Bulletin of Insectology **62** *(2): 209-213, 2009*
ISSN 1721-8861

Flight period of *Gasterocercus depressirostris* in relation to temperature in North-eastern Italy

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Abstract

Gasterocercus depressirostris (F.) (Coleoptera Curculionidae) is a rare species found in European "*Querco-Carpinetum*" primary forests. From the literature of Central Europe it is known that the larvae live in trunks of dying oak and beech trees, and the adults fly from June to September. In some natural woodlands in the Friuli Venezia Giulia region (North-eastern Italy), trunk window traps were placed to monitor weevil phenology by the capture of adult insects during flight. A relationship was established between capture numbers and temperature by use of the Day Degrees (DD) method, with the aim of acquiring data on the flight period of this species and the use of DD as an estimator of this aspect of *G. depressirostris* phenology. The insect flight was observed from the end of May to the end of July and for its flight to occur, approximately 750 DD and an average minimum temperature above 15 °C were necessary.

Key words: oak, primary forest, weevil, relict species, flight period, Day Degrees.

Introduction

Gasterocercus depressirostris (F.) (Coleoptera Curculionidae) is a relict species with larvae living in trunks and large branches of dying oaks [mainly *Quercus robur* L., but also found on other species of the genus *Quercus* such as *Q. petraea* (Mattuschka) Liebl.] or beech (*Fagus sylvatica* L.). It is the only European species of the genus *Gasterocercus* (Hoffmann, 1958; Csóka and Kovács, 1999).

The species is known to live in primary "*Querco-Carpinetum*" forests, which can still be found scattered all over Europe, including Italy.

This weevil is recorded from some areas of France, Germany, Romania (Hoffmann, 1958), Ukraine (Kudela, 1974), the Czech Republic (Strejček, 1993), Hungary (Csóka and Kovács, 1999), Poland (Mokrzycki *et al*., 2008) and Italy (Caldara and Angelini, 1997). This species is rare, probably because its habitats are being destroyed across Europe. In fact, in some countries (Austria, Germany, Hungary and Poland) it is included in the Red list of endangered species (Franz, 1994; Binot *et al.*, 1998; Csóka and Kovács 1999; Mazur, 2004).

From literature of Central Europe is known that *G. depressirostris* overwinters as larvae in tree trunks and pupates in May-June. Adults emerge from June to September and have crepuscular habits. During the day they are barely noticeable on oak trunks because of their camouflaged tegument. The emergence holes are 3-4 mm in diameter and are grouped in lines 3-10 cm apart (Hoffmann, 1958; Kudela, 1974).

The presence of this species in Italy had not been known until 1993, when a few specimens were collected in Basilicata (Southern Italy) by using light traps from May to August (Caldara and Angelini, 1997). In the summer of 2001, some specimens of *G. depressirostris* were found on a dead oak in a marshy area, named Palude Moretto, in the municipality of Castions di Strada (Udine, Friuli Venezia Giulia, North-eastern Italy).

In 2002 and 2003, further investigations were carried out to assess the presence of *G. depressirostris* in the main lowland woods of North-eastern Italy (Bernardinelli *et al*., 2003).

In the summer of 2004, a strong infestation by *G. depressirostris* was observed in a small wood with a large number of oaks (Bosco Boscat) in the municipality of Castions di Strada (Udine) (Stergulc *et al.*, 2005; Bernardinelli and Stergulc, 2006). This outbreak occurred after the 2003 season, which was characterised by a particularly hot and dry summer. The presence of a high number of specimens made it possible to perform a study on the flight phenology of this species in North-eastern Italy.

The aim of this study was to find out the flight period of *G. depressirostris* using the Day Degrees (DD) method as a predictor, so as to increase knowledge of this rare species and to provide further information to help reveal its presence.

Materials and methods

Study area

Three localities in the lowlands of the Friuli Venezia Giulia region (North-eastern Italy) were investigated during this study (table 1 and figure 1). Site 1 is where the species caused a strong infestation in 2004. Site 2 is a natural wood where many declining oaks were present, which is located in the municipality of Muzzana del Turgnano (Udine), not far away from site 1. Site 3 is located far to the north of the other two sites, in an area recently designated as a natural protected area in the municipality of Martignacco (Udine) where oaks are present in small groups or as single trees.

Insect sampling

In 2004, during the outbreak of *G. depressirostris* in site 1, most of the infested oak (*Q. robur*) trees were cut and rapidly removed. In the same site and year, trunk

Table 1. Data on sampling sites and meteorological stations.

