EDUCATUM - Journal of Science, Mathematics and Technology Vol. 2 No.1 (2015) 13 - 23
ISSN 2289-7070

Distribution of Teak Skeletoniser *Paliga damastesalis* Walker in a Young Teak *Tectona grandis* planting

Taburan Larva Peranggas Pokok Jati Palida damastesalis Walker dalam Tanaman Baharu Pokok Jati Tectona grandis

Lim Wui Oi[1], Yusof Ibrahim[2*], Laurence D. Kirton[1] & Faizah Abood Harris[3]
[1] Forest Research Institute Malaysia (FRIM), Kepong, 52109 Selangor, Malaysia
[2] Faculty of Technical and Vocational Education, Universiti Pendidikan Sultan Idris, 35900, Tanjong Malim, Perak, Malaysia
[3] Faculty of Forestry, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
e-mail: [*]yusofib@yahoo.com

Abstract

The within-tree distribution of the pupae and larval stages of *Paliga damastesalis* Walker was studied on young 6-12 month old teak *Tectona grandis* L. at two different sites outside outbreak periods in the year 2000. At each site, trees below 1.8 m in height with at least four nodes were inspected thoroughly for the presence of larvae or pupae. The larvae were strongly associated with leaves of the upper nodes, which were comparatively younger than those of the lower nodes, indicating that the larvae preferred and actively sought to consume younger leaves. More than 60% of the larvae were found on leaves between the second and fourth nodes. However, oviposition behaviour could have also influenced the larval distribution since the larvae completed their development not far from where the eggs were oviposited. A skewed sex ratio with adult males consistently not exceeding 3.5% of the samples was reported.

Keywords Distribution, oviposition behaviour, *Paliga damastesalis*, *Tectona grandis*

Abstrak

Taburan dalam pokok peringkat pupa dan larva *Paliga damastesalis* Walker telah dikaji pada pokok kayu jati *Tectona grandis* L berumur antara 6-10 bulan di dua tempat berlainan yang mana telah berlaku serangan wabak sepanjang tahun 2000. Di setiap tempat berkenaan, kehadiran larva dan pupa telah diperiksa pada pokok yang tidak melebihi 1.8 m tinggi dan mempunyai tidak kurang daripada empat buku ruas. Larva banyak didapati pada dedaun di ruas atas yang mana agak lebih muda berbanding dedaun di ruas bawah, dan ini menandakan larva ini memilih dan secara aktif mencari dedaun muda untuk dimakan. Begitupun, perlakuan oviposisi berkemungkinan mempengaruhi taburan larva oleh kerana tumbesaran larva dilengkapkan tidak jauh daripada tempat oviposisi telur. Nisbah seks yang pencong dengan bilangan dewasa jantan secara konsisten tidak melebihi 3.5% daripada sample dilaporkan.

Kata kunci taburan, perlakuan oviposisi, *Paliga damastesalis, Tectona grandis*

ISSN 2289-7070

INTRODUCTION

The distribution of insects in their environment is influenced by gradients in abiotic factors such as temperature and moisture, the distribution of food and predators, and the inherent behaviour of the insects to congregate or disperse (Turchin and Omland, 1999). The study of a species distribution and patterns of movement through time, in relation to spatial heterogeneity, is the basis of understanding its population dynamics, which is an important component of management of the insect (Binns, M.R., Nyrop, J.P. and van der Werf, W., 2000). Therefore, an essential step towards managing the teak skeletoniser, *Paliga damastesalis* Walker, is to enumerate the larvae on teak trees in the field in order to obtain information on its abundance an distribution on the trees. Such information could subsequently contribute towards future efforts in developing a sampling technique, which is required for studies on population dynamics of the pest.

To date, no quantification or enumeration of the larvae on teak trees in the field has been carried out and their distribution on the tree has never been systematically studied. Intachat (1999) reported that the first instar larvae occurred only on the underside of the leaves. Lim, W.O., Ibrahim, Y.B., Kirtin, L.G. and Faizah, A., (2013) reported their assessment on the influence of leaf age on larval growth and development revealed that 1st and 2nd instar larvae preferred young leaves while older 5th instars consumed more mature leaves and had significantly longer larval period. The larvae of a closely related species in India and Myanmar, *Paliga machaeralis* Walker, had been reported to prefer young tender leaves over mature ones (Patil and Thontadarya, 1987; Roychsodhury and Joshi, 1997), but as with *P. damastesalis*, the distribution of *P. machaoeralis* on teak has yet to be studied.

