First report of caper (Capparis spinosa) serious infestation by Eurydema eckerleini in Cyclades Islands, Greece (Hemiptera: Heteroptera, Pentatomidae)

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Abstract
The islands of Tinos and Syros in the Cyclades Archipelago, Greece, have a hilly terrain, a mild Mediterranean climate and vegetation adapted to drought conditions. Caper (Capparis spinosa L.) is highly adapted to arid environments and grows successfully during the Mediterranean summer. In August 2015, we detected serious infestations on wild caper by Eurydema eckerleini (Pentatomidae), which was formerly considered a species endemic to Crete and the Peloponnese, with an isolated report in Turkey. This is the first record of the presence of E. eckerleini in the Cyclades.

Key words: Eurydema eckerleini, Pentatomidae, Caper, Cyclades, Greece.

Introduction
Six Heteroptera insect pests, of the Pentatomidae family, have been reported worldwide to infest caper: Bagrada hilaris (Burmeister), Nezara viridula (L.), Eurydema ventralis Kol., Eurydema ornata (L.), Holcostethus punctatus (Lindberg), Antheminia lunulata (Goeze) (Infantino et al. 2007). All these species are polyphagous and rarely represent a serious problem for caper, but B. hilaris is an oligophagous species which, besides infesting crucifers (Huang et al. 2011), is a major pest of caper crops in many parts of Asia and Africa (Colazza et al. 2004, Infantino et al. 2007). Another species, Eurydema eckerleini Josifov, 1961, considered endemic to the island of Crete and Peloponnese, Greece (Josivov & Simov 2006; Derjanschi & Péricart 2006), was reported also in Turkey (Rider 2006); it is monophagous on caper.

In August 2015, extensive infestations by nymphs and adults of a Pentatomidae insect species were observed on foliage of wild caper plants (Capparis spinosa L.) on the islands of Tinos and Syros (Northern Cyclades, Aegean Archipelago, Greece). Both adults and nymphs were observed feeding on the foliage and flower buds of caper, causing white chlorotic spots from the sucking of the leaf parenchyma tissues. The pale spots where progressively merged in severely infested plants. These plants had a diffuse pale yellow tint. Local, brown necrotic lesions on the leaves at the insects’ feeding points were also observed (Fig. 3). No heavily infested plant was observed bearing flowers. According to local agronomists, infestations of caper were observed in the last three or four years. The establishment of E. eckerleini on Tinos is probably recent; in August 1993 Attilio Carapezza (pers. communication) collected extensively on the island inspecting several wild plants of Capparis, but no specimen of this Pentatomidae was observed.

Methods of identification and results
Adult specimens were collected from infested plants and were retained in 70% alcohol for species identification.

Based on both external shape and male genitalia morphology, the species was identified as Eurydema eckerleini Josifov, 1961, by the second author. The species is new to the Cyclades.

The genus Eurydema Laporte, 1833 is classified in the Strachiini tribe of the Pentatominae subfamily (Rider 2006). The species of this genus are generally coloured white/yellow and black or red and blue and black. This aposematic coloration functions as a warning signal of toxicity even when the species possesses chemical or physical defences to deter predators. Species of this genus are usually trophically bound to the plants of the family Brassicaceae and some of them, especially Eurydema (Eurydema) oleracea (Linnaeus, 1758), are known to cause damage to cultivated crops (Bohine & Trdan 2012).

Today, 33 species of Palaearctic Eurydema are cata-
They are classified into three subgenera: *Eurydema s. str.* (13 species), *Horvatheurydema* Dupuis, 1951 (4 species) and *Rubrodorsalium* Stichel, 1944 (10 species). Six species remain incerta sedis. A review and an illustrated key to western Palaearctic *Eurydema* are provided by Derjanschi & Péricart (2006).

*Eurydema eckerleini* (Fig. 1), is distinguished by its larger dark spots on the apical parts of the corium than *E. spectabilis* Horváth, 1882 and the base of the scutellum is coarsely punctuated, with a large dark spot extended to the base of the corium and the clavus. But the distinguishing characteristic is the different shape of the paramera allowed into the genital capsula: the blade of the paramera is much thinner than that of *E. spectabilis*.

The body is oval, oblong and shiny, the dorsum is black with orange-red drawings and more densely rugulose and heavily dotted on the head, rather coarsely punctuated on the pronotum and more finely and densely on the hemelytra; the antennae, rostrum and legs are black, including the trocanteres and the coxae.

