SHORT COMMUNICATION

Susceptibility of eucalyptus species and hybrids to the gall wasp
Leptocybe invasa (Hymenoptera: Eulophidae) in northern Misiones, Argentina

Edgar R. Eskiviski1, Maria E. Schapovaloff1, Delia M. Dummel1, Margarita M. Fernandez2, and Fernando L. Aguirre3

1INTA-EEA Montecarlo, Av. El Libertador 2472, CP 3384, Montecarlo, Misiones, Argentina.
2FCF-UNaM, Bertoni 124, CP 3380, Eldorado, Misiones, Argentina.
3ARAUCO, CP 3374, Puerto Libertad, Misiones, Argentina.

Abstract

Aim of study: To analyze the susceptibility of Eucalyptus and hybrids species to Leptocybe invasa through field assays.
Area of study: The north of the Argentine province of Misiones (Colonia Delicia).
Material and methods: A total of 11 Eucalyptus species and 2 hybrids were surveyed for damage and severity of L. invasa infestation. Six evaluations were made during an annual period.
Main results: The susceptibility ranking to L. invasa from highest to lowest was E. tereticornis > E. propinqua > E. dunni > E. camaldulensis > E. grandis > E. major > E. longistata > E. grandis × E. camaldulensis. However, E. moluccana, E. urophylla × E. grandis and E. urophylla were tolerant to L. invasa.
Research highlights: This study suggests that in Misiones, E. tereticornis is the most sensible eucalyptus species to gall wasp attack, whereas other species and hybrids presented low damage levels or tolerance to L. invasa region.

Additional key words: forest plantation; exotic pest; damage infestation.
Abbreviations used: ADI (average damage index); DI (damage index).
Authors' contribution: Conceived and designed the experiments, and wrote the paper: ERE and MES. All authors performed the experiments, read and approved the final manuscript.

Citation: Eskiviski, E. R.; Schapovaloff, M. E.; Dummel, D. M.; Fernandez, M. M.; Aguirre, F. L. (2018). Short communication: Susceptibility of eucalyptus species and hybrids to the gall wasp Leptocybe invasa (Hymenoptera: Eulophidae) in northern Misiones, Argentina. Forest Systems, Volume 27, Issue 1, eSC01. https://doi.org/10.5424/fs/2018271-11573

Received: 21 Apr 2017. Accepted: 10 Apr 2018.
Copyright © 2018 INIA. This is an open access article distributed under the terms of the Creative Commons Attribution 4.0 International (CC-by 4.0) License.
Funding: INTA, Forest Protection (PNFOR 1104072).
Competing interests: The authors have declared that no competing interests exist.
Correspondence should be addressed to Edgar Eskiviski: eskiviski.edgar@inta.gob.ar

Introduction

Eucalyptus is the most widely planted exotic species in the tropics, and play important roles in reforestation and production of timber, pulp, potential bioenergy feedstock, and other forest products (Wyle & Floyd, 1998; Rejmánek & Richardson, 2011). In Argentina, Eucalyptus spp. plantations occupy about 261,000 ha, mainly in the northeast region (MAGyP, 2015).

The eucalyptus gall wasp, Leptocybe invasa Fisher & La Salle (Hymenoptera: Eulophidae), native from Australia, is a worldwide pest in Eucalyptus plantations. L. invasa has expanded to more than 29 countries in Asia, Europe, Africa and the Americas (Mendel et al., 2004; Zheng et al., 2014). This insect was first reported in Argentina in 2009 (Aquino et al., 2011). The female L. invasa lays her eggs in plant tissues causing the formation of galls on the leaf midribs and petioles and on the stem of new shoots, eventually leading to leaf-curling and premature aging of the leaves. Eggs overloading might cause death of young shoots, while severe attacks lead to leaf fall, stunted growth and may seriously weaken the tree (Mendel et al., 2004). Gall development occurs as response to a physiological disorder caused by a specific relationship between plant and insect. It is highly dependent on specific small changes in morphological and phenological characteristics of the plant, which determines the degree of susceptibility and coevolution between plant and insect (Stone & Schönrogge, 2003; Zheng et al., 2014).