This paper reports a study on larval distribution of *P. damastesalis* on young teak in the field, assuming that preference for younger leaves would be reflected in the distribution of the larvae on the teak tree. In addition, the distribution pattern of the larval and pupal stages on teak saplings in the field was studied in relation to leaf age and leaf bearing at two different geographical sites.

MATERIALS AND METHODS

Study Site

The landscape unit of PLUS North-South Highway Project Corporation planted teak on land bordering along the highway. *Paliga damastesalis* occurs at low levels throughout the year on these trees. Assessments were conducted at two different sites outside outbreak periods in the year 2000 for a combined total of 143 trees (Table 1). The trees were between six to 12 months of age. At each site, all trees below 1.8 m in height with at least four nodes were thoroughly inspected for the presence of larvae or pupae. When present, the parameters summarised in Table 2 were recorded.

Treatment of Data

A preliminary correspondence analysis (Manly, 1994) was used to explore the various relationships between leaf node position, leaf aspect and stage of development of sites A and B, and also between leaf node position and leaf bearing at site A. Strong associations

Table 1 Site localities and characteristics for the two assessments conducted along the North-South PLUS Highway, Malaysia

Information	Site A	Site B
State	Selangor	Perlis
Assessment date	October, 2000	June, 2000
Climate	Tropical equatorial monsoon with primary dry season in February, and indistinct second dry season. Shielded from monsoons by the main range and Sumatera Island.	Tropical monsoon with primary dry season from January to February and secondary dry season from June to July.
Annual rainfall	2209 - 2900 mm	1800 - 1850 mm
No. of trees sampled	99	44
Tree characteristics	Trees were between 6 - 12 months old. Trees below 1.8 m (6 ft.) in height and with more than eight leaves were examined.	
Site characteristics	Moderate to poor soil due to site leveling and top soil removal during construction of highway.	

Table 2 Data recorded on the location and developmental stage of each occurrence of *P. damastesalis* on trees at the study sites

Parameter	Code	Description
Leaf node position	N1 - N12	Node 1 - 12 on the tree. Node 1 was the first pair of leaves below the apical shoot. Nodes occasionally bore only one leaf, but most nodes bore two leaves.
Leaf aspect	U or L	Upper or lower surface of the leaf.
Bearing*	N, S, E & W	North, south, east and west; the direction at which the leaf was facing.
Stage of development	I - v (or I - V) or p	First to fifth larval instars or pupa

* Bearing was recorded only for site A

identified from the overall patterns in the ordinations were subsequently tested for significance using the Kruskall-Wallis and Chi-square tests.

RESULTS

Distribution in Relation to Leaf Age

Correspondence analysis revealed that thirteen trees (13%) at site A and three trees (7%) at site B had more than nine and up to 12 nodes per tree but no insects were found past node nine; leaf nodes 10-12 were small thus they were not included in the analysis. Site A showed a strong association of most of the larvae, instars II-V, with leaf nodes 2-4 (Figure 1), less associated with node 1, nodes 5-6, and least with nodes 7-9. Larval instar I was more evenly distributed between nodes 1-5 and with which it was more closely associated

