Bulletin of Insectology ***63*** *(1): 45-50, 2010*
ISSN 1721-8861

Observations on the life cycle of *Pissodes castaneus* in central Italy

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Abstract

Field and cage studies on the life cycle of *Pissodes castaneus* (De Geer) (Coleoptera Curculionidae) and on its larval parasitoids were carried out in central Italy. Oviposition occurred in the spring and in the late summer/early autumn; the larvae were present throughout the year, with the exception of a few summer months; *P. castaneus* mainly overwintered as third and fourth instar larvae, as well as adults of previous generations. This study also provides evidence that a part of adults which emerged in the spring, at beginning of the emergence period, may lay eggs which give rise to new adults within July. In conclusion, in central Italy two generations of the weevil were observed, of which one had a slow development, originating from eggs laid in autumn, and the other had a very rapid preimaginal development, originating from eggs laid in the spring. The most common larval parasitoids of *P. castaneus* were *Metacolus unifasciatus* Förster (Hymenoptera Pteromalidae) and *Coeloides sordidator* (Ratzeburg) (Hymenoptera Braconidae); which are parasitoids of species belonging to the genus *Pissodes*, as well as many bark beetles.

Key words: behaviour, small banded pine weevil, *Pinus pinaster* forest, *Pissodes castaneus*, *Metacolus unifasciatus*, *Coeloides sordidator*.

Introduction

The small banded pine weevil, *Pissodes castaneus* (De Geer) (Coleoptera Curculionidae) is distributed in Europe, Siberia, North Africa (Bichão *et al*., 2003), Turkey (Tozlu, 2001) and it has also been introduced in South America: Argentina (Marvaldi and Lanteri, 2005), Uruguay and Chile, where it is considered a harmful forest phytophagous insect (Abgrall *et al*., 1999). It attacks all pine species and occasionally also larches and spruces. In Chile and Uruguay it has also been recorded on some species of the *Abies* and *Pseudotsuga* genera. It attacks trees of all ages, clearly preferring young ones, as long as they are weakened by biotic or abiotic stresses. In Italy, outbreaks, and therefore relevant damage, occur from mountain pine forests to coastal pine forests (Triggiani and Santini, 1989; Masutti and Battisti, 1991; Tiberi, 1995) of various regions.

Larvae of this xylophagous insect feed on the inner bark of tree branches, trunks and also roots, while adults, which can survive up to three years (De Viedma, 1961), gnaw feeding holes in the bark of young trees, which are soon covered by scars of callus tissue.

Studies on the life cycle of *P. castaneus* were carried out in several European and Non-European countries (Mayné, 1926; Kangas, 1931; De Viedma, 1961; Bukzeyeva, 1965; Lavrova, 1967; Carle, 1974; Alauzet, 1977; Plata-Negrache and Prendes-Ayala, 1979; Abgrall and Soutrenon, 1991; Abgrall *et al*., 1999), while in Italy knowledge about its life cycle and behaviour is still limited and fragmented. It was therefore considered interesting to study the development of the weevil, mainly by recording its life stages in the field during the year. In parallel with such investigations, insect rearings in cage were set up, in order to compare the data with those of field observations.

Materials and methods

The study was carried out in a pine forest located in Tuscany, at Poggio Valicaia, municipality of Scandicci, in Southwest Florence, Italy at about 350 m above sea level (11°10'27"E 43°43'4"N). This pine forest mainly consists of 10-15-year-old *Pinus pinaster* Aiton trees and of a few specimens, usually quite large in size, of *Pinus pinea* L.

Field studies

P. castaneus life cycle

In 2004 and 2005 investigations on the life cycle of *P. castaneus* were carried out. Every week, from January 2004 to December 2005, two attacked *P. pinaster* trees were selected, and one log sample (7-10 cm diameter, 70-80 cm length) per each tree was collected and taken to the laboratory. All the sampled trees were young, about 2-3 m tall and with a diameter at the base of 10-15 cm. Samples were collected not only from visibly attacked trees (with orange-red crown or desiccated crown) but also from recently attacked trees which had green crowns and the first symptom of weevil attack only (resin oozing from small oviposition and feeding holes). In the laboratory, length and diameter of sampled logs were measured. The logs were debarked to expose and count eggs, larvae, pupae and newly-formed adults of *P. castaneus*; eggs and first instar larvae were detected by means of a binocular microscope. In order to distinguish the larvae according to their instar, head capsule width and length were measured, and "size ranges" calculated for this insect species in the same pine forest (Panzavolta, 2007) were used.

