Philippine Journal of Science
149 (4): 1019-1028, December 2020
ISSN 0031 - 7683
Date Received: 22 May 2020

Abundance and Diversity of Thrips (Insecta: Thysanoptera) in Conventional "Carabao" Mango Orchard in Piat, Cagayan, Philippines

Cecilia P. Reyes[1]*, **Bonifacio F. Cayabyab**[2], and **Maria Katherine M. Copuyoc**[1]

[1]College of Agriculture, Cagayan State University, Tuguegarao 3500 Philippines

[2]National Crop Protection Center, University of the Philippines Los Baños College, Laguna 4030 Philippines

The study aimed to determine the abundance and diversity of thrips on "Carabao" mango, *Mangifera indica* L., at Hacienda Villa Bianca in Maguilling, Piat, Cagayan, Philippines. Thirty (30) mango trees of various ages were selected randomly and grouped into Center, North, East, West, and South with six mango trees per group. Thrips were collected weekly from February–March 2020 from five randomly selected flowering twigs per tree by flower shaking/tapping method. Thrips were sorted and examined under the microscope. Climate data were obtained from the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA). A total of 3,100 adult thrips collected were represented by *Thrips hawaiiensis* (Morgan) (98.581%), *Scirtothrips dorsalis* Hood (1.097%), *Megalurothips usitatus* (Bagnall) (0.290%), and *Haplothrips gowdeyi* (Franklin) (0.032%). *M. usitatus* and *H. gowdeyi* are new records on mango in the Philippines. Analysis of variance (ANOVA) between thrips counts per group was not significantly different while counts of four thrips species showed a significant difference ($p < 0.05$). The thrips were distributed equally and dominated by *T. hawaiiensis.* The existence of the thrips was positively correlated with temperature and weakly correlated with relative humidity. Thrips were most diverse in the North group, followed by the East, West, Center, and South based on Shannon's diversity index.

Keywords: *Haplothrips gowdeyi*, *Megalurothrips usitatus*, *Scirtothrips dorsalis*, Terebrantia, *Thrips hawaiiensis*, Tubulifera

INTRODUCTION

Mango, *Mangifera indica* L., is the third most important fruit crop next to banana and pineapple in the Philippines (PSA 2018). Mango has an established international niche market and our country gained its credibility in supplying high-quality mango to Hong Kong, Japan, Singapore, United Kingdom, the United States, Switzerland, and South Korea. The Department of Agriculture (DA) and the Department of Science and Technology are continually supporting programs in the development of the Philippine mango industry. The "Carabao" mango, also known as "Manila super mango," is one of the world's best because of its sweet and excellent eating quality. It is the variety that is widely grown throughout the country and is the sole exported variety. The mango industry supports about 2.5 M farmers nationwide. In 2019, the National Mango Congress was hosted by the DA's Region 2 Office since

*Corresponding Author: reyescecilia.p@gmail.com

Cagayan Valley has the potential areas to grow more mango trees to meet the rising demand of domestic and international market (Gallibu 2019). In the province of Cagayan, "Carabao" mango is grown in many towns, including Piat. Piat is a landlocked municipality that is known as the homeland of the Itawes people and in which Cagayan State University has a campus with an integrated nature farm.

Mango trees harbor many insects including thrips. Thrips are pale yellow, brown, black, or bicolored small insects with piercing-sucking mouthparts. Thrips' life cycle varies from 10–30 days depending on the host plant and temperature. Larvae and adult thrips prefer to feed on young leaves that may induce galls or curling of leaves due to heavy feeding on actively growing plant tissues. In Australia, the red-banded thrips, *Selenothrips rubrocinctus* (Giard), is considered an economically important pest of mango (Peng and Christian 2007). In the Philippines and Indonesia, *Scirtothrips dorsalis* Hood is a key pest of mango (Apolinario *et al*. 2018; Affandi *et al*. 2018) and, recently, *Thrips hawaiiensis* (Morgan) was also reported as the only pest of "Carabao" mango and pomelo "Magallanes" in Ato Belen's farm in Laguna (Bagaoisan *et al*. 2019). In Thailand, *S. dorsalis* and *T. hawaiiensis* are pests of mango, pomelo, and mangosteen (Thongjua and Thongjua 2015). In Malaysia, *T. hawaiiensis*, *S. dorsalis*, *Frankliniella schultzei* (Trybom), and *Megalurothrips usitatus* (Bagnall) are infesting both the pesticide-treated and untreated mango orchards with two additional thrips species – namely, *Haplothrips* sp. and *Thrips palmi* Karny – found in the untreated orchard (Aliakbarpour *et al*. 2010; Aliakbarpour and Rawi 2012).

