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Original scientific paper

Bionomy of the laurel scale *Aonidia lauri* (Bouche) (Hemiptera: Diaspididae) in Podgorica, Montenegro

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SUMMARY

Aonidia lauri (Bouche) (Hemiptera: Diaspididae) is a serious pest of laurel (*Laurus nobilis* L.) in urban parts of the City of Podgorica (Montenegro). Severe infestation causes chlorotic spots and necrotic rings around feeding spots, drying and dieback of leaves and buds. In addition, plants become physiologically weak and lose in aesthetic quality, while continuous infestation in urban areas often leads to partial or complete drying of plants.

This study of the biology of *A. lauri* on *L. nobilis* was carried out at three locations in Podgorica ('Stara Varoš', 'Centar' and 'Preko Morače'), Montenegro, in 2010 and 2011. *A. lauri* developed three generations annually and overwintered on laurel leaves and branches as the second-instar nymph-larval stage. An extended period of larval development ensures a continuous presence of all development stages on plants, which leads to overlapping of generations.

Sporadic predatory ladybirds, *Chilocorus bipustulatus* (L.) (Coleoptera: Coccinellidae), whose larvae and adults feed on scales, were detected inside *A. lauri* colonies.

Keywords: Laurel scale; Bionomy; Predators; Montenegro

INTRODUCTION

The laurel scale *Aonidia lauri* (Bouche) (Hemiptera Diaspididae) occurs in almost all regions of the world, except Australia and the Pacific Islands (Danzig & Pellizzari, 1998). It is a monophagous species that infests *Laurus* sp. (Lauraceae) and causes serious damage in all laurel-growing areas (Borchsenius, 1966; Miller & Davidson, 1990). *A. lauri* sucks sap from all above-ground parts of laurel, causing abnormal shoot growth and physiological weakening of the plant. By injecting toxic substances into plant tissue during feeding, *A. lauri* also causes chlorotic spots and necrotic rings on leaves.

Symptoms of discoloration, followed by drying of leaves and dieback of branches, even of entire plants, are visible on infested plants. Such plants not only lose in aesthetic quality but also their usability as food.

The species has been researched by many foreign authors, who have contributed to better understanding of the laurel scale morphology, biology and natural enemies.

After *A. lauri* was introduced into Russia, damage was detected in greenhouses in many Russian cities

(Borhsenius, 1963, 1966; Terezikova & Chumak, 1989; Kozarževskaja, 1992; Danzig, 1993). Damage was also reported in urban areas of Turkey in which chemical control was not practiced (Ulgenturk et al., 2008; Erler & Tunç, 2001), as well as in France (Foldi, 2001), Italy (Leonardi, 1920) and Croatia (Schmidt, 1956; Masten-Milak, 2007). However, although *A. lauri* was detected on laurel trees in the towns of Bar and Risan, Montenegro, early in the 20th century, those are the only published data available on this species so far (Lindinger, 1911, cited by Bachmann, 1952-1953).

Over the past few years, symptoms resembling very much those caused by laurel scale, some of them quite severe, have been noticed on some older laurel plants in the urban area of Podgorica.

Laurel trees had grown only sporadically in Podgorica until some ten years ago, mainly as solitary old trees, although groups of several trees, densely planted next to each other do occur in such locations as parks, small green urban plots or in private gardens. But laurel has over the past decade gained in importance as an ornamental plant, and is increasingly an integral part of urban greenery, both private and public. Although domestic production of laurel nursery plants has increased, they are also being imported.

A. lauri has not been studied in detail in Montenegro but, as the proportion of laurel trees in Podgorica's greenery has significantly increased, the present study aimed to investigate the life cycle and general biology of *A. lauri* and to identify its natural enemies.