The temperatures of the two-year period were measured by the 'Servizio Idrologico Regionale' of Tuscany in a meteorological station close to the study site.

Parasitoids

From 2003 to 2005, observations on the parasitoids of *P. castaneus* were carried out. In 2003 two log samples (7-10 cm diameter, 70-80 cm length) from two attacked *P. pinaster* trees were collected once a month, while in 2004 and in 2005 investigations were carried out on the same logs used to study the life cycle of *P. castaneus*. Parasitoid specimens observed under the bark were counted and preserved: both mature larvae and pupae were placed separately in vials and allowed to continue development to adulthood. The most frequent species were sent to the Museum of Natural History of London to be identified.

Cage studies

Emergence periods

To determine the beginning of the emergence period of *P. castaneus* adults from overwintering larvae, in January of 2004 and 2005 six attacked *P. pinaster* trees were selected and one log (7-10 cm diameter, 1 m length) per each tree was sampled and was placed in a cage (50 × 50 × 120 cm) with aluminium screening located outdoors under a roof in climatic conditions similar to those of the study site. The cage was checked on a weekly basis, when newly emerged adults were taken and counted.

Reproduction of newly emerged adults

In order to clarify whether adults from overwintering larvae emerging in spring were able or unable, to reproduce within the same season, the individuals which emerged from the logs in the rearing cage (used to determine the beginning of the emergence period) in both 2004 and 2005 were collected and placed in another similar cage located outdoors under the same roof. 80 *P. castaneus* adults were tested in the rearing trials in 2004, while 125 adults were tested in 2005. They were fed with shoots and fresh branches of *P. pinaster* and were allowed to lay eggs in logs (7-10 cm diameter, 1 m length) from young not attacked *P. pinaster* trees, which were also placed in the cage. Adults were kept in the rearing cage for one month, and then they were removed, leaving there only the oviposition logs. In both years the cage was checked on a weekly basis to monitor new adult emergence from the oviposition logs. After the end of adult emergence, the logs were debarked to expose and count *P. castaneus* individuals and empty pupal cells.

Statistical analysis

Percentages of parasitoids observed each year were compared by means of the χ^2 test and applying an orthogonal chi-decomposition according to Kimball (1954).

Results and discussion

A number of 412 eggs and 1481 individuals in the other life stages of *P. castaneus* were recorded in 2004, while 71 eggs and 613 individuals in the other life stages were observed in 2005.

Eggs

P. castaneus females lay eggs in small holes gnawed through the bark of pines. In each hole the female can lay either one egg or a small number of eggs. In the holes examined in both 2004 and 2005 one to four eggs were recorded. In agreement with other authors (De Viedma, 1961; Carle, 1967; Plata-Negrache and Prendes-Ayala, 1979) holes with one egg were dominant (74.32%), those with two eggs were less frequent (21.62%), and few holes with three (3.24%) or four eggs (0.81%) were recorded.

Eggs were mainly present in the spring (March-June 2004 and March-April 2005) and at the end of summer/autumn (September-December 2004 and September-October 2005) (figure 1). In September of both years and October 2005 they were even dominant (over 38%) in comparison with the other life stages under the bark (figure 2). In June-August and in January-February periods of both years no eggs were recorded. The oviposition pattern may be related to that of temperature: at the beginning of both 2004 and 2005 eggs were recorded more frequently as the average monthly mean temperatures reached 13 °C (figure 1); while in the hottest months (June-August), when average monthly mean temperatures oscillated between 23 and 25 °C, with maximum daily temperatures often over 32 °C, eggs were never observed. Eggs were recorded again when temperatures decreased, i.e. September of both years (figure 1). These results support Carle's hypothesis (1974), also confirmed by Alauzet (1977), about the adult need to suspend their activity in the summer, when the maximum daily temperatures are over 32 °C.