Thrips cause damage to plants directly through feeding and oviposition on leaves, buds, flowers, and fruits or indirectly through the transmission of viral, bacterial, and fungal pathogens (Garcia-Rodriguez *et al.* 2014) and their population builds rapidly. If not managed well in plants and in the soil where they usually pupate, thrips cause significant yield loss – alone or in combination with microbial diseases. In mango, thrips feed and oviposit on the pericarp of the fruits, which causes bronzing of the fruit surface, and severe infestation often results in the cracking of the fruit skin (Grove *et al*. 2000; Nault *et al*. 2003). These injuries reduce the economic value of mango fruits and their marketability. The main control method against thrips relies heavily on insecticides. However, this control effort has met limited success due to the efficacy of strategy, which included the emergence of insecticide resistance (Allen *et al*. 2005; Nauen and Denholm 2005). Insecticide resistance can lead to increased application rates, frequency of pesticide-use, and ultimate loss of efficacy (Fu *et al.* 2018). To reduce the amount of product sprayed onto crops, correct information regarding the peak of abundance, spatial distribution, and seasonal population variation is needed. Thus, this study was conducted to determine the abundance and diversity of thrips on "Carabao" mango at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines. Specifically, it aimed to 1) identify species of thrips infesting "Carabao" mango trees in the orchard, 2) determine the effect of temperature and relative humidity to the population of thrips, and 3) determine species diversity index of thrips in the orchard.

MATERIALS AND METHODS

The study utilized a descriptive research method. The survey is a part of a two-year project with the goal of developing an appropriate control strategy for mango thrips in the Philippines. This study was conducted at Hacienda Villa Bianca conventional mango "Carabao" orchard in Barangay Maguilling, Piat with coordinates 17.7698° N, 121.5256° E while the municipal center of Piat is situated at approximately 17.48° N, 121.29° E. Elevation at these coordinates is estimated at 61.8 m or 202.6 ft above mean sea level (PhilAtlas 2020). According to the climate classification by PAGASA, the climate in Cagayan falls under Type III. This climate type is characterized by pronounced rainy season (June–February) and dry season (March–May). Sampling was conducted from 24 Feb 2020 to 09 Mar 2020.

Thirty (30) mango trees of various ages and at the flowering stage were selected randomly for this study from over 300 trees in the orchard. The trees were grouped into five – namely, North, East, West, South, and Center – with six mango trees assigned to each group (Figure 1). Thrips samples were collected weekly for three weeks from five randomly selected flowering twigs per tree by flower shaking/tapping on the plastic tray(Aliakbarpour and Rawi 2010). Plastic trays and bags with specimens and labels were brought to the laboratory and washed thoroughly with 70% ethanol. Thrips were transferred to vials with 70% ethanol, sorted, examined (adults), counted, and identified under the microscope. The book entitled "Thysanoptera (Hexopoda) of the Philippine Islands" (Reyes 1994) and the online resource "Lucid Key Server – Lucid Central" (Hoddle *et al.* 2019) were used as references for species identification.

Temperature and relative humidity data of the study site were obtained from PAGASA. Table 1 is a climate data of Piat, Cagayan for the three collection dates from 24 Feb 2020 to 09 Mar 2020. Among the sampling dates, the hottest maximum average temperature recorded was on 09 Mar 2020 at 32 °C. Meanwhile, the first week of collection (24 Feb 2020) was the most humid [relative

Figure 1. Site collection map and the grouping of mango "Carabao" trees at Hacienda Villa Bianca Orchard in Maguilling, Piat, Cagayan, Philippines.

Table 1. Climate data of Piat, Cagayan, Philippines during the sampling dates taken from PAGASA.

Date	Maximum average temperature (°C)	Minimum average temperature (°C)	Average temperature (°C)	Maximum average RH (%)	Cloud cover (%)	Wind (km/h)
24 Feb 2020	30	19	25	94	42	3
02 Mar 2020	28	19	24	86	63	5
09 Mar 2020	32	18	25	81	92	8

humidity (RH) = 94%]. There was no rainfall observed from the three-week collection period. The maximum average temperature and RH for each sampling date were used to analyze the effect of temperature and relative humidity on thrips counts.

Statistical Analyses

The one-way ANOVA was used to determine differences between thrips counts on mango tree groups and to determine differences between counts of each thrips species. Regression analysis was used to determine the effect of maximum average temperature and maximum average relative humidity on counts of each thrips species. Data were analyzed using Minitab statistical software version 17.

RESULTS

Thrips Abundance

Thrips hawaiiensis (Morgan) was the most abundant species with the total count of 3,056 or 98.581%; *Scirtothrips dorsalis* Hood distantly followed with 34 individuals or 1.097%, *Megalurothrips usitatus* (Bagnall) with nine individuals or 0.290%, and *Haplothrips gowdeyi* (Franklin) with one individual or 0.032% (Figure 2). *T. hawaiiensis* (Thripidae), *S. dorsalis* (Thripidae), and *M. usitatus* (Thripidae) are polyphagous terebrantians under subfamily Thripinae while *H. gowdeyi* (Phlaeothripidae) is a polyphagous tubuliferan under subfamily Phlaeothripinae. This is the first record of *M. usitatus* and *H. gowdeyi* on "Carabao" mango in the Philippines. Studies conducted on thrips showed that only *S. dorsalis* and *T. hawaiiensis* were associated with mango in the country (Reyes 1994; Medina and Apolinario 2015;

Bagaoisan *et al*. 2019). In Malaysia, *M. usitatus* and a species of *Haplothrips* were also found on mango together with *S. dorsalis* and *T. hawaiiensis* (Aliakbarpour *et al*. 2010; Aliakbarpour and Rawi 2012). The total counts of four species of thrips after the three-week collection is presented in Figure 2.

