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Research Article

Population Demographics of *Helopeltis bradyi* Waterhouse (Hemiptera: Miridae) from Three Different Locations

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ABSTRACT

Helopeltis bradyi Waterhouse has been reported to attack tea plantations in Batang District and cocoa plantations in Sleman District and Kulon Progo District. Information about the life parameters of *H. bradyi* reared using alternative feed cucumbers in the laboratory helps pest management efforts. This study aimed to determine the life demography of *H. bradyi* from two plants and three different locations. The study was conducted with cohort observations consisting of gross reproduction rate (GRR), net reproduction rate (Ro), intrinsic growth (r), average generation length (T), and population doubling time (DT) of three populations of *H. bradyi*. Results showed that there were differences in living individuals (ax), mortality, and life duration of the three *H. bradyi* populations. The survival type of the three populations of *H. bradyi* was classified as type IV. The survival of the three *H. bradyi* populations were influenced by their ability to adapt to new environments. From the three populations of *H. bradyi* observed, Sleman population survived longer because they had adapted to the rearing environment and were able to maintain the population numbers for two generations. Demographic parameters of *H.bradyi* from Sleman showed gross reproduction rate (GRR) of 88 individuals/generation, net reproduction rate (Ro) of .97 individuals/parents/generation, the increase in population rate (r) of 0.02 individuals/species/day, extended duration (T) of 39.50 days, and doubling time (DT) of 40.49 days.

Keywords: cohort; cucumber; Hemiptera; lifespan; Miridae; survivorship

INTRODUCTION

Indonesia is a country in Asia that has experienced economic losses due to Helopeltis attack or commonly known as the Tea Mosquito Bug (Roy *et al*., 2015). Helopeltis in Indonesia has been recorded since 1984 and was commonly found in tea plants (Rao, 1970). Helopeltis is a polyphagous insect and recorded to often attack acacia (*Acacia nilotica*), black pepper (*Piper nigrum*), cashew (*Anacardium occidentale*), quinine (*Cinchona* spp.), cocoa (*Theobroma cocoa*), and tea (*Camellia sinensis*) (Stonedhal *et al*., 1991; Srikumar *et al*., 2013; Melina *et al*., 2016; Anggarawati *et al*., 2017). Karmawati *et al.* (2010) stated that cocoa pod production reductions due to Helopeltis attacks can reach 50−60%.

There are several species of Helopeltis in Indonesia, viz. *Helopeltis antonii, Helopeltis bradyi,* and *Helopeltis theivora*. Misidentification between *H. antonii* and *H. bradyi* that attacked cacao plants in Java once occurred because of the similarity of their body morphology. Melina *et al.* (2016) has confirmed that the species spread across Yogyakarta or Java Island is *H. bradyi*.

The description of survivorship, development, and life expectations are important analytical tools that provides detailed information on population dynamics. The data on different environmental conditions gives important information for pest management (Ali & Rizvi, 2007; Ali & Rizvi, 2010). Pest management requires knowledge of the biology, morphology, and growth of pests, which are summarized in life tables (Buurma, 2008; Kakde *et al*., 2014; Arif *et al*., 2017). Observation of *H. bradyi* biology and demography from Kulon Progo District has been conducted by Simanjuntak *et al.* (2022). To provide more comprehensive information, this study will compare the biology and demography of *H. bradyi* from three locations and two different hosts, viz. Kulon Progo District, Sleman District, and Batang District.

MATERIALS AND METHODS

Insect Sampling and Identification

H. bradyi were collected from three locations: 1) Tea Plantation, Batang District, Central Java (7°6’ 39.906”S 109°51’11.7036” E); 2) Cocoa Plantation, Sleman District, Special Region of Yogyakarta (7°37’33.348”S 110º25’7.6938”E); 3) Cocoa Plantation, Kulon Progo District, Special Region of Yogyakarta (7°40’27.5”S 110°08’19.7”E) in May–September 2022 (Figure 1). *H. bradyi* was identified based on Melina *et al.*, (2016) using a Leica WILD M3B microscope with magnifications of 6.4×, 16×, and 40×.