Label	Locality	Municipality	Longitude	Latitude
	Sampling sites			
1	Bosco Boscat	Castions di Strada	13.1710	45.8419
2	Selva di Arvonchi	Muzzana del Turgnano	13.1186	45.7886
3	B. Bertrando Biotope	Martignacco	13.1571	46.1058
	Meteo stations			
1	Paradiso	Talmassons	13.1567	45.8833
2	Palazzolo	Palazzolo dello Stella	13.0536	45.8067
3	S. Osvaldo	Udine	13.2278	46.0361

Figure 1. Location of sampling sites and meteorological stations.

window traps (Birtele, 2003) were placed on three declining oaks, from the middle of May to the end of August. In 2005-2007 traps were placed on declining trees from the beginning of spring to the end of summer. Three traps were placed in site 1, three in site 2 and six traps in site 3. All the traps were attached to declining oaks, on which holes, presumably caused by *G. depressirostris*, were found. In 2008, traps were also placed from the beginning of spring to the end of summer on oak trees with evidence of oak-decline, with four placed in site 1 and eight in site 2.

Trunk window traps consisted of a 20x30 cm Plexiglass panel with a 20 cm funnel and a flask containing a saturated solution of water and NaCl. Each trap was fixed to the tree trunk at a height of about 1.5 m from the soil level (Birtele, 2003).

Trap flasks were collected every 2 weeks during the whole sampling period.

All insects captured within the traps in each sampling interval were examined and the number of *G. depressirostris* specimens was counted.

In 2006 and 2007 no data were collected due to damage and vandalism to the traps; and in 2008, traps did not catch any specimens of *G. depressirostris.* Therefore, the flight period was studied on the basis of the 2004 and 2005 captures.

Damage survey

The Forest Phytopathology Inventory (BAUSINVE) is a monitoring network that was established in Friuli Venezia Giulia in 1994. In this inventory, all the information about forest pests and diseases as well as fallen trees in the regional forests, are recorded (Stergulc and Frigimelica, 1997). For each event the information on the causal agent, location and characteristics of the damage have been stored in a database.

Meteorological data

For each sampling site, daily minimum and maximum temperatures were taken from the nearest OSMER – FVG meteorological station (table 1).

These data were used to determine parameters useful to easily predict the flight period of the insect.

Data analysis and statistics

Flight periods and data on temperature collected in the first sampling year were evaluated together to calculate the number of Day Degrees (DD) (10 °C based) and the minimum temperature necessary for the flight of this species. A weighted average of DD (on the basis of the number of captured specimens) was calculated to assess the average flight period.

Data on captures and temperatures collected in following years in the different localities were used to establish whether the DD and minimum temperatures observed in the first year of this study, could be used to predict the flight of this species.

The minimum temperature (instead of the average temperature) was preferred as a parameter to evaluate the flight of the species because of its crepuscular and nocturnal habits.

Due to the fact that sampling occurred every two weeks, the DD necessary for emergence of the insect from the trees, were considered as a range. For the same reason, calculations of DD were performed using the median value for each sampling interval. For minimum temperatures the average over the two-week period was used for all calculations.

The abundance of the specimens captured was considered for each site by summing all the insects captured in the traps, without considering differences among the traps.

The probability that the captured specimens responded to temperatures similar to those observed in the first year was assessed by a “one sample t-test”. The comparison was performed between the average DD value necessary for the flight in 2004 and the same data for each locality in 2005; the same test was performed also between the average minimum temperature necessary for the flight in 2004 and the same data for each locality in 2005.

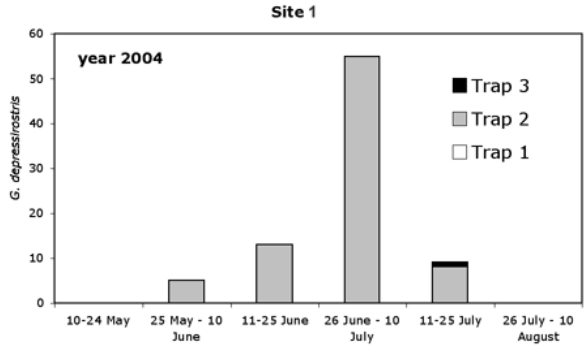

Figure 2. Specimens of *G. depressirostris* captured during spring and summer 2004.

