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Population dynamic of the swallowtail butterfly, *Papilio polytes* (Lepidoptera: Papilionidae) in dry and wet seasons

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ABSTRACT

Suwarno (2010) Population dynamic of the swallowtail butterfly, Papilio polytes *(Lepidoptera: Papilionidae) in dry and wet seasons. Biodiversitas 11: 19-23.* The population dynamic of *Papilio polytes* L. (Lepidoptera: Papilionidae) in dry and wet seasons was investigated in the citrus orchard in Tasek Gelugor, Pulau Pinang, Malaysia. Population of immature stages of *P. polytes* was observed alternate day 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 population dynamics of the immature stages of *P. polytes* varied between seasons. The immature stages of *P. polytes* are more abundance and significantly different in the PWS than those of the DS and the SWS. The larval densities in all seasons decreased with progressive development of the instar stages. Predators and parasitoids are the main factor in regulating the population abundance of immature stages of *P. polytes.* There were positive correlations between the abundance of immature stages of *P. polytes* and their natural enemies abundance in each season. *Ooencyrtus papilioni* Ashmead (Hymenoptera: Encyrtidae) is the most egg parasitoid. *Oxyopes quadrifasciatus* L. Koch. and *O. elegans* L. Koch. (Araneae: Oxyopidae) are the main predators in the young larvae, meanwhile *Sycanus dichotomus* Stal. (Heteroptera: Reduviidae), *Calotes versicolor* Fitzinger (Squamata: Agamidae), birds and praying mantis attacked the older larvae.

Key words: population dynamic, seasons, *Papilio polytes,* immature stages, natural enemies.

INTRODUCTION

Most studies on population dynamics of tropical butterflies were focused on the adult populations (Ehrlich and Gilbert 1973; Hayes 1981; Koh et al. 2004); only few reported on the larval population and their relationship with the environmental factors, particularly the biological factors (Hirosie et al. 1980; Watanabe 1981). Hirosie et al. (1980) and Watanabe (1981) reported that the population of immature *Papilio xuthus* L. (Lepidoptera: Papilionidae) varied throughout the year with the population of young larval instars fluctuated differently from the older instars. Meanwhile, Diez et al. (2006) reported that the population of *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) in lemon orchard as well as its parasitoids increased from spring to fall and declined during the winter. Usually, the butterflies display different growth performances (Rafi 1999a; Baguette and Schtickzelle 2003; Munir et al. 2007), fecundity (Davies et al. 2006) and population density in different weather conditions (Davies et al. 2006; Woods et al. 2008; Tiple et al. 2009).

Papilio polytes L. (Lepidoptera: Papilionidae) is a tropical or subtropical papilionid butterfly distributed from Southeast Asia to the Southwestern Island of Japan (Corbet and Pendlebury 1992; Nakayama and Honda 2004). They have a wide ecological tolerance enabling them to thrive in a broad variety of climatic conditions (Rafi et al. 1999a). However there are no studies or reports on the growth performances of *P. polytes* in different seasons in tropical areas.

Generally, in tropical regions, there are two seasons, dry and wet seasons. The temperature is usually higher in the dry season than in the wet season; meanwhile humidity and rainfall are lower in the dry than in the wet season. The weather parameters such as temperature, humidity, and rainfall are environmental factors that affect the development, growth and abundance or population dynamics of insects (Bryant et al. 2000; Warren et al. 2001; Perdikis et al. 2003; van Nouhuys and Lei 2004; Freitas et al. 2005; Pickens 2007).

Therefore, the objectives of this research were first, to study the population dynamics of the immature stages of *P. polytes* in different seasons. Secondly, to determines the relationship between the immature stages of *P. polytes* and their natural enemies.