MATERIAL AND METHODS

The population density of *A. lauri* was determined visually and by sampling infested plants in parks and other public greenery at three locations in Podgorica, namely 'Stara Varoš', 'Centar' and 'Preko Morače'. Podgorica is situated at an altitude of 44.5'm, on the geographical coordinates of 42 ° 26 '17 „N and 19 ° 15' 29" E (www.toolserver.org), and it has a Mediterranean climate. The data for mean monthly temperatures and mean monthly relative humidity in 2010 and 2011 are presented in Figures 6 and 7 (Hydrological and Meteorological Service of Montenegro).

Each laurel plant was examined visually and pest population density recorded using the Borhsenius (1963) scale: 0 – no scales, 1 – sporadic specimens only, 2 – both sporadic specimens and small colonies, 3 – small or large colonies, and 4 – all plant parts covered with large colonies.

Plant material was sampled every 7-15 days during the vegetative season, and once a month during dormancy. Five one- or two-year-old twigs, about 20 cm long, were cut off from each of four sides of each infested plant and examined in the laboratory in order to determine the number of scales and their development stage.

To monitor the scale life cycles, the sampled twigs were placed in glass cylinders or photoeclectors, where both the scales and their natural enemies (present in sampled colonies) were reared. Also, the duration of larval emergence period, postembryonic development, the number of generations and mode of overwintering were analyzed.

Permanent microscopic slides of females were made according to Kosztarab & Kozar (1988) for morphological studies.

RESULTS AND DISCUSSION

Morphology of *A. lauri*

A. lauri is characterized by pronounced sexual dimorphism. The scale cover of an adult female is 0.9-1.3 mm in diameter, round or broadly oval, convex, brown, with one orange sub-central larval exuvia. The scale cover of a male is oval, much narrower than the female's,and brown with an orange larval exuvia at the apex.

The female has no eyes, wings or legs, and is immobile. It develops within the second-instar nymphal exuvia, the so-called puparium, and belongs to the pupillarial group of disaspidid species (Figure 1). An adult female may live for several weeks. The male is winged, with well-developed antennae, legs and eyes but lacks mouthparts and only lives for a few days (Figure 2).

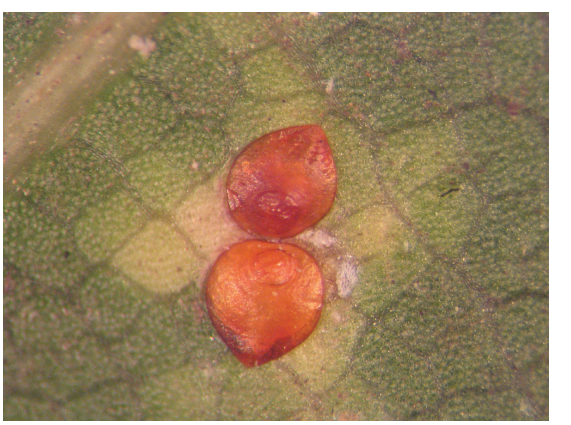

Figure 1. Females of *A. lauri* within the second-instar nymphal exuviae, so-called puparium

