

***Dryocosmus kuriphilus* Yasumatsu: An outline seven years after the first report in Piedmont (Italy)**

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Abstract

In 2002, for the first time in Europe, the oriental chestnut gall wasp (CGW), *D. kuriphilus*, was reported spreading in a large chestnut area in the south of Piedmont (Northwest Italy). Movement of infested plants from nurseries of this area have allowed the pest to progressively reach many other regions in Italy. CGW infestation has contributed, together with other factors such as drought and fungal diseases, to a significant reduction in chestnut fruits production. To date, however, the death of chestnut trees due to CGW attack has not been observed. Chemical treatments have proved ineffective in preventing the diffusion of this pest. Indigenous parasitoids, shifting from oak cynipids, show a low rate of parasitism on CGW. Since the first years of the CGW outbreak, the Plant Health Service of Regione Piemonte has been trying to respond to the emergency by monitoring chestnut areas, surveying nurseries, funding research projects for biological control and evaluation of cultivar susceptibility.

Introduction

In 2002, for the first time in Europe, the oriental chestnut gall wasp *Dryocosmus kuriphilus* Yasumatsu (Hymenoptera: Cynipidae) was recorded in the Piedmont region of Italy, near the city of Cuneo (Brussino *et al.*, 2002). The introduction of this insect, one of the most dangerous pests attacking chestnut trees, is very worrisome for chestnut farmers. In the past the spread of other exotic pests, such as the fungi *Cryphonectria parasitica* (Murr.), responsible for the "chestnut blight", and *Phytophthora cambivora* (Petri), responsible for the "ink disease," had already caused serious damage to chestnut orchards. In the twentieth century these pests, combined with industrialization, emigration from rural areas and the economic decline of mountainous and hilly areas, resulted in a steep decrease in chestnut fruit production and the end of chestnut cultivation in many sites. In recent years, many activities have been developed in various Italian regions to recover from this situation and to improve chestnut orchards, profiting by a period of reduced virulence of "chestnut blight". Nevertheless as has already happened with others parasites, the chestnut gall wasp has been progressively spreading to other areas, thus putting at risk the economic recovery of chestnut cultivation.

Distribution

The oriental chestnut gall wasp is indigenous to China. In 1941 it was reported in Japan, where in the following years it caused serious damages to chestnut orchards. In 1958 it was observed in Korea, while in 1974 it was found for the first time in Georgia (United States), where within 10 years it gravely affected local chestnut orchards, which were based on Chinese and Japanese chestnut varieties (Aebi *et al.*, 2006). More recently, in a survey conducted in 1999, *D. kuriphilus* was detected in the north of Nepal (Ueno, 2006).

In Europe, besides Italy, the oriental chestnut gall wasp was reported in France in 2005, in an orchard of Saint-Dalmas Valdéblore (a municipality in the region of Provence-Alpes-Côte d'Azur) made up of young plants from Cuneo province. Other infestation hotspots were observed in 2007 in four municipal districts of Roya Valley (Tende, La Brigue, Fontan and Saorge) (EPPO RS, 2007). The spread in this area is probably due to the traffic through Tenda tunnel. Also in 2005, the gall wasp was found in Slovenia, after importation of young infested plants from Piedmont (EPPO RS, 2006). After attempts at eradication, researchers confirmed the continued presence of *D. kuriphilus* in 2007. In spring 2009 the gall wasp was detected in Switzerland, in chestnut areas in Canton Ticino (data available from <http://www.ti.ch/DT>).

