12405

Sirex noctilio PROBLEM IN BRAZIL - DETECTION, EVALUATION AND CONTROL

Edson Tadeu Iede; Susete do Rocio Chiarello Penteado; Erich Schaitza.
EMBRAPA Florestas. Estrada da Ribeira km 111, Cx. Postal 319, CEP 83.411.000.
Colombo, PR, BR. e-mail **iedeet@cnpf.embrapa.br**

SUMMARY

Brazil has about 6 million ha of forest plantations of which 2 million ha consist of *Pinus* spp. Most of these stands were planted a small number of species at high density and inadequate forest management. In 1988 an outbreak of *Sirex noctilio* Fabricius was recorded in Rio Grande do Sul State. Its is present in 250.000 ha, and is also advancing on Santa Catarina and Paraná States. The use of biological control is the best measure to control *S. noctilio*. The most effective agent is *Deladenus siricidicola* Bedding, a nematode that sterilizes the females. Other parasite introduced was *Ibalia leucospoides.* In 1989, it was bred by the PROGRAMA NACIONAL DE CONTROLE À VESPA-DA-MADEIRA (PNCVM). This programme is broad in scope and also includes: the early detection and monitoring of the spread through the use of trap trees and ground inspections, and the adoption of preventative measures, through adequate forest management. Plans for the future include the introduction of the parasitoid *Rhyssa persuasoria* (L.) and *Megarhyssa nortoni* (Cresson) to compliment the nematode.

INTRODUCTION

There are about 6 million hectares of forest plantations in Brazil, 2 millions of which are planted with *Pinus* spp. Most of these plantations were implanted using a restricted number of species managed in high density under inappropriate silvicultural practices. The southern region concentrates approximately 1 million hectares of plantations mainly of *Pinus taeda* and *P. elliottii*. These characteristics are quite ideal for pest and disease outbreaks. *Sirex noctilio* attacks were registered in Rio Grande do Sul state in 1988, awakening the Brazilian forestry sector for the need of control strategies in prevention and monitoring actions. The woodwasp can currently be found in 200,000 hectares throughout the states of Paraná and Santa Catarina. *S. noctilio* is a minor pest in its regions of origin, Europe, Asia and North Africa, but has become the main pest in pine plantations where it was been introduced, in countries such as New Zealand, Australia, Uruguay, Argentina, Brazil and

more recently South África.

Biological control strategies are the most efficient for controlling *S. noctilio*, especially when the nematode *Deladenus siricidicola*, which sterilizes up to 70% of the females through parasitism, is used. The pest has been kept under control with the application of forest management techniques associated to biological control.

As the pest became a serious problem to Brazilian forestry, the FUNDO NACIONAL DE CONTROLE À VESPA-DA-MADEIRA (FUNCEMA) was created in 1989 by public and private organizations in order to support the National Program of Woodwasp Control (PNCVM). This program includes research activities in creating and adapting technologies for the control of *S. noctilio* and, at first, gave priority to the introduction of *D. siricidicola*. The National Program of Woodwasp Control still includes: **1)** monitoring for the early detection and dispersal of the pest, using trap trees which are intentionally stressed to attract the insects by receiving applications of the Dicamba herbicide; **2)** adopting prevention strategies to improve the phytosanitary conditions of forest stands using silvicultural practices, especially thinning, to minimize the attacks; **3)** adopting quarantine strategies to control and slow down dispersal; **4)** introducing the parasites *Ibalia leucospoides*, *Rhyssa persuasoria* and *Megarhyssa nortoni* to increase the range of natural enemies. *M. nortoni* and *R. persuasoria* was introduced in 1996 and 1997, respectively, by a project supported by the International Institute of Biological Control and the United States Department of Agriculture - Forest Service. *Ibalia leucospoides* was accidentally introduced and detected in 1990 in Rio Grande do Sul state, being currently present in nearly all forest stands attacked by the woodwasp; **5)** publicizing, using the media and the researchers involved, in a vast training program for technical personnel and forest producers to improve specific abilities and give information to the society. The integration within the National Program of Woodwasp Control has been an example to the research and development policy nationwide, as more than a hundred private enterprises in Southern Brazil are involved together with public organizations. Besides using the technology, these enterprises also offer technical assistance to small forest-planters so the control strategies can reach all plantations attacked by the woodwasp.

