Spatial Distribution of the Blue Gum Chalcid, *Leptocybe Invasa* on *Eucalyptus* Species in Kenya

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Abstract

Blue gum chalcid (BGC), *Leptocybe invasa* is a gall-forming wasp, which causes an extensive damage to *Eucalyptus*. It attacks mostly seedlings and field saplings. It causes damage on its host by forming massive typical bump-shaped galls on tree canopy, specifically on the leaf midribs, petioles and stems of new growths. Repeated attacks leads to twisted and knobbed appearance of the leaves and terminal leader shoot degenerates into lateral shoot. The objective of this study was to determine the spatial distribution of BGC damage incidence and severity patterns in Kenya. A total of 155 selected stands from five major *Eucalyptus* growing provinces were assessed. Three randomly established plots per stand consisting of 20 trees were assessed for BGC damage severity on a 4-point scale. This was used to determine the mean severity patterns. All descriptive statistics were analysed using percentage damage score. Mean damage score were analysed using ANOVA procedures by first checking homogeneity of variance. Generalised linear modelling procedures were employed to determine the relationship between BGC damage and topography, agro-ecological zones, age of trees and host species. BGC was found to be spreading fast and had infested the five provinces of Kenya. It was observed that there was significant difference on the mean severity between provinces and districts. Agro-ecological zones had significant difference on the mean severity. Further studies of the effect of factors that affected the distribution and severity patterns of BGC should be conducted.

Key words: Leptocybe invasa, Blue gum chalcid, distribution, damage severity, Eucalyptus, agro-ecological zones, pest management.

Résumé:

Le chalcidien bleu à résine (BGC), *Leptocybe invasa* est une sorte de petite guêpe qui provoque la formation de nodules et qui inflige beaucoup de dégâts à l'eucalyptus. La plupart des fois il attaque de jeunes plants et de jeunes arbres en champ. Il endommage son hôte par la formation d'une masse de nodules typiques, en forme de bosses dans la couronne de l'arbre, particulièrement sur son pourtour, sur les nervures centrales des feuilles et sur de nouvelles tiges en croissance. Des attaques répétées résultent en un rabougrissement de feuilles et le bourgeon terminal dégénère en bourgeon latéral secondaire. L'objectif de cette étude était de déterminer la distribution spatiale de l'incidence et la sévérité des dégâts de BGC au Kenya. En tout 155 peuplements choisis dans cinq principaux provinces qui plantent l'eucalyptus ont été évalués. Trois parcelles aléatoirement délimitées par peuplement et incluant chacune 20 arbres ont été évaluées pour la sévérité des dégâts de BGC, à l'aide d' une échelle de 4 points. Cette échelle a servi pour déterminer les taux moyens de sévérité. Toutes les statistiques descriptives ont été analysées en utilisant les pourcentages des points des dégâts. Les moyennes de points des dégâts ont été analysées à l'aide de l'ANOVA en vérifiant d'abord l'homogénéité de la variance. La modélisation linéaire généralisée a été utilisée afin de déterminer le rapport entre les dégâts de BGC et la topographie, les zones agro-écologiques, l'âge des arbres et les espèces hôtes. BGC a semblé se propager rapidement et il avait infesté les cinq provinces du Kenya. Des différences significatives de la sévérité moyenne ont été observées entre les provinces et les zones. Les zones agro-écologiques ont montré des différences significatives entre les moyennes de sévérité. D'autres études sur l'effet des facteurs qui affectent les modèles de distribution et la sévérité de BGC devraient être menées.

Mots clés : Leptocybe invasa, chalcidien bleu à résine, distribution, sévérité des dégâts, eucalyptus, zones agro-écologiques, gestion de parasite

Introduction

Leptocybe invasa Fisher & La Salle, sp. n (Hymenoptera: Eulophidae) is a small (1.5 mm) wasp that belongs to the gall-forming hymenopterans locally termed as Blue gum chalcid (BGC). Its origin is believed to be Australia, the native country of *Eucalyptus* species. This wasp has been reported on several *Eucalyptus* species in Algeria, Iran, Israel, Italy, Jordan, Morocco, and Uganda (Mendel *at el.*, 2004). Most of the members of this super family Chalcidoidea are known to be beneficial insects, mostly as parasitoids. Thus, BGC is a unique member of this group of insects as it is a pest of economic importance. The biology and taxonomy of BGC is well documented by Mendel *et al.*, (2004).

