

COST Short Term Scientific Mission Scientific report

COST-STSM-FP1203-25224

under COST Action FP1203: European Non-Wood Forest Products (NWFPs) Network

Dr Sven MUTKE

Head of Service for Forest Industries

INIA-CIFOR Madrid, Spain

COST STSM Reference Number:	COST-STSM-FP1203-25224
Period:	4th–8th May 2015
STSM type:	Regular (from Spain to France)
STSM Applicant:	Dr Sven MUTKE, INIA-CIFOR Madrid (ES)
STSM Topic:	<i>Severe seed yield loss in Mediterranean stone pine</i>
Host:	Dr. Alain ROQUES, INRA
Host Institution:	UR0633 Zoologie Forestière – INRA Val De Loire, Orléans (F)
COST STSM Manager:	Tine GREBENC, tine.grebenc@gozdis.si

• Purpose of the Short Term Scientific Mission (STSM)

The STSM *COST-STSM-FP1203-25224* under COST Action FP1203 *European Non-Wood Forest Products (NWFPs) Network* was conducted at the Forest Zoology Laboratory, INRA Orleans, in May 2015.

The laboratory directed by the host, **Dr. A. Roques**, is a reference for forest entomology and pest management in Europe, and has been developing research also on pine cone pests, with a PhD Thesis directed by Dr. Roques recently presented at U. Orleans¹. Dr. Roques has hosted recently another FP1203 STSM by a Portuguese PhD student from ISA (U. Lisbon), about assessment and diagnostic methods for pine seed damages caused by *Leptoglossus occidentalis*².

The goal of scientific collaboration in the present STSM was the discussion of pine seed yield (*i.e.* % seed or kernel weight per cone weight) data series from different countries, in order to describe and evaluate the recently arisen phenomenon of **Mediterranean pine nut yield loss** known also as **Dry Cone Syndrome**. Another issue was to learn about cone damage assessment methods developed in the host institute. An advanced draft of a peer reviewed paper regarding yield loss series from processing industries in several countries would be carried out.

Background. The relevance of the Mediterranean stone pine, *Pinus pinea* L., for economic sustainability of Mediterranean forests is based on the harvest of its pine cones, the main marketed product from its forests, for extracting and shelling their seeds, obtaining the edible Mediterranean pine nuts kernels³. But in the last years, a severe loss of seed-per-cone yield has been reported by processing industries for stone pine cones collected in all main producing countries, namely Portugal, Spain, Italy, and Turkey⁴, and last year in Lebanon, too⁵: When cracking apparently sane cones, up to half of the seeds have been found to be empty.



Additionally, cone pickers have reported also an unusual high percentage of dried first- or second-year conelets (stone pine cone ripen only in their third winter), resulting in a drastically reduced final cone yield.

The coincidence of appearing both phenomena only recently has coined the common name *Dry Cone Syndrome*, suggesting a possible common agent. As consequence of the pine nut shortage, the wholesale

price of shelled Mediterranean pine nuts had been rising from formerly 25 € to currently 45 € in the last two years, retail prices exceeding now 100 €/kg; and the market has broken down greatly due to lack of supply. In conclusion, the *Dry Cone Syndrome*, if persisting, is regarded as a serious threat for commercial pine nut harvesting, an activity essential for the economic

¹ LESIEUR, Vincent (2014). Invasion de la punaise américaine *Leptoglossus occidentalis* en Europe: une contribution à la compréhension des invasions fulgurantes [*Invasion of the American bug Leptoglossus occidentalis* in Europe: a contribution to understanding fulgurant invasions], U. Orléans.

² FARINHA, A. (2015). Final Report COST-STSM-FP1203-21557 The Western Conifer Seed Bug, *Leptoglossus occidentalis*: important methodologies and techniques.

³ MUTKE, S.; CALAMA, R.; GONZÁLEZ-MARTÍNEZ, S.C.; MONTERO, G.; GORDO, J.; BONO, D.; GIL, L. (2012). Mediterranean Stone Pine: Botany and Horticulture. Horticultural Reviews 39, John Wiley & Sons, Inc., Hoboken, New Jersey: 153-201.

⁴ MUTKE, S.; MARTÍNEZ, J.; GORDO, J.; NICOLAS, J.L.; HERRERO, N.; PASTOR, A.; CALAMA, R. (2014). Severe seed yield loss in Mediterranean stone pine cones. medPINE 5 – 5th International Conference on Mediterranean Pines. Solsona, 22nd -26th September 2014.

