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Reproductive Biology of the White-Spotted Longicorn Beetle, *Anoplophora macularia* (Thomson) (Coleoptera: Cerambycidae), on Sweet Oranges[1]

Chi-Yang Lee and Kang-Chen Lo[2]

Abstract : The objective of this study is to elucidate the reproductive biology of the white-spotted longicorn beetle, *Anoplophora macularia* (Thomson) on the leu-cheng sweet orange. Ten pairs of adults which emerged in mid-April in 1995 from the leu-cheng sweet orange orchards of TARI in Taichung were reared under the conditions of natural daylength, 25±2°C, 70±10% RH in the laboratory. The mean length of the preovipositional period was 9.8±2.8 days with a range of 6 to15 days. The mean longevity of female adults was 114.8±18.0 days with a range of 84 to 144 days. The mean number of eggs laid during the life of a female was 204±56 eggs, ranging form 114 to 265 eggs. The fecundity curve appeared in an irregular-shape. The highest number of eggs deposited was 4.4±2.5 per female per day on the 56th day after emergence. The mean number of oviposition sites, i.e., egg-laying scars, made by a female during her life was 590.4±127.1 and the range was 316 to 770. The mean oviposition ratio, i.e., number of eggs/number of oviposition sites, was 34.9±7.5% with a range of 20 to 45%. The hatchability of 634 eggs was 0.81.

Key words : *Anoplophora macularia* (Thomson), Reproductive biology, Sweet orange.

INTRODUCTION

The white-spotted longicorn beetle, *Anoplophora macularia* (Thomson) (Coleoptera: Cerambycidae), is a major borer of fruit trees and woods in Taiwan. The beetle attacks 66 species of trees, belonging to 19 families. The host trees include citrus, litchi, starfruit, Indian jujube, beef-wood, China-fir and Taiwan red cypress, all of which are seriously damaged by this beetle(3,4,5,6,7,8,11,16). Larvae bore into the living trunk through egg-laying scars and destroy the pholem and xylem during their long development period, causing the deterioration or death of the tree and resulting in serious economic losses. Control measures for this pest are difficult because of prohibitions on the use of organochloride insecticides, the increase in abandoned, uncontrolled citrus orchards(8) and the active migration of longicorn beetles(13).

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There have been studies of beetle damage to host plants such as litchi[3] and beef-wood[11]. There remain some questions as to identification. Apparently *A. macularia* and the insects studied by Chang[3] and Kan[11] were the same species[4,5]. On the other hand, the *Melanauster chinensis* studied by Lieu in China[14], was a different species[4].

There has also been confusion over the reproductive biology of the white-spotted longicorn beetle. Chang reported that the number of eggs laid by a female during her life in litchi was 10 eggs[3]. Kan reported 70-80 eggs in beef-wood[11]. These figures seem too low compared to *A. malasiaca*[1]. The objective of this study is to elucidate the reproductive biology of the beetle by rearing it on the leu-cheng sweet oranges (*Citrus sinensis* Osb.) .

MATERIALS AND METHODS

Materials and methods were modified from Adachi[1] as follows: In Wufeng, Taichung Hsien, most adult *A. macularia* beetles emerge in April to June. Adults used in this study were collected in mid-April, 1995. The trunks of the leu-cheng sweet orange trees infested by *A. macularia* were identified. Before adults emerged, close-meshed nets were wound loosely around the trunks leaving spatial gaps. New adults which emerged inside these nets were collected every day.

Within a day after collection, one adult pair was released into each of 10 glass cylinders, 15 cm in diameter and 40 cm in depth, supplied with sand, a fresh branch and a log cut from a leu-cheng sweet orange citrus tree. The sand, which had been sterilized by heating, filled the cylinder to a depth of 10 cm and was kept humid. A fresh tree branch with leaves, which was put in a glass tube with water, was supplied as food for the insects, and renewed every two or three days. A log (15 cm long and ca. 3-5 cm in diameter) cut from the living tree was supplied for oviposition, and replaced by a new one every three days. The top of the container was covered with close-meshed wire net. The rearing containers were placed in the laboratory with blinds to interrupt the direct sunlight, under the conditions of natural daylength, 25±2°C, and 70±10% RH.