Eucalyptus species show different susceptibility to L. invasa attacks (Mendel et al., 2004) with Eucalyptus grandis W. Hill, Eucalyptus camaldulensis Dehnh and Eucalyptus tereticornis Smith being the most susceptible
ones (Thu et al., 2009). However, the susceptibility can be strongly influenced by local environmental factors, and therefore further susceptibility tests are needed in locations where eucalyptus trees are cultivated. The objective of the present study was to evaluate the susceptibility of different Eucalyptus species and hybrids to L. invasa planted in the field in Argentina.

Material and methods

This study was conducted from March to November 2014 in Colonia Delicia, Misiones, Argentina (26°10'16" S, 54°33'15" W). The climate is subtropical without dry seasons. Eucalyptus seedlings, less than one year old, were planted in a field experiment without irrigation. L. invasa damages were evaluated in a 1.35 ha field plot, with a spacing between plants of 3.0 × 2.5 m (1,333 plants/ha). The evaluated species were E. camaldulensis, E. grandis, E. major, E. propinqua, E. tereticornis, E. dunni, E. moluccana, E. longirostrata, E. urophylla and the hybrids E. grandis × E. camaldulensis and E. urophylla × E. grandis (Table 1), planted in October 2013.

The experiment was designed as a complete randomized block, with 4 blocks and 5 replications. In each block, 11 experimental plots of each species with 5 plants were randomly established, and all trees in these plots were surveyed for damage and severity of L. invasa infestation. Six evaluations were made during 2014 between March and November, evaluating the damage index (DI) and average damage index (ADI).

\[
\text{ADI} = \frac{\sum n_i v_i}{N_i}
\]

where \( n_i \) is the number of trees infected at DI = i, \( v_i \) the damage index at level i, and \( N_i \) is the number of trees assessed per species. Based on maximum ADI values, a damage severity level was defined (Thu et al., 2009): nil (ADI = 0), low (ADI: 0-1.0), medium (ADI: 1.1-2.0), severe (ADI: 2.1-3.0) and very severe damage (ADI: 3.1-4.0).

Statistical analysis was performed using analysis of variance (ANOVA) after checking that normality and homoscedasticity were fulfilled, and means were compared with the Tukey test (\( p<0.05 \)), using InfoStat statistical software V 2016 (Di Rienzo et al., 2016).

Results and discussion

Damage incidence by L. invasa significantly differed among the tree species (\( df=18, F=28.42, p<0.0001 \)). The highest damage incidence was observed on E. tereticornis and the lowest in E. urophylla, E. urophylla × E. grandis and E. moluccana. E. grandis × E. camaldulensis, E. longirostrata, E. major, E. grandis, E. camaldulensis, E. dunni and E. propinqua showed medium damage incidence (Table 2).

Based on ADI, in the six evaluations between March and November 2014, the resistance of eucalyptus species differed widely. E. urophylla and the hybrid E. urophylla × E. grandis seemed tolerant to L. invasa and no galls were produced. Six species (E. moluccana, E. longirostrata, E. major, E. grandis, E. camaldulensis, E. dunni) and the hybrid E. grandis × E. camaldulensis showed low damage severity. Medium damage was observed in one species, E. propinqua and severe damage occurred in E. tereticornis (Table 2).

Table 1. Provenances of Eucalyptus species selected for the field trial.