⁵ TCP/LEB/3501baby. Assessment on *Pinus pinea* in Lebanon. FAO (unpublished).

sustainability of Mediterranean pine forests and especially for the cone processing industry in Europe, a market of several hundred million euros annually before this collapse.

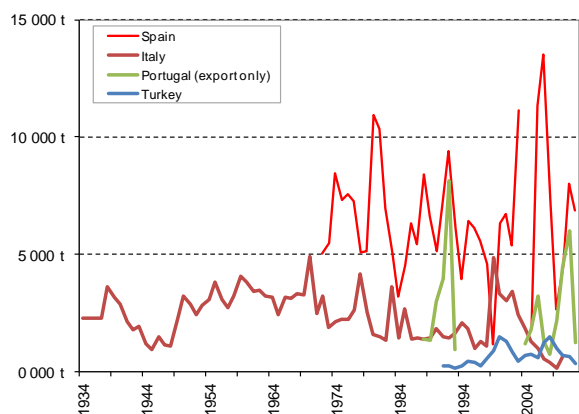
Objectives. The aim of the present STSM was to discuss collected with the hosts the available data about the *Dry Cone Syndrome* in stone pine observed all over the Mediterranean Basin, in order to elucidate the possible agents responsible for this problem, and especially to discuss the possible role of the alien invasive bug, *Leptoglossus occidentalis*, feeding on conifer seeds that has spread in the last years all over Europe and around the Mediterranean^{6,7}.

• Description of the work carried out during the STSM

The visiting researcher, S. Mutke from INIA-CIFOR, coordinates a working group on Mediterranean stone pine within the *FAO/CIHEAM International Collaborative Research Network on Nuts* (http://www.iamz.ciheam.org/en/pages/paginas/pag_investigacion2a.htm) joined by members from Spain, Portugal, France, Tunisia, Maroc, Turkey, Lebanon, and Chile. He has been participating in research projects or as consultant on Mediterranean stone pine and its pine nuts for over twenty years in Spain, and more recently in Portugal, Lebanon, and Chile, and has been involved also in consultative or participative panels on this topic, in direct contact with forest and pine nut sector stakeholders.

Within these networks, awareness has grown of the emergence of the *Dry Cone Syndrome* all over the Mediterranean range of stone pine only in the last three years, after previous alarms from Italy⁸ since early 21st c., from Catalonia after⁹. In 2014, a first survey of cone processing industries produced a short dataset⁴, which has now been updated and enlarged, in order to assess the real impact of the Syndrome on the pine nut sector in different countries.

However, it is noteworthy that the amount of the cone yield of Mediterranean of stone pine is very variable among years in all countries, due to the strong masting habit of the species,



mainly driven by the erratic rainfall pattern of Mediterranean climate¹⁰. The extremely low productions observed in the last four years are hence not necessarily an exceptional phenomenon by themselves, comparing with other bad crops reported in official data series¹¹.

Annual pine nut production in the main producing countries [t pine nuts in shell]¹¹.

Furthermore, extensive field work would be

⁶ BRACALINI, M.; BENEDETTELLI, S.; CROCI, F.; TERRENI, P.; TIBERI, R.; PANZAVOLTA, T.; 2013. Cone and Seed Pests of *Pinus pinea*: Assessment and Characterization of Damage. *For. Entomol.* 106 229–234.

⁷ LESIEUR, V.; YART, A.; GUILBON, S.; LORME, P.; AUGER-ROZENBERG, M.-A.; ROQUES, A.; 2014. The invasive *Leptoglossus* seed bug, a threat for commercial seed crops, but for conifer diversity? *Biol. Invasions* 1–17.

⁸ TIBERI, R. 2007. *Danni alla fruttificazione del Pino Domestico: indagine sulle cause e sulle perdite di produzione. Progetto Territoriale.* Università degli Studi Firenze

⁹ CASTEDO, A.; 2011. Los pinos del Empordà pierden su fruto. *El País*, 20/11/2011.

