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Age-specific life table of swallowtail butterfly *Papilio demoleus* (Lepidoptera: Papilionidae) in dry and wet seasons

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ABSTRACT

Suwarno. 2012. Age-specific life table of swallowtail butterfly Papilio demoleus *(Lepidoptera: Papilionidae) in dry and wet seasons. Biodiversitas 13: 28-33.* Age-specific life table of *Papilio demoleus* L. in dry and wet seasons was investigated in the Tasek Gelugor, Pulau Pinang, Malaysia. Development of *P. demoleus* was observed from January to March 2006 (dry season, DS), April to July 2006 (secondary wet season, SWS), and October to December 2006 (primary wet season, PWS). Survivorship of *P. demoleus* in the DS was lower than in the SWS and in the PWS. The mortality (q_x) of the fifth instar larvae *P. demoleus* in all seasons was higher than in other stages. Predators, parasitoids, and rainfall were the most important factors of mortality in immature stages of *P. demoleus*. Predators caused the highest mortality in all stages of *P. demoleus*, except the pupal stage. Predation in the DS (94.39%) was higher than in the SWS (90.88%) and PWS (84.04%) but no significantly different among the seasons. Meanwhile there was significantly different of mortality caused by parasitoids and the rain among the seasons. Spiders were the important mortality agent in the eggs and young larvae, meanwhile in the older larvae were *S. dichotomus* and *Podisus* sp. Ooencyrtus papilioni and *Pteromalus puparum* were the important parasitoids for the eggs and pupae of *P. demoleus*, respectively. In summary, the season influenced the survivorship of *P. demoleus* in citrus plantation. *P. demoleus* had the highest survival in the wet primary season (PWS), while the lowest survival was observed in the dry season (DS).

Key words: life table, *Papilio demoleus*, dry seasons, wet seasons, predators, parasitoids.

INTRODUCTION

In many insects population studies, the age-specific life table is more widely applicable because insects have discrete generations. Age-specific life table shows organism's mortality or survival rate as a function of age. In nature, mortality rate may depend on numerous factors (Southwood and Henderson 2000). The factors force may be naturally occurring, as in the case of predators, parasitoids, pathogens, host-plant effects, and weather (Naranjo and Ellsworth 2005). A life table reveals the "key mortality agents" at different stages and help in the construction of survival curves. Such curves in turn are useful for detecting weak links (most susceptible or vulnerable stages) in life history of a pest (Norris et al. 2003).

Papilio demoleus was reported in many countries as a serious pest on *Citrus* orchard such as in India (Gangwar and Singh 1989), Pakistan (Munir 2004), Indonesia (Matsumoto and Noerdjito 1996), Malaysia (Malaysian Tropical Fruit Information System 2004), Caribbean and Florida (Homziak and Homziak 2006). In Malaysia this pest is gaining important. Based on observations in Malaysian Peninsular, it was found that *P. demoleus* attacked the citrus plantations throughout the year and its populations fluctuate depending on several factors such as natural enemies, food resources and weather. These factors are important in predicting population growth, survival rate, mortality and fecundity (Yang and Chi 2006).

A greater understanding of caterpillar behavioral ecology and naturally occurring mortality agents will enhance our abilities to effectively manage caterpillar populations. The objectives of this study were, first, to construct and compare the age-specific life tables of *P. demoleus* during dry and wet seasons. The second objective was to identify the mortality factors of various life stages of the butterflies and finally, to determine the key mortality factors and the weakest stages of immature of *P. demoleus.*

MATERIALS AND METHODS

The study site

The study of life table of *P. demoleus* were conducted in Tasek Gelugor, Pulau Pinang, Malaysia, located at $5^0$28'60"-$5^0$29'89" North latitude, and $100^0$30'0"-$100^0$32'15" East longitude, and 34 m above sea level. The study area is a tropical fruits plantation. The experimental observations were done on the 210 seedlings of *Citrus reticulata* (height 50-75 cm).