MATERIALS AND METHODS

The study of population dynamic of the immature stages of *P. polytes* was conducted in the Taman Firdauce orchard, Tasek Gelugor, Pulau Pinang, Malaysia located at 5° 28’ 60 north latitude, and 100° 30’ 0 east longitude, 34 m above sea level. Taman Firdauce is an orchard planted with several tropical fruits, such as star fruit (*Averrhoa carambola* L.), citrus (*Citrus microcarpha* Bunge*, C. maxima* (Burm.) Merr.), mango (*Mangifera indica* L.), guava (*Psidium guajava* L.), avocado (*Persea americana* Mill.), jackfruit (*Artocarpus integra* Merr.), longan

(*Dimocarpus longan* Lour.), rambutan (*Nephelium lappaceum* L.), sour sop (*Annona muricata* L.) and water apple (*Syzygium aqueum* Merr.).

In the Taman Firdauce orchard, 216 seedlings of *Citrus reticulata* Blanco were planted in six rows, with each row containing 36 seedlings that were planted in "triangles" of 3.0 m apart and 4.5 m between the rows. Regular farming practices, such as fertilization, irrigation, and insecticidal applications were carried out to ensure a proper and healthy growth. A month prior to observation, insecticide applications were terminated. Unfortunately, six seedlings died during the preparation. The experimental observations were initiated after six months of planting and the plants attained a height of 50-75 cm.

The natural population of *P. polytes* was observed on 210 young plants of *C. reticulata* (50-75 cm in high) in orchard. Based on the data of climatic factors (temperature, humidity and rainfall) during six years (2000-2005) (Figure 1), the observations were carried out in three different seasons, whereby three months (January – March 2006) was the dry season (DS), four months (April – July 2007) was the secondary wet season (SWS) and three months (October – December 2006) was the primary wet season (PWS). The weather data were taken from Bayan Lepas Meteorological station, in Penang, Malaysia. The population levels of all stages of growth from egg to adult were recorded. Before starting the observation in each season, all immature stages of *P. polytes* was removed from the host plants to prevent overlapping of seasons.

The eggs of *P. polytes* was attached to the citrus plant (leaves and stems) were counted and labelled. The newly hatched larvae were recorded and their development was labelled and monitored in the alternate day until the adult emerged. The observations were made on specific seasonal cohorts.

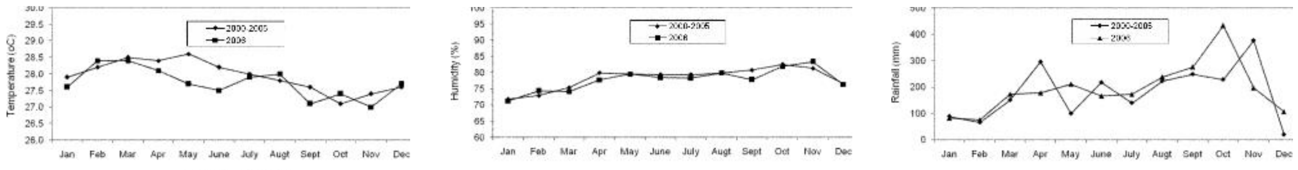
The data on abundance of immature stages and natural enemies of *P. polytes* in all seasons were not normally distributed (Smirnov-Kolmogorov, $P < 0.05$) hence they were all analyzed using the non-parametric procedures. The abundance of the immature stages in various seasons was analysed using the Friedman test (Dytham 2003; Pallant 2005).

The relationships of the abundance of immature stages of *P. polytes* with their natural enemies were evaluated by simple correlation and simple linear regression analyses. The data of eggs, larvae, parasitized and predated egg and predated larvae population in each season were pooled and transformed using $\log_{(x)}$, $\log_{(x+1)}$ or $\sqrt{(x)}$, $\sqrt{(x+1)}$ whenever appropriate (Dytham 2003; Pallant 2005), to normalize their distributions before data use subjected to ANOVA. All the above comparisons and relationships were analyzed using the SPSS software version 12 (Dytham 2003; Pallant 2005).

