New data on Ovalisia (Palmar) festiva (Linnaeus) (Coleoptera: Buprestidae) and its natural enemies reported from Bulgaria

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Abstract
In the last decade the cypress jewel beetle Ovalisia festiva (Linnaeus, 1767) has become a real threat in many European countries. Although it was reported from Bulgaria long ago, there is no data on its current status. The aim of this study is to present new data on cypress jewel beetle’s distribution, damage and natural enemies in the country. The research was conducted in the period 2016-2019, with 106 localities on the territory of Bulgaria examined. As a result of the current study 16 localities new for this species were found. Our rearings identified adults of the parasitoid Metacolus unifasciatus Forster, 1856 (Hymenoptera, Pteromalidae) and the parasitizing mites belonging to genus Pyemotes. Amerling, 1861 (Acarina: Pyemotidae). The parasitoid-host association of M. unifasciatus with O. festiva is considered here a new biological relationship, not previously recorded for these species. Currently the cypress jewel beetle O. festiva is widely distributed in Bulgaria and can be regarded as an important pest in landscaping.

Key words: cypress jewel beetle, damage, pest, parasitoid, Metacolus unifasciatus, mites, Pyemotes.

Introduction
The first record of cypress jewel beetle, Ovalisia (Palmar) festiva (Linnaeus, 1767) from Bulgaria was nearly ninety years ago (Roubał 1931). Until the last few years, the species was considered rare and did not pose a threat to the plants in the country. Recently it has been reported as a serious pest on many ornamental species, mostly representatives of Cupressaceae, from many European countries (Razinger et al. 2013; Salvetti 2012; Nitzu et al. 2016; Volkovitsh & Karpun 2017; Rabl et al. 2017). Its range has notably extended northwards and eastwards, thus reaching the Caucasian coast of the Black Sea (Volkovitsh & Karpun 2017). Taking into account the extensive use of cupressaceans in the landscape practice, the damage caused by O. festiva is of great importance. The aim of this study is to present new data on the distribution, damage and natural enemies of cypress jewel beetle in Bulgaria.
Materials and Methods

One hundred and six localities on the territory of Bulgaria were examined in the period 2016-2019. Stem and branch cuttings of visibly affected plants, belonging predominantly to genera *Thuja* L. and *Juniperus* L. (Cupressaceae), were collected. In some localities adults of *O. festiva* were collected directly from a tree. The plant material was transported to the Laboratory of Entomology in the University of Forestry in Sofia and stored in plastic boxes. All samples were examined regularly for emerged insects.

In Locality 6 (Table 1.), 67 trees of *Juniperus scopulorum* Sarg. `Skyrocket` (10-12 - years old) were examined in detail, with their health status and presence of exit holes recorded. An independent-samples t-test was conducted to compare the diameters at the base of the trunks between healthy and infested saplings. The parasitoids were identified following the keys in Graham (1969).

Results and Discussion

In the near past *O. festiva* was recorded mainly from Southwest Bulgaria (Buresch 1932; Obenberger 1933; Angelov 1964, 1979; Weidlich 1989; Sakalian & Langourov 2001, 2007) and Plovdiv (Djuleva & Stoeva 2015). The research was conducted in 106 localities in 5 towns, 2 villages and a sea resort. As a result of the current study 16 new localities of this species were found. All established localities are given in Fig. 1 according to their respective number in Table 1. Six of the localities are ornamental nurseries, one is a roadside landscaping, eight - private properties and one – an arboretum (Table 1). Obviously, *O. festiva* range has extended and has already taken over almost the entire territory of the country.