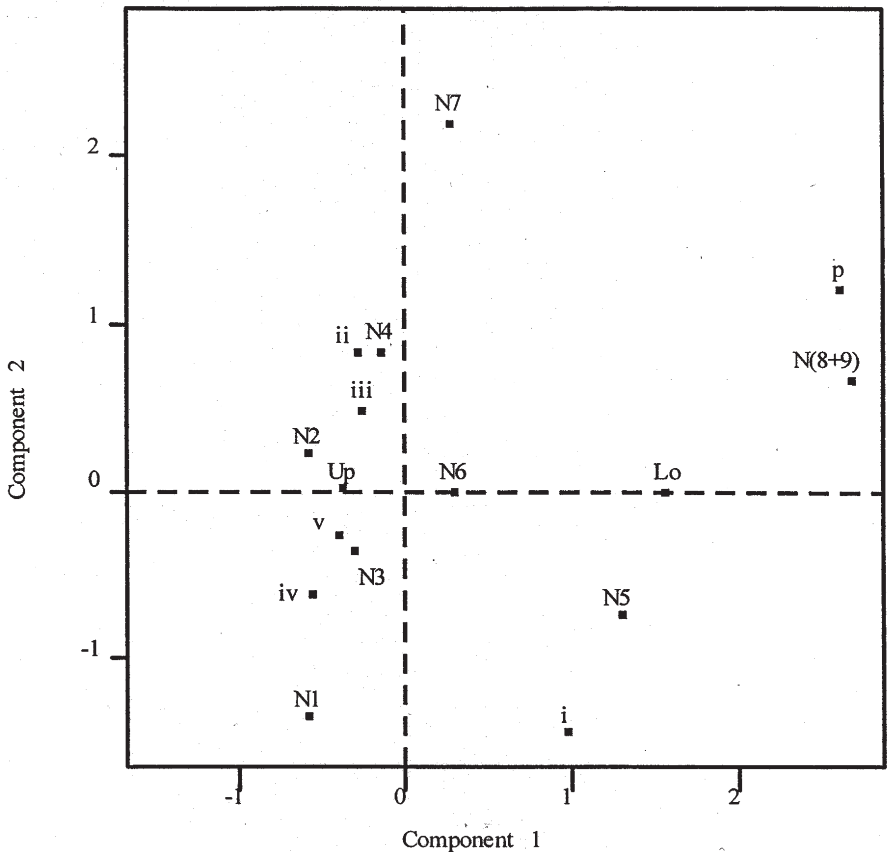

Figure 1 Ordination of leaf node position, leaf aspect and stage of development* at site A by correspondence analysis (n=221). (* N1-N7 = nodes 1-7, N(8+9) = nodes 8 and 9 combined; Up = upper leaf surface, Lo = Lower leaf surface; i-v = larval instars I-V, p = pupa; Component 1 and 2 account for 13% and 10% respectively, of the total variation in the sample)

Table 3 Density of *P. damastesalis* relative to leaf age as indicated by node number for site A

Node no.	Mean no. of insects per 100 nodes ± S.D.					
(N) Stages:	Instar I	Instar II	Instar III	Instar IV	Instar V	Pupa
1 (99)	2.0 ± 1.7	0.0 ± 0.0	3.5 ± 3.1	2.5 ± 1.9	3.5 ± 1.9	0.0 ± 0.0
2 (99)	1.5 ± 1.2	6.1 ± 2.4	6.1 ± 2.6	4.0 ± 2.0	6.1 ± 2.6	0.0 ± 0.0
3 (99)	3.0 ± 1.7	3.5 ± 1.9	8.1 ± 3.2	4.5 ± 2.1	4.0 ± 2.2	0.5 ± 0.7
4 (99)	2.0 ± 1.4	4.0 ± 2.0	7.1 ± 3.1	3.0 ± 1.7	4.0 ± 2.0	0.5 ± 0.7
5 (87)	4.0 ± 3.9	2.3 ± 1.5	2.3 ± 1.5	0.6 ± 0.8	2.9 ± 1.7	2.9 ± 1.7
6 (68)	2.2 ± 1.9	2.2 ± 1.9	5.1 ± 3.1	3.7 ± 1.9	2.2 ± 1.5	1.5 ± 1.2
7 (56)	0.0 ± 0.0	1.8 ± 1.3	2.7 ± 1.6	0.0 ± 0.0	1.8 ± 1.3	1.8 ± 1.3
8 (32)	0.0 ± 0.0	0.0 ± 0.0	1.6 ± 1.3	0.0 ± 0.0	0.0 ± 0.0	1.6 ± 1.3
9 (24)	2.1 ± 1.4	0.0 ± 0.0	0.0 ± 0.0	2.1 ± 1.4	0.0 ± 0.0	2.1 ± 1.4
Total (663)	2.1 ± 2.0	2.7 ± 1.7	4.8 ± 2.6	2.6 ± 1.7	3.4 ± 1.9	1.0 ± 1.0

