DIVERSITY AND ABUNDANCE OF PEST MITES (ACARI: TETRANYCHIDAE) ON PAPAYA IN TANAH LAUT AND BANJARBARU CITY, SOUTH KALIMANTAN, INDONESIA

Muhammad Indar Pramudi*, Helda Orbani Rosa & Hamidah
Department of Plant Protection,
Faculty of Agriculture,
Universtas Lambung Mangkurat,
Jl. A. Yani Km. 36 Banjarbaru,
70714 Indonesia
Corresponding author: indar_pramudi@yahoo.com*

Received: 14 November 2021 / Accepted: 10 December 2021

ABSTRACT

Information on the diversity and abundance of mites on papaya in South Kalimantan is still limited and needs further study. Thus, a study was conducted in Banjarbaru and Tanah Laut, South Kalimantan, Indonesia on three varieties of papayas (California, Hawaii, and Merah Delima). Four species of mites that attacked papayas in Banjarbaru were identified as *Tetranychus piercei*, *Aculops pelekassi*, *Brevipalpus phoenicis,* and *Eutetranychus africanus*, while in Tanah Laut *T. piercei* and *E. africanus*. *Tetranychus piercei* with 2557 individuals was the most abundant at both locations. *Tetranychus piercei* was found to be in the highest number observed on papayas varieties, while *A. pelekassi* was found on Hawaii varieties with 13 individuals, *E. africanus* on California varieties with nine individuals, and *B. phoenicis* with only eight individuals on Hawaiian varieties. The diversity index value (H') of mites at the research areas was low (H'<1.5) indicated the communities formed were less stable (H'<1) probably under pressure. The species dominance index (C) value was significantly close to 1 (≥0.5), and indicative of certain species dominated (in this study was *T. piercei*) at the two research sites. The results of this research could provide important information about mites and be useful as the first step in developing effective pest control strategies.

Keywords: Mites, papaya varieties, diversity index, South Kalimantan

ABSTRAK

Maklumat kepelbagaian dan kelimpahan hama pada buah betik di Kalimantan Selatan, Indonesia masih kurang dan diperlukan kajian lebih lanjut. Kajian dijalankan di Banjarbaru dan Tanah Laut, Kalimantan Selatan ke atas tiga varieti betik (California, Hawaii, dan Merah Delima). Empat spesies hama yang menyerang betik di Banjarbaru dicamkan sebagai *Tetranychus piercei, Aculops pelekassi, Brevipalpus phoenicis,* dan *Eutetranychus africanus*, manakala di Tanah Laut *T. piercei* dan *E. africanus. Tetranychus. piercei* dengan 2557 individu adalah spesies yang paling melimpah di dua lokasi. Spesies *T. piercei* dijumpai dalam jumlah

tertinggi pada semua varieti betik, *A. pelekassi* direkodkan pada varietas Hawaii dengan 13 individu, *E. africanus* pada varieti California dengan sembilan individu, dan *B. phoenicis* dengan hanya lapan individu pada varieti Hawaii. Nilai indeks kepelbagaian (H') hama pada dikelaskan adalah rendah (H'<1.5) yang menunjukkan komuniti yang kurang stabil (H'<1.0) kemungkinan berada di bawah tekanan. Nilai indeks dominansi spesies (C) secara signifikan mendekati 1 (≥0.5) dan indikasi dominasi spesies tertentu (dalam kajian ini adalah *T. piercei*) di kedua lokasi kajian. Hasil kajian ini dapat memberikan maklumat penting tentang hama dan berguna sebagai langkah awal dalam mengembangkan strategi kawalan pengendalian hama yang efektif.