Larvae

First (L1) and second (L2) instar larvae were present mainly in the spring and the autumn of both 2004 and 2005. During the spring, the highest percentages of L1 relative to all the life stages were recorded in April 2004 and in March 2005, that is, later than those of L2 (March 2004 and February 2005) (figure 2). Whereas at the end of summer/autumn the highest percentages of L1 were observed in September of both years, and those of L2 in September 2004 and in December 2005 (figure 2). It is worth noticing that in the springtime infested trees can often be separated in three categories, depending on the date of *Pissodes* attack: trees attacked in the previous autumn, newly attacked trees and trees with both spring and autumn attacks. Therefore in logs sampled during this season overwintering larvae and larvae from egg laid at the beginning of the same spring can be present together.

Third (L3) and fourth (L4) instar larvae in the whole two-year period (2004-2005) were found dominant in comparison with the other larval instars. This may relate to the higher thermal needs of L3 and L4 compared to L1 and L2, and to their longer development rates (Alauzet, 1985). As a matter of fact, overwintering L3 and L4 interrupt their development for a long period, and in addition, as regards overwintering L4, they undergo also prepupal diapause (Carle and Gayraud, 1971; Alauzet, 1986). Moreover individuating the recently attacked trees in the field (therefore with higher number of eggs, L1 and L2) is rather difficult.

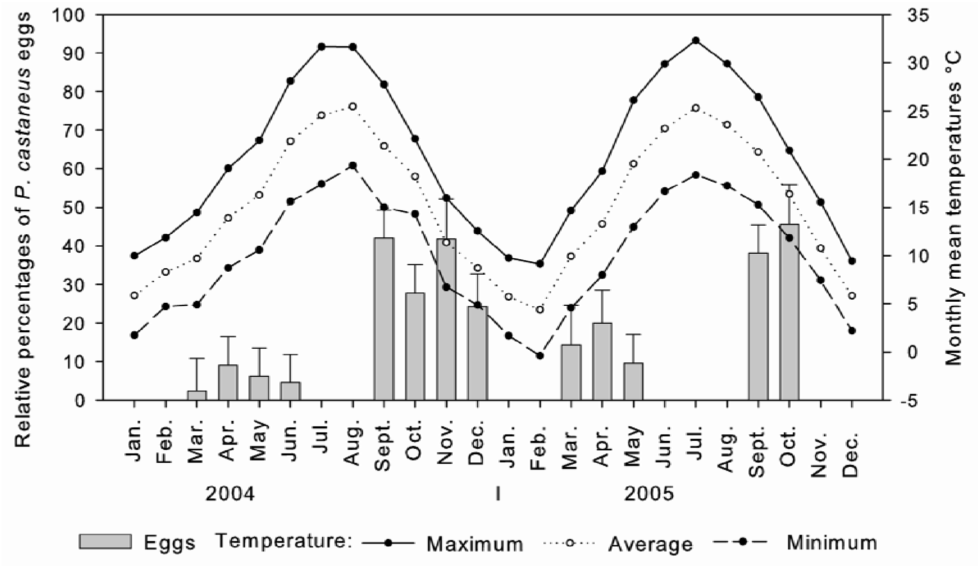

Figure 1. Seasonal pattern of temperatures and percentages of *P. castaneus* eggs relative to all the other life stages recorded in the sampled logs in 2004 and 2005. Bars indicate standard error.

