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Demography Statistics of *Arthroschista hilaralis* (Lepidoptera:Pyralidae) at Jabon (*Anthocephalus cadamba*) Plants in South Sumatra, Indonesia

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Abstract

Arthroschista hilaralis (Lepidoptera: Pyralidae) is a defoliator pest that prevalently attacks jabon (*Anthocephalus cadamba*) trees. Data and information about demography statistics of such pest are unfortunately still limited. Relevantly, this research aimed to look into the demographic statistics of *A. hilaralis* which were obtained from areas that are a month after historic forest and land fire, and normal condition areas as the comparison. Life table was determined by calculating mortality of *A. hilaralis* individuals and fecundity at each age. The mortality and fecundity data of *A. hilaralis* were then used to calculate the parameters of population growth including gross reproduction rate (GRR), net reproductive rate (Ro), mean generation time (T), intrinsic rate of increase (rm), and doubling time (DT).

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The growth parameter characteristics of *A. hilaralis* after forest and land fire show the GRR value of 42.79 individuals/generation; Ro as many as 11.44 individuals/female/generation; T lasting for 29.26 days; rm of 0.08 individuals/female/day; and DT for 0.02 days. Meanwhile under normal condition, characteristically the GRR of *A. hilaralis* corresponds to 180.6 individuals/generation; Ro is 81.58 individuals/female/generation; T lasts for 22.18 days; rm is 0.21 individuals/female/day; and DT is 0.03 days.

Keywords: *Arthroschista hilaralis*; demographic statistic; life table.

1. Introduction

Arthroschista hilaralis insects (Lepidoptera: Pyralidae) is one of defoliator pests which prevalently attack jabon (*Anthocephalus cadamba*) trees. This pest species attacks the leaves of jabon trees which grow in the nurseries as well as o in the fields. If the environment condition is supportive and convenient, *Arthroschista hilaralis* larvae can also attack jabon seeds which are still at their young ages. The attacks with heavy intensity by these insect larvae can render jabon trees scanty and barren. Even, at several jabon trees which have already been 5 years old or more and developed their fruits, when the tree canopies were already severely attacked by the larvae, then these larvae could attack jabon fruits as well. There were numerous reports regarding attacks of *A. hilaralis* insect on jabon trees either in Kalimantan, Sumatra, or in Java. Ngatiman and Tangketasik [1] reported that there was the attacks of *A. hilaralis* pest on jabon tress also occured in East Kalimantan. Furthermore, the pest that attacked jabon trees in East Kalimantan was that of *Margaronia* sp. (another name of *Arthroschista* sp.) which performed as tree defoliator [2]. The attacks of this pest were not only encountered in East Kalimantan, but it also took place in other regions. Selander [3] reported that there were heavy attacks by caterpillars on jabon trees in South Kalimantan. Besides, Nair [4] reported that *A. hilaralis* insects that attacked jabon tress brought serious damages. In Riau (Sumatera), *A. hilaralis* insects have become the dominant pest that attacked jabon trees causing as much as 63% in portion as high-intensity damages [5]. Meanwhile, jabon trees that grew in Forest Areas with Special Purposes (FASP) at Kemampo, administratively under Banyuasin Regency (South Sumatera Province) were attacked by *A. hilaralis* pest with its attack intensity averaged about 95% [6]. Attacks of caterpillars that occurred in Java was reported by Susanty [7], who further alleged that these caterpillars could attack jabon trees which have already been consecutively 0.5; 1.0; and 1.5 years old and which were planted both on low level (plain) areas as well as on highland (plateau) areas. Viewing and contemplating the intensity of pest attacks, damages as inflicted, and extent of pest spread, therefore, it deserves to look into the population growth of *A. hilaralis* insect. One of the initial stages to learn the population growth of a particular pest is by exploring aspects of the pest demography. Demography refers to quantitative analysis on characteristics of particular population, particularly its relation with patterns of population growth, survivorship linkages, and population migration. These matters relate closely to population dynamics but with rather different emphasizes. Demography in this respect focuses more on patterns of growth, birth, death, and migration. Meanwhile, causes and consequences of these phenomena are put under deep scrutiny in the population dynamics. Demography aspects of a particular population are set forth in the form of a life table [8]. Life table presents a technique to calculate birth and death figures of a particular population. The such life table serves as summary of statement, regarding the life of population of individuals or groups. There are two types of life table, which comprise horizontal life tables for age-specific patterns and vertical life tables for time-specific patterns [9]. To prevent and control the attacks of *A. hilaralis* pest on jabon trees, research on demographic statistics of the particular pest needs to carry out, because the research can be considered useful in controlling the pest and determining the strategy to deal with them. Relevantly, this research was carried out with the main objectives to look into the life table and demographic statistics of *A. hilaralis* pest which were found in the areas of a month after forest and land fire compared to those found in normal condition areas.