1 - BIOLOGY AND ECOLOGY OF *Sirex noctilio*

Sirex noctilio F. belongs to the order Hymenoptera, sub-order Symphyta, family Siricidae, sub-family Siricinae. Siricidis develop inside tree trunks of several species and are known as woodwasps or horntails. This group is associated with conifers and angiosperms of northern hemisphere origin.

The woodwasp is endemic of Eurasia and North Africa, with high density

populations in the Mediterranean zone, and shows preferences for species of the genus *Pinus*, also attacking *Abies*, *Picea*, *Larix* and *Pseudotsuga*.

In its countries of origin, *S. noctilio* normally develops in trees damaged or dead due to biotic or abiotic factors, such as fire, wind, other insects, diseases, snowstorms or mechanical operations, developing in healthy trees as well.

According to Smith (1988), it is also found in Germany, Australia (where it was introduced in 1951), Austria, Belgium, Cyprus, Denmark, Finland, France, Greece, Hungary, England, Mongolia, Norway, New Zealand (introduced in 1900), Poland, Romania, Ex-Czechoslovakia and Ex Soviet Union (Community of Independent States). It has more recently been introduced in Uruguay (1980), Argentina (1985), Brazil (1988), and South Africa (1994).

Most of the adults emerge between November and April in Brazil, with emergence peaks in November and December. The males emerge before the females, and there is a male/female proportion varying from 1.5 : 1 to 32 : 1.

After the initial flight period, females perforate tree trunks with their ovipositors and lay their eggs in the sapwood. They can perforate up to four galleries each continua time they lay eggs and the average number of eggs in each oviposition process is 2.2. The largest females lay 300 to 500 eggs in approximately 10 days. During this process, the females introduce spores (artrospores) of the symbiotic fungus *Amylostereum areolatum* (Fr.) Boidin along with a mucous secretion which cause toxicity and the consequent death of plants.

The plantations most susceptible to *S. noctilio* attacks are generally 10 to 25 years old and under stress. Stands not subjected to thinning are more susceptible than thinned ones. The insect weakens trees due to the injection of the phytotoxic mucus and the spores of the symbiotic fungus *A. aureolatum* in the sapwood, during oviposition. This pathogenic fungus, which is the source of nutrients for the pest larvae, dries up the wood and makes it rot. Besides, the wood quality is affected by the larvae building galleries and by the entrance of secondary agents which help damage the wood, limiting its use or ruining it for the market. Once the tree is dead the wood is degraded quickly and must be used at the most six months after the attack.

The attack symptoms begin to show right after the insect population peaks in the months of November and December, but become more visible from March on. The most visible external symptoms are the progressive yellowing of the crown, which becomes brownish-red afterwards, wilting of the foliage, loss of leaves, resin drops on the bark (due to the perforations made for oviposition) and holes drilled for the emergence of the adults. Internal symptoms are brown spots along the inner bark caused by the fungus *A. aureolatum* and galles drilled by larvae which affect wood quality.

Sirex noctilio completes its development in one or two years. Approximately 75% emerge in the first year, and although some may emerge in the third year, these are not likely to survive. The larvae that complete their development within a year go through an average number of six instars, while those which take two years to develop usually go through eight. In a temperate climate in Tasmania up to twelve instars have been observed.

2 - THE DETECTION OF THE WOODWASP IN BRAZIL

A *Sirex* attack was registered in October 1988 in a *Pinus taeda* stand in Gramado, Rio Grande do Sul state. That was the first registry of an outbreak of the insect in Brazil.