| Seedlot | Section | Series | Species | Collection location |
|---------|---------|--------|---------|--------------------|
| ECA90   | Exsertaria | Rostratae | E. camaldulensis | Kenya |
| EDU64   | Maidenaria | Globulares | E. dunni | Buenos Aires, Argentina |
| EGC91   | Transversaria | Salignae | E. grandis | São Paulo, Brazil |
| EGC91   | Transversaria | Salignae | E. grandis × E. camaldulensis | São Paulo, Brazil |
| EUG92   | Transversaria | Punctatae | E. grandis × E. urophylla | São Paulo, Brazil |
| ELO119  | Transversaria | Punctatae | E. longirostrata | South Africa |
| EMJ110  | Transversaria | Punctatae | E. major | Queensland, Australian |
| EMO33   | Adnataria | Moluccanae | E. moluccana | Queensland, Australia |
| EPR103  | Transversaria | Punctatae | E. propinqua | Unumgar, Australia |
| ETE63   | Exsertaria | Tereticornes | E. tereticornis | Buenos Aires, Argentina |
| EUR94   | Transversaria | Resiniferae | E. urophylla | São Paulo, Brazil |
Differences in susceptibility to the gall-forming insects of eucalyptus tested may indicate that genetic factors are involved in both, attractiveness to \textit{L. invasa} for oviposition and suitability for \textit{L. invasa} larval development. Similarly, synchronization of gall-forming species with host plant phenology is behind many cases of susceptibility as consequence of coevolution between eucalyptus plants and \textit{L. invasa}. These factors open the chance of coping with this pest through the development of resistant and productive genetic stock, better than through chemical means (Dungey \textit{et al.}, 2000; Guerreiro \textit{et al.}, 2015). In this context, the order of susceptibility to \textit{L. invasa} in Misiones was \textit{E. tereticornis} \textgreater \textit{E. propinqua} \textgreater \textit{E. dunni} \textgreater \textit{E. camaldulensis} \textgreater \textit{E. grandis} \textgreater \textit{E. major} \textgreater \textit{E. longistata} \textgreater \textit{E. grandis} \times \textit{E. camaldulensis}. Other studies have also showed susceptibility to \textit{L. invasa} of these species (Mendel \textit{et al.}, 2004; Thu \textit{et al.}, 2009; Javaregowda & Prabhu, 2010; Zhu \textit{et al.}, 2012). On the other hand, \textit{E. moluccana}, \textit{E. urophylla} \times \textit{E. grandis} and \textit{E. urophylla} resulted tolerant to \textit{L. invasa}, as previously shown by Thu \textit{et al.} (2009), Nyeko \textit{et al.} (2009) and Guerreiro \textit{et al.} (2015).

This study suggests that in Misiones, \textit{E. tereticornis} is the most sensible eucalyptus species to gall wasp attack, whereas other species and one hybrid of regional economic importance like \textit{E. dunni}, \textit{E. camaldulensis}, \textit{E. grandis} and \textit{E. grandis} \times \textit{E. camaldulensis} presented low damage levels. The hybrid \textit{E. urophylla} \times \textit{E. grandis} showed tolerance to \textit{L. invasa}. More studies are necessary to determine the tolerance to \textit{L. invasa} of different eucalyptus species and hybrids cultivated in the northern Argentine region.

### Table 2. Damage incidence (DI) and average damage index (ADI) of \textit{Leptocybe invasa} infestation on \textit{Eucalyptus} species and hybrids in the field.

| Eucalyptus                  | DI (%) | ADI          | Damage severity |
|-----------------------------|--------|--------------|-----------------|
|                             | March  | April        | May  | July | August | November |       |
| \textit{E. urophylla}       | 0°     | 0°           | 0°   | 0°   | 0°     | 0°       | nil   |
| \textit{E. urophylla} \times \textit{E. grandis} | 0°     | 0°           | 0°   | 0°   | 0°     | 0°       | nil   |
| \textit{E. moluccana}       | 2°     | 0°           | 0°   | 0°   | 0°     | 0°       | low   |
| \textit{E. grandis} \times \textit{E. camaldulensis} | 11°    | 0°           | 0.25°| 0.40°| 0.25°  | 0.05°    | low   |
| \textit{E. longistata}      | 26°    | 0.10°        | 0.60°| 0.50°| 0.55°  | 0.30°    | low   |
| \textit{E. major}           | 29°    | 0.15°        | 0.75°| 0.85°| 0.75°  | 0.35°    | low   |
| \textit{E. grandis}         | 29°    | 0°           | 0°   | 0°   | 0°     | 0°       | low   |
| \textit{E. camaldulensis}   | 34°    | 0.45°        | 0.65°| 0.70°| 0.80°  | 0.60°    | low   |
| \textit{E. dunni}           | 38°    | 0.45°        | 0.75°| 0.90°| 0.95°  | 0.30°    | low   |
| \textit{E. propinqua}       | 41°    | 0.11°        | 0.83°| 1.33°| 1.39°  | 0.78°    | medium |
| \textit{E. tereticornis}    | 72°    | 1.55°        | 2.60°| 2.65°| 2.30°  | 1.80°    | severe |

Mean values followed by the same letter within a column are not significantly different according to Tukey test ($p<0.05$).