Female aduts make scars (oviposition sites) on the bark with their mandibles, then deposit eggs into these scars. The number of scars, i.e., oviposition sites, and eggs laid on each log were counted every day.

Eggs taken from logs were reared in petri dishes, 9 cm in diameter and 1.6 cm in depth, with moist filter paper in the same laboratory under dark conditions to examine hatchability.

When a male adult died before the death of his paired female, another partner was supplied.

RESULTS AND DISCUSSION

Longevity and fecundity

The date of collection, the body length (from top of the head to end of the elytron) , the body weight which were measured on the date of collection and reproductive properties of *A. macularia* females used in this study are listed in Table 1. Reproductive properties of some cerambycids (*A. macularia, M. chinensis, A. malasiaca*) are summarized in Table 2. The mean length (± SD) of the sexual maturation period, i.e., the preovipositional period, of *A. macularia* was 9.8±2.8 days, similar to that of *A. malasiaca* , which was 9.8±1.4 days. The range of the sexual maturation period was 6 to 15 days, similar to that found in other studies. The mean life span of female adults, i.e., mean longevity, was 114.8±18.0 days, more than the 28.5±6.0 days reported by Lieu[14] and also more than the 77.6±20.3 days of *A. malasiaca* reported by Adachi[1]. The life span range of female adults was found to be 84 to 144 days, whereas Lieu reported that it was 13 to 40 days[14] and Chang reported that it was 300 to 330 days[3]. The longevity range of adult females of *A. macularia* is similar to that of *A. malasiaca.* The mean number of eggs laid during the life of a female was found to be 204 ±56 eggs, Whereas Lieu reported that it was 14.1±4.4 eggs[14], but the finding of this study was similar to the figure for *A. malasiaca* which was 193.8±65.2 eggs. The range of eggs laid during the life of a female was from 114 to 265 eggs, more than the same species reported before, but less than that of *A. malasiaca* which was 91 to 325 eggs. Adachi stated that low mean daily temperature reduced numbers of deposited eggs in *A. malasiaca*[1]. A similar result was reported for *Psacothea hilaris*[9]. Our finding of the mean number of eggs laid during the life of a female was several times greater than the result studied by Lieu[14]. This might be the reason for this large difference. The body weight had no significant effect on longevity ($F=1.46$; df=1,8; $P>0.05$), total number of eggs deposited ($F=1.01$; df=1,8; $P>0.05$), or total number of oviposition sites ($F=1.99$; df=1,8; $P>0.05$). The preovipositional period had no significant effect on longevity ($F=1.06$; df=1,8; $P>0.05$), or the total number of eggs depostied ($F=0.36$; df=1,8; $P>0.05$). The fecundity in the present study showed a tendency to increase as longevity increased ($R^2=0.62$; $F=13.04$; df=1,8; $P<0.01$). This result was similar to that for *Monochamus alternatus*[15] while Adachi stated that the fecundity of female adults of *A. malasiaca* was correlated with both the size and longevity[1].

Table 1. Date of collection, body length, body weight, and some reproductive properties of *Anoplophora macularia* females used in this study

Individual number	Date of collection	Body length (mm)	Body weight (g)	Preovipositional period (day)	Longevity (day)	Total number of eggs deposited	Total number of oviposition sites	Oviposition ratios (%)
1	4/14	31	1.54	8	129	261	770	34
2	4/16	31	1.39	8	84	114	316	36
3	4/16	30	1.50	8	108	223	640	35
4	4/17	33	2.04	12	119	265	590	45
5	4/17	31	1.65	8	144	218	568	38
6	4/18	31	1.48	9	127	252	629	40
7	4/18	30	1.38	11	100	155	496	31
8	4/18	32	1.81	13	118	232	548	42
9	4/19	34	2.36	6	124	200	740	27
10	4/19	30	1.55	15	95	120	607	20
Range		30-34	1.38-2.36	6-15	84-144	114-265	316-770	20-45
Mean		31.3	1.67	9.8	114.8	204	590.4	34.9
SD		1.3	0.30	2.8	18	56	127.1	7.5

Table 2. Reproductive properties of some cerambycids.