The insect was found at first in a 5 hectare stand 13 years old, planted at a 2 x 2 m spacing (2,500 trees per hectare) where the first thinning was being conducted. Some trees showing attack symptoms were cut and siricide larvae were found inside the trunk. Galles containing larvae and drilled holes were recently found in logs obtained from thinned trees piled inside the stand.

In the same occasion a mortality of 240 trees/ha was registered in another *P. taeda* plantation on the limit between Canela and São Francisco de Paula, also in Rio Grande do Sul state. The stands, which had not undergone thinning, were about 17 years old and the trees spaced 2 x 2 m. The average mortality of 9.6% was being attributed to soil exhaustion and excessive competition of plants for nutrients, once the stand had not been thinned. When some of the trees with yellowing or dry crowns were cut, *S. noctilio* larvae were found. One of the trees cut was quite dry and had old *Sirex* galles, proving the occurrence of attacks in former years (Iede et al., 1988).

earlier introduction + spread in Brazil.

In December 1989 the woodwasp was found in Lages, Santa Catarina state, in *P. taeda* trap trees. Two interceptions were made in Paraná state in 1993 and 1994, avoiding the establishment of the insect. In July 1996, however, the pest managed to get established in *P. taeda* plantations in General Carneiro, Paraná state.

Sirex noctilio currently occurs in approximately 200,000 hectares of *Pinus* spp. plantations in about 60 cities of the three southern states of Brazil.

3 - NATIONAL PROGRAM OF WOODWASP CONTROL

As the woodwasp has been found in *Pinus* stands in the country, the Brazilian forestry sector is undergoing a critical phase due to the damage potential of the pest. The infestation of *P. taeda* stands by *Sirex noctilio* in southern Brazil is serious and gradually increasing. The dissemination of the pest to other *Pinus* plantations in Brazil is inevitable once it can spread 30 to 50 km per year. Urgent and efficient strategies are required in order to control, monitor and delay its advance. The National Fund for Woodwasp Control was

created in June 1989 to manage the problem. It is a non-lucrative civil organization formed by private and public institutions whose main objective is to generate funds for the development of the PROGRAMA NACIONAL DE CONTROLE A VESPA-DA-MADEIRA (PNCVM). This program has the following activities.

3.1 Monitoring for the early detection of *Sirex noctilio*

The program originally intended to have all the *Pinus* plantations in the country mapped from satellite images. All the plantations in Rio Grande do Sul, Paraná and Satna Catarina states were to be allocated in detailed maps with data on the number and location of the groups of trap trees installed, the spots where *Sirex* was found and the places where nematodes and parasites were released. Aerial and terrestrial searches were also planned.

3.1.1 AERIAL MONITORING

Aerial monitoring with visual observations in quick surveys for early detection of the pest and estimate of attacked areas were planned. This procedure has not been evaluated because of its lack of precision, since dominated trees, normally preferred by the insect, are not detected in this kind of survey once they are not visible under the forest canopy.

3.1.2 TERRESTRIAL MONITORING

The trees initially attacked by *S. noctilio* tend to present smaller diameters or be somehow damaged, although attacks to dominant trees do occasionally happen.

The use of trap trees stressed by herbicide injection is the most appropriate and efficient technique for the early detection of the pest, as well as for monitoring dispersion. Detecting *S. noctilio* during its early stages of development and colonization help define locations for releasing biological control agents and allow thinning practices to be carried out before the pest reaches high levels of damage. Keeping a trap tree system may greatly increase the efficiency of biological control of the woodwasp.

The choice of a detection method, as well as the intensity with which it should be applied, must be based on a risk analysis of the introduction and dispersal of the pest in each region. The Centro Nacional de Pesquisa de Florestas - EMBRAPA recommends that trap trees, preferably between diameters at breast height (DBH) of 10 and 20 cm, be installed in groups of five, and that the distance among the groups varies according to where the pest is established:

- in areas where *Sirex* is present, as well as in areas up to 10 km away from the infestation focus, install groups of five trap trees at every 500 m;
- at distances between 11 and 50 km from the focus, the groups should be spaced 1000

m;

- over 50 km from the infestation focus, especially near borders, the groups should be spaced 10 km;
- in areas where the insect is further than 200 km forest vigilance is the most appropriate technique;

The groups of trap trees should be installed in easily accessible areas and cover the entire stand.