2. Limitation

This study is limited to analyze life table and statistic demography of *A. hilaralis* in the Laboratory of Forest Protection, under The Institute for Research and Development on Life Environment and Forestry, in Palembang, South Sumatra Province, Indonesia. *A. hilaralis* sample was acquired from jabon stands which attacked, collected under two circumstances, one month after forest and land fire and normal condition.

3. Research Methods

3.1. Rearing of A. hilaralis

The procurement of *A. hilaralis* pest was conducted twice in succession. Initially the first procurement was carried out in areas of a month after severe forest and land fire; and another one was taken in normal condition areas or areas that had not been fired. The *A. hilaralis* pest referred to was procured from the same locations, where in the forest/land fires had once occurred one month earlier and where in the normal condition usually took place. The locations were situated in jabon plantation in Karang Anyar Village, administratively under Banyuasin II's Sub District, Banyuasin Regency (South Sumatera Province). The *A. hilaralis* insects in the form of larvae (pupae) were taken from the field at that location, and then to be raised for further nurturing. *A. hilaralis* larvae were nurtured in the plastic jar of 28 cm high, 21 cm long and 6 cm wide. The larvae which then became pupae were then put into a plastic container with 6 cm in diameter and 8 cm high. The imagoes which were already developed from *A. hilaralis* pupae and then moved out were placed into the plastic cage that had diameter of 25 cm and height of 30 cm. The *A. hilaralis* adults were further fed with aqueous honey solution with 20% concentration as their fodder (food stuffs). The adults kept being nurtured until they gradually became eggs. When the eggs already hatched, the newborn insects were further used as the test insects.

3.2. Observation associated with demographic statistics of the pest

There were 30 eggs of *A. hilaralis* hatched and they were used in this research. Immediate observation and recording were conducted regarding to the mortality of the pests individually and the fecundity of adult female insects almost throughtout their growing time every day. The obtained data regarding pest mortality and fecundity were then is listed into the so-called life table. After that, the life table which had already contained the data about survivorship capacity (l_x) and age-specific fecundity (m_x) were then used as a basis to calculate parameters associated with the insects population growth. The obtained statistics related to the life table were then constructed and rearranged using the so-called Jacknife's method. The Jacknife's pertains to the method of repeated sample taking (resampling) which is used to estimate the bias and to predict the standard deviation

[10]. The basic principle underlying the Jacknife's method lies at the calculation manner of particular statistics that is carried out repeatedly by removing one observation or more of a sample, which have been already predetermined. In this way, accordingly, it will come up with a separate sample, whereby each discloses its own size as many n-1 or n-d items as sample member (d<n). The repeated sample taking or resampling in this research was performed 30 times as replicates.