Figure 2. Male of *A. lauri*

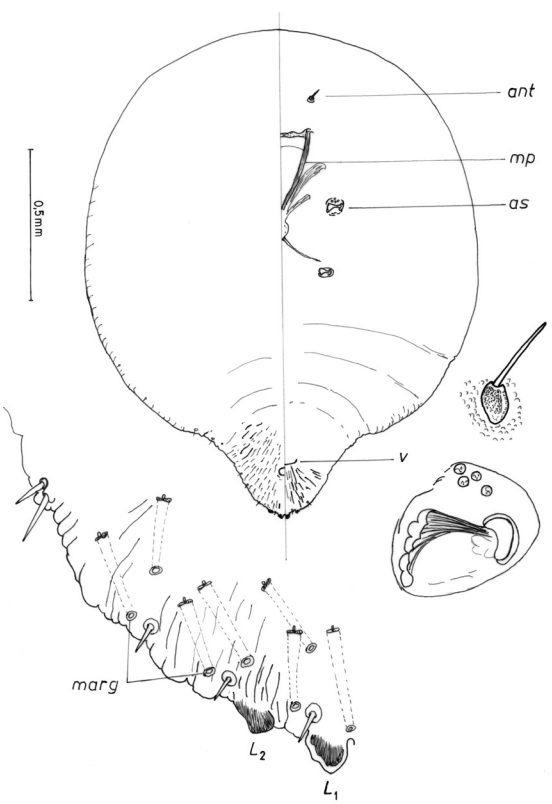

Figure 3. Female *A. lauri* - morphology: ant - antenna; mp - mouthpart; as - anterior spiracle; v - vulva; marg - marginal macroducts; L_1, L_2 - median and second lobe

Species identification is based on the morphological characteristics of females (Figure 3). The female is pear-shaped and pink. The antennae (ant) are reduced to unsegmented papillae bearing one seta. The mouthpart (mp) is for piercing and sucking, placed at the level of the anterior thoracic spiracle. The anterior spiracles (as) contain 2-4 disc glands. The pygidium has two pairs of lobes. The medial lobes (L_1) are triangular, close to each other at the basis and sharpened at the top. The second pair of lobes (L_2) is smaller than the medial lobes, and sometimes even completely missing. One - barred marginal macroduct (marg) is placed on the pygidium and along the edges of pygidial segments of the abdomen. The pygidium is without perivulvar pores and paraphysis. The first-instar larva or 'crawler' is pink, with well-developed legs, eyes and antennae. It is, with an exception of adult males, the only mobile stage, and is the dispersive stage of the species. The second-instar female nymph is pink and similar to the adult female, from which it differs only by the presence of three pairs of lobes and gland setae on the pygidium.

Intensity of infestation and symptoms of damage

A. lauri was detected on some laurel plants in Bar and Risan early in the twentieth century but there were no records of it for a long time after that (Lindinger, 1911, cited in Bachmann, 1952-1953). *L. nobilis* is an ornamental plant which has been increasingly used in Podgorica urban greenery over the past ten years. Today, a hundred years after the first records, the species was detected again on laurel plants at three locations in Podgorica, namely: 'Stara Varoš', 'Centar' and 'Preko Morače'.

All sampled plants were rated 4 (on the Borhsenius scale), indicating that all plant parts were covered by numerous dense colonies. In small populations, larvae and females settled on the leaf underside, but large populations included all stages and spread to the upper side of the leaf as well (Figure 4), causing chlorotic spots and necrotic rings (Figure 5). Damaged leaves are not acceptable for human consumption, they dry out prematurely and fall off.

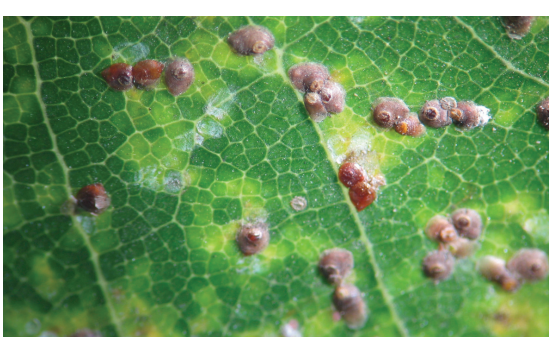

Figure 4. Colonies of *A. lauri* on the leaf of *Laurus nobilis*

Figure 5. Chlorotic spots on the leaf of *Laurus nobilis*

Other symptoms include weak growth of shoots and general physiological weakening of plants, causing drying of branches and even of entire plants. Such plants lose in their aesthetic qulity not only as a result of new damage but also because dry scales leave covers from previous years.

Our observations are similar to those of Miller and Davidson (1990); Kozarževskaja (1992); Danzig (1993); Ulgenturk et al. (2008); Erler & Tunç (2001); Foldi (2001), and Masten-Milak (2007).

