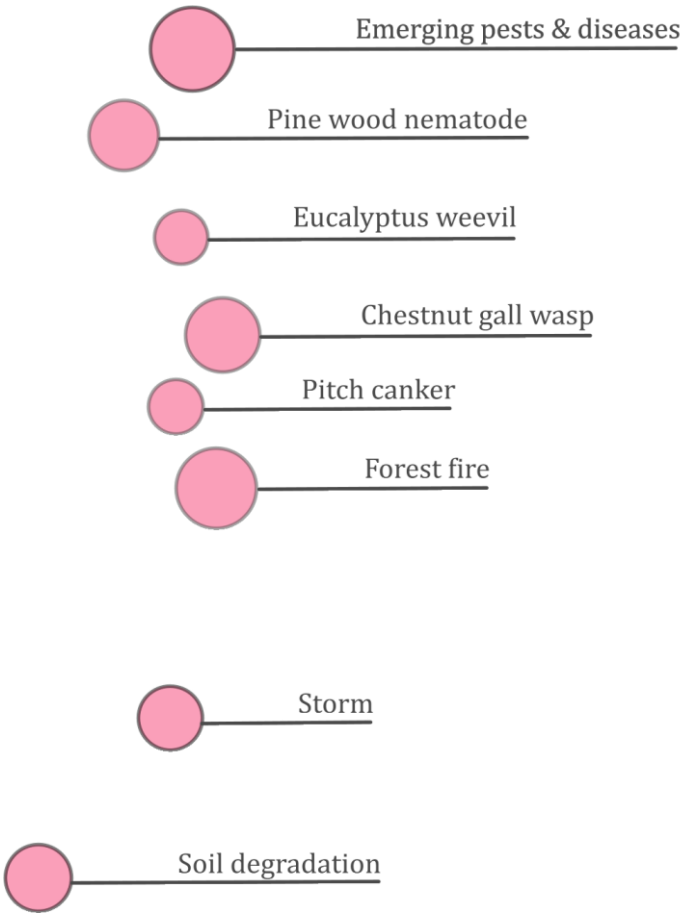
Minutes of the chestnut gall wasp (*Dryocosmus kuriphilus*) workshop

State-of-the art knowledge, prevention, monitoring and control systems



Universidade Trás-os-Montes e Alto Douro
Vila Real, Portugal
19 October 2017

Author of the minutes: Eduard Mauri (EFIATLANTIC)

Reviewer of the minutes: Edmundo Sousa (INIAV)

Workshop organiser: Edmundo Sousa (INIAV)

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PLURIFOR PROJECT
CHESTNUT GALL WASP RISK WORKSHOP:
STATE-OF-THE ART KNOWLEDGE, PREVENTION, MONITORING AND CONTROL SYSTEMS

The **chestnut gall wasp** (*Dryocosmus kuriphilus*) heavily affects the chestnut production in NW Iberian Peninsula; collaborative research efforts and sharing of results between Portugal and Spain will help improve the management of this pest.

This workshop **aims** to provide an overview of the current knowledge on this pest as well as the most recent measures and tools on prevention, monitoring and biological control in Portugal and Spain. It will also explore how to fill the identified gaps to better manage the chestnut gall wasp.

This workshop is open to forest authorities, forest managers and researchers.

THURSDAY 19 OCTOBER 2017	**Organiser**: Edmundo Sousa, INIAV. Tel: (+351) 21 4463712, edmundo.sousa@iniav.pt **Language:** Portuguese & Spanish **Venue:** Universidade Trás-os-Montes e Alto Douro (UTAD), auditório das Ciências Florestais of UTAD, Quinta de Prados, 5001-801, Vila Real

9:30	**Welcome**	
10:00	**Presentation of PLURIFOR WP2 objectives**	**Edmundo Sousa (INIAV)**
10:15	**General knowledge, prevention and monitoring of the chestnut gall wasp** Presentations by different project partners: 10 min each	
	Phenology, life cycles of chestnut varieties	Teresa Valdiviesso (INIAV)
	Productivity of the different varieties of nuts	Abel Rodrigues (INIAV)
	Susceptibility of chestnut varieties to *D. kuriphilus*	Rita Costa (INIAV)
	Chestnut health monitoring by aerial photography obtained by Unnamed Aerial Vehicle	Luis Martins (UTAD)
	Outcome of the survey and how to address identified gaps	Edmundo Sousa (INIAV)
	North and Central DRAP - Evolution of the space and time distribution of the pest in Portugal	*To be confirmed* (DRAP North)
11:30	**Coffee break**	
11:45	**Biological control of the chestnut gall wasp** Presentations by different project partners: 10 min each	
	Evolution of the pest in Galicia (NW Spain), monitoring and experimental biological control (*to be confirmed*)	*To be confirmed* (Xunta de Galicia)
	D. kuriphilus and *Torymus sinensis* in the TRAGSA nursery in Maceda (Orense, Spain): life cycle of the parasite, susceptibility of rootstocks and varieties, natural parasitoids and development of parasite production system in captivity	Beatriz Cuenca Valera (TRAGSA)
	Control methods currently used - biological control	José Laranjo (UTAD)
	Evaluation of the role of autochthonous parasitoids in the control of *D. kuriphilus*	Frederico Preza (INIAV)

