

## Research Article

### Biology of Red Palm Mite, *Raoiella indica*, on Different Coconut Varieties

#### *Biologi Tungau Merah Kelapa, Raoiella indica, pada Beberapa Varietas Kelapa*

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#### ABSTRACT

Red palm mite, *Raoiella indica* Hirst (Acari: Tenuipalpidae), has emerged as a new threat to coconut plantation in Indonesia. To control this mite, understanding on its biology is essential. The effects of three coconut varieties (Salak Dwarf, Local Sumenep Tall, and Hybrid coconuts) on the development and fecundity of *R. indica* were determined under laboratory conditions at 26–28°C, 80% RH, and photoperiod of 12:12 (L:D). The life cycle of *R. indica* consisted of the egg, larva, protonymph, deutonymph, and adult stages. Total development time of immature females was significantly influenced by coconut varieties. The shortest immature developmental time occurred at Salak Dwarf variety (26.07 days), whereas no significant difference of development time of immature female on Hybrid and Local Sumenep Tall varieties was found. Moreover, there was also no significant difference on the development time of immature male and on the fecundity of the mite among different coconut varieties.

Keywords: development, fecundity, Tenuipalpidae, variety

#### INTISARI

Tungau merah kelapa, *Raoiella indica* Hirst (Acari: Tenuipalpidae), merupakan ancaman baru bagi perkebunan kelapa di Indonesia. Pemahaman mengenai biologi diperlukan untuk strategi pengendalian tungau tersebut di masa datang. Pengaruh tiga varietas kelapa yang berbeda (Genjah Salak, Lokal Sumenep, dan Hibrida) terhadap perkembangan dan keperidian *R. indica* diamati pada kondisi laboratorium dengan suhu 26–28°C, kelembapan nisbi 75–85%, serta pencahayaan 12 jam terang dan 12 jam gelap (L:D=12:12). Siklus hidup tungau terdiri dari telur, larva, protonimfa, deutonimfa, dan dewasa. Hasil pengujian menunjukkan bahwa waktu perkembangan betina pradewasa dipengaruhi secara nyata oleh varietas kelapa. Waktu perkembangan paling pendek terdapat pada kelapa Genjah Salak (26,07 hari), sedangkan waktu perkembangan betina pradewasa tidak berbeda nyata pada kelapa Hibrida dan Dalam Lokal Sumenep. Hasil lain pengujian menunjukkan tidak terdapat perbedaan nyata waktu perkembangan jantan pradewasa dan keperidian pada ketiga varietas.

Kata kunci: keperidian, perkembangan, Tenuipalpidae, varietas

#### INTRODUCTION

The red palm mite, *Raoiella indica* Hirst, is a serious pest commonly found on many arecaceous plants in the world (Roda *et al.*, 2008; Prabheena & Ramani, 2014; Hamza *et al.*, 2015). It was first reported and described by Hirst (1924) based on specimens taken from coconut plants grown in Tamil Nadu, India. Since then, *R. indica* has been found infesting palms in many countries in Asia and Africa, such as Sri Lanka, Pakistan, Egypt, Iran, Sudan, and the Philippines (Kane & Ochoa, 2006). Recently, *R. indica* have been invading throughout

America region and causing severe damage on coconut plantation. In the Caribbean, this mite can reduce 50–90% crop production on many coconut farms (Pena *et al.*, 2012; Roda *et al.*, 2008). Although palms is its main host, *R. indica* also has been found on many hosts, including banana and plantain (Rodrigues & Irish, 2011). This mite feeds through the stomata of the host plant causing scattered yellow spots or strong yellowish coloration on the entire leaflet (Ochoa *et al.*, 2011). The symptoms caused by mites could be confused with lethal yellowing disease (Pena *et al.*, 2012).

In Indonesia, *R. indica* was first found on coconut plants in Tarakan Island, Province of North Kalimantan in 2012 (Antarjo Dikin, Head of Center for Plant Quarantine and Biosafety, personal communication). Afterwards, this mite has been reported from other parts of Indonesia including East Kalimantan, Nusa Tenggara, Moluccas, as well as several coconut plantations in Java (Nusantara *et al.*, 2017). So far, *R. indica* was not considered as harmful pest. However, the feeding damage by this mite seems more significant on young coconut plants.

The biology of *R. indica* under Indonesian conditions is still unknown. The biology of *R. indica* maintained on leaf arena has been studied by a number of researchers in other countries. Previous studies showed that the population growth parameters of *R. indica* such as developmental rate, longevity and fecundity depend on the environmental conditions such as temperature, relative humidity, and host plants (Moutia, 1958; Zaher *et al.*, 1969; Cocco & Hoy, 2009; Flores-Galano *et al.*, 2010; Gonzalez-Reyes & Ramos, 2010).