Life table data collection

The study of the age-specific life tables of *P. demoleus* was conducted during dry and wet seasons in 2006. Development of *P. demoleus* was observed from January to March 2006 (dry season, DS), from April to July 2006 (secondary wet season, SWS), and from October to December 2006 (primary wet season, PWS).

The number of eggs oviposited, surviving larvae, dead eggs and larvae and their mortality factors in the study area in each season were determined by direct counting every alternate days. All stages of larvae and their respective causes of mortalities (egg, first to fifth instars, pupae and emerging adult) were recorded. Mature eggs and pupae with signs of parasitism (dark upper surface of eggs and black spot on the pupae) were taken to the laboratory until the natural enemies emerged (Munir 2004; Okolle 2007).

Life table construction and analysis

To obtain complete information of each life stage of *P. demoleus* life tables was constructed using the data from continuous field observations on all stages of life cycles. The data of all generations in each season were pooled at the end of observation into respective stages. The life table calculation followed the method of Southwood and Henderson (2000) and was used to calculate the table. The data were summarized into columns of life table analysis whereby:

X = age interval

l_x = number of living individuals at the start of age.

d_x = number of dying individuals during the stage interval X to X+1

D'_x = number of deaths from different agents

q'_x = mortality from different agent (D'_x / l_x)

q_x = total mortality of each stage ($q'_{x1} + q'_{x2} + q'_{x3} + ... + q'_{x\,n}$)

s = survival during the stage interval (1-q_x)

Life table data were subjected to "key-factor" analysis. In this study, the key factor analysis, were carried out following the method of Varley et al. (1973), whereby:

$$K = k_e + k_1 + k_2 + k_3 + k_4 + k_5 + k_p$$

K = total generation mortality
k_e = mortality of eggs
k_1 = mortality of first instar larvae
k_2 = mortality of second instar larvae
k_3 = mortality of third instar larvae
k_4 = mortality of fourth instar larvae
k_5 = mortality of fifth instar larvae
k_p = mortality of pupa

Isolating of mortality agents

In this study, six categories of egg mortality factors had been identified based on evidences from the field observations. First, if the eggshell was broken or there was a remnant of shell with no leaf damage around the egg shell, the mortality factor was classified as caused by predators. Second, if the egg has a black spot with the absence of a red spot on its upper area and it did not hatch until the third observation (5 or 6 days), the egg was taken to the laboratory and kept in plastic vials for up to 10 days. Parasitoids would likely emerge from the egg. Therefore the mortality factor in this case was considered as parasitoids. Third, if no parasitoids emerge from the egg, it would be dissected under a light microscope. Sometimes parasitoids may fail to develop inside the eggs and the eggs too failed to hatch. Here, parasitoids were also the cause of the egg mortality. However, when no parasitoid was found after dissection, the egg was considered as failed to hatch due to natural causes. Fourth, in the absence of both eggshell and damaged leaves around eggs but there were heavy or moderate rainfalls two days prior to the observation; mortality was classified as caused by rain. Fifth subsequently, broken eggs that fell to the ground or went missing were considered dead due to human error. Finally, for the eggs found on the ground or which were missing due to attack by leaf feeders such as curculionid beetle and grasshopper they considered eaten by this insects hence then mortality factor.

For the larval stage, four mortality factors were identified; predator, parasitoid, rain, and human error. The characteristics of the last three factors were similar to those described for the egg stage. Predations in the larvae were concluded through several evidences, such as the presence of larval fluid or larval skin or dead larval bodies on the host plant. Predators, such as spiders and ants usually lived together with the larvae on the same plant.

Predators and parasitoids were the major mortality agents in the pupal stage. Missing pupae were classified as being killed by the predators. The presence of black spots on the pupal body was an indicator of parasitism. Pupa was collected from the field and kept in a plastic vial in the laboratory until a parasitoid emerged. The parasitoid and predator were identified to the lowest possible taxa using keys of Zhang et al. (2005) and Hayat and Khan (2007). The spiders were identified using Comstock (1971). They were also compared to several available photographs in various websites on the internet.