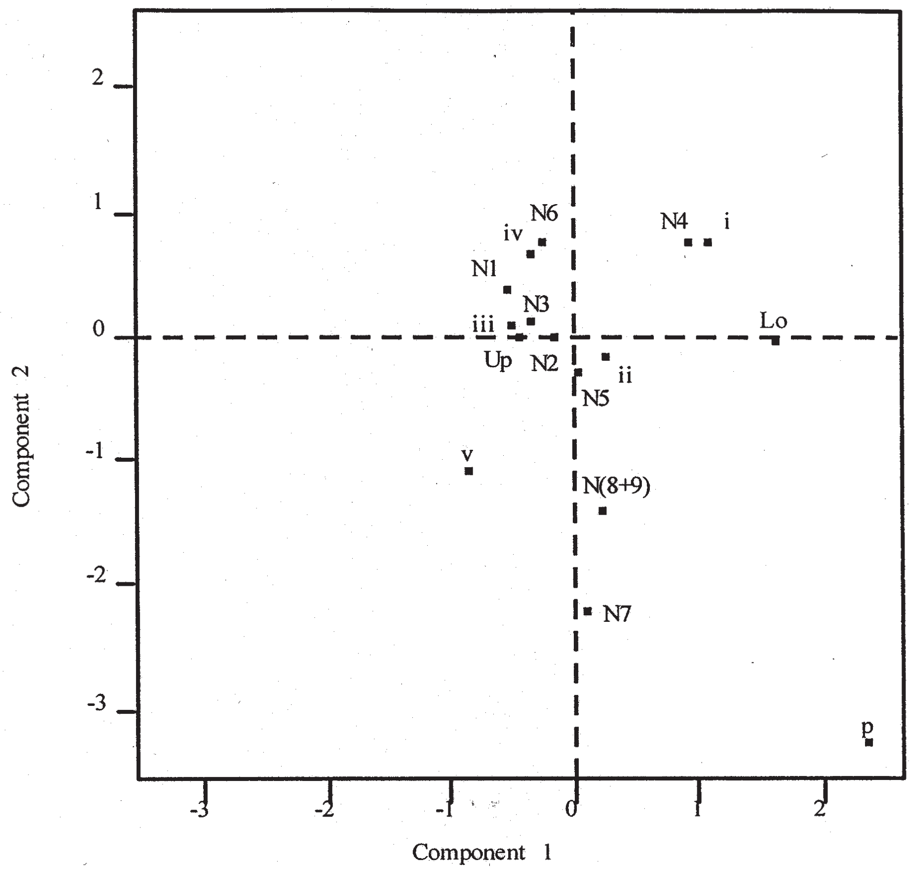

Figure 2 Ordination of leaf node position, leaf aspect and stage of development* at site B by correspondence analysis (n=144). (* N1-N7 = nodes 1-7, N(8+9) = nodes 8 and 9 combined; Up = upper leaf surface, Lo = Lower leaf surface; i-v = larval instars I-V, p = pupa; Component 1 and 2 account for 13% and 10% respectively, of the total variation in the sample)

Table 4 Density of *P. damastesalis* relative to leaf age as indicated by node number for site B

Node no.	Mean no. of insects per 100 nodes ± S.D.					
(N) Stages:	Instar I	Instar II	Instar III	Instar IV	Instar V	Pupa
1 (44)	4.5 ± 2.6	6.8 ± 3.7	5.7 ± 2.8	5.7 ± 2.8	3.4 ± 1.8	0.0 ± 0.0
2 (44)	3.4 ± 2.4	3.4 ± 1.8	5.7 ± 2.8	2.3 ± 1.5	3.4 ± 1.8	0.0 ± 0.0
3 (44)	3.4 ± 1.8	6.8 ± 2.5	5.7 ± 2.8	8.0 ± 3.8	2.3 ± 1.5	1.1 ± 1.1
4 (44)	8.0 ± 3.1	4.5 ± 2.1	5.7 ± 2.8	6.8 ± 2.5	3.4 ± 1.8	0.0 ± 0.0
5 (40)	3.8 ± 2.5	6.3 ± 2.4	7.5 ± 2.7	5.0 ± 2.2	3.8 ± 1.9	1.3 ± 1.1
6 (35)	2.9 ± 1.7	7.1 ± 3.1	5.7 ± 2.9	4.3 ± 2.0	0.0 ± 0.0	0.0 ± 0.0
7 (30)	1.7 ± 1.3	3.3 ± 2.6	3.3 ± 1.8	0.0 ± 0.0	5.0 ± 2.2	1.7 ± 1.3
8 (20)	0.0 ± 0.0	10.0 ± 3.0	5.0 ± 2.2	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
9 (10)	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	10.0 ± 3.1	10.0 ± 3.1	5.0 ± 2.2
Total (311)	3.7 ± 2.2	5.6 ± 2.6	5.5 ± 2.6	4.7 ± 2.4	3.1 ± 1.7	0.6 ± 0.8

than the lower nodes 6-9. Pupae were more closely associated with the lower nodes 5-9 than the upper nodes. For site B, correspondence analysis revealed instars I-V were more associated with the upper nodes 1-6 (Figure 2). As with site A, the pupae at site B were more closely associated with the lower nodes 7-9.

Tables 3 and 4 give the mean density of the different stages of development in relation to leaf age as indicated by leaf node positions at sites A and B, respectively. At both sites A and B, the variances were larger than the means, indicating a negative binomial distribution (Figure 3); aggregates of up to five larvae were observed. Kruskal-Wallis test showed a significant difference between insect counts on different leaf node positions at site A ($H = 36.1$; $df = 8$; $p<0.001$, adjusted for ties), but no difference was recorded at site B ($H = 4.3$; $df = 8$; $p>0.6$, adjusted for ties). The strong association of most of the larvae (instars II-V) with the upper nodes 2-4 in site A likely contributed to the significant result obtained.