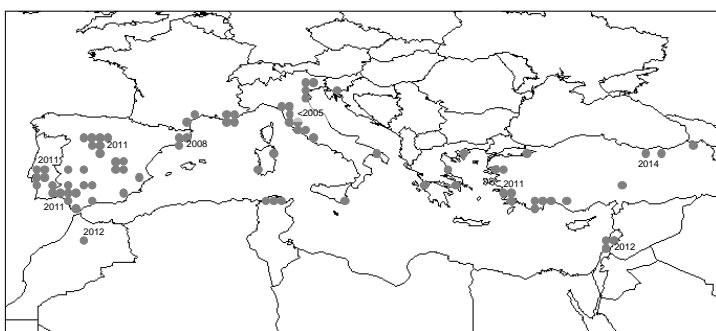
¹⁰ MUTKE, S.; GORDO, J.; GIL L. (2005). Variability of Mediterranean Stone pine cone yield: yield loss as response to climate change. *Agricultural and Forest Meteorology* 132(3/4): 263-272.

¹¹ Sources: <http://www.magrama.gob.es/es/estadistica/temas/publicaciones/anuario-de-estadistica/>, http://seriestoriche.istat.it/fileadmin/allegati/Agricoltura/tavole/Tavola_13.17.xls, http://www.unac.pt/attachments/162_02_Nuno_Calado_-_UNAC.pdf, <http://web.ogm.gov.tr/BilgiServisleri/agacturleri/agac7.html>.

necessary for assessing quantitatively an increase of conelet losses in all countries as putatively relevant cause reported for the reduction in number of harvested cones. Even then, only few long term data series exist for the percentage of conelet survival in the past for comparison. For the moment, available data do hence not allow to rule out the role of existing weather-driven mastings as possible concurrent explanation for the low number of ripe cone harvested^{10,12}.

For this reason, the present first step for a study on the *Dry Cone Syndrome* (DCS) has centred on the other phenomenon reported, the high percentage of aborted, empty or damaged seeds found in ripe cones that would reduce drastically the seed output of post-harvest processing. As a matter of fact, the seed-per-cone yield had been considered always a nearly constant ratio in this species: 16-18% of the cone weight were seeds in shell, only 3.5-4 % kernels (*i.e.* 20-25% of the pine nut weight in shell), rendering hence a ton cones only about 40 kg pine nut kernels³. These values were known to decrease only in very dry years producing abnormal small cones¹³.

Available time series of seed per cone yield data from cone processors in Spain and Portugal have been analysed and discussed. This information, together with published data and verbal



reports gathered from colleagues in the FAO/CIHEAM Research Network on Nuts, allows reflecting the spread of the DCS over the Mediterranean.

Dots: Range of *Pinus pinea*.
Year: First report of the Dry Cone Syndrome (unpublished data).

On the other hand, during the STSM visitor and hosts discussed different interpretations and comparison of diagnostic methods for seed damages. Research on pine nuts at his home institute INIA-CIFOR^{12,14,15} has defined several damages types, analogous to the grading made before by Italian researchers⁸, based on visual assessment of shelled pine nuts, differing among:

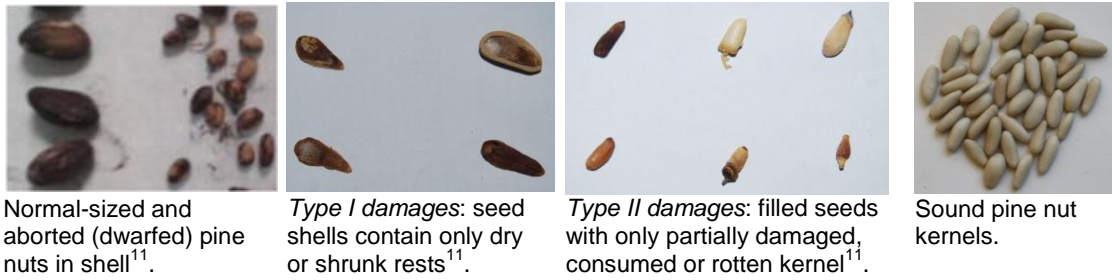
- aborted (fused or dwarfed) seeds;
- normal-sized, but empty seeds shells (*Type I damages*: containing only dry or shrunk kernel rests, if any);
- well-developed seeds, but with *Type II damages*: only partially damaged, consumed or rotten kernel;
- sound pine nuts with normal kernels, no damages (commercial output).

¹² CALAMA, R.; GORDO, J.; CONDE, M.; MADRIGAL, G.; MUTKE, S.; PARDOS, M.; GARRIGA, E.; MONTERO, G.; FINAT, L.; MARTÍN, R.; CUBERO, D. (2014). Pérdidas de rendimiento de piña y piñón en las masas de *Pinus pinea*. Jornada presentación proyecto PROPINEA. Pedrajas de San Esteban, 21st November 2014.

