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Original Article

Distribution of *Cylas formicarius* (Coleoptera: Brentidae) and assessment of knowledge, attitudes and practices of community towards pests in Terengganu, Malaysia

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Abstract

Sweet potato is one of an important cash crop in Malaysia. Varieties such as orange, white and purple fleshed were planted in Terengganu state which is one of the biggest sweet potato producer in Malaysia. The production of sweet potato is limited by the infestation of insect pests. Farmers in Terengganu have reported that sweet potato weevil, *Cylas formicarius* attacked their sweet potatoes during cultivation and this problem continue after harvest where the pest affected produces at commercial centres. To study the distribution of sweet potato weevil, field sampling were conducted in eight districts of Terengganu by visiting sweet potato cultivation areas and commercial centres (market, stalls and grocery stores). In this study, five kilogram of damaged sweet potatoes from variety orange, white and purple fleshed collected from all eight districts of Terengganu were highly infested by *C. formicarius* where Besut was recorded with the highest number of weevil emergence, $X^2(7, N = 7748) = 1764.79$, $p < 0.05$. This showed that *C. formicarius* population had distributed all over Terengganu. A survey was conducted on 240 respondents showed that the majority (72.92%) of them have low knowledge level regarding sweet potato weevil and its associated problems which led to the low level of awareness/attitude (71.25%) and practice (99.58%) on this issue. The findings of this study are useful to plan guidelines for sweet potato integrated pest management (IPM) programs which will ensure adequate food production and food security for the nation.

Keywords: Pest infestation, Cash crop, Cultivation, Post-harvest, Wetland

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Introduction

Sweet potatoes are widely grown in tropical and subtropical regions (Chandrasekara and Joseph Kumar, 2016). This crop is listed as an important crop for food security (Woolfe, 1992; Bourke, 2001; Zhang et al., 2009). Sweet potato contains calories and a major source of vitamins (Lebot, 2010; Chandrasekara and Joseph Kumar, 2016). In Malaysia, sweet potatoes are grown either in small or large scale for commercial uses (Tan and Zaharah, 2015). This plant is considered as an important cash crop to generate side income for farmers (Alumira and Obara, 2008).

Terengganu is one of the biggest sweet potato producers in Malaysia (Department of Agriculture Peninsular Malaysia, 2017). Several sweet potato varieties are grown in this state such as orange (VitAto), white and purple fleshed. However, insect pest attacks are the major constraints in the sweet potato production in Terengganu. Sweet potato weevil (SPW), *Cylas formicarius* attacks on sweet potatoes occurred during cultivation in every planting seasons (personal communication with farmers). The problem became more serious when the weevil infestation continues on harvested sweet potatoes especially at commercial centers (markets and grocery stores). Pests including *C. formicarius* are huge limitation in sweet potatoes production (Horton and Ewell, 1991). If there is no action taken, farmers and traders will experience huge losses. The infestation of the weevils caused damage that reduced the quality and marketability of sweet potatoes (Ndunguru et al., 1998; Nur Aida et al., 2017a). To date, there is no research on the distribution of SPW in Terengganu is ever documented, thus there is a gap in knowledge of the community's perspective and dispersal status of this pest in this state.

Fundamental information such as distribution and also communities' level of knowledge, attitude and practices toward this pest are crucial for effective control and pest outbreak prevention can be planned. As compared to other countries, knowledge of people on sweet potato damage and its associated problems have been researched and well documented in other countries (Epeju, 2014; Okonya et al., 2014; Adam et al., 2015). Therefore, the present study was conducted to determine the distribution of *C. formicarius* in Terengganu and to assess communities' knowledge, attitude and practices towards the weevils. Better understanding of the communities towards this pest might reduce the weevil dispersal in Terengganu.

Material and Methods

Study areas

Terengganu is located at latitude 5°19'48''N and longitude 103°08'26''E in northeastern Peninsular Malaysia, bordered by the Kelantan and Pahang at the northwest and southwest respectively. Terengganu covers a land area of 12,995 km^2 with 244 km of beautiful coastline, facing the South China Sea ("Tourism in Terengganu," n.d). Terengganu experienced hot and humid weather throughout the year. Its temperature averaging from 23ºC to 32ºC and received heavy rain when the northeastern monsoon hit in November to January (Terengganu Tourism, 2014). Terengganu recorded Gross Domestic Product (GDP) at RM 28.6 million, of which the main industries such as manufacturing and utilities of petroleum and gas sector contributed to the economic growth (Department of Statistics Malaysia, 2017). In addition, tourism, fisheries and agriculture remain important to generate the state's economy. Terengganu is divided into eight administrative districts starting from Besut which borders Kelantan at the north followed by Setiu, Hulu Terengganu, Kuala Nerus, Kuala Terengganu, Marang, Dungun and Kemaman at the south bordering Pahang (southern entrance to the state of Terengganu).