Kata kunci: Hama, varieti betik, Indeks kepelbagaian, Kalimantan Selatan

INTRODUCTION

Pests that can economically affect papaya plants are lice, nematodes, and mites. Leaf lice can transmit the papaya ringspot virus (PRSV), white peach scales (*Pseudaulacaspis pentagona*) which are post-harvest pests, and papaya white lice (*Paracoccus marginatus*) are able to kill papaya plants. The two species of nematodes are reniform (*Rotylenchulus reniformis*) and Root Knot Nematodes (*Meloidogyne incognita*). The severe infestation of nematodes can cause wilted plants, stunted growth, decreased plant endurance, reduced yields, and shortened the productive life of papaya trees. Some species of mites, which are broad mites (*Polyphagotarsonemus latus*), flat mites (*Brevipalpus phoenicis*), spider mites (*Tetranychus cinnabarinus, Eutetranychus banksi, and Panonychus citri*), and papaya leaf edgerolle mites (*Calacarus flagellis*), can attack from seedling to fruiting phase.

Mites are one of the pests that affect many plants throughout the world, eating many species of vegetable plants (Childers et al. 2003; Mamahit 2011), fruits (Childers et al. 2003; Dina & Santoso 2017; Nuraini 2018), and also ornamental plants (Childers et al. 2003; Silva et al. 2009). Some types of these mites can also be a vector of plant viruses (Bastianel et. al 2010; Childers & Rodrigues 2011; Kitajima et al. 2010). Mites become one of the important pests on papaya plants because their attacks can cause various symptoms in plants such as curly leaves and cause plants unable to bear fruit.

In Indonesia mites often attack cassava, orange, tomato, chilli, and papaya plants. Abato Zarate et al. (2014), stated that papaya production in Mexico decreased due to the mites attack of *Eutetranychus banksi* (McGregor), *Eotetranychus lewisi* (McGregor), *Polyphagotarsonemus latus* Banks, *Tetranychus urticae* Koch CL, *Tetranychus merganser* Boudreaux, and *Calacarus citrifolii* Keifer. Mites that attacked papaya in Lombok, Indonesia were *Aculops pelekassi* Keifer, *Calacarus carinatus* Keifer, *Tarsonemus bilobatus* Suski, *Brevipalpus californicus* Banks, *Brevipalpus obovatus* Dannadieu, *Brevipalpus phoenicis* Geijskes, *Tenuipalpus pasificus* Baker, *Eutetranychus africanus* Tucker, *Panonychus citri* McGregor, *Tetranychus fijiensis* Hirst, *Tetranychus kanzawai* Kishid and *Tetranychus piercei* McGregor (Dina & Santoso 2017).

According to Badan Karantina Pertanian (2013), some pest mites have not been yet recorded in Indonesia namely *Aceria cajani, Aceria ficus, Aceria guerreronis, Aculops lycopersici, Aculops pelekassi, Aculus schlechtendali, Phyllocoptes vitis, Phyllocoptruta oleivora, Retracrus elaeis, Brevipalpus californicus, Raoiella indica, Penthaleus major, Rhizoglyphus echinopus, Tyrophagus castellanii, Steneotarsonemus laticeps, Tarsonemus myceliophagus, Bryobia rubrioculus, Eotetranychus willamettei, Eutetranychus orientalis,*

Mononychellus tanajoa, Oligonychus peruvianus, Oligonychus yothersi, Panonychus ulmi, Petrobia latens, Tetranychus pacificus, and *Tetranychus schoenei*. The data distribution of mites from other regions or mites species that are not yet found in Indonesia is important to provide information for preventing and controlling if the attacks.

Until now, studies and documentations on mite species and abundance on papaya in South Kalimantan are lacking. Therefore, the main objective of this research was to identify and find out the diversity and Abundance of mite species on papaya plants in South Kalimantan.

MATERIALS AND METHODS

Study Sites

Study was conducted in Banjarbaru City (03°27' - 03°29' S and 114°45' - 114°48' E) and Tanah Laut District (3°30’33” – 4°11’38” S and 114°30’20” – 115°23’31” E) at South Kalimantan Province, Indonesia with four and three sampling locations, respectively. Mite species identification, counting and recording number of mites on leaves, and slide preparation were conducted at the Entomology Laboratory of the Faculty of Agriculture, Lambung Mangkurat University (3°26’43,84644”S 114°50’44,8908”E), and Banjarmasin Class 1 Quarantine Laboratory (3°19’17,4864”S 114°34’19,26552”E) for identification. This research was conducted from February to July 2019.