4. Results

4.1. Life table of A. hilaralis

Referring to the counting and calculation results of any quantitative items associated with the created life table, information on almost any aspects regarding the life traits of *A. hilaralis* insects could be acquired. Among others is survivorship curve. The survivorship curve in this respect illustrated the survivorship probability of *A. hilaralis* individuals which were maintained at all stadia started from egg, larvae, pupae, until imago (l_x) and depicted the fecundity of corresponding female imagoes per day. More specifically, the survivorship curve featured the survivorship chance of *A. hilaralis* insects, while fecundity curve described the natality of *A. hilaralis*.

The already established survivorship curve for *A. hilaralis* insects (obtained after forest and land fires) showed that their death rate ranged from zero to 23 days (Figure 1); and started from 24 days old the death of insects just occurred. The figure also disclosed the survivorship chance of *A. hilaralis* insects, which began to diminish when the age of *A. hilaralis* individuals reached 24 days.

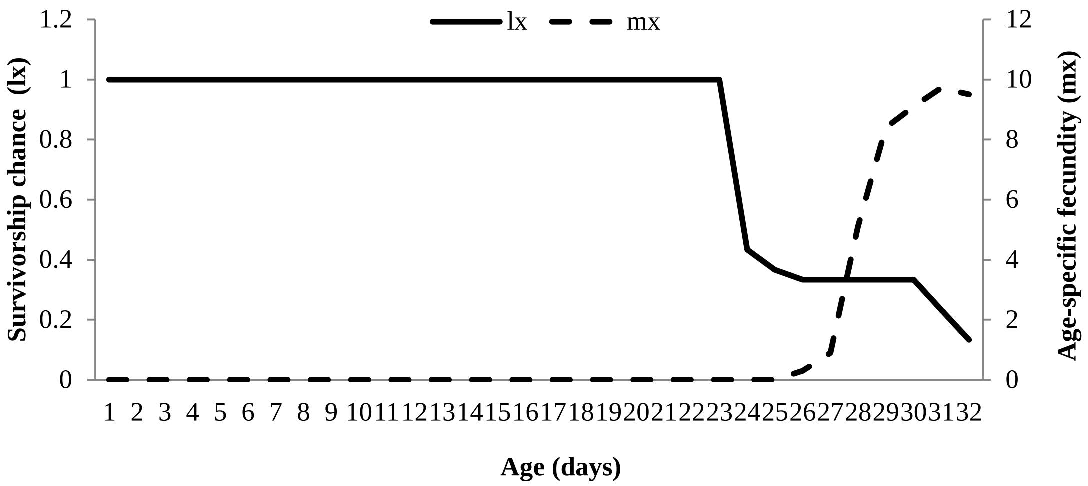

Figure 1: Features about the survivorship curve (l_x) and fecundity curve (m_x) of *A. hilaralis* insects (acquired one month after the disaster of forest and land fires)

Price [11] asserted that there were three kinds of curves regarding the survivorship success of insects in nature, which comprised types I, II, and III. Type-I curve describes that survivorship chance is initially high at the early growth of organisms (i.e. low death rate), and then decreases gradually along with the concomitant increase in their ages. The next is type II curve illustrating the survivorship chance which is fairly constant throughout the span of particular ages. Ultimately, type III curve depicts the survivorship chance which is lower at the early growth stage of organisms, and then increases gradually along with the progressive age increase. Scrutiny results of observation on 30 *A. hilaralis* insects which were obtained following the forest/area fire disaster strongly suggested that the survivorship curve shape that was associated with their life growth belonged to type I, which implied that the high death rate occurred as the insects grew older. Subsequently, fecundity of female imagoes could be confirmed by counting the number of eggs they laid every day. In Figure 1, it is shown that the laying of *A. hilaralis* eggs begins at the 27th day; and such phenomenon reaches the peak onthe 30th day, when the number of eggs which were laid reached 9 eggs in average. Also in average, the imagoes laid their eggs 2 to 3 days after the female adults were grown through their metamorphosis stages.