Statistical analysis

The mortality factors data in various seasons were analyzed by the Kolmogorov-Smirnov test for normality. Based on the abnormality of data distribution, and non-effective transformation, the non-parametric analyses were used to analyze the collected data. Differences in mortality of the immature stages during different seasons (three seasons) were analysed using the Friedman test. The Mann-Withney U test were subsequently used to compare mortalities between two seasons, when necessary. All data were analyzed using the SPSS software version 12 (Pallant 2005).

RESULTS AND DISCUSSION

Life table of *P. demoleus*

In the present study revealed that survivorship of *P. demoleus* varied in the various seasons. Percentages of eggs of *P. demoleus* that successfully developed to adults in the DS (1.74%) were lower than in the SWS (2.15%) and in the PWS (3.20%) (Table 1 and Figure 1).

Generally in all seasons showed that mortality (q_x) of the young larvae was lower than the older larvae. The mortality of the fifth instar larvae in the DS, SWS and PWS were higher than in other stages. Mortality of the first and second instars larvae in the SWS and PWS was lower than the third and fourth instars. Contrarily, the mortality of the first and second instars in the DS was higher than the third and fourth instars (Table 1).

Table 1. Age-specific life table of *Papilio demoleus* during the three seasons (DS, SWS and PWS) in tropical fruits plantation, Tasek Gelugor, Pulau Pinang, Malaysia.

X	l_x			d_xF	D'_x			q'_x			S			*k*-value;-[ln(s)]		
	DS	SWS	PWS		DS	SWS	PWS	DS	SWS	PWS	DS	SWS	PWS	DS	SWS	PWS
Egg	979	3261	2000	Failure to hatch	4	13	21	0.004	0.004	0.011	0.713	0.734	0.743	0.338	0.309	0.297
				Rain	4	82	78	0.004	0.025	0.039						
				Predator	239	616	297	0.244	0.189	0.149						
				Parasitoid	27	132	100	0.028	0.040	0.050						
				Leaf feeder	6	15	17	0.006	0.005	0.009						
				Human error	1	8	2	0.001	0.002	0.001						
L1	698	2395	1485	Abiotic factor							0.569	0.711	0.657	0.564	0.341	0.420
				Rain	6	13	62	0.009	0.005	0.042						
				Bioitic factor												
				Predator	294	672	446	0.421	0.281	0.300						
				Others												
				Leaf feeder		4			0.002							
				Human error	1	2	1	0.001	0.001	0.001						
L2	397	1704	976	Abiotic factor	165			0.416			0.584	0.746	0.720	0.538	0.239	0.328
				Rain		2	7		0.001	0.007						
				Biotic factor												
				Predator		429	266		0.252	0.273						
L3	232	1272	703	Predator	70	446	262	0.302	0.351	0.373	0.698	0.649	0.627	0.360	0.432	0.467
L4	162	826	441	Predator	39	200	107	0.241	0.242	0.243	0.605	0.538	0.642	0.503	0.620	0.443
				Birds												
				Praying mantis												
				C. versicolor												
				S. dichotomus + *Podisus* sp.	25	182	51	0.154	0.220	0.116						
L5	98	444	283	Predator	31	148	102	0.316	0.333	0.360	0.306	0.218	0.332	1.184	1.523	1.103
				Birds												
				Praying mantis.												
				C. versicolor												
				S. dichotomus + *Podisus* sp.	37	199	87	0.378	0.448	0.307						
Pupa	30	97	94	Predator							0.567	0.722	0.681	0.567	0.326	0.348
				Birds + *C. versicolor*	6	6	6	0.200	0.062	0.064						
				S. dichotomus	2	1	2	0.067	0.010	0.021						
				Ant		1	1		0.010	0.011						
				Parasitoid												
				P. puparum	5	19	21	0.167	0.196	0.023						
Adult	17	70	64													
				Total killing power (∑*k*-value)										4.054	3.844	3.442