Life cycle

A. lauri has three generations per year and overwinters as the second-instar nymph on leaves and branches (Table 1). In the spring, larvae resume development into males or females. In 2010, adults of the first generation were detected on 15th April, when the mean monthly temperature was 15.9°C and mean monthly relative humidity 64%, while in 2011 adult females were detected earlier, on 25th March, when the mean monthly temperature was 10.7 °C and mean monthly relative humidity 63% (Figures 6 and 7).

Table 1. The emergence time of *Aonidia lauri* by development stage and year in the area of the City of Podgorica

Year	2010		2011	
Development stage	Female development	Male development	Female development	Male development
Female	15. 04.	-	29. 03.	-
Male	-	13. 04.	-	27. 03
N_1	07. 05.	07. 05.	19. 04.	19. 04.
N_2	14. 06.	14. 06.	26. 05.	26. 05.
pn	-	20. 06.	-	02. 06.
n	-	26. 06.	-	09. 06.
Female	04. 07.	-	18. 06.	-
Male	-	02. 07.	-	16. 06.
N_1	21. 07.	21. 07.	06. 07.	06. 07.
N_2	25. 08.	25. 08.	11. 08.	11. 08.
pn	-	02. 09.	-	19. 08.
n	-	10. 09.	-	27. 08.
Female	20. 09.	-	05. 09.	-
Male	-	18. 09.	-	04. 09.
N_1	08. 10.	08. 10.	25. 09.	25. 09.
N_2	15. 11.	15. 11.	01. 11.	01. 11.