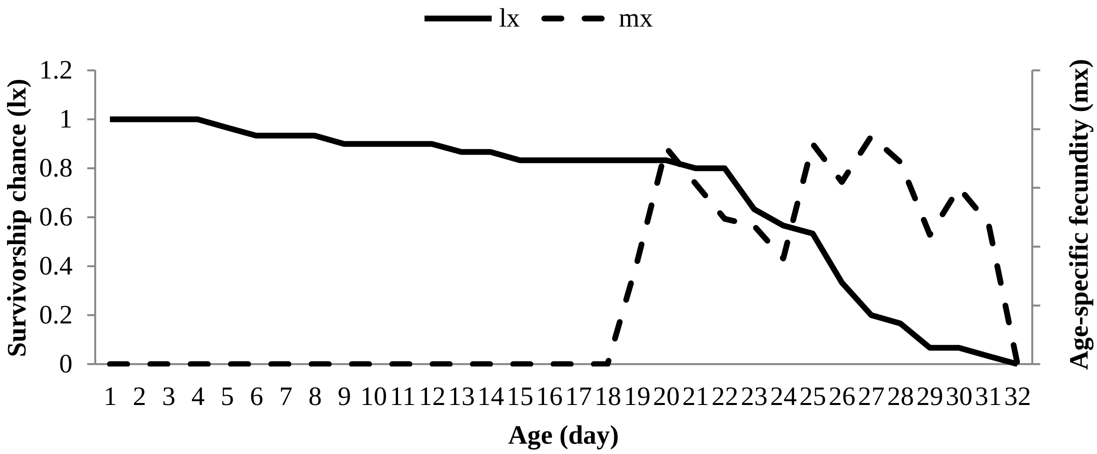

Figure 2: Features of the survivorship curve (l_x) and fecundity curve (m_x) of *A. hilaralis* insects (obtained under normal condition; or acquired not during the forest and land fire season)

Meanwhile, the survivorship curve of *A. hilaralis* insects, which were obtained under normal condition (acquired not during the forest/ land fire season) reveals their low death rate at their early growth stage (at larva stadia), and then is followed by the high death rate as their age increased progressively. The survivorship curve shape of the life growth of those insects belongs also to type I (Figure 2). The figure discloses the survivorship chance of *A. hilaralis* insects (l_x) that began to diminish when they were 22 days old. Figure 2 also shows that the laying of eggs occurred initially on the 19th day (m_x) and in average it took place 2 days after *A. hilaralis* became imago (through metamorphosis). The peak of egg laying came about the 25th day when in average, the number of eggs which were laid reached 19 eggs.

4.2. Demographic statistics of A. hilaralis insects

The parameters associated with demography statistics of *A. hilaralis* insects (obtained one month after forest/land fires (as described before) that covered gross reproduction rate (GRR), net reproduction rate (Ro), intrinsically rate of increase (rm), average/mean generation time (T), and doubling time (DT) are presented in Table 1. The GRR illustrates the average number of female offsprings (descendants) per female adults born by

A. hilaralis individuals, whereby their life reached maximum ages. The GRR value of *A. hilaralis* insects from forest/land fire areas reaches 42.79, implying that those insects is able to produce as many as 42.79 individuals/generation of offsprings/descendants. The Ro value of *A. hilaralis* shows that the average number of female offsprings produced by one female adults corresponds to 11.44 individu/female adult/generation; or in other words it means that the population of *A. hilaralis* insects is able to reproduce as many as 11 times in each generation.

The rm value, which stands for intrinsic rate of increase, of *A. hilaralis* reaches 0.08 individu per day (Table 1). Meanwhile, the value of T (mean generation time) describes the time duration which is counted (required) from the first time they laid their eggs to the female adults hatched from those eggs produce (give birth) their offsprings/descendants.

The smaller the T values, then the faster the performance of their reproduction would be. The T value of *A. hilaralis* insects that is 29.26 days, suggests that in such 29.26 days their corresponding female adults are able to bear their offsprings/descendants. Further, doubling time (DT) refers to the time which is needed for a population of organisms to double its population two times greater than before. The DT value of 0.02 days implies that *A. hilaralis* insects take 0.02 days for them to double their number.

