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The Demographic of *Brontispa longissima v*ariety of *celebensis* Gestro (Coleoptera: Chrysomelidae) on Mapanget Tall Coconut and Brown Dwarf Coconut

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Abstract: *Brontispa longissima variety of celebensisis considered an important pest on coconut trees. Basic information such as the biology and the life table of the species is extremely important in the effort to control its attack. The life table of B. longissima variety of celebensis on Mapanget Tall Coconut (MTC) and Brown Dwarf Coconut (BDC) can be examined in laboratory. The study aimed at examining the biology and the life table of B. longissima variety of celebensis on MTC and BDC. The study was conducted at Entomology Laboratory of Indonesia Palmae Research Institute, Manado, from June to November 2012. The parameters examined during the study consisted of the followings: 1) the development period from larvae of each instar into adult, 2) the longevity of adult, and 3) the number of eggs laid. The results of the study show that the young leaves of DMT are more suitable to support the life of B. longissima variety of celebensis compared to the young leaves of GRA, and this could be seen from the shorter immature development periods, the higher number of eggs laid, and the longevity of adult. B. longissima variety of celebensisis more suitable to live and grow on the young leaves of DMT than on the young leaves of GRA. This could be seen from the average* r_m *value which was higher on DMT leaves, that was 0.123 individual per adult per day, and mean generation time (T) which was 35.28 days, as compared to the* r_m *value on GRA leaves, that was 0.108 individual per adult per day, and mean generation time (T) which was 39.61. The* r_m *value shows the suitability of the host plants to increase the population of arthropods by considering the development periods, fecundity, longevity, survivorship, and sex ratio.*
Keywords: *life table, intrinsic rate of increase (*r_m*), B. longissima, DMT, MTC*

I. Introduction

Coconut (*Coconut nucifera* L.) is one of the most important commodities for farmers in Indonesia, especially those living at the central and eastern part of the country. At these regions, coconut trees become the main source of family income. The products derived from the plant are used to meet the domestic demands as well as to be exported to other countries helping to increase national foreign exchange. These products have contributed as much as $250 million each year to the national revenue. Coconut indeed plays such important role to encourage the growth of new economic centers in the developing regions of Indonesia (Tarigans, 2004). There are 3.88 million hectares or 31.2% from the total areas used for second-class coconut cultivation in Indonesia, and 98% of it is in the form of smallholder farms spreading all across the country (Syakir, 2008).

One of the factors hindering the programs to improve the production of coconut in Indonesia is the attack of pests and plant diseases. One type of pests attacking the coconut trees is the coconut leaf beetles, *B. longissima* Gestro (Coleoptera: Chrysomelidae) (Tjoa, 1953; Kalshoven, 1981; Singh and Rethinam, 2005). Coconut leaf beetles are as native to Indonesia and Papua New Guinea. These beetles have long threatened the coconut industry both in Indonesia and internationally, since the pest has spread to Malaysia, Sri Lanka, Australia, Maldives, India, Myanmar, Bangladesh, Thailand, Vietnam and South China (Liebregts and Chapman, 2004; Liu *et a.l*, 2010) due to intensive transportation and weak regulation on quarantine of coconut and palm (Goles, 2003). In order to control the attack of this beetle, basic information such as biological information and life table of the arthropod is needed. The first step in studying an arthropod is by studying its demographic aspects. Demography is a quantitative analysis toward the characteristics of certain population, especially related to the growth patterns of the population, resilience, and population movement(Krebs, 1972; Price, 1984; Carey, 1993). According to Price (1997), a life table refers to summary of statements on the life of individuals in certain population or groups. Tarumingkeng (1992) asserts an additional statement that a life table can be used in calculating population statistic on population growth behaviors, which can give insight into important information such as birth, mortality, and breeding opportunities. The information then can be used as a reference in determining parameters of growth behavior. Life table information is systematic description of mortality and longevity of certain population. That kind of information is basic in comprehending density and increase or decrease in number of population (Price, 1997; Smith, 1990). A life table helps to choose the best and the most suitable ways in controlling pests by understanding the survivorship strategies of the pests. The study aimed at comparing biological parameters and life table parameters of *B. longissima* on MTC leaves and BDC leaves.