Sampling Methods

Survey and collection of mites were collected from two sampling locations by using purposive sampling. The sampling area was determined by a minimum planting area of 0.25 hectares in one stretch of land or with a plant population of 300 plants. Sampling was carried out using a diagonal system. There are 5 points or sample units or sub-locations in one field. At each sampling point, five papaya plants were selected at random, with uniform age criteria or those that were already fruiting (7-9 months). At each sampling point, five papaya plants were randomly selected. Young leaf and one old leaf that had the characteristics of the symptom of mites attack per plant were brought to the laboratory.

Symptoms of mite attacking papaya plants can be seen in leaf color changes from normal to a lighter green, with white or yellowish-white spots, especially near the leaf bones and yellow spots on the leaf surface. Further attacks, the yellow spots spread to all parts of the leaves, often the leaves become dwarfed like an inverted spoon and on the underside of the leaves there are fine threads like spider webs and finally, defoliation occurs. The same symptom was also stated by Fasulo & Denmark (2009) and Mahr (2018).

Specimen Mounting and Species Identification

Adult mite specimens were sorted and selected by placing one drop of Hoyer's media on a sliding glass and carefully covering it with a glass cover. A circle mark was made around mites using a permanent pen. The slides with mites were incubated at 45^{o}C for 48 hours or until the preparate was clear (Henderson 2021). The slide was then observed under a binocular stereoscopic microscope for morphological identification specimens were identified based on the morphological characters of the mites following Dina & Santoso (2017), Fan and George, (2012), and by the Badan Karantina Pertanian (2013) as well as based on related scientific reports (Keifer et al. 1982; Naing et al. 2014; Seeman & Beard 2011; Vacante 2010; Zhang 2003). The mite slides were deposited at the Centre for Agricultural Quarantine Standards Test (BBUSKP).

Population and Abundance
The value of the Shannon-Wiener Diversity Index (H '), the Simpson Domination Index (C) Simpson (1949) in Odum (1996), and the Evenness Index (E) (Odum 1996) were estimated as below:

Shannon-Wiener Diversity Index (H')

$$H' = -\sum[\left(\frac{ni}{N}\right) x \ln(\frac{ni}{N})]$$

Annotation:
H': Shannon-Wiener Diversity Index
ni: Number of individuals in a species
N: Total number of individuals found in species

If the value of H'<1 then the community is less stable, if the value of H' is between 1-2 then the community is stable, and if the value of H'>2 is said to be very stable (Kent & Paddy 1992). The criteria for the level of pest diversity based on this index are high if the value of H'>3.5, moderate if H'=1.5-3.5 and low if H'<1.5.

Simpson Domination Index (C)

$$C = \sum(\frac{ni}{N})^2$$

Annotation:
C: Simpson Domination Index
ni: Number of individuals in a species
N: Total number of individual found in species

Odum (1993) stated that the criteria for dominance were:
• If the C value approaches 0 (<0.5), then no species dominate.
• If the C value approaches 1 (≥0.5), then there is a dominant species.

Evenness Index (E)

$$E = H'/H\ maks$$

Annotation:
H maks: ln S from total specie
E~0: There is a dominance of species
E~1: The same number of individuals in each species

RESULTS AND DISCUSSION

Symptoms and Identification of Mites Attacking Papaya Plant

At the papaya planting sites in Banjarbaru City and Tanah Laut District, four species of mites were obtained i.e *Tetranychus piercei*, *Aculops pelekassi*, *Brevipalpus phoenicis*, and *Eutetranychus africanus*. (Figure 1 & Figure 2).