Other recommendations are:

- the installation of trap trees in Brazil must be done from august to october in Brazil, two months before the population peaks of the adult woodwasps, which generally occur between November and December;
- the groups of trap trees should be revised in January and May to check on insect attack;
- the installation process of trap trees must be carried out every year, since there is a progressive reduction in trees attracting *Sirex noctilio* from one year to the next;
- trees with DBH under 30 cm should receive a dose of 1 to 2 ml of the herbicide Dicamba at 20% or Tordon at 10% every 10 cm in the circumference, while trees with DBH greater than 30 cm should receive the same dose every 8 cm in the circumference.

As soon as *S. noctilio* is detected in a region the number of groups of trap trees should be increased and installed in susceptible plantations, close to saw mills, along the main wood transportation routes and on the borders of the area of natural dispersion of the pest. After detection, trap trees must be annually installed to receive the inoculation of *D. siricidicola*. Once the biological control agents are established in the region and the population of *S. noctilio* declines, the groups of trap trees must be implanted for monitoring the presence of the pest and its natural enemies.

3.2 Prevention strategies

It is currently estimated that most of plantation still show low levels of mortality and only a small portion is under high attack levels. If, however, monitoring, prevention and control strategies are not carried out, this state will be affected.

Trees resistant to *S. noctilio* are those which remain free of injuries and continue growing vigorously in good sites and well-managed blocks. The level of mortality of the trees is significantly related to the DBH of the trunk. Trees with low DBH show higher levels of mortality than thicker ones inside the same stand.

Management practices tend, therefore, to impose limits to long rotations and, what's more important, draw attention to the composition, structure, age and vigor of the forest, avoiding serious insect attacks. According to Davis (1966), more effective pest control may

be obtained through silvicultural practices in the long run, creating a reasonable forest-insect resistance. Complete control will never be attained this way, but the loss caused by insects may be reduced.

Thinning is one of the most important silvicultural practices, conducted in order to accelerate or modify the course of competition. The position of the crown is an important criteria in deciding which trees to cut and which to favor. Vigorous trees that outgrow their neighbors dominate the canopy and usually have a greater chance of surviving future competition than less vigorous ones which take lower positions in the forest.

Most of the thinning practices reduce loss due to damaging agents not only because it works as a prevention strategy but also because the vigor and resistance of the trees is increased. Thinning can only enhance the susceptibility of trees to insect attack under special circumstances, as when it is carried out during the flight period of the pest.

3.3 Biological control

Successful experiences in which the pest was introduced have demonstrated that biological control, along with prevention strategies, is the most efficient and economical method for controlling *Sirex*, especially since it is an exotic insect introduced to the advantage of not having natural enemies.

In order to test a similar system in Brazil, the nematode *Deladenus siricidicola* and the parasites *Ibalia leucospoides, Rhyssa persuasoria* and *Megarhyssa nortoni*, were introduced to control the woodwasp, to make the ecosystem of the pest more stable.

3.3.1 NEMATODES

The most effective biological control agent of the woodwasp is the nematode *Deladenus siricidicola*, which sterilizes females. Cultures of these agents have been developed in Australia and sent to Brazil in 1989 and 1990. The first inoculations were exceptionally made at the end of August 1989 and between February and August in the following years.

This nematode has two life cycles: a free-life one during which it feeds on the same symbiotic fungus the woodwasp associates with and a parasite-life one inside larvae, pupae and adults of *Sirex noctilio*. As its free-life cycle is based on the fungus *A. areolatum* it is easily bred in laboratory conditions and then released in the field by application into trees attacked by *S. noctilio*, achieving parasitism levels close to 100%.