PLURIFOR PROJECT
CHESTNUT GALL WASP RISK WORKSHOP:
STATE-OF-THE ART KNOWLEDGE, PREVENTION, MONITORING AND CONTROL SYSTEMS

12:30	**Participative debate**: constraints and needs regarding new tools
13:00	**Lunch at Restaurante Panorâmico – University campus**
14:30	**Field visit**
	Visit of a young chestnut stand, located in Loureiro, Peso da Régua. With an area of about 10 ha and several chestnut varieties (judia, longal and bouche de betizac), the stand has a high degree of *Dryocosmus kuriphilus* infestation.
17:00	**Return to the campus**

Places are limited to 50 people.

Register for the workshop by 6 October 2017.

Chestnut gall wasp WP2 objectives

Chestnut gall wasp risk partners and associated partners

Region	Organisation	Contact person	Associated partners
Portugal	INIAV	Edmundo Sousa	Altri Florestal Instituto da Conservação da Naturesa e das Florestas RAIZ - Instituto de Investigação da Floresta e Papel
Castilla y Leáon	TRAGSATEC	Jorge Casado	Junta de Castilla y León Empresa de Transformación Agraria

Tools and risk management plans to be developed within PLURIFOR project

As decided by the PLURIFOR Technical committee n°2 meeting (25-26 January 2017 at NEIKER, Parque Tecnológico de Bizkaia, Parcela 812, calle Berreaga 1, Derio, Spain), the following tools and risk management plans will be developed by the chestnut gall wasp risk team in WP2:

- Review existing knowledge (survey, eradication, control and contingency) from Europe, in particular from southwestern Europe;
- Evaluate the environmental impact of the introduced parasitoid *Torymus sinensis* on native species;
- Survey native parasitoids parasitizing *Dryocosmus kuriphilus* galls in mixed and pure stands;
- Develop rehabilitation proposals;
- Update the Portuguese national plan and make a first draft for Castilla y León.

Attendees

Attendees

Participants

First name	Last name	Organisation
Alda	Antunes	ICNF-DCNFLVT
Andrea	Ferreira	Município de Oliveira de Azeméis
António	Matos	Município de Sabrosa
António	Rocha	DRAP Norte
António	Silva	Prodtor
Artur	Santos	DRAP Norte
Augusto	Assunção	DRAP Norte
Carlos	Lira	DRAP Norte
Carlos	Ramos	Serviruri Ldª
Diana	Blanco	Univesidade de Santiago de Compostela
Eduard	Mauri	EFIATLANTIC
Edurne	Lacalle	USSE
Fernando	Marques	DRAP Norte
Francisco	Oliveira	DRAP Norte
João	Silva	ICNF-DCNF Alentejo
João	Teixeira	Aflodounorte
João	Silva	Aflodounorte
Joaquim	Alves	DRAP Norte
Joaquim	Moreira	DRAP Norte
Joaquim Fernando	da Ribeiro	Quinta do Pombal - Meireles Moreira Lda
José	Reis	DRAP Norte
José	Mouro Pinto	DRAP Norte
José Carlos	Marques	Câmara Municipal Funchal
José Carlos Magalhães	Campelo	DRAP Norte
Laura	Luquero	Grupo TRAGSA
Leire	Salaberria	USSE
Luís	Bonifacio	INIAV
Luís	Francisco	Município de Montalegre
Luisa	Hipolito	DRAP Norte
Manuel	Machado	Aguiarfloresta

First name	Last name	Organisation
Marco	Sequeira	Município de Sabrosa
Maria Adelaide	Pinto Silva	Câmara Municipal de Resende
Maria Emília	Silva	DRAP Norte
Nadine	Lopes	FCT / UNL
Noémia	Janela	Câmara Municipal de Mirandela
Olga	Borges	DRAP Norte
Oscar	Esteves	DRAP Norte
Paula	Afonso Pinto	ICNF
Pedro	Naves	INIAV
Pedro	Fidalgo	Câmara Municipal de Trancoso
Rafael	Pinheiro	Serviruri
Rui	Guedes	DRAP Norte
Rui	Morêda	Trab. Independente (Eng. Florestal)
Sandra	Pereira	Câmara Municipal de Viseu
Sérgio António	Monteiro Pinto	Câmara Municipal de Resende
Sílvio	Silva	Município de Chaves
Susana	Guerra	Município de Alfândega da Fé
Susana	Jorge	Câmara Municipal de Oliveira de Azeméis
Teotónio	Castro	DRAP Norte