Species	Food	Range of Preovipositional period (day)	Mean (±SD) Preovipositional period (day)	Range of longevity (day)	Mean(±SD) longevity (day)	Range of eggs deposited	Mean(±SD) fecundity	Oviposition ratio (%)	Reference
Anoplophora macularia	Leu-cheng	6—15	9.8±2.8	84—144	114.8±18	114—265	204±56	34.9	Present study
Anoplophora macularia	Litchi			300—330		10			Chang (1970)
Melanauster chinensis	Citrus	7—14		13—40	28.5±6.0	6—19	14.1±4.4		Lieu (1945)
Melanauster chinensis	Beef-wood					70—80			Kan (1958)
Anoplophora malasiaca	Citrus	8—13	9.8±1.4	47—109	77.6±20.3	91—325	193.8±65.2	72.5	Adachi (1988)

Oviposition sites and oviposition ratios

Female adults made scars (oviposition sites) on the bark with their mandibles, then deposited eggs into these scars using the ovipositor. These scars were T-shaped or L-shaped. Similar oviposition processes were also reported by Chang[3] and Lieu[14]. The mean number of oviposition sites, i.e., egg-laying scars, made by a female during her life was 590.4±127.1, and the range was 316 to 770. The mean oviposition ratio, i.e., number of eggs/number of oviposition sites, was 34.9±7.5% with a range of 20 to 45%. In the total of 5,904 oviposition sites found in this study, one egg was found in each of 2,040 sites and no egg in 3,864 sites. The mean oviposition ratio was 34.9% in the present study, similar to that of *M. alternatus*, whose mean oviposition ratio during adult life, except for the periods of both immaturity and senility, was 30.9-55.9%[15]. Both of them were less than that of *A. malasiaca* which was 72.5%[1]. The oviposition ratio, which was the ratio of eggs to oviposition sites, represented the ability to complete oviposition. *A. macularia* seemed to spend twice the energy to complete oviposition that *A. malasiaca* spent.

Fecundity curve

Figure 1 shows the survival rate curve of females and the fecundity curve which was determined from the number of eggs laid by a female every day after emergence. The fecundity is an irregular-shaped curve. The highest number of eggs deposited was 4.4±2.5 per female per day on the 56th day after emergence. Adachi stated that the fecundity curve of *A. malasiaca* was a bell-shaped curve with a long rightward tail[1]. This indicated that *A. malasiaca* females laid more eggs in the first half of their life than in the second half. A similar result was reported for *M. alternatus*[15]. But egg depositions by *A. macularia* females in the first half of their life was similar to those in the second half. The difference in quality of food is considered to be a factor which causes the differences of the fecundity of the cerambycids. The mean length of no egg deposited by a female before the death was 13.3±9.7 days and the range was 3 to 38 days.

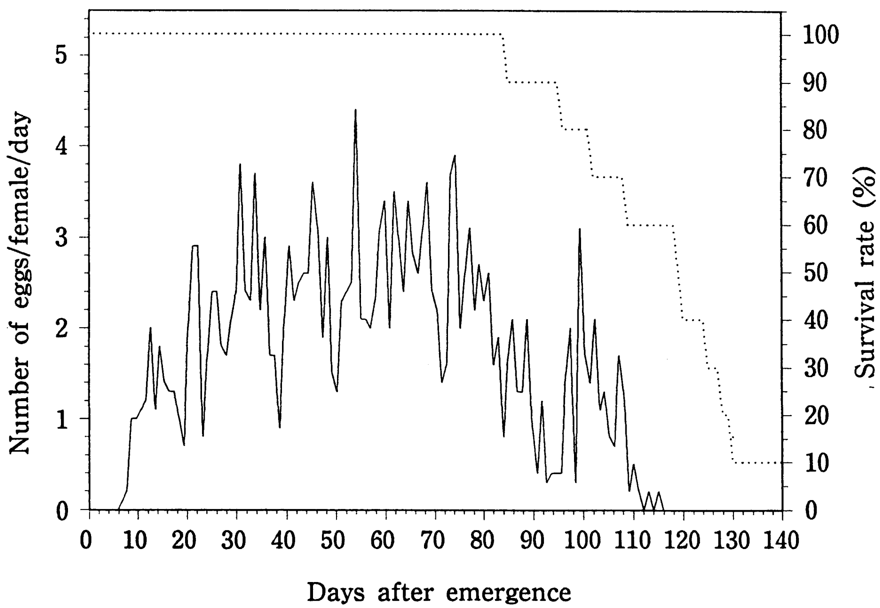

Fig. 1. Fecundity curve (—) and survival rate (···) of female adults after emergence