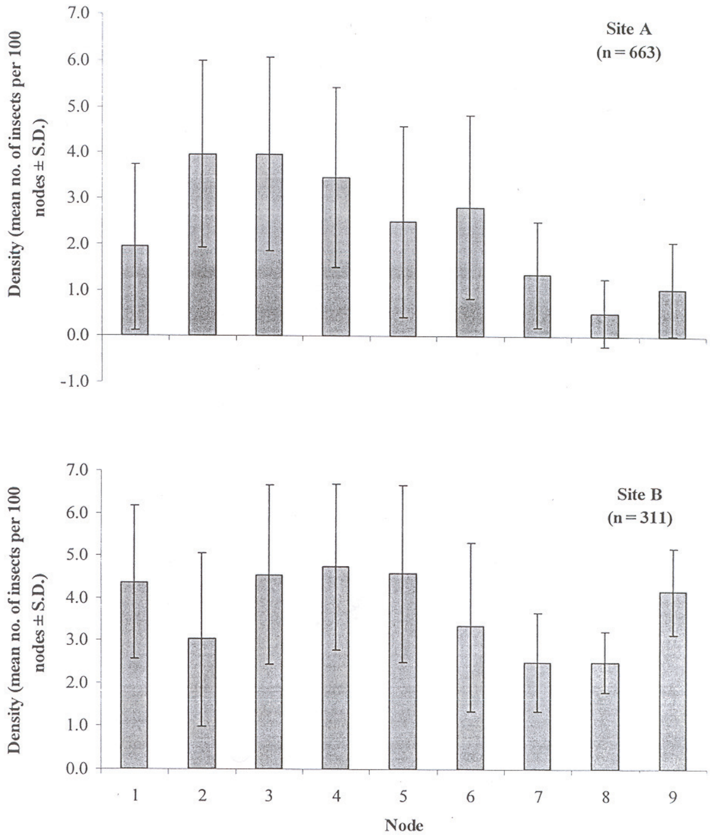

Figure 3 Density of *P. damastesalis* in relation to leaf age as indicated by node number at both study sites

Distribution on Upper and Lower Leaf Surfaces

Correspondence analysis showed a strong association of most of the larval instars (II-V) with the upper leaf surface at both study sites (Figures 1 and 2); however, instar I was more evenly distributed between the upper and lower surfaces of leaves. Pupae were also associated with both the upper and lower leaf surfaces, but more occurred on the latter. Figure 4 shows the strong association of instars II-V with the upper leaf surface boe both study sites, and a more even distribution of instar I on either leaf surfaces. A large percentage of pupae occurred on the lower leaf surface. Larval counts on the lower leaf surface were significantly higher than the upper leaf surface at both sites A (χ^2 = 11.2; df = 4; p <0.024) and B (χ^2 = 16.4; df = 4; p <0.003).