Tables 2–5 show the total counts of four thrips species in a three-week collection from different mango tree groupings (Center, North, East, West, and South) in the orchard. ANOVA between mango tree groups was not significantly different ($p > 0.05$). This means that, regardless of the groupings of mango trees, the total counts of each thrips species in different locations has no variation.

Table 2 shows the number of *T. hawaiiensis* taken from five mango tree groups on the three-week period. For all groups, the number of thrips collected was highest on Week 2 with 59.33%, followed by Week 3 with 28.89% and Week 1 with 11.78%.

Table 3 shows the number of *S. dorsalis* taken from five mango tree groups on the three-week period. The number of thrips collected was highest on Week 2 with 64.71%, followed by Week 1 with 35.29%, and none was collected on Week 3.

Table 4 shows the number of *M. usitatus* taken from five mango tree groups on the three-week period. The number of thrips collected was highest on Week 2 with 66.67%, followed by Week 1 with 22.22% and Week 3 with 11.11%.

Table 5 shows the number of *H. gowdeyi* taken from five mango tree groups on the three-week period. The single specimen was collected on week 2 (02 Mar 2020) on mango in the West group.

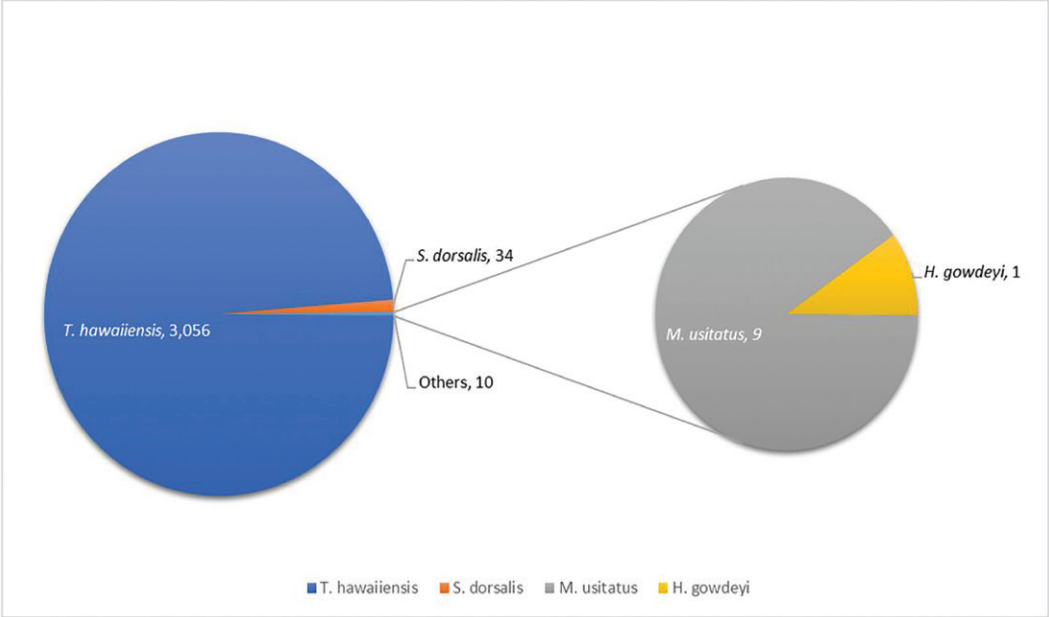

Figure 2. Total counts of *Thrips hawaiiensis* (Morgan), *Scirtothrips dorsalis* Hood, *Megalurothrips usitatus* (Bagnall), and *Haplothrips gowdeyi* (Franklin) on "Carabao" mango trees at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines.

Table 2. *Thrips hawaiiensis* (Morgan) taken from flowers of "Carabao" mango trees at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines showing (a) no significant difference of counts in the Center, North, East, West, and South groups.

Group (six trees)	Week 1 (24 Feb 2020)	Week 2 (02 Mar 2020)	Week 3 (09 Mar 2020)	Total	Mean
Center	74	398	100	572	190.67 a
North	48	406	221	675	225 a
East	73	280	182	535	178.33 a
West	60	245	166	471	157 a
South	105	484	214	803	267.67 a
Subtotal	360	1,813	883	3,056	1018.67 –

Table 3. *Scirtothrips dorsalis* Hood taken from flowers of "Carabao "mango trees at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines showing (a) no significant difference of counts in the Center, North, East, West, and South groups.