Rearing *H. bradyi*

Helopeltis bradyi was reared in the Laboratory of Biological Control, Department of Plant Protection, Faculty of Agriculture, Universitas Gadjah Mada, with temperatures ranging between 25–28°C and humidity ranging between 61–78%. A pair of imagoes were placed in a 9 cm diameter and 16 cm tall plastic container to induce mating. Cucumbers were placed inside for feed and oviposition. *H. bradyi* from each location was kept in different plastic containers. Eggs on cucumber surfaces were counted every four days and cucumbers were transferred to a new container. The imagoes received new cucumber and it will be continuously replaced until dead. *Helopeltis* hatched from a pair of imagoes were given new cucumbers and replaced every two days. Observed parameters for each cohort were mating duration, mortality, number of eggs produced, number of eggs hatched, sex ratio, and lifespan. Observation of data started from a pair of imagoes mating until the next generation reached adults. Observations of the Sleman population were carried out on 3 pairs of insects, while the Kulon Progo and Batang populations were carried out on 2 pairs of insects.

Cohort and Demographic Analysis

Cohort observations and life tables consisted of the number of live insects at age x (ax), the probability of survival at age class x (lx), the number of individuals that died at age class x (dx), and the proportion of individuals that died to the number of individuals living at age class x (qx) (Tarumingkeng, 1994; Southwood & Henderson, 2000). To analyze insect demography, average number of individuals at age class x and the next age class ($Lx=(lx+lx+1)/2$), number of individuals at age class x and besides x+1 ($Tx=Tx-1-Lx-1$), individual life expectancy at each age class x ($ex=Tx-lx$), the specific personality of individuals at age class x (mx), number of off springs at age class x (lxmx), multiplication x, lx, and mx to calculate the length of generation (T), the length of generation ($T=\sum xlxmx/\sum lxmx$), the gross reproduction rate ($GRR=\Sigma mx$), the net reproduction rate ($Ro=\Sigma lxmx$), the intrinsic rate ($r=InRo/T$), and when the population doubles ($DT=In(2)/r$) were calculated (Tarumingkeng, 1994; Kakde *et al.*, 2014, and Ali & Rizvi, 2010).

Figure 1. *Helopeltis bradyi* sampling location in Java Island

RESULTS AND DISCUSSION

Morphological Identification of *H. bradyi*

Helopeltis obtained from three different locations were identified as the same species, namely *Helopeltis bradyi* (Figure 2). *H. bradyi* had smooth body surface, early-stage nymphs were yellow, 1st and 2nd instar nymphs were covered with setae. Body of imagoes were yellow, dark brown, brownish gray or black, and possessed transparent wings. The posterior was brighter than the anterior, and antennae consisted of four segments. These features were similar with Helopeltis morphological features from Melina *et al.* (2016) as *H. bradyi* was taken from a tea plantation, Batang. The difference between *H. bradyi* and other Helopeltis species is the presence of pale bands on the front, middle, and back of the femur (Figure 3).

Cohort and Life Table of *Helopeltis bradyi*

Observation of *H. bradyi* development from Sleman, Kulon Progo, and Batang were carried out successively in the fifth (F5), second (F2), and first (F1) generations. Observation of *H. bradyi* development from Sleman and Batang were carried out on 3 pairs of imago, while for *H. bradyi* from Kulon Progo was carried out on 2 pairs of imago. Observations of the three *H. bradyi* populations were done at 25−28°C and showed differences in life duration, survivorship, and fecundity. The highest number of eggs was produced from a pair of *H. bradyi* originating from cacao plants in Sleman District, followed by Kulon Progo District and Batang District, respectively 88 (Table 1), 28 (Table 2), and 14 eggs/generation (Table 3). Research conducted by Simanjuntak *et al.* (2022) on *H. bradyi* from Kulon Progo which was also reared using cucumber at 28−30°C showed that three pairs of imago were able to produce 304 eggs.

The study of Anggarawati (2014) showed that *Helopeltis* sp. which was reared from 15 pairs of imagoes for 3 days on tea shoots was able to produce 30 eggs and on cocoa as many as 44 eggs. The incubation period of eggs until they hatch into 1st instar in Sleman, Kulon Progo, and Batang populations was 6.67 ± 2.91 days, 8.50 ± 0.50 days, and 6.00 ± 3.06 days, respectively. The incubation period for *H. bradyi* eggs by Simanjuntak *et al.* (2022) lasted 6.33 ± 0.47 days.