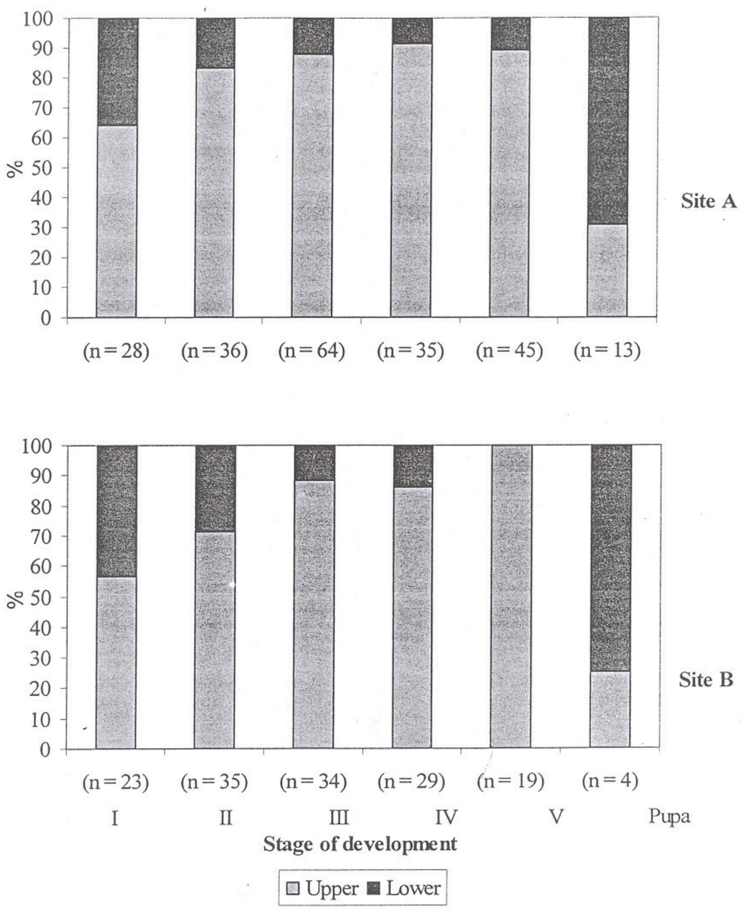

Figure 4 Percentage of *P. damastesalis* on upper and lower leaf surfaces at sites A and B

Influence of Leaf Bearing on Distribution Pattern

The ordination of leaf bearing and stage of development by correspondence analysis for site A showed no visible pattern of distribution, even for leaves facing east and west, where possible effects of solar radiation may have been evident (Figure 5). There was no significant difference in counts of the various stage of development, in relation to the bearing of the leaves on which they were found (χ^2 = 15.6; df = 15; p >0.49) (Table 5).

Also, insect abundance on the upper and lower leaf surfaces was not significantly different in relation to leaf bearing ($\chi^2 = 3.6$; df = 3; $p > 0.34$) (Table 6).

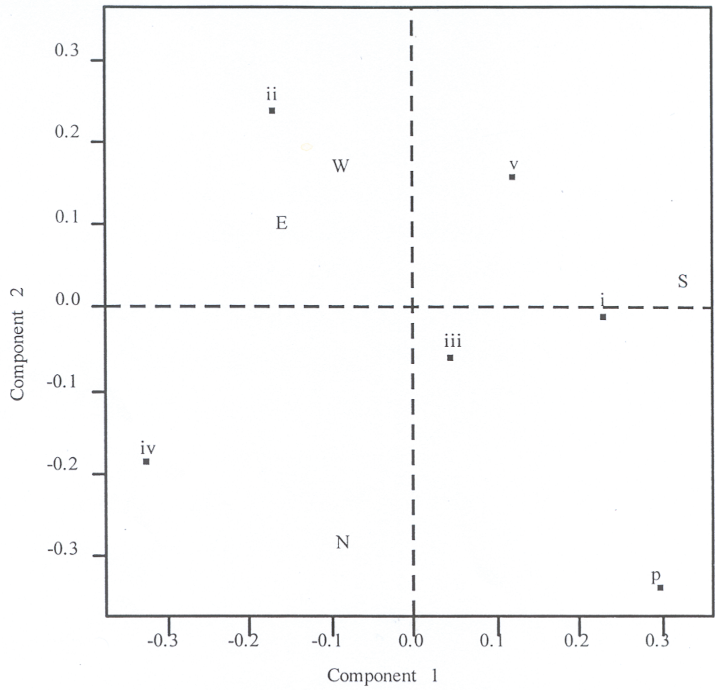

Figure 5 Ordination of leaf bearing and stage of development* at site A by correspondence analysis (n=221). (* N – north, S = south, E = east, W = west; i-v = larval instars I-V, p = pupa;Component 1 and 2 account for 53% and 40% respectively, of the total variation in the sample)

Table 5 Percent distribution of immatures of *P. damastesalis* on leaves facing different bearings at site A

Stage of development	N	Leaf bearing (%)			
		North	South	East	West
Instar I	29	6 (20.7)	10 (34.5)	5 (17.2)	8 (27.6)
” II	37	5 (13.5)	7 (18.9)	13 (35.1)	12 (32.4)
” III	63	15 (23.8)	17 (27.0)	15 (23.8)	16 (25.4)
” IV	37	12 (32.4)	4 (10.8)	11 (29.7)	10 (27.0)
” V	42	6 (14.3)	13 (31.0)	11 (26.2)	12 (28.6)
Pupa	13	4 (30.8)	5 (38.5)	3 (23.1)	1 (7.7)
Overall	221	48 (21.7)	56 (25.3)	58 (26.2)	59 (26.7)

Age Structure of Immature Stages

Both sites A and B showed low counts of early and late instar larvae, and comparatively higher counts of middle instar larvae (Figure 6). There was no significant difference