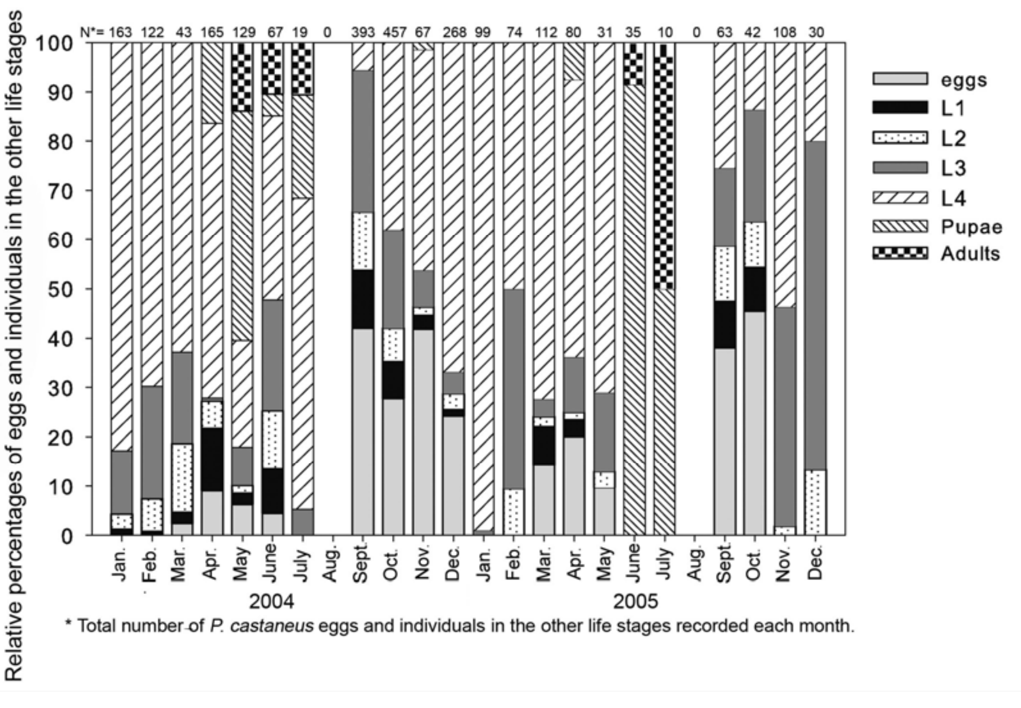

Figure 2. Relative percentages of each *P. castaneus* life stage recorded in the sampled logs in 2004 and 2005.

L3 and L4 were present throughout the year, with the exception of some summer months (August 2004 and June-August 2005) (figure 2). In these same summer months larvae (L1-L4) were never recorded, in contrast to what Carle (1974) and Alauzet (1977) observed in France, and in the case of Carle (1974) this occurred in both coastal and continental environments.

As regards life stages under the bark, in agreement with Alauzet (1977), *P. castaneus* mainly overwintered as L3 or L4. As a matter of fact, in January of both years they were over 95% relative to all the other life stages under the bark, and in December 2005 they were about 87%.

Pupae and adults

Pupae and adults (inside pupal cells) were observed in the field in the spring and the summer periods of both years (figure 2), in agreement with preliminary investigations carried out in the same study site in 2002-2003 (Tiberi and Panzavolta, unpublished data). However, in 2002-2003 pupae and adults were observed earlier (March-June) (Tiberi and Panzavolta, unpublished data) than in 2004-2005 (April-July). Probably the climatic pattern played a relevant role, as the average monthly mean temperatures in March 2002 and 2003 were over 10 °C, while those recorded in March 2004 and 2005 never reached the 10 °C threshold.

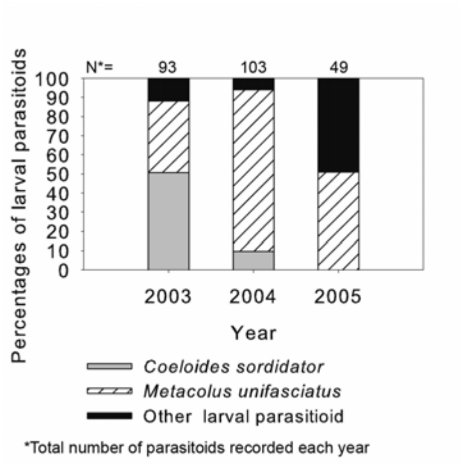

Figure 3. Relative percentages of larval parasitoids of *P. castaneus* recorded under the bark of the sampled logs in 2003, 2004 and 2005.

The first empty pupal cells were recorded in May 2004 and in June 2005, in agreement with the emergences from the logs kept in cages, which were recorded from the last 10 days of May till mid-June. In August of both years only several empty pupal cells were observed in sampled logs. It is worth noticing that during June-August period of both years empty pupal cells in the sampled logs were more numerous than larvae, pupae and adults together, and for this reason the total numbers of individuals reported in the summer months in figure 2 are quite low.

Few pupae were also found in November 2004, but no newly-formed adults were observed later (figure 2) in contrast with other authors (Alauzet, 1977; Plata-Negrache and Prendes-Ayala, 1979; Alauzet, 1986), who observed adults in cells also in the autumn period. This discrepancy may relate to the higher temperatures recorded in our study site both in the 2004 and 2005 summer periods, which might have caused a marked interruption of the oviposition activity in the summer.