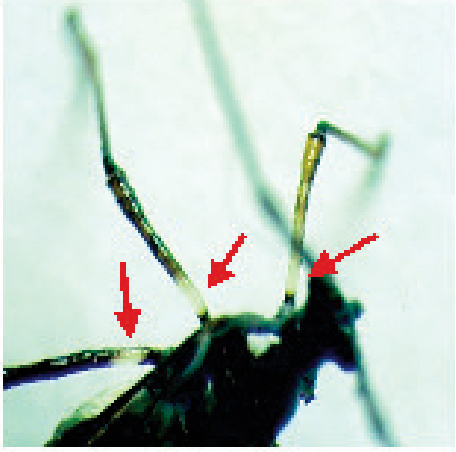

Figure 3. Three pale bands on the femurs of *Helopeltis bradyi*

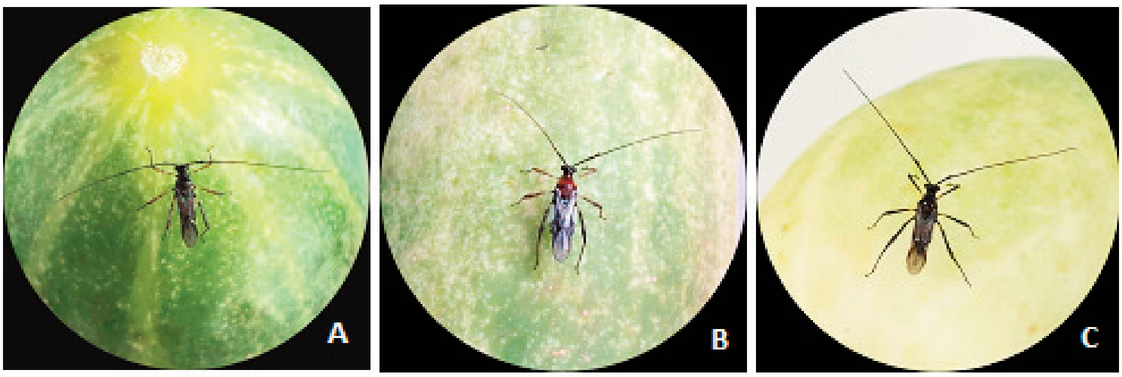

Figure 2. Imagoes of *Helopeltis bradyi* from three locations (A. cacao plantation, Sleman; B. cacao plantation, Kulon Progo; C. tea plantation, Batang)

Table 1. Life development of *Helopeltis bradyi* from Sleman

Age average (day)	**Stage**	**Individu (n)**	**Mean ± SE (day)**
1−7	Egg	88	6.67±2.91
7−11	Instar 1	62	4.00±0.58
11−15	Instar 2	27	3.67±0.67
15−19	Instar 3	21	4.00±0.58
19−23	Instar 4	13	4.00±1.00
23−25	Instar 5	11	2.00±1.00
25−32	Male Imago	1	6.67±3.76
25−34	Female Imago	5	9.00±4.93

Table 2. Life development of *Helopeltis bradyi* from Kulon Progo

Age average (day)	**Stage**	**Individu (n)**	**Mean ± SE (day)**
1−9	Egg	28	8.50±0.50
9−14	Instar 1	23	4.50±0.50
14−18	Instar 2	15	4.00±1.00
18−22	Instar 3	14	6.00±2.00
22−25	Instar 4	7	3.00±1.00
25−31	Instar 5	6	6.00±1.00
0	Male Imago	0	0
31−34	Female Imago	2	2.50±2.50

Table 3. Life development of *Helopeltis bradyi* from Batang

Age average (day)	**Stage**	**Individu (n)**	**Mean ± SE (day)**
1−6	Egg	28	8.50±0.50
6−8	Instar 1	23	4.50±0.50
8−9	Instar 2	15	4.00±1.00
9−11	Instar 3	14	6.00±2.00
11−12	Instar 4	7	3.00±1.00
12−16	Instar 5	6	6.00±1.00
0	Male Imago	0	0
16−23	Female Imago	2	2.50±2.50