Note: DS = Dry Season, SWS = Secondary Wet Season, PWS = Primary Wet Season. X = stage of *P. demoleus* and *P. polytes*. l_x = initial number of insects. d_xF = mortality agents. D'_x = number of deaths from different agents. q'_x = mortality from different agents. s = survival. k-value = killing power at each stage. L1 = 1^{st} instar. L2 = 2^{nd} instar. L3 = 3^{rd} instar. L4 = 4^{th} instar. L5 = 5^{th} instar.

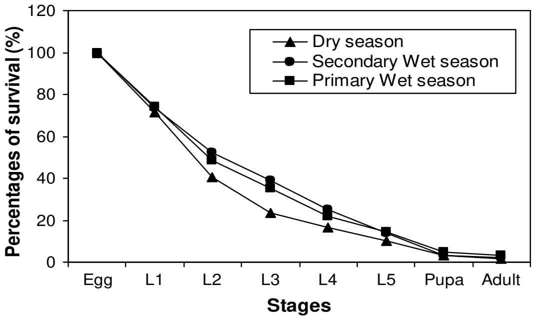

Figure 1. Survivalship curves for *Papilio demoleus* in each season in the tropical fruits plantation, Tasek Gelugor, Pulau Pinang, Malaysia.

Predators, parasitoids, and rain were the important factors of mortality in immature stages of *P. demoleus.* Predators caused the highest mortality in all stages except the pupal stage. Predation on eggs (24.41%) in the DS was higher than predatism on eggs in the SWS (18.89%) and in the PWS (14.85%). In contrast, parasitized eggs and mortality caused by rain recorded in the DS were lower than in the SWS and PWS (Table 1). Three other mortality factors such as, failed to hatch, fell onto the ground, and human error only caused a low percentage of mortality of the eggs.

In general, predator was the main mortality factor in the larval stage. Predators such as spiders from the family Salticidae, Oxyopidae (especially *Oxyopes* sp.) and Thomisidae contributed significant amount of young larval mortality of *P. demoleus.* Insect predators such as *Sycanus* *dichotomus* (Heteroptera: Reduviidae), *Podisus* sp. (Heteroptera: Pentatomidae), praying mantis, and Tettigonidae (mostly in nymphal stages) also played a part in decreasing the population of younger instars larvae. Assasin bug, *S. dichotomus* was the most important mortality factor of the fourth and fifth instars. Parasitoids however, killed the pupae of *P. demoleus* in the SWS and PWS were higher than the predators. Meanwhile in the DS parasitoids contributed 16.67% mortality of the pupae, lower than predators' contribution (26.67%). The parasitoid *Pteromalus puparum* on the other hand was a major mortality factor for the pupae.

The total killing power (*K*-value) of immature stage *P. demoleus*, in the DS was 4.054, higher than in the SWS (3.844) and in the PWS (3.442). Among all life stages, the *k*-value of the fifth instar of *P. demoleus* in total all seasons was the highest, followed by the fourth instar larvae. The lowest *k*-value of *P. demoleus* was in the egg stage. Its mean that mortality the older larvae were the weakness stage among the life stage of *P. demoleus.*

Quantification of mortality factors

During the DS, predators caused higher mortality (94.39%) of *P. demoleus* than in the SWS (90.88%) and in the PWS (84.04%) (Figure 2). However, Table 2 shows that the percentages of mortality that caused by these predators in the three seasons were not significantly different (Friedman test, P = 0.05). Generally, spiders and ants preferred younger instars (L1-L3) of their hosts. The nymphs of *S. dichotomus, Podisus* sp. and praying mantis preyed on young instars also. However their adults usually preyed on L4 and L5, and the prepupa. Among the predators, *S. dichotomus* was observed to be the major threat to the fourth and fifth instars of *P. demoleus.* The garden lizards were often observed to prey on caterpillar. As they were bigger in size, they preferred the bigger instars (L4 and L5) and the pupa. Similarly, several species of birds showed strong size specific preference. Small birds usually preyed on the younger instars while the bigger birds took the older larvae, prepupae and pupae.

