured the abdomen are stout, brown to reddish color. Wing pods are begin to develop at the fourth instar. The adult had a triangle-shape located at the dorsal part of the thorax



and has seven segments on the abdomen. The three segment of antennae were clavated type and the three pairs of legs were cursorial type. The full grown adult female has stouter brown abdomen and adult male was slender and pointed black abdomen.

The length measurement of the egg ranged 0.49 to 0.65 mm with a width of 0.16 to 0.22 mm. The body measurement of the first instar nymph was 0.7 to 0.8 mm long with 0.3 to 0.4 mm wide; second instar, 1.0 to 1.3 mm long with 0.4 to 0.7 mm wide; third instar, 1.5 to 1.8 mm long with 0.7 to 0.9 mm wide; fourth instar, 2.3 to 2.5 mm long and 1.1 to 1.4 mm wide; and the fifth instar, 3.2 to 3.5 mm long with 1.5 to 1.6 mm wide. The adult female was 3.5 to 4.0 mm long and 1.0 to 1.4 mm wide; fore wingspan was 2.4 to 3.0 mm long and 0.9 to 1.0 mm wide while the hind wingspan was 2.1 to 2.5 mm long and 0.9 to 1.0 mm wide. The adult male was 3.1 to 3.4 mm long and 0.8 to 1.0 mm wide; fore wingspan was 2.4 to 2.7 mm long and 0.8 to 1.0 mm long wide while the hind wingspan was 1.8 to 2.0 mm long and 0.8 to 1.0 mm wide.

Conclusion

The total number of eggs laid by *L. hesperus* bug female with pair adult male ranged of 41 to 180 eggs with an average of 111.75 ± 8.996 eggs and the without paired female laid of 31 to 112 eggs with an average of 70.35 ± 5.047 eggs throughout its reproductive period.

The insects did not undergo the process of parthenogenetic reproduction.

The nymph and adult have piercing-sucking mouthparts that they used in proving and penetrating the content liquid of seeds of the host plant. The nymph feed on the seeds 4 to 8 times a day with a range of 49 minutes to 1:57 hours while the adults feed 3 to 7 times a day with a range of 23 minutes to 58 minutes.



The adults male and female mates with a range of 2:30 to 5:46 hours. The female and male adults mate 3 to 6 times a day and female can be mated by different males. No courtship when the insect mates.

Recommendation

It is recommended that life cycle of *L. hesperus* will be studied on the different temperature regimes and other host plant such as peg weed, dandelion and pechay.



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APPENDICES

Appendix Table 1. Number of days (incubation period) the egg hatched

SAMPLED NUMBER	LAYING TO HATCHING
1	8
2	8
3	8.12
4	8.12
5	9
6	9
7	9
8	9
9	9
10	9
11	9
12	9
13	9
14	9
15	9.12
16	9.12
17	9.12
18	10
19	10
20	10
TOTAL	179.6
MEAN	8.98

Appendix Table 2. Number of days (duration) of the first instar to fifth instar

SAMPLED NUMBER	INSTARS					TOTAL
	First	Second	Third	Fourth	Firth	
1	6	4	5.12	6	10	31.12
2	6.12	4.12	6.12	6	10	33.12
3	6.12	4.12	5.12	6	9	31.12
4	5.12	5.12	5.12	5	9	30.12
5	6	4	5.12	5	8.12	29
6	6.12	4.12	6.12	7	9.12	34
7	6	4.12	5	6.12	9.12	31.12
8	6.12	4	4	6	9.12	30
9	6.12	4	6	6	9.12	32
10	6.12	4.12	5	6.12	9	31.12
11	6	4.12	6.12	6	10.12	33.12
12	6.12	4.12	5.12	5.12	8.12	30.12
13	6	4	4.12	6	9.12	30
14	7.12	5	5	5.12	9	32
15	6.12	5	4.12	6	9	31
16	6	4.12	6	6	10	32.12
17	5.12	4	5.12	5.12	9	29.12
18	7	6	5.12	6	9	33.12
19	6	4	6.12	7	9.12	33
20	6.12	4.12	6	6.12	9	32.12
TOTAL	121.44	86.2	105.56	117.72	183.08	628.44
MEAN	6.072	4.31	5.278	5.886	9.154	31.422

Appendix Table 3. Longevity (Emergence to death) of adult female *L. hesperus* (with food)