Diffusion in Piedmont and in other Italian regions

In May 2002 shoots with strange galls, collected in chestnut orchards in the municipal districts of Boves and Peveragno, situated at the feet of the Alps in Cuneo province, were sent to the Plant Health Service of Regione Piemonte in Torino. They were identified as *D. kuriphilus* galls (Brussino *et al.*, 2002). As in that year the pest had already spread to many chestnut areas of five municipal districts south of Cuneo city (Boves, Peveragno, Chiusa Pesio, Roccavione, Robilante), it was probably introduced some years earlier through imports of infested twigs or shoots. By that time pest eradication was impossible to achieve being the gall wasp well established on thousands of chestnut trees. *D. kuriphilus* spread has been monitored every year since 2003 by extension services technicians under the coordination of the Plant Health Service, with the help of reports coming from chestnut growers, forest and park warders, and officials of provincial and mountain communities agricultural departments. Due to the large diffusion in Piedmont of chestnuts as forest trees (woods) or fruit trees (orchards) in the vegetative belt between 400 and 900 m a.s.l., in the first years the gall wasp's local spread was mainly supported by the females' natural flight, while in the following years transportation by cars and trucks contributed to medium or long distance diffusion such as the movement of young infested plants. New hotspots were in fact detected on chestnuts growing near a picnic area and a sanctuary, crowded with people in summer, far from old infestation points. Since 2005 new infestation areas have been marked using a global positioning system (GPS). Official records of diffusion of the pest show that it was confined to Cuneo province until 2006. In 2007 *D. kuriphilus* was found in a hilly area around Lake Orta, in northern Piedmont, and in a municipal district of Torino province (Almese) as well as in a few locations in the south of Asti (Vesime, Roccaverano, Bubbio, Rocchetta Palafea) and Alessandria (Spigno) provinces. In

2008 new infestation points were detected in the provinces of Biella (Cavaglià, Ronco Biellese, Valdengo), Vercelli (Borgo d'Ale), Torino (San Giorio, Cavour, Torre Pellice, Mazzè, Cuceglio), Asti (San Damiano, Loazzolo, Cessole, Monastero Bormida, S. Giorgio Scarampi, Serole) and Alessandria (Bistagno, Terzo). In 2009 the Plant Health Service received many complaints about the oriental chestnut gall wasp, which indicates that by now it's widespread in all of Piedmont. This is confirmed by different surveys that show how the infestation has encompassed, besides the whole Cuneo province, almost all the alpine valleys from Torino province to Novara province, sometimes with a high gall infestation rate, as around Lake Orta, but most often with a very low number of galls, which indicates that the cynipid has just arrived in those areas. In southeastern Piedmont the pest has been found in the chestnut areas around the town of Ovada (Alessandria province) (Fig. 1).

Since 2005 *D. kuriphilus* has been detected in other Italian regions (Graziosi and Santi, 2008). In 2008 the Central Plant Health Service led, in collaboration with regional offices, a national survey to analyze the spread of the pest around the country. In Lazio region the pest was found in 2005 in a chestnut area near the municipality of Canepina, and subsequently it gradually expanded its range to many other municipalities in Viterbo and Roma provinces. In Campania the cynipid appeared for the first time in 2005 in the Picentini Mountains near Serino (Avellino province). Now it's also present in Salerno and Caserta provinces. In Lombardia *D. kuriphilus* was recorded for the first time in 2006; currently it's spreading in Bergamo (Albino), Brescia (Esine, Bagolino) and Varese (Ternate, Venegono Superiore) provinces. In the same years the pest was found in Liguria, in a large area bordering Cuneo province (Imperia and Savona provinces). In 2008 the distribution included a few municipalities of La Spezia province on the borderline with Toscana region. The first record of a gall wasp's appearance in Veneto was in 2007 in a chestnut orchard in Treviso province (Cavaso del Tomba), and *D. kuriphilus* local diffusion now includes many municipal districts in Treviso, Belluno, Vicenza and Padova provinces. In 2007 the gall wasp infestation appeared in Trento province in two chestnut plantations situated in the municipal districts of Pergine and Civezzano. After an attempt at eradication by pruning and destroying the infested shoots, in 2008 *D. kuriphilus* was detected again in new sites in the municipalities of Storo and Nago-Torbole. In 2007 *D. kuriphilus* was reported in Sardegna, and it has now spread to the municipal districts of Aritzo, Belvì, Arzana, Lanusei, Desulo and Tonara in Nuoro province. By May 2008 the first focus was found in Emilia-Romagna in the municipality of Carpineti (Reggio Emilia), and during the summer of 2008 the cynipid was found in new sites in Modena, Forlì-Cesena, Parma and Bologna provinces. In the same year *D. kuriphilus* was also found in a small chestnut orchard in the municipality of Terlano (Bolzano province) and in wood on the east area of Friuli Venezia Giulia region, bordering with Slovenia. In the Toscana region, after a first case detected in 2005 in a nursery, on young plants later destroyed, the presence of the pest was verified in 2008 in a large area of Massa-Carrara province and in other hotspots in Pistoia, Prato and Firenze provinces. In Abruzzo, after a first report in 2005 in a nursery, the gall wasp was recorded in June 2009 in chestnut orchards in the municipality districts of Capistrello, Canistro and