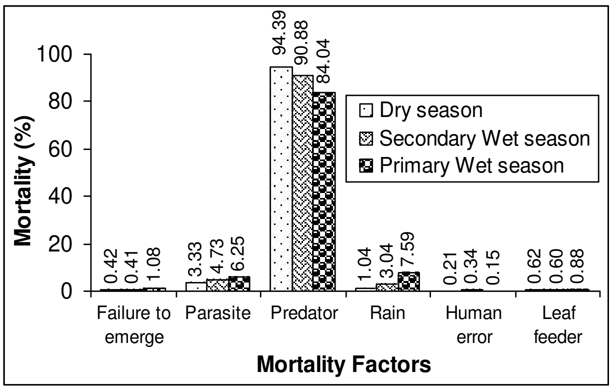

Figure 2. Percentage mortality of a. *Papilio demoleus* in the tropical fruits plantation, Tasek Gelugor, Pulau Pinang, Malaysia due to various factors.

Parasitoids caused 3.33-6.25% mortality of immature stages of *P. demoleus* (Figure 2). The amount of parasitism varied during the period of study and the percentages of mortality of *P. demoleus* caused by these parasitoids was significantly different in the three seasons (Friedman test P = 0.05) (Table 3). During heavy rain, eggs that were attached to leaves of the host plants were washed to the ground and subsequently died. The mortalities of *P. demoleus* due to rain were significantly different in all three seasons (Mann-Whitney test, P=0.05) (Table 3).

Although contributions of other three mortality agents (failure to hatch, human error and leaf feeders) were less than 2% (Figures 2), they affected the abundance of the immature population. Perhaps the mortality due to human error was rather insignificant (0.15-0.69%).

Table 2. The Friedman test percentage of the main mortality factors of immature stages of *Papilio demoleus* in different seasons

Factors	*P. demoleus*		
	Chi-Square	df	sig.
Predators	2.254	2	0.324
Parasitoids	46.265	2	0.000*
Rain	58.772	2	0.000*

Note: Significant values marked with an asterisk "*" are significantly different (Friedman test, $P < 0.05$)

Table 3. The Mann-Whitney U test on the effect of parasitism and the rain on *Papilio demoleus*

Species	DS vs. SWS		DS vs. PWS		SWS vs. PWS	
	Mann-Whitney U	sig.	Mann-Whitney U	sig.	Mann-Whitney U	sig.
Parasitism	14709.00	0.000*	16403.50	0.000*	21101.50	0.490*
Rain	16308.00	0.000*	14689.50	0.000*	19226.00	0.010*

Note: Significant values marked with an asterisk "*" are significantly different (Mann-Whitney U test, $P < 0.05$)

Discussion

Survivorship of egg turn to adult of *P. demoleus* was varied in various seasons or generations. The similar results were found on *P. polyxenes* (Feeny et al. 1997). They stated that the environmental condition and host plant were determined the survivorship of those butterflies.

It was obvious that two kinds of natural enemies, predators and parasitoids were very important in determining the survivorship of their immature stages in this study. This two biotic agents were also found to be the main mortality factors acting upon immature stages of *Hypna clytemnestra* (Lepidoptera: Nymphalidae) (Gomes-Filho 2003) and *Iphiclides podalirius* (Lepidoptera: Papilionidae) (Stefanescu et al. 2006). The fifth instar larva of *P. demoleus* was observed to be longer. Consequently, they were more exposed to the parasitoids and predators. The pupal parasitoid, *P. puparum* injected their eggs in the late fifth instar larvae, prepupa or freshly moulted pupa, developed inside the host and finally emerged when these stages turned to old pupae.

