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Research Article

First Record of Two Invasive Eucalypt Psyllid and Aphid (Hemiptera: Psylloidea and Thaumastocoridae) in CRSN/Lwiro, Eastern of the Democratic Republic of Congo

Rubabura K.JA.*[1], Bugeme M.D[2], Basengere S.G[3], Schmitt A[4]

[1]Agricultural Entomology laboratory, Entomology Section, Research Centre in Natural Sciences, Bukavu, South Kivu, Democratic Republic of the Congo
[2]Faculty of Agricultural Sciences, Catholic University of Bukavu and Lubumbashi University, South Kivu and High Katanga, Democratic Republic of the Congo
[3]Aquatic and Terrestrial Ecosystem Section, Research Centre in Natural Sciences, Bukavu, South Kivu, Democratic Republic of the Congo
[4]Senior Technical Advisor, Deutsche-Gesellschaft fur international Zusammenarbeit (GIZ) GmbH, South Kivu and Maniema Provinces, Democratic Republic of the Congo

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Abstract: *Thaumastocoris peregrinus* (Hemiptera,Thaumastocoridae) and *Glycaspis brimblecombei* Moore (Hemiptera, Psylloidea), are eucalyptus pest native to Australia. They were also detected within the main European and North African infested areas. This study, carried out in CRSN/Lwiro, Kabare, South Kivu in eastern of the DRC, aimed to assess the origins and the seasonal incidences of eucalyptus dieback during the two consecutive years 2015 and 2016 dry (March to August or Season B) and rainy seasons (September to February or Season A). Two species are responsible of eucalyptus dieback in CRSN/Lwiro of hemiptera order, *Thaumastocoris peregrinus* Carpintero & Dellapé in Thaumastocoridae family and *Glycaspis brimblecombei* Moore (1964) in Psyllidae family were captured and identified. The number of healthy eucalyptus is very high during the rainy season and the attack of the insect is very high in the dry season and the infested plants and relative abundance of eucalyptus are very high during dry season to compare to rainy period. Near future activity should focus on the question whether the parasitoid and eucalyptus species strength to *G. brimblecombei*, *T. peregrinus* are already present in DRC or should be introduced.

Keywords: Eucalyptus, psyllid, aphid, dieback and CRSN/Lwiro.

INTRODUCTION

Eucalypts have been planted around the world for a variety of uses including hardwood, fiber, and fuel or as ornamental trees in urban areas (Ball, 1995). According Brooker (2000), *Eucalyptus* including *Angophora* and *Corymbia* comprise of over 700 species of trees and shrubs, mostly native to Australia. Those authors Withers (2001) and Queiroz *et al.* (2012) demonstrated Eucalypts are widely used because of their significant advantages over other forest tree species mainly because they are relatively pest-free in their new areas. The increasing rates of introduction and establishment of Australian insects has become an important management issue in most eucalypt growing areas. In the last 100 years, fifteen insect species native to Australia and specialists on eucalypts, have been established (Paine, 2000; Queiroz *et al.*, 2012; BurcKhardt *et al.*, 2014).

According those authors Floris *et al.*(2018), the most widely cultivated species in Mediterranean basin is the river red gum, *Eucalyptus camaldulensis* Dehnh, followed by *E. globulus* Labill. And *E. gomphocephala* DC. Again, they show that, over the last few decades, a number of phytophagous insects and pathogenic fungi have threatened Eucalyptus species in the Mediterranean area. Among the most recent exotic invasive species, the red gum lerp psyllid, eucalyptus psyllid, and bronze bug have caused extensive damage to eucalypt plantations in consecutive years.