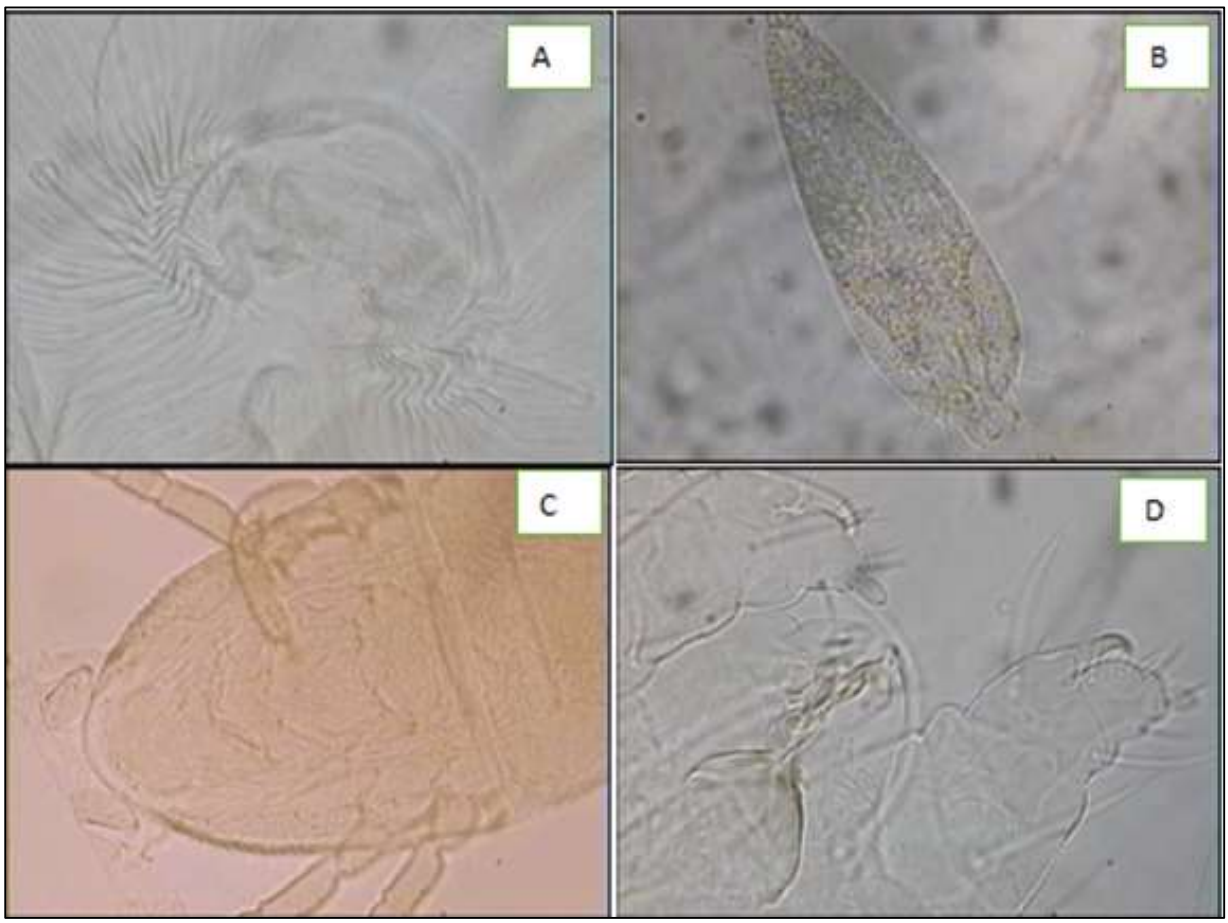

Figure 1. Morphological characters. A: A pair of *Tetranychus piercei* para-anal seta (100x magnifications); B: *Aculops pelekassi* fusiform body shape (40x magnifications); C: Pedipalp slender and five-segmented *Brevipalpus phoenicis* (100x magnifications); D: *Eutetranychus africanus* palpus claw (100x magnifications)

Figure 2. Four species of mites were obtained a: *Tetranychus piercei*; b: *Aculops pelekassi*; c: *Brevipalpus phoenicis*; d: *Eutetranychus africanus*