Speakers

First name	Last name	Organisation
Abel	Rodrigues	INIAV
Beatriz	Cuenca Valera	TRAGSA
Edmundo	Sousa	INIAV
Frederico	Preza	INIAV
José	Laranjo	Universidade de Trás-os-Montes e Alto Douro
José Carlos	Costas	Xunta de Galicia
Luís	Martins	Universidade de Trás-os-Montes e Alto Douro
Maria Amália	Xavier	DRAP Norte
Rita	Lourenço Costa	INIAV
Teresa	Valdeviesso	INIAV

Organisers

First name	Last name	Organisation
Edmundo	Sousa	INIAV

Apologies

First name	Last name	Organisation
Alexandra	Nogueira	Município de Arcos de Valdevez
Luís	Macedo	Município de Arcos de Valdevez

Absent

First name	Last name	Organisation
Ana	Vieira	Município de Allijó
Angela	Fraga	Câmara Municipal de Penacova
António	Barros	DRAP Norte
Artur	Santos	DRAP Norte
Aurora	Pereira	DRAP Norte
Carla	Antunes	Câmara Municipal Tondela
Cosme	Neves	DRAP Norte
Davide	Gaião	IPV - ESAV
Dina	Ribeiro	Instituto da Conservação da Natureza e das Florestas
Duarte	Figueiredo	ICNF
Francisco	Cardoso	Câmara Municipal de Santa Marta de Penaguião
Helena	Marques	ICNF
Hugo	Teixeira	Municipio de Gouveia
João	Ribeiro	DRAP Norte
José	Fernandes	DRAP Norte
José	Rebelo	Município de Alijó
José Manuel Moreira	Matias	DRAP Norte
Lino	Sampaio	MORAIS, Lda
Manuel	Pereira	EPA Carvalhais/Mirandela
Manuela	Branco	Instituto Superior Agronomia
Marco	Teixeira	Câmara Municipal de Santa Marta de Penaguião
Margarida	Mota	Hubel Verde SA
Maria	Portas	DRAP Norte - DNT
Mercedes	La Nefer	Universidad de Valladolid
Nuno	Neves	DRAP Centro
Nuno	Santos	-
Olga	Borges	DRAP Norte
Olga	González Raposo	ASFOSA

First name	Last name	Organisation
Pedro	Amaral	Município de Mangualde
Rosa	Prata	DRAPLVT
Rui	Morêda	Private
Sandra	Dinis	RIBAFLOR - Associação Florestal das Terras de Ribadouro
Sónia	Lopes	ICNF/DCNF Centro
Vitório	Martins	ICNF
Xavier	Rui	URZE

Because of the intense forest fire episode that Portugal lived in mid-October 2017, many forest professionals could not attend the workshop.

Presentation of the knowledge, prevention, monitoring and control systems

General knowledge, prevention and monitoring of the chestnut gall wasp

Goal

Inform the attendees about the latest knowledge about the chestnut gall wasp, and the prevention and monitoring about this pest.

Introduction

Edmundo Sousa, INIAV

Chestnut gall wasp (*Dryocosmus kuriphilus*) is considered throughout the world as one of the most important pests of the chestnut tree. It is a Hymenopteran of the family Cynipidae. Most Cynipidae species form galls. The most well-known species colonize the oaks, with more than 1,000 species in the world (more than 100 in Europe). The formation of galls affects the growth of the branches and reduces the fruiting.

The species is native from Chine. I was first detected outside China in 1941 in Japan, then in 1958 in Korea, in 1974 in USA, in 1999 in Nepal and then in Europe: Italy (2002), France and Slovenia (2005), Switzerland and Hungary (2009), Croatia (2010), Czech Republic and Spain (2012), Germany (2013) and Portugal (2014). The spread is due to the circulation of plants or parts of infested plants containing eggs or larvae. The fruits are not a pathway of dispersion of the insect. The circulation of woody material and wooden packaging is also not a form of dispersion. The pest is currently in the A2 List of the European and Mediterranean Plant Protection Organization (EPPO) as a quarantine agent.

Phenology, life cycles of chestnut varieties

Teresa Valdiviesso, INIAV

It is necessary to know the phenology of the chestnut (*Castanea sativa*), the host plant, to know the best moment to do the treatment against *Dryocosmus kuriphilus*. The phenology of the chestnut depends on its genetics and on environmental factors (temperature, precipitation, soil, etc.).

Efforts have been done by the INIAV to characterize the phenology of the different varieties of chestnut. Different chestnut varieties growing in the same zone can show differences in phenology of up to nearly two months. Chestnut varieties have been compared and the studies concluded that hybridization between varieties exists, even if chestnut flowers are unisexual and male flowers sprout before female flowers. Leave sprouting takes place at the same time than flower sprouting,

approximately. It is important to connect this phenology information with the biological cycle of the insect.

D. kuriphilus females lay their eggs into the resting buds in June and July. At that time, buds have not started their differentiation between leave buds or flower buds yet. The differentiation will take place the following year. Therefore, galls can appear on leaves and on flowers. If eggs are laid in reproductive buds (or flower buds) they will interfere in the chestnut production of the following year. Consequently, current galls come from previous year laying. Galls formation start in autumn, they develop in winter, and mature in spring. The entire gall is fed by the plant.