Egg depositing frequency curve

Figure 2 shows the egg depositing frequency curve of females which was determined from the frequency of eggs laid by a female every day after emergence. The egg depositing frequency is a positive skew with a long rightward tail. The mean egg depositing frequency

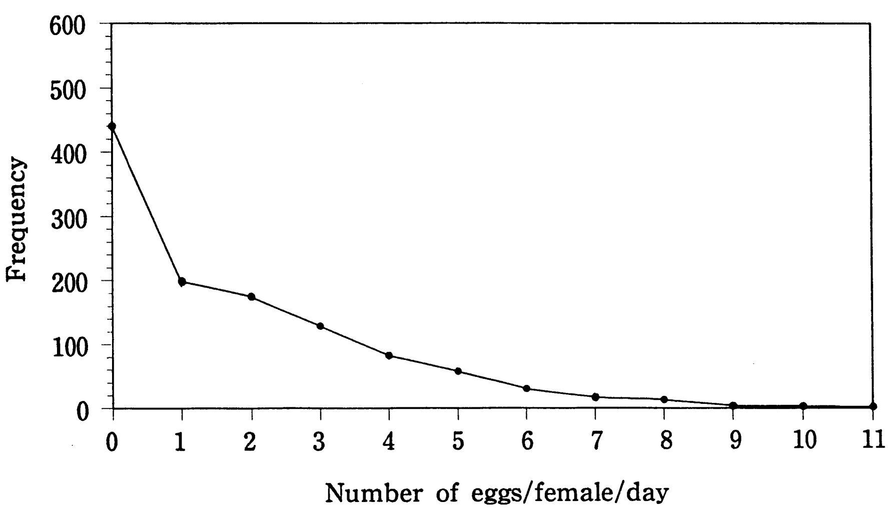

Fig. 2. Egg depositing frequency of female adults after emergence

per female per day was 1.8±2.04 eggs, similar to that of *M. alternatus*, for which the average number of eggs laid by one female per day was 1.7[12]. The egg depositing frequency per female per day ranged from 0 to 11 eggs. The possibility of frequency of no egg depositing, including the sexual maturation period, was 0.38.

Hatchability

A total of 634 *A. macularia* eggs were tested in this study from May 3 to June 19, in 1995. 516 of these hatched. The hatchability in this study was 0.81, similar to rates for other cerambycids; 0.9 in *A. malasiaca*[1], 0.87 in *Eupromus ruber*[2], 0.79-0.88 in *M. alternatus*[12]. The most important mortality factor was the unfertilized eggs deposited in cerambycids[1,10]. The mean number of hatching days was 11.3±2.0 days and the range was 8 to 22 days, also similar to those of other records.