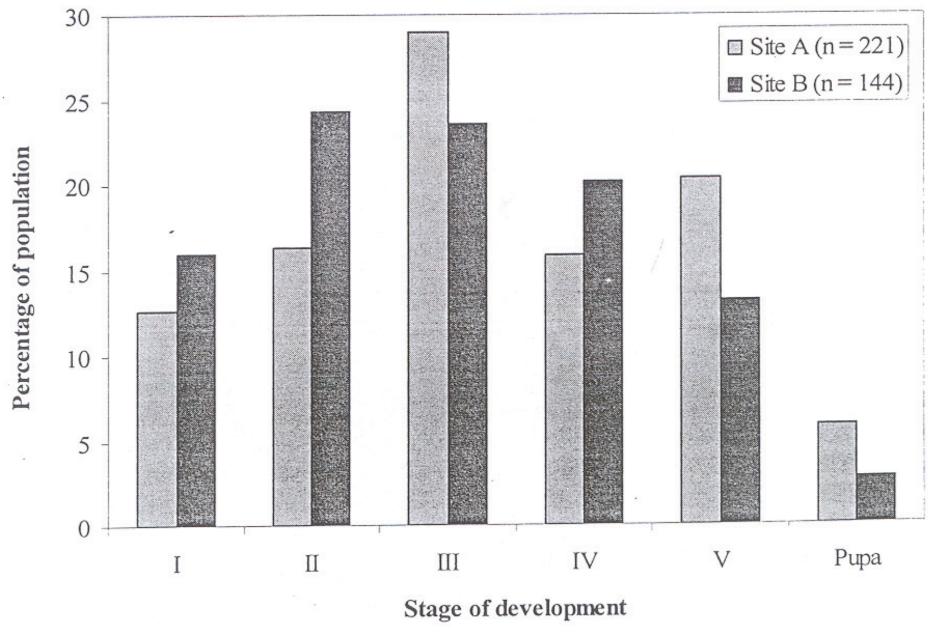

Figure 6 Abundance of the different developmental stages of *P. damastesalis* at the two study sites A and B

Table 6. Distribution of *P. damastesalis* on leaves facing different bearings in relation to leaf aspect at site A

Leaf Aspect	N	Leaf bearing (%)			
		North	South	East	West
Upper	180	36 (20.0)	47 (26.1)	51 (28.3)	46 (25.6)
Lower	41	12 (29.3)	9 (22.0)	7 (17.1)	13 (31.7)
Overall	221	48 (21.7)	56 (25.3)	58 (26.2)	59 (26.7)

between the proportions of the various larval instars and pupae and pupae in relation to the study sites ($\chi^2 = 9.8$; df = 5; p >0.08).

DISCUSSION

Distribution in Relation to Leaf Age

The significant difference in the within-node distribution of *P. damastesalis* at site A where there was a strong association of most of the larvae (instars II-V) with the upper nodes 2-4 (young leaves) concurs with observations by Roychoudhury *et al*. (1995) and Roychoudhury and Joshi (1997). The association, albeit not significant, of the first to fifth

EDUCATUM - Journal of Science, Mathematics and Technology Vol. 2 No.1 (2015) 13 - 23
ISSN 2289-7070

instar larvae with the upper nodes 1-6 at site B also supports this, thus may have active preference for young leaves. Although the association was not significant, higher count of first instar on the upper nodes could have been due to the oviposition preference for the young leaves by the females, thus giving rise to a predetermined initial distribution pattern for the first instar larvae. Easier mastication of young leaves (Hodkinson and Hughes, 1982; Quiring, 1992) and higher nutrient content (Barbehenn, R.V., Reese, J.C. and Hagen, K.S., 1999) could have influenced larval preference for young leaves located on the upper nodes; the high polyphenol (tannin) content in young leaves of teak seemed not to deter feeding as similarly observed by Avinash *et al*. (2000) with *P. machaeralis* in India. The adverse effects of secondary metabolites could have been averted by th high nutrient levels of young foliage (Slansky, 1992).

At both study sites, a larger proportion of pupae were found on the lower nodes. Lepidopteran larvae often disperse before pupation (Holloway, J.D., Bradley, J.D. and Carter, D.J., 1987), and the larvae of *P. damastesalis* could do so with the aid of silken threads, suggesting that pupal distribution pattern differs form that of the larvae. At very high insect densities such as those during an outbreak, the within-node distribution may differ from the present study; the larvae tend to disperse when overcrowded and may move to leaves on the lower nodes to feed either by crawling or by lowering themselves down with silken threads or even to adjacent trees (Roychoudhury and Joshi, 1997).

Distribution on Upper and Lower Leaf Surfaces

There was a moderate association of larval instar I with the upper leaf surface and increasingly stronger associations of the larvae with the upper leaf surface from instar II to V. It is probable that the distribution of the instar I was determined by where the eggs were laid, and the high population of early instars on the upper leaf surface indicated that *P. damastesalis* oviposited on both sides of the leaves on saplings in the field. The epidermis of the upper leaf surface might be easier to feed due to a lower trichome density, hence the preference for the upper leaf surface. Additionally, the silk webs spun over portions of the leaf would create temporary shelter with less variability of the ambiance and lesser risk to predation.