The inoculation of *D. siricidicola* in trees is done with a special hammer used to make holes in the trunk at 30 cm spacing. The nematodes, sent to the field in 20 ml doses (each one containing approximately one million nematodes measuring 5 to 25 mm in length),

are mixed in a gelatinous solution at 10% and introduced by a syringe in the wood holes made with the hammer.

After the inoculation the nematodes penetrate the wood in search of the fungus they feed on, and reproduce originating young nematodes in free-life cycle. When they find *Sirex* larvae, however, they develop into infectious adult forms and penetrate the larvae, leaving a scar in the tegument. They double their size inside the larvae and when the host pupates they move to the reproduction organs and penetrate the ovaries, sterilizing the female *Sirex noctilio*. The infected adult females emerge from the trees and lay their eggs in different ones, but these eggs are not fertile and may contain between 100 and 200 nematodes.

The average level of parasitism obtained in Australia with the nematode was 70%. Although the level of parasitism verified for the nematode in the attacked areas in Rio Grande do Sul and Santa Catarina in Brazil has been quite variable, it was found to be as high as 70 or 80% in a 12,000 ha *Pinus taeda* plantation in Encruzilhada do Sul, Rio Grande do Sul.

3.3.2 PARASITES

Ibalia leucospoides was registered in Brazil for the first time in December 1990 in *Pinus* plantations attacked by the woodwasp around the city of São Francisco de Paula, Rio Grande do Sul (Carvalho, 1991). It is nowadays possibly established in nearly all cities in Rio Grande do Sul and Santa Catarina where the woodwasp occurs and in Paraná state where the pest is more recent. Evaluations indicate a level of parasitism up to 39%, with an average close to 25%.

Eggs and larvae of first and second instar suffer parasitism. This parasite is attracted to the oviposition holes of the host when the fungus *Amylostereum areolatum* begins to spread (Madden, 1968; Spradbery, 1974).

The parasites *R. persuasori* e *M. nortoni,* have long ovipositor and therefore attack larvae in more advanced stages of development. The parasite introduces the ovipositor in the wood in search of the host larvae. The larvae are paralyzed when stung by the parasite and their eggs are then lain on the body of the host. After they hatch, the larvae of the parasite feed externally and, after consuming the host, are transformed in pupae.

In this group of species, most of the members of each generation undergo a diapause in the larval state once they are completely fed. They pupate in the following spring and emerge when the host larvae move towards the tree bark to pupate. Those which do not undergo diapause pupate immediately to emerge in the beginning of summer.

According to Taylor (1967), *I. leucospoides* may spread quickly over long distances

up to 80 km and when new areas are reached it reproduces intensively. It has also been observed that *I. leucospoides* is more efficient in dry places.

Taylor (1967) observed that *Rhyssa* spp. and *Megarhyssa* spp. can spread over all areas infected by *Sirex*, between 7 and 18 km respectively, from the release point.

The complex of parasites (*Ibalia* + Rhyssinae) can eliminate up to 70% of the population of *Sirex noctilio* in certain places (Nuttal, 1989). It doesn't usually, however, exceed 40% of the population, an insufficient percentage to keep the woodwasp attacks from reaching high levels, but nevertheless important to maintain the ecosystem/pest equilibrium.

3.4 Quarantine strategies

Sirex noctilio can spread naturally between 30 and 50 km per year. However, the transportation of wood from attacked areas to plantations where it hasn't been detected yet increases its possibilities of dispersal. That is probably how *S. noctilio* was introduced in Brazil, coming from Uruguay. For that reason, monitoring affected areas and prohibiting transportation of wood from attacked areas to non-attacked ones are strategies created to avoid the dispersal of the pest.

3.5 General recommendations

Sirex noctilio is essentially a secondary, opportunistic pest. The prevention of economically important damage in *Pinus* spp. plantations is a management problem which may be mitigated by monitoring forest stands and using appropriate silvicultural practices. Healing procedures include phytosanitary thinning and the use of biological control agents.