SAMPLED NUMBER	NUMBER OF DAYS			TOTAL
	PRE- REPRODUCTIVE	REPRODUCTIVE	POST- REPRODUCTIVE	
1	7.6	32	20.6	59.12
2	7.6	43	7.6	57.12
3	9.6	48	14.6	71.12
4	9.6	39	7.18	56
5	4.6	38	6.6	48.12
6	11.6	40	8.6	59.12
7	7.6	46	4.6	57.12
8	8.6	47	6.6	61.12
9	11.6	49	7.6	67.12
10	16.6	19	9.6	44.12
11	8.6	30	6.6	44.12
12	7.18	29	5.6	42
13	9.6	49	7.6	65.12
14	9.6	35	11.18	56
15	15.18	37	5.6	58
16	10.6	30	9.18	50
17	10.6	44	5.6	59.12
18	11.6	26	9.6	46.12
19	15.18	35	6.6	57
20	11.6	38	4.6	53.12
TOTAL	204.74	754	165.74	1,110.68
MEAN	10.237	37.7	8.287	55.534

Appendix Table 4. Longevity (days) of the adult male *L. hesperus* (with food)

SAMPLED NUMBER	NUMBER OF DAYS
1	46.12
2	45
3	31
4	37
5	44
6	32.12
7	53
8	50
9	40.12
10	63
11	43.12
12	56.12
13	56.12
14	43.12
15	42.12
16	49.12
17	48.12
18	43.12
19	32.12
20	34
TOTAL	888.44
MEAN	44.422

Appendix Table 5. Longevity (days) of the adult female *L. hesperus* (without food)

SAMPLED NUMBER	NUMBER OF DAYS
1	6
2	5.12
3	4.12
4	5.12
5	7
6	4
7	7
8	8.12
9	5.12
10	5
11	5.12
12	5
13	5.12
14	5
15	9
16	6
17	5
18	4.12
19	7
20	9
TOTAL	116.96
MEAN	5.848

Appendix Table 6. Longevity (days) of the adult male *L. hesperus* (without food)

SAMPLED NUMBER	NUMBER OF DAYS
1	7.12
2	4
3	7
4	3.12
5	7.12
6	5
7	4
8	5
9	4.12
10	4
11	8
12	3.12
13	5.12
14	3.12
15	3.12
16	7.12
17	5
18	3.12
19	3
20	8
TOTAL	99.2
MEAN	4.96

Appendix Table 7. Length and width of the egg of *L. hesperus* in mm

SAMPLED NUMBER	BODY	
	LENGTH	WIDTH
1	0.63	0.18
2	0.59	0.22
3	0.60	0.18
4	0.63	0.21
5	0.61	0.18
6	0.49	0.21
7	0.53	0.16
8	0.60	0.21
9	0.62	0.18
10	0.56	0.19
11	0.62	0.18
12	0.61	0.18
13	0.57	0.18
14	0.61	0.21
15	0.57	0.20
16	0.60	0.20
17	0.59	0.21
18	0.65	0.16
19	0.57	0.17
20	0.59	0.19
TOTAL	11.84	3.8
MEAN	0.592	0.19

Appendix Table 8. Length and width of the first instar nymph in *mm*

SAMPLED NUMBER	FIRST DAY		LAST DAY	
	LENGTH	WIDTH	LENGTH	WIDTH
1	0.7	0.3	0.7	0.3
2	0.6	0.2	0.8	0.4
3	0.6	0.2	0.7	0.3
4	0.7	0.3	0.7	0.3
5	0.6	0.1	0.7	0.3
6	0.5	0.2	0.7	0.3
7	0.5	0.1	0.8	0.4
8	0.6	0.2	0.8	0.4
9	0.6	0.1	0.8	0.4
10	0.6	0.2	0.7	0.3
11	0.6	0.1	0.7	0.3
12	0.6	0.2	0.8	0.4
13	0.6	0.2	0.8	0.4
14	0.7	0.3	0.7	0.3
15	0.6	0.3	0.8	0.4
16	0.6	0.2	0.7	0.3
17	0.6	0.2	0.7	0.3
18	0.5	0.1	0.7	0.3
19	0.6	0.2	0.8	0.4
20	0.6	0.3	0.8	0.4
TOTAL	12	4	14.9	6.9
MEAN	0.6	0.2	0.745	0.345