The objective of the present work was to study the development and reproduction of a local population of *R. indica* on coconut varieties in Indonesia, *i.e.*: Salak Dwarf, Local Sumenep Tall, and Hybrid coconut. The result of this study was the first report of biology of *R. indica* in Indonesia.

## MATERIALS AND METHODS

### *Red Palm Mite Culture*

*R. indica* colonies were collected from coconut plants in Slipi, District of Palmerah, West Jakarta (located at 6°12'05.74"S latitude and 106°48'0.67"E longitude). Stock cultures were reared on 1–2 year-old coconut seedlings in the screen house of Tanjung Priok Agricultural Quarantine Station in Bogor since July 2014. The coconut varieties used for mite culture were Salak Dwarf, Local Sumenep Tall, and Hybrid coconut. Colonies establishment was obtained by transferring mites from infested plants by smooth brush (no. 0000) or sticking mite-infested leaves on non-infested seedlings. All infested seedlings were kept in the gauze cage to prevent the contamination of natural enemies or other arthropods. These mite cultures were used for all the studies in laboratory of Tanjung Priok Agricultural Quarantine Station in Bogor.

### *Experimental Design*

The immature developmental time and female performance were studied on three varieties: Salak Dwarf, Local Sumenep Tall, and Hybrid (Figure 1). The dwarf variety was obtained from Indonesian Industry and Freshner Crops Research Institute (IIFCRI) in Parungkuda (Sukabumi), the tall variety was obtained from coconut farms in Dongkek (Sumenep, Madura Island), and hybrid coconut from commercial nursery and coconut farms in Bogor. A completely randomized design with three treatments and 30 replications for each treatment was employed. This study were conducted under the laboratory conditions at 26–28°C, 75–85% RH, and a photoperiod of 12:12 (L:D).

### *Developmental Time of Immature Stages*

The length of each developmental stage was studied on arena following procedures described by Hoy (2011) with some modifications. The arena unit consisted of a coconut leaf piece (2×2 cm) with the lower surface facing upward was placed on a layer of cotton (4×4 cm). The cotton was put on a piece of foam (5×5 cm) in plastic plate (diameter = 9 cm). The cotton and foam were moistened with sufficient water daily to maintain leaf freshness and avoid mites from escaping.

Three to four females of *R. indica* from same variety of stock culture were placed on a leaf arena and allowed to lay eggs. After 12 hours, leaf pieces were observed to determine when oviposition took place. Each arena only had one egg and the excess eggs were removed. Egg was observed at 12 hours intervals (at 06.00 am and 06.00 pm) until reaching adulthood to determine the duration of each developmental stage, including quiescent period before molting. Leaf pieces were renewed every 4–5 days to avoid leaf deterioration and provide adequate nutrition.

### *Female Longevity and Fecundity*

A female teliochrysalis from stock culture was placed on arena. Each arena was provided two males to increase the chances of mating. The female teliochrysalis was observed on 12 hour intervals to determine when adulthood started. The number of eggs laid by the female was recorded daily and then removed. Dead or missing males were replaced by new males from the same culture. As previous experiment, leaf pieces were replaced with new leaf after 4–5 days. Observations were continued until the females died.

### Data Analyses

The effects of coconut varieties on the immature developmental time, along with females fecundity and longevity parameters were analyzed by one-way analysis of variance (Anova). The means were compared using Tukey test or Kruskal-Wallis test ( $\alpha=0.05$ ) after normality and homogeneity data were checked by Kolmogorov-Smirnov test and Levene's test, respectively. A *t*-test or Mann-Whitney test was run for comparison of total immature developmental times of males and females on the same coconut variety. All statistical analyses were carried out using SPSS Statistic 23.0 version.

### RESULTS AND DISCUSSION

*Raoiella indica* had five developmental stages: egg, larva, protonymph, deutonymph, and adult (Figure 2). Eggs incubation period of male and female did not differ among varieties. On motile stadia, the differences were found on immature females. The developmental time of females immature showed significant differences on larvae ( $df=2$ ,  $\chi^2=10.781$ ;  $P\text{-value}<0.05$ ) and protonymphs ( $df=2$ ;  $\chi^2=11.057$ ;  $P\text{-value}<0.05$ ), whereas the developmental time was not significantly different on deutonymphs ( $df=2$ ;  $\chi^2=3.082$ ;  $P\text{-value}>0.05$ ). On the other hand, there were no differences of developmental time on all