### References

Aquino D, Botto E, Loiacono M, Patahuer P, 2011. "Avispa de la agalla del eucalipto", \textit{Leptocybe invasa} Fisher & Lasalle (Hymenoptera: Eulophidae: Tetrastichinae), en Argentina. RIA 37 (2): 159-164.

Di Rienzo JA, Casanoves F, Balzarini MG, Gonzalez L, Tablada M, Robledo CW, 2016. InfoStat vers. 2016. Grupo InfoStat, FCA, Universidad Nacional de Córdoba, Argentina. http://www.infofost.com.ar

Dungey HS, Potts BM, Whitham TG, Li HF, 2000. Plant genetics affects arthropod community richness and composition: evidence from a synthetic eucalypt hybrid population. Evolution 54 (6): 1938-1946. https://doi.org/10.1111/j.0014-3820.2000.tb01238.x

Guerreiro J, Del Quiqui EM, De Oliveira AH, Maciel JP, Dileli, MW, Ferreira-Filho PJ, 2015. Susceptibility of Eucalyptus spp. (Myrtales: Myrtaceae) and clones to \textit{Leptocybe invasa} (Hymenoptera: Eulophidae) in Paraná, Brazil. Fla Entomol 98 (2): 787-789. https://doi.org/10.1653/024.098.0 260

Javaregowda J, Prabhu ST, 2010. Susceptibility of eucalyptus species and clones to gall wasp, \textit{Leptocybe invasa} Fisher and La Salle (Eulophidae: Hymenoptera) in Karnataka. Karnataka J Agric Sci 23 (1): 220-221.

MAGyP, 2015. Producción Forestal. Argentina: Plantaciones forestales y gestión sostenible. Ministerio de Agricultura, Ganadería y Pesca, Buenos Aires, 1-22 pp.

Mendel Z, Protasov A, Fisher N, La Salle J, 2004. Taxonomy and biology of \textit{Leptocybe invasa} gen. & sp. n. (Hymenoptera: Eulophidae), an invasive gall inducer on \textit{Eu-
Nyeko P, Mutitu E, Day RK, 2009. *Eucalyptus* infestation by *Leptocybe invasa* in Uganda. Afr J Ecol 47: 299-307. https://doi.org/10.1111/j.1365-2028.2008.01004.x

Rejmánek M, Richardson DM, 2011. Eucalypts. In: Encyclopedia of Biological Invasions; Simberloff D & Rejmánek M (Eds). University of California Press, Berkeley, USA. pp: 203-209.

Stone GN, Schönrogge K, 2003. The adaptive significance of insect gall morphology. Trends Ecol Evol 18 (10): 512-522. https://doi.org/10.1016/S0169-5347(03)00247-7

Thu PQ, Dell B, Burgess TI, 2009. Susceptibility of 18 eucalypt species to the gall wasp *Leptocybe invasa* in the nursery and young plantations in Vietnam. Sci Asia 35: 113-117. https://doi.org/10.2306/scienceasia1513-1874.2009.35.113

Wyle FR, Floyd R, 1998. The insect threat to eucalypt plantations in Australia and Asia. Paper presented at the International Workshop on Protection of Forest in the Tropics, Bangkok, Thailand, 25-29 May 1998. FAO, Rome.

Zheng XL, Li J, Yang ZD, Xian ZH, Wei JG, Lei CL, Wang XP, Lu W, 2014. A review of invasive biology, prevalence and management of *Leptocybe invasa* Fisher & La Salle (Hymenoptera: Eulophidae: Tetrastichinae). Afr Entomol 22 (1): 68-79. https://doi.org/10.4001/003.022.0133

Zhu F, Ren, S, Qiu B,Huang Z, Peng Z, 2012. The abundance and population dynamics of *Leptocybe invasa* (Hymenoptera: Eulophidae) galls on *Eucalyptus* spp. in China. J Integr Agric 11 (12): 2116-2123. https://doi.org/10.1016/S2095-3119(12)60470-5