RESULTS AND DISCUSSION

The abundance of the immature stages of *P. polytes* was investigated in three seasons; dry season, secondary and primary wet seasons. Each stage fluctuated differently and significantly at $P < 0.05$ in all seasons (Table 1). Among the three seasons, the abundance of *P. polytes* was very low in the dry season and the highest in the primary wet season.

Predators and parasitoid are the main natural enemies of the immature stages of *P. polytes*. The increased and decreased in number of immature stage of *P. polytes* closely related to the increase and decrease of their natural enemies. A strong positive correlation between the immature stages density of *P. polytes* and their natural enemies was recorded in the dry season (r = 0.94), in the secondary wet season (r = 0.89) and in the primary wet season (r = 0.96). Furthermore, the regression analysis showed that the density of immature stage of *P. polytes* in dry season, secondary and primary wet seasons were significantly affected on their natural enemies (Figure 2).



A B C

Figure 1. The distribution abiotic factors in Tasek Gelugor, Pulau Pinang, Malaysia from 2000-2005 (average) and 2006. (a) Temperature (°C), (b) Relative humidity (%), (c) Rainfall (mm).

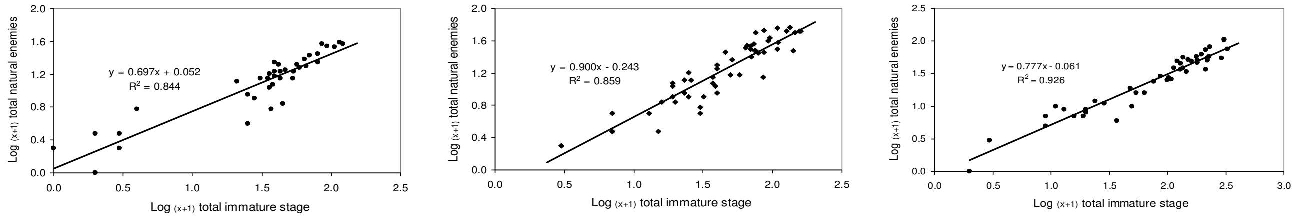


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Figure 2. Relationship of total number of immature stage (egg to larva instar 5) of *P. polytes* and their natural enemies on *Citrus reticulata*, in Taman Firdauce orchard, Tasek Gelugor, Pulau Pinang, Malaysia in different season from January to December 2006. A. DS = Dry Season, B. SWS = Secondary Wet Season, C. PWS = Primary Wet Season.

Generally, fluctuation of natural enemies density of the immature stage of *P. polytes* in each season depended on the immature stage density. During the dry season egg predated and egg parasitized of *P. polytes* increased significantly positive correlated to increasing of egg density (Table 2). Regression analysis showed that the increased of egg density significantly affected ($P < 0.01$) on the predators of egg (Table 2).

The larval density was related to predators of larval density. The positive correlation was recorded between the density of *P. polytes* larval and their natural enemies in dry season (Table 2). Furthermore, the regression analyses showed that the predated larval density on each instar was significantly affected ($P < 0.01$) by each larval density of *P. polytes* (Table 2).

A modest to strong positive correlation was observed between immature stages density of *P. polytes* and its natural enemies in the secondary wet season. Furthermore, a simple linear regression analyses showed that the increased in the egg and larvae density of *P. polytes* in secondary wet season significantly increased ($P < 0.01$) the number of the natural enemies (Table 3).

In the primary wet season, fluctuation density of the egg of *P. polytes* closely related to their predated and parasitized egg. A strong positive correlation was recorded between the egg density of *P. polytes* and the predated and parasitized egg in this season (Table 4). The similar phenomenon was observed on the larvae whereby, fluctuation of larvae in each instar was closely related to their predated larvae fluctuation. The strong positively correlations were observed between the larval density of *P. polytes* and predated larvae in each instar (Table 4). The simple linear regression analyses showed the egg and larvae density of *P. polytes* in primary wet season significantly affected ($P < 0.01$) on predated egg and larvae with the equation as shown on Table 4.