Table 1: Demography statistics of *A. hilaralis* insects, obtained one month after the occurrence of forest and land fires

Parameters	Average ± Standard deviation
Gross reproduction rate (GRR)	42.79 ± 0.24 (individuals/generation)
Net reproduction rate (Ro)	11.44 ± 0.12 (individuals/female/generation)
Intrinsic rate of increase (rm)	0.08 ± 0.00 (individuals/female/day)
Generation time (T)	29.26 ± 0.06 (days)
Doubling time (DT)	0.02 ± 0.00 (days)

Information about the parameters associated with the demographic statistics of *A. hilaralis* insects, whereby the insects were acquired under normal condition or not during the forest/land fire season is presented in Table 2. The GRR value corresponds to 180.60, suggesting that the insects are able to bear their offsprings/descendants as many as 180.60 individuals/female adults/generation.

The Ro value is 81.58 individuals/female adults/generation, implying that the population of *A. hilaralis* insects could reproduce as many as 82 times in each generation. The rm value of *A. hilaralis* reaches 0.21 individuals per female per day (Table 2).

Furthermore, the T value of *A. hilaralis* insects that reaches 22.18 days, implies that their corresponding female adults are able to reproduce their offsprings/descendants in 22.18 days. The DT value of 0.03 days suggests that *A. hilaralis* population takes 0.03 days to double its population two times greater than the previous one.

Table 2: Demography statistics for *A. hilaralis* insects, obtained under normal condition (not during the forest/ land fire season)

Parameter (Parameters)	Rata-rata ± SD (Average ± Standard deviation)
Gross reproduction rate (GRR)	180.60 ± 0.82 (individuals/generation)
Net reproduction rate (Ro)	81.58 ± 0.52 (individuals/female/generation)
Intrinsic rate of increase (rm)	0.21 ± 0.00 (individuals/female/day)
Generation time (T)	22.18 ± 0.02 (days)
Doubling time (DT)	0.03 ± 0.00 (days)