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REFERENCES

1. Adachi, I. 1988. Reproductive biology of the white-spotted longicon beetle, *Anoplophora malasiaca* Thomson (Coleoptera: Cerambycidae), in citrus trees. Appl. Entomol. Zool. 23(3) : 256-264.
2. Banno, H. and A. Yamagami. 1991. Life cycle and larval survival rate of the redspotted longicorn beetle, *Eupromus ruber* (Dalman) (Coleoptera: Cerambycidae). Appl. Entomol. Zool. 26(2) : 195-204.
3. Chang, K. P. 1970. A study of serious insect pest of litchi *Anoplophora macularia* (Thom.) (in Chinese). Taiwan Agric. 6(3) : 133-143.
4. Chang, S. C. 1954. A preliminary note on the longicorn beetles destructive to citrus plant in China (in Chinese). J. Agric. For. 3 : 55-75.
5. Chang, S. C. 1975. The host plants, egg laying and larva feeding habits of *Macularia* white spotted longicon beetles (in Chinese). J. Agric. For. 24 : 13-20.
6. Hou, R. F. 1978. Studies on control of the white-spotted longicorn beetle, *Anoplophora macularia* (Thomson), in the coastal windbreaks. I. Artificial rearing and chemical attractants. Bull. Soc. Entomol. NCHU 13(1) : 63-72.
7. Hou, R. F. 1979. Studies on control of the white-spotted longicon beetle, *Anoplophora macularia* (Thomson), in the coastal windbreak. II. Tunnel fumigation and factors affecting infestation. Bull. Soc. Entomol. NCHU 14(1) : 35-41.
8. Ho, K. Y., K. C. Lo, C. Y. Lee and A. S. Hwang. 1995. Ecology and control of the white-spotted longicorn beetle on citrus. Proc. Sym. Research and Development of Citrus in Taiwan. TARI, Spec. Publ No. 50 : 263-278.
9. Iba, M. 1985. Effect of temperature on oviposition of the yellow-spotted longicorn beetle, *Psacothea hilaris* Pascoe (in Japanese). J. Seric. Sci. Jpn. 54(2) : 169-170.
10. Itami, J. K. and T. P. Craig. 1989. Lite history of *Styloxus bicolor* (Coleoptera: Cerambycidae) on *Juniperus monosperma* in northern Arizona. Ann. Entomol. Soc. Am. 82(5) : 582-587.

11. Kan, W. H. 1958. Investigation on the injury and its control of silver spotted longicorn beetle to beef-wood (in Chinese). Bull. Taiwan For. Res. Inst. No.58 : 1-24.

12. Kobayashi, F., A. Yamane and T. Ikeda. 1984. The Japanese pine sawyer beetle as the vector of pine wilt disease. Ann. Rev. Entomol. 29 : 115-135.

13. Komazaki, S. and Y. Sakagami. 1989. Capture-recapture study on the adult population of the white spotted longicon beetle, *Anoplophora malasiaca* (Thomson) (Coleoptera: Cerambycidae), in a citrus orchard. Appl. Entomol. Zool. 24(1) : 78-84.

14. Lieu, K. O. V. 1945. The study of wood borers in China I. Biology and control of the citrus-root-cerambycids, *Melanauster chinensis*, Forster (Coleoptera). Florida Entomol. 27(4) : 62-101.

15. Togashi, K. and H. Magira. 1981. Age-specific surival rate and fecundity of the adult Japanese pine sawyer, *Monochamus alternatus* Hope (Coleoptera: Cerambycidae), at different emergence times. Appl. Entomol. Zool. 16(4) : 351-361.

16. Wen, H. C. 1987. Field investigation of white spotted longicorn beetle (*Anoplophora maculata*) on Indian jujube and control (in Chinese). J. Agric. Res. China 36(3) : 327-330.

斑星天牛（*Anoplophora macularia*（Thomson)）在柳橙上的繁殖生物學研究[1]

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摘　要

斑星天牛（*Anoplophora macularia*（Thomson））爲果樹柑桔類、荔枝、楊桃及印度棗的嚴重害蟲，在森林方面危害木麻黃、杉木及紅檜等珍貴樹種，造成莫大損失。本試驗的目的是研究斑星天牛在柳橙上的繁殖生物學，以提供防治該蟲的參考。1995年4月中旬自臺中農試所柳橙園中，捕獲當日鑽咬出樹幹的斑星天牛10對，試驗於25±2°C，相對溼度70±10%，正常日照下在實驗室內進行。結果發現當日配對的斑星天牛即會交配，產卵前期6—15天，平均9.8±2.8天；雌蟲壽命84—144天，平均114.8±18.0天；產卵數114—265粒，平均204±56粒；繁殖曲線不規則，在配對後於第56日爲產卵高峰，平均產4.4±2.5粒卵；產卵位置數（即成蟲咬破樹皮裂痕數目）爲316—770，平均590.4±127.1，產卵比率（產卵數／產卵位置數）爲20—45%，平均34.9±7.5%。卵發育所需時間爲8—22天，平均11.3±2.0天，卵孵化率爲81%。

關鍵詞：斑星天牛、繁殖生物學、柳橙。

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