Population dynamics of the immature stages of *P. polytes* varied between seasons. It might be affected by several factors such as climate, nutrient and natural enemies. Natural enemies are the important component in the population dynamics of this butterfly. The natural enemies have influence on total insect number and some-times their impact is related to the density of their prey (Hirosie et al. 1980; Watanabe 1981; Feeny et al. 1985; Stefanescu 2000; Zalucki et al. 2002; Pearce et al. 2004; Nava et al. 2005; Stefanescu et al. 2006).

Table 1. The abundance of immature stage of *P. polytes* on *C. reticulata* in all seasons in Taman Firdauce orchard, Tasek Gelugor, Pulau Pinang, Malaysia, from January 2006 to December 2007.

Stages	Chi-Square	df	sig.
Egg	82.88	2	0.00*
L1	129.97	2	0.00*
L2	79.02	2	0.00*
L3	84.63	2	0.00*
L4	71.16	2	0.00*
L5	42.67	2	0.00*
Pupa	18.09	2	0.00*

Note: L1 = first instar larvae; L2 = second instar larvae; L3 = third instar larvae; L4 = fourth instar larvae; L5 = fifth instar larvae; Significant values marked with an asterisk "*" are significantly different (Friedman test, $P < 0.05$)

Table 2. Correlation and regression analyses between the number of each stage of *P. polytes* and they had attacked by natural enemies on *C. reticulata* in Taman Firdauce orchard, Kampong Paya Tok Akil, Tasek Gelugor, Pulau Pinang, Malaysia in dry season from January to March 2006. r = The Pearson correlation ($P = 0.01$).

Relationships	n	r	*F* value	y = a + bx	R^2	*P* value
EggVs.Parasitoids	31	$0.49^{\#}$	-	-	-	-
Egg Vs. Predators	31	0.69	15.985	y = 0.127+0.341x	0.60	< 0.01
L1 Vs. Predators	32	0.86	87.582	y=-0.381+0.759x	0.87	< 0.01
L2 Vs. Predators	32	0.80	40.765	y = 0.097+0.588x	0.76	< 0.01
L3 Vs. Predators	30	0.62	14.521	y=-0.449+1.005x	0.60	< 0.01
L4 Vs. Predators	30	0.60	14.758	y = 0.282+0.560x	0.60	< 0.01
L5 Vs. Predators	32	0.81	51.872	y = 0.122+0.992x	0.80	< 0.01

$^{\#}$) Data not normally distribution, L1 = first instar larva, L2 = second instar larva, L3 = third instar larva, L4 = fourth instar larva, L5 = fifth instar larva.

Table 3. Correlation and regression analyses between the number of immature stage of *P. polytes* and they had attacked by natural enemies on *C. reticulata* in Taman Firdauce orchard, Tasek Gelugor, Pulau Pinang, Malaysia in SWS from April to July 2006. r = The Pearson correlation ($P = 0.01$).

Relationships	n	r	F value	y = a + bx	R^2	P value
EggVs.Parasitoids	46	$0.654^{\#}$	-	-	-	-
Egg Vs. Predators	46	0.677	70.431	y = 0.285+0.861x	0.788	< 0.01
L1 Vs. Predators	48	0.645	30.954	y = 0.050+0.655x	0.638	< 0.01
L2 Vs. Predators	47	0.447	13.964	y = 0.068+0.487x	0.483	< 0.01
L3 Vs. Predators	48	0.861	79.342	y = 0.013+0.677x	0.799	< 0.01
L4 Vs. Predators	49	0.776	65.454	y = 0.069+0.723x	0.767	< 0.01
L5 Vs. Predators	50	0.887	65.597	y = 0.103+0.891x	0.763	< 0.01

$^{\#}$) Data not normally distribution, L1 = first instar larva, L2 = second instar larva, L3 = third instar larva, L4 = fourth instar larva, L5 = fifth instar larva.