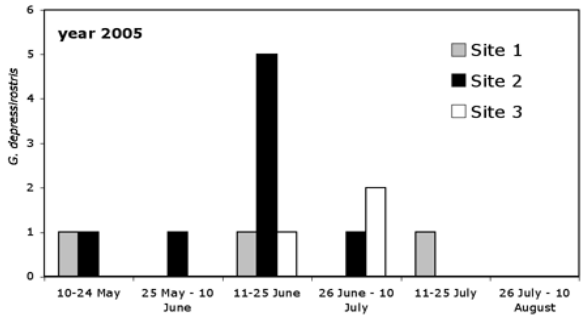

Figure 3. Specimens of *G. depressirositris* captured during spring and summer 2005.

Results

Number of captures

In 2004, one of the three traps captured almost all the specimens of *G. depressirostris* detected in the year (figure 2), suggesting that oak trees are not equally attractive to this species and that there is a high probability of not detecting the insect, even if it is present, due to a very aggregate distribution.

In 2005, captures in all the studied localities were very low (figure 3) suggesting that the population level of the insect had strongly decreased, as supported by the fact that significant damage by this species was not observed over the entire region (Stergulc *et al.*, 2007).

In 2008, no specimens were caught at all, and no damage was discovered over the entire survey region (BAUSINVE data), so it can be considered that the population level of *G. depressirostris* was below the detection limit.

Flight period

In 2004, in site 1 the flight period of the insect started in the last week of May and ended by the second half of July. The DD necessary for the capture of the first specimens were included in the range from 373 and 521 (figure 4a) and a weighted average of 750 DD were necessary for the flight (table 2). The minimum temperature at which the insect showed its flight was slightly below the yearly maximum level of this parameter, with the first captures observed at an average minimum temperature of 15.6 °C (table 2).

In 2005, in site 1 (figure 4b) and 2 (figure 4c) the emergence was observed two weeks earlier than the previous year and the flight period was also observed between May and July. The DD necessary for the first captures were included in a similar range (321-468). In site 3 (figure 4d), all the specimens were captured later in the season, with the first capture in a DD range between 461 and 628, but probably due to the small sample size, the earliest flight of the insects was not detected. No significant differences were in fact observed in the weighted average of DD and minimum temperature necessary for the insect flight at each site in 2005 when compared to the observations in 2004 (table 2).

Presence of damage and infested forest management

Damage caused by *G. depressirostris* in Friuli Venezia Giulia were observed for the first time in 2003 where two very small areas (one with 5 and one with 10 infested trees) were observed in the forest location where this study was carried out. Due to the small number of infested trees and the fact that this is a rare species, no management activity was carried out in 2003 in the infested trees. In 2004, over one hundred trees were found strongly infested in a forest of a private owner. In this case most of the infested trees were rapidly removed from the forest, even if this species is so rare, due to the fact that in Italy there are no protection laws for this species, so it can be considered in the same way as other pests affecting trees.

According to data coming from BAUSINVE Forest Phytopathology Inventory, it is possible to establish that from 2005 to 2009 no further damage by *G. depressirostris* was observed in Friuli Venezia Giulia region.

Table 2. Data on Day Degrees (10 °C based) and minimum temperature (°C) observed in the three sites (P values obtained by one sample t-test by comparison with data coming from site 1 in 2004).

Site	Year	Average value for the flight			
		DD (SE)	P value	min Temp (SE)	P value
1	2004	751 (13)		15.6 (0.1)	
1	2005	761 (204)	0.96	15.2 (1.3)	0.79
2	2005	659 (55)	0.14	15.5 (0.4)	0.81
3	2005	854 (55)	0.20	17.2 (0.89)	0.32