Individual numbers decreased during early instar nymph stages. The number of *H. bradyi* eggs from Sleman, Kulon Progo, and Batang that hatch were 62, 23, and 11 respectively. Nymphs of *H. bradyi* from Sleman and Kulon Progo continued until they reached adults. The number of nymphs that reached imago from Sleman population was 6 individuals consisting of 1 male and 5 females, followed by the Kulon Progo population with 2 females, and the Batang population with 1 female. The sex ratio of insects was not related to the number of eggs produced because female imagoes have been documented to be capable of producing infertile eggs (Siswanto *et al.*, 2009). The three populations of *H. bradyi* also showed differences in their life duration. To complete one life cycle, the Sleman population took 34 days, while the Kulon Progo population took 34 days, and the Batang population took 23 days.

Adaptation is a form of insect survival against environmental changes (Sheikh *et al.*, 2017). Each insect has its own criteria for environmental conditions such as temperature, light intensity, humidity, air, host, and others. The changes in abiotic factors that occur in the laboratory may affect individuals at each level of development. The rearing environment influences rearing insects (Singh, 2012). The large number of eggs produced and the number of nymphs that were able to survive to become adults in the fifth generation of *H. bradyi* from Sleman compared to the other two populations may be caused by the adaptation that had been formed in the new environment. The changes that occur continuously encouraged *H. bradyi* to adapt and be able to maintain the population size.

Simanjuntak *et al.* (2022), stated that young Helopeltis were not able to adapt to changes in feeding sources and disturbances when the rearing area was cleaned. This is supported by Sétamou *et al.* (1999), which stated that the survival of the insect *H. bradyi* was strongly influenced by the type of host plant, even though it is classified as a polyphagous insect. The unsuitability of alternative hosts for insects will affect several aspects of their life, such as slowing their development and reducing their fecundity. This can happen because the protein and nutrient content in each type of plant is different (White, 1970; Savopoulou-Soultoni *et al.*, 1994). *H. bradyi* nutritional and protein needs were not fulfilled by cucumber as alternative hosts could experience several disturbances. The low number of surviving *H. bradyi* from Kulon Progo and Batang indicated that these populations required several generations to adapt to their new environment.

The high mortality of *H. bradyi* at a young age was classified into type IV based on the survival curve or survival type. If the mortality rate at a young age was low, then it would be classified as type I. If the mortality rate was constant over time, then it would be classified as type II. If mortality was constant then it would be classified as type III (Southwood & Henderson, 2000). Observation of mortality at each stage of insect development is used to obtain demographic data. Cohort analysis included observing the proportion of living individuals (lx) which was carried out by calculating the number of individuals who survived at the previous stage, the proportion of deaths (qx) which was calculated by the number of individuals who died (dx), and the number of individuals who lived (Table 4 and Table 5).

Table 4. Cohort data of *Helopeltis bradyi* from Kulon Progo

Stage	x	ax	lx	dx	qx
Egg	9	28	1	5	0.18
Instar 1	14	23	0.82	8	0.36
Instar 2	18	15	0.53	1	0.03
Instar 3	22	14	0.51	7	0.50
Instar 4	25	7	0.25	1	0.14
Instar 5	31	6	0.22	4	0.67
Imago	34	2	0.07	0	0.00

Notes: x: development stage (day), ax: living individuals, lx: proportion of living individuals, dx: number of dead individuals, qx: proportion of dead individuals

Table 5. Cohort data of *Helopeltis bradyi* from Batang

Stage	x	ax	lx	dx	qx
Egg	6	14	1	3	0.23
Instar 1	8	11	0.77	7	0.64
Instar 2	9	4	0.28	2	0.50
Instar 3	11	2	0.14	0	0.00
Instar 4	12	2	0.14	0	0.00
Instar 5	16	2	0.14	1	0.33
Imago	21	1	0.09		0.00

Notes: x: development stage (day), ax: living individuals, lx: proportion of living individuals, dx: number of dead individuals, qx: proportion of dead individuals