The red gum lerp psyllid was recorded for the first time in Italy in 2010 (Laudonia and Garonna, 2010; Germinara *et al.*, 2011; Frasconi *et al.*, 2013; OEPP, 2014; CABI / OEPP, 2015) and spread rapidly in central and southern regions, including the islands. It was reported for the first time in Sardinia in spring 2010 (Buffa, 2015; EPPO, 2011; EPPO, 2014; CABI / EPPO, 2015). The invasive red gum lerp psyllid, *Glycaspis*

***Corresponding Author:** Rubabura K.JA Email: dodorubabura [at]gmail.com

brimblecombei Moore (Hemiptera: Psyllidae), is the most serious Eucalyptus pest in the Mediterranean area (Mendel *et al.*, 2016), especially for *E. camaldulensis*, which has been shown to be extremely susceptible to *G. brimblecombei* infestations (Deidda et al., 2016). The first record of *G. brimblecombei* in Africa was reported as a harmful species since 2010 in Canaries island (Malumphy, 2010; OEPP, 2014 ; CABI / OEPP, 2015) and in 2014 in Tunisia (Attia et Rapisarda, 2014; Dhahri *et al.*, 2014; CABI / OEPP, 2015), Madagascar and Mauritius (OEPP, 2014; CABI / OEPP, 2015) , in 2013 in Algeria (Reguia et Peris-Felipo, 2013; CABI / OEPP, 2015). This harmful specie occurs in Morocco with restricted distribution in 2014 (EPPO, 2014; Messoudi *et al.*, 2014; CABI / EPPO, 2015).Again, it has been reported since 2015 in South Africa (CABI / OEPP, 2015) and in 2017 in Zambia (Chungu *et al.*, 2017) and in 2019 in Ethiopia (Abraham Yirgu et Agena Anjulo, 2019).

The bronze bug, *Thaumastocoris peregrinus* Carpintero & Dellapé (Hemiptera: Thaumastocoridae) is a sap-sucking pest infesting eucalyptus plantations. It originates from Australia (Noack and Rose, 2007; Nadel *et al*., 2010), where it has been reported as a harmful species since 2002. The bronze bug is now widespread in many other areas: Africa (2003) (Zimbabwe, South Africa) (Jacobs and Neser, 2005; Giliomee, 2011), South America (2005) (Uruguay, Paraguay, Brazil, Chile, Argentina) (Carpintero and Dellape, 2006; Noack and Coviella, 2006; Martínez and Bianchi, 2010; Wilcken *et al.*, 2010; Ide *et al*., 2011; Soliman *et al.*, 2012), Europe (2011), and recently the Middle East (2014) and New Zealand (Sopow et al., 2012). The first report in Europe was recorded in Italy (2011) in the Lazio region (Laudonia and Sasso, 2012), followed by Portugal in 2012 (Garcia *et al.*, 2013), Sicily in 2014 (Suma *et al.*, 2014) and Sardinia in 2015 (Deiana *et al.*, 2018), where the first record was reported in the south of the island on *E. camaldulensis*.

It was recorded for the first time in 2007 in Zimbabwe , since 2008 in Malawi and 2009 in Kenya (Nadel *et al.*, 2010; OEPP, 2014; CABI / OEPP, 2017),in 2014 in Uganda (BiCEP, 2014 ; CABI / OEPP, 2017), in 2016 in Reunion (Streito *et al.*, 2016 ; CABI / OEPP, 2017), in 2017 in Tanzania, Rwanda and Mozambique (CABI / OEPP, 2017).

In eastern of the Republic Democratic of Congo, South Kivu province, Kabare territory at the Research Centre in Natural Sciences (CRSN/Lwiro), field surveys were carried out in eucalyptus plantations in order to assess the origins and the seasonal incidences of eucalyptus dieback during the two consecutive years 2015 and 2016 dry (March to August or Season B) and rainy seasons (September to February or Season A).

MATERIAL AND METHODS

Study Area

The study was conducted at the Research Centre in Natural Sciences (C.R.S.N) in Lwiro. It is based in Lwiro and located at 28º48 'east longitude, 2º15' south latitude on 1750 m of altitude. The choice of the Natural Sciences Research Center (C.R.S.N) and surroundings is nevertheless oriented by the presence of Eucalyptus spp. attacked by insect pests that is the focus of our study. The Center for Research in Natural Sciences (C.R.S.N) is a state research institution, located 40 Km north of Bukavu and 7 Km from the western edge of Lake Kivu, in Kabare, South Kivu in the Democratic Republic of Congo. Kabare is dominated by highland and it has borders with Rwanda and North Kivu province. The annual precipitation average of the study area is 1300 mm with a maximum of 1800 mm and minimum of 800 mm. The average for temperature is annually 19, 5 °C. The soil is of volcanic nature but dominated by clay. Figure 1 below shows the CRSN / Lwiro.