According to Mutitu (2003), *L. invasa* was first recorded in November 2002 in the Western Kenya region. It is believed to have invaded Kenya from the neighbouring border districts of Uganda. The pest was noted attacking most of the commercially widely grown Eucalypt species like *Eucalyptus camaldulensis* Dehnh, *E. grandis* Hill Ex Maid and *E. saligna* Smith. The pest spread from the border districts of Kenya and Uganda into Western highlands of Kenya. By May 2004, the pest had spread to districts like Busia, Vihiga, Kisumu, Nyando, Butere–Mumias, Bungoma and Teso. Due to the capability of the insect pest to spread through flight, its thelytokous reproduction (only females are asexually produced), mulivotinous development, absence of its principal natural enemies and the large tracts of host plant in this area, it is likely that it will spread into the whole country within a short period.

Blue gum chalcid attacks mostly the young seedlings in nursery and field saplings of up to five years old. However, trees of even ten years old have been observed with symptoms of the attack. The insect causes damage on its host by forming massive typical bump-shaped galls on tree canopy, specifically on the leaf midribs, petioles and stems of new growths. On heavily infested host plants, galls are found on lateral and terminal growing shoots. Repeated attacks leads to twisted and knobbed appearance of the leaves and the terminal leader shoot degenerates into a lateral shoot causing canopy to be umbrella shaped. This leads to a deformed plant. On older infestations it is possible to observe adult emergence holes. The infested plant shows stunted lateral and terminal shoots. There is need to study the BGC damage relationship with the possible associated factors altitude, agro-ecological zones, topography, host species etc. This knowledge contributes to the development and implementation of management strategies. The objective of this paper was to determine the spatial distribution of BGC damage incidence and severity patterns in Kenya. Such information is necessary for the development and implementation of sustainable management strategies against *L. invasa*.

Materials and Methods

Study Sites

This study was conducted in 18 districts of Kenya, belonging to five provinces and two Agro-ecological zones (AZ) (Table 1) from December 2005 to May 2006. These provinces are the cradle of *Eucalyptus* growing in Kenya. The sites were selected to cover wide variations in biophysical factors and host species. Accessibility of *Eucalyptus* stands was also considered.

Table 1: Location and climatic characteristics of study sites

Zones (AZ)	Provinces	Districts	Rainfall	Temperature
AZ2	Western Nyanza Central Coast Rift Valley	Vihiga, Busia Gucha Kirinyaga, Nyeri Kwale Bureti	Mean annual rainfall 1201 – 1600 mm Heavy rains in March – May, October to December Dry season January and February	Mean annual Maximum temperature 20 – 25 °C Mean annual Minimum temperature 10 – 15 °C
AZ3	Western Nyanza Central Coast Rift Valley	Bungoma Kisii, Nyamira. Kuria, Migori Maragua Kilifi Nandi South	Mean annual rainfall 1201 – 1600 mm Heavy rains in April – September, Low rains in January and February	Mean annual Maximum temperature 25 – 30 °C Mean annual Minimum temperature 15 – 20 °C

Sampling Design and Procedure

In each district, a list of *Eucalyptus* growers was obtained from the District Forest Office. Farmers who had planted at least 100 *Eucalyptus* trees were randomly selected from the district list. *Eucalyptus* stands with less than five year-old trees were selected not only because BGC is known to severely infest young tress but also for ease of accessibility to tree crowns during damage assessment (Mendel *et al.*, 2004). Each *Eucalyptus* stand was divided into three blocks. In each block, a plot of 20 trees was randomly established. All trees in the plot were assessed for BGC damage incidence and severity. Incidence was scored, based on the presence and absence of BGC induced galls on the tree canopy. The severity of infestation was scored on a four-point scale, based on the gall density on the tree canopy as below:

- Scale 1: None- Seedlings/trees with no gall damage.
- Scale 2: Minor- Seedlings/trees with galls less than 25% of total shoots.
- Scale 3: Moderate- Seedlings/trees with galls between 25-50% of total shoots
- Scale 4: Severe- Seedlings/trees with galls more than 50% of total shoots.