Group (six trees)	Week 1 (24 Feb 2020)	Week 2 (02 Mar 2020)	Week 3 (09 Mar 2020)	Total	Mean
Center	2	1	0	3	1 a
North	3	3	0	6	2 a
East	6	7	0	13	4.33 a
West	1	2	0	3	1 a
South	0	9	0	9	3 a
Subtotal	12	22	0	34	11.33 –

Table 4. *Megalurothrips usitatus* (Bagnall) taken from flowers of "Carabao" mango trees at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines showing (a) no significant difference of counts in the Center, North, East, West, and South groups.

Group (six trees)	Week 1 (24 Feb 2020)	Week 2 (02 Mar 2020)	Week 3 (09 Mar 2020)	Total	Mean
Center	0	0	1	1	0.33 a
North	2	4	0	6	2 a
East	0	1	0	1	0.33 a
West	0	0	0	0	0 a
South	0	1	0	1	0.33 a
Subtotal	2	6	1	9	3 –

Table 5. *Haplothrips gowdeyi* (Franklin) taken from flowers of "Carabao" mango trees at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines showing (a) no significant difference of counts in the Center, North, East, West, and South groups.

Group (six trees)	Week 1 (24 Feb 2020)	Week 2 (02 Mar 2020)	Week 3 (09 Mar 2020)	Total	Mean
Center	0	0	0	0	0 a
North	0	0	0	0	0 a
East	0	0	0	0	0 a
West	0	1	0	1	0.33 a
South	0	0	0	0	0 a
Subtotal	0	1	0	1	0.33 –

For the four thrips species, thrips count was highest on Week 2 (02 Mar 2020) when the maximum average temperature in the study site was 28 °C. In a study conducted under laboratory condition using constant temperatures of 18, 21, 24, 27, and 30 °C by Cao *et al*. (2018), they reported that the highest generational survival rate of thrips and highest oviposition rate of female *Thrips hawaiiensis* occurred at 27 °C.

Table 6 shows the total count of four species of thrips collected from five groups. ANOVA showed a significant difference between the four thrips species ($p < 0.05$). *T. hawaiiensis* count was significantly different compared to those of the three other thrips species. *T. hawaiiensis*' was the dominant species in the orchard.

Abiotic Factor

Regression analysis between maximum average temperature during sampling dates and *T. hawaiiensis* showed that thrips counts were positively affected by temperature but in a lesser degree ($R^2 = 0.3992$), *S. dorsalis* count was highly affected ($R^2 = 0.9973$), while *M. usitatus* and *H. gowdeyi* counts were moderately affected by temperature ($R^2 = 0.8929$; $R^2 = 0.7500$). This implies that as temperature increases, thrips population also increases. Previous studies conducted elsewhere showed that thrip population is positively correlated with temperature (Bagaoisan *et al*. 2019; Murai 2001). According to Cao *et al*. (2018), *T. hawaiiensis* is adapted to temperate and tropical conditions with an optimal temperature suitable for reproduction and development ranging from 24–30 °C.

Table 6. Total counts of four species of thrips collected from five locations on Carabao mangotrees at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines showing (a and b) significant difference of *Thrips hawaiiensis* count from those of *Scirtothrips dorsalis*, *Megalurothrips usitatus*, and *Haplothrips gowdeyi*.

Species	Center	North	East	West	South	Total	Mean
T. hawaiiensis	572	675	535	471	803	3056	611.2 a
S. dorsalis	3	6	13	3	9	34	6.8 b
M. usitatus	1	6	1	0	1	9	1.8 b
H. gowdeyi	0	0	0	1	0	1	0.2 b
Subtotal	576	687	549	475	813	3100	620 –

