DISPERSAL AND DYNAMICS OF THE WOODWASP *SIREX NOCTILIO* IN ARGENTINA

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ABSTRACT

Sirex noctilio F. (Hymenoptera: Siricidae) is probably the most important pest of softwood plantations in the Southern Hemisphere. Native to Eurasia, this wood-boring, solitary wasp in the last century successfully invaded South Africa, Australia, New Zealand, and South America. More recently, the species has been found along the east coast of North America. Characteristic of the species is the occurrence of severely damaging, pulse-like eruptive population outbreaks.

In Patagonia (Southern Argentina), pine trees (mainly *Pinus ponderosa*) are increasingly being planted in steppe areas. Currently, plantations in this region cover nearly 60,000 ha of which most bear established populations of *S. noctilio*. The first recordings of this pest in the region date back to the early nineties. Since then, woodwasp populations seem to have spread at approximately 9 to 14 km per year, a much slower rate than that observed in Australia and South Africa (J. Corley and A. Liebhold, unpub.data).

To understand local population dynamics and dispersal of wasps, we summarize here our recent study of the spatial redistribution of attacked trees within a *Pinus spp.* plantation. Then, we report on our work on the potential dispersal capacities of *Sirex noctilio* females, and how this is influenced by the introduction of biological control measures. Our emphasis is on summing up recent ecological and behavioral studies of this forest pest carried out in Patagonia. Our aim is to help increase our understanding of wasp spread and improve our abilities to manage expanding populations, especially in more recently invaded areas.

Local spatial dynamics. Spatial dynamics of *S. noctilio* were studied within two independent patches of pine stands, adding up to a total of 70 ha. Invasion by *S. noctilio* had occurred recently at the site, and through a census of all trees in the plantation, we were able to map attacked trees for 3 successive years. Dating of attack was based on tree symptoms (for details on the methods, refer to Corley et al. 2007). Using buffer areas drawn from the oldest attacked trees with GIS tools, we were able to tally and establish the distance at which trees attacked the following season were encountered. The results show that 50 percent of trees attacked in the latest years (years 0 and -1) were found at less than 60 m from the oldest attacked individuals (trees attacked in year -2), and 90 percent were found within a 120-m radius (Fig. 1).

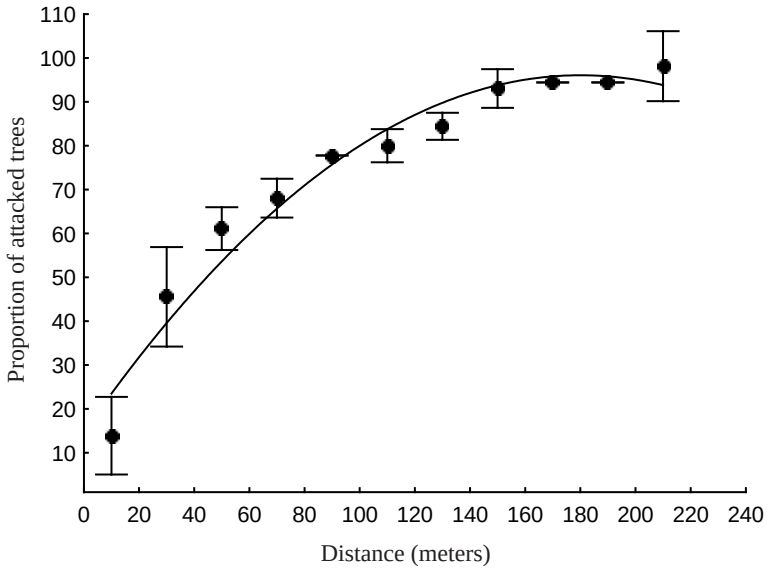

Figure 1.–Proportion of trees attacked by *Sirex noctilio* wasps in recent years (years -1 and 0) with respect to those attacked at a previous time (year -2). Number of attacked trees was estimated through a census of a 70-ha pine plantation in Northwest Patagonia. The figure shows that most new attacks are found close to previous attacks.

Spatial statistics of this database reported elsewhere (Corley et al. 2007) indicate that spatial aggregation of *S. noctilio* infestations during the early stages of pest colonization was strong. Also, the spatial pattern of attacked trees shows a tendency to increase aggregation, together with an increase in the number of attacked trees, throughout the 3 consecutive years studied. The spatial aggregation of woodwasp attacks may relate to the observed population dynamics, as was shown recently through spatially explicit, individual-based models (Aparicio et al., in prep.). Also, reported strong spatial aggregation should be taken into account when designing sampling protocols of damaged trees as well as during the introduction of the nematode *Beddingia* (=*Deladenus*) *siricidicola* (Tylenchida: Neotylenchidae) on the main natural enemies used in wasp bio-control programmes.

