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Status of Pine Woolly Aphid (*Pineus boerneri*) in Sao-Hill Forest Plantation, Tanzania

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ABSTRACT

The status of Pine Woolly Aphid (*Pineus boerneri*) was studied at Sao-Hill forest plantation, Southern Highlands of Tanzania. The major objectives of the study were to determine distribution and abundance of Pine Woolly Aphid (PWA) affecting main plantation species (*Pinus patula* and *P. elliottii*) and to assess intensity of damage between different age classes. Other objectives were to determine the parts of the tree crown mostly damaged and the extent of damage and to find out relationship between aphid abundance and damage. The main findings of the study were; the population densities of adult PWA did not differ significantly ($p>0.05$) for both *P. patula* and *P. elliottii* among the three blocks (Divisions) studied. However, Division one was more affected by aphids than other Divisions with the mean total adult population number of 17.4, 16.5 and 13.6 for *P. patula* and 6.7, 6.3 and 6.1 for *P. elliottii* for Divisions I, II and III, respectively. The mean total adult aphid population was found to be 10.1, 20.2 and 17.3 for *P. patula* for young, middle and old age classes respectively. In *P. elliottii* stands where only old class was observed, the mean total adult aphid was 19.1. Similarly, this age class was more affected than *P. patula*. On the other hand, the middle part of the tree crown was more damaged than other crown parts. There was a strong relationship between aphid abundance and damage between Divisions and age classes with coefficient of determination (R^2) of 99.7 and 99.9%, respectively. The overall low intensity of aphid population recorded was probably due to the effect caused by predators like *Tetraphleps raoi* and some native natural enemies. Silvicutural operations, regular insect survey and monitoring programmes should be intensified in order to reduce the intensity of attack and spread of the pest.

Key words: *Pineus boerneri* Pinus, Sao Hill, distribution, abundance, intensity of attack

INTRODUCTION

Pine Woolly Aphid (PWA) is native to Europe, where it has been reported to cause a lot of serious damages to various species of pines. The pine woolly aphid was first introduced simultaneously in Kenya and Zimbabwe in 1968 and was probably introduced into Zimbabwe with *Pinus taeda,* scions from Australia in 1962 (Massawe, 1991). Since 1968, the aphid has spread throughout African pine plantations and the other countries including Ethiopia, Tanzania, Malawi and South Africa (Murphy *et al*., 1991). Towards the end of 1984 nearly all pines plantations in Tanzania had been infested, showing varying degrees of attack (Madoffe and Day, 1995). In East Africa the most planted pines are *Pinus patula, P. elliottii* and *P. kesiya* of which *Pinus kesiya* and *P. patula* appear more susceptible to attack than other pines grown (Odera, 1991). In Zimbabwe,

the pine plantations seemed to be very safe from serious damage of pine woolly aphid and the aphid was no longer causing economic damage (Mazodze *et al*., 1990). The commonest control method of PWA is by practicing proper silviculture e.g., sites amelioration and use of resistant pines. Biological control has also been used successfully for example in Tanzania, native predators such as the *Coccinellids* sp., *Chaelemens* sp., *Chilocorus* sp. and *Rodolia* sp. have been found keeping down the aphid population in some pine plantations in the Sao Hill, West Kilimanjaro and Meru Forest projects (Kisaka, 1990). Various exotic predators which have been evaluated for control of PWA include *Leucopis nigraluua, L. manii, L. tapiae, Ballia eucharis, Scymnus* species and *Tetraphleps raoi* (Hemiptera: Anthocoridae). Most of these predators have been found feeding on the aphids, hence helping in suppression of the pest. Conversely, Madoffe (2006) considered the predator to contribute to the reduced numbers and damage of the pine woolly aphid in Sao Hill forest plantation. Similarly some chemicals have been reported to suppress the pest though they are expensive and not environmentally friendly. The use of chemicals has been supported by Muthomi *et al*. (2008) and Ullah *et al*. (2005), who reported that pesticides spray, showed significantly reduction of the incidences of insect species like the flower thrips, the African bollworm and the legume pod borer.