To generate Geographical Information System (GIS) maps for incidence and severity patterns, the Global Position System (GPS) points were obtained for all the stands using GPS receiver (12Channel XL). The GPS readings were collected about 2 m from the edge of the stand. Topograpy, agro-ecological zone, age of trees and host species at every sampled stand was recorded. Topography of the whole stand was classified into four level; plain, hilltop, valley and slope.

Data analysis

All data were entered into Microsoft Excel for Windows 2000 and analysed using Genstat release 8.11 statistical software tools (Genstat, 2005). Descriptive statistics was used to determine the percentage incidence of BGC damage in each stand. The mean percentage incidence and severity of BGC damage was compared between provinces, districts and agro-ecological zones using Analysis of Variance (ANOVA) upon testing for homogeneity. Significance levels of ($p<0.01$ and $p<0.05$) were used to declare the differences in incidence and severity.

Results

A total 9,267 *Eucalyptus* trees from 155 stands were assessed. Of these 45.6%, 39.6% and 14.9% were *Eucalyptus grandis*, *E. saligna* and *E. camaldulensis*, respectively. Blue gum chalcid was observed in all the five provinces studied (Figure 1). There was no significant ($p<0.05$) difference on the percentage BGC damage incidence and mean severity amongst the three major commercially grown species (Table 2).

Table 2: Percentage BGC damage incidence and severity *Eucalyptus* species in Kenya

Species	% Incidence	Mean severity	% trees in each severity scale			
			Scale 1	Scale 2	Scale3	Scale 4
E. camaldulensis	52.2*	1.6*	47.8	43.8	6.5	1.9
E. grandis	56.4*	1.9*	43.9	35.9	11.1	9.0
E. saligna	53.8*	1.7*	48.0	37.5	11.1	3.4

*no significant difference for damage incidence amongst species

Generally over 80% of the trees were in the least damage categories 1 and 2 as compared to the 15% in the higher damage scale 3 and 4 (Figure 2). Only 5.8% of the host trees were in the worst damage (Scale 4). Such trees had deformed tree trunks, branches and umbrella shaped canopy

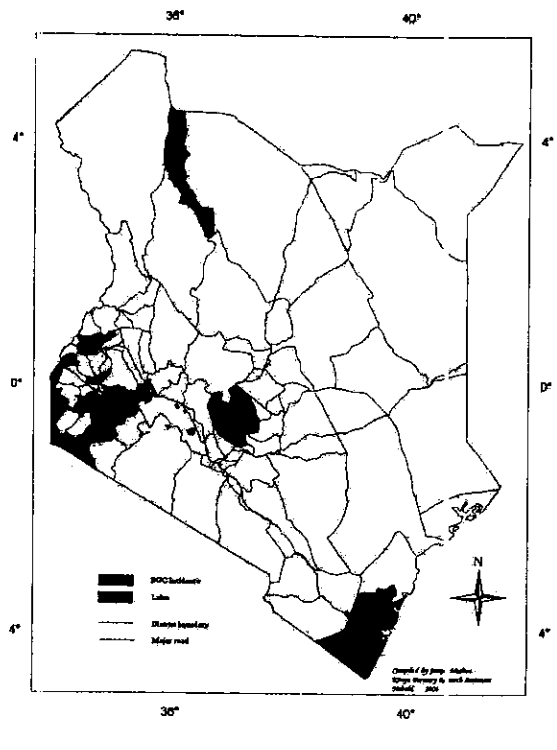

Figure 1: Blue gum chalcid distribution in Kenya.