N_1 - first instar „crawler", N_2 - second instar, pn - prepupa, n - pupa

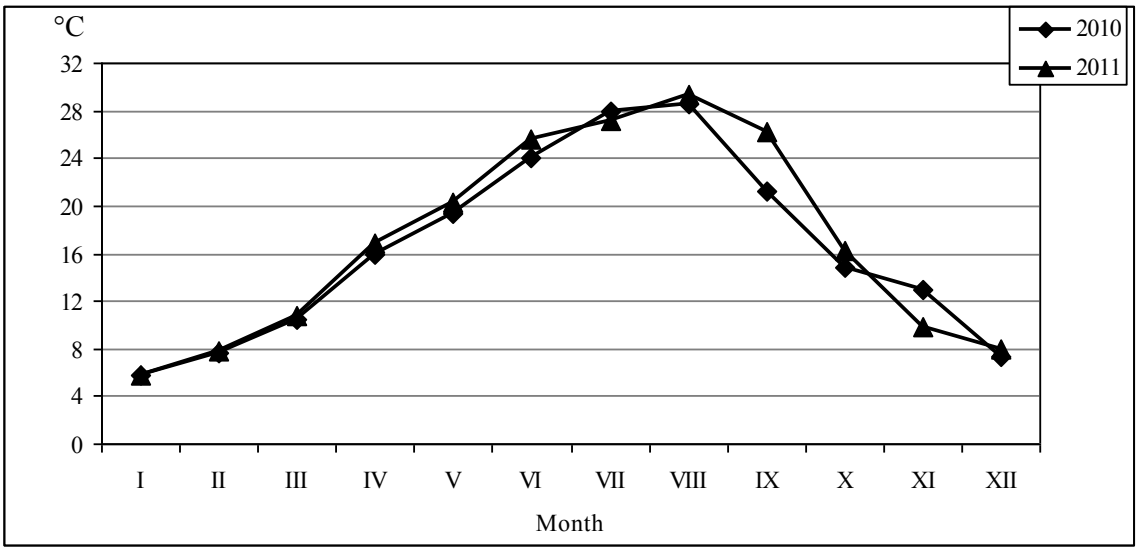

Figure 6. The average monthly temperature in Podgorica in 2010 and 2011

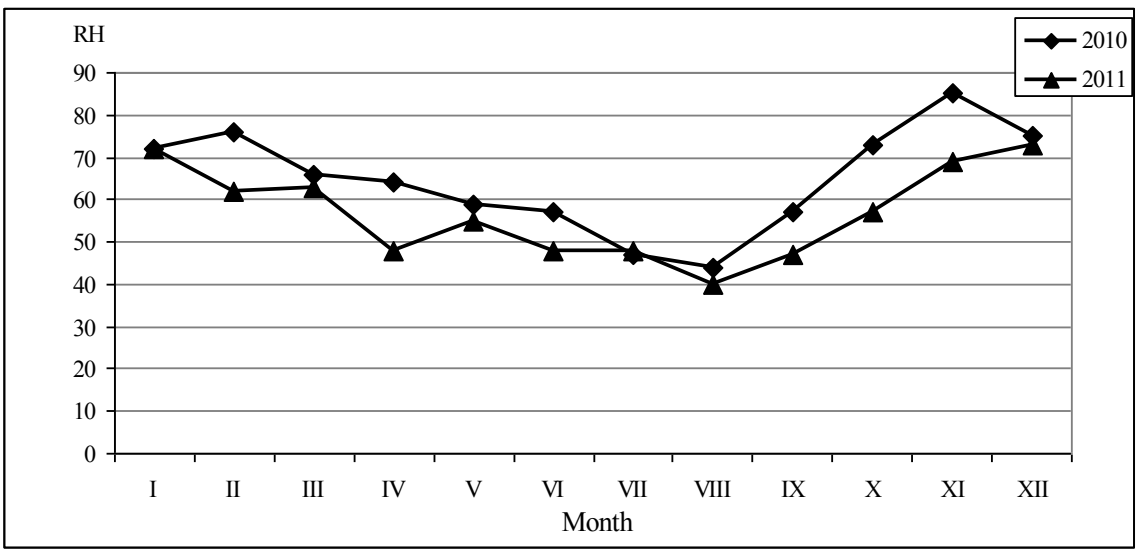

Figure 7. The average monthly relative humidity in Podgorica in 2010 and 2011

In both years, the mean monthly temperatures were similar over the spring months (February, March, April) when growth resumed. Minimum mean monthly temperatures in both years were recorded in January (5.8°C), while the highest were recorded in August of 2010 and 2011 (28.5 °C and 29.3 °C, respectively). The mean relative humidity over the spring months of 2010 was higher than in the spring of 2011 and resulted in a delayed development of adults, considering that this is a thermophilic species. The minimum mean relative humidity was recorded in August of 2010 and 2011 (44% and 40%, respectively), while mean relative humidity was at the maximum in November 2010 (85%) and December 2011 (73%). *A. lauri* is a viviparous species and the first generation female begins to give birth to nymphs after twenty days. First ''crawlers'' appeared on 7 May 2010, and 19 April 2011. The nymphs moved actively over plants in search of a suitable place to settle, usually on leaves and branches, and then stopped moving and began to feed. At the same time, they excreted wax to form white circular scale covers.

Nymphs appeared over a prolonged period of about two months.The development of first instar nymphs (''crawlers'')

of the first generation lasted 37-38 days, so that second-instar nymphs appeared in mid-June (14 June 2010), or at the end of May (26 May 2011). Sexual differentiation takes place at this nymphal stage, and the development of second-instar females lasted 20-23 days. After moulting, nymphal exuviae remain around scale bodies, so that females develop within the nymphal exuviae of the second instar. Due to this hidden way of female development, *A. lauri* belongs to the group of pupillarial scales.

The second generation adult females first appeared on 4 July 2010 and 18 June 2011, so that total development time for the second-generation females was 58-60 days. The development of second-instar males took 6-7 days, after which prepupae and pupae appeared. Their development also lasted 6-7 days and the adult males first emerged on 2 July 2010 and 16 June 2011. The overall development of males lasted 56-58 days. Second-generation females gave birth after 17-18 days, and crawler emergence was detected on 21 July 2010 and on 6 July 2011. The development of 'crawlers' lasted 35-36 days, so that the second-instar nymphs were detected on 25 and 11 August, respectively. Adult females of the third generation were detected on 20 September 2010 and 5 September 2011. Total development time of the third generation females lasted 61 days, while males developed over 59 days. The emergence of 'crawlers' was detected on 8 October 2010 and 25 October 2011, and the overwintering second-instar nymphs appeared in the first half of November 2010 and 2011 (15 November and 11 November, respectively). The proportion of females to males in our samples was approximately 2:1.