5 - REFERÊNCIAS

BEDDING, R. Biology of *Deladenus siricidicola* (Neotylenchidae) an entomophagous-mycethophagous nematode parasitic woodwasps. Nematologica, v.18, p.482-493, 1972.

BEDDING,R.A. Relatório e recomendações sobre o ataque de *Sirex* no Brasil. Curitiba:EMBRAPA-CNPF, 1989. 8p.

BEDDING,R.A.;AKHURST,R.J. Use of *Deladenus siricidicola* in the biological control of *Sirex noctilio* in Australia. 8p.Journal of Australian Entomological Society, v.13, p.129-135, 1974.

CARVALHO,A.G. Parasitismo de *Ibalia* sp. (Hymenoptera: Ibaliidae) em *Sirex noctilio* Fabricius, 1973 (Hymenoptera: Siricidae) em São Francisco de Paula, RS.Curitiba:EMBRAPA/CNPF-Boletim de Pesquisa Florestal,1991(no prelo).

CHRYSTAL,A.G. Studies on the Sirex parasites. The Biology and post-embryonic development of *Ibalia leucospoides* Hochew. (Hymenoptera-Cynipoidea). Oxford Forestry Memories. n.11.p.1-63, 1930.

COUTTS,M.P. Rapid physiological change in *Pinus radiata* following attack by *Sirex noctilio* and its associated fungus *Amylostereum* spp. Australian Journal Science.v. 30,n.7,p.274-276,1968.

COUTTS,M.P. The mechanism of pathogenicity of *Sirex noctilio* on *Pinus radiata*. I. Effects of the symbiotic fungus *Amylostereum* (Thelophoraceae). Australian Journal of Biological Science. v.22,p.915-924, 1969.

DAVIS, K.M. Forest management: regulation and valuation. 2. ed. New York: Mcgraw-Hill. 1966. 516 p.

FURNISS,R.L.:CAROLIN,V.W. Western forest insects. Washington: USDA Forest Service, 1977. 654p.

GILBERT,J.M.:MILLER,L.W. An outbreak of *Sirex noctilio* (F.) in Tasmania. Australian Forestry,v.16,p.63-69,1952.

GILMOUR,J.M. The life cycle of the fungal symbiotic of *Sirex noctilio*. New Zealand Journal of Forestry,v. 10,n.1,p.80-89, 1965.

HANSON,H.S. Ecological notes on the *Sirex* woodwasps and their parasites. Bulletin of Entomological Research,v. 30,n.1,p.27-65. 1939.

HAUGEN,D.A. Control procedures for *Sirex noctilio* in the green triangle: review from detection to severe outbreak (1977-1987). Australian Forestry,v. 53,n.1,p.24-32. 1990.

HAUGEN,D.A.;UNDERDOWN,M.G. *Sirex noctilio* control program in response to the 1987

green triangle outbreak. Australian Forestry,v.53,n.1,p.33-40,1990.

IEDE,E.T. Estratégia de ação para a busca e controle de *Sirex noctilio* em *Pinus*. Curitiba:EMBRAPA-CNPF,1988.5p.

IEDE,E.T.;PENTEADO,S.R.C.;BISOL,.J.C. Primeiro registro de ataque de *Sirex noctilio* em *Pinus taeda* no Brasil. Curitiba:EMBRAPA-CNPF.EMBRAPA-CNPF. Circular Técnica, 20. 1988.12p.

IEDE,E.T.;BEDDING,R.A.;PENTEADO,S.R.C.;MACHADO,D.C. Programa Nacional de Controle da vespa-da-madeira-PNCVM. Curitiba: EMBRAPA-CNPF. 1989.10p.

KILE,G.A.;TURNBALL,C.R.A. Drying in the sapwood of radiata pine after inoculation with *Amylostereum areolatum* and *Sirex* mucus. Australian Forestry Research,v.6,n.4,p.35-40, 1974.