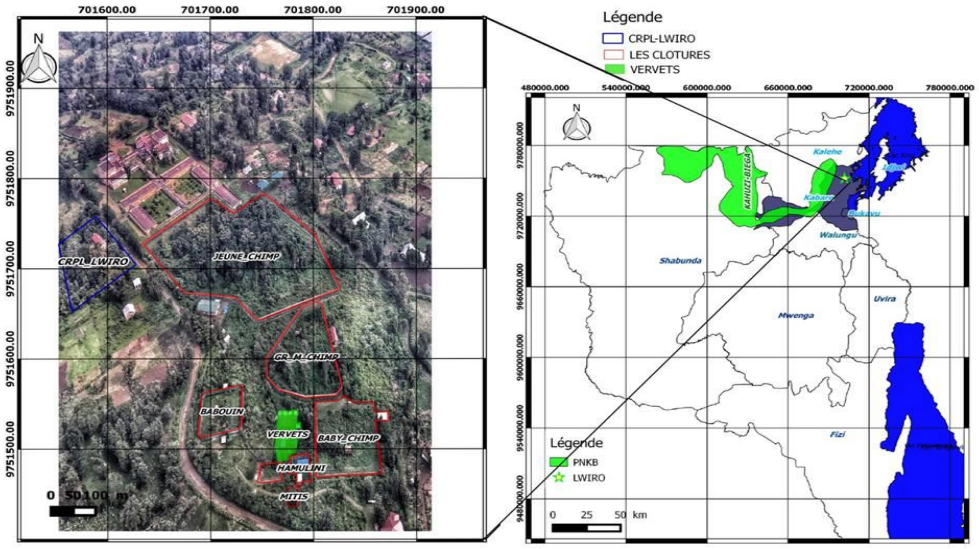

Figure 1. Research Centre in Natural Sciences (CRSN / Lwiro)

Material

The material for this study is eucalypts. According to the APG (Angiosperms Phylogeny Group) scientific classification (Guignard, 2001 cited by Mekelleche, 2015), it belongs to the plant kingdom, Spermatophyte branching, subphylum Angiosperm, class Eudicotes, subclass of Rosidae, the Myrtales order, family Myrtaceae, genus *Eucalyptus* and species *Eucalyptus.*

According Cooper (1983), the genus *Eucalyptus* is one of the most characteristic genera of the Australian flora and contains about 300 species. These trees have economic value due to their use in many sectors. In 1960, the export of eucalyptus seed project was started by the Australian government and the FAO (1980) and a great deal of eucalyptus seeds were introduced into numerous developing countries without any phytosanitary certificate.

Methods

Prospecting of *Eucalyptus* trees

Phytosanitary rounding or phytosanitary prospecting (Dupriez and Simbizi, 1998) was carried out in these associations studied by the quadrat and eucalyptus observation (Dagnelie , 1992) methods.

- **Inventory of the entomofaunal**

The threshing for the harvest of insects living on the foliage and on the branches of *Eucalyptus* trees and collected by hand. Those insects were placed in the plastic bottle and preserved in 96% alcohol, afterwards to the Agricultural Entomology Laboratory of Biology at the Research Center in Natural Sciences, CRSN / Lwiro.

- **Pest insects identification at the laboratory**

The insect pests of *Eucalyptus* were recorded and identified by several specialists (Moore, 1964; Carpintero and Dellapé, 2006; Noack *et al*., 2011; Soliman *et al*., 2012; Mutitu *et al.,* 2013; Buffa, 2015; Mendel *et al.,* 2016; Deidda *et al.,* 2016; Floris *et al.,* 2018; Garonna *et al*., 2018). The sample of pest insect collected in quadrats was observed on microscope for identification in the laboratory by using photography proposed by Noack *et al*.(2011), Messoudi *et al*.(2014), Mendel *et al*.(2016) and Floris *et al*.(2018) and Garonna *et al*.(2018).