The total number of collected specimens is 102. In the course of this study the cypress jewel beetle (Fig. 2a) was found on *Juniperus scopulorum* `Blue Arrow`, *J. scopulorum* `Skyrocket`, *Thuja occidentalis* L., *T. occidentalis* `Brabant`, *T. occidentalis* `Columnaris`, *T. occidentalis* `Danica`, *T. occidentalis` `Elegantissima`, *T. occidentalis` `Fastigiata`, *T. occidentalis` `Globosa`, *T. occidentalis` `Golden Globe`, *T. occidentalis` `Little Champion`, *T. occidentalis` `Malonyana Aurea`, *T. occidentalis` `Rheingold` and *T. occidentalis` `Smaragd`.
### Table 1. New localities of *O. festiva*, established in Bulgaria during the current study.

| №  | Established Localities                        | Altitude, m | Host plant                  | Number of collected specimens, | Personal communication (photos) | Observation period/Sample collecting period | Flight period/Emergence period in laboratory conditions |
|----|-----------------------------------------------|-------------|-----------------------------|--------------------------------|----------------------------------|-------------------------------------------|---------------------------------------------------------|
| 1  | Ornamental Nursery, Ravda Vill.               | 5           | *Thuja occidentalis*        | 16                             | -                                | 20.10.2016                               | 05.05.2017-28.05.2017                                   |
| 2  | Private property, Sofia                       | 700         | *Thuja occidentalis*        | 46                             | -                                | 02.07.2016                               | adult specimens collected from the tree                |
| 3  | Arboretum, Sofia, Forest Research Institute   | 650         | *Thuja occidentalis*        | 1                              | -                                | 23.05.2017                               | 30.05.2017                                             |
| 4  | Roadside landscaping, Gorni Dabnik Vill.     | 130         | *Thuja occidentalis* Columnaris’ | 1                              | -                                | 08.06.2017                               | 14.06.2017                                             |
| 5  | Private property, Sofia                       | 590         | *Thuja occidentalis*        | 1                              | -                                | 20.09.2017                               |                                                        |
| 6  | Ornamental nursery, Sofia                     | 570         | *Thuja occidentalis*        | 35                             | -                                | 30.03.2018                               | 30.04.2018–21.05.2018                                   |
| 7  | Private property, Sofia                       | 690         | *Thuja occidentalis* Smaragd’ | 1                              | -                                | 07.05.2018                               | 21.05.2018                                             |
| 8  | Ornamental nursery, Stara Zagora              | 210         | *Thuja occidentalis* Danica’, *Thuja occidentalis* Smaragd’, *T. occidentalis* Fastigiata’ | -                              | +                                |                                                        |                                                        |
| №  | Established Localities          | Altitude, m | Host plant                        | Number of collected specimens, photos | Observation period/Sample collecting period | Flight period/ Emergence period in laboratory conditions |
|----|--------------------------------|-------------|----------------------------------|---------------------------------------|--------------------------------------------|---------------------------------------------------------------|
| 9. | Private property, Sofia        | 670         | *Thuja occidentalis* `Smaragd`   | 1                                     | 24.08.2018                                 | 17.06.2019                                                    |
| 10.| Private property, Bansko       | 1000        | *Thuja occidentalis* `Smaragd`   | Observed exit holes                   | 11.10.2018                                 | -                                                            |
| 11.| Private property, Sofia        | 560         | *Thuja occidentalis*             |                                       | 12.06.2019                                 | -                                                            |
| 12.| Ornamental nursery, Varna      | 100         | *Juniperus scopulorum* `Sky Rocket`, *Thuja occidentalis* `Smaragd` | -                                     | -                                          | -                                                            |
| 13.| Ornamental nursery, Septemvri  | 240         | *Thuja occidentalis* `Golden globe`, *T. occidentalis* `Little Champion`, *T. occidentalis` `Smaragd` | -                                     | -                                          | -                                                            |
| 14.| Private property, Sunny Beach  | 5           | *Thuja occidentalis* `Smaragd`   | -                                     | 23.09.2016                                 | -                                                            |
| 15.| Ornamental nursery, Sofia      | 620         | *Thuja occidentalis* `Brabant`   | -                                     | -                                          | -                                                            |
| 16.| Private property, Sofia        | 560         | *Thuja occidentalis* `Smaragd`   | Observed exit holes                   | 12.09.2019                                 | -                                                            |
The observation results from Locality 6 of health status and presence of distinctive exit holes of cypress jewel beetle (Fig. 2b) are presented in Table 2. In summary, out of 67 trees 20 (30%) were healthy, 25 (37%) were infested and the rest 22 (33%) were dead. According to Wermelinger (2011) the larvae prefer to develop in branches and small stems (2-10 cm) although Karpun et al. (2017) found them in trunk with a diameter of 24 cm. The results of the statistical analysis of the measured diameters did not show significant difference between the trunk diameters within the two groups of trees (healthy and infested), p=0.6 (Table 3).