Appendix Table 9. Length and width of the second instar nymph in *mm*

SAMPLED NUMBER	FIRST DAY		LAST DAY	
	LENGTH	WIDTH	LENGTH	WIDTH
1	0.9	0.4	1.2	0.6
2	0.8	0.3	1.2	0.6
3	0.9	0.4	1.3	0.6
4	0.9	0.4	1.1	0.5
5	0.8	0.4	1.2	0.5
6	0.8	0.4	1.2	0.6
7	0.9	0.4	1.1	0.4
8	0.7	0.3	1.2	0.6
9	0.7	0.3	1.1	0.5
10	0.8	0.4	1.2	0.6
11	0.9	0.4	1.3	0.7
12	0.8	0.4	1.1	0.4
13	0.9	0.4	1.3	0.7
14	0.8	0.3	1.2	0.6
15	0.8	0.3	1.2	0.5
16	0.8	0.4	1.3	0.6
17	0.8	0.4	1.2	0.5
18	0.7	0.3	1.1	0.4
19	0.9	0.4	1.0	0.4
20	0.8	0.4	1.3	0.6
TOTAL	16.4	7.4	23.8	10.9
MEAN	0.82	0.37	1.19	0.545

Appendix Table 10. Length and width of the third instar nymph in *mm*

SAMPLED NUMBER	FIRST DAY		LAST DAY	
	LENGTH	WIDTH	LENGTH	WIDTH
1	1.4	0.7	1.5	0.7
2	1.1	0.5	1.6	0.8
3	1.2	0.5	1.6	0.7
4	1.3	0.7	1.5	0.7
5	1.4	0.6	1.7	0.9
6	1.3	0.7	1.6	0.8
7	1.3	0.7	1.5	0.8
8	1.4	0.7	1.7	0.9
9	1.2	0.6	1.6	0.9
10	1.4	0.6	1.8	0.8
11	1.3	0.7	1.7	0.7
12	1.2	0.6	1.5	0.9
13	1.3	0.8	1.6	0.8
14	1.2	0.5	1.5	0.8
15	1.3	0.7	1.8	0.9
16	1.3	0.8	1.7	0.7
17	1.2	0.5	1.8	0.9
18	1.4	0.6	1.5	0.7
19	1.3	0.7	1.7	0.8
20	1.3	0.6	1.6	0.8
TOTAL	25.8	12.8	32.5	16
MEAN	1.29	0.64	1.625	0.8

Appendix Table 11. Length and width of the fourth instar nymph in *mm*

SAMPLED NUMBER	FIRST DAY		LAST DAY	
	LENGTH	WIDTH	LENGTH	WIDTH
1	1.7	0.9	2.3	1.3
2	1.8	1.0	2.5	1.4
3	1.6	1.0	2.5	1.3
4	1.9	0.9	2.3	1.1
5	1.8	0.9	2.4	1.2
6	1.9	1.0	2.5	1.4
7	1.6	0.8	2.3	1.3
8	1.7	0.8	2.3	1.1
9	1.6	0.9	2.5	1.3
10	1.8	0.8	2.3	1.2
11	1.9	0.9	2.4	1.4
12	1.7	0.9	2.5	1.4
13	1.8	0.8	2.4	1.3
14	1.6	1.0	2.4	1.2
15	1.7	0.8	2.3	1.3
16	1.8	1.0	2.4	1.3
17	1.6	0.9	2.5	1.4
18	1.7	0.9	2.5	1.4
19	1.7	1.0	2.4	1.3
20	1.6	0.8	2.3	1.3
TOTAL	34.5	18	48	25.9
MEAN	1.725	0.9	2.4	1.295

Appendix Table 12. Length and width of the fifth instar nymph in *mm*

SAMPLED NUMBER	FIRST DAY		LAST DAY	
	LENGTH	WIDTH	LENGTH	WIDTH
1	2.6	1.4	3.4	1.5
2	2.5	1.3	3.2	1.5
3	2.5	1.4	3.5	1.5
4	2.5	1.3	3.4	1.6
5	2.7	1.4	3.3	1.5
6	2.5	1.3	3.4	1.5
7	2.5	1.3	3.3	1.5
8	2.6	1.4	3.3	1.6
9	2.5	1.3	3.4	1.5
10	2.7	1.4	3.5	1.6
11	2.6	1.4	3.3	1.6
12	2.6	1.3	3.5	1.6
13	2.7	1.4	3.5	1.5
14	2.6	1.4	3.3	1.6
15	2.5	1.3	3.4	1.5
16	2.6	1.4	3.5	1.6
17	2.5	1.3	3.5	1.5
18	2.6	1.4	3.3	1.6
19	2.5	1.3	3.4	1.6
20	2.7	1.4	3.4	1.5
TOTAL	51.5	27.1	67.8	30.9
MEAN	2.575	1.355	3.39	1.545