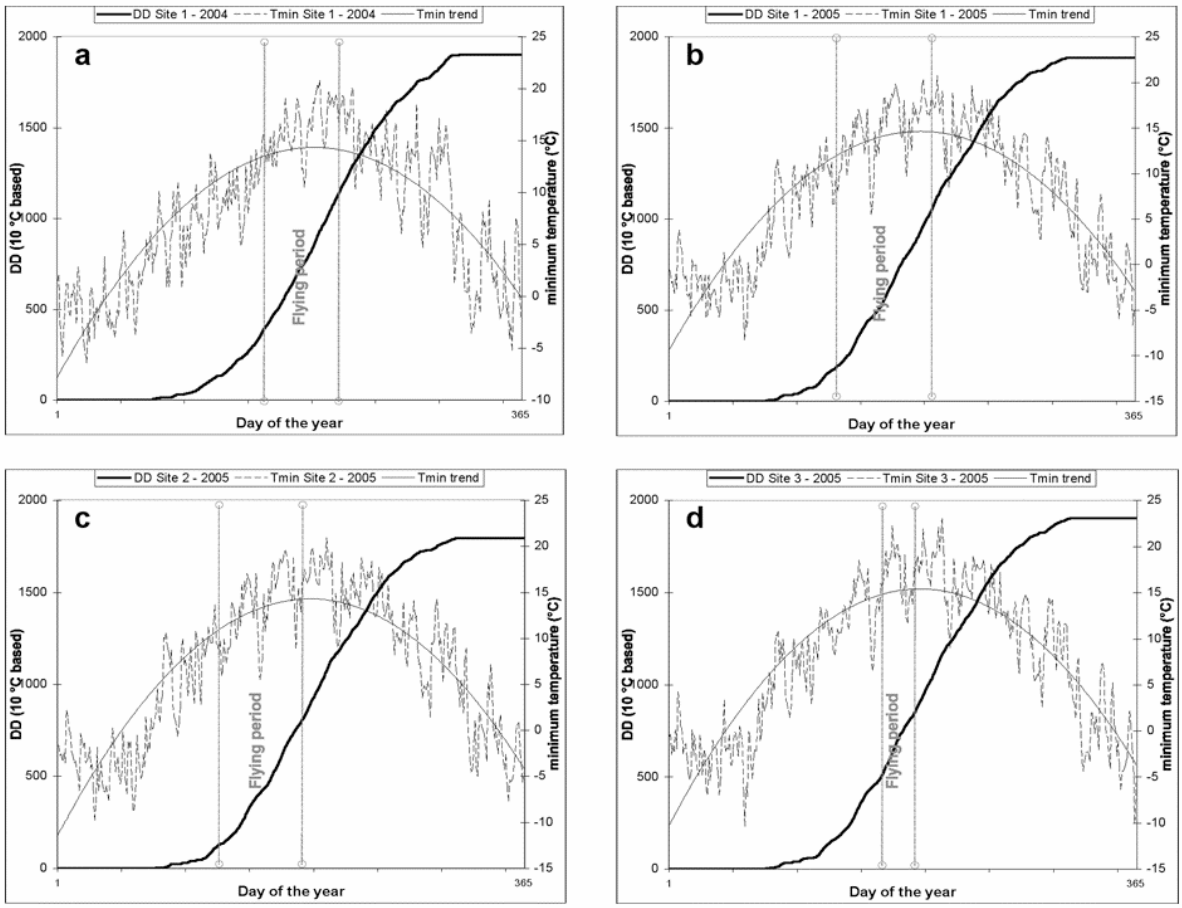

Figure 4. Day Degrees (10 °C based) and minimum daily temperature and minimum temperature trend lines referring to the sampling sites: a) Site 1 - 2004, b) Site 1 - 2005, c) Site 2 - 2005, d) Site 3 - 2005.

Discussion and conclusion

The presence of an abundant population of *G. depressirostris* allowed the flight period of this rare species to be recorded and to relate this with temperature parameters such as DD and minimum temperature.

The number of captures of the insect strongly decreased from 2004 to 2005 and no specimens were captured in 2008; damage by this species was not found in years following 2004. Therefore it appears that this outbreak is now over, probably due to the timely removal of most of the strongly infested trees from the infestation spot, as well as meteorological conditions that are no longer characterized by heavy drought like those observed in 2003.

Even though a strong reduction in the number of specimens captured occurred, in the study areas the flight period of the insect was confirmed to be from the end of May to the end of July, and this is far shorter from previous reports in the literature (Hoffmann, 1958; Kudela, 1974).

The DD necessary for the emergence of the insect are difficult to predict with precision due to their rapid increase in values between sampling dates; even so, a value of around 750 DD could be a good predictor for the average flight period of this species.

The usual low level of the population of *G. depressirostris* made finding the insects very difficult but by having the possibility to estimate the flight of this rare species calculating DD, could give some more chances in its findings.

Acknowledgements

The research was carried out within the project BAUSINVE - ERSA, Direzione Centrale delle Risorse Agricole, Naturali, Forestali e della Montagna, Friuli Venezia Giulia, Italy.

Meteorological data originated from Osservatorio Meteorologico Regionale, ARPA, Friuli Venezia Giulia, Italy.

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Received April 7, 2009. Accepted September 7, 2009.