Reproduction of newly emerged adults

In 2004 and 2005 caged adults (emerged in the spring: during the first 10 days of June 2004 and during the last 10 days of May 2005) mated, and during the same season females laid eggs in the available logs. As a matter of fact, in July 2004 larvae and pupae were observed under the bark of the oviposition logs, and at the end of July 2005 a number of 48 emerged progeny adults were also observed in the cage. Therefore, some adults, from those emerged in spring, are able to lay eggs in the same season and progeny adults emerge within July, i.e. about two months later. This acquisition was pointed out only in the course of the experiment of Abgrall and Soutrenon (1991); on the contrary, for other authors (Bukzeyeva, 1965; Plata-Negrache and Prendes-Ayala, 1979) newly emerged adults require a long feeding period before oviposition. However, our results are supported by a previous study (Carle, 1967), in which 14 days after their emergence *P. castaneus* adults were observed mating and reproduction occurred.

Parasitoids

Among the larval parasitoids of *P. castaneus* found in the pine forest of Poggio Valicaia, the most numerous were *Metacolus unifasciatus* Förster (Hymenoptera Pteromalidae), and *Coeloides sordidator* (Ratzeburg) (Hymenoptera Braconidae); already reported by other authors (Kenis *et al.*, 2004) as larval parasitoids of species belonging to the genus *Pissodes*, and also of numerous bark beetles. As regards all larval parasitoids recorded in the whole three-year period (figure 3), in 2003 the highest parasitism rate (relative to mature larvae) was recorded: 29.90%. More precisely *M. unifasciatus* and *C. sordidator* together were the significantly dominant parasitoids (χ^2 = 12.30, df = 1, p < 0.01), as a matter of fact, they represented more than 88% of the all parasitoids recorded in 2003, with a parasitism rate of 11.25% and 15.11%, respectively. In 2004 total parasitism rate decreased (12.50%): *M. unifasciatus* was the significantly dominant parasitoid (χ^2 = 79.71, df = 1, p < 0.01), representing about 84% of all recorded parasitoids, and its parasitism rate was 10.56%, whereas the parasitism rate of *C. sordidator* was 1.21%. Finally in 2005 total parasitism rate was 13.66%: *C. sordidator* was absent and *M. unifasciatus* (parasitism rate = 6.83%) represented about 51% of all parasitoid species collected, however this percentage was not significantly higher in comparison with that of the other parasitoid species considered together (χ^2 = 0.01, df = 1, not significant).

As regards *Eubazus semirugosus* (Nees) (Hymenoptera Braconidae), one of the most common parasitoids of *Pissodes* spp. in Europe (Kenis *et al*., 2004), adults were not recorded among emerged parasitoids, however its presence in the study site cannot be excluded.

Conclusions

In Northern-Eastern regions of Europe one generation of *P. castaneus* was reported, with a single oviposition period at the end of spring, and one single period of adult emergence between summer and autumn (Kangas, 1931; Bukzeyeva, 1965; Lavrova, 1967). In France two generations per year were recorded (Abgrall and Soutrenon, 1991; Lévy, 1992). More precisely Carle (1974) and Alauzet (1977) observed that different *P. castaneus* generations are characterized by a different developmental rate: to complete the cycle, from egg to adult, one requires 11 or 12 months, while the other has a quicker development rate of two-three months; the latter has no prepupal diapause (Alauzet, 1986). Our results are in agreement with the observations carried out in France, as a matter of fact, in our study site two generations were recorded (figure 4): one from eggs laid in the autumn, which had a long development rate (at least eight months from egg to adult), and one from eggs laid in the spring, which had a shorter development rate (two-three months). Basically, these findings confirm what Alauzet (1977) already recorded in France. However, in contrast with his observations, we recorded a sharp interruption of the weevil activity in the midsummer months; this may be related to the higher summer