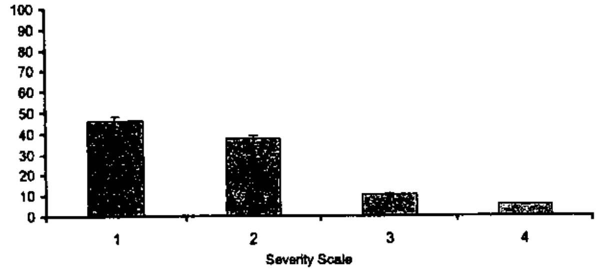

Figure 2: Percentage number of trees per severity scale in Kenya

Table 3: Severity of BGC damage in different districts of Kenya

			Severity (% of trees)			
Province	District	Mean	Scale1	Scale 2	Scale 3	Scale 4
Central	Kirinyaga	1.6	53.1	35.3	12.3	1.4
	Maragwa	1.2	82.1	16.3	6.7	0.0
	Nyeri	1.0	100.0	0.0	0.0	0.0
	Muranga	1.2	76.7	23.0	0.6	0.0
Coast	Kilifi	1.4	66.2	27.3	7.8	0.0
	Kwale	1.7	52.7	30	33.3	3.3
Nyanza	Gucha	1.6	59.8	27.9	5.7	6.7
	Kisii	2.3	17.2	51.3	19.2	11.7
	Kuria	2.8	13.7	25	26.7	34.7
	Migori	2.7	9.2	43.9	18.9	28.1
	Nyamira	1.4	68.7	21.7	7.0	2.7
	Nyando	1.9	22.2	70.0	5.6	2.2
	Rachuonyo	2.4	14.4	50.0	20.0	15.6
Rift Valley	Bureti	1.1	85.0	15.0	0.0	0.0
	Nandi south	1.1	90.0	10.0	0.0	0.0
Western	Bungoma	1.9	31.5	51.0	11.5	5.8
	Busia	1.7	47.5	34.7	13.6	4.8
	Vihiga	1.5	57.0	34.8	7.2	1.0

s.e.d for mean scale = 0.05034

There was significant ($p<0.01$) difference in the mean damage severity between districts (Table 3). However, mean damage severity in districts within each province, showed no significant ($p>0.05$) difference among the districts in all provinces, except Nyanza. There was no significant ($p>0.05$) difference in mean severity between Kisii, Kuria, Migori and Rachuonyo as well as Gucha, Nyamira and Nyando. Similarly some differences ($p<0.05$) occurred between districts in different provinces. These were Kirinyaga and Kuria, Kilifi and Bungoma, Migori and Bureti, Nyando and Muranga. Figures 3 and 4 show the districts mean damage severity for Western and Nyanza, respectively

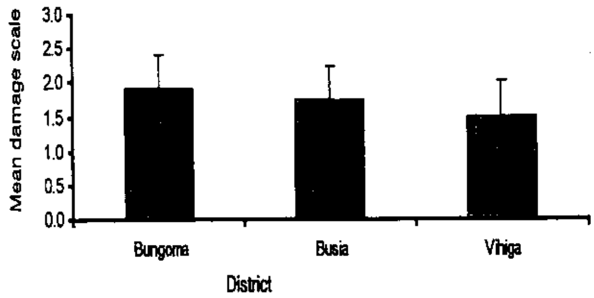

Figure 3: BGC mean damage severity in Western province districts

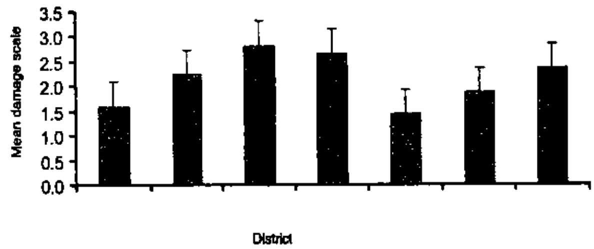

Figure 4: BGC mean damage severity in Nyanza province districts

Mean BGC damage severity was significantly ($p<0.01$) higher in AZ3 (1.9) than AZ2 (1.5). The most damaged trees were in Nyanza and Western provinces. Nyanza province had the highest attack followed by Western province. In Nyanza, 69% of the *Eucalyptus* is under BGC attack, with 14% suffering severe attack. Only 31% of *Eucalyptus* in Nyanza is showing no symptoms of attack. In Western province, 55% of the total trees had been attacked by BGC, with 4% being severely attacked. In Coast province, 62% of the trees in the province showed no signs of BGC attack. About 38% of *Eucalyptus* in Coast province is attacked with 0.5% showing severe symptoms. In Central, province there is BGC infestation with only 29% of the *Eucalyptus* trees under low attack. Rift valley is the least attacked province in the country having 8% of trees with only slight attack (Table 4). The mean severity BGC damage varied significantly ($p<0.01$) between provinces (Table 4). The mean severity was significantly higher in Nyanza than in all the other provinces. In contrast, Western and Coast hand significantly low BGC mean severity. Central and Rift Valley had statistically similar mean BGC damage severity.