Long distance flight potential. Flight potential of *S. noctilio* females was studied on individuals tethered to flight mill devices. Details of the flight mill design and the program designed for collecting the output data are given in Villacide and Corley (in review). Individuals used were recently emerged females, collected from cages holding 1-m-long billets obtained from several *Pinus contorta* var. *latifolia* trees recently attacked by *S. noctilio*, from plantations located in Northwest Patagonia. Before and after flight, each female was weighed (*Scientech SA210*; d: 0.0001 g.). We recorded the accumulated flight distance (in kilometers) and flight speed (in meters/second) during a period of 23 hours for 28 wasps. The effects of infection by the nematode on flight parameters were studied separately by flying 46 (22 infected and 24 uninfected) female wasps. Infection status was determined after flight by dissecting wasps and inspecting their abdomens under a stereo-microscope.

The flight parameters of *S. noctilio* were highly variable between individuals, with some females able to perform long flights. The average distance flown by a wasp during the 1- day-long trial was 17.4 km with a maximum of 49.7 km and a minimum of 1.1 km. The average speed for all wasps was 0.37 m/s, but most of the time individuals remained at rest. In a related paper (Bruzzone et al., in prep.), we show that wasps display different flight patterns that relate closely to initial body size (Fig. 2).

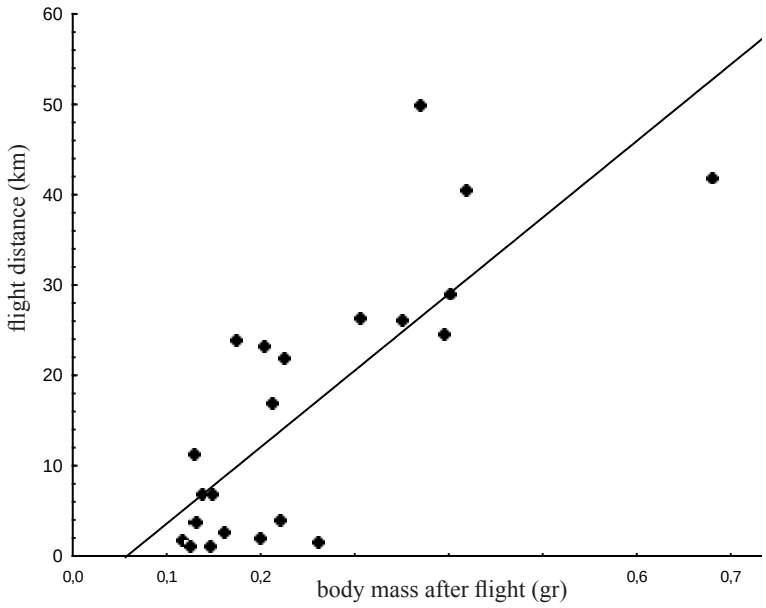

Figure 2.–Distance flown by 28 tethered female *Sirex noctilio* wasps as a function of initial body size ($r^2 = 0.6354$, p = 0.000003). Flight was performed in flight mills during a 23-hour-long period. The figure shows that larger wasps are capable of longer flights.

Through a separate set of experiments, we observed that nematode-infected *S. noctilio* females showed reduced flight performances compared to control wasps. The average maximum speed recorded for parasitized individuals was 0.79 m/s, in contrast with the 1.16 m/s observed for uninfected females. Similarly, we observed a marked difference in between infected and uninfected females in the total flight distances displayed (infected wasps flew 16.1 km while uninfected wasps flew 30.5 km), but reduced flight capabilities are probably a consequence of the effects of parasitism on wasp adult size (Villacide and Corley, in review).

Our results show that *S. noctilio* woodwasps have a variable flight behavior, which relates to initial body size. In turn, parasitism by *Beddingia siricidicola* has significant consequences on flight performance of *Sirex noctilio* wasps through its effects on adult body size. Smaller, parasitized females displayed lower flight speeds and shorter flight distances than larger (and healthy) individuals.

In conclusion, while a strong, local demographic aggregation may help explain observed outbreaking population dynamics and successful establishment of *Sirex noctilio* in invaded regions, the contribution of female dispersal potential to wasp geographical spread should not be disregarded. From an applied perspective, we underline the contribution of knowledge on the spatial distribution of attacked trees and wasp flight potential for the designing of sampling protocols and the introduction of natural enemies for the biological control of this important forest pest.

Acknowledgments

Research reported in this work was partially funded by grants PICT 2003 # 08-14661 (ANPCyT), PNFOR 2212 (INTA), ECOS SUD (SECyT) #A04B02 and funds provided by the U.S. Forest Service, Northern Research Station 07-JV-11242300-062. JC also acknowledges Sandy Liebhold's support to attend the 2008 Annapolis Research Forum.

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