5. Discussion

The life table for *A. hilaralis* insects as already established is used to comprehend in depth the population growth and other related processes that occurred in *A. hilaralis* insect population. As set forth before also, based on the counting and calculating of particular quantitative aspects referring to the life table, useful information could be obtained, among others is the survivorship curve. Price [11] asserted that the shape of survivorship curve was needed to help understanding the reproduction strategy among insect population. The shape of acquired survivorship curve of *A. hilaralis* insects obtained either from forest/land fire areas or under normal condition areas (not during the fire/land fire season) belonges to type I (Figures 1 and 2), which illustrates the death of organisms in few number when the ages of their population were still young; and the death in great number as the population grew older. *A. hilaralis* insects which were obtained from the area one month after the disaster of forest/land fire however indicatively exhibited their constant survivorship chance; and then tended to decrease as their ages steadily increased (Figure 1). Meanwhile, *A. hilaralis* insects which were acquired under normal condition revealed a low death rate during their early growth, then it was followed with high death rate or sharp decrease in survivorship curve as their ages increased (Figure 2). Related to the information, Morgan [12] explained that life table of particular organisms was affected by several factors such as species, host plants, local climate condition where the research took place, and methods of insect rearing. Contemplating those factors in the research location, such cases could also be attributed to the condition of jabon trees as the host plant, whereby the condition of the tree vigor shortly after the forest/land fire are different from the one under the one under normal condition; and also climate condition on the field where the insects are obtained. Those two factors are strongly presumed affecting the trait (behaviours) of *A. hilaralis* insects, thereby bringing out two notably different shapes of survivorship curve. The fecundity of female adults as described before could be assured by counting the number of eggs they laid every day. The value of m_x exemplifies the number of eggs produced by female imagoes when their ages reach x days after accounting for the so-called gender ratio. From the fecundity curve, it could be indicated that *A. hilaralis* insects obtained from forest/land after fire begin to lay their eggs on the 30th day, whereby the number of eggs in average corresponds to 9 eggs (Figure 1). Meanwhile the insects acquired under normal condition laid their eggs on the 19th day with their average number reaching 19 eggs (Figure 2). There were numerous factors that affected fecundity of organisms, among others are temperature [13, 14, 15] and fodder quality [16, 17, 18, 19]. Fecundity of insects however could be different, depending on kinds of fodder. Fecundity correlates strongly not only to the traits (behaviour) of how the adult insects eat, but also to the condition of fodder of each stadia. Fodder nutrition which is essential and affects the production of eggs principally consists of protein, while carbohydrate served as important nutrition that affects the survival of adults [19]. It was strongly presumed that the condition of jabon trees as host plant were affected by the way *A. hilaralis* insects ate; and consequently the characteristics of insect samples obtained from the field of the burnt forest/land; and also from the same field but under normal condition (not during the forest/area fire season) significantly differed each other with respect to insect growth, survival, and reproduction. Scrutinizing the observation results, it shows that the condition of jabon trees after the disaster of forest/land fire in their early recovery stage had their jabon leaf grew, but the leaves development were rather in a short time and with rather swallow (small) shape compared to the leaves of normal area. Besides the stems or twigs of jabon trees a were rather dry. This situation was quite different from the host condition of normal jabon trees, whereby their canopies looked green with their leaves growing enormously length wise and widely in size. Contemplating the constructed life table (Figures 1 and 2), the controlling of *A. hilaralis* insect pest should be performed when those insects are in the early age or being still in their larva phase. This is because the insects exhibited high death rate at their old ages; and conversely low death rate at their young ages. Likewise, the low death rate of *A. hilaralis* insect larvae comes naturally. Moreover, the larvae phase becomes the longest stadium in *A. hilaralis* lifecycle. In this stadium, the larvae are quite active eating and consuming jabon leaves, thereby bringing about severe destruction enormously. Accordingly, it urgently necessitates the thorough controlling of *A. hilaralis* insects during their larva phase or stadium. Demography statistics signify as quantitative analysis on characteristics (traits) of particular population of organisms, which closely relate to the patterns of population growth, survival-related population, and population migration [11]. More specifically, the knowledge about demography aspects can serve as one of initial steps in looking into the growth of particular population for insects. Research results show that the values of all parameters associated with demographic statistics of *A. hilaralis* insects obtained from the burnt forest/area fire are obviously different from those acquired under normal condition (Table 1 and 2). The gross reproduction rate (GRR) as described before depicts the average number of female offsprings/descendants per female adult which was produced by *A. hilaralis* individuals, whereby their life could achieve maximum age. The GRR value of *A. hilaralis* insects which were obtained from the location of the burnt forest/area fire is smaller than the value acquired under normal condition. Likewise, the similar phenomena also occurrs to the net reproduction rate (Ro) of those insects, whereby Ro as explained before describes the average number of offsprings produced by female adults for each generation, after being countied for the insect death or survivorship chance. The Ro value for *A. hilaralis* insects obtained from the burnt forest/area (11.44) osoverwhelingly lower than the one acquired under normal condition (81.58). Price [11] alleged that the population of an organism was regarded stable, when the Ro value was equal to zero (Ro = 0); but if the Ro value was greater than unity (Ro > 1), then the population would increase in number; and ultimately if Ro value was lower than unity (Ro < 1), then the population would otherwise decrease. Further, the Ro value of *A. hilaralis* insects (obtained after forest/ land fire) which corresponded to 11.44, implies that at a particular environment, *A. hilaralis*'s population would increase as much as 11.44 times as that of their previous generation. Meanwhile, the Ro value of *A. hilaralis* insects (acquired under normal condition) which reached 81.58, strongly suggests that under such particular environment, the population would increase as much as 81.58 greater than their previous generation. These figures hints that under normal condition the explosion of *A.*