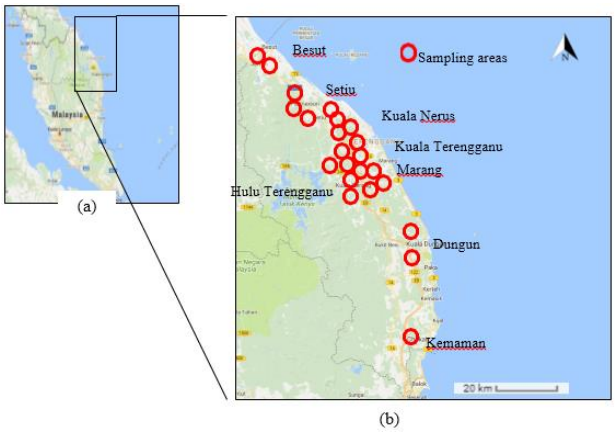

Figure-1: (a) Map of Malaysia; (b) Map of Terengganu and sampling areas

Surveys and sampling was conducted in all the eight administrative districts in Terengganu between July 2016 and May 2017. Map of Malaysia and the sampling areas around Terengganu were shown in Figure 1. The areas chosen are the main sweet potato cultivation areas and centers where harvested sweet potatoes were marketed such as wet markets, grocery shops and stalls.

Collection of sweet potatoes and weevils

Field sampling were conducted by visiting selected cultivation areas and commercial centers such as general market, wholesale market, grocery store and roadside stalls at selected localities to obtain damaged sweet potato samples. The damaged sweet potatoes harbored puncture and holes on the skin which indicated sweet potatoes have been attacked by weevil (Figure 2).

Figure-2: Damaged sweet potatoes at the market

Five kilogram of damage sweet potatoes were purchased from farmers or traders from each district. These sweet potatoes were brought back to the Laboratory for Pest, Disease and Microbial Biotechnology (LAPDiM), Universiti Malaysia Terengganu. All the damaged sweet potatoes were placed in insect cages (30 cm x 30 cm x 30 cm) and labelled according to the study sites. Emergence of adult weevils from each cage were observed and the number of weevils were counted and recorded daily until no more weevil emergence was observed.

Emerged weevils were examined under a compound microscope (Olympus, SZX16). SPWs was identified by examining their characteristics such as the head, thorax, body, antennae and legs in details. The identification of adult weevil was performed by using the taxonomic key by Wolfe (1991).

Surveys

A community-based cross-sectional study was carried out which covers sweet potato cultivation areas, sweet potato trade centres and residential areas. Judgmental sampling technique was chosen to obtain representativeness in this survey. The respondents were selected according to the inclusive criteria; either men or women, who cultivated, sold or purchased sweet potatoes at the markets. Respondents were approached directly by face to face and individually interviewed. Respondents in the study areas were given all the information about the study prior the interview session to give them comfort and understand the objective of the survey. The participation was voluntary and all the information obtained were kept confidential.

Semi structured questionnaires including open and close-ended questions was designed as the inquiry instruments in this study. It was made up of four sections; (1) socio-demographic characteristics, (2) knowledge, (3) attitudes and (4) practices. Immediately following the interview session, each respondent was showed a photo of damaged sweet potato together with adult and immature *C. formicarius* live samples to clarify their description on the pest.

Each respondent was assigned a separate score for knowledge, attitude, and practice based on the number of correct or suitable answers. Each appropriate and positive answer was assigned one point and no response was assigned zero. The total knowledge scores ranged from 0 to 16 points, the attitude score from 0 to 5 points and the practice score from 0 to 7 points. The total scores achieved by respondents were further dichotomized into two levels of Knowledge, Attitude and Practice by referring Aung et al. (2016) and modified to suit the survey design in this study. The level of Knowledge, Attitude and Practice of respondents were determined by using the following score:

Knowledge (low = 0 - 6 points; high = 7 - 16 points)
Attitude (bad = 0 - 2 points; good = 3 - 5 points)
Practice (bad = 0 - 3 points; good = 4 - 7 points)

Statistical analysis

The data collected were entered into Microsoft Excel 2010 spreadsheet and descriptive statistics such as frequency and percentages were calculated. All data were subjected to statistical analysis by using Statistical Package for Social Science (SPSS) version 22. For *C. formicarius* distribution, Chi Square test for goodness of fit was used to analyse the differences between total number of male and female weevils emerged and total number of weevils among all

districts. For survey data, each question from each section were analyzed individually by using Chi Square test for goodness of fit. The associations of respondents' knowledge, attitude and practice on SPW damage with socio-demographic characteristics were analyzed by using Chi Square test for relatedness or independence.

