

Damage Caused by White Snail *Cer­nuella virgata* (Da Costa) to Green Onion Crop

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SUMMARY

Damage caused by the white snail *Cer­nuella virgata* (Da Costa, 1778) was for the first time observed in vegetable crops in Serbia during the summers of 2011 and 2012. In this country, serious damage to vegetable crops is usually caused by slugs, while snails do not normally cause any significant harm. Typical xerophilic snail species in the genera *Cer­nuella*, *Xerolenta* and *Theba* cause damage even more rarely since they are limited to wild flora in uncultivated and ruderal areas, and local outbreaks occur seldom and only in forage leguminous crops. The species *C. virgata* was for the first time found to cause damage to a number of vegetable crops during long periods of extremely warm and dry weather, including total devastation of a green onion crop.

Keywords: Damage; White snail; Vegetables

INTRODUCTION

Untypical damage caused to vegetable crops by massive aggregation of small white-shelled snails was observed during inspection initiated by individual growers in gardens of Belgrade's suburbs of Zemun Polje and Altina in early June of 2011 and June and July of 2012. A significant similarity was observed with earlier records of damage by the sand hill snail *Theba pisana* (O.F. Müller, 1774) in Montenegro (Stojnić and Radonjić, 2010). Besides, the present species was found to be conchologically related to the xerophilic species *T. pisana* and the eastern heath snail *Xerolenta obvia* (Menke, 1828), both belonging to the family Hygromiidae. Eastern heath snails are common on above-ground

parts of ruderal herbaceous plants growing on dry substrates in Serbia where they often form aggregates. In our experience, that species rarely overpopulates locally in plots with forage leguminous crops and does not affect the yield, but it pollutes forage. We have been repeatedly consulted by various farmers over low-quality hay associated with high populations of heath snails.

Data from studies conducted outside Serbia (Godan, 1983; Baker, 1986, 1996, 2002; Barker, 2002; Cowie et al., 2009; White-McLean, 2011) have shown that hygromiid snails may have considerable economic effect on cultivated plants, including vegetable crops. A survey of domestic and international literature revealed no report on damage by xerophilic snails on vegetables in our country, so that the data presented here constitute an initial report.

MATERIAL AND METHODS

Samples of 100 adult snails each were collected at Belgrade's Zemun Polje and Altina suburbs and transferred to a laboratory of the Department of Entomology and Agricultural Zoology of the Faculty of Agriculture, Belgrade. Snails were reared in plastic boxes for several days (Örstan, 2006) during measurement, dissection and fixation (Pearce and Örstan, 2006; Donovan, 2009; White-McLean, 2011). Identification was based on taxonomical keys and description of the family Hygromiidae Tryon, 1866, and genus *Cerneuella* Schlüter, 1838 (Hausdorf and Sauer, 2009; Welter-Schultes, 2009). Damage on plants in the field was assessed according to instructions by Liharev and Shapiro (1987).

RESULTS