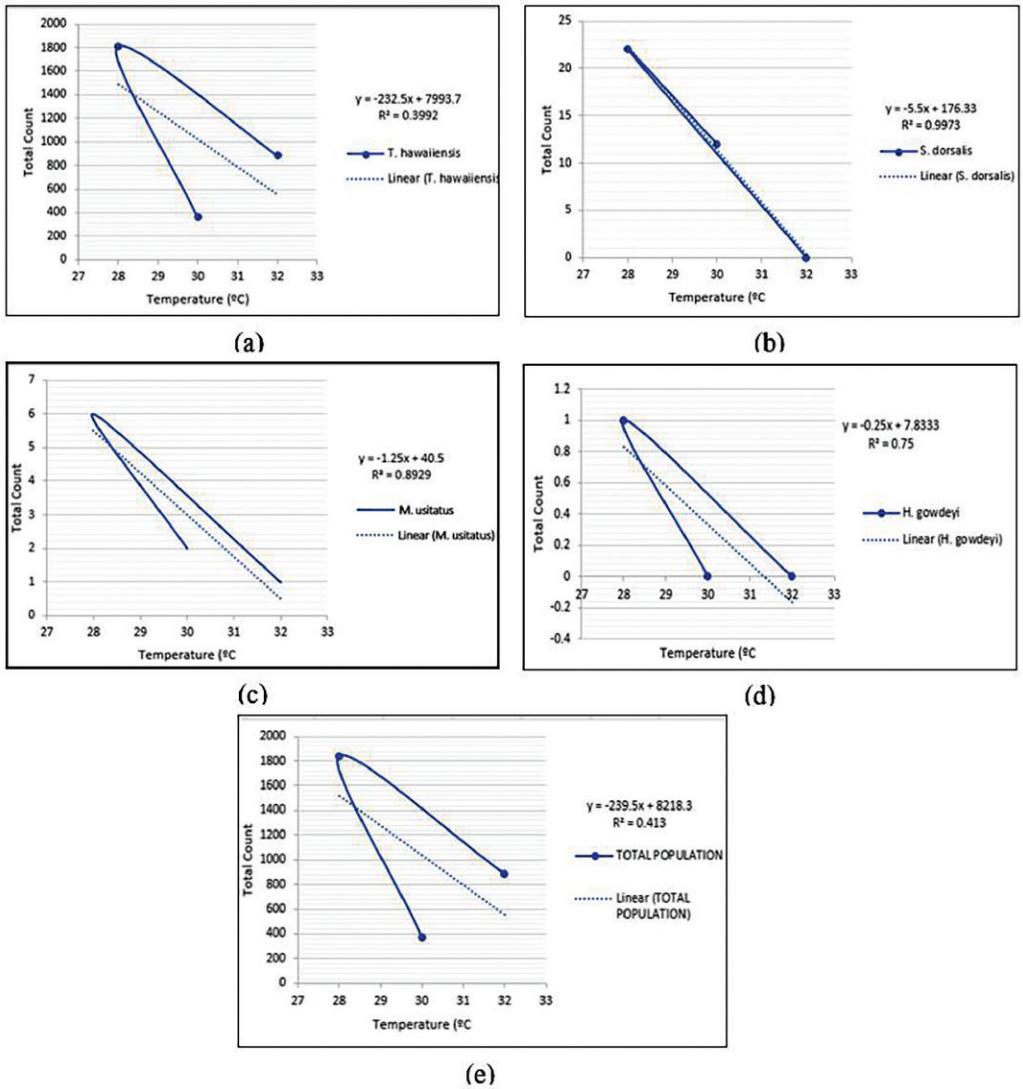

Figure 3. Regression line on temperature *vs.* the total counts of (a) *Thrips hawaiiensis* (Morgan), (b) S*cirtothrips dorsalis* Hood, (c) *Megalurothrips usitatus* (Bagnall), (d) *Haplothrips gowdeyi* (Franklin), and (e) total population of all thrips species on "Carabao" mango trees at Hacienda Villa Bianca in Maguilling, Piat, Cagayan, Philippines.