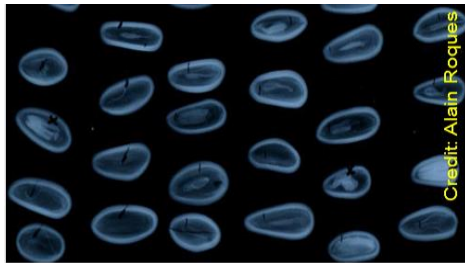
¹³ CALAMA, R.; MUTKE, S.; SANCHEZ, M.; GARRIGA, E.; MONTERO, G. (2007). Modelling spatial and temporal variability on stone pine (*Pinus pinea* L.) cone quality: preliminary results. EFIMED Scientific Seminar on 'Modelling, valuing and managing Mediterranean Forest ecosystems for non-timber goods and services', Palencia, 26th-27th October.

¹⁴ CALAMA, R.; GORDO, J.; MADRIGAL, G.; CONDE, M.; GARRIGA, E.; BACHILLER, A.; PARDOS, M.; MUTKE, S.; MONTERO, G. (2013). Rendimiento en piñón de *Pinus pinea* en la Meseta Norte. Jornada "Irregularidad de las cosechas y pérdidas de rendimiento en piñón de *Pinus pinea* L. en la Meseta Norte", Junta de Castilla y León/INIA-CIFOR, Pedrajas de San Esteban, 1st October 2013.

¹⁵ CALAMA, R.; GORDO, J.; CONDE, M.; MADRIGAL, G.; MUTKE, S.; PARDOS, M.; GARRIGA, E.; MONTERO, G.; FONTES, L. (2015). Rendimiento de piñón en piña de *Pinus pinea* en Portugal: caracterización y comparación con otras regiones. Seminário UNAC Avanços no conhecimento na Fileira do Pinheiro Manso. Alcácer do Sal (Portugal), 6th March 2015.



These kind of damages were contrasted with the typology of damages caused by cone pests, especially by the Western conifer seed bug, *Leptoglossus occidentalis*, quoted as putative main biotic agent causing the Dry Cone Syndrome^{6,7}. The host laboratory applies x-ray based diagnosis for *Leptoglossus* damages in stone pine seeds^{1,2}, a standard technique for conifer seed damage assessment¹⁶, especially for those species with small seeds not easy to shell.



Radiography of empty, partially empty and full *Pinus pinea* seeds.

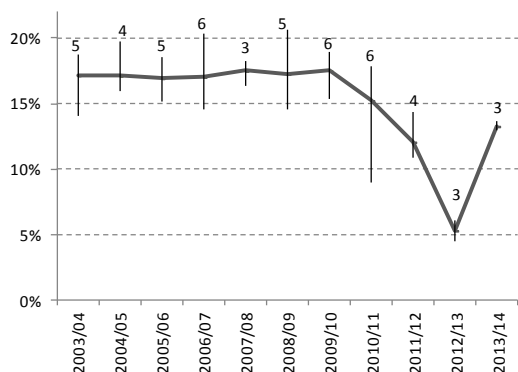
• **Description of the main results obtained**

Seed-per-cone yield series from cone processors. The processors survey on pine nut yield loss gathered very few responses, in consonance with other recent failed attempts to run a survey for a Supply Chain Analysis on Mediterranean pine nut in the framework of the European StarTree project 311919 on *Multipurpose trees and Non Wood Forest Products*. The reason might be that, in spite of formally more than four hundred cone picker and/or processing enterprises (most of them self-employed pickers) registered in Spain alone, no effective traceability for actual cone harvest and trade exists yet (only the pine nut kernel once shelled being considered the primary food item subjected European regulation), and hence most enterprises are not keen at all to display to third parts any information related to their account books or actual cash flow.

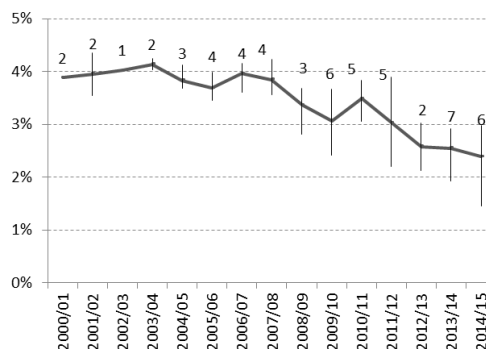
The only responses obtained are from the following enterprises in Spain: Piñonsol Coop, COFOREST Coop, and Óscar García Nieto, with data series for different regions each. The former two are cooperatives that process the cone harvested by their members, with a relevant market share in Spain. These data series for seed yield per cone in the last 10–15 years have been completed with data for stone pine provided by the National Centre for Forest Genetic Resources ‘El Serranillo’, the main provider of Forest Reproductive Materials (certified seeds and cuttings) in Spain depending on the Ministry for Agriculture, Food and Environment. Some series are expressed in seed yield (in shell) per cone weight, others in shelled kernels per cone weight.