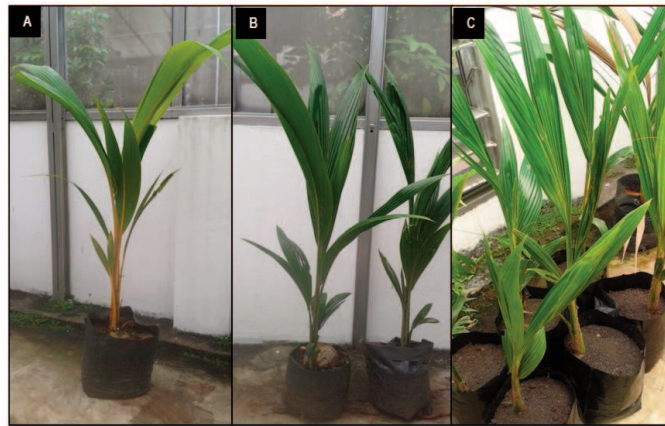


Figure 1. Tested coconut varieties: Hybrid (A), Salak Dwarf (B), and Local Sumenep Tall (C)

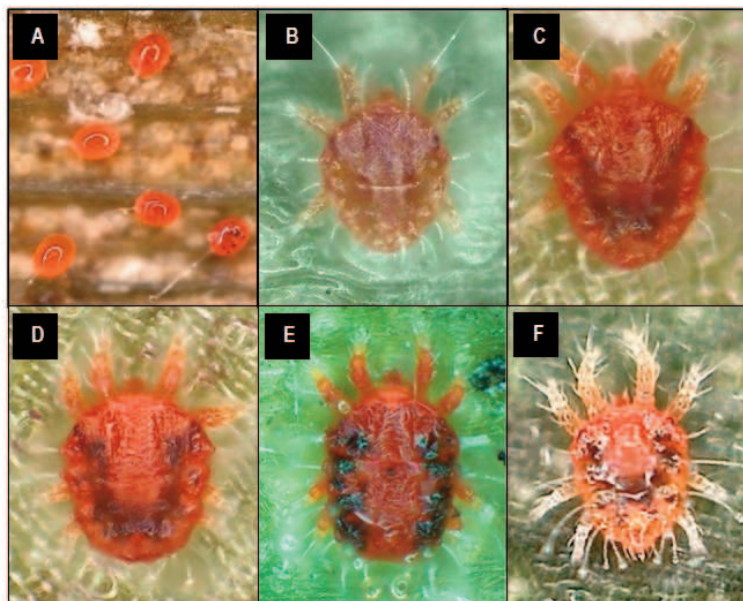


Figure 2. All-stages of *Raoiella indica*: egg (A), larva (B), protonymph (C), deutonymph (D), female adult (E), and male adult (F)

immature stages of male: larvae (df=2; F=1.306; P-value>0.05), protonymphs (df=2;  $\chi^2=3.514$ ; P-value>0.05), and deutonymphs (df=2; F=2.922; P-value>0.05). Inactive phase of *R. indica* (protochrysalis, deutochrysalis, and teliochrysalis) also showed no significant differences among varieties. Generally, the longest inactive phase was teliochrysalis on all varieties (Table 1).

The longest developmental time of immature stages in total was on local sumenep tall (28.43±2.38 days for females, 26.88±2.77 days for males), followed by Hybrid (28.26±2.38 for females; 25.00±1.00 for males), and the shortest was Salak Dwarf (26.07±2.52 for females; 23.57±2.95 for males). There were significant differences of females immature developmental time on those varieties (df=2;  $\chi^2=10.896$ ; P-value<0.05). However, the development of males immature was not significantly different among coconut varieties (df=2; F=3.372; P-value>0.05). The total developmental periods of males immature were shorter than the females. Within variety,

the developmental time of males and females significantly different on Hybrid coconut (Mann-Whitney test; P-value<0.05) and Salak Dwarf (t-test; P-value<0.05), but it was not different on Local Sumenep Tall (Mann-Whitney test; P-value>0.05).

No significant effects of varieties were observed on the preoviposition (df=2;  $\chi^2=0.439$ ; P-value>0.05), oviposition (df=2; F=1.018; P-value>0.05), and postoviposition periods (df=2;  $\chi^2=0.599$ ; P-value>0.05). The different coconut varieties also did not affect the females longevity (df=2;  $\chi^2=0.543$ ; P-value>0.05). The fecundity per capita of *R. indica* ranged from 14.03±3.84 eggs on Salak Dwarf to 13.43±3.72 eggs on Hybrid, and their numbers was not significantly different.