MADDEN,J.L. Oviposition behavior of the woodwasp, *Sirex noctilio* F. Australian Journal of Zoology,v.22,p.341-51,1974.

MADDEN,J.L. An analysis of an outbreak of the woodwasp, *Sirex noctilio* F. (Hymenoptera:Siricidae), in *Pinus radiata*. Bulletin of Entomological Research,v.65,p.491-500, 1975.

MADDEN,J.L. Sirex in Australia. In:Dynamics of Forest Insect Populations. A.A. Berryman. Plenum Pub. Corp. p. 407-427. 1988.

MILLER,D.;CLARK,A.F.*Sirex noctilio* F. and its parasite in New Zealand. Bulletin of Entomological Reseach,v.26,p.149-154,1935.

MORGAN,D.F. Bionomics of Siricidae. Annual Review of Entomology,v. 13, p.239-256, 1968.

MORGAN,F.D.;STEWART,N.C. The biology of the woodwasp *Sirex noctilio* (F) in New Zealand. Transactions of the Royal Society of New Zealand,v.7,n.14,p.195-204.1966.

NEUMANN,F.G. Insect pest management in Australian radiata pine plantations. Australian Forestry,v. 42,p.30-38,1979.

NEUMANN,F.G.;MOREY,J.L.;McKIMM,R.J. The *Sirex* wasp in Victoria. Lands and Forest Division Bulletin,v. 29,p.1-41,1987.

NUTTALL,M.J. *Deladenus siricidicola* Bedding. (Nematoda: Neotylenchidae) Nematode parasite of *Sirex*.Forests and Timber Insects in New Zealand,n. 48,p.1-8, 1980.

RAWLINGS,G.B. Insect epidemics on forest trees in New Zealand.New Zealand Journal of Forestry,v.6,n.5,p.405-412,1953.

RAWLINGS,G.B.;WILSON,N.M. *Sirex noctilio* as a beneficial and destructive insect to *Pinus radiata*. New Zealand Journal of Forestry,v. 6,p.1-11, 1949.

REBUFFO,S. La "Avispa de la Madera" *Sirex noctilio* F. en el Uruguay. Montevideo:Dir.For.,1990.17p.

SMITH,D.R. Hymenopterorum Catalogus - Suborder Symphita (Xyelidae, Pararchexyelidae, Parapamphiliidae, Xyelydidae, Karatavitidae, Gigasiridae, Sepulcidae, Pseudosiricidae, Anaxyelidae, Siricidae, Xiphydriidae, Paroryssidae, Xyelotomidae, Blasticotomidae, Pergidae). W. Junk B. V. : Holand. p. 59-63. 1978.

SPRADBERY,J.P.;KIRK,A.A. Aspects of the ecology of siricid woodwasps (Hymenoptera:Siricidae) in Europe, North Africa and Turkey with special reference to the biological control of *Sirex noctilio* F. in Australia. Bulletin of Entomological Research,v. 68,p.341-359, 1978.

TAYLOR,K.L. The introduction, culture, liberation and recovery of parasites of *Sirex noctilio* in Tasmania, 1962-67, Melbourne:CSIRO, 1967.19p.(CSIRO. Paper, 8).

TAYLOR,K.L. The introduction and establishment of insect parasitoids to control *Sirex noctilio* in Australia. Entomophaga,v. 21,p.429-440, 1976.

TAYLOR,K.L. The Sirex woodwasp: ecology and control of an introduced forest insect. In: The Ecology of Pests. Some Australian case histories. CSIRO Australia. Cap. 12, p. 231-248. 1981.

ZONDAG,R. Progress Report on the Establishment in New Zealand of *Ibalia leucospoides* a parasite of *Sirex noctilio* .New Zealand Forestry Research Notes,n. 20,p.1-9,1959.

ZONDAG,R. A nematode infection of *Sirex noctilio* F. in New Zealand. New Zealand Journal of Science,v. 12,n.4,p.732-747, 1969.