Limited numbers of studies on the status of PWA have been initiated in Tanzania. This includes population dynamics, the impact on tree growth and biological control (Madoffe, 1989, 2006; Madoffe and Austar, 1990; Massawe, 1991; Nsolomo *et al*., 2006). Survey carried out at Sao Hill revealed that tree mortality and growth loss was associated with heavy attacks of PWA, especially in young stands grown on inferior sites (Madoffe and Austar, 1993). In spite of the PWA problems in Sao Hill and Tanzania in general, there is lack of control measures and monitoring of the outbreaks. For example in Sao-Hill, no study has been conducted in the last twenty years to determine the status (population abundance, density and distribution) of PWA in the plantation. There are contradicting reports, which indicate that the PWA situation has stabilized while others report on worsening of the situation. This study was therefore initiated to generate valuable information on the status of pine woolly aphid in Sao-Hill, which will be useful to policy makers and forest managers in dealing with the problem.

MATERIALS AND METHODS

The study area: The study was conducted at Sao Hill Forest Plantation located at 8°18'S to 8°33'S and 35°6'E to 35°20'E at an altitude ranging from 1700 m to 2000 m.a.s.l. in Mufindi district, Iringa region in the Southern highlands of Tanzania. The area is characterized by single rain season from November to May with a mean precipitation of 600 to 1300 mm perannum. Mean monthly temperatures vary between 10 and 23°C. The soils are relatively homogenous and are mainly dystric nitosols in association with orthic acrisols (Ngegba, 1998).

Data collection: Data were collected from two main plantation species *Pinus patula* and *P. elliottii*. Stratified sampling was adopted whereby three Blocks/Divisions with the study tree species with different age classes were selected. In each block, three compartments with different age classes were picked for each tree species. Trees were grouped into three age groups i.e., young (0-10 years), middle age (11-25 years) and old age (>25 years). Visual observation on the crown was used to determine the intensity of damage. This was expressed in percentage of attack/damage. On the other hand, the intensity of attack was subjectively ranked into four subjective levels namely low, mild, high and very high with percentage attack and scores of (0-15%) (1 score), (16-30%)

(2 score), (31-49%) (3 scores) and (>50%) (4 score), respectively. Trees were selected systematically from sampled plots whereby every fourth tree along the row was considered as a candidate. From the tree crown, five twigs in each crown were randomly cut at lower/middle/upper crown of tree and put in a polythene bags for laboratory insect counting. *Pinus elliottii* trees were difficult to climb due to lack of strong lower branches and therefore twenty three trees were felled down for sample (twigs) collection which were also put in polythene bags. The polythene bags containing twigs were put in a refrigerator and PWA (eggs, nymph and adult) counted at a later stage. The insects (eggs, nymph and adult) were washed with a help of brush and ethanol (70%) to a Petri dish and counted under microscope.

Data analysis: Data were analysed using Statistical Analysis System (SAS) software. Two way Analysis of Variance (ANOVA) at 0.05% level of significance was used to compare the differences in abundance and damage between blocks, tree species, upper/middle/lower crown and age classes. Regression analysis was run to determine the relationship between the abundance of pine woolly aphids and intensity of damage.

RESULTS AND DISCUSSION

Distribution and abundance of Pine Woolly Aphid in Sao Hill Forest Plantation: The Pine Woolly Aphid was not uniformly distributed between the tree blocks (Table 1). The mean number of adult aphid per twig at Sao Hill was 17.4, 16.5 and 13.6 for *P. patula* and 6.7, 6.3 and 6.1 for *P. elliottii* for Division I, II and III, respectively. Division one had more adult aphids than other Divisions for both tree species although the difference was not statistically significant ($p>0.05$). The insignificant difference observed might have been caused by relative homogeneity

Table 1: Mean of Pine Woolly Aphid population per twig for various Divisions/Blocks in Sao-Hill forest plantation