Table 4. Correlation and regression analyses between the number of immature stage of *P. polytes* and they had attacked by natural enemies on *C. reticulata* in Taman Firdauce orchard, Tasek Gelugor, Pulau Pinang, Malaysia in PWS from October to December 2006. r = The Pearson correlation ($P = 0.01$).

Relationships	n	r	*F* value	y = a + bx	R^2	*P* value
EggVs.Parasitoids	39	0.72	50.57	y=-0.558+0.678x	0.76	< 0.01
Egg Vs. Predators	39	0.86	77.26	y = 0.154+0.656x	0.83	< 0.01
L1 Vs. Predators	40	0.74	60.11	y = 0.041+0.617x	0.79	< 0.01
L2 Vs. Predators	39	0.87	137.00	y = 0.192+0.584x	0.89	< 0.01
L3 Vs. Predators	39	0.86	97.62	y = 0.036+0.667x	0.86	< 0.01
L4 Vs. Predators	40	0.88	151.55	y = 0.033+0.619x	0.90	< 0.01
L5 Vs. Predators	39	0.85	97.13	y = 0.007+0.653x	0.86	< 0.01

L1 = first instar larva, L2 = second instar larva, L3 = third instar larva, L4 = fourth instar larva, L5 = fifth instar larva.

The lower abundance of eggs and larvae of *P. polytes* in dry season was probably due to a lesser amount of young leaves and poorer quality of leaves of *C. reticulata*. Females of *Papilio* species (Ono et al. 2000; Saljoqi et al. 2006) and *Hypna clytemnestra* Cramer (Lepidoptera: Nymphalidae) (Gomes-Filho 2003) have great precision to lay their eggs on the healthiest young leaves which subsequently prefer to lay their eggs on its as preparation for their offsprings. This statement supported the results in the present *P. polytes* study.

In the secondary and primary wet seasons, flushes of the young leaves after the rains attracted more females to oviposit on them. Barone (2000) found that the spatial and temporal distributions of *Bassaris gonerilla* Fabr. (Lepidoptera: Nymphalidae) are correlated to the availability of young leaves. Furthermore, Ba et al. (2008) stated that the adult populations of *Chilo* spp. (Lepidoptera: Pyralidae) were more abundant during the wet than the dry cropping seasons.

When more eggs of *P. polytes* were laid by females in the secondary and primary wet seasons, the larval abundance were subsequently higher in those seasons. Rafi et al. (1999b) reported that the egg density of *Papilio demoleus* L. (Lepidoptera: Papilionidae) was correlated to their larval density. Since the larvae were growing into the adulthood, many factors affected their population.

The larval densities of *P. polytes* in all seasons decreased with progressive development of the instar stages. The abundance of larvae (Instar 1-5) of *P. polytes,* were generally significantly different in the various seasons. The variation in the number of eggs determined the larval abundance in each season. The abundance certain stage of the life cycle was determined by the abundance and mortality of the previous stage. Since the mortality agents in the larval stage of *P. polytes* were living together on the same host plant, it would strongly affect the butterflies' population. As a result constant mortality rate occurred in that population.

In the Firdauce orchard, natural enemies were found to be the most important factor regulating the population of *P. polytes*. Among all stages, the eggs suffered the most attack especially by the predators and parasitoids. Spiders, such as *Oxyopes* spp. were the most important predators. Others include the red ant, *Solenopsis* sp. Parasitoid species was mostly *Ooencyrtus papilioni* Ashmead (Hymenoptera: Encyrtidae). At the young larval stage, spiders such as *Oxyopes quadrifasciatus* L. Koch. and *O. elegans* L. Koch. were considered as the principle enemies to the *P. polytes*. The other larval predators such as, *Sycanus dichotomus* Stal. (Heteroptera: Reduviidae), *Calotes versicolor* Fitzinger (Squamata: Agamidae), birds and *Mantis* attacked the older larvae.