¹⁶ BATES, S.L.; BORDEN, J.H.; KERMODE, A.R.; BENNETT, R.G. (2000) Impact of *Leptoglossus occidentalis* (Hemiptera: Coreidae) on Douglas-fir seed production. *J Econ Entomol* 93:1444–1451.

Until the recent past the seed-per-cone-weight ratio had been nearly constant 16-18%. But in the crop in winter 2010/11, for the first time some cone lots of the series rendered less than 10% of “externally sound”, filled seeds (*i.e.* kernels might have been sound, or only partially damaged *type II*). Since the following crop, no seed lot have reached 15% any more, though in 2013/14 the seed output recovered to a average of 13%, after the worst year 2012/13, with only 50 kg of seed in shell output per ton of processed cones (5%), less than the third part of a normal value.

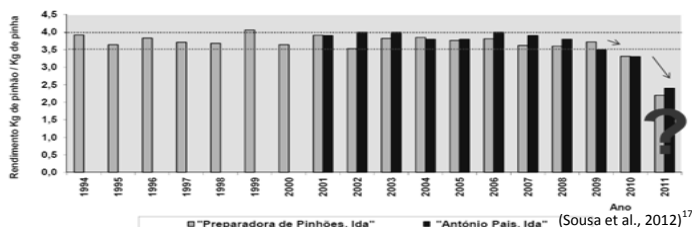


Range and mean seed yield of *Pinus pinea* cones [kg seed in shell/kg cones; n 3-6 data per year, from Castile and Andalusia (Spain)].



Range and mean kernel yield of *Pinus pinea* cones [kg kernel/kg cones; n = 1-6 data per year, from Spain (Castile-Leon, Madrid, Catalonia, Andalusia) and Portugal]

Also in the series for shelled kernel, the ratio of sound (commercial) kernel per cone weight, formerly quite constant 3.5-4%, has dropped parallelly to currently only 1.5-3%. Actually, a first, slight decrease can be observed in the dataset even already since the crop 2008/09, though in the bumper crop 2010/11, the value had recovered to 3-4%, and no real alarm had spread until the year after, when the number of empty seeds increased again, rendering many cones less than 3% sound kernels. Since then, this value has been the upper threshold that has



not been surpassed any more. Two kernel yield series from Portuguese processors published by INIAV¹⁷ present a similar decrease, still pending the updating of these series.

Seed damage typology – diagnostic methods. The assessment of damages in normal-sized stone pine seeds by removing the seed shell for classifying endosperm damages in two categories (empty or partially damaged), results in three damage categories, if aborted fused or dwarfed seeds are included. This categories used by INIA-CIFOR in Spain¹¹ and at University Firenze in Italy⁸ coincides plainly with the types of damaged described to be provoked by feeding of the bug *Leptoglossus occidentalis* on seeds of other conifer species^{6,7,16}. Nevertheless, Mediterranean pine nuts are considerably larger (0.5-0.6 g a pine nut in shell, 0.12-0.15 g a kernel) than in most other species, thus doubts had been expressed if the bug might be really the responsible for complete abortions or complete endosperm collapse in a seed several times its own weight – as a matter of fact, completely empty seeds (*damage type*

¹⁷ SOUSA, E.; FERREIRA, C.; PIMPÃO, M.; NAVES, P.; VALDIVIESSO, T.; VARELA, C. (2012). Sanidade dos povoamentos de pinheiro manso em Portugal. Seminário “Valorização da Fileira da Pinha/Pinhão” Alcácer do Sal, 18th September 2012. http://www.unac.pt/attachments/162_03_EdmundoSousa-INIAV.pdf

l) emptied by *Leptoglossus occidentalis* would be virtually undistinguishable from empty seeds that have been naturally aborted due to other environmental or genetic factors⁶. Several ongoing caging trials that enclose bugs with green, ripening cones in the pine crown during spring and summer will elucidate the effect of feeding on cone and seed development in *Pinus pinea*. On the other hand, the host Laboratory for Forest Zoology at INRA Orleans has been applying x-ray based assessment for these damages types at single-seed scale in stone pine, discriminating damaged seeds (*type I, type II*) with success from sound ones, confirming the plain congruence of results in both methods. Moreover, recent work at this laboratory with reiterated radiographies of the same seed array exposed to *Leptoglossus occidentalis* has confirmed that bug feeding on mature pine nuts do cause partial endosperm consumption (*damages type II*) in stone pine, the same as in other conifers with smaller seeds and thinner shell².