Civitella Roveto (Aquila province). In Umbria the first report was in spring 2009, in the municipalities of Avigliano Umbro and Montecchio (Terni province). In summer 2009, *D. kuriphilus* was detected in Calabria, near San Luca village (Reggio Calabria province), and Marche, in chestnut areas of three municipalities: Talamello, Novafeltria and Sant'Agata Feltria (Pesaro Urbino province) (Fig. 2).

Lifecycle in Piedmont

The lifecycle of *D. kuriphilus* is closely related to the spring temperature, and it also depends on factors such as altitude and exposure. In Japan adult wasps emerge from galls at various times in different sites, and there is a wide range among provinces due to the diversity of climatic conditions (Ôtake, 1980). The surveys developed in recent years in Piedmont showed that, depending on different chestnut orchard sites, adult wasps emerge from early June till the first half of August, with a range influenced by altitude, exposure, chestnut cultivars and climatic trend. In 2007 the Plant Health Service executed a survey of the *D. kuriphilus* lifecycle in two different sites of Cuneo province. The data display an evident advance (averaging 18 days) of the beginning of every instar at the lower-altitude sites (Fig. 3). In addition, the instars lasted longer (by about 17 days) at higher altitudes. This is probably due to a slowed development cycle during wintry weather.

The most critical time for the cycle, also for the risk of spread of the pest, is the emergence of the adult wasps from galls. This period, in a restricted area, lasts for about three weeks. In the sites placed at the bottom of the valleys, with a good exposure and with earlier cultivars (Euro-Japanese hybrids), generally gall wasp females begin to appear in the first half of June, with an emerging peak in the last week of June and the first week of July. The higher areas (700-900 m a.s.l.), with unfavorable exposure and with European chestnut cultivars, show the emergence of adults gall wasps one month later, toward mid-July, with a peak at the end of the month and in early August. In 2009 the high temperatures recorded in May led to a faster cycle: the adult females appeared, in favorable sites, in early June, with a maximum emergence in mid-June. The emergence of females at higher altitudes started in the second half of June, with a peak in the first half of July.

In relation to the life span of the adult female, some Japanese researchers reported a long time inside the gall, about seven days (Ôtake, 1980), and at most two days after the emergence (Kato and Hijii, 2001). Specimens of *D. kuriphilus* were reared in summer 2007 at the Plant Health Service in Torino, with climatic conditions similar to the natural ones and without feeding. They displayed from a maximum of seven days to a minimum of one day of life, with an average of four days, which was longer than that recorded in the Japanese data.

Damages

Some researchers claim that severe and repeated infestations lead gradually to the decline of chestnut tree vigor (Kato and Hijii, 1997) and often can result in tree mortality (Dixon *et al.*, 1986).

To date in Piedmont, in chestnut orchards that were experiencing heavy attacks by 2002, no death of trees has been reported. At its worst the pest caused the death of some twigs with severe gall infestation.

With regard to the effects on fruit output, the commercial growers owning sites with a longer and higher-level attack of *D. kuriphilus* have reported yield decreases of 50-70%. This reduction is similar to that recorded in other countries (Dixon *et al.*, 1986). Nonetheless, we note that in recent years the climatic trend has been adverse, with long dry seasons and often with high temperatures. Therefore it's very difficult to evaluate the responsibility of *D. kuriphilus* in yield reductions. Furthermore it is important to bear in mind that chestnut fruits are put out by terminal buds of the twigs. Thus, if the climatic and agronomic conditions, especially water availability, are favorable to the increase of shoots after the females' flying period, the new buds will not be affected by eggs laying. In this situation chestnuts would normally bear fruits in the next spring. In this circumstance the yield of the following year would be less affected by the pest.