Head with juga strongly bisinuate. Eyes rounded and contiguous forward. Rostrum reaching the metacoxae. Pronotum with the forelimbs angles with a small tip. All widely partour orange-red as a large longitudinal median strip. The rest of it is occupied by two anterior and four posterior black spots, or by only two large black spots, each of them results from the merger, more or less complete, of the previous three. Disk of pronotum coarsely punctuated, with a fairly clear anterior bulge followed by a transverse furrow. Scutellum black, a little longer as wide, convex forward, with medio-apical red spot, arrow-shaped, with enlarged base in two arms and the triangular tip that corresponds to the whole apex of the scutellum. Hemelytra red with black-blue spots: clavus completely black, corium with a central black spot and, apically, a smaller one. Esocorium with a medial, sub-rectangular, black spot. Membrane black with bluish reflections.

**Discussion**

The general distribution of *E. eckerleini* is restricted to Crete, the Peloponnese (Derjanski & Péricart 2006) and Turkey (Rider 2006).

This taxon is very similar to *E. spectabilis*, a Ponto-East-Mediterranean species, as it was recorded in seacoasts of Albania, Greece, Crete, Bulgaria, Romania, Ukraine, the South European Territory of Russia, Georgia and the Asian part of Turkey (Rider 2006; Derjanschi & Péricart 2006; Kment & Jindra 2008). The records from Israel and Syria (Bodenheimer 1937) are doubtful.

*Eurydema eckerleini*, *E. spectabilis* and *E. ventralis* (Fig. 2) appear to coexist in Greece where they occupy three different ecological niches: *E. ventralis* is the most common throughout the Palaearctic Region and lives in gardens and cultivated fields of *Brassicaceae* (Derjanski & Péricart 2006).

*E. spectabilis* was recorded behind the dunes on *Cakile maritima* Scop., *Crambe maritima* L. (syn: *C. pontica* Rupr.) (*Brassicaceae*) and on *Salsola kali* I. (*Amaranthaceae*) (*Brassicaceae*) and *Sinapis arvensis* L. (*Brassicaceae*). Finally, *E. eckerleini* is monophagous on *Capparis spinosa* (Josifov, 1960).

The Cyclades islands comprise one of the thirteen distinct phytogeographical regions of Greece according to the Flora Hellenica Project (Strid & Tan 1997). The islands of Tinos and Syros belong to the specific biogeographical module of the Northern Cyclades (Kougioumoutzis et al. 2014). Thirtythree cruciferous plant species (*Brassicaceae*) have been recorded on the islands of Tinos and/or Syros and could potentially be hosts of *E. spectabilis* along the coasts of the islands (Tan 2002b). In addition, *Salsola kali* I., a member of the subfamily Salsoloideae in *Amaranthaceae* (Bremer et al. 2009) has been recorded in Tinos and Syros Islands (Tan 1997), which is a known host plant of *E. spectabilis* (Josifov 1957).

Most of the Cyclades islands have hilly interiors, rocky valleys and precipitous coastlines, with few fertile plains. The general maximum altitude is between 600 and 700 m in most of the Cyclades. The climate is mild temper-

![Fig. 1 – Eurydema eckerleini (photo by P. Dioli).](image-url)
Eurydema eckerleini in Cyclades Islands

Mediterranean and frosts are absent or rare (Polunin 1987; Gouvas & Sakellarios 2011). Winds blow predominantly from the north-west but in summer fierce north-east winds, the etesians, prevail (Tyrlis & Lelieveld 2013) with mean wind speeds between 10-14 kt (18-26 km/h) (HNMS 2015). The Mediterranean climate is distinguished by its hot and rainless summers, contrasting strongly with the rainy but mild winter months. The annual total rainfall may be below 400 mm in the Cyclades. Rain falls almost entirely during the winter months, from November to April (Polunin 1987; Gouvas & Sakellarios 2011) with a low overall rainfall erosivity factor (Panagos et al. 2016). This is followed by as much as 3-5 months of summer drought, with an average monthly rainfall below 25 mm (Polunin 1987; Ljubenkov 2013).

The periodicity of rainfall has an overriding effect on the vegetation of the Mediterranean Basin. In consequence of the long period of drought and often uncertain rainfall, plants have evolved protective adaptations against desiccation, such as the evergreen shrubs’ sclerophyll feature.