Morphological Characteristics of Mites

***1. Tetranychus piercei* McGregor**

Tetranychus piercei has a bright red body and black spots on its body. The mite's legs are whitish and the tarsus on the first leg has faded yellow color (Figure 2a). The *T. piercei* has a size almost the same as *E. africanus*. Besides the color, things that distinguish *T. piercei* from other species are its body with a round dorsoventral shape, strong pedipalps, claws on the palpus, a five-segmented palpus, tibia nails and a pair of para-anal setae (Figure 1a). According to Waterhouse (1993), *T. piercei* belongs to the Tetranychidae family, native to Central America and has been reported to be one of the main pests on cocoa plants in Southeast Asia. In addition, *T. piercei* is also reported as a major pest on papaya and banana plants and even become a major pest in papaya cultivation on Lombok Island, Indonesia (Dina & Santoso, 2017).

***2. Aculops pelekassi* Keifer**

Aculops pelekassi has a dull yellow body, smaller size (Figure 2b), fusiform body shape, a granulating body, and only has two pairs of legs (Figure 1b). Mites from the Eriophyidae family have only two pairs of limbs. According to Dina & Santoso (2017) *A. pelekassi* species were found on the papaya plants on Lombok Island and this mite was also the main pests on citrus plants, even though they are categorized as OPTK A1 or in other words those pests are prevented from entering Indonesia (Regulation of the Minister of Agriculture of the Republic of Indonesia No.51/Permentan/KR.010/ 9/2015). This mite prefers young leaves and sunlight exposure.

3. *Brevipalpus phoenicis* Geijskes

Brevipalpus phoenicis is orange in color with black spots on its body (Figure 2c), smaller body size compared to *T. piercei*, has multiple furrows in dorsal disjugal, flat body shape, clawless palpus, slender pedipalp with one to five segments (Figure 1c), no nail tabia, and opisthosoma no narrower than podosoma (Childers and Rodrigues 2011). It is a mite from the Tenuipalpidae family classified as pest mites (A2) found in Indonesia. The hosts plants are tea, orange, coffee, coconut, papaya, apple, guava, and others (Dina & Santoso 2017).

***4. Eutetranychus africanus* Tucker**

Eutetranychus africanus has dark green color and reddish at the base of the legs (Figure 2d), the palpus has claws (Figure 1d) and five segments, the body size is larger than *A. pelekassi* and *B. phoenicis*, does not have a single furrow, the body parts (dorsoventral) are round, limbs I and II has no duplex setae and does not have an empodium. This mite is in Tetranychidae family which widely distributed in Africa, India, Southeast Asia, Papua New Guinea, the Indian Ocean islands and according to Dina & Santoso (2017), *T. africanus* has been found in Indonesia on Lombok Island. These pest mites are important pests on citrus, eggplant, cotton, apples, grapes, guava, ornamental plants, and papayas. According to the Indonesian Plant Quarantine Agency, *T. piercei* belongs to OPTK A2.

Abundance and Diversity Index of Mites

In total, four species of mites were found in Banjarbaru City, while in two spesies in Tanah Laut District (*T. piercei* and *E. africanus*), but the population of mites in Tanah Laut District was higher than in Banjarbaru (2362: 225) (Table 1). The largest population was *T. piercei* with 2557 individuals and the smallest was *B. phoenicis* with eight individuals. The difference in the number of mite populations was probably caused by controlling papaya pests using synthetic pesticides. In Banjarbaru, this control was carried out every three or six days. Even though there were no visible signs of pest attack, control was still carried out. In Tanah Laut District, the farmers did not control the pest mites.

Table 1. Species and number of individual mites in Banjarbaru City and Tanah Laut District

No	Species	Banjarbaru (No of individuals)	Tanah Laut (No of individuals)	Total number of individuals
1.	*Tetranychus piercei*	196	2361	2557
2.	*Aculops pelekassi*	13	0	13
3.	*Brevipalpus phoenicis*	8	0	8
4.	*Eutetranychus africanus*	8	1	9
Total		**225**	**2362**	**2587**

A total of 2587 individuals consisting of four pest mites species was found in the California, Hawaiian, and Merah Delima papaya plants. *Tetranychus. piercei* had the highest number with 2557 individuals and observed on all varieties of papaya, while the *A. pelekassi* with 13 individuals only found in Hawaiian varieties, 9 individuals of *E. africanus* were found

in California varieties, and eight individuals of *B. phoenicis* were found in the Hawaiian variety (Figure 3).