Appendix Table 13. Measurement (size) of adult female *L. hesperus* in mm

SAMPLED NUMBER	WINGSPAN					
	BODY		FOREWING		HINDWING	
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH	WIDTH
1	3.6	1.3	2.7	0.9	2.2	0.9
2	3.5	1.1	2.5	0.9	2.1	0.9
3	3.7	1.2	2.6	0.9	2.3	0.9
4	4.0	1.4	3.0	1.0	2.5	1.0
5	3.5	1.1	2.6	0.9	2.1	0.9
6	3.8	1.1	2.8	1.0	2.4	1.0
7	3.5	1.0	2.5	0.9	2.1	0.9
8	4.0	1.3	3.0	1.0	2.5	1.0
9	3.6	1.2	2.6	0.9	2.2	0.9
10	3.5	1.4	2.5	0.9	2.1	0.9
11	4.0	1.3	2.9	1.0	2.5	1.0
12	4.0	1.4	3.0	1.0	2.5	1.0
13	3.5	1.0	2.6	0.9	2.1	0.9
14	3.6	1.3	2.6	0.9	2.2	0.9
15	3.5	1.1	2.5	0.9	2.1	0.9
16	3.5	1.2	2.6	0.9	2.1	0.9
17	3.5	1.2	2.6	0.9	2.1	0.9
18	3.8	1.3	2.9	1.0	2.4	1.0
19	3.6	1.1	2.6	0.9	2.2	0.9
20	3.5	1.1	2.4	0.9	2.1	0.9
TOTAL	73.2	24.1	53.5	18.6	44.8	18.6
MEAN	3.66	1.205	2.675	0.93	2.24	0.93

Appendix Table 14. Measurement (size) of adult male *L. hesperus* in mm

SAMPLED NUMBER	WINGSPAN					
	BODY		FOREWING		HINDWING	
	LENGTH	WIDTH	LENGTH	WIDTH	LENGTH	WIDTH
1	3.4	1.0	2.6	1.0	2.0	1.0
2	3.1	0.9	2.5	0.9	1.9	0.9
3	3.3	0.9	2.5	0.9	2.0	0.9
4	3.1	0.9	2.7	0.9	2.0	0.9
5	3.2	0.9	2.5	0.8	1.9	0.8
6	3.3	0.9	2.5	0.8	1.9	0.8
7	3.4	0.9	2.4	0.8	1.9	0.8
8	3.3	1.0	2.4	0.8	1.8	0.8
9	3.2	0.9	2.5	0.9	1.9	0.9
10	3.4	1.0	2.6	0.9	2.0	0.9
11	3.3	0.9	2.5	0.8	1.9	0.8
12	3.2	0.9	2.4	0.8	1.9	0.8
13	3.1	0.9	2.4	0.9	2.0	0.9
14	3.4	0.9	2.5	0.8	1.9	0.8
15	3.2	0.8	2.4	0.8	1.8	0.8
16	3.1	0.9	2.4	0.9	1.9	0.9
17	3.2	0.8	2.5	0.8	1.8	0.8
18	3.4	1.0	2.6	1.0	2.0	1.0
19	3.3	0.9	2.5	0.8	1.9	0.8
20	3.2	0.8	2.4	0.9	1.8	0.9
TOTAL	65.1	18.1	49.8	17.2	38.2	17.12
MEAN	3.255	0.905	2.49	0.86	1.91	0.86

Appendix Table 15. The total number of eggs laid by the female per day (with pair)

Sampled Number	Number of Days																		
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1								9	12	6	6	5	9	5	6	15	5	6	10
2								8	5	2	0	4	14	0	1	7	11	1	1
3								1	1	0	5	0	4	3	6	8	9	3	4
4							6	0	5	9	1	8	7	7	21	10	1	5	6
5								5	0	3	0	0	6	3	5	2	0	4	1
6						2	2	6	14	4	8	16	4	4	5	4	3	4	17
7								12	5	7	13	8	2	3	4	1	5	1	3
8								2	1	2	1	7	9	7	9	8	4	6	4
9									17	6	2	19	3	4	0	0	1	0	0
10							12	9	11	12	13	5	4	10	1	6	3	8	14
11								1	2	1	7	1	10	8	5	9	5	4	3
12								2	4	10	0	1	2	3	2	3	0	2	1
13											6	0	2	0	1	2	1	2	6
14									1	13	5	0	2	8	2	0	0	0	0
15										1	4	2	5	8	1	0	1	1	9
16							3	2	6	1	4	1	12	6	6	5	8	3	2
17								2	8	9	5	17	4	3	5	0	9	10	10
18								2	8	5	8	6	5	3	1	0	0	10	0
19									2	3	9	5	4	12	0	0	1	12	5
20					6	7	2	5	4	4	15	8	5	4	17	2	5	3	1
TOTAL																			
MEAN																			