Portuguese chestnut varieties form their new buds in June and July, when *D. kuriphilus* females lay their eggs, therefore being more sensitive to this pest. Hybrid varieties form their new buds in May and June, and French varieties do it later, July and August, and for these reasons these varieties are less sensitive to the pest: bud formation of early varieties is too premature to be attacked by *D. kuriphilus* females. Late varieties show high synchronization with the biological cycle of the wasp. As a result, they are more vulnerable to this pest.

Productivity of the different varieties of chestnuts in Portugal

Abel Rodrigues, INIAV

In Portugal, chestnut tree stands for chestnut production cover 34,600 ha and produce 44,000 tons of chestnuts yearly. There are 16,500 chestnut producers and land ownership is very fragmented. In Portugal, 86% of the chestnut tree stands are located between 500 and 1,000 metres above the sea level, where the most appropriate conditions for chestnuts are found. Agroforestry system is the most common structure for chestnut stands, with 70 to 100 trees/ha. Production starts when the trees are 6 years old, producing between 1 and 3 kg of chestnuts/tree/year. At the age of 10 the maximum production is reached, with 30 to 50 kg of chestnuts/tree/year, slowly decreasing afterwards. The Portuguese mean production is 17.3 kg of chestnuts/tree/year, but the most productive varieties easily reach more than 20 kg of chestnuts/tree/year. Granitic soils feature twice productivity than shale soils. Cultural treatments, such as natural grazing, seeded pasture grazing, biomass mobilization and irrigation influence productivity. Chestnut production per tree increases when tree density decreases: halving the tree density can triple the production per tree (or multiply by 1.5 the production per ha).

From 2006 to 2010 chestnut productivity has decreased. The objective for producers would be to increase productivity to 3 tons/ha/year for the 10 following years in the new plantations.

The value of the fruit is mainly driven by its size. The size is given by the number of chestnuts contained in a kilogram. Therefore, lower size values (bigger chestnuts) represent higher values. The mean Portuguese chestnut size is 86 chestnuts/kg (or 11.6 grams per chestnut). The major Portuguese chestnut varieties are Martaínha, Longal, Judia and Boa Ventura.

Chestnut production is concentrated in north-east Portugal, where the three of the four major protected designations of origin are found. More experimental plots are needed in these areas for the definition of multidisciplinary deadlines and objectives for the whole chestnut life cycle, to evaluate the chestnut productivity and the added value of the treatments, and to coordinate public and private institutions for the achievement of these objectives.

Susceptibility of chestnut varieties to *Dryocosmus kuriphilus*

Rita Lourenço Costa, INIAV

The main threats of chestnut trees are the chestnut blight (*Cryphonectria parasitica*), the ink disease (*Phytophthora cinnamomi*) and the chestnut gall wasp (*Dryocosmus kuriphilus*). Italian knowledge about *D. kuriphilus* (the first country in Europe where it appeared) is being used in Portugal to manage this pest. The main varieties of chestnut in Portugal are Longal, Judia and Martaínha. There are three silvicultural regimes: *souto* (chestnut trees plantation for fruit production), coppice and high forest (for timber production).

Chestnut genetic diversity is higher in northern Portugal than in the south. There has been, and there is still, a lot of vegetal material exchange within the Iberian Peninsula between chestnut producers. Therefore, there is a lot of genetic diversity within this species in Portugal and Spain, a diversity that does not exist in the rest of the European countries. Even within a given variety there is a lot of genetic diversity. In a *souto* the producer can even plant several tree varieties that cross-pollinate and produce hybrid fruits. This would influence tree phenology of the future generations, which can be labelled as a variety but are, in fact, a hybrid.

In 2003, the Portuguese Directorate General of Agriculture delimitated six provenance regions to protect the genetic heritage of the species. Later, the four Portuguese protected designations of origin of chestnuts were created to highlight and certify the Portuguese varieties.

Chestnut susceptibility to chestnut gall wasp is measured as the number of galls per bud. After an evaluation of 62 varieties that lasted eight years, different varieties showed different susceptibility. Two of the seven resistant varieties come from Italy. Judia variety is classed “low susceptibility”, and Longal “medium susceptibility”.

Chestnut health monitoring by aerial photography obtained by Unmanned Aerial Vehicle

Luís Martins, Universidade de Trás-os-Montes e Alto Douro

Chestnut tree plantations are nowadays one of the most profitable crops. Abiotic factors causing chestnut productivity decrease are soil compaction, deep soil tillage, lack of magnesium in young trees, hydric stress and climate change. Chestnut gall wasp is the newest pest and has a very fast spread. Other biotic agents are the chestnut blight (*Cryphonectria parasitica*) and the ink disease (*Phytophthora cinnamomi*).