Predators were the main mortality factor of *P. demoleus* in all seasons. In general, mortality by predation was the highest throughout the stages except for pupae. This result agrees with (Fenny et al. 1997), where the mortality of black swallowtail butterfly due to predators was higher than the amount killed by parasitoids. In contrast, Hawkins et al. (1997) and Okolle (2007) reported that parasitoids killed more herbivores than the predators. According to Hawkins et al. (1997), ecological and biological differences among herbivores could lead to variations in attack rates by different types of respective natural enemies.

The presence of many kinds of predators such as spiders, birds, assassin bugs (Reduviidae), tettigonids, preying mantis and garden lizard in this orchard resulted in high predation on the immature of *P. demoleus*. Variation in the amount of predation was very much related to the size of the larval instars. The common predators of young instars as well as eggs were spider and ants. The spiders live in the same habitats as the larvae. It was observed that the small spiders preferred the eggs and the larger spiders attacked on the larvae. According to Li et al. (2006), the eggs of *Byasa impediens* are easily eaten by spiders, earwigs, and bugs. During this study the spiders were observed attacking the eggs and larvae several times.

A small bodied Oxyopidae and Thomisidae presumably have stronger preference for the first and second instars of *P. demoleus*. *Oxyopes elegans* and *O. quadrifasciatus* in the family Oxyopidae were the commonest spider in the citrus field. Both spiders were very active and attacked the first and second instars of *P. demoleus*. Thomisidae and Oxyopidae have already been identified in agro ecosystem for a number of years (Evans 1985). According to Pearce et al. (2004) they ate approximately 9. 37 first instar *H. armigera* per spider per day.

Nymph of *Mantis*, katidid and assassin bugs, attacked the second and third instar larvae. Older nymphs could attack the older larvae because of size compatibility. *Sycanus dichotomus* (Heteroptera: Reduviidae) displayed size preference for their preys (larvae). The adults of this reduviid are the major predator for the fourth and the fifth instars. They would search for the fourth and the fifth instars larvae on all citrus seedlings and contributed to 40-50% mortalities of these stages. Its nymphs attacked younger instar in the second and third larval stages. *Sycanus dichotomus* fed on larvae by inserting its rostrum through the cuticle of the larvae and extracted the internal tissue. After feeding on one larva, it would search for another. The dead larva changed to black after several hours. This reduviid is a common and an important predator of nettle caterpillars and bagworms in oil palm plantation (Zulkifli et al. 2004).

Birds and the garden lizard (*Calotes versicolor*) are vertebrate predators which attacked the larvae and pupae of *P. demoleus*. Small sized birds such as *Lonchura* spp. (Passeriformes: Ploceidae), *Passer montanus* (Passeriformes: Motacilidae), and *Prinia familiaris* (Passeriformes: Cisticolidae) usually ate on young larvae. Meanwhile, the garden lizards feed largely on insects, but they also eat on other animals. These two vertebrate predators were also reported to attack the larvae of *P. polytes* and *P. demoleus* in citrus plantation in Lower Sindh, Pakistan (Munir 2004). According to Catta-Preta and Zucoloto (2003) birds are the most important natural enemies of *Ascia monuste* butterflies and its larvae in cabbage farms.

This particularly citrus plantation in area was not properly managed. High infestation of *P. demoleus* and other butterflies were observed in the study area. These pests in turn provided ample food supply for the predators. During the SWS and PWS, weeds and herbaceous plants grew profusely, supplying food to the herbaceous pests. Consequently, their population increased during this season. In the absence of these growths in the DS, the pest populations declined.

The percentage of larvae of *P. demoleus* which successfully became adults in the DS was lower than in the SWS and PWS. Predators as the main factor in population mortality of *P. demoleus* were believed to have an important role in this phenomenon. Fewer weed populations around the study area during the DS could presumably reduce the population of other pest that served as alternative foods for the predators; hence more larvae of *P. demoleus* were taken.