***Eucalyptus* trees observation**

Seventeen quadrats selected at random contained 50 *Eucalyptus* were prospected. The direct observation (Dagnelie, 1992) on all vegetative and enumeration of infected plants were used.

Data Processing and Statistical Analyses

The percent of infested plants (% IP) was calculated by the following equation proposed by Harrison, 1984; Urbaneja Garcia, 2000; Diez, 2001; Murúa *et al.,* 2006:

$$\%\ IP = \frac{Infested\ eucalyptus\ plants}{Total\ eucalyptus\ plants} x\ 100$$

The formulae of Berger (1980)shown as follows of incidence (% I) and relative abundance (RA) were used for estimations**:**

$$\%\ I = \frac{No\ of\ eucalyptus\ attacked}{No\ total\ of\ all\ eucalyptus\ of\ quadrant} x\ 100$$

$$R\ A = \frac{Number\ of\ eucalyptus\ attacked}{Total\ number\ of\ all\ eucalyptus\ attacked\ of\ all\ quadrants} x\ 100$$

The Microsoft Office Excel 2010(Curties, 2010) was used to encode data collected. Percent of infested plants, incidence and relative abundance data were angularly transformed and subjected to analysis with the software Past (Hammer *et al.*, 2001). Principal components analysis (PCA) was carried out.

RESULT AND DISCUSSION

Pest insects of eucalypts trees observed on study area

Two species are responsible of eucalyptus dieback in CRSN/Lwiro of hemiptera order, *Thaumastocoris peregrinus* Carpintero & Dellapé in Thaumastocoridae family and *Glycaspis brimblecombei* Moore (1964) in Psyllidae family were captured and identified (Figure 2 and 3).