Results

Cylas formicarius distribution in Terengganu

In this study, it was observed that all damaged sweet potatoes collected from cultivation areas and markets were highly infested by *C. formicarius*. The adults of *C. formicarius* successfully emerged from all samples collected that represented each districts in Terengganu (Table 1).

A total of 7748 weevils successfully emerged from all damaged sweet potatoes collected. Out of this, 3816 were males and 3932 were females, $X^2(1, N = 7748) = 1.74$, $p>0.05$. All districts recorded sex ratio of almost 1:1. Based on districts, samples from Besut showed the highest number of weevil emergence (25.46%). This followed by Marang (16.74%), Setiu (13.53%), Dungun (12.22%), Kuala Terengganu (10.70%), Kuala Nerus (8.40%) and Kemaman (8.03%). Hulu Terengganu recorded the least emergence of SPW which is only 381 or 4.92%. There was significant difference in the total number of weevils emerged among all districts in Terengganu, $X^2(7, N = 7748) = 1764.79$, $p< 0.05$. The presence of *C. formicarius* is shown in Figure 3. *Cylas formicarius* had widely presence all over Terengganu.

Socio-demographic characteristics

The socio-demographic characteristics of the respondents are presented in Table 2. A total of 240 respondents from eight administrative district of Terengganu were interviewed. Most of the respondents were females, 168 (70%). Majority of respondents' age are senior citizen with age between 51 – 60 years (27.1%) followed by ≥ 61 years (20%), 41 - 50 years (18.8%), 20 - 30 years (16.7%), 31 - 40 years (15.8%) and < 20 years (1.7%). Most of the respondents (65%) have secondary school level of education and only 1.7% was illiterate. Substantial portions (84.6%) of the respondents were self-employed to support their lives by having their own business. The rest (15.4%), were unemployed, government worker or student.

Table-1: Adult emergence and sex ratios of *Cylas formicarius* according to district in Terengganu

District	Adult emergence				X^2	p-value
	Total (%)	Male	Female	Sex ratio		
Besut	1973 (25.46)	991	982	1.0:1.0	0.41	>0.05
Dungun	947 (12.22)	454	493	1.0:1.1	1.606	>0.05
Hulu Terengganu	381 (4.92)	174	207	1.0:1.2	2.858	>0.05
Kemaman	622 (8.03)	349	273	1.3:1.0	9.286	<0.05
Kuala Nerus	651 (8.40)	275	376	1.0:1.4	15.670	>0.05
Kuala Terengganu	829 (10.70)	406	423	1.0:1.0	0.349	>0.05
Marang	1297 (16.74)	633	664	1.0:1.1	0.741	>0.05
Setiu	1048 (13.53)	534	514	1.0:1.0	0.382	>0.05
Total	7748 (100)	3816	3932			
X^2	1764.79	1.74				
p-value	<0.05	>0.05				

Table-2: Socio-demographic characteristics of respondents from eight administrative districts of Terengganu (n=240)