			Age classes in years			
Division/Block	Tree species	PWA growth stage	Young (0-10)	Middle (11-25)	Old (>25)	Total
I	*P. patula*	Egg	2.00	5.25	4.70	11.95a
		Nymph	5.56	7.67	5.15	18.38b
		Adult	4.78	6.25	6.40	17.43b
	P. elliottii	Egg			5.17	5.17c
		Nymph			6.34	6.34c
		Adult			6.66	6.66c
II	*P. patula*	Egg	3.40	7.10	3.56	14.06d
		Nymph	4.83	5.09	4.44	14.36d
		Adult	2.44	8.46	5.63	16.53d
	P. elliotii	Egg			4.99	4.99c
		Nymph			4.83	4.83c
		Adult			6.34	6.34c
III	*P. patula*	Egg	2.00	2.28	5.83	10.11a
		Nymph	5.58	6.22	6.17	17.97b
		Adult	2.88	5.44	5.27	13.59d
	P. elliottii	Egg			6.00	6.00c
		Nymph			6.79	6.79c
		Adult			6.13	6.13c

Values followed by different letters in a given column are significantly different ($p<0.05$)

Table 2: Mean total number of Adult Pine Woolly Aphid per tree for different age classes at Sao-Hill forest plantation

	Mean No.	
Age classes in years	*Pinus patula*	*Pinus elliottii*
Young (0-10)	10.1a	
Middle (11-25)	20.2b	
Old (>25)	17.3b	19.1b

Values followed by different letters in a given column and row are significantly different ($p<0.05$)

of the soil present within the plantation (Ngegba, 1998). Another possible reason for insignificant difference in abundance of aphid might be due to the similarity of silvicultural operations carried out within the plantation. Tending operations like thinning and pruning are done equally throughout the plantation which makes the plantation to have almost the same microclimates hence no block is more preferable to aphid (Mlowe, 2007).

The results further showed that nymph were found in highest numbers, followed by adults and eggs the least. The population difference of the three stages could have been caused by predators present at the study site because some aphid predators (e.g., *Tetraphleps raoi*) are host specific, they usually prefer adults, but may feed on eggs and rarely on nymph. Similarly, the total number of nymph was high probably because the nymph life span is longer than adult life span which always makes the population densities of nymph higher than that of adults (Mailu *et al*., 1980). However, the results did not differ with that of Clementine *et al*. (2005) who observed bug egg and/ or larvae or adults of *Clavigralla tomentosicollis* through the dry season as an indication of continuous of insect reproduction in the absence of cowpea.

The mean total numbers of adult aphid which were found to attack pines were 10.1, 20.2 and 17.3 for *P. patula* for the young, middle and old age classes, respectively (Table 2). *Pinus elliottii* which was observed only in old class was insignificantly more attacked by aphids than *P. patula* having the mean total adult aphid of 19.1 comparing to 17.3 of *P. patula* of the same class age. The trend on *P. patula* indicated that middle age trees were more preferred by adult aphid than other tree age classes. The preference was significantly different between young age and middle and old age classes but not between middle and old age class ($p>0.05$). Adult aphids probably preferred to attack/damage middle age trees because of high foliage quality they have compared to other age classes, which always create good rooms for aphid survival. In earlier studies, Ruohomaki *et al*. (2000) found that *Epirrita autumnata* outbreaks took place mostly in mature birch trees because of low parasitism or high foliage quality and availability of more suitable oviposition sites in mature trees. This is in contrary with Madoffe (1989) whose results indicated that young trees were vulnerable to aphid infestation than old trees.

This abundance of PWA recorded here is lower than that reported by Madoffe and Austra (1993) in the same plantation. The population decrease recorded during this study could have been caused by availability of predators like *Tetraphleps raoi,* a natural enemy that was imported to Tanzania from Pakistan in 1974 and released at Sao Hill. The results is similar to that of Solang *et al*. (2008), Mimoayedi and Maniee (2009), who reported that the sucking insect pests were below the economic injury level at all phonological stages of the cotton plant due to the regular increase in predator population. During the study, playmates, ants and dragonflies were seen visiting shoots affected by PWA. In spite of these indigenous natural enemies living in association with aphids, there was no clear evidence that they were feeding on aphids consequently contributing to the declining aphid population.