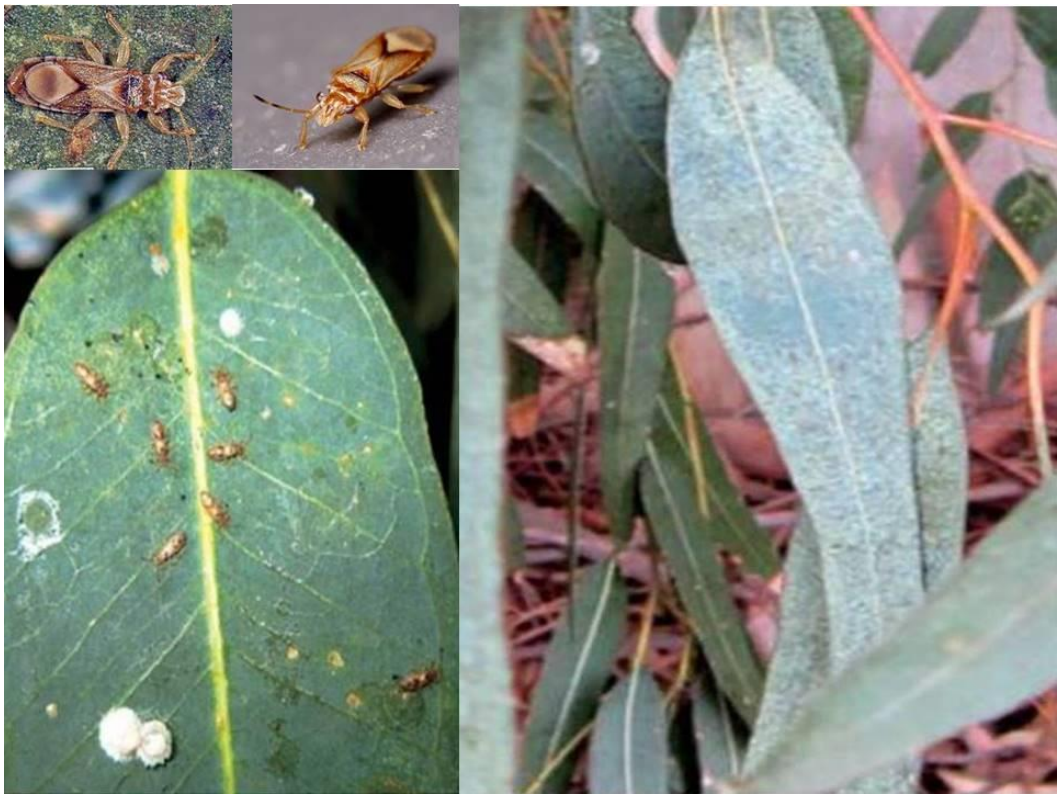

Figure 2. Effect of the feeding activity of *T. peregrinus* on leaves of *E. Camaldulensis* associated with the red gum lerp psyllid *G. brimblecombei.*

Figure 3. *Glycaspis brimblecombei* and colonies *of G. brimblecombei*

Damage of Those Insects Specimens on Eucalypts

The figure 4 illustrates the foliar discoloration of eucalyptus in the study area from those specimens.

Figure 4. Foliar discoloration of eucalyptus

Pest Importance

The figure 5 presents the PCA scatter diagram which classifies eucalyptus in groups: (5a) the number of healthy eucalyptus is very high during the rainy season and the attack of the insect is very high in the dry season and (5b) the infested plants and relative abundance of eucalyptus are very high during dry season to compare to rainy period.