Socio-demographic characteristics	Besut n (%)	Setiu n (%)	Kuala Nerus n (%)	Kuala Terengganu n (%)	Hulu Terengganu n (%)	Marang n (%)	Dungun n (%)	Kemaman n (%)	Total n (%)
Gender									
Male	10 (33.3)	5 (16.7)	4 (13.3)	7 (23.3)	12 (40)	14 (46.7)	13 (43.4)	7 (23.3)	72 (30)
Female	20 (66.7)	25 (83.3)	26 (86.7)	23 (76.7)	18 (60)	16 (53.3)	17 (56.7)	23 (76.7)	168 (70)
Age (year)									
< 20	2 (6.7)	0	0	1 (3.3)	0	0	1 (3.3)	0	4 (1.7)
20 – 30	3 (10)	5 (16.7)	3 (10)	4 (13.3)	1 (3.3)	11 (36.7)	6 (20)	7 (23.3)	40 (16.7)
31 – 40	6 (20)	4 (13.3)	8 (26.7)	5 (16.7)	2 (6.7)	2 (6.7)	6 (20)	5 (16.7)	38 (15.8)
41 – 50	8 (26.7)	6 (20)	4 (13.3)	2 (6.7)	7 (23.3)	7 (23.3)	4 (13.3)	7 (23.3)	45 (18.8)
51 – 60	4 (13.3)	10 (33.3)	8 (26.7)	14 (46.7)	8 (26.7)	5 (16.7)	10 (33.3)	6 (20)	65 (27.1)
≥ 61	7 (23.3)	5 (16.7)	7 (23.3)	4 (13.3)	12 (40)	5 (16.7)	3 (10)	5 (16.7)	48 (20)
Education level									
Illiterate	0	1 (3.3)	2 (6.7)	0	1 (3.3)	0	0	0	4 (1.7)
Primary	11 (36.7)	6 (20)	12 (40)	8 (26.7)	11 (36.7)	4 (13.3)	6 (20)	2 (6.7)	60 (25)
Secondary	15 (50)	17 (56.7)	15 (50)	18 (60)	18 (60)	25 (83.3)	23 (76.7)	25 (83.3)	156 (65)
Tertiary	4 (13.3)	6 (20)	1 (3.3)	4 (13.3)	0	1 (3.3)	1 (3.3)	3 (10)	20 (8.3)
Occupation									
Unemployed	4 (13.3)	2 (6.7)	13	2 (6.7)	0	0	0	5 (16.7)	26 (10.8)
Government workers	0	2 (6.7)	1 (3.3)	4 (13.3)	2 (6.7)	0	0	0	9 (3.8)
Self employed	25 (83.3)	25 (83.3)	16 (53.3)	24 (80)	28 (93.3)	30 (100)	30 (100)	25 (83.3)	203 (84.6)
Student	1 (3.3)	1 (3.3)	0	0	0	0	0	0	2 (0.8)

n = number

Knowledge, attitudes and practices of community towards sweet potato and its pest

A total of 92.9% respondents in this study revealed that they had encountered damage sweet potatoes either during cultivating, purchasing or preparing sweet potatoes at home (Table 3) [$X^2(1, N = 240) = 176.817$, $p<0.05$)]. Only 37.1% of respondents ever found insect larvae in sweet potato, $X^2(1, N = 240) = 16.017$, $p<0.05$) while 31.7% of the respondents encountered adult weevil [$X^2(1, N = 240) = 32.267$, $p<0.05$). Of the 240 respondents who had ever experienced problems with sweet potatoes, 233 (92.9%) could mentioned at least one symptom of damage. The most common symptom mentioned by respondents was tiny holes in the skin of sweet potatoes (88.3%). Other symptoms mentioned by respondents included sweet potatoes have watery and spongy textures (50.4%), unappealing colour (49.2%), have bitter taste (45.8%), produced bad odour (23.8%) and the presence of larva or insect inside the sweet potato (10.8%) [$X^2(6, N = 651) = 312.258$, $p<0.05$)].

With regards to sweet potato damage symptoms, respondents were asked about the causes for this problems and the majority of them (59.9%) unable to mention any causal agent for the damages. The rest (42.91%) opined the damage problems were due to disease infection, insect attack, cultivation environment, storage handling practice and transportation from farm to the market [$X^2(5, N = 265) = 298.298$, $p<0.05$)].

Related to susceptibility of sweet potato variety with SPW, 59.6% of respondents have no idea which varieties are the most susceptible. However, about 62 (25.8%) respondents answered that orange-fleshed sweet potato to be more encountered with the weevil infestation. Besides SPW, other pests of sweet potato were mentioned by 13 (5.42%) respondents. The pests include rats, wild boar, termites, moths and ants.