Due to a prolonged period of nymphal emergence, the generations overlapped over the year, and nymphs of both the first and second instars were present in colonies when the next generation of adults appeared.

These observations, the first for Montenegro, are consistent with those of Danzig (1993) and Danzig & Pellizzari (1998).

Natural enemies

There were no data on natural enemies of *A. lauri* in Montenegro before this study. We observed *Chilocorus bipustulatus* (L.) (Coccinellidae) adults and larvae feeding on *A. lauri* colonies. *C. bipustulatus* is a cosmopolitan species and feeds on many different scale insect genera (Drea & Gordon, 1990). *C. bipustulatus* has been detected in neighbouring Serbia as a predator of *Quadraspidiotus perniciosus* Comstok, *Lepidosaphes ulmi* L. and *Pseudaulacaspis pentagona* Targioni Tozzetti (all Diaspididae) (Graora, 1994, Graora et al., 2009).

The ladybird larvae preferred feeding on settled 'crawlers', while adult ladybirds bit through the scale cover first, and then ate the adult scale. Larval *C. bipustulatus* usually pupated on the leaf underside. After eclosion, however, adult ladybirds were only rarely detected feeding but were then seen to eat all instars of *A. lauri*. Although seven species of Aphelinidae (Chalcidoidea: Hymenoptera) have been recorded as parasitoids of *A. lauri* (Noyes, 2015), none were detected in Montenegro in this study. A small number of predators and absence of parasitoids is almost certainly one of the reasons for such rapid and unimpeded spread of the species.

The absence of specific natural enemies, as well as the limited use of chemicals in urban areas of Podgorica, make control of this species very difficult. Since *A. lauri* probably spreads mainly by transport of infested planting material, using healthy nursery plants for new green areas is one of the necessary preventive measures, as well as strict control rules for transports of fresh leaves (Burger & Ulenberg, 1990).

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Bionomija lovorove štitaste vaši, *Aonidia lauri* (Bouche) (Hemiptera: Diaspididae) na području Podgorice, Crna Gora

REZIME

Aonidia lauri (Comstock) (Hemiptera: Diaspididae) je na području Podgorice veoma opasna štetočina lovora (*Laurus nobilis* L.). Visok stepen infestacije biljaka izaziva pojavu hlorotičnih pega i nekrotičnih polja oko mesta ishrane, sušenja lišća i pupoljaka. Pored toga, biljke fiziološki slabe, gube estetsku vrednost, a kontinuirani napad u gradskim uslovima često dovodi do njihovog delimičnig ili potpunog sušenja. U više lokacija na teritoriji Podgorice, na uzorkovanim biljkama lovora intenzitet napada je ocenjen sa 4, odnosno svi delovi biljke su bili naseljeni brojnim jedinkama koje su formirale guste kolonije.

Biologija i štetnost *Aonidia lauri* proučavana je u 2010. i 2011. godini, na *L. nobilis*. Utvrđeno je da vrsta ima tri generacije godišnje i da prezimljava u drugom larvenom stupnju na listovima i granama lovora.

Imaga prve generacije registrovana su krajem marta i početkom aprila, druge generacije krajem juna i početkom jula i treće, tokom septembra. *A. lauri* je viviparna vrsta. Razvučen period pojave larvi obezbeđuje stalno prisustvo svih razvojnih stadijuma na biljkama, što dovodi do preklapanja generacija.

U kolonijama *A. lauri*, registrovani su pojedinačni primerci predatorske bubamare *Chilocorus bipustulatus* (L.) (Coccinellidae) čiji su se larve i imaga hranili vašima.

Ključne reči: Lovorova štitasta vaš; Bionomija; Predatori; Crna Gora