II. Method

Augmentation of *B. longissima* variety of *celebensis*

The imagos of *B. longissima* variety of *celebensis* were collected from the coconut trees in Minahasa Regency, North Sulawesi Province. They were then grown and augmented at Entomology Laboratory of Indonesia Palmae Research Institute, Manado, from June to November 2012. The augmentation of *B. longissima* variety of *celebensis* were done in containers sized 30x10x6 cm. The beetles were fed on the leaves of MTC and BDC. The young leaves were changed with the new and fresh ones once in two days. This augmentation aimed at collecting uniform eggs, which were eggs laid by all female imagos at the same day. The second-generation arthropods were examined for their development, from eggs, first larval instars, second larval instars, third larval instars, fourth larval instars, fifth larval instars, pupae, female imagos, and male imagos.

The Effect of Coconut Varieties of MTC and BDC on the Development of *B. longissima*

Observation was done toward 130 eggs of *B. longissima* variety of *celebensis*. Each egg was put in different plastic containers, one container held one egg, and the containers were all labeled (date, variety, and number). The eggs were fed on the leaves of MTC and BDC. The young leaves were changed with the new and fresh ones once in two days. Examination was done every day from the time the eggs hatched until they turned into first larval instars, second larval instars, third larval instars, fourth larval instars, fifth larval instars, pupae, female imagos, and male imagos. The parameters to examine included sex and the number of imagos; the length of time needed for pre-oviposition, oviposition, and post-oviposition; and the number of eggs laid by female imagos. If male imagos died before the female did, new male imagos were taken as substitute. Data was tabulated on the life table using columns namely column x, l_x, and m_x. The x column represented the age of adult, from their birth until their death. The l_x column represented the survivorship of the female adult, and this was resulted from the division of the number of female adult at the age of x with the total number of adult at the beginning, while m_x represented the number of eggs laid by each female adult multiplied with the sex ratio. The calculation of life table parameters was done using the following formula (Birch, 1948):

Net reproduction rate (R_o) : $R_o = \sum lx.mx$

Generation time (T) : $T = \dfrac{\ln Ro}{r}$

Intrinsic rate of increase (r_m) : $r = \sum e^{-rx} l_x m_x = 1$

Finite rate of increase : $\lambda = e^r$

Definite time (λ)

Data Analysis

Data was analysed using analysis of variance, and continued with contrast orthogonal analysis employing Minitab version 14.0. Data on survivorship as well as data on the number of eggs laid each day and sex ratio was used in making the life table lx and mx (lx: the ratio of female adult at age x, and mx: the number of offspring produced by female adult at age x). The curve of survivorship of female adult was made using Exel 2007 program.

III. Results And Discussion

The biology of *B. longissima* variety of *celebensis*

B. longissima variety of *celebensis* possesses has a holometabola metamorphosis type, which includes stages of egg, larva, pupa, and adult (Figure 1). The eggs of *B. longissima* are flat and brown, and are put in short chains consisting of two to five eggs on the young coconut leaves (Figure 1a). The first larval instars were white in color, and within 2-3 hours, the instars turned into yellowish color. The end of the abdomen of the first larval instar shaped like U-letter (Figure 1b). The size of eggs, larvae, and imagos of *B. longissima* variety of *celebensis*is presented in Table 1. The results of the study show that differences in coconut varieties significantly affect the period for egg development and immature development of *B. longissima* variety of *celebensis* (Table 2).

A b c d e

Figure 1. Development phases of *B. Longissima* variety of *celebensis* a: egg, b: larval, c: pupa, d: imago, e: first larval instar until adult.

Table 1.The size of the egg, larva, pupa and adult of *B. longissima* variety of *celebensis*

Development Phases	Length (mm) (x ± SD)	Width (mm) (x ± SD)
Egg	1.37 ± 0.08	0.48 ± 0.03
First larval instar	1.80± 0.24	0.99 ± 0.01
Second larval instar	3.50 ± 0.34	1.30 ± 0.02
Third larval instar	5.01 ± 0.39	1.50 ± 0.03
Fourth larval instar	7.41 ± 0.52	1.76 ± 0.07
Fifth larval instar	9.5 ± 0.50	1.92 ± 0.04
Pupa	10.55 ± 0.50	1.95 ± 0.04
Male adult	11.04 ± 0.34	1.99 ± 0.01
Female adult	11.48 ± 0.38	2.0 ± 0.00

Table 2.The Development of *B. longissima* variety of *celebensis*on MTC and BDC

Variable	*B. longissima* variety of *celebensis*on	
	MTC	BDC
Egg	5.23± 0.76	6.62±0.59
First larval instar	5.60±0.55	6.89±0.73
Second larval instar	5.56±0.49	7.08±0.73
Third larval instar	7.03±1.0	8.01±0.91
Fourth larval instar	9.52±1.36	10.86±2.01
Fifth larval instar	13.03±1.49	14.07±1.94
Pupa	6.60±0.49	6.97±0.70
Life cycle	52.57±2.75	60.5±2.98