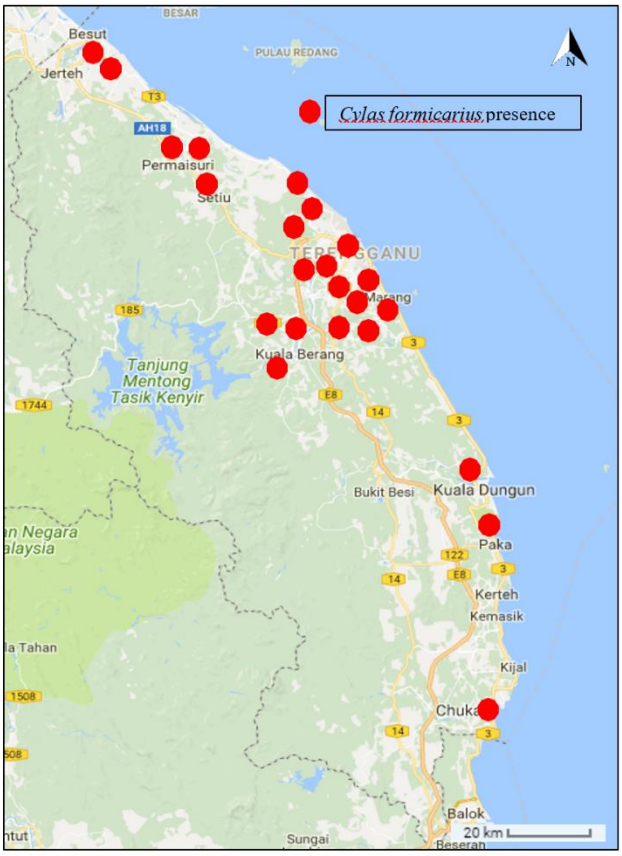

Figure-3: *Cylas formicarius* presence (red dot) in Terengganu

Most of the respondents showed indifference reaction (89.58%) when encountered sweet potato damage (Table 4). The rest (10.42%) felt angry and disgusted when dealing with this problem [$X^2(2, N = 240) = 342.025$, $p<0.05$]. A large percentage (74.6%) of respondent will not eat damaged sweet potato [$X^2(1, N = 240) = 58.017$, $p<0.05$]. Almost all respondents (99.6%) still wanted to buy sweet potato again after experiencing damaged sweet potato [$X^2(1, N = 240) = 236.017$, $p<0.05$]. About 180 (75%) of respondents did not think that the improper handling of damaged sweet potatoes can resulted in infection to the healthy sweet potatoes [$X^2(1, N = 240) = 60.000$, $p<0.05$]. Majority (67.5%) of respondent believed sweet potato damage problems will not affect their quality of life [$X^2(1, N = 240) = 33.750$, $p<0.05$].

All 240 respondents (100%) threw away damaged sweet potato when encountered the problem (Table 5). Some respondent used insecticides (0.42%), feed the damaged sweet potatoes to animals (2.5%) or return back to the seller (0.42%) [$X^2(3, N = 240) = 681.645$, $p<0.05$]. Out of 240 respondents, there was only 105 (43.75%) respondents practiced good storage handling by separating damaged sweet potato away from healthy ones [$X^2(1, N = 240) = 3.750$, $p>0.05$].

It was found that the respondents in this study had low level of knowledge on damaged sweet potatoes and its associated pest problems. They also had bad attitude (71.25%) when facing this problem where majority of respondents showed poor awareness on sweet potato pest issues (Table 6). The respondents in this study (99.58%) also did not practice proper way when handling damage sweet potatoes and its pest.

Cross tabulations analyses were done between knowledge, attitude and practice level with the socio-demographic characteristics of respondents. There is no significant association between the three attributes ($p>0.05$). The results are presented in Table 7. Knowledge level of respondents did not influenced by socio-demographic characteristics such as gender [$X^2(1, N = 240) = 2.035$, $p>0.05$], age [$X^2(5, N = 240) = 4.870$, $p>0.05$], education [$X^2(3, N = 240) = 3.387$, $p>0.05$] and occupation [$X^2(3, N = 240) = 5.786$, $p>0.05$]. There is also no significant association between attitude level of respondents with age [$X^2(1, N = 240) = 0.922$, $p>0.05$], gender [$X^2(5, N = 240) = 2.255$, $p>0.05$], education [$X^2(3, N = 240) = 6.841$, $p>0.05$] and occupation [$X^2(3, N = 240) = 2.803$, $p>0.05$]. Similar result was also observed where there is also no significant association between practice level with gender [$X^2(1, N = 240) = 0.864$, $p>0.05$], age [$X^2(5, N = 240) = 2.534$, $p>0.05$], education [$X^2(3, N = 240) = 4.809$, $p>0.05$], and occupation [$X^2(3, N = 240) = 0.368$, $p>0.05$].