Aerial campaigns were done in 1985, 1995 and 2006 in Padrela protected designation of origin to evaluate chestnut trees health. Higher rate spread of chestnut decline is observed in 2006, particularly in areas with the same altitude and smooth slope, where the soil tillage is more frequent. Reasons of the increased decline are: chestnut blight incidence, management practices and climate factors.

The methodology developed by the Universidade de Trás-os-Montes e Alto Douro to detect mortality spots in chestnut stands using aerial photos taken from an airplane is nowadays adapted to use an UAV (or drone) equipped with a near infrared (NIR) sensor. The flight is done at 350 m above the

ground and the image has a resolution of 15 cm/pixel. The result is an automated map of chestnut level of damage prediction. This remote sensing technique only detects mortality: to know the cause of it a field survey must be performed.

There are advantages on using UAV for the study purposes:

- Due to the low flying heights, resulting high resolution imagery, and lower image acquisition costs, compared to piloted aircraft or satellite images;
- UAV cover wide areas, and are virtually undetectable (flights 300 m, up ground), so animals won't be disturbed;
- The electric UAVs, do not have polluted emissions, resulting no negative impacts to the environment.

During the last years, mortality due to *D. kuriphilus* is decreasing, but the area of chestnut plantations is increasing, so globally the affected area by this pest remains more or less constant.

Outcome of the WP1 survey and how to address identified gaps

Edmundo Sousa, INIAV

Four interviews were done, three in Portugal (DRAP Norte, DGAV and REFCAST) and one in Spain (Centro de Sanidad Forestal de Calabazanos – Consejería de Fomento y Medio Ambiente de Castilla y León). According to the results:

Strengths against chestnut gall wasp:

- In Spain, concerning surveillance and monitoring:
    - Continuous, rigorous and intensive monitoring;
    - Inspection of stands and nurseries;
    - Delimitation of infected areas.
- In Spain, concerning eradication and control:
    - Destruction of affected plants in nurseries and garden centres;
    - Under analysis, a study about the release of parasitoid *Torymus sinensis*.
- In Portugal, concerning surveillance and monitoring:
    - Continuous, rigorous and intensive monitoring;
    - Inspection of stands and nurseries;
    - Uniform methodology;
    - Identification of risk areas;
    - Sensitization and training of technicians;
    - Efficient alert network during periods of high risk;
    - Delimitation of infected areas.
- In Portugal, concerning eradication and control:
    - Destruction of galls in stands and plants in nurseries and garden centres;
    - Characterization of infested areas;
    - Releases of the parasitoid *Torymus sinensis* paid by the municipalities;
    - Support for nurseries and garden centres.

Weaknesses against chestnut gall wasp:

- In Spain, lack of legislation for actions to be taken against this pest.
- In Portugal, concerning surveillance and monitoring:
    - Little dissemination of information in major communication channels;
    - Difficult control of plant origin in new plantations;
    - Absence of devices that allow phytosanitary inspectors to update the database in real time;
    - The communication of new outbreaks is not completely efficient.
- In Portugal, concerning eradication and control:
    - Lack of knowledge of the best time for release the parasitoid;
    - Improve municipal decision making and financing capacities for parasitoid releases;
    - Low funding for pest management (non-eligible expenditure in the EU) and for research.

Possible improvements or new tools:

- Review existing knowledge (prospecting, eradication, control and contingency) in south-eastern Europe;
- Evaluate the environmental impact of the introduced parasitoid *Torymus sinensis* in the native entomolfauna;
- Evaluate native parasitoids that may parasite D. kuriphilus galls;
- Develop rehabilitation proposals;
- Assist in the updating of Portugal's national plan and make a first draft for the region of Castilla y León.

North and Central DRAP - Evolution of the space and time distribution of the pest in Portugal

Amália Xavier, DRAP Norte

The first focus of *D. kuriphilus* was detected on June 2014 in north-west of Portugal. The pest arrived through the introduction of infested material with dormant eggs in buds laid in 2013. In December 2014, galls were already present in 56 municipalities in northern Portugal. In March 2015, galls were present in 138 municipalities and that year marked the first introduction in the Trás-os-Montes province. Teams were organised in Trás-os-Montes to cut all the galls and delay the spread of the pest into the protected designations of origin of chestnuts in this province.

In October 2016, the galls were present in of 250 municipalities. In October 2017, in 494 municipalities (data only from Norte region, municipalities are also affected in Centro region). The first phase of the spread was towards de east, and then towards the south, into the Centro region. The spread is being exponential. Consequently, the releases of *Torymus sinensis*, an exotic egg parasitoid, have also largely increased, with 35 releases in 2015, 62 in 2016 and 125 in 2017.

Biological control of the chestnut gall wasp

Goal

Inform the attendees about the latest knowledge about the control of the chestnut gall wasp pest.

Evolution of the pest in Galicia (NW Spain), monitoring and experimental biological control

José Carlos Costas, Xunta de Galicia

D. kuriphilus pest started in Galicia in 2014, in the centre of Lugo and Ourense provinces from infested material imported from Italy. From there, the pest spread in concentric waves.