Phytosanitary rules

D. kuriphilus was considered one of the most serious pests of chestnut trees worldwide, but despite this fact it was not included in the European list of quarantine pests (Directive 2002/89/CE and subsequent integrations). In 2003, after the arrangement of a specific Pest Risk Assessment (PRA), it was added to the EPPO (European and Mediterranean Plant Protection Organization) A2 action list, which includes pests locally present in the E.U. EPPO member countries are thus recommended to consider it as a quarantine pest to prevent the introduction and the spread in other areas. The need for control measures, such as the regulation of nursery activities and commercialization of chestnut young plants, was underlined by a Ministerial Decree issued by the Italian Government on February 23, 2006, outlining compulsory measures for the pest's control. Also in 2006 the Commission of the European Community issued Decision 2006/464/CE, the "Provisional emergency measures to prevent the introduction into and the spread within the Community of *Dryocosmus kuriphilus* Yasumatsu." In a decree of October 30, 2007 (published on February 19, 2008), the Italian government issued legislation to comply with this EU decision. Official measures provide for an annual survey of the territory, establishment of demarcated zones, production of young chestnut plants in pest-free areas and allow movements of plants only if they are accompanied by a plant passport. Moreover, the commercial growers of chestnut plants for planting have to inform the local plant health services about the movement of plants and grafts, including the details of the purchasers.

Regione Piemonte's actions

Since 2002 the Plant Health Service of Regione Piemonte has taken many actions to contain the damage due to the spread of *D. kuriphilus* and to find possible solutions. These measures include:

- Verifying the local spread of the pest.

- Preparing the Pest Risk Assessment (PRA) for the European and Mediterranean Plant Protection Organization (EPPO).
- Performing phytosanitary supervision of nurseries.
- Organizing and participating in local information events and establishment, with Provincia di Cuneo – Agricultural Department, of a local committee charged with providing periodic news regarding CGW issues.
- Producing informative and scientific articles.
- Organizing a meeting in Cuneo on *D. kuriphilus* (2004) and a workshop with EPPO's experts (2006).
- Studying *D. kuriphilus*'s lifecycle in Cuneo province and reporting on native parasitoids (Aebi *et al.*, 2006).

Since 2003 the Agriculture Department of Regione Piemonte has funded a “Regional program of activities against the chestnut gall wasp *Dryocosmus kuriphilus* Yasumatsu.” The project finances a series of research projects focused on the following targets:

- Assessment of the introduction of a specific parasitoid (*Torymus sinensis* Kamijo) in Piedmont for the purpose of biological control of the chestnut gall wasp (Quacchia *et al.*, 2008).
- Research of selected chestnut cultivars with various types of sensibility and analysis of genetic resistance mechanisms (Botta *et al.*, 2008).
- Studies on the reduction in fruit and wood productions in CGW-infested chestnut trees.
- Chemical and physical defense trials to control the cynipid in nurseries and young breeding.

These projects were assigned, except for the one on chemical control, to the University of Torino, DIVAPRA - Entomology and Zoology applied to the Environment “C. Vidano” and Department of Tree Cultivation.

Chemical control

Chemical control of the pest with insecticides isn't realistically achievable for legal and technical reasons, and it carries huge environmental hazards. In Italy the insecticides licensed for use on chestnut trees, for other pests, are *Beauveria bassiana*, *Bacillus thuringiensis* var. *kurstaki*, azadirachtin, rotenone, bifenthrin, ethofenprox, spinosad and thiacloprid. Most of these insecticides are not likely to provide good control of the chestnut gall wasp. Included in the bibliography are reported control trials, executed in the past, with strongly toxic insecticides. In China, for instance, good efficacy was achieved by means of injections of methamidophos and omethoate in the tree trunks and also by spraying dichlorvos, methyl parathion and methamidophos (Yan *et al.*, 1995).

Regione Piemonte Plant Health Service, in partnership with C.R. e S.O., a local centre for research on fruits and vegetables, investigated the efficacy of some insecticides allowed on other fruit trees, but not on the chestnut. Treatments were performed in various phenological phases on different stages of the insect, to control the pest both in nurseries and in young orchards. The systemic or cytotoxic insecticides vamidothion, imidacloprid, thiamethoxam and dimethoate were tested on galls growing in spring, a short time after buds development. Moreover, endotherapy