Table-3: The knowledge of 240 respondents towards sweet potato damage and pests

Knowledge variables of sweet potato damage and pests	n	%	X^2	p-value
Have you ever encountered/purchased damaged sweet potato?				
Yes	223	92.9	176.817	<0.05
No	17	7.1		
Have you ever encountered larvae in purchased/prepared sweet potato?				
Yes	89	37.1	16.017	<0.05
No	151	62.9		
Have you ever seen an adult weevil when purchased/prepared Sweet potato?				
Yes	76	31.7	32.267	<0.05
No	104	68.3		
Which sweet potato damage symptoms you have encountered?				
Skins of tubers have tiny pores/punctured signs	212	88.3	312.258	<0.05
Watery and spongy textures	121	50.4		
Colour of tubers looks unappealing	118	49.2		
Taste bitter when cooked	110	45.8		
Tubers emit bad odour	57	23.8		
Presence of larva/insect inside tubers	26	10.8		
Do not know	7	2.92		
Do you know the causes for sweet potato damage?				
Disease infection	7	2.92	298.298	<0.05
Insect attack/fed on tubers	56	23.33		
Cultivation and field environment	46	19.2		
Storage handling	16	6.7		
Transportation	1	0.42		
Do not know	139	57.9		
Which sweet potato variety is the most susceptible to insect attack?				
Orange	62	25.8	376.950	<0.05
White	16	6.7		
Purple	4	1.7		
Orange and white	7	2.9		
Purple and orange	0	0		
Purple and white	0	0		
All of them	8	3.3		
Do not know	143	59.6		
Do you know other pests for sweet potato?				
Yes	13	5.42	190.817	<0.05
No	227	94.6		

Table-4: Respondents attitude towards damaged sweet potato and pest

Attitude variables of sweet potato pest problems	n	%	X^2	p-value
What is your reaction when you see damaged sweet potato?				
Angry	9	3.75	342.025	<0.05
Disgusted	16	6.67		
Fear	0	0		
Indifference	215	89.58		
Will you eat damaged sweet potato?				
Yes	61	25.4	58.017	<0.05
No	179	74.6		
Will you buy sweet potato again after experiencing damaged sweet potato?				

Yes	239	99.6	236.017	<0.05
No	1	0.4		
Do you think damaged sweet potato can infect healthy sweet potato by improper handling practice during storage?				
Yes	60	25	60.000	<0.05
No	180	75		
Do you think damaged sweet potato will affect your quality of life?				
Yes	75	31.25	33.750	<0.05
No	165	67.5		

Table-5: Respondents practices towards damaged sweet potato and pest

Practice variables of sweet potato pest problems	n	%	X^2	p-value
What did you do with damaged sweet potato?				
Just throw it	240	100	681.645	<0.05
Use insecticides	1	0.42		
Feed to the animals	6	2.5		
Burn it	1	0.42		
Return to seller/farmers	0	0		
Other method				
Did you separate damage and healthy sweet potatoes in the storage?				
Yes	105	43.75	3.750	>0.05
No	135	56.25		

Table-6: Knowledge, attitude and practice level on sweet potato damaged and pest among respondents (n= 240)

Variables	Frequency (%)	X^2	p-value
Knowledge level of respondents regarding sweet potato weevil and its associated problems			
High level (7-16 scores)	65 (27.08)	50.417	<0.05
Low level (0-6 scores)	175 (72.92)		
Attitude of respondents towards sweet potato damage and pest			
Good attitude (3-5 scores)	69 (28.75)	43.350	<0.05
Bad attitude (0-2 scores)	171 (71.25)		
Practice of respondents on sweet potato damage and pest			
Good practice (3-5 scores)	1 (0.42)		
Bad practice (0-2 scores)	239 (99.58)	236.017	<0.05

Table-7: Association between knowledge, attitude and practice on SPW damage and the socio-demographic characteristics of the communities in Terengganu

Socio-demographic characteristics	p-value		
	Knowledge	Attitude	Practice
Gender	0.154	0.337	0.353
Age	0.440	0.813	0.771
Level of education	0.336	0.077	0.186
Occupation	0.122	0.423	0.947

Level of significance, $\alpha = 0.05$

Discussion

Sweet potato weevil, *C. formicarius*, is one of the most devastating insect pest of sweet potatoes (Hue & Low, 2015). In this study, it was revealed that this pest is now widely distributed all over Terengganu. All markets visited had supplied sweet potatoes that were readily infested with SPW to consumers. This condition contributed to the widespread of *C. formicarius* around Terengganu.