Table 3: Mean intensity* of damage by Pine Woolly Aphid in percentage and Standard error (SE) for various age classes in Sao-Hill forest plantation

		Age classes		
Block/Division	Tree species	Young (0-10 years)	Middle (11-25 years)	Old (above 25 years)
I	*Pinus patula*	11.62 (1.11)	14.53 (2.08)	13.26 (1.58)
	Pinus elliottii			14.67 (1.02)
II	*Pinus patula*	7.45 (1.2)	14.78 (2.3)	14.56 (1.44)
	Pinus elliottii			14.89 (1.32)
III	*Pinus patula*	9.8 (2.30)	12.54 (0.14)	9.88 (2.1)
	Pinus elliottii			12.54 (0.9)

Mean Intensity of damage: -Low (0-15%)-Mild (16-30%)-High (31-49%)-Very high (>50%)

Intensity of damage of Pine Woolly Aphid in Sao Hill Forest Plantation: The intensity of damage between age classes and blocks for both *P. patula* and *P. elliottii* is given in Table 3. The percentage mean intensity of damage was low (between 0-15%) for all Divisions. There was no significant difference in mean intensity damage of aphid either between age classes or blocks ($p>0.05$). In spite of that, it appears that the middle age class (11-25) was more damaged than old age class (>25) while young age class (<10) was the least damaged and Division I was more damaged than Division II and Division III being least damaged. *Pinus elliottii* was found to be more damaged by PWA than *P. patula* although statistically insignificant ($p>0.05$). Adult pine woolly aphid feeding preference appears to be for *P. elliottii* than *P. patula*. This shows that *P. elliottii* tree is more suitable host for PWA probably due to composition and quality of volatile substances responsible for orienting the insects toward attacking PWA than *P. patula*. Similarly, Leather *et al.* (1994) reported that some trees emit repellent compounds, which could deter insects, or the bark of these trees could contain compounds that could kill insects if consumed. Probably this could be the reason as to why *P. patula* was found to be relatively resistant compared to *P. elliottii*. The same difference has been recorded in South Africa where by Zwolinski (1989) reported that *P. kesiya*, *P. elliottii* and *P. radiata* were found to be highly to moderately susceptible while *P. patula* and *P. taeda* are only slightly susceptible to attack than other pine trees. The same results were recorded in Kenya by Mailu *et al.* (1980) that *P. patula* was found to be relatively resistant to *P. boerneri* attack in the highland plantations than other pine species.

Extent of damage of Pine Woolly Aphid in different parts of the tree crown: The extent of damage of aphids in different parts of the tree crowns which was determined by the available mean number of aphids present in crown parts differed between blocks and age classes. The total mean numbers of aphids recorded (egg, nymph and adults) were 43.4, 47.1 and 43.0 for *P. patula* and 18.1, 19.2 and 15.6 for *P. elliottii* for lower, middle and upper crown, respectively (Fig. 1). The middle crown part for both tree species had higher total mean number of aphids, followed by lower crown part and upper crown part had lowest total mean number of aphids which implies that middle crown part was more damaged than lower crown and upper crown being last in damage. In spite of the differences observed in damage, the damage between crown parts was not significant ($p>0.05$) for *P. patula* and *P. elliottii*.