treatments were done on 10- to 12-year-old chestnuts, with imidacloprid and vamidothion. None of these treatments showed good effectiveness: larvae in galls are well protected, and insecticides can't reach them due to the particular histological conformation of the galls. Similarly, active substances sprayed in late August/early September, when first larval stages are present inside the galls, didn't show a significant control action, due to the leaf-bud scales. Only treatments realized at the emergence of adults from galls with kaolin, a mineral dust acting like a physical barrier, or with lambda-cyhalothrin, alpha-cypermethrin and chlorpyrifos ethyl mixed with mineral oil contributed to a lower infestation, increasing females' mortality and reducing eggs laying in the buds. These results were obtained on young plants, grown in pots, and therefore with a perfect coverage of insecticides. However, five to six treatments were needed to protect the plants during the flying stage of *D. kuriphilus*. This means that, on larger trees, it would be a very expensive and polluting technique. Furthermore, the risks of killing pollinators and of toxic residues in honey must be taken in consideration as first treatments may overlap with chestnut flowering. Thus it is evident that chemical control could present more risks than advantages. Therefore, Regione Piemonte, since the beginning and following Japan's example, has chosen to pursue biological control of this pest.

Chestnut nurseries

In the Piedmont region, and in Cuneo province particularly, there are some big nurseries producing thousands of chestnut plants sold in other Italian and European regions. These nurseries sell mainly young plants with one-year vegetation after grafting. These plants in summer may be infested by gall wasp females laying eggs in buds. Infested buds will develop galls only in the following spring, when plants will have been sold and planted by the buyers. Therefore, visual inspection of these plants is ineffective; infestation can only be discovered by sampling shoots and examining buds under a stereomicroscope in a laboratory. Furthermore, in the last few years the Plant Health Service has detected some nurseries in Piedmont growing and trading chestnut plants without any license or official control, which has favored in the first years the spread of the pest in other regions. Based on checks carried out in Piedmont, more than 130,000 young chestnut plants have been destroyed in these years, because they were infested by the pest or grown in infested areas. In compliance with the decree of February 23, 2006, some nurseries have moved to *D. kuriphilus*-free areas in Piedmont or in other regions, while others have stopped chestnut plant production. Probably, with the gradual spread of the pest throughout Italy, the only solution to continuing chestnut nursery activity would be cultivation under insect-proof nets during females' flight. Trials performed in the past have shown the effectiveness of this technique of covering young plants with nets for two or three months in the summer.

References

- Aebi, A., K. Schönrogge, G. Melika, A. Alma, G. Bosio, A. Quacchia, L. Picciau, Y. Abe, S. Moriya, K. Yara and G. Stone (2006) Parasitoid recruitment to the globally invasive chestnut

- gall wasp *Dryocosmus kuriphilus*. In *Galling arthropods and their associates: ecology and evolution* (K. Ozaki, J. Yukwa, T. Ohgushi, P.W. Price, eds.). Springer-Verlag, Tokyo, pp. 103-121.
- Brussino, G., G. Bosio, M. Baudino, R. Giordano, F. Ramello and G. Melika (2002) Pericoloso insetto esotico per il castagno europeo. *L'Informatore Agrario* 37: 59-61.
- Botta, R., C. Sartor, D. Torello Marinoni, A. Quacchia and A. Alma (2008) Differential gene expression in chestnut bud following infestation by gall wasp (*Dryocosmus kuriphilus* Yasumatsu, Hymenoptera: Cynipidae). IV International Chestnut Symposium September 25-28, 2008, Beijing (China).
- Dixon, W. N., R. E. Burns and L. A. Stange (1986) Oriental chestnut gall wasp *Dryocosmus kuriphilus* Yasumatsu (Hymenoptera: Cynipidae). Entomology Circular No. 287. Florida Dept. of Agric. & Consumer Serv., Division of Plant Industry.
- EPPO (2005) Data sheets on quarantine pests - *Dryocosmus kuriphilus*. *EPPO Bull.* 35: 422-424.
- EPPO RS (2006) First record of *Dryocosmus kuriphilus* in Slovenia. *EPPO Reporting Service* 5: 2006/101.
- EPPO RS (2007) *Dryocosmus kuriphilus* found in the south of France (Alps-Maritimes). *EPPO Reporting Service* 5: 2007/086.
- EPPO RS (2008) Situation of *Dryocosmus kuriphilus* in France. *EPPO Reporting Service* 5: 2008/097.
- Graziosi, I., and F. Santi (2008) Chestnut gall wasp (*Dryocosmus kuriphilus*): spreading in Italy and new records in Bologna province. *Bull. Insectol.* 61: 343-348.
- Kato, K., and N. Hijii (1997) Effects of gall formation by *Dryocosmus kuriphilus* Yasumatsu (Hym., Cynipidae) on the growth of chestnut trees. *J. Appl. Entomol.* 121: 9-15.
- Kato, K., and N. Hijii (2001) Ovipositional traits of the chestnut gall wasp, *Dryocosmus kuriphilus* (Hymenoptera: Cynipidae). *Entomol. Sci.* 4: 295-299.
- Ôtake A. (1980) Chestnut gall wasp, *Dryocosmus kuriphilus* Yasumatsu (Hymenoptera: Cynipidae): A preliminary study on trend of adult emergence and some other ecological aspects related to the final stage of its life cycle. *Appl. Entomol. Zool.* 15: 96-105.
- Quacchia, A., S. Moryia, G. Bosio, I. Scapin and A. Alma (2008) Rearing, release and settlement prospect in Italy of *Torymus sinensis*, the biological control agent of the chestnut gall wasp *Dryocosmus kuriphilus*. *BioControl* 53:829-839.
- Ueno W. (2006) Occurrence and control of chestnut gall wasp in Nepal. *Shokubutsu Bôeki (Plant Protection)* 60: 510-512.
- Yan, Y.-Z., Y.-S. Liu, D.-A. Jiang, G.-Y. Li. and Z.-X. Zhang (1995) Study on techniques for integrated control of *Dryocosmus kuriphilus* Yasumatsu in North Hubei. (abstract in English). *Plant Protection* 1: 5-8.