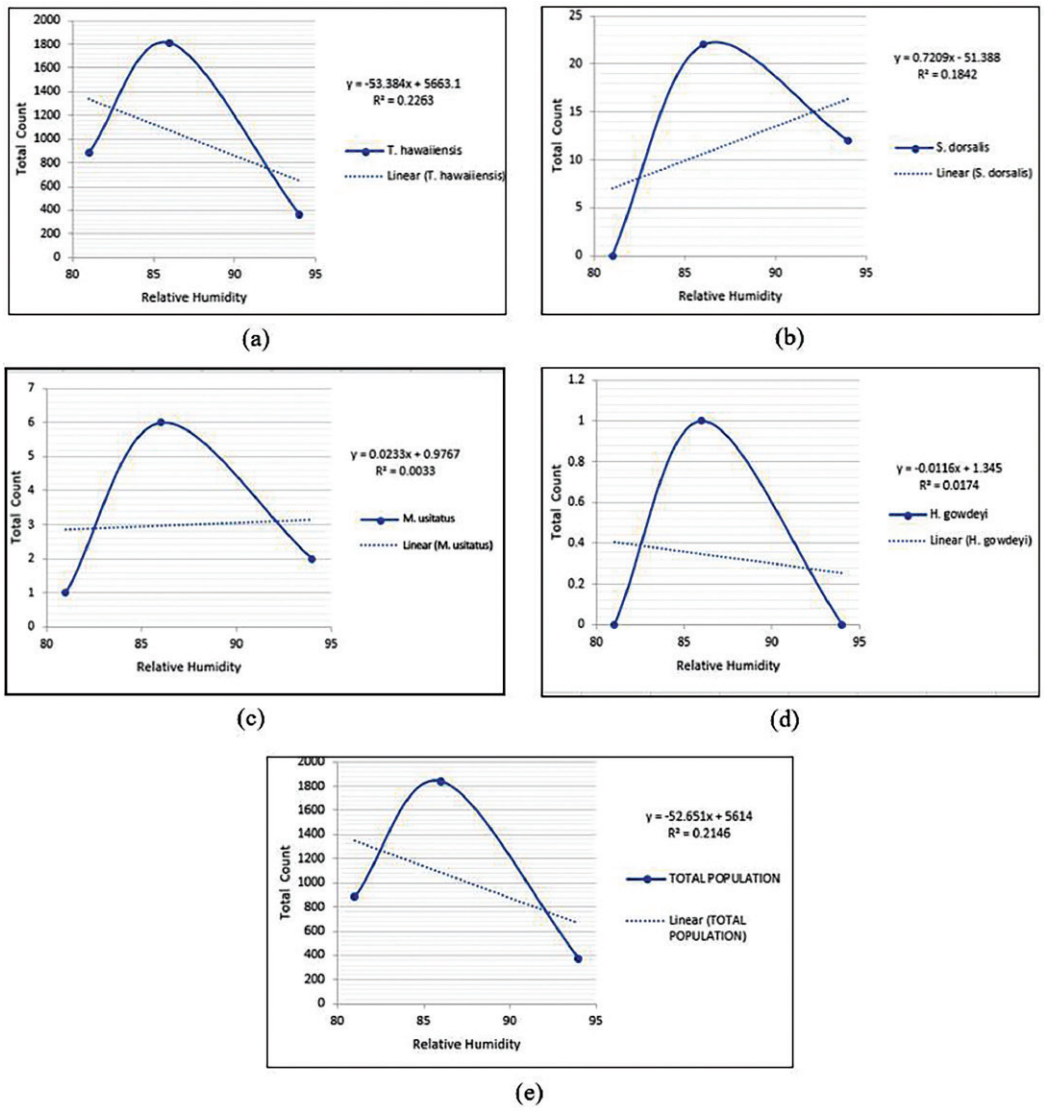

Figure 4. Regression line on relative humidity *vs.* the total counts of (a) *Thrips hawaiiensis* (Morgan), (b) S*cirtothrips dorsalis* Hood, (c) *Megalurothrips usitatus* (Bagnall), (d) *Haplothrips gowdeyi* (Franklin), and (e) total population of all thrips species on "Carabao" mango trees at Hacienda Villa Bianca in Maguilling, Piat, Cagayan, Philippines.

Regression analysis of *T. hawaiiensis* count and maximum average relative humidity showed a low correlation (R^2 = 0.2263) while the counts of *S. dorsalis, M. usitatus*, and *H. gowdeyi* showed near-zero correlation with relative humidity (R^2 = 0.1842; R^2 = 0.0033; R^2 = 0.0174). This implies that the thrip population was weakly affected by relative humidity. Previous studies conducted elsewhere showed almost no association or negative correlation between thrips population and relative humidity (Waiganjo *et al*. 2008).

Diversity Index

Species diversity indices obtained using Shannon's index (Center: H = 0.0649; North: H = 0.2348; East: H = 0.2031; West: H = 0.0784; South: H = 0.1053) showed that thrips were the most diverse on mango trees in the North group, followed by those in the East, West, Center, and South groups (Table 7). Thrips were the most diverse on mango trees in the North group probably because there were grasses in the area that served as alternate host plants. Thrips were the least diverse on mango trees in the South group probably because the trees were near the highway. Altogether, the diversity of thrips in the orchard was low and over 98% of the individuals belong to one species, *T. hawaiiensis*.

Table 7. Diversity indices of thrips collected on the five groups of "Carabao" mango trees at Hacienda Villa Bianca orchard in Maguilling, Piat, Cagayan, Philippines.

Group (six trees)	Shannon's index (H)			Thrips population (four species)		Shannon's index (H)
	Week 1 (24 Feb 2020)	Week 2 (02 Mar 2020)	Week 3 (09 Mar 2020)	Total	Mean	Mean
Center	0.1217	0.0175	0.0555	576	144.00	0.0649
North	0.3758	0.0977	0	687	171.75	0.2348
East	0.2686	0.1375	0	549	137.25	0.2031
West	0.0837	0.0731	0	475	118.75	0.0784
South	0	0.1053	0	813	203.25	0.1053

DISCUSSION

Thrips hawaiiensis and *Scirtothrips dorsalis* were the most prevalent species of thrips in the sprayed and unsprayed orchards in Penang, Malaysia (Aliakbarpour and Rawi 2010) and thrips abundance for both species were high during the mango flowering stage. The population of *T. hawaiiensis* peaked two weeks after the onset of the flowering period in pesticide-treated and untreated orchards, while the population of *S. dorsalis* peaked one week earlier in the pesticide-treated orchard and three weeks after the start of the flowering period in the untreated orchard (Aliakbarpour and Rawi 2012).

Thrips hawaiiensis is an invasive insect pest of Asian or Pacific origin with a wide distribution and host range (Reyes 1994). The species has been recorded in Africa, North America, the Caribbean, South America, France, Spain, Turkey, and Italy (Reynaud *et al.* 2008; Goldarazena 2011; Etakan *et al*. 2015; Marullo and De Grazia 2017). In this study, a few *T. hawaiiensis* males were found in the collection while surveys conducted earlier at Ato Belen's Farm in Laguna (Bagaoisan *et al*. 2019) and in Italy reported that there were no male thrips found in their samples (Marullo and De Grazia 2017). Moreover, in banana plantations of Davao, the feeding and oviposition injury of *T. hawaiiensis* affects the quality and marketability of Cavendish banana (Reyes *et al*. 2019).