Fig. 2 – a, Eurydema spectabilis; b, E. eckerleini; c, E. ventralis (photos by P. Dioli).

Fig. 3 – Infested caper plants in Tinos Island (photo by K.B. Simoglou).
leaf shedding of above-ground shoots, bulb and rhizome formation (Poluin 1987), or the formation of extended root systems, as in the case of caper (Rhizopoulou & Kapolas 2015).

Caper (Capparis L., Capparaceae) is found growing both in the wild and under cultivation and its flower buds are widely accepted for their pungent and strong aromatic properties. Capparis spinosa ssp. rupestris is found all over the Cyclades Islands, on coastal rocks and cliffs, mostly limestone, at altitudes between 0-500 m (Heywood et al. 1993; Tan 2002a; Fici 2014). It is a perennial deciduous plant that becomes woody at maturity. It has a very large root system which may account for 65% of the total biomass. The plant canopy is made up of 4-6 radial decumbent branches from which many secondary stems grow. Flowers are 5-7 cm across, axillary, solitary and have four imbricate, white petals. The flowering period is from May to July (-September). The fruit is ellipsoid, ovoid with a thin pericarp (Sozzi 2001).

Caper is one of the few perennial shrubs that grow and flower entirely during summer (Sozzi 2001). It possesses many adaptations that enable it to survive in arid environments such as that of the Cyclades. The caper bush can withstand temperatures above 40°C in the summer (Sozzi 2001), as well as combat desertification (Sakcali et al. 2008; Suleiman et al. 2009). This is achieved by the extension of the root system downward to a depth of up to 20 m in order to reach subsoil water (Rhizopoulou & Kapolas 2015) and horizontally in order to maximize access to rainfall water (Sozzi 2001). This characteristic is supported by a high hydraulic conductivity achieved by highly specialized conducting tissue, both in roots and stems, along with the presence of thick, amphistomatous and highly photosynthetically efficient leaves (Rhizopoulou et al. 1997; Sozzi 2001; Rhizopoulou & Psaras, 2003; Sakcali et al. 2008; Gan et al. 2013).

Caper, as a member of Capparaceae (Brassicaceae), is closely related, on the basis of molecular and morphological analysis, to the members of the Brassicaceae (Sozzi 2001; Hall et al. 2002; Bremer et al. 2009; Ittis et al. 2011), to which the host plants of the other two Eurydema species (E. ventralis, E. spectabilis) belong. Bioactive secondary metabolites (glucosinolates) are abundant in crucifers as well as in caper species (Kidde et al. 2001; Bor et al. 2009; Argentieri et al. 2012; Bianco et al. 2012; Lansky 2014). Volatile, glucosinolate hydrolysis products play an important role as plant defense chemicals against polyphagous insect-pests including aphids, grasshoppers and many non-cruifer-feeding lepidopterans (Sadasivam & Thayumanavan 2003; Walters 2011).

On the contrary, glucosinolates are attractive to the major specialized crucifer herbivores, by possessing phagostimulatory effects and playing a key role on the oviposition behavior of crucifer-infesting insects [e.g. Pieris brassicae L. (Lepidoptera: Pieridae), Plutella xylostella L. (Lepidoptera: Plutellidae), Brevicoryne brassicae L. (Hemiptera: Aphididae), Delia radicum L. (Diptera: Anthomyiidae)] (Bernays & Chapman 1994; Price et al. 2011). Similarly, it has been assumed that secondary metabolites present in Brassica oleracea (L.) play an important role in selection of host plant by Eurydema pulchrum Westwood, an oligophagous, crucifer-infesting pest (Rather et al. 2010). We speculate here that, in the same way, E. eckerleini as a monophagous species is also attracted by similar volatile secondary metabolites of caper plants, during the host selection process, under hot and dry summer conditions, when probably the choice of available hosts is limited in the isolated Cyclades Islands. Nevertheless, more research is needed to confirm this.

In conclusion, this is the first record, to our knowledge, of the presence of E. eckerleini in the Cyclades Islands. Also, we report for the first time the detection of severe infestation (Fig. 3) on wild caper plants in the Cyclades, caused by E. eckerleini. More research is needed to guarantee possible environmentally friendly control methods in the case of infestation of cultivated caper plants.

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