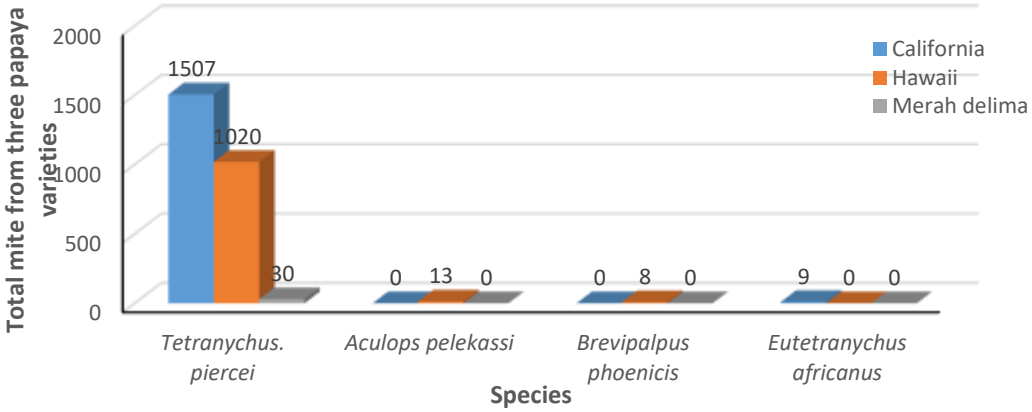

Figure 3. Species of pest mites in three varieties of papaya

Results on the abundance of mites are presented in Tables 2 and 3. The Shannon-Wiener diversity index (H') was very low (H'<1.5) and less stable of mite communities (H'<1). In the uniformity index (E) certain species was dominant so that the formed community was depressed (Odum 1996), Based on the data in Table 2, it is known that each different papaya variety is dominated by different species, so the ability of the species to survive is highly dependent on its adaptability, playing a role in choosing species to survive in a habitat. This is an indication that the species is considered dominant in the area. Ecologically this species has relatively better adaptability and tolerance than other species (Setiadi 2005). While the species dominance index (C) indicated the value close to 1 (≥0.5 some species dominate, in this case, the dominant species in the two research locations was the *T. piercei* species. These results corroborate to the Dominance Index Criteria of Simpson (1949) in Odum (1996) that if the value of the dominance index is between 0.5-1 (0.5<D<1) it means that there are species that dominate in the area.

Table 2. Diversity Index on Research Site

Index	Banjarbaru	Tanah Laut	Conclusion
H'	0.522	0.004	Low diversity and less stable communities
E	0.377	0.003	Depressed community
C	0.765	0.999	High dominance

Table 3. Diversity index (H'), dominance index (C) and evenness index (E) on three varieties of papaya

Index	Papaya Variety			Conclusion
	California	Hawai	Merah Delima	
H'	0.036	0.112	0	Low diversity and less stable
E	0.027	0.081	0	High dominance
C	0.988	0.960	1	Depressed community

The low H' value of pest mites species showed a potential to cause an explosion of certain mites species, especially the dominant species. The dominant mite population can increase rapidly if there are large numbers of papaya plants or the availability of other hosts, which eventually can cause damage and economic losses to the papaya crop. Pest mites can take advantage of the existing papaya plants to develop and increase their population, then spread to other plants around them (Dina & Santoso 2017).

The Shannon Weiner diversity (H') of mites at two locations with different heights where Banjarbaru is 7 m a.s.l (Bhirawan et al. 2014) and Tanah Laut is 25 m a.s.l (KPHP Model Tanah Laut 2014), the difference in elevation at both locations shows H 'higher in Banjarbaru (0.522) compared to Tanah Laut (0.003). This is supported by research by Khairul et al. (2018) which stated that the diversity and abundance of Diptera were higher at low elevation compared to high elevation.