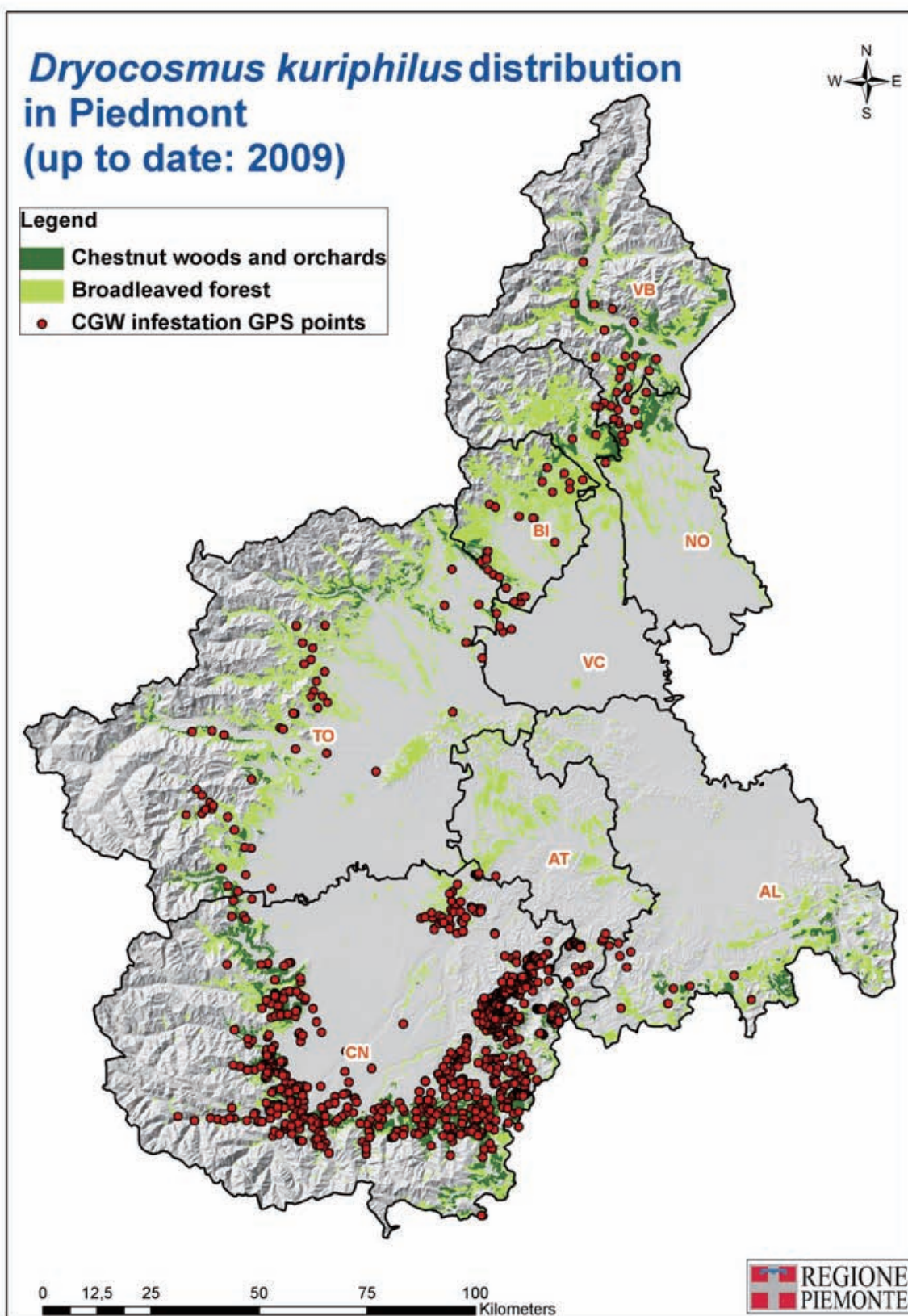


Fig. 1. *D. kuriphilus* distribution in Piedmont (summer 2009).



Fig. 2. *D. kuriphilus* distribution