In Galicia, the releases of *Torymus sinensis*, an exotic egg parasitoid, are done in stands where the chestnut trees have more than 100 galls per tree, to favour the establishment of the parasitoid. In 2017, *D. kuriphilus* was already present in the four Galician provinces and 4,100 release requests were directed to the regional government. These points for potential releases, distributed along a 4 km x 4 km grid, are visited every week to evaluate the correct moment for the release of the parasitoid, that is when leaves measure between 2 and 5 cm long and the galls are green and small. The whole operation is coordinated and performed by SEAGA, a Galician public company for the management of natural resources and natural areas. There are no *T. sinensis* rearing facilities in Spain. SEAGA imports the parasitoid from Portugal, needing an extra coordination caused by the importation process.

T. sinensis releases are done between the weeks 15 and 19. The peak of releases is during the last week of April. In 2017, 4,200 phials were released, each phial containing between 30 and 32 individuals. Each year, between 1,000 and 1,300 galls are collected to evaluate the success of the parasitism. These samples are taken from a 4 km x 4 km grid points, on the sample points and around them if chestnut trees are present.

Dryocosmus kuriphilus and *Torymus sinensis* in the TRAGSA nursery

Beatriz Cuenca Valera, TRAGSA

D. kuriphilus was first detected in 2015 in the tree nursery that TRAGSA has in Ourense province (Galicia, Spain). The main problem for tree nurseries is that, because chestnut trees are sold when they are one year old (overwintered) and before sprouting, infested trees are not detected: eggs have been laid the previous autumn and at the beginning of the following spring, before the growing season, the galls have no started their development yet. Therefore, galls appear when the trees have already been planted in the forest.

To test the success of parasitism on *D. kuriphilus* by *T. sinensis*, some chestnuts lots were infested with *D. kuriphilus* and cultivated in mesh cages to keep the chestnut gall wasp inside but let its parasitoid pass through. It was noticed that the appearance of the galls moved forward more than one week. Under these growing conditions, the plants cannot be taken out of the cage until August and they have to be hardened before being commercialized. It has been noticed that *D. kuriphilus*

does not penetrate into a plant lot if the plant density is high enough because this makes *D. kuriphilus* flight more difficult. In this test, the less infested lots contained up to 320 plants/m².

Another test was conducted to search for local parasitoids that could control *D. kuriphilus*. Fifty chestnut galls per tree were collected in March from 24 trees in six locations. They matured in the laboratory. Nine local non-specific parasitoids emerged; all of them were parasitoids of insects causing galls on *Quercus robur* and not specific of the chestnut. Four species delayed their emergence: some individuals emerged in summer and some others the following spring. Summer emergence is too late to control *D. kuriphilus*. The percentage of parasitism was low: spring emerging parasitoids caused a parasitism rate of only 0.52%, adding the four species together, because the parasitoid species that have biological life cycles with enough "useful" days to parasite *D. kuriphilus* have low success of parasitism, while those with high success of parasitism have biological life cycles with few "useful" days to parasite.

Finally, a susceptibility test of chestnut tree varieties showed that the less susceptible varieties are the hybrid ones. The three most cultivated varieties in Galicia, however, are among the most susceptible. On the one hand, among the traditional varieties, the less susceptible are: Negral, Longal and Judia. On the other hand, among the traditional varieties, the more susceptible are: Ventura and Amarelante. However, there is a lot of intra-variety variability.

Currently, TRAGSA imports the *T. sinensis* from Italy. An alternative could be to harvest chestnut galls in the forest and use the emerging parasitoids for new releases where needed. However, this is not an appropriate option as it is preferable that *T. sinensis* individuals remain in the forest to establish and increase its natural populations. TRAGSA is currently testing *T. sinensis* rearing in Galicia under controlled conditions to avoid depending on imports.

Control methods currently used as biological control

José Laranjo, Universidade de Trás-os-Montes e Alto Douro

Three families of control methods exist for pests: cultural control, chemical control and biological control.

Cultural control of *D. kuriphilus* consists in collecting the galls and pruning the branches with galls. This has to be done before the emergence of the adults. Planting resistant or tolerant chestnut varieties is another method.

Chemical control is difficult to be applied against *D. kuriphilus* as the insect spends about 350 days of the year inside de gall, where it is not reached by the pesticides. Adults only live between 10 and 12 days outside of the galls. However, in Italy, chemical control is considered the most efficient method of control and is being used in that country since 2010 (the chestnut gall wasp was introduced in Italy in 2002).

Biological control is considered one of the most efficient methods to reduce the impacts of the chestnut gall wasp. Portuguese forest managers took advantage of the Italian experience with the release of the parasitoid, that started in 2005. Currently, in Portugal, the chestnut gall wasp spreads about 6.6 km per year.