Few studies have been performed on the biology of *R. indica* in several countries. However, it was difficult to compare the present results with the others as the experimental conditions (temperature, humidity, host plant) were different. However, most previous works did not specify coconut varieties on their

Table 1. The developmental time of immature stages of *Raoiella indica* on three coconut varieties under the laboratory\*

Stages**	Developmental times (mean±SD, days)		
	Salak Dwarf	Local Sumenep Tall	Hybrid
Egg			
Female	7.15±0.28	7.05±0.47	7.24±0.50
Male	7.36±0.56	7.00±0.50	7.10±0.22
Larvae			
Female***	4.02±1.08 <sup>a</sup>	5.07±1.11 <sup>b</sup>	4.72±0.95 <sup>ab</sup>
Male	3.64±1.07	4.33±0.61	4.10±0.89
Protochrysalis			
Female	1.52±0.38	1.60±0.54	1.74±0.50
Male	1.79±0.49	1.67±0.50	1.60±0.55
Protonymph			
Female***	3.96±0.96 <sup>a</sup>	5.21±1.33 <sup>b</sup>	4.64±1.12 <sup>ab</sup>
Male	3.50±0.96	4.72±1.46	3.90±0.65
Deutochrysalis			
Female	1.72±0.33	1.60±0.52	1.68±0.41
Male	1.50±0.58	1.83±0.79	1.70±0.27
Deutonymph			
Female	5.63±1.60	5.79±1.47	6.10±1.12
Male	3.79±1.60	5.44±1.10	4.80±1.44
Teliochrysalis			
Female	2.07±0.48	2.12±0.59	2.14±0.53
Male	2.00±0.50	1.89±0.89	1.80±0.45
Egg-Adult			
Female***	26.07±2.52 <sup>a</sup>	28.43±2.38 <sup>b</sup>	28.26±2.38 <sup>b</sup>
Male	23.57±2.95	26.89±2.77	25.00±1.00

\*Laboratory condition: 26-28°C, 75-85% RH, and a photoperiod of 12:12 (L:D).

\*\*Mites on Hybrid coconut were 25 females and 5 males; Salak Dwarf: 23 females and 7 males; Sumenep Tall: 21 females and 9 males. Sex was determined after each egg developed to adult.

\*\*\* Significant differences were based on Kruskal-Wallis test ( $\alpha = 0.05$ ). Means in each row not followed by small letter were not significant different.

studies. Moutia (1958) found that *R. indica* required 18–26 days to develop from eggs to adult at 24.2°C on coconut leaves, while Hoy *et al.* (2010) reported the total developmental immature was 23–28 days (for females) and 20–22 (for males). In our finding, the development times was 26.07–28.43 days for females and 23.57–26.89 days for males, showing that the development time of *R. indica* were longer than previously reported. Longer immature developmental times of *R. indica* was reported by Galano-Flores *et al.* (2010) (29.72 for females and 32.7 for males) at 25.4°C on areca nut leaves.

The present study showed that the egg was the longest immature stage of *R. indica* on all varieties (7.00–7.36 days). This result was in agreement with the report of Hoy *et al.* (2010). Larval and protonymphal stages developed the fastest among immature stages. Larva was the shortest duration stage on Local Sumenep Tall (4.33–5.07 days), whereas protonymph was the shortest stage on Hybrid (3.90–4.64 days) and Salak Dwarf (3.50–3.96 days). Similar results were also reported for other tenuipalpid mites such as *Brevipalpus lewisi* McGregor (Buchanan *et al.*, 1980), *Tenuipalpus heveae* Baker (Pontier *et al.*, 2000), and *Tenuipalpus pacificus* Baker (Zhang, 2003).

The female longevity on this study was 25.93–26.47 days, showing longer duration than previously reported by Vasquez *et al.* (2014) at 29°C (21.5 days). However, the present study was far shorter than the report from Nageschachandra and Channabasavanna (1984) which mentioned that the mite longevity was 48.6–50.9 days on coconut leaves. The fecundity (13.43–14.03 eggs/female) was higher than several previous works (Gonzalez-Reyes & Ramos, 2010; Lima *et al.*, 2010), but lower than some literatures. Welbourn (2006) mentioned that *R. indica* could produce 28–38 eggs throughout its life. Pena *et al.* (2006) also reported that the fecundity of *R. indica* could reach 50 eggs per female.

In general, the present study showed that there are no significant differences among coconut varieties to mite development, longevity, and fecundity (Table 2). These results might be due to less prominent differences in structure morphology and chemical content among the three coconut varieties. The previous study of *R. indica* indicated that the mites developmental greatly influenced by many ecological factors such as host plant, humidity and temperature (Moutia, 1958; Pena *et al.*, 2006; Cocco & Hoy, 2009). The host factors could be related to the leaves characteristics, including the thickness of wax layer, stomata density, leaf texture, trichome density, secondary metabolites, and nutrition.