The high dominance of species indicates that the number of individuals of each species is not equally distributed. The ability of each species to maintain its population was different (Oka 1995). One treatment that had been done to avoid the diversity of mites was the use of pesticides in papaya fields. Spraying was carried out intensively from the beginning of planting until right before harvest (based on interviews with local farmers), reduce the population of pest mites. According to Bernard et al. (2010), the main cause of the decline in insect populations is habitat loss due to land use change, pollution, natural enemies, competition with other species and climate change. Meanwhile, according to Masnita et al. (2018), the high and low temperature, humidity and rainfall affect the distribution of species.

CONCLUSION

In this study, four species of mites were found in three varieties of papaya such as *T. piercai*. *A. pelekassi*, *B. phoenicis*, and *E. africanus*. It needs to be supported by ecological data and environmental factors, so that we will get data on the distribution of mites in South Kalimantan and observations are made from the beginning of planting to harvesting so that the data obtained is even more detailed.

ACKNOWLEGEMENTS

The author thanks reviewers for valuable suggestions that help improve quality of the manuscript.

REFERENCES

Abato, Z.M., Villanueva, J.J., Otero, C.G., Avila, R.C., Hernandez, C.E. & Reyes, P.N. 2014. Acarofauna associated to papaya orchards in Veracruz, Mexico. *Acta Zoologica Mexicana* 30: 595-609.

Badan Karantina Pertanian. 2013. *Diagnosis Protokol OPTK Kelompok Tungau*. Jakarta: Pusat Karantina Tumbuhan dan Keamanan Hayati Nabati.

Bastianel, M., Novelli, V.M., Kitajima, E.W., Kubo, K.S., Bassanezi, R.B., Machado, M.A. & Freitas-Astua, J. 2010. *Citrus leprosis*: Centennial of an unusual mite–virus pathosystem. *Plant Disease* 94(3): 284-292.

Bernard, M.B., Peter, C., Amanda, K., Paul, A.H., James, A., Stephen, D.W. & Alan, L.Y. 2010. Reducing the impact of pesticides on biological control in Australian vineyards: Pesticide mortality and fecundity effects on an indicator species, the predatory mite *Euseius victoriensis* (Acari: Phytoseiidae). *Journal of Economic Entomology* 103(6): 2061-2071.

Bhirawan, B., Edy, D. & Bambang, S. 2014. Banjar Baru Internasional Sirkuit. *Imaji* 3(4): 565-570.

Childers, C.C., Rodrigues, J.C.V. & Welbourn, W.C. 2003. Host plants of *Brevipalpus californicus*, *B. obovatus*, and *B. phoenicis* (Acari: Tenuipalpidae) and their potential involvement in the spread of viral diseases vectored by these mites. *Experimental & Applied Acarology* 30(1-3): 29-105.

Childers, C.C. & Rodrigues, J.C.V. 2011. An overview of *Brevipalpus* mites (Acari: Tenuipalpidae) and the plant viruses they transmit. *Zoosymposia* 6: 180–192.

Dina, W.M. & Santoso, S. 2017. Identification of pest mites on papaya in the Lombok Island. *Indonesia Journal of Entomology* 14(1): 37-43.

Fan, Q.H. & George, S. 2012. *Keys to Higher Taxa and Commonly Intercepted Families of Mites (Acari)*. New Zealand: Plant Health & Environment Laboratory, MPI.

Fasulo, T.R. & Denmark, H.A. 2009. *Tetranychus urticae* Koch *(Arachnida: Acari: Tetranychidae).* Florida: Division of Plant Industry (DPI) Entomology, Department of Agriculture and Consumer Services. https://edis.ifas.ufl.edu/pdf/IN/IN307/IN307-16638004.pdf. [26 October 2019].

Henderson, R.C. 2021. Technique for positional slide-mounting of Acari. *Systematic & Applied Acarology* [Special Publications] 7: 1-4.

