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Original Article

Biology and Predatory Behavior of *Metioche vittaticollis* (Stal) (Orthoptera: Gryllidae)

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Abstract

Metioche vittaticollis (Stal) is one of the generalist predator in rice field habitat. The biology and predatory behavior were studied in the laboratory. The life cycle of *M. vittaticollis* (Stal) averaged 40–61 days at 26°-28°C. The eggs were inserted singly within the leaf sheath of rice or weeds and hatched in 14.28 days. The nymphal period was varied between 27 and 45 days and passed four nymphal stadia. Female fecundity was averaged 50 eggs during her lifetime. The longevity of the female or male adult was ranged from 20 to 38 days. The average longevity of females and males were 29.24 and 25.00 days, respectively. The longevity of unmated female or male were longer than the mated female or male. The egg and first instar nymph sustained the high mortality of 30% and 25%, respectively, whilst there was less mortality in the third and fourth instar nymph. The adult females of *M. vittaticollis* survived for 32 days and the rate of survival was high in the young adults but decreased as the cricket aged. The females were more preferred to Brown Plant Hopper (BHP) nymph than the males. The early nymph stage of prey was the most stage to be fed by *M. vittaticollis*. However, the predation declined when they were given prey of late instar of BPH nymphs. Fewer adult stage of BPH was consumed by both male and female crickets.

Key words: biology; generalist predator; prey consumption; *Metioche vittaticollis*

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INTRODUCTION

Silent Leaf Runner *Metioche vittaticollis* is one of the generalist predators in rice field habitat and non irrigated dry field. This cricket is a member of subfamily Trigonidiinae, family Gryllidae and of ordo Orthoptera (CSIRO, 1970), and it is often mentioned as predators of the early developmental stages of rice pests. *Metioche vittaticollis* (Stal) and *Anaxipha* sp. were recorded as predators of eggs of defoliating caterpillars *Mythimna separata* and stem-borers *Chilo suppresalis* (Rubia and Shepard, 1987; Islam, 2002) and eggs of leaf-folders *Cnaphalocrosis medinalis* (de Kraker, 1999) as well as becoming predator for nymph of plant hopper and green leaf hopper (Rubia and Shepard, 1987; Shepard, Barrion and Litsinger, 1994). *Methioche vittaticollis* is also found in Malaysia (van Vreden and Ahmadzabidi, 1986); India, Thailand, Philippines and Northern Australia (Chopard *in* Rubia *et al.,* 1987).

Effective manipulation of natural enemies requires a thorough knowledge of their biology and host associations, whereas that background information could be gained through laboratory studies. The biology of *M. vittaticollis*, especially its ability as a predator against brown plant hopper, has not been explored in Indonesia. Therefore the present study was to

determine the biology and predatory behavior of *M. vittaticollis* under laboratory conditions.

MATERIALS AND METHODS

Laboratory experiments were conducted at the Laboratory of Entomology Department of Plant Pests and Diseases, Brawijaya University, from January to December 2005.

Field-collected adult of *M. vittaticollis* were confined on IR 64 rice plants in a rectangular cage (35x35x40 cm). Brown Planthopper (BPH) and eggs of *Corcyra cephalonica* were provided as foods. The emerged adults from the second generation were paired, and the females were allowed to oviposit in *Eleusine indica* and one month rice plants, which were changed daily. Rice and *E. indica* were cut to collect the cricket's eggs.

1. Life History Study. The cut stalks which contained eggs were kept in Petri dishes (∅ 14 cm) lined with moist tissue paper. Newly-hatched nymphs were caged in tubular millar cages (∅ 10 cm and 28 cm height) and provided with first nymph of Brown Planthopper (BPH) on IR 64 rice seedling. There were five Nymphs of cricket in each caged. From the previous observation, the newly first nymph did not consume the offered prey when they reared individually, that caused great mortality of the first instar. After three days they were moved to individual rearing cages (∅ 6 cm and 28 cm height) with IR 64 rice seedling. When the nymphs reached second instar, they were fed with second or third instar of BPH nymphs until the adult stage. Observations were conducted on the incubation period, duration of stages, sex ratio, fecundity and longevity of the adults (mated and unmated male and female). Quantities measurements were chosen to measure the representatives of immature and adults. The developmental stages were described and then the survival was also recorded daily until the death of each individual. The reproduction and longevity of the female and male were recorded after being paired.

2. Predatory Behavior. Three experiments of predatory behavior were carried out in a consecutive period in the laboratory as followed:

1. The consumption rates were determined separately for each stage of the cricket; first to fourth instar nymph and adult stage. Twenty of first instar of predators was introduced to a tubular milar cage (∅ 6 cm and 28 cm height) individually, and provided with 25 of BPH nymphs on IR64 rice seedlings. The instar of BPH nymphs which were given according to the instar of the cricket, first nymph of BPH were given to first and second instar nymph of the cricket. While the *M. vittaticollis* nymphs reached third instar, they fed second or third instar of BPH nymphs until the adult stage. The prey consumed within 24 hours was recorded. The numbers of preys were replaced to the original density after 24 hours.

2. Male or female of short winged cricket was introduced to a tubular milar cage (∅ 10 cm and 28 cm height) with IR64 rice seedlings, and provided 25 of second andthird instar, 25 of fourth and fifth instar nymphs or 25 of adult BPH. The prey consumed within 24 hours was recorded. The numbers of preys were replaced to the original density after 24 hours. The consumption rate treatment for each stage of prey was replicated 5 times and recorded daily within 5 days. Test for significance of the treatments was carried out using Two-ways ANOVA and means were compared by Least Significant Difference test.

3. Male or female of short winged cricket was introduced to a tubular milar cage (∅ 10 cm and 28 cm height) with IR64 rice seedlings, and provided 10, 15 or 20 of fourth or fifth instar of BPH nymphs. The prey consumed was recorded twice for a day-period, i.e. at 6 am and 6 pm. The

numbers of preys were replaced to the original density after 24 hours. The consumption rate treatment for each number of prey was replicated 10 times and determined daily within 5 days. The proportion of prey consumed (each predator/day) were tested for significance of the treatment using General ANOVA with three factors, and means were compared by Least Significant Difference test.

RESULTS

1. Biology of *M. vittaticollis*

Eggs. The eggs were inserted singly in the leaf midrib, the leaf sheath or in the collar. The egg cap was visible to the outside but was often covered with soil particles. The egg was cylindrical, often sharply angled near the point of attachment to the plant tissue. Newly laid eggs were transparent, smooth and shiny white. As they become older they turned translucent, and when egg nearly hatched it become brownish yellow (Figure 1). Newly deposited eggs measured 0.8 to 1.0 mm long and there was a distinct black spot at the anterior part of the egg. The volume of eggs gradually increased, especially at the anterior part. The average incubation period of *M. vittaticollis* eggs in the laboratory was 14.28 ± 0.08 days (Table 1).

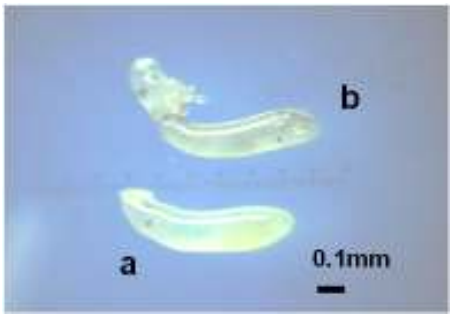

Figure 1. Eggs of *M. vittaticollis*; a) newly and b) 10 days deposited eggs.

There were four instars nymph of *M. vittaticollis*. The average of development period from first to fourth instar of males and females was 33 and 35 days, respectively. *First instar nymph*. The head was larger than the thoracic and abdominal segments (Fig. 2a). Newly emerged first instar nymphs whitish transparent with black setae over the body and moved slowly. There were two grayish bands parallel to each other from the head to the abdomen. The average of body length was 1.4 ± 0.02 mm. Nymphs became active and start to feed after about one hour. The average developmental period for the first instar nymph was 6.84 ± 0.08 days (Table 1) There were five nymphs of cricket in each caged. From the previous observation, the newly first nymph did not consume the prey when they reared individually that caused great mortality of the first instar. *Second instar nymph*. The coloration varied from brown to grey. Antennae and legs were larger and longer than those of the first instar (Figure 2b) and moved faster.

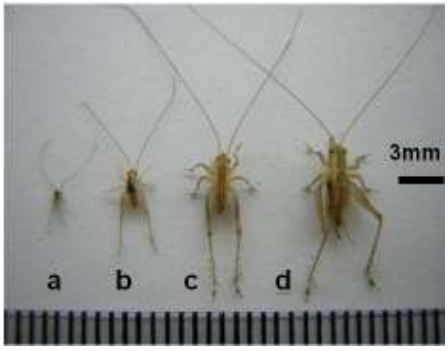

Figure 2. *M. vittaticollis* nymph, a) first instar, b) second instar, c) third instar and d) fourth instar.

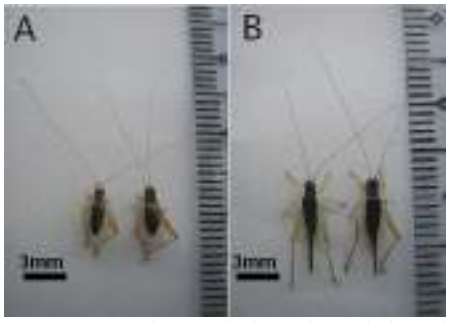

Figure 3. Male and female adult of *M. vittaticollis*, A) short winged; B) long winged.

Table 1. The mean of developmental period and adult longevity of *M. vittaticolis*

Stage	Developmental period (days)		Range (days)
	n	Mean ± SE	
Egg	141	14.28 ± 0.08	13 - 16
Instar 1	111	6.84 ± 0.08	6 - 9
Instar 2	88	7.66 ± 0.08	6 - 10
Instar 3	70	10.66 ± 0.18	8 - 13
Instar 4	63	8.70 ± 0.16	7 - 13
Adult male	26	25.00 ± 0.61	20 - 31
Adult female	37	29.24 ± 0.49	25 – 38
Male longevity (mated)	10	30.10 ± 2.20	26 - 30
Female longevity (mated)	10	35.20 ± 2.28	32 - 38
Male longevity (unmated)	10	35.50 ± 1.38	46 - 51
Female longevity (unmated)	10	46.00 ± 3.01	43 - 50

Table 2. The average of pre-oviposition, oviposition and post-oviposition period, the number of *M.vittaticolis* eggs and the percentage of hatched eggs

Parameters	n	Mean ± SE
Preoviposition period (days)	20	8.40 ± 0.32
Oviposition period (days)	20	21.70 ± 0.78
Post oviposition period (days)	20	1.90 ± 0.14
Average number of eggs per female	20	50.55 ± 1.18
Percentage of hatched eggs (%)	100	69.31 ± 2.59

Table 3. The average number of different stage of BPH was consumed by *M. vittaticollis* and the average number of BPH consumed by female and male (d^{-1}) *)

Stage_of_prey	Mean ± SE***)	Sex	Mean± SE***)
Nymph 2-3	13.64 ± 0.97 a	Female	12.75 ± 0.86 a
Nymph 3-4	11.44 ± 0.96 a b	Male	10.63 ± 0.77 b
Adult	9.98 ± 0.93 b		

*)In a column, means followed by a common letter are not significantly different by LSD at 5% level, **)LSD (5%): 2.232 and ***) LSD (5%): 1.822

Table 4. The average percentage of preys consumed by *M. vittaticollis* on different number of preys during day and night

Time of Feeding Activity	Average of percentage number of prey consumed (d^{-1}) ± SE Sex*)	
	Female	Male
Night (6 p.m - 6 a.m)	43.58 ± 0.02 a	30.97 ± 0.02 b
Day (6 a.m – 6 p.m)	19.25 ± 0.01 c	16.39 ± 0.01 c

*) In a column and a row, means followed by a common letter are not significantly different at the p = 0,05 by LSD: 0.0474

The average of body length was 2.1±0.054 mm. The average developmental period of the second instar nymph was 7.66 ± 0.08 days (Table 1).

Third instar nymph. The body length was 3.1 ± 0.053 mm, bands extending from the head to the tip of the abdomen. Tibial spines were distinct and three grayish bands were present on the femur. Wing pads were present. At the third nymph the ovipositor appeared though it was still short, therefore sexing could be determined at this instar (Figure 2c). The average developmental period of the third instar nymphs was 10.66 ± 0.18 days (Table 1). *Fourth instar nymph.* The head was smaller than the body. The body was 4.4 ± 0.053 mm long. Wing pads were prominent and sometimes reached half the length of abdomen. The ovipositor was distinctly long and dark brown in color (Figure 2d). The average developmental period of the fourth instar nymphs was 8.70 ± 0.16 days (Table 1).

Adult. Head and body were chitinized, varying from dark brown to black. The forewings were somewhat elytriform-like covering half the abdomen. All legs were yellow to orange except tibia III with seven dark brown spines. There are two forms of adult, short (Figure 3A) and long (Figure 3B) winged adult. The long-winged adults have membranous hind wings almost twice as long as the abdomen. Females have brown curved and serrated ovipositor. The female was 5.10 ± 0.06 mm long and the male was 4.90 ± 0.06 mm. The weight of female and male were 24.18 ± 5.68 mg and 19.25 ± 6.98 mg respectively. The longevity of female or male adult was ranged from 20 - 38 days. The longevity of unmated female or male were longer than the mated female or male (Tabel 1). The average longevity of females and males was 29.24 and 25.00 days respectively. *M.vittaticollis* started to oviposite on day 8 after being paired, and the average oviposition period was 22 days. One female could lay her eggs in the average of 50.55 ± 1.18 eggs and the percentage of hatched in the laboratory was ca 69.31 % (60% - 80%)(Table 2).

The age-stage survival rate curve of *M. vittaticollis* was showed in Figure 4. From 70% of eggs hatched and became first instar nymph, then 55%, 44%, 35% and 31.5% of initial population became second, third, fourth instar nymph and adult, respectively. The period from egg to adult ranged from 33 to 48 days.

2. Predatory Behavior

2.1. *First Experiment*

The first and second instar nymph of *M. vittaticollis* consumed the average of 2.02 ± 1.57 and 3.44 ± 2.33 of first instar BPH nymphs per day, respectively. The female and male of the third instar nymph consumed the average of 5.07 ± 2.74 and 4.62 ± 2.10 of second instar BPH nymphs per day, respectively. Whereas the female and male of the fourth instar nymph of *M. vittaticollis* consumed 6.50 ± 2.88 and 4.76 ± 1.91, respectively. The female and male adult consumed the average of 7.68 ± 2.23 and 5.98 ± 1.83 BPH nymphs, respectively. It was showed that females consumed higher numbers of BPH nymph than the males.

2.2. *Second Experiment*

When different stages of *Nilaparvata lugens* were exposed to the adult male and female of *M. vittaticollis*, the predators were influenced significantly in feeding preference by the stage of prey ($p = 0{,}009$). The crickets were significantly more consuming early stage nymph of prey, but predation declined as nymphs of BPH developed. Fewer adult stage of BPH was consumed by both male and female crickets (Table 4.). Female cricket consumed significantly more nymphs instead of adult BPH than male ($p = 0{,}024$).

2.3. *Third Experiment*

Statistic analysis showed that there was an interaction between the times of feeding activity with the sex of crickets (p =

0,006). *Metioche vittaticollis* spent their time actively for feeding all day. Nevertheless the percentage of preys consumed was higher during night rather than the day time by female and male cricket (Table 5). However, the average percentage numbers of prey consumed were not significantly different on different density level of prey. Figure 6 showed that the proportion of prey consumed by the male or female was not significantly different, when the cricket was offered with 10, 15 or 20 prey numbers.

DISCUSSION

The egg and first instar nymph of *M. vittaticollis* sustained the high mortality of 30% and 25%, respectively, whilst there was less mortality in the fourth instar nymph. The immature stages sustained about 70% mortality before adult emergence. The high number of unhatched eggs was probably caused by the drying of the egg during incubation time in the laboratory. Since the egg was inserted in the stem, a cut or dissection of the plant stem had to be done to get the egg. Then the cut stem was kept in the petridish. The pieces of stem, which bear some eggs, would easily be drying after several days before the eggs hatched. This matter probably does not happen in nature. However, according to Rubia *et al.* (1987) percentage hatch of *M. vittaticollis* was reduced by egg parasitism and predation in the field. The average incubation period of *M. vittaticollis* eggs in the laboratory was 14.28 ± 0.08 days (Table 1), and longer than the incubation period which observed by Rubia *et al.* (1987), the average period was 10.60 ± 0.21 days.

The high mortality also happened to first instar nymph. The death of the immature stages most happened shortly after they were molting. The adult females of *M. vittaticollis* can live for 32 days and the rate of survival was high in the young adults but decreased as the cricket aged. The survival curve of a cohort showed stage overlapping, because of the variable developmental rate among individuals. Although they have birth on the same day, they did not develop to the next stage at the same period of time (Table 1). The survival rate of *M. vittaticollis* decreased along with the development of the cricket (Figure 4). The survivorship curve demonstrated a high initial mortality followed by a steady decline in numbers to the death of the first, second and third nymph. There were minimum mortality of the fourth nymph to the half life of adult stage, and then mortality increased to the last individual in day 86. This survivorship curve fit with the type 2 survivorship (Price, 1975). The death of the immature stages most happened shortly after they were molting.

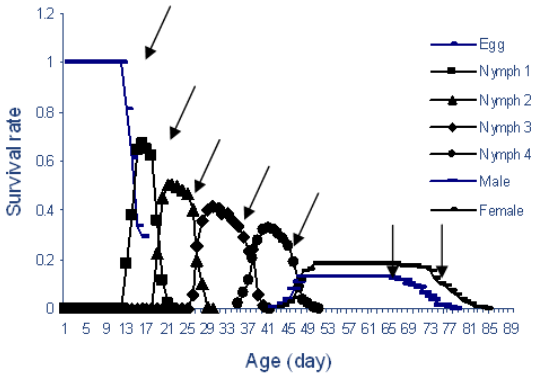

Figure 4. The age-stage specific survival rate of *M. vittaticollis*

One female could lay her eggs in the average of 50.55 ± 1.18 eggs and percentage hatch in the laboratory was ca. 69.31% (60 - 80%)(Table 2). The number of produced eggs was nearly the same with the result of Rubia and Shepard (1987) on *Diatraea grandiosella* diet which was 51.60 ± 5.10. However, the fecundity of *M. vittaticollis* were less than were observed by Rubia *et al.* (1987) that the female produced in average of 82 eggs on leaf folders eggs diet and the percentage hatch was ranged from 50 to 86 %.

Males of *M. vittaticollis* were on average smaller than females. Several

hypotheses have been proposed to account for the relatively small size of males in most poikilotherms (including insect). Among other things females should be bigger than males simply because a female's fecundity is directly related to her size. Moreover, sexual size dimorphism appears to be a consequence of males beginning to develop their gonads earlier in larval development than females, possibly in order to synchronize their sexual maturity with that of females (Dixon, 2000).

Mated or unmated females of *M. vittaticollis* lived longer than the males. There have several laboratories studies on the longevity of mated and virgin female ladybirds. These have all revealed that virgin females will lay eggs, but far fewer, and live longer than mated females. This also appears to apply to males (Dixon, 2000). Unmated females of *M. vittaticollis* do not lay eggs (Karindah, unpublished), therefore they live longer than mated females. It seemed there appear to be a trade-off between adult longevity and fecundity.

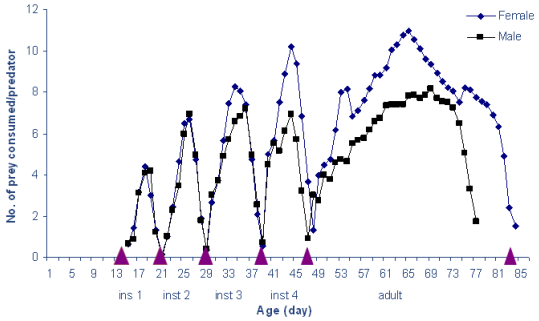

Figure 5. The curve of daily number of prey consumption of nymph to adult stage of M. vittaticollis

Figure 5 illustrated the daily number of prey consumption of the nymph to the adult stage. The number of prey consumed by *M. vittaticollis* increased to a maximum number in the middle of each instar, and then it decreased at the end of each instar of nymphal stage. The cricket consumed only a few numbers of preys before molting (*ecdysis*), and even stopped feeding during molting. When different stages of *N. lugens* were exposed to the adult male and female of *M. vittaticollis*, the predators were observed significantly more feeding on the early nymph instars of prey. However, the predation decreased when they were given prey of late instar rather than early instar of BPH nymphs. Fewer adult stage of BPH was consumed by both male and female. The females preyed upon BPH nymph more than the males. This experiment showed that *M. vittaticollis* might prey the immature stage or small insect more than larger one. Therefore, the preference of *M. vittaticollis* for small immature forms of BPH or other insect pests of rice (Rubia and Shepard, 1987; de Kraker, 1999) it could be suggested that it may be important in maintaining these species. A major effort should be extended to conserve *M. vittaticollis* through judicious use of chemicals and perhaps habitat manipulation.

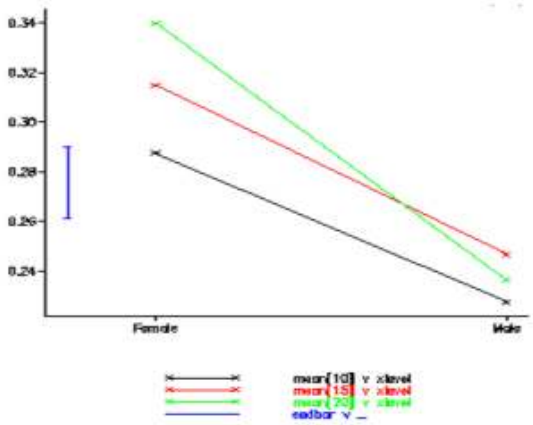

Figure 6. The means of proportion numbers of BPH consumed by female and male M. vittaticollis at different density level of prey (10, 15 and 20 BPH)

The addition of prey density level (10 to 20 BPH); therefore, might increase the number of prey which was consumed either by each female or male cricket per day. Figure 6 showed that the proportion of prey consumed by the male or female was

not significantly different, when the cricket was offered with 10, 15 or 20 prey numbers. Nevertheless the percentage of preys consumed was higher during night rather than in the day time by female and male cricket. de Kraker (1999) found that this cricket seemed to be more active in the early morning and evening, with a higher walking activity to forage the prey. *M. vittaticollis* known as a predator in rice habitat with several species of prey (van Vreden and Ahmadzabidi, 1986; Rubia and Shepard, 1987; Islam, 2002) and were more active when night come. In the daytime it is hard to see they forage for their food. This cricket seemed are creepy insect.

M. vittaticollis has a potential to be a biological control agent for insect rice pest. *M. vittaticollis* had a high consumption rate among the five species of predators, *M. vittaticollis* preyed upon more than *A. longipennis, Micraspis* sp., *P. fuscipes*, and *Ophionea* sp. (Karindah, unpublished). Although *M. vittaticollis* is a generalist predator, it may complete its life cycle solely on brown planthopper, without other supplement foods. However, in Indonesia this cricket was still get a little attention compared to other generalist predator in rice habitat. de Kraker (1996) had found out that *M. vittaticollis* was the effective predator to suppress rice leaffolder population in Philippine.

CONCLUSIONS

1. The life cycle of *M. vittaticollis* (Stal) averaged ca 66 days.
2. *Metioche vittaticollis* completed its development feeding solely on *N. lugens*
3. The adult females of *M. vittaticollis* can live for 32 days and the rate of survival was high in the young adults but decreased as the cricket aged. The longevity of the female or male adult was ranged from 20 - 38 days. The average longevity of females and males were 29.24 and 25.00 days, respectively. The longevity of unmated female or male were longer than the mated female or male.
4. Female fecundity was averaged 50 eggs during her lifetime. Males were on average smaller than females.
5. Female cricket consumed significantly more nymphs instead of adult BPH. The females preyed upon BPH more than the males. Preying activity was more during night time.

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