The results of the study show that differences in coconut varieties significantly affect the period for egg development and immature development of *B. longissima* variety of *celebensis*. The development phases of eggs, larvae, pupae, and adult were shorter on MTC variety than on BDC variety. The eggs of *B. longissima* variety of *celebensis* on MTC developed in a shorter period on than those on BDC, which were 5-6 days on MTC and 6-7 days on BDC. This result is in line with the results of the study by Waterhouse and Norris (1987). This means that BDC variety is more suitable for the growth and development of *B. longissima* variety of *celebensis*, as compared to MTC variety. The oviposition period, the longevity of both male and female imagos, and the number of eggs laid on BDC variety are longer than those on MTC variety (Table 3). Life cycle as well as development period until the formation of adult on MTC variety is shorter than on BDC variety.

Data on survivorship or the chance of life for *B. longissima* variety of *celebensis* was collected from the daily observation since egg phase into adult phase that was arranged in a life table. Based on the life table, the survivorship curve (l_x) and the fecundity of female adult (m_x) could be found out. The survivorship curve (l_x) of *B. longissima* variety of *celebensis* on both MTC and BDC leaves is presented in Figure 2.

The survivorship of female adult of *B. longissima* variety of *celebensis* seemed to decrease when they were 41-day old on MTC and 36-day old on BDC. The survivorship of *B. longissima* variety of *celebensis* on BDC variety was found to be lower than the survivorship of *B. longissima* variety of *celebensis* on MTC. This means that death of*B. Longissima* variety of *celebensis* happens faster on BDC variety than on DMT variety.

The survivorship curve of *B. longissima* variety of *celebensis* shows Type I Pattern, in which death mostly happens to adult or those at the end of the development phase.

Table 3.Pre-oviposition, Oviposition, Post-oviposition, and length of life of adult of *B. Longissima* variety of *celebensis* on MTC and BDC leaves

Variable	*B. longissima*variety of*celebensis*on	
	MTC	BDC
Pre-oviposition period	13.97±2.68	20.28±2.6
Oviposition period	46.1±11.1	36.44±7.22
Post-oviposition period	30.58±5.05	29.77±7.59
Length of life for female adult	90.6±12.2	86.49±9.74
Length of life for male adult	87.0±12.5	82.24±9.65
Number of eggs laid (female/number)	76.0±23.7	58.5±18.4
Sex ratio (♂ : ♀)	1 ; 1.14	1 ; 1.04

MTC variety was more suitable to become the host for *B. longissima* variety of *celebensis* based on the number of offspring per day (m_x) (Figure3). The value of m_x showed that the number of female offspring produced by the female adult of *B. longissima* variety of *celebensis* on MTC was higher than on BDC. The highest value of m_x happened on day 12 for MTC and day 21 for BDC. This means that the young leaves of MTC is more suitable for the growth and development of *B. longissima* variety of *celebensis* than the young leaves of BDC.

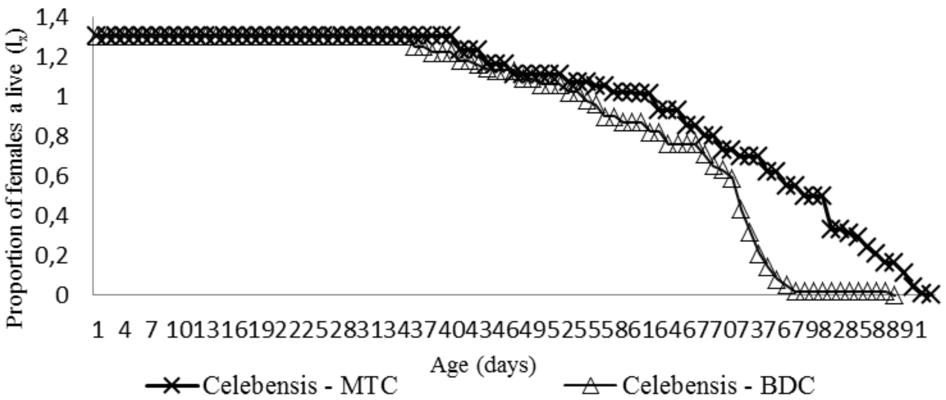

Figure 2.The survivorship of *B. longissima* variety of *celebensis* on BDC and MTC