hilaralis's population would developed faster. As such, Kurniawan [20] reported that the high GRR and Ro values indicated high suitability (compatibility) that occurred between insect life and host plants. Conversely, low GRR and Ro values implied that there were incompatibility or less suitability of insect life with host plants. The T value discloses the time duration of the insect organisms from the beginning of laying their eggs to when the female adults originated from those eggs bear their own offsprings. Lower T value implies that particular organisms reproduce their offsprings faster. The T value of *A. hilaralis* insects (obtained after the disaster of forest/ land fire) was greater than the value of the insects (acquired under normal condition), which were 29.26 days vs 22.18 days, respectively (Tables 1 and 2). Scrutinizing those two figures, it implies that in one year span *A. hilaralis* (obtained after forest/ land fire) is able to produce 12 generations (obtained from 365 days divided by 29.26 days), while the insects (acquired under normal condition) are able to bear 16 generations (from 365 days divided by 22.18 days). Further, *A. hilaralis* insects in West Bengal (India) could bring out 11-12 generations [21]. Such discrepancy in the number of generation among, consecutively, the situation after forest/land fire, under normal condition, and results by Thapa and Bhandari [21] could be brought about by the difference of environmental factors, such as temperature and humidity. Those conditions could affect the time the insects take to develop themselves. By acquiring the Ro and T values, then intrinsic increase rate (rm) of the generation of particular organisms, including insects could be determined [22], as also disclosed in Figures 1 and 2. The rm value of *A. hilaralis* insects acquired under normal condition (0.21) was much greater than the value for insects obtained after forest/land fire (0.08). Such high rm value for the normal insects could be affected by their high fecundity and low mortality (death rate) during the pre-adult as well as adult life span. In this regard, the fecundity of *A. hilaralis* insects acquired under normal condition was higher than that obtained after forest/land fire (Figures 1 and 2; Tables 1 and 2). Doubling time (DT) refers to the time a particular population takes or requires to double the number of individuals two times greater in a population. The DT value of *A. hilaralis* insect acquired under normal condition (0.03) was greater than the value for the insects obtained after the forest/ land fire (0.02) (Tables 2 and 3). As described before, the higher the DT value, the longer the time for particular population of organisms to double their population would be. Conversely, the smaller the DT value, the shorter the time for organisms to double their population would be. A particular population that exhibits low DT value would be faster to drain or exhaust the natural sources compared to the population with high DT values. High DT value can bring about the increase in gross reproduction rate (GRR) and net reproduction rate (Ro) in particular time unit. According to Birch [23], high DT value of a particular population could render the environment sources to decrease and affect the intrinsic increase rate (rm).

6. Conclusion and suggestion

The population growth of *A. hilaralis* insects which were obtained one month after the disaster of forest and land fires at particular locations as well as acquired under normal condition at the similar location belonged to Type-I survivorship curve.

Life table of *A. hilaralis* insects particularly obtained under normal condition strongly indicates that those insects afforded fast development intensity, high growth rate, high survival capability, and extremely high reproduction capacity, thereby severely widespreading and rendering cause the insects able to inflict serious damages on particular plants, i.e. jabon trees.

Meanwhile, *A. hilaralis* insects obtained one month after the forest/land fire could also afford such biological capacity/capability, exhibit their behaviour (traits), and cause inflict on jabon tress almost similarly to those under normal condition, but mostly at lower intensity. This worrying situation therefore necessitates immediate action to deal with *A. hilaralis* insect pest in saving jabon trees. Accordingly, urgent and thorough actions deserve to be carried out properly in periodic and regular ways to control and handle the pest brought by *A. hilaralis* insects. Otherwise, such pest can cause serious damage not only to jabon trees but also sooner or later in larger scale to natural sources and environments.

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