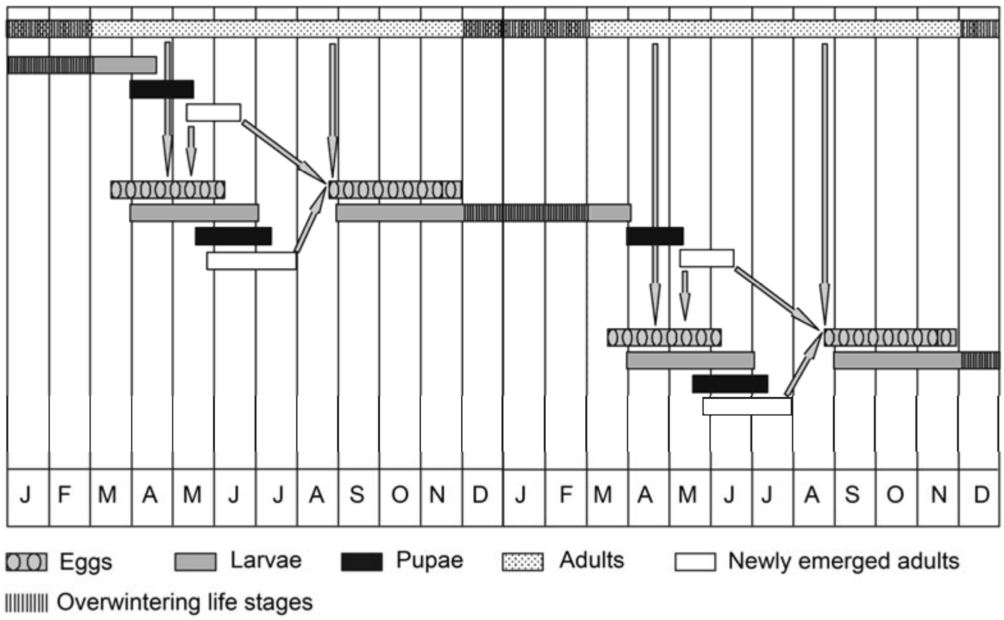

Figure 4. General scheme of the life cycle of *P. castaneus*.

temperatures in our study site, compared to those recorded in the French environments during his study.

P. castaneus under the bark overwintered mainly as L3 and L4. In addition, according to some authors (De Viedma, 1961; Plata-Negrache and Prendes-Ayala, 1979; Abgrall and Soutrenon, 1991) emerged adults also overwinter in the litter. Although we did not investigate this aspect, it is highly possible that the eggs we observed from March to May were laid by overwintering adults, as already reported by Alauzet (1977), since no emergences of adults from overwintering larvae was observed before mid-May.

Particular attention should be paid to the real possibility that a part of the adults which emerge at the beginning of the emergence period in the spring may, under favourable climatic conditions, lay eggs in the same season. The eggs give rise to new adults within July, coinciding with the end of the emergence period in our study site.

Acknowledgements

We would like to thank Prof. S. Benedettelli for his precious advice regarding the statistical analysis of the data.

References

ABGRALL J. F., SOUTRENON A., 1991.- Le pissode du pin, pp. 120-122. In: *La Forêt et ses ennemis* (ABGRALL J. F., SOUTRENON A., Eds).- CEMAGREF, Grenoble, France.

ABGRALL J. F., VILLÈN GONZÁLEZ V., PORCILE J. F., 1999.- Estudios de investigación sobre gorgojo de los pinos (I parte). Peligro a la vista.- *Chile forestal*, 24: 9-13.

ALAUZET C., 1977.- Cycle biologique de *Pissodes notatus* (Coleoptera, Curculionidae) dans la région toulousaine (France).- *Canadian Entomologist*, 4: 597-603.

ALAUZET C., 1985.- Développement sous-cortical d'un ravageur des pins: *Pissodes notatus* F. (Col., Curculionidae). I. Exigences thermiques du développement dans la nature.- *Bulletin d'Ecologie*, 16: 265-268.

ALAUZET C., 1986.- Développement sous-cortical d'un ravageur des pins: *Pissodes notatus* F. (Col., Curculionidae). II. Mise en évidence d'une diapause facultative.- *Journal of Applied Entomology*, 2: 134-140.

BICHÃO H., BORG-KARLSON A. K., ARAÚJO J., MUSTAPARTA H., 2003.- Identification of plant odours activating receptor neurones in the weevil *Pissodes notatus* F. (Coleoptera, Curculionidae).- *Journal of Comparative Physiology*, 189: 203-212.

BUKZEYEVA O. N., 1965.- Duration of generations of the pine weevil, *Pissodes notatus* F., (Coleoptera, Curculionidae) in the Voronezh region.- *Entomological Review*, 44: 22-24.

CARLE P., 1967.- Contribution à l'étude biologique de *Pissodes notatus* F. (Col. Curculionidae).- *Revue de Zoologie Agricole et Appliquée*, 10-12: 139-151.