*Raoiella* are the first mites genus to be observed feeding through the stomata of the host (Ochoa *et al.*, 2011). Therefore, among morphological factors, the stomata seem to be one of the most influential factor for feeding activity of this mite. Stomatal density could determine the suitability of host plant for this mite. However, there was no significant difference in stomatal density was observed among tested coconut varieties ( $df=2$ ;  $\chi^2=2.023$ ;  $P\text{-value}>0.05$ ). The highest stomatal density (per 0.2 mm<sup>2</sup>) was found on Local Sumenep Tall variety (24.15±2.67 stomata), followed by Salak Dwarf (24.07±3.19) and Hybrid (23.38±3.52).

Different coconut variety may contain different proportion of nutritional contents on the leaves. Those differences has positive correlation with *R. indica* densities (Sakar & Somchoudhury, 1989). Based on proximate test (Table 3), the highest crude protein was found on Salak Dwarf, while the highest crude fibre and crude fat were on Hybrid. However, the results indicate that different chemical on tested coconut varieties have little impact on the biology performance of this mite.

The development time of immature females were the only variable which significantly influenced by

Table 2. Various parameters of female of *Raoiella indica* on three coconut varieties in laboratory conditions\*

Parameters	Developmental times (mean ± SD, days)**		
	Salak Dwarf	Local Sumenep Tall	Hybrid
Pre-oviposition period	5.23±2.19	5.30±1.66	5.13±1.36
Oviposition period	15.37±3.96	15.13±4.03	16.47±3.59
Post-oviposition period	5.47±2.57	5.20±2.07	4.87±1.55
Longevity	26.27±3.56	25.93±3.29	26.47±3.72
Total fecundity (eggs/female)	14.03±3.84	13.63±4.05	13.43±3.72

\* Laboratory condition: 26–28°C, 75–85% RH, and a photoperiod of 12:12 (L:D).

\*\*No significant different based on Kruskal-Wallis test ( $\alpha = 0.05$ ).

Tabel 3. Proximate composition on the leaves of different coconut varieties\*

Varieties	Crude Protein (%)	Crude fibre (%)	Crude fat (%)	Ash content (%)
Salak Dwarf	11.82	33.88	5.17	7.62
Local Sumenep Tall	10.98	32.59	4.93	6.60
Hybrid	11.01	35.39	6.01	6.47

\*Tested in RC for Biotechnology, Indonesian Institute of Sciences (LIPI).

coconut varieties. Immature female period of *R. indica* was significantly shorter on Salak Dwarf than the others. These results were probably attributed by nutrient content of tested coconut varieties. The leaf of Salak Dwarf has higher protein content than the other varieties. Awmack and Leather (2002) mentioned that protein is an important nutrient for arthropods development. Protein is also important nutrient for insect reproduction, particularly in contributing to higher rate of offspring production (Lardies *et al.*, 2004). Sakar and Somchoudhury (1989) stated that coconut varieties which contained higher amounts of nitrogen and crude protein showed higher incidence and mite population densities. The present results showed that immature male development and fecundity of *R. indica* also better performed on Salak Dwarf, although it is not statistically different.

The results suggest that the tested varieties have equal susceptibility to *R. indica*. This finding similar to other work which stated that no differential susceptibility of Pacific Tall and Malayan Yellow Dwarf variety against *R. indica* (Otero-Colina *et al.*, 2016). However, other works indicate that several coconut varieties has different susceptibility, particularly related to chemical composition of the leaves. Vasquez *et al.* (2016) suggested that Jamaica Tall variety more resistant to Malayan Yellow Dwarf and Hybrid variety based on higher oxidative enzyme activity in response to mite feeding.

Finally, the results of this study will be important for the management of *R. indica* as a potential pest of coconut in Indonesia by providing a better understanding of its biology on different coconut varieties. Using resistant variety might be an alternative to reduce yield losses due to this mite. However, there were no significant differences among coconut varieties in relation to mite development and reproduction.

## CONCLUSION

The biology of *R. indica* consists of egg, larva, protonymph, deutonymph, and adult. There are also quiescent phase between motile stages which called

protophysis, deutophysis, and teliochysis. The total immature development period of *R. indica* on coconut leaves were varied from 26.07–28.43 days (for females) and 23.57–26.89 days (for males). The longevity of females ranged from 25.93–26.47 days. Total development time of immature females were significantly influenced by coconut varieties. However, the different coconut varieties did not affect other variables such as the developmental time of immature males, longevity, and fecundity.

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