Table 4: Percentage trees in different severity scales in different provinces of Kenya

Province	Mean Scale	Severity (% of trees) Scale 1	Scale 2	Scale 3	Scale 4
Central	1.35a	70.6	24.5	4.4	0.5
Coast	1.46ac	61.9	9.2	8.4	0.5
Nyanza	2.10b	31.5	40.7	13.7	14.1
Rift valley	1.08a	91.7	8.3	0.0	0.0
Western	1.74c	44.9	40.3	10.8	4.0

S.e.d = 0.2909 figures with same letters mean no significant difference

On the overall, the districts BGC damage incidence and severity accounted for 22.4% source of variation while the provinces accounted for 16.4%, whereas topography, altitude, tree species varied greatly among the districts and provinces.There was no significant relationship between topography, altitude, tree species, and age of trees and BGC damage incidence and severity. The mean severity did not significantly correlate with tree species and age. However, there was significant ($p<0.05$) correlation between topography and mean damage severity.

Discussion

According to Mutitu (2003), BGC was first reported in the Western province near the Uganda-Kenya boarder in May 2004. However, from these results, the pest has spread to five major tree growing provinces of Kenya. Amongst the provinces, Nyanza had the highest mean damage severity (2.1) followed by Western (1.7), with Rift Valley showing a negligible mean damage severity of 1.1. In Nyanza, the highest infestation was found in Kuria (3.2) Migori (2.8) and Rachuonyo (2.5) districts whereas mean damage score in Western province for Bungoma, Busia and Vihiga was almost the same (1.6 – 2.0). This rapid spread and pattern of damage severity is within a period about four years since the pest was first recorded in Kenya. This can be attributed to *L. invasa* thelytokous reproduction, mulivotinous development and also due to the absence of its principal natural enemies in these new areas of invasion.

Other contributing factors to the spread can be associated to host tree, favourable climate, amongst others. The Western region of Kenya has the highest area of *Eucalyptus* planting, particularly in small woodlots and plantations owned by the tea growing companies. These large tracts of monocultures of host trees favours the fast spread of the pest. The favourable climatic conditions prevailing in the tropics like moderate temperature and photo-period favour the fast life cycle development. This has been observed in the Coastal region, where the spread has been faster than any other region due to higher temperature in region. This pest is likely to spread more rapidly in the near future covering the whole of the country. It is expected that within a period of five to ten years, the pest will have spread in the whole of Eastern and Central Africa.

The differences that exist amongst districts can be attributed to the period the pest has been in these areas and the climatic conditions prevailing in those districts. Districts with two rainfall seasons and high temperatures show moderate BGC damage severity (Table 1). This is due to the capability of the plant to respond to the attack by developing high foliage. Trees that are wrongly sited are highly damaged by a small BGC population compared to those that are correctly sited. *Eucalyptus grandis*, that is grown on low rainfall areas is more susceptible than when in high / moderate rainfall areas.

The study also showed that site topography and altitude did not significantly influence the infestation, even though it was anticipated that areas with low altitudes are likely to have high infestation. The difference in altitude has an effect on the temperatures that play a crucial role in the insect pest population dynamics. These factors needs to be further investigated, as they are likely to play a great role in the population and damage trends.

The significant difference attributed to the agro-climatic zones AZ2 and AZ3 can be possibly due to the difference in temperature. AZ2 has a temperature range of 20-25°C compared to AZ3, which has temperature range of 25-30°C. Temperature plays a great role in the insect development. High temperature favours rapid pest population increase compared to low temperatures. This is likely to be the cause of high damage in AZ3 than AZ2.

Conclusion and Recommendations

The results of this study showed that over 80% of the trees assessed in all the districts had low damage with only 20% falling in the worst damage. This implies that the distribution and severity pattern of BGC across the country is not alarming. However, the results provide a progressive indication on the progression and distribution of the insect pest in Kenya since it was reported in November 2002. The three commercially grown *Eucalyptus* tree species are equally susceptible to *L. invasa*, thus host resistance materials should be selected from each species, as each is suitable for certain climatic conditions.

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