Seasons of the year was observed to indirectly influence parasitization activities of the parasitoids. Very likely the activities of the parasitoids were correlated to the availability of food for their adults in their habitat. The floral resources positively affected on the activity and density of several parasitoids (Lavandero et al. 2005). During the PWS, most of the weeds that grew around the field were flowering and producing nectar. The adult parasitoids fed on these nectar hence became more active which resulted in more eggs were laid in their hosts. Further studies by Gamez-Virues et al. (2008) found that, the nectar of herbaceous plants added value to the agro-ecosystem through enhanced population and longevity of parasitoids. Similarly parasitism of the egg and pupal stage of *E. thrax* was higher in subsystem farms and during the wet season as reported by Okolle (2007). Similar as reported by Zalucki et al. (2002) that, generally, parasitism is a major cause of mortality in eggs but not for early instar.

Ooencyrtus papilionis and *Pteromalus puparum* are an egg and pupal parasitoid, respectively. The females of *O. papilionis* oviposite their eggs on freshly eggs laid of *P. demoleus*. On certain occasion, the females of *O. papilionis* waited for the females of *Papilio* to oviposit their eggs on the young leaves and the parasitoids injected the host eggs as soon as they were laid. Egg parasitoids generally preferred the new eggs (Fatouros et al. 2005; Okolle 2007). *Pteromalus puparum* is a gregarious parasitoid of lepidopterous pupa and attack the fifth instar, prepupa and new pupa of *P. demoleus*. This parasitoid caused high mortality of pupal stage. Earlier studies also found *P. puparum* in pupa of many other species of *Papilio* (Munir 2004).

Quality of host plant could also affect on the survivorship of *P. demoleus* larvae in the SWS and PWS. More young shoots and young leaves of *C. reticulata* were produced because more rainfall in these seasons. Young leaves contain higher protein compared to mature leaves. Barron et al. (2004) found that the population density of *Bassaris gonerilla* (Lepidoptera: Nymphalidae) was lower in a low rainfall season caused by the lower nutritional quality of the host plant, *Urtica ferox*, hence high of larval mortality.

Heavy rain in the wet season significantly contributes mortalities to egg and young instar of *P. demoleus*. According to Feeny et al. (1997) some eggs or small larvae of *P. polyxenes* may succumb to drowning or dislodgement by rain or strong wind. The late instar larvae and pupae were less affected by rain because they strongly adhered to the leaves or stems of the host plants. Li et al. (2006) reported that the hot and dry weather in summer and the heavy rain in autumn considerably reduce the survival rate of eggs and larvae of *Byasa impediens* (Lepidoptera: Papilionidae). Weather factor (heavy rain and strong wind) presumably were more detrimental to the young instars, while natural enemies killed both the young and older instars of phytophagous insects (Hawkins et al. 1997).

CONCLUSION

The season influenced the survivorship of *P. demoleus* in citrus plantation. *Papilio demoleus* had the highest survival in the wet primary season (PWS), while the lowest survival was observed in the dry season (DS). The *k*-values were varied in various stages and seasons. Predators were the most important population regulator of this species in all seasons. *Ooencyrtus papilionis, Selenopsis* sp. and some of small spiders were the important mortality agents on the egg stage. The other spiders and Tettigoniidae were the important mortality agent of young instars while, *S. dichotomus*, birds and *Calotes versicolor* were the main mortality agent in older instars. Parasitoid *Pteromalus puparum*, attacked and caused the highest mortality in the pupal stage. Mortality of immature stage of *P. demoleus* due to predator was no different in the seasons, whereas mortality due to parasitoids and rain was significantly different in each season. *Sycanus dichotomus* was very active predator this assassin bug can be use as to control of *P. demoleus* in the citrus plantation.

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