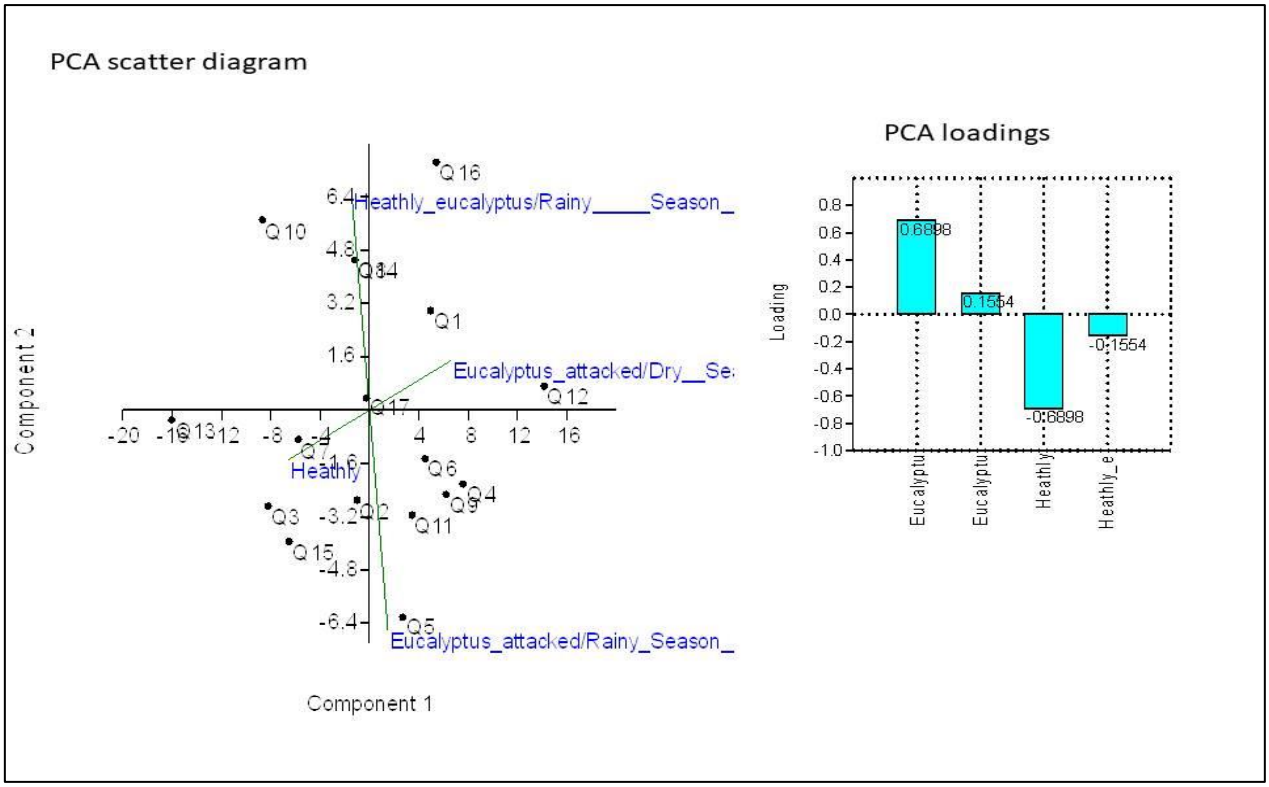

Figure 5 a. PCA scatter diagram and loadings of healthy eucalyptus and attack insect

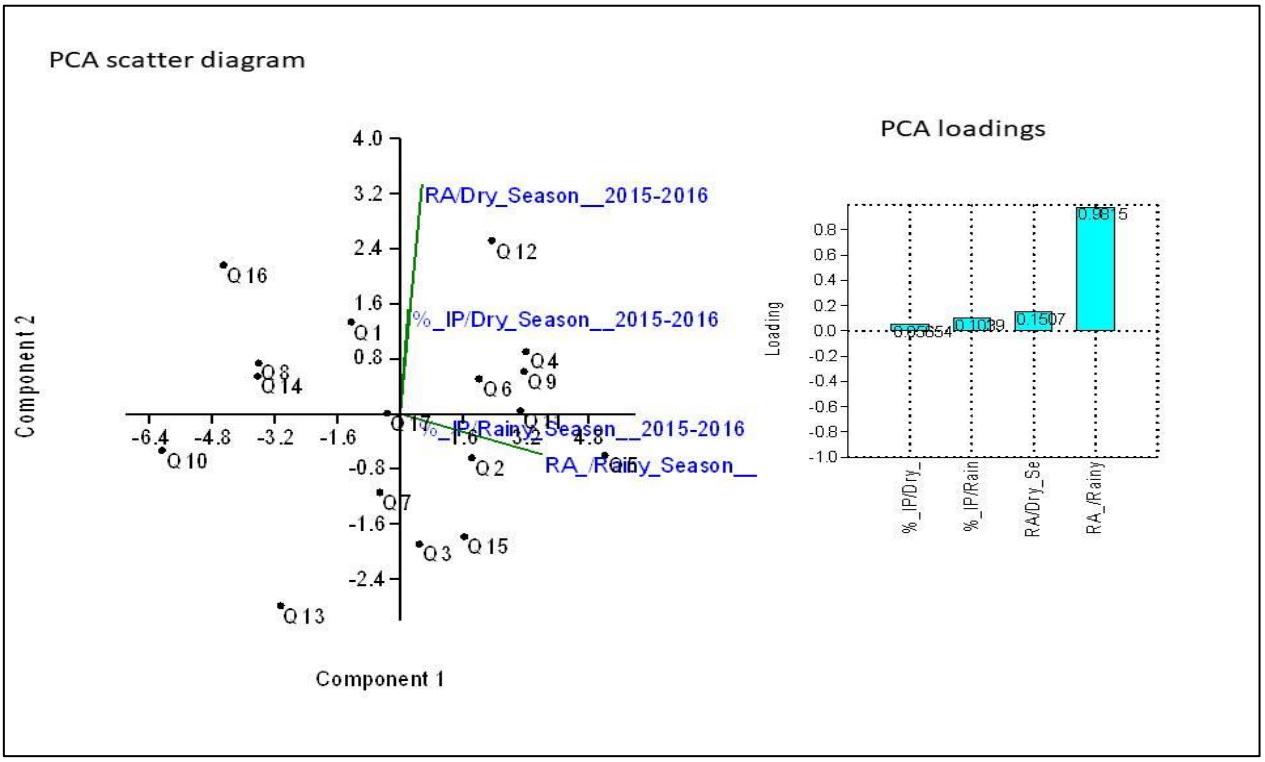

Figure 5b. PCA scatter diagram and loadings of healthy eucalyptus and attack insect