The differences in number of aphids observed in crown parts is probably due to the fact that PWA crawlers are positively phototactic, but do not settle onto surface exposed to strong light. They

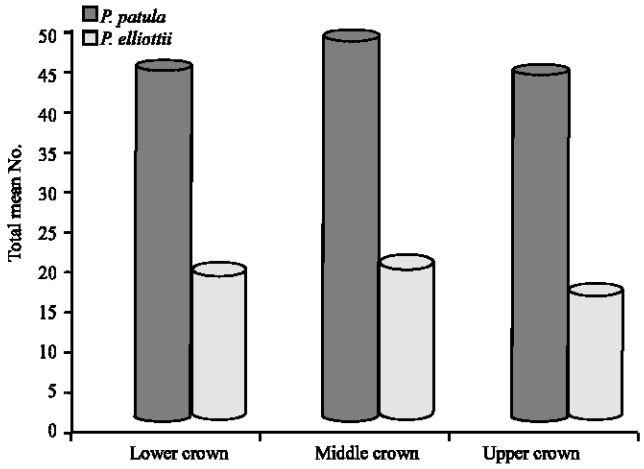

Fig. 1: Mean total of Pine Woolly Aphid population per twig for various parts of the tree crown in all age classes in Sao-Hill forest plantation

appear negatively phototactic to strong light and consequently tend to settle in hidden and light crevices. The undersides of lateral branches, which receive only moderate light, tend to harbour a higher concentration of aphids than the upper surfaces. The middle crown of *P. patula* and *P. elliotti* receives less light of the sun owing to shade of branches above it. This would tend to encourage aggregation of aphids in the middle crown where there is less strong direct light consequently contributing to high extent of damaging of aphid. The result agrees with Madoffe (1989), who reported that the mode of insect distribution on the tree is mainly affected by light, temperature and wind and so the insects could attain the favourable microclimatic sites.

Relationship between aphid abundance and damage: The relationship between aphid abundance and intensity of damage in different Divisions at Sao Hill forest plantation for both *P. patula* and *P. elliottii* was represented by the Equation:

$$Y = 0.007 + 0.563\,X$$

where, x and y represents abundance of aphids in different divisions and percentage mean of damage, respectively.

The results showed that the relationship was significant ($p<0.05$, $R^2 = 99.7\%$), which means that the aphid abundance in different Divisions had a significance contribution to percentage mean of damage. The coefficient of determination (R^2) explains that 99.7% of the variation in percentage mean damage can be explained/ caused by variation in the aphid abundances in different Divisions. The total mean numbers of adult aphid were found to be higher in middle age class than in old age class and young age class had lowest total mean adult aphids. This corresponds exactly with the intensity of damage, which was recorded to be greater in middle class than old age class and young age class being least damage. This relationship is represented by the following regression Equation:

$$Y = 5.26 + 0.427\,X$$

where, x and y represents total mean numbers of adult aphid at different age classes and percentage mean of damage, respectively.

Results of this regression analysis indicated that the relationship was significant ($p<0.05$). The R^2 was very high (99.9%) which would indicate that intensity of damage between tree age classes increased with an increase in mean number of adult aphids. Higher number of adult aphid was recorded in *P. elliottii* in old class than that which was recorded in *P. patula* of the same class age although their difference was not statistically different. Likewise, it was recorded that the former tree species was more damaged by aphids than *P. patula*. Therefore it is most likely that the higher the number of aphids attacking pines, the higher the damage they cause.

CONCLUSION AND RECOMMENDATIONS

The study revealed that all three studied divisions/blocks at Sao Hill forest plantation exhibited presence of PWA. The abundance of adult aphid per twig was found to be 17.4, 16.5 and 13.6 for *P. patula* and 6.7, 6.3 and 6.1 for *P. elliottii* for Division I, II and III, respectively. The abundance of aphids did not differ significantly between Divisions although Division one was seen to harbour more aphids than other Divisions for both tree species. There was a very strong relationship between aphid abundances and damage between Divisions and age classes with coefficient of determination (R^2) of 99.7 and 99.9%, respectively. Furthermore *P. elliottii* was seen to be more affected by PWA than *P. patula* but the effect was not statistically different. The middle age class (11-25 years) and the middle crown were more damaged than other age classes and other crown parts, respectively. From this study, it is recommended that thinning and pruning must be intensified in order to reduce favourable environment for insect pests performance (reproduction/growth). The government should also intensify classical biological control with an ultimate goal for an Integrated Pest Management.

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