The population of parasitoids and predators increased with increasing number of eggs and larvae of *P. polytes*. There was a positive relationship between the egg densities of *P. polytes* and the number of predated eggs. Such relationship was observed in *Papilio polyxenes* Fabr. (Feeny et al. 1985), *P. xuthus* (Hirosie et al. 1980; Watanabe 1981), *P. demoleus* and *P. polytes* in Lower Sindh, Pakistan (Munir et al. 2007). Many egg predators (such as spiders and ants) attacked the eggs and each of them ate many eggs during their attack. For all three seasons the egg mortality of *P. polytes* due to predation was 24.5%, higher than mortality due to parasitoid (6.6%).

Predators were also found to be the most important mortality factor of the larval stages of *P. polytes* in all three seasons, because they killed more than 25% of each larval instar. The numbers of larvae *P. polytes* killed by predators were strongly correlated to population densities of each instar. The most important predator, spider was well adapted to living on the same host plant with *P. polytes* larvae. On grain crop in Australia, Pearce et al. (2004) reported that spiders were also among the most abundant predators. Since the spiders are voracious predators and combined with their high abundance, they played an important role in the reduction of the pest populations. Meanwhile another predator, *S. dichotomus*, was very active and it searched the larvae on every part of the host plant.

This study also revealed that a member of the egg parasitized fluctuated closely with the total number of eggs of *P. polytes*. Obviously, the availability of eggs determined predatory success in the field. In a banana plantation Okolle (2007) reported a significant positive correlation between the density of egg of *Erionota thrax* L. (Lepidoptera: Hesperiidae) and its parasitoid, *Ooencyrtus erionotae* Ferrière (Hymenoptera: Encyrtidae) population. This finding was similar to previous studies on *P. xuthus* by Watanabe (1981), *P. polyxenes* by Feeny et al. (1985), and citrus leafminer, *Phyllocnistis citrella* Stainton (Lepidoptera: Gracillariidae) by Legaspi et al. (1999, 2001). Meanwhile, Fleming et al. (2005) reported that the egg parasitism affect the population dynamic of *Heliconius charithonia* L. (Lepidoptera: Nymphalidae).

The effect of predation on the fifth instar was higher compared to other larval stage due to the presence of many predator species such as *S. dichotomus*, *Mantis* sp., birds and garden lizard during this stage. These predators were very active and they consumed large number of larvae. Hirosie et al. (1980) and Watanabe (1981) found that S. *dichotomus* and *Mantis* were very important predators of *P. xuthus*, while predation by vertebrate, particularly bird and garden lizard accounted for a low proportion of the mortality of the fourth and fifth instar larvae. Higher mortality rate in the fifth instar larvae resulted in a low pupal population.

The relationship between the egg and its parasitoid in the secondary and primary wet seasons were higher than in the dry season. Higher rainfall and humidity in these seasons produced suitable host and the presence of food for adult. Legaspi et al. (1999) found that the higher parasitism on the leafminer, *P. citrella* in August compared to February was due to more rainfall in August which increased the humidity level. Furthermore they found that the presence of suitable hosts may also contribute to the increased incidence of the leaf miner parasites.

The availability of young leaves in secondary and primary wet seasons affected on abundance of *P. polytes* and subsequently correlates with their natural enemies density. Riihimäki et al. (2006) stated that the plant structure may have direct effects on herbivores as well as indirect effects mediated by natural enemies. Predator-prey and parasitoid-host relationships more frequently occur in simple vegetation structures than in complex ones (Cudington and Yodzis 2002).

CONCLUSION

As a conclusion of this study, the abundance of *P. polytes* in the Firdauce orchard varied in different seasons. The biotic factor, mainly the attack of natural enemies was of considerable importance. Number of parasitized eggs and predated larvae were strongly influenced by egg and larval densities, respectively. Predators were the key mortality factor of immature stages in *P. polytes* in all seasons.

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