The final objective of the biological control is that the parasitoid eventually establishes itself in the forest to avoid annual releases and keeping *D. kuriphilus* at tolerated level. It can take up to two years before the effects of the *T. sinensis* releases are noticeable, but releases have to be done annually. The natural spread of the parasitoid is slower than the one of the pest: during the first five years it reached 25 km (5 km per year), but should increase exponentially as soon as the populations are suitably established. The initial dispersion is very slow, but it accelerates some years later. For this reason it is necessary to keep up with the release efforts. For example, in Italy, releases were done in 2005, 2006 and 2007, but the first parasitism was first detected in 2007, and only at a rate of 0.04%. The rate increased to 0.86% in 2008 and to 29.35% in 2009.

In Portugal, releases started in 2015, after a national action plan was approved the previous year. A standard release consists in 10 phials with *T. sinensis* per group of three or four severely infested chestnut trees. The release protocol, called BioVespa, was designed and coordinated with 66 municipalities. Regional and national coordination is essential to ensure the success. Long-term annual monitoring efforts are also important to measure the efficiency of the biological control measures. Thirty-five releases were done in 2015, 104 in 2016 and 306 in 2017; accompanied by the detection of new foci of the pest and by gall collection to evaluate the parasitism rate.

In the action plan, the Commissions for municipal support decide about the increase of the infested area and the increase of the releases, and coordinate the purchase order of parasitoids in order to respond on time for the releases. Each week, until Friday, the places with conditions for the start of the releases are communicated to RefCast. RefCast informs the rearing facilities of the number of releases to be dispatched the following week. On Monday, the rearing facilities post the phials by air, being received on Monday afternoon at the DRAP delegation. The parasite is transported in refrigerated boxes, in bags containing 10 tubes each. In each tube are about 12 females and 7 males. The releases are made by the technicians of the Commissions for municipal support, by RefCast or other trained technicians. All releases places are georeferenced. The 2014 action plan has been updated in October 2017 with measures including: control, prevention, fight, good practices, needed research and awareness.

Evaluation of the role of autochthonous parasitoids in the control of *Dryocosmus kuriphilus*

Frederico Preza, INIAV

Local parasitoids have low parasitism rates on *D. kuriphilus*. Moreover, their parasitism rates are very variable, depending on their provenance. Parasitism rate for a given location is measured from 150 galls collected at the end of the spring. Fifty of them are dissected to count the number of *D. kuriphilus* larvae with parasites and the other 100 are stored and the emerging insects are collected. Parasitism rates are very variable, from 1% to 28%. Without releases of *T. sinensis*, parasitism rates are higher in locations where *D. kuriphilus* arrived earlier.

Eight autochthonous parasitoids exist in Portugal; *Sycophila* sp. is the more abundant, representing more than half of the captured individuals. Of the most representative species of this study, *Ormyrus* sp. was the one that presented greater regularity of emergence along the sampling period; *E. annulatus*, *Megastigmus* sp. and *Sycophila* sp. presented peaks of emergence in the second week of July. Some Portuguese areas host up to seven local parasitoids of *D. kuriphilus*, while other have only

two. Further research is needed to explore the potential of appropriate combinations of local parasitoids with *T. sinensis* to foster biological control of the chestnut gall wasp.

Participative debate

Discussion

The most relevant questions or comments from the attendees were:

- Unidentified: forest managers have to provide forest owners with measures that they would accept to apply, and avoid measures that the forest owners would not apply because they find them too complicate or because they do not understand them. E. Sousa replied that this is the reason why best practices guidelines will be publish as a PLURIFOR WP2 output.
- An unidentified person complains that forest technicians are not well informed and that they do not have the required knowledge.
- An unidentified person says that chestnut production model has to be updated and modernized.
- An unidentified person says that subsidizing agricultural practices does not solve the problem. According to him, irrigation of the chestnut tree plantations increases the productivity and compensates the losses caused by the chestnut gall wasp.

The most relevant answers from the speakers were:

- R. Costa: for chestnut producers, it is essential to buy vegetal material adapted to the conditions where it will be planted, from reliable sources and with a warranty that it is not infested.
- E. Sousa: wind is the main dispersion agent of the chestnut gall wasp within a region. Then, the parasitoid follows the spread of the wasp.
- J. Laranjo: it is possible to combine biological control measures with chemical control measures. However, pesticides have to be applied at the right moment to affect the chestnut gall wasp and avoid harming the parasitoid and the bees.

Field trip

General plan

Where	Who	What
Municipality of Loureiro, Peso da Régua, Trás-os-Montes e Alto Douro region	Tour guided by J. Laranjo and the land owner	Chestnut *souto* (plantation for fruit production)

Visit

The lot was formerly a vineyard transformed into a chestnut *souto* 14 year ago. The young chestnut plantation covers an area of about 10 ha and is located under limiting conditions, at 750 m of altitude. It has several chestnut varieties (Judia, Longal and Bouche de Betizac).