in Italy (summer 2009).

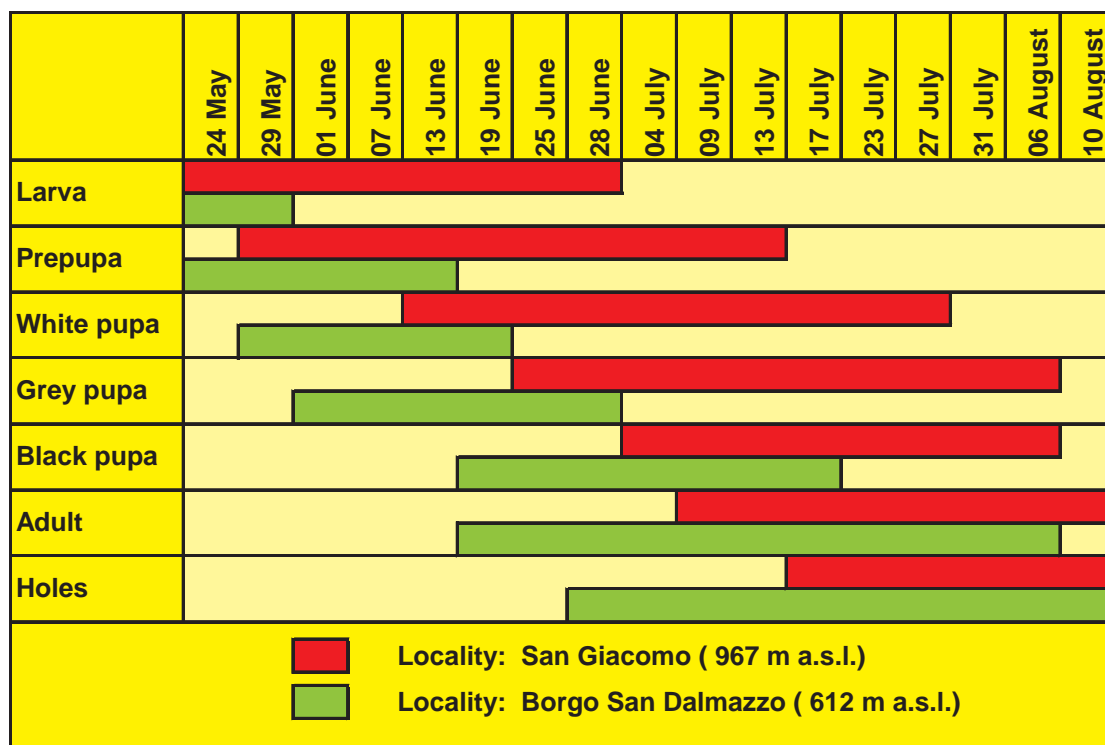


Fig. 3. *D. kuriphilus* lifecycle development in two sites at different altitudes.