DISCUSSION

Pest Insects Of Eucalypts Trees Observed On Study Area

The *Glycaspis brimblecombei* Moore (1964) and *Thaumastocoris peregrinus* Carpintero & Dellapé specimens were identified by comparing them with the description given by Noack *et al.*(2011), Mendel *et al.*(2016), Messoudi *et al.*(2014), Floris *et al.*(2018) and Garonna *et al.*(2018) . The Eastern DR Congo, South Kivu, CRSN Lwiro specimens have all body

parts very similar to those in figure 1 in Floris *et al.*(2018) and Garonna *et al*.(2018).

In Australia, it is estimated that about 15,000-20,000 species of phytophagous insects feed on *Eucalyptus* ssp. Some of these pests were accidentally introduced into developing countries during the eucalyptus seed project (Doğanlar and Doğanlar, 2008).

The red gum lerp psyllid (*G. brimblecombei*) are laid eggs on the leaf surface, where nymphs develop under protective white conical coverings (lerps) composed of lipids, proteins and carbohydrates (Morgan, 1984)). According Mendel *et al.*(2016) and Cuello *et al.* (2018), adults and nymphs are phloem feeders and produce large amounts of honeydew, thus promoting the development of sooty mold. The bronze bug (*T. peregrinus*) is known to attack at least 30 Eucalyptus species and three common commercial hybrids (Jacobs and Neser, 2005; Carpintero and Dellapé, 2006; Noack and Coviella, 2006). *E. urophylla* and *E. grandis* were found to be the most suitable host species, as nymph development was faster and female fecundity higher than on E. *camaldulensis* (Soliman *et al.,* 2012). Adults are light brown in color with darker spots, approximately 3 mm long, with a flattened body. Each female is capable to product about 60 eggs during the life cycle, generally it hatch in 6 days. Eggs are black, elliptical in shape and can be found individually or in patches on leaves and twigs. The life cycle of *T. peregrinus* is 60 days. Nymphs develop through five instars to the adult stage in approximately 20 days, whereas adult longevity ranges from 14 to 42 days (Noack and Rose, 2007; Soliman *et al.,* 2012).

Damage of Those Insects Specimens on Eucalypts

The foliar discoloration of eucalyptus in CRSN/Lwiro study area from those specimens is the same with those observed by those authors Brennan *et al*. (1999, 2001), Daane *et al.*(2005, 2012). The later show that the damage resulting from leaf feeding includes foliar discoloration, and, in cases of heavy infestations, dieback, early leaf fall and reduced plant growth. In fact, defoliation in consecutive years can lead to the death of young plants or susceptible clones (Daane *et al.,* 2005). In addition, the most suitable host species of *G. brimblecombei* are *Eucalyptus blakelyi, E. camaldulensis, E. dealbata, E. tereticornis,* and eventually *E. nitens* in Australia (Moore 1970, 1975). The red gum lerp psyllid is also present at *E. brassiana, E. bridgesiana, E. camphora et E. mannifera subsp. maculosa. E. camaldulensis* outside of Australia in California and in United states), *E. diversicolor, E. globulus and E. sideroxylon* (Brennan *et al*., 2001) are supplementary host. The later same author lead study to determine the resistance degree cultivated eucalyptus species in California. Several species show more and less high resistance on attack of psyllid, but three species, *E. rudis, E. camaldulensis* and *E. tereticornis*, were revealed very susceptibles. According the bronze bug, it completes multiple generations per year and all life stages can be observed at the same time on leaves. The damage is caused by the feeding punctures of adults and preimaginal stages on expanded leaves, causing silvering chlorosis that evolves to leaf bronzing and drying. The canopy turns progressively to a brownish reddish discoloration, and thus has the common name of "winter bronzing". In addition to this symptom, early leaf fall and complete defoliation have been observed. Repeated infestations may cause branch dieback, reduce tree growth, and lead to the death of young weak plants (Soliman *et al.,* 2012).