Sample from Besut was recorded with the highest number of weevil emergence as compared to other districts. High number of weevil emergence in Besut indicated that the infestation of this pest probably begin here and later on spread out to all major commercial centres of Terengganu. Besut is the main producer of sweet potato in Terengganu and harvested sweet potatoes from this district were marketed all over the state. In addition, the harvested sweet potatoes from Besut also exported to other states in Malaysia. Thus, the damaged sweet potatoes obtained and sold at the markets at the other seven districts in Terengganu may also come from Besut. Kelantan, Thailand, Besut and Setiu are the main suppliers for sweet potatoes in Kuala Terengganu, Kuala Nerus, Marang, Hulu Terengganu, Kemaman and Dungun (personal communication with traders). *Cylas formicarius* is the key pest in sweet potato cultivation in Terengganu and also had caused severe damage to sweet potatoes in storage. Previous studies reported that coleopterans are the most economically important post-harvest insect pest and ultimately caused damage to many agricultural products in stores (Kurup and Balagopalan, 1991; Lale and Ofuya, 2001; Mtunda et al., 2001) including sweet potatoes (Nur Aida et al., 2017a,b)

Rapid spread of weevil from cultivation areas to the commercial centers might be due to various factors such as inefficient planting management (Talekar, 1987) and climate change condition during the growing season (Okonya and Kroschel, 2013). Cultivation areas with poor sanitary practices are favorable for insect attack including *C. formicarius* (Talekar, 1987). During field visit to the sweet potato cultivation areas in Besut, it was observed that farmers usually harvested sweet potatoes four to five months after planting. After that, the land will be left unused and unattended for about six months until the next planting season. Other poor agriculture practice was also observed where sweet potato crop residues were left to rot in the field. This condition contributed to the weevil outbreak. Sweet potato crop residues should be destroyed promptly after harvest to reduce weevil population build up that eventually will be carried over into new crop fields. Weevils that survived from infested sweet potato plant parts might disperse to another area if no proper action is taken.

Other than farm sanitation, abiotic factor like environmental condition during planting season also have an effect on weevil infestation. Dry season with high temperature may promote insect population growth and increased risk of outbreak (Gomi et al., 2007). Sweet potatoes in Besut were usually harvested before monsoon season started. During this period, a lot of sweet potatoes are sold by farmers and traders along the roadside in Terengganu. These sweet potatoes were planted in February to May during dry season. High levels of weevil incidence commonly related with low rainfall level (Powell et al., 2000; Parr et al., 2014). Soil crack during dry season will assist weevil to reach sweet potatoes buried in the soil. During rainy season, soil is more compact and hinders the penetration of weevil (Parr et al., 2014). Weevils will lay eggs and larvae feeding inside sweet potato under the soil will emerge into adults shortly after harvesting become the main cause for the widespread of the pest at the markets around Terengganu.

Under tropical environment, continuous infestation of insect pests can occur in storage (De Lima, 1987). Once the sweet potatoes reach at commercial centers, it was sold loosely or in bulk together with other vegetables and raw products. In such case, traders invariably placed old and new sweet potatoes together making cross infestation possible. Adult weevils that emerged from infested sweet potatoes will forage the healthy sweet potatoes.

Injuries due to weevil feeding also deteriorate sweet potatoes quality and shelf life rapidly. Wounding of sweet potato roots increase both the respiration rate and weight loss which lead to post-harvest losses (Jenkins, 1982; Picha, 1986). Prolonged storage under high temperature and humidity at the market place is not suitable to extend the shelf-life of sweet potatoes (Alumira and Obara, 2008). In addition, small puncture wounds on sweet potatoes by the weevils may also cause secondary infection by fungi and bacteria (Onwueme and Charles, 1994). This infection caused rots and surface blemishes which make sweet potatoes unappealing and unmarketable (Ray and Ravi, 2005).

In the present study, community's knowledge, attitude and practices towards sweet potatoes and its associated

problems were assessed. Majority of respondents in this study were female. Female respondents are easily approached and have positive attitude to cooperate for interview. Female respondents also have more knowledge on sweet potatoes since they were involved in food preparation at home or the person in-charge to buy food and groceries for household. As surveys took place at public areas such as markets which are centers to get fresh household supplies, thus the respondents involved in this study were from various background and education level. Some of them were self-employed as trader or a housewife. Kagimbo et al. (2018) reported that women have an important role in sweet potato production activities including growing, processing and marketing.