KPHP Model Tanah Laut. 2014. *Rencana Pengelolaan Jangka Panjang Kesatuan Pengelolaan Hutan Produksi Model Tanah Laut (UNIT VII) Tahun 2014 – 2023*. Provinsi Kalimantan Selatan: Kabupaten Tanah Laut.

Kent, M. & Paddy, C. 1992. *Vegetation Description and Analysis: A Practical Approach*. London: Belhaven Press.

Keifer, H.H., Baker, E.W., Kono, T., Delfinado, M. & Styer, W.E. 1982. *An Illustrated Guide to Plant Abnormalities Caused by Eriophyid Mites in North America*. Washington: US Government Printing Office.

Khairul, H.N, Noor, N.A.A, Saiyid, J.S.S, Muhammad, L.H.A, Idris, A.G & Siti, K.M.H. 2018. Diversity and abundance of dipteran species at two different elevations in Gunung Datuk, Negeri Sembilan, Malaysia. *Serangga* 23(2): 194-202.

Kitajima, E.W., Rodrigues, J.C.V. & Freitas, A.J. 2010. An annotated list of ornamentals naturally found infected by *Breviaplpus* mite-transmitted viruses. *Scientia Agrícola* (Piracicaba, Brazil) 67(3): 1–25.

Mahr, S. 2018. *Two spotted Spider Mite, Tetranychus urticae.* USA: University of Winconsin-Madison. https://hort.extension.wisc.edu/articles/twospotted-spider-mite-tetranychus-urticae/. [12 July 2019]

Mamahit, J.M.E. 2011. Biologi dan Demografi Tungau Merah *Tetranychus spp.* (Acari: Tetranychidae) Pada Tanaman Kedelai. *Eugenia* 17(2):128-134.

Masnita, M.Y., Nazri, C.D., Rodziah, I. & Ariza, Z. 2018. Assessing the temporal distribution of dengue vectors mosquitoes and its relationship with weather variables. *Serangga* 23(1):112-125.

Naing, H.H., Chandrapatya, A., Navajas, M. & Auger, P. 2014. Know more about spider mites (Acari: Tetranychidae) in Myanmar. *Zootaxa* 3802: 257–275.

Nuraini, D.R. 2018. Tungau: Kelimpahan pada tanaman apel di Lahan monokultur dan tumpangsari. Sarjana Thesis, Universitas Brawijaya.

Odum, E.P. 1996. *Dasar-Dasar Ekologi*. Edisi ke-3. Yogyakarta: Gadjah Mada University Press.

Oka, I.N. 1995. *Pengendalian Hama Terpadu dan Implementasinya di Indonesia*. Yogyakarta: Gadjah Mada University.

Seeman, O.D. & Beard, J.J. 2011. Identification of exotic pest and Australian native and naturalised species of *Tetranychus* (Acari: Tetranychidae). *Zootaxa* 2961: 1–72.

Setiadi, D. 2005. Keanekaragaman spesies tingkat pohon di Taman Wisata Alam Ruteng, Nusa Tenggara Timur. The diversity of trees species in Taman Wisata Alam Ruteng, East Nusa Tenggara. *Biodiversitas* 6(2): 118-122.

Silva, E.A., Reis, P.R., Carvalho, T.M.B. & Altoe, B.F. 2009. Biology *Tetranychus urticae* (Acari: Tetranychidae) on *Gerbera jamesonii* Bolus and Hook (Asteraceae). *Braz. J. Biol*. 69(4): 1121-1129.

Simpson, E.H. 1949. Measurement of diversity. *Nature* 163: 688.

Vacante, V. 2010. *Citrus Mite: Identification, Bionomy and Control*. Wallingford (GB): CABI Publishing Division of CABI International.

Waterhouse, D.F. 1993. *The Major Arthropod Pests and Weeds of Agriculture in Southeast Asia: Distribution, Importance and Origin*. Monograph Series No. 21. Canberra: Australian Centre for International Agricultural Research (ACIAR).

Zhang, Z.Q. 2003. *Mites of Greenhouses, Identification, Biology and Control*. Wallingford: CABI Publishing.