Scirtothrips dorsalis is an invasive insect pest of Asian origin with a broad host range (Reyes 1994, 2017). It is also known abroad as a vector of seven viral pathogens, namely: Chili leaf curl virus, Capsicum chlorosis virus, Peanut necrosis virus, Peanut yellow spot virus, Tobacco streak virus, Melon yellow spot virus, and Watermelon silver mottle virus (Riley *et al*. 2011). Its damage to young leaves, buds, flowers, and fruits results in curling, deformation, and scarring. In Taiwan, *S. dorsalis* has recently become one of the key pests causing economic damage to the fruit production of mango (Chun *et al*. 2015). In Davao, Philippines, *S. dorsalis* damage to mango is locally known as "chico-chico" due to the brown scarring injury on the fruit skin (Medina *et al*. 2011; Apolinario *et al*. 2018).

This is the first report of *Megalurothrips usitatus* and *Haplothrips gowdeyi* on flowers ofmango in the Philippines. *M. usitatus* is a pest of leguminous crops while *H. gowdeyi* is associated with numerous plants in the Philippines and other countries (Reyes 1994).

CONCLUSION

There are four phytophagous species of thrips infesting flowers of Carabao mango in Hacienda Villa Bianca orchard. *Thrips hawaiiensis* (Morgan) *Scirtothrips dorsalis* Hood, *Megalurothrips usitatus* (Bagnall), and *Haplothrips gowdeyi* (Franklin) counts were positively affected by temperature while relative humidity had weak or almost no effect on thrips counts. *Thrips hawaiiensis* was the dominant thrips species in the orchard. *M. usitatus* and *H. gowdeyi* are new records on Carabao mango in the Philippines. Thrips were most diverse on trees in the North group and thrips were least diverse in the South group.

ACKNOWLEDGMENTS

The authors are very grateful to Atty. Carmelo O. Villacete and Mrs. Beatriz G. Villacete, owners of Hacienda Villa Bianca, for the opportunity to conduct the study in their orchard. The kind assistance of Engr. Romeo Sagun, municipal agriculturist of Piat, and Mr. Carmelito Ruam, caretaker of the orchard, are acknowledged. The manuscript reviewers are also acknowledged, as well as Carl Johnjay Ayen for his assistance in data analysis. The support of the management and staff of Cagayan State University is acknowledged with much appreciation. The research project was funded by the DA's Bureau of Agricultural Research.

REFERENCES

AFFANDI A, MEDINA CDR, VELASCO LRI, JAVIER PA, DEPOSITARIO DPT. 2018. Development and survivorship of *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) in different growth stages of mango and selected weeds. AGRIVITA J Agri Sci 40(1): 101–106.

ALIAKBARPOUR H, RAWI CSMD. 2010. Diurnal activity of four species of thrips (Thysanoptera: Thripidae) and efficiencies of three nondestructive sampling techniques for thrips in mango inflorescenses. J Econ Entom 103(3): 631–640.

ALIAKBARPOUR H, RAWI CSMD. 2012. Seasonal abundance of *Thrips hawaiiensis* (Morgan) and *Scirtothrips dorsalis* Hood in mango orchards in Malaysia. Pertanika J Trop Agri Sci 35(3): 637–645.

ALIAKBARPOUR H, SALMAH C, DIENG H. 2010. Species composition and population dynamics of thrips (Thysanoptera) in mango orchards of Northern Peninsular Malaysia. Entom Soc Amer 39(5): 1409–1419.

ALLEN JK, SCOTT-DUPREE CD, TOLMAN JH, HARRIS CR. 2005. Resistance of *Thrips tabaci* to pyrethroid and organophosphorus insecticides in Ontario, Canada. Pest Mgt Sci 61(8): 809–815.

APOLINARIO JJ, MEDINA CDR, VELASCO LRI, MENDIORO MS. 2018. Morphological, molecular and life-history homogeneity among local populations of *Scirtothrips dorsalis* Hood (Thysanoptera: Thripidae) in the Philippines. Philipp Agri Sci 101(3): 270–277.

BAGAOISAN MQR, KHO PJL, MACAWADIB ATKA, REYES CP. 2019. Thrips infesting mango 'Carabao' and pomelo 'Magallanes' in Ato Belen's farm, Laguna, Philippines. Asia Life Sci 28(1): 107–114.

CAO Y, LI C, YANG W, MENG Y, WANG L, SHANG B, GAO Y. 2018. Effects of temperature on the development and reproduction of *Thrips hawaiiensis* (Thysanoptera: Thripidae). J Eco Entom 3(2): 755–760. https://doi.org/10.1093/jee/tox359

CHUN NL, MIAO YW, NIANN TC, YI YC. 2015. The occurrence of *Scirtothrips dorsalis* Hood in mango orchards and factors influencing its population dynamics in Taiwan. J Asia-Pacific Entomol 18(3): 361–367.

ETAKAN E, OLCULU M, PEHLIVAN S, SATAR S. 2015. A new thrips species recorded in Turkey: *Thrips hawaiiensis* (Morgan,1913) (Thysanoptera: Thripidae). Turk Entom Bull 5(2): 77–84.