Conclusion.

The reduction and damages in Mediterranean pine nut yields known as *Dry Cone Syndrome* is present in all relevant pine nut producing countries around the Mediterranean. It is a serious threat for commercial pine nut crops from *Pinus pinea*.

The damages observed, conelets abortion as well as seed abortion or only partially filled seeds that reduce the kernel-per-cone-weight yield, are plainly compatible with the kind of damages in other conifer species attributed to the introduced invasive seed-feeding bug *Leptoglossus occidentalis*. The causality of *Leptoglossus* as main biotic agent, however, or possible implications of increasing draughts or phenological shifts due to climatic change, must be elucidated by ongoing work of various research groups, including that of the host Laboratory for Forest Zoology at INRA Orleans and that of the visiting researcher at INIA-CIFOR Madrid led by Dr. R. Calama, as well as Portuguese groups at ISA (U. Lisbon) and INIAV.

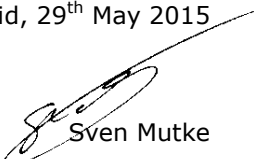
• Future collaboration with host institution

Future collaborative work with INRA Orleans is expected both at the INIA-CIFOR and through the Sustainable Forest Research Institute (Mixed Institute of the University of Valladolid and INIA) with its leading forest entomologist Prof. J. Pajares, as well as with other research centres studying the Dry Cone Syndrome or *Leptoglossus occidentalis*, such as the Portuguese ISA.

Foreseen publications/articles to result from the STSM (if applicable);

This STSM has served for carrying out an advanced draft of a peer reviewed paper regarding yield loss series from several Mediterranean countries. The goal is to submit this paper to a peer reviewed forestry journal like Annals of Forest Science in 2015.

Madrid, 29th May 2015



Sven Mutke

- Confirmation (a signed letter) by the host institution of the successful execution of the STSM



STATION DE ZOOLOGIE FORESTIERE

REPUBLIQUE FRANCAISE

INSTITUT NATIONAL DE LA RECHERCHE AGRONOMIQUE
Centre de Recherches d'Orléans
2163 Avenue de la Pomme de Pin CS 40001 Ardon
F-45075 ORLEANS cedex 2- FRANCE
☎ : +33(0)2.38.41.78.00 - Fax : +33(0)2.38.41.78.79

To the ~~responsible~~ of the COST Action FP1203
"European non-wood forest products (NWFPs) network".

N/Ref :

V/Ref :

Objet :

ORLEANS, 9 May 2015

CERTIFICATE

I, undersigned, Dr. Alain ROQUES, Head of the Orléans Forest Zoology Laboratory with the Institute National de la Recherche Agronomique (INRA), France, certifies that Dr. Sven Mutke, Head of Service for Forest Industries in INIA-CIFOR, stayed in my laboratory from 4 May to 8 May 2015 for a short-term scientific mission (STSM) under the COST Action FP1203 "European non-wood forest products (NWFPs) network".

The aim of the STSM was to discuss the data collected Dr. Mutke about the collapse of seed production in stone pine all over the Mediterranean Basin in order to elucidate the possible agents responsible for this collapse, and especially to discuss the possible role of the invasive bug threatening edible pine seeds all over Europe, *Leptoglossus occidentalis*.

The stay resulted in a proposal of a joint paper dealing with the possible causes of 'Dry cone syndrome' in the Mediterranean to be submitted to *Annals of Forest Science*. Thus, the stay was highly beneficial for the two parts.

The detailed results could be found in the report supplied by the STSM applicant.

Dr. Alain ROQUES
Directeur de Recherches
INRA- Zoologie Forestière
2163 Avenue de la Pomme de Pin
CS 40001 ARDON
45075 ORLEANS Cedex 2
FRANCE
Tel: (33)0238417858
Fax : (33)0238417879
Mail : alain.roques@orleans.inra.fr

A handwritten signature in black ink, appearing to be 'AR', written over a horizontal line.