This study revealed that almost all respondents have encountered sweet potato problems. Terengganu people consumed sweet potatoes from various varieties either it is orange, white or purple-fleshed as one nutritious dish at home. Tomlins et al. (2004) reported that consumers prefer to consume sweet potato due to the high starch content and good taste when cooked. Despite substantial portion of respondents experienced damaged sweet potatoes, only small percentage showed awareness on the existence of SPW as the pest or the causal agent for the damage. Most of them have never seen the two common life stages of the weevil; larva and adult. Throughout the survey, it was found that the respondents have confused the adult weevil with an ant since it has ant-like appearance. The respondents also cannot associate the larvae or white grub they have found in the damaged sweet potatoes to the adult weevil sample shown to them during the interview. Thus, this perception corroborated with the previous finding by Smit and Matengo (1995) where some farmers cannot relate between the larvae inside the sweet potato roots and the mobile adult weevils on the leaves.

Majority of respondents are aware and can mention at least one symptom of damage on sweet potato. Many of them were able to recognize the sweet potato as spoilt or infested by unappealing physical appearance during purchasing. Respondents attitude of being selective help them to buy safe and fresh sweet potatoes for their family. Although almost all respondents can state the symptom of damage, half of them have no idea about what caused the damages. This is because they feel that this problem has nothing to do with them. The prices of sweet potato around RM 2 to RM 5 per kilogram in the market are very affordable for them. Thus encountering once or twice damaged sweet potatoes does not concern them. Other than that, some respondents referred the cause of sweet potato damage as *"kelarah"*, which is local name for the damaged sweet potato with white grubs inside. However, most of them cannot give the correct description about the adult pest. This indicated that Terengganu communities have low knowledge about *Cylas formicarius* as the pest for sweet potato. Simple description on morphological characteristics of the pest should be prepared to assist farmers and consumers to recognize the pest correctly.

Other than SPW, vertebrate pests are also one of the biological constraints in sweet potato production. Throughout the survey, small fraction of respondents viewed other animals such as wild boar, rats, small gastropods and other insects including ants, termites and caterpillars as the pests for sweet potatoes in the field and storage. Bashaasha et al. (1995) have reported that vertebrate pests comprising monkeys, moles and rats were serious nuisance in sweet potato field. Overall, most Terengganu respondents in this study have low knowledge on sweet potato resistance varieties towards SPW.

It was found that only small number of respondents in this study used proper way to dispose damaged sweet potatoes. Proper disposal of damaged tubers will help to reduce the spreading of weevils to healthy sweet potatoes. Some respondents feed the potatoes to the poultry and cattle. Sweet potatoes are valuable source of energy for ruminants (Woolfe, 1992). According to Scott (1992), it is a good practice to feed grazing animals with leftover and unsold sweet potatoes. This practice will prevent sweet potato residues from rotting in the field and become breeding ground for insect pest such as *C. formicarius*.

In this study, it was observed that Terengganu respondents showed lack of concern or awareness towards sweet potato problems and its pest. This is reflected by their attitude toward proper storage handling of damaged sweet potatoes which can reduce weevil infestation. This probably because the respondents who are represent as consumers are not economically affected by the problems as much as for farmers and traders. SPW attack reduced the quality and marketability of sweet potatoes. As the sales of storage roots and tubers for fresh human consumption and or processed products are the way of improving farmers' income in Asia (Peters and Wheatley, 1997; Kapinga et al., 2005), all consumers, farmers and traders need to know about SPW and its economic

importance to ensure sweet potato production and supply uninterrupted by the insect pest.

In this KAP study, it was found that the knowledge, attitude and practice level of Terengganu respondents on sweet potato damages and pest are poor. There was no significant association between knowledge level of the respondents with the socio-demographic characteristics such as age, gender, education background and occupation. No association was found between attitude and the socio-demographic factors. The majority of respondents in this study belong to consumer group which considered the issue not as major problem in their life compared to farmers and traders. There is no significant association between the practice to handle SPW problems and all socio-demographic factors.

Conclusion

The finding of SPW distribution in this study can be used in determining the focal point to start control program. For the first step, it is reasonable to educate farmers, consumers and traders in Besut as the highest emergence of weevils were observed in the sample from the area. This finding also indicated that authorities such as Department of Agriculture should focus to educate people in Terengganu about *Cylas formicarius*, the sweet potato weevil and the proper way to dispose damaged sweet potatoes. So that, the spreading of the pest to other areas can be prevented.

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