CARLE P., 1974.- Le dépérissement du pin mésogéen en Provence. Rôle des insectes dans les modifications d'équilibre biologique des forêts envahies par *Matsucoccus feytaudi* Duc (Coccoidea, Margarodidae).- *Annales des Sciences Forestières*, 31: 1-26.

CARLE, P., GAYRAUD Y., 1971.- Essais de lutte chimique contre le charançon du pin *Pissodes notatus* Fabr. (Col. Curculionidae).- *Phytiatrie Phytopharmacie*, 20: 239-248.

DE VIEDMA M. G., 1961.- Estudio monográfico sobre el género *Pissodes* en España.- *Boletin del Servicio de Plagas Forestales*, 4: 3-61.

KANGAS E., 1931.- Siikakankaan mäntytaimistojen tuhoista. Uber die Schädigungen der kiefernpflanzenbestände in Siikakangas.- *Silva Fennica*, 17: 1-107.

KENIS M., WEGESTEINER R., GRIFFIN C. T., 2004.- Parasitoids, predators, nematodes and pathogens associated with bark weevil pests, pp. 395-414. In: *Bark and woodboring insects in living trees in Europe, a synthesis* (LIEUTIER F., DAY K. R., BATTISTI A., GRÉGOIRE J. C., EVANS H. F., Eds).- Kluwer Academic Publishers, Dordrecht, Netherlands.

KIMBALL A. W., 1954.- Short-cut formulae for the exact partition of chi-square in contingency tables.- *Biometrics*, 10: 452-458.

LAVROVA N. K., 1967.- Data on the ecology of the pine weevil *Pissodes notatus* F. (Coleoptera, Curculionidae) in the conditions of Byelorussia, pp. 56-63. In: *Fauna i ekologiya nasekomykh Belorussii* (LOPATIN I. K., Ed.).- ill. HB., Minsk, Belarus.

LEVY A., 1992.- La santé des forêts dans le massif des landes de Gascogne en 1991 (1re partie).- *Phytoma*, 438: 53-56.

MARVALDI A. E., LANTERI A. A., 2005.- Clave de taxones superiores de gorgojos sudamericanos basada en caracteres de los adultos (Coleoptera, Curculionoidea).- *Revista Chilena de Historia Natural*, 78: 65-87.

MASUTTI L., BATTISTI A., 1991.- Entomofaune dei pini del gruppo *Pinus nigra*, pp. 147-155. In: *Atti delle giornate di studio sulle avversità del pino"* (GIOVI G., MASUTTI L., Eds), Ravenna, Italy, 6-7 November 1989. Regione Emilia-Romagna, Bologna, Italy.

MAYNE R., 1926.- Les *Pissodes* en Belgique.- *Annales de Gembloux*, 32: 234-245.

PANZAVOLTA T., 2007.- Instar determination for *Pissodes castaneus* (Coleoptera: Curculionidae) using head capsule widths and lengths.- *Environmental Entomology*, 36: 1054-1058.

PLATA-NEGRACHE P., PRENDES-AYALA C., 1979.- Contribucion al conoscimiento de la bioecologia de *Pissodes notatus* F., en las poblaciones de pinos de canarias.- *Boletin de la Estacion Central de Ecologia*, 8 (16): 33-47.

TIBERI R., 1995.- Ruolo degli insetti nel deperimento del pino domestico del litorale toscano, pp. 41-45. In: *Salvaguardia delle pinete litoranee* (BINI C., MAIANI S., Eds) Grosseto, Italy, 21-22 October 1993. Edizioni Regione Toscana, Florence, Italy.

TOZLU G., 2001.- Sarkams (Kars) Ormanlarnda Sarcam (*Pinus sylvestris* L.)'da zarar yapan Elateridae, Buprestidae, Cerambycidae, Curculionidae (Coleoptera) ve Diprionidae (Hymeoptera) familyalarna bagl turler uzerinde calsmalar.- *Turkiye Entomoloji Dergisi*, 25: 193-204.

TRIGGIANI O., SANTINI L., 1989.- Fattori entomologici nel deperimento delle pinete litoranee ioniche e tirreniche, pp. 325-337. In: *Convegno sulle avversità del bosco e delle specie arboree da legno*, Florence, Italy, 15-16 October 1987. Accademia Nazionale Italiana di Entomologia, Accademia Italiana di Scienze Forestali, Florence, Italy.

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Received April 23, 2009. Accepted November 10, 2009.