Health problems

The *souto* is currently under a server infestation of *Dryocosmus kuriphilus*. However, in this area the ink disease (*Phytophthora* spp.) is a more important threat that the chestnut gall wasp because the Trás-os-Montes e Alto Douro region is protected by the release of the parasitoid, *Torymus sinensis*, started two years ago in the north, that prevents the arrival of big quantities of *D. kuriphilus*. In this *souto*, the problems caused by *D. kuriphilus* can be mainly solved with chemical treatment by the end of August, as its emergence from the galls in the area is done by the 22nd of August. However, two releases of the parasitoid have been performed in 2015 and 2016. In order to reduce the virulence of the ink disease it is suggested to avoid any soil movement, as ploughing and tillage.

The galls on the leaves make them dry and prevent them from falling. Dry galls, in autumn, must never be cut because they host the larvae of the parasitoid. It is important to leave them on the trees to allow the *T. sinensis* to complete its life cycle. In autumn, the chestnut gall wasp larvae are already in the buds that will develop a gall the following spring. If we want to reduce the amount of *D. kuriphilus* by cutting the galls, those that must be cut are the green ones. They must be burnt to ensure that the *D. kuriphilus* adults do not emerge.

In case of having planted infested plants from a tree nursery, the best strategy is to coppice them and use the new shoot.

Productivity issues

This *souto* is annually weeded and fertilized with nitrogen in June. There is no irrigation. Its average annual productivity of national chestnut varieties is between 1 and 1.2 tons/ha.

In order to increase productivity, plantations can be irrigated. Well drilling and equipment costs between 4,000 and 5,000 euros. Drip irrigation equipment costs between 700 and 1,000 euros/ha.

Irrigation season in this area goes from end of July to beginning of September. Irrigation allows reaching bigger chestnut sizes.

The main chestnut commercialization problem in the Trás-os-Montes e Alto Douro region is the small size of the fruits. Smaller chestnuts are not harvested, thus reducing the production. A *souto* is profitable when chestnuts are paid at least 50 cents/kg to the producer. The market is very fluctuating. However, in a correctly managed *souto* with big sized chestnuts the price would never be lower than 1 euro/kg, and under these conditions the average productivity is 30 to 40 kg/tree. At 150 trees/ha, with this productivity the producer can expect an annual harvest of 6 tons of chestnuts/ha.

General workshop evaluation questionnaire

Questions

Workshop content

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
1.	I was well informed about the objectives of this workshop and they were clear to me.			9	5		
2.	This workshop fulfilled my expectations.		1	6	7		
3.	The content is relevant to my job tasks concerning forest risks management.			5	9		
4.	The quality and depth of knowledge of this workshop were appropriate and represented state-of-the-art tools/technologies.			8	6		

Workshop design

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
5.	The workshop activities/case studies stimulated my learning.			5	9		
6.	The activities/case studies in this workshop gave me sufficient practice and feedback.		1	5	6		2
7.	It was easy for me to understand the messages of the professionals/lecturers, they were good communicators.		1	6	7		
8.	The pace of this workshop was appropriate.	1	3	4	6		

Workshop instructor/facilitator/lecturer

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
9.	The instructor/facilitator/lecturer was well prepared.			2	12		
10.	The instructor/facilitator/lecturer was helpful.		1	5	8		

Workshop results

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
11.	I accomplished the objectives of this workshop.		1	8	5		
12.	I would be able to use the tools that I learned in this workshop on my tasks concerning forest risks management.		1	8	5		
13.	The exchanges with other professionals/instructors/lecturers were fruitful and will be useful for accomplishing my tasks concerning forest risks management.		1	7	6		

Self-paced delivery

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
14.	The workshop was a good way for me to learn its content.		1	5	6		

Field trip

		Strongly disagree	Partially disagree	Partially agree	Strongly agree	Not applicable	No opinion
15.	The field trip was appropriate for the content of the workshop.				1	11	2
16.	The exchanges with the professionals during the field trip were relevant and helped me to understand the issues about this forest risk management.				1	11	2

Improvements and values

How would you improve this workshop? (Check all that apply)

_3_Provide better information before the workshop.
_2_Clarify the workshop objectives.
___Reduce the content covered in the workshop.
___Increase the content covered in the workshop.
_1_Update the content covered in the workshop.
___Improve the instructional methods.
_1_Make workshop activities more stimulating.
_4_Improve workshop organization.
___Make the workshop less difficult.
_1_Make the workshop more difficult.
___Slow down the pace of the workshop.
___Speed up the pace of the workshop.
___Allot more time for the workshop.
___Shorten the time for the workshop.
___Improve the tests used in the workshop.
___Add (more) video to the workshop.

What other improvements would you recommend in this workshop? *The order of the answers is not relevant.*

Provide printed documents to complete the information showed on the slides.
Two Spanish participants complained that most of the workshop has been only in Portuguese, so it was difficult to follow and understand some speakers, and these participants could not take full advantage of the workshop.

What is least valuable about this workshop? *The order of the answers is not relevant.*

The participative debate.

What is most valuable about this workshop? *The order of the answers is not relevant.*

Have access to the updated scientific and technical information about the pest.
Have access to information about this pest from different points of view.