Regarding the natural enemies of cypress jewel beetle, no published data has been found. According to Lim et al. (2006), only Sclerodermus harmandi (Buysson 1903) (Hymenoptera, Bethylidae) is known to parasitize stem boring insects belonging to genus Ovalisia, in particular O. vivata (Lewis 1893). In April, 2018, in laboratory conditions 3 adults (2 males and 1 female) of Metacolus unifasciatus Forster, 1856 (Hymenoptera, Pteromalidae) (Fig. 3a) emerged from plant material of J. scopolorum ‘Skyrocket`. Two of them emerged from trunk cuttings with a diameter of 2-4 cm and the third - from the terminal shoot (40 cm in length) collected in Locality 6.

![Figure 2](image_url). Ovalisia festiva, adults (a); exit hole (b).

After collecting the parasitoids, the trunk bark around the parasitoid exit holes was peeled off and larval galleries only of O. festiva were established. Presence of other xylophagous insects and potential hosts such as Phloeosinus aubei (Perris, 1855) and P. thujae (Perris, 1855) was not detected. Thus we consider that in this particular sample the individuals of M. unifasciatus completed their development as parasitoids on O. festiva larvae or pupae. As an oligophagous parasitoid on many xylophagous beetles (Cerambycidae and Curculionidae), mainly scolytids (Noyes 2019), M. unifasciatus is commonly found when concealed wood-boring insects are reared. However, unlike its association with bark beetles, the established one with Buprestidae could be considered more or less random and unusual, mostly due to the similar situations in which the host larva feeds. Only one possible relation of M. unifasciatus with a buprestid species, Anthaxia quadripunctata (Linnaeus, 1758), has been published until now (Mitroiu et al. 2007). M. unifasciatus has been reported as associated only with trees belonging to genera Pinus, Picea and Thuja (Noyes 2019).

### Table 2. Results from Locality 6 (67 saplings of Juniperus scopolorum `Skyrocket`)  

| Plant health status | Number | % | Presence of exit holes |
|---------------------|--------|---|------------------------|
| healthy             | 20     | 30| -                      |
| infested            | 25     | 37| +                      |
| dead                | 22     | 33| +                      |

On 06 October 2016 the larvae of O. festiva found under the bark of Thuja occidentalis were massively covered with parasitizing mites belonging to genus Pyemotes Amerling, 1861 (Acarina: Pyemotidae) (Fig. 3b). The genus Pyemotes comprises fourteen species in Europe (Magowski 2013) divided into scolyti and ventricosus groups (Cross et al. 1981). No information about association with genus Ovalisia has been found. The straw itch mite Pyemotes tritici (LaGreze-Fossot & Montagne, 1851) is known to
parasitize on Lepidoptera, Hymenoptera and Coleoptera, including some species of *Agrilus* Curtis, 1825 (Coleoptera, Buprestidae). The mite is considered a potential biological control agent although it has a detrimental effect on human health (Coleman et al. 2014).