FU B, LI Q, QIU H, TANG L, ZENG D, LIU K, GAO Y. 2018. Resistance development, stability, cross-resistance potential, biological fitness and biochemical mechanisms of spinetoram resistance in *Thrips hawaiiensis* (Thysanoptera: Thripidae). Pest Mgt Sci 74(7): 1564-1574. https://doi.org/10.1002/ps.4887

GALLIBU M. 2019. Cagayan Valley as a "new player" for mango production in PH. Retrieved on 22 Apr 2020 from http://rfo02.da.gov.ph/2019/03/26/cagayan-valley-as-a-new-player-for-mango-production-in-ph/

GARCIA-RODRIGUEZ OG, PEREZ-MORENO L, NAVARRO-LEON MJ, SALAS-ARAIZA MD, MARTINEZ-JAIME OA, LEON-GALVAN MF, NUNEZ-PALENIUS HG. 2014. Plant viruses in garlic-associated insects. Rev Chap Ser Hort 20(2): 147−156.

GOLDARAZENA A. 2011. First record of *Thrips hawaiiensis* (Morgan, 1913) (Thysanoptera: Thripidae), an Asian pest thrips in Spain. EPPO Bulletin 41(2):170−173. https://doi.org/10.1111/j.1365-2338.2011.02450

GROVE T, GILIOMEE, JH, PRINGLE KL. 2000. Seasonal abundance of different stages of the citrus thrips, *Scirtothrips aurantii,* on two mango cultivars in South Africa. Phytoparasitica 28(1): 43–53.

HODDLE MS, MOUND LA, PARIS D. 2019. Thrips of California 2019. Retrieved on 22 Apr 2020 from https://keyserver.lucidcentral.org/key-server/search.jsp

MARULLO R, DE GRAZIA A. 2017. *Thrips hawaiiensis*, a pest from Asia newly introduced to Italy. Bull Ins 70(1): 27–30.

MEDINA CDR, VELASCO LRI, BELTRAN MJ. 2011. Preliminary observations on the biology and damage of thrips infesting mango fruits and flowers. 19th National Fruits Symposium, October 25–27, 2011, Cebu, Philippines.

MEDINA CDR, APOLINARIO JJG. 2015. Localization of populations of *Scirtothrips dorsalis* Hood collected from various mango-growing areas in the Philippines.

XI International Mango Symposium 1183: 305–310. Retrieved on 06 May 2020 from https://www.actahort.org/books/1183/1183_44.htm

MURAI T. 2001. Development and reproductive capacity of *Thrips hawaiiensis* (Thysanoptera: Thripidae) and its potential as major pest. Bull Entomol Res 91: 193–198.

NAUEN R, DENHOLM I. 2005. Resistance to insect pests to neonicotinoid insecticides: current status and future prospects. Arc Ins Biochem Physio 58: 200–215.

[PAGASA] Philippine Atmospheric, Geophysical and Astronomical Services Administration. 2020. Retrieved on 22 Apr 2020 from http://bagong.pagasa.dost.gov.ph/

PENG RK, CHRISTIAN K. 2007. Integrated pest management in mango orchard in Northern Territory Australia, using weaver ant, *Oecophylla smaragdina*, (Hymenoptera: Formicidae) as a key element. Inter J Pest Mgt 51(2): 149–155.

PHILATLAS. 2020. Piat, Province of Cagayan. Retrieved on 26 Jun 2020 fromhttps://www.philatlas.com/luzon/r02/cagayan/piat.html

[PSA] Philippine Statistics Authority. 2018. Fruits: Supply utilization accounts for mango. Retrieved on 22 Apr 2020 from http://countrystat.psa.gov.ph/selection.asp

REYES CP. 1994. Thysanoptera (Hexapoda) of the Philippine islands. Raffles Bull Zoo 42(2): 107–507.

REYES CP. 2017. Updates on the Cecilia P. Reyes collection of Philippine thrips (Insecta: Thysanoptera). Manila J Sci 10: 131–135.

REYES CP, JUMAMOY MC, CORCOLON BM. 2019. *Thrips hawaiiensis* (Morgan) pest of Cavendish banana in a plantation in Panabo, Davao del Norte. Book Abst Inter Conf Food Econ Sec Envi Sustain CSU, Tuguegarao. 28p.

REYNAUD P, BALMES V, PIZZOL J. 2008. *Thrips hawaiiensis* (Morgan, 1913) (Thysanoptera: Thripidae), an Asian pest thrips now established in Europe. https://doi.org/10.1111/j.1365-2338.2008.01201.x

RILEY DG, JOSEPH SV, SRINIVISAN R, DIFFIE S. 2011. Thrips vectors of tospovirus. J Integ Pest Mgt 1(2): 1–10.

THONGJUA T, THONGJUA J. 2015. The relationships between thrips population and climatic factors, mangosteen development stage in Nakhon Si Thammarat province, Thailand. J Agri Tech 11(8): 1887–1896.

WAIGANJO MM, GITONGA LM, MUEKE JM. 2008. Effects of weather on thrips population dynamics and its implications on the thrips pest management. Afri J Horti Sci 1: 82–90.