Continuation of Appendix Table 15

Number of Days																							
20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
9	10	6	9	7	1	1	0	0	0	0	1	Dam											
4	11	5	5	3	1	3	0	4	0	0	0	2	1	13	0	1	2	4	0	0	0	Dam	
15	3	4	2	5	1	1	0	8	4	4	0	0	0	0	5	2	0	0	0	0	0	0	
26	2	13	11	12	1	0	1	1	4	1	4	2	0	1	3	2	1	0	0	0	3	1	0
1	0	2	3	2	10	8	5	2	3	1	0	0	0	0	Dam								
4	0	2	0	0	0	0	0	0	0	0	0	Dam											
4	10	6	4	0	2	5	3	4	8	6	0	3	4	5	3	4	3	3	3	0	0	2	0
9	3	8	0	12	3	2	5	6	5	5	1	8	1	2	7	9	2	3	0	2	1	3	5
0	1	0	4	8	3	5	0	0	0	2	0	2	0	1	7	4	6	8	2	5	6	2	9
0	5	6	3	0	0	0	0	3	6	7	1	4	11	2	1	1	2	4	2	2	1	0	3
0	1	0	0	2	0	3	0	3	2	5	2	2	1	1	1	2	2	3	1	0	0	0	0
2	3	2	0	5	0	3	0	1	2	0	3	3	0	0	0	Dam							
5	5	4	6	1	6	5	5	2	2	9	1	1	1	4	2	4	2	0	0	0	Dam		
3	0	0	0	0	1	0	3	3	0	0	0	0	0	0	0	0	0	0	0	0	0	Dam	
2	0	1	2	1	2	3	2	2	0	0	1	0	2	4	1	1	0	0	0	0	0	Dam	
0	4	0	1	4	2	0	3	2	6	5	3	3	3	3	3	4	0	3	0	0	1	2	0
0	5	0	4	1	5	0	1	2	0	0	0	1	0	0	0	0	0	0	0	0	0	0	Dam
15	4	3	0	1	10	2	4	4	0	3	4	1	2	0	1	0	1	0	3	0	0	0	6
1	7	1	4	3	8	0	2	1	0	3	0	Dam											
1	8	6	3	9	2	2	2	4	1	0	Dam												

Continuation of Appendix Table 15

Number of Day												Total
44	45	46	47	48	49	50	51	52	53	54	55	
												138
												113
0	0	0	Dam									98
0	0	0	Dam									175
												70
												99
0	Dam											146
5	1	0	0	0	1	4	0	0	Dam			173
5	12	4	0	3	0	0	0	0	0	0	Dam	151
1	2	1	2	0	0	2	0	0	0	Dam		180
0	0	1	0	4	2	2	2	0	0	Dam		98
												56
												85
												41
												56
0	Dam											114
												106
5	0	0	Dam									119
												91
												126
												2,235
												111.75

Legend:

Dam = dead at 6
o'clock am

Appendix Table 16. The total number of eggs laid by the female per day (without pair)