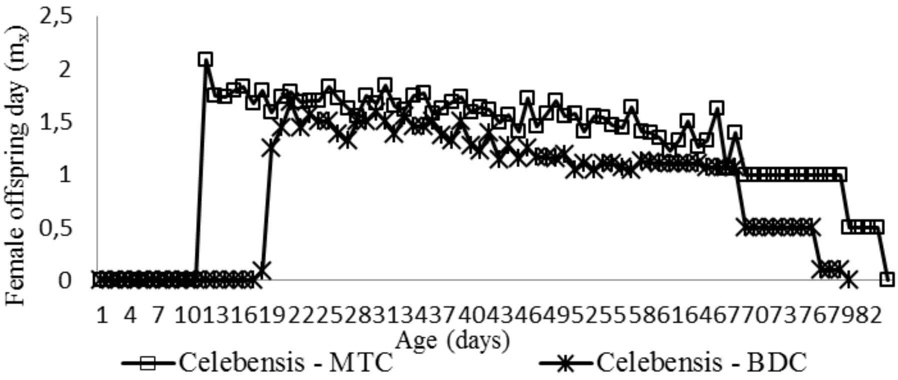

Figure 3.The number of offspring per day (m_x) produced by adult female adult based on age on MTC and BCD variety

The life table of *B. longissima* variety of *celebensis* on MTC and DBC consists of net reproduction rate (R_o), intrinsic rate of increase (r_m), finite rate of increase (λ) and mean time generation (T) calculated based on survivorship (l_x) and daily fecundity (m_x). The results of the calculation is presented in Table 4. The value of R_o shows the multiple numbers of populations on each generation (Birch, 1948). The value of R_o *B. longissima* variety of *celebensis* was higher on MTC than on BDC. Thus, it means that in one generation, the multiple of the four varieties of *B. longissima* variety of *celebensis* on MTC was 1.13 times higher than on BDC variety. If the value of $R_o < 1$, this means that the population of the arthropod is going to extinction, whereas the value of $R_o > 1$

means that the arthropod is increasing (Birch, 1948). The R_o value of *B. longissima* variety of *celebensis* is >1, meaning that their number was increasing.

Table 4.Demographic Parameters of *B. longissima* variety of *celebensis* on MTC and BDC

Variety	Parameter			
	R_o	r_m	T	ƛ
Mapanget Tall Coconut	76.67	0.123	35.28	1.13
Brown Dwarf Coconut	72.16	0.108	39.61	1.11

Note: R_o = net reproduction rate (individual/adult/generation), r_m = intrinsic rate of increase (individu/adult/day), ƛ = finite rate of increase (per day), T= mean time generation (day)

The value of r_m shows the number of female offspring produced by female adult per day, and represents the multiple of population per day (Birch, 1948; Tarumingkeng, 1994). The r_m value was 0.123 per individual/adult/day on MTC variety, with the value of ƛ of 1.13 dayand 0.108per individual/adult/day on BDC variety, with the value of ƛ of 1.11day. The multiple population of *B. longissima* variety of *celebensis* on MTC was 1.13 day, and was higher than on GRA, which was only 1.11 day. The difference in the value of r_m was caused by the difference in the mortality, birth rate, and the development time of *B. longissima* variety of *celebensis* on MTC and BDC. The high r_m value shows the suitability of the host plant to support the population of arthropods (Jin *et at.*, 2012), by considering the development periods, survivorship, longevity, fecundity, and sex ratio (Carey, 1993).

Intrinsic rate of increase (r_m) of a species cannot always be compared to the successful level of a species to live in a certain habitat. This simply is due to the selection process of the species that the r_m value is relatively high so the species can compete with other species (Birch, 1948). Thus, in predicting the survivorship of arthropods, data on mean generation time (T) is needed. Generation time usually expresses the average age of breeding females within a population, which represents the time needed since eggs until the eggs hatch, become adult, and produce half of their offspring. The generation time of *B. longissima* variety of *celebensis* was shorter on MTC than on BDC. Birch (1948) states a species in a population having lower T value will grow faster than a species in a population having high T value. This means that MTC variety is more suitable for the growth and development of *B. longissima* variety of *celebensis* than BDC variety.

IV. Conclusion

The young leaves of BDC are more suitable for the growth and development of *B. longissima* variety of *celebensis* than the young leaves of MTC, as shown from the shorter immature development period, higher number of eggs laid, and longer life of female adult. This can be seen from the higher r_m value on MTC, that was 0.123 individual/adult/day, and the mean generation time (T), which was 35.28 days, as compared to the r_m value on BDC, which was 0.108 individual/adult/day, and mean generation time (T), which was 39.61.

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