Results of the present study concur with the observation by Intachat (1999) that larval instars III-V were often found under silk webs on the upper surfaces of teak leaves. The occurrence of instars I and II of *P. damastesalis* on the upper leaf surface does however corroborate with laboratory observations by Roychoudhury and Joshi (1997) who reported *P. machaeralis* early instar larvae feed on both upper and lower leaf surfaces. They also reported females of *P. machaeralis* displayed an indiscriminate oviposition pattern on leaf surfaces. The present study is also in agreement with Roychoudhury and Joshi (1997) who suggested that the lower leaf surface may be the preferred pupation site for the teak skeletoniser.

Influence of Leaf Bearing on Distribution Pattern

There was no clear effect of solar radiation on the distribution of the larvae in relation to leaf bearing. The open and unbranched canopy of the teak saplings and the alternate positions of the leaves might have resulted in all the leaves receiving approximately equal intensities of solar radiation, regardless of the bearing or node position of the leaves.

Age Structure of Immature Stages

The time-specific age structure based on the immature stage from population samples of the two sites indicated that the population of *P. damastesalis* was on the decline. The low proportion of early instars compared to the middle instars would eventually lead to lower population levels as the population aged. This could be due to decreased recruitment rate (reduced fecundity and fertility) and increase in mortality of immatures or adult stages, and emigration or dispersal of the larvae. The low proportion of the late instar larvae compared to the middle instars could be due to combined effect of mortality and the active dispersal for pupation.

ACKNOWLEDGEMENT

The authors wish to thank FRIM for the research facilities provided, and MOSTI for the financial support (IRPA 30070102001 "Developing Integrated Pest Management Strategies for Teak in Malaysia").

REFERENCES

Barbehenn, R.V., Reese, J.C. and Hagen, K.S. (1999). The food of insets. In: *Ecological Entomology* (2nd ed.) (Huffaker, C.B. and Gutierrez, A.P., eds.), pp 83-122. John New York: Wiley & Sons.

Binns, M.R., Nyrop, J.P. and van der Werf, W. (2000). *Sampling and Monitoring in Crop Protection*: *The Theoretical Basis for Developing Practical Decision Guides*. London: CABI.

Hodkinson, I.D. and Hughes, M.K. (1982). Insect herbivory. In: *Outline Studies in Ecology* (Dunner, G.M. and Gimingham, C.H., eds.). London: Chapman and Hall.

Holloway, J.D., Bradley, J.D. and Carter, D.J. (1987). *Lepidoptera. CIE Guides to Insects of Importance to Man No. 1.* London: CABI.

Intachat, J. (1999). The life history of *Paliga damastesalis* Walker (Lepidoptera: Crambidae), a teak skeletoniser in Malaysia. *Journal of Tropical Forest Science* 11: 663-671.

Lim, W.O., Ibrahim, Y.B., Kirtin, L.G. and Faizah, A. (2013). Feeding preference and growth of *Paliga damastesalis* Walker (Lepidoptera: Crambidae) on teak, *Tectona grandis*. *Journal of Science and Technical Education* 2: 67-73.

Patil, B.V. and Thontadarya, T.S. (1987). Biology of the teak skeletoniser, *Pyrausta machaeralis* Walker (Lepidoptera: Pyralidae). *Mysore Journal of Agricultural Science* 21: 32-39.

Quiring, D.T. (1992). Rapid change in suitability of white spruce for a specialist herbivore, *Zeiraphera canadensis*, as a function of leaf age. *Canadian Journal of Zoology* 70: 2132-2138.

Roychsodhury, N. and Joshi, K.C. (1997). Larval feeding habits and moulting behaviour of leaf skeletoniser, *Eutectona machaeralis* Walker, on teak. *Indian Forester*: 438-439.

Slansky, F. Jr. (1992). Allelochemical nutrient interactions in herbivore nutritional ecology. In: *Herbivores: Their Interactions with Secondary Plant Metabolites* (2nd ed.) (Rosenthal, G.A. and Berenbaum, M.R., eds.), pp. 135-174. New York: Academic Press,

Turchin, P. and Omland, K.S. (1999). Migration and movement. In: *Ecological Entomology* (2nd ed.) (Huffaker, C.B. and Gutierrez, A.P., eds.), pp. 463-502. New York: John Wiley and Sons.