SAMPLED NUMBER	NUMBER OF DAYS																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
1									5	1	0	2	1	0	0	1	0	3	5	5	4	3	1	2	6	3
2									4	2	0	2	1	6	2	1	0	9	4	1	1	0	4	4	4	0
3											1	1	1	3	5	1	3	7	1	1	6	7	6	4	1	12
4											2	1	1	1	0	1	1	0	0	0	0	2	6	5	4	0
5						2	0	0	10	5	3	1	0	3	7	4	6	3	0	0	0	0	1	3	3	0
6													1	2	2	2	0	0	0	3	0	3	0	0	3	2
7								1	0	1	10	6	1	4	3	5	0	3	3	5	3	3	3	2	2	0
8									4	2	4	0	3	2	1	2	1	6	1	2	1	2	3	2	1	
9													1	3	2	2	10	2	2	8	0	0	3	0	0	0
10																		3	3	4	6	4	2	2	6	2
11										1	0	0	0	0	0	4	2	0	0	2	7	0	0	0	0	2
12									1	4	2	1	2	4	7	4	6	1	7	3	4	6	2	0	2	15
13											3	1	2	1	2	5	6	0	0	3	3	1	0	1	0	1
14											1	0	2	0	1	0	1	0	0	0	0	0	1	9	3	2
15																	2	2	1	4	3	0	0	0	0	0
16												1	1	0	1	4	5	6	2	9	2	0	2	1	2	2
17												1	0	0	0	2	1	0	3	0	0	0	0	0	4	5
18													1	1	5	11	0	5	2	0	0	0	1	0	0	4
19																	1	0	0	0	0	0	0	2	2	4
20													2	0	4	0	1	1	1	0	4	1	1	1	0	1
TOTAL																										
MEAN																										

Continuation of appendix table 16

NUMBER OF DAYS																												
27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55
1	8	5	4	3	2	1	1	2	0	2	1	2	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	0	1	1	0	2	0	1	3	1	0	0	0	1	1	0	0	0	0	1	1	1	1	1	0	0	0	0
2	0	1	0	0	3	1	1	4	3	2	6	0	2	2	2	2	1	0	1	3	3	0	0	0	2	2	0	2
1	0	3	0	7	0	0	0	3	4	4	3	1	1	1	2	3	3	0	1	1	2	6	0	0	0	0	0	0
0	0	1	2	6	3	1	1	1	3	3	6	7	1	2	1	1	0	0	0	0	0	0	Dam					
1	0	1	2	2	0	1	2	2	0	0	0	0	0	1	2	0	0	0	3	2	1	0	0	1	1	0	0	0
0	4	1	1	1	0	0	0	1	0	0	0	0	0	0	2	5	1	5	3	0	0	1	4	0	0	0	1	0
2	2	0	2	0	0	0	0	0	1	2	3	3	8	1	3	2	2	1	2	2	0	0	2	1	2	2	3	3
1	0	0	0	1	1	0	0	1	2	1	8	3	2	1	0	0	0	4	3	2	1	1	2	2	3	1	4	0
1	0	0	0	0	0	1	2	4	2	0	0	0	0	0	0	0	0	0	Dam									
1	1	2	2	0	1	0	1	1	0	3	1	1	0	0	0	0	0	0	Dam									
0	0	0	8	7	0	0	0	6	2	2	0	0	0	0	1	Dam												
0	3	1	3	2	6	3	0	1	2	1	0	0	1	1	2	0	3	3	5	1	5	3	0	3	0	0	2	0
4	4	0	0	1	4	1	7	0	1	4	5	1	6	1	6	2	3	4	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	2	2	3	3	2	7	5	1	5	3	0	3	0	0	2	0	0	5	4	5	0	1	0	0
0	2	0	7	4	4	0	0	0	0	1	4	2	7	5	0	0	0	0	0	0	0	0	0	Dpm				
0	1	4	2	2	3	1	2	1	3	4	2	0	0	0	10	5	2	5	1	7	4	2	2	6	0	0	3	6
0	3	4	5	0	0	0	0	6	5	1	2	0	0	0	0	0	0	0	0	0	Dam							
0	0	1	6	0	5	5	4	1	0	2	0	1	0	0	0	3	2	4	1	0	3	1	3	1	0	0	0	0
0	1	0	2	5	0	2	0	0	2	0	0	0	1	0	0	0	0	0	0	0	0	1	0	0	0	0	Dam	

Continuation of appendix table 16

NUMBER OF DAYS																	TOTAL	
56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	
0	0	0	0	0	Dam													75
0	0	0	Dam															64
3	3	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	Dam	112
0	Dpm																	70
																		90
0	0	0	0	0	Dam													40
0	0	0	Dam															82
3	0	0	0	0	0	0	Dam											89
0	0	0	0	1	2	0	0	0	0	0	0	0	Dam					80
																		42
																		32
																		97
0	5	2	1	0	0	0	0	0	0	0	Dam							88
0	Dpm																	74
0	0	0	Dam															65
																		74
0	0	0	0	0	Dam													94
																		56
0	0	Dam																52
																		31
																	1,407	
																	70.35	

Legend:

Dam = dead at 6
o'clock am

Dpm = dead at 6
o'clock pm