Pest Importance

The number of healthy eucalyptus is very high during the rainy season and the attack of the insect is very high in the dry season. Among the most recent exotic invasive species, the two new eucalypt-feeding psyllid and aphid species in CRSN//Lwiro, *G. brimblecombei* and *T. peregrinus* have caused extensive damage to eucalypt plantations in consecutive years and are known as the more aggressive to trees as it also develops on old leaves (Floris *et al.,* 2018). Resulting in production losses, this psyllid has become a serious pest in the New World (including Brazil, Chile and Peru) causing severe defoliation and some tree mortality (Queiroz *et al.,* 2013). However, it has been noted that the attack of these phloem feeding insects produces large quantities of honeydew, facilitating subsequent cover of the foliage by sooty mold. As time progresses, fungal cover can cause leaf discoloration, falling, stunted growth and general abatement of plant vigour. This general deterioration could facilitate further attacks by other insect pests (Reguia and Peris-Felipo, 2013).

In addition, the studies of Oliveira et al. (2012) in their first experimentally show that the rain has regulatory effects on *G. brimblecombei* populations, with an effectiveness of up to 96%. These results corroborate with those obtained by Ramirez et al. (2003), who observed that frequent rains contributed to lerp fall, causing a populational decline of the red gum lerp psyllid. According to our results and observations, rainfall has two synergistic effects on *G. brimblecombei*. The first is the effect of leaf wetting, which can lead to the solubilization of the lerp sugars, exposing the nymphs to adverse environmental conditions or predator attack. This proposition is supported by the reduction of the lerp abundance in the "leaf wetting" treatment and direct observations of lerp melting. Furthermore, the increase in humidity may have slower, indirect effects on nymphs, since it can facilitate the occurrence of entomopathogenic fungi.

In fact, Favaro (2006) showed that much of the reduction of this insect population during the rainy season is due to the action of microorganisms. It is possible that the greater water availability for individuals of *E. camaldulensis* during the rainy season

increases the concentration of chemical defenses or decreases the nutrient content in the plant sap, with negative consequences to population of the red gum lerp psyllid (Oliveira *et al.*, 2012) and the bronze bug.

The infested plants and relative abundance of eucalyptus are very high during dry season to compare to rainy period . This result can be explain by temperature because some crop pests are ‘‘stop and go’’ developers in relation to temperature. Thus, they develop more rapidly during periods of time with suitable temperatures. In fact, increased temperatures will accelerate the development of these types of insects possibly resulting in more cycles of generations per year (Awmack *et al.*, 1997). It has been estimated that with a 2ºC temperature increase, insects might experience one to five additional life cycles per season (Yamamura and Kiritani, 1998). In addition,those pest insects are native to Australia, which infests plant species belonging to Myrtaceae (Noack *et al.*, 2011).The large number of species and the wide adaptability to different environments make it difficult to generalize the ecological characteristics and potential uses of the species of eucalyptus (Brundu, 2017).

CONCLUSION

Two species of eucalypt-feeding psyllid and aphid, *Glycaspis brimblecombei* and *T. peregrinus*, are reported from CRSN/Lwiro, Kabare, South Kivu in eastern of DRC for the first time. Both originate in Australia and are now established in other areas of the world on commercial and ornamental eucalypt trees. The establishment of these two species in eastern of DRC was not unexpected, considering their rapid colonization in other countries like Zambia and Uganda. The two Hemiptera species in eastern of DRC are likely to spread to other areas in the country and become established as a pest. However, in eastern of DRC, the eucalypts tree, are the most susceptible tree species to both insects. It should therefore be monitored for hemiptera occurrence, together with eucalypt tree species in eastern of DRC. Near future activity should focus on the question whether the parasitoid, native insect pest, map of infested /no infested and eucalyptus species strength to *G. brimblecombei*, *T. peregrinus* and other pest is already present in DRC or should be introduced.

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Compliance with Ethical Standards

Conflict of Interest: We declare that there is no conflict of interest with the publication of this manuscript. No human/animal participants were involved in the preparation of this manuscript.

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