**Figure 3.** Natural enemies of *O. festiva*: *Metacolus unifasciatus*, female (a); *Pyemotes* sp. parasitizing on *O. festiva* larva (b)

The cypress jewel beetle’s expansion is considered to be due to enhanced trade of ornamental plants and global warming (Wermelinger 2011; Rabl et al. 2017). In this regard it should be pointed out that in the last years climate change in Bulgaria has significantly affected the spread of some important insect pests such as the pine processionary moth - *Thaumetopoea pityocampa* (Denis & Schiffermüller, 1775) (Zaemdzhikova & Doychev 2019; Raev et al. 2011). The results from the present study are consistent with the data from other authors about the expansion of *O. festiva* in Europe. In personal communications with ornamental plant producers we found out that most of the infested plants were imported from European countries (Hungary, Italy and Germany).

| Plant health status | Diameter at the base (cm), Mean | Standard error of Mean | Standard Deviation | Variance |
|---------------------|---------------------------------|-------------------------|--------------------|----------|
| healthy             | 6.6                             | 1.91                    | 3.83               | 14.65    |
| infested            | 6.16                            | 0.78                    | 1.75               | 3.06     |

*Ovalisia festiva* is a holomediterranean species with larval development of one year in the Mediterranean region (Hellrigl 1972; Mohamed et al. 2015; Schmidt et al. 2014) or even two to three in Central Europe (Germany, Romania) (Wermelinger 2011; Nitzu et al. 2016). It is reported in North Africa: Algeria, Tunisia, Morocco and Libya, and Europe: Portugal, Spain, France, Italy, Austria, Germany, Serbia, Bulgaria, North Macedonia, Greece, Croatia, Bosnia and Herzegovina, Montenegro, Slovenia, Luxembourg, Switzerland, Netherlands, Hungary, Romania, Russia (Hellrigl 1972; Thoma & Eickermann 2014; Rabl et al. 2017; Nitzu et al. 2016; Sakalian 2003; Schmidt et al. 2014; Volkovitsh & Karpun 2017). According to literature sources (Hellrigl 1978; Volkovitsh & Karpun 2017; Mohamed et al. 2015; Pedersoli 2016, Sakalian 2003; Schmidt et al. 2014) the species feeds on Cupressaceae family: *Juniperus communis* L., *J. chinensis* L. ‘Keteleeri’, *J. oxycedrus* L., *J. phoenicea* L., *J. scopulorum* ‘Sky Rocket’, *J. thurifera africana* (Maire) Gauquelin & Idr.Hass. & P.Lebreton, *Callitris* sp., *Chamaecyparis lawsoniana* (A.Murray bis) Parl., *Ch. pisifera* (Siebold & Zucc.) Endl., *Cupressus atlantica* Gaussen, *C. sempervirens horizontalis* L., *Thuja occidentalis*, *T. plicata* ´Zebrina´ Donn ex D.Don, *Platycladus orientalis* (L.) Franco, *Tetraclinis articulate* Mast., as well as *Ziziphus lotus* Lam. and *Tamarix* sp. The first attack symptoms are chlorosis and leaf dying followed by death of branches or the whole plant (Razinger et al. 2013; Mohamed et al. 2015). Until now the cypress jewel beetle has not been considered a threat in Bulgaria. There is no direct information about its host plants with the exception of the reports on *Juniperus* sp. (Obenberger 1933) and *T. occidentalis*.
(Djuleva & Stoeva 2015), although no specific evidence to support such a link has been provided (e.g., rearing or larval collection). During our study we found that *O. festiva* is definitely harmful to the ornamental plantings from Cupressaceae especially in places where they are used as hedge plants as well as in the ornamental nurseries. In half of the observed private properties the jewel beetle had destroyed all hedges thus causing significant financial damage.

After personal communications with six ornamental plant producers, five of them had informed that they had to destroy considerable amount of infested plants.

**Conclusions**

The cypress jewel beetle *O. festiva* can already be considered widely distributed in Bulgaria and an important pest in the landscape practice. A few natural enemies have been identified that may have the potential to reduce its population density. Additional studies are necessary to further investigate the spread and control of this pest.

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