Demographic Analysis of *H. bradyi* from Sleman

The number of individuals from the Sleman population that survived was the highest and still survived after two populations which allowed allow for further demographic observations to be carried out. The population structure and development of *H. bradyi* can be estimated by observing the static life balance. The demographic parameters listed in the static life balance table is a method of estimating the population growth of an organism based on life chances (lx) and the average number of offspring produced by female imago (mx) (Hidayat *et al.*, 2019). Table 6 shows the gross reproduction rate (GRR) was 88 individuals/generation. The net reproduction rate (Ro) was 1.97 individual/parent/generation. The intrinsic rate (r) was 0.02 individual/mother/day. The average length of generation (T) was 39.50 days and doubling time (DT) was 40.50 days. The demographic observations of *H. bradyi* are in line with those conducted by Simanjuntak *et al.* (2022) at higher room temperatures showing a GRR was 296 individuals/parents/generation, Ro was 196 individuals/parents/generation, r was 0.18 individuals/parents/day, T was 29.34 days, and DT was 3.85 days.

Natality, mortality, and developmental time were three aspects that determine the capacity of a population to increase or are referred to as the intrinsic growth rate (Hidayat *et al.*, 2017). Birch (1948) states that the value of the intrinsic growth rate (r) and the decrease in environmental resources can be caused by an increase in gross reproduction value (GRR) and net reproduction value (Ro). The r value indicates the suitability of an insect species for its host, therefore the higher the r value for a host plant, the potential population of insect species to be suitable on hosts increase (Maharani *et al.*, 2016).

Abiotic factors have an important role in the development and reproduction of insects (Gillot, 2005; Syarkawi *et al.*, 2015). The environmental temperature will affect insect metabolism which will impact its ability to survive, while climate will affect insect abundance (Rockstein, 1973; Syarkawi *et al.*, 2015). This was explained by Sari *et al.* (2022) that the low intrinsic growth rate and limited growth rate are in line with a decrease in ambient temperature. A low intrinsic rate indicates that a species has little possibility of continuing to grow (Hidayat *et al.*, 2019).

Table 6. The static life balance of *Helopeltis bradyi* from Sleman

x	ax	lx	dx	qx	Lx	Tx	ex	mx	lxmx	xlxmx	px
1	88	1	0	0.00	1.00	15.28	15.28	0	0.00	0.00	1.00
2	88	1	0	0.00	1.00	14.28	14.28	0	0.00	0.00	1.00
3	88	1	0	0.00	1.00	13.28	13.28	0	0.00	0.00	1.00
4	88	1	0	0.00	1.00	12.28	12.28	0	0.00	0.00	1.00
5	88	1	0	0.00	1.00	11.28	11.28	0	0.00	0.00	1.00
6	88	1	0	0.00	1.00	10.28	10.28	0	0.00	0.00	0.94
7	88	1	0	0.00	0.94	9.28	9.28	0	0.00	0.00	0.93
8	78	0.89	10	0.13	0.88	8.33	9.40	0	0.00	0.00	0.99
9	77	0.88	1	0.01	0.88	7.45	8.52	0	0.00	0.00	0.90
10	77	0.88	0	0.00	0.79	6.58	7.52	0	0.00	0.00	0.86
11	62	0.70	15	0.24	0.68	5.79	8.21	0	0.00	0.00	0.93
12	58	0.66	4	0.07	0.64	5.11	7.75	0	0.00	0.00	0.94
13	54	0.61	3	0.06	0.60	4.47	7.28	0	0.00	0.00	0.95
14	51	0.58	2	0.04	0.57	3.87	6.68	0	0.00	0.00	0.85
15	49	0.56	13	0.27	0.48	3.87	6.95	0	0.00	0.00	0.69
16	36	0.41	13	0.36	0.34	3.39	8.28	0	0.00	0.00	0.78
17	23	0.26	0	0.00	0.26	3.05	11.68	0	0.00	0.00	0.93
18	23	0.26	3	0.13	0.24	2.79	10.68	0	0.00	0.00	0.91
19	20	0.23	1	0.05	0.22	2.55	11.21	0	0.00	0.00	0.92
20	19	0.22	2	0.11	0.20	2.33	10.78	0	0.00	0.00	0.81
21	17	0.19	5	0.29	0.16	2.12	10.99	0	0.00	0.00	0.79
22	12	0.14	1	0.08	0.13	1.96	14.35	0	0.00	0.00	0.96
23	11	0.13	0	0.00	0.13	1.83	14.61	0	0.00	0.00	1.00
24	11	0.13	0	0.00	0.13	1.70	13.61	0	0.00	0.00	1.00
25	11	0.13	0	0.00	0.13	1.58	12.61	0	0.00	0.00	0.77
26	11	0.13	5	0.45	0.10	1.45	11.61	0	0.00	0.00	0.65
27	6	0.07	1	0.17	0.06	1.36	19.87	0	0.00	0.00	0.91
28	5	0.06	0	0.00	0.06	1.29	22.75	0	0.00	0.00	0.90
29	5	0.06	1	0.20	0.05	1.24	21.75	0	0.00	0.00	0.78
30	4	0.05	1	0.25	0.04	1.18	26.06	0	0.00	0.00	0.86
31	3	0.03	0	0.00	0.03	1.14	33.58	0	0.00	0.00	1.00
32	3	0.03	0	0.00	0.03	1.11	32.58	0	0.00	0.00	1.00
33	3	0.03	0	0.00	0.03	1.08	31.58	0	0.00	0.00	0.83
34	3	0.03	1	0.33	0.03	1.04	30.58	0	0.00	0.00	0.80
35	2	0.02	0	0.00	0.02	1.01	44.62	1	0.02	0.80	1.00
36	2	0.02	0	0.00	0.02	0.99	43.62	13	0.30	10.64	1.00
37	2	0.02	0	0.00	0.02	0.97	42.62	15	0.34	12.61	1.00
38	2	0.02	0	0.00	0.02	0.95	41.62	13	0.30	11.23	1.00
39	2	0.02	0	0.00	0.02	0.92	40.62	9	0.20	7.98	1.00
40	2	0.02	0	0.00	0.02	0.90	39.62	6	0.14	5.45	1.00
41	2	0.02	0	0.00	0.02	0.88	38.62	6	0.14	5.59	1.00
42	2	0.02	0	0.00	0.02	0.86	37.62	20	0.45	19.09	1.00
43	2	0.02	0	0.00	0.02	0.83	36.62	0	0.00	0.00	1.00
44	2	0.02	0	0.00	0.02	0.81	35.62	0	0.00	0.00	1.00
45	2	0.02	0	0.00	0.02	0.79	34.62	0	0.00	0.00	1.00
46	2	0.02	0	0.00	0.02	0.76	33.62	0	0.00	0.00	1.00
47	2	0.02	0	0.00	0.02	0.74	32.62	0	0.00	0.00	1.00
48	2	0.02	0	0.00	0.02	0.72	31.62	0	0.00	0.00	1.00
49	2	0.02	0	0.00	0.02	0.70	30.62	0	0.00	0.00	1.06
50	2	0.02	0	0.00	0.02	0.67	29.62	0	0.00	0.00	1.07
51	2	0.03	0	0.00	0.03	0.65	25.31	0	0.00	0.00	1.01
52	2	0.03	0	0.00	0.03	0.62	24.00	0	0.00	0.00	0.81
53	2	0.03	1	0.50	0.02	0.60	23.00	0	0.00	0.00	0.38
54	1	0.02	1	1.00	0.01	0.58	35.73	5	0.08	4.35	0.00
55	0	0	0	0.00	0.00	0.57	0.00	0	0.00	0.00	0.00

GRR=88 Ro=1.97 r=0.02 T=39.50 DT=40.49

Notes: S: stage, x: age class, ax: living individuals, lx: proportion of living individuals, dx: number of dead individuals, qx: proportion of dead individuals, Lx: average number of individuals in age class x and age class x +1, Tx: number of individuals in age class x and besides x+1, ex: life expectancy, mx: fecundity of each individual at age x, lxmx: number of children born in age class x, xlxmx: to approximate the length of generation (T), px: probability of survival, GRR: gross reproduction rate, Ro: net reproduction rate, r: instrinsic growth, T: average generation length, DT: doubling time.

CONCLUSION

The differences in mortality, fecundity, and survivorship among the three populations were caused by each population ability to adapt to new locations and different host plants. Cohort observations of each *H. bradyi* population started at different generations, but only *H. bradyi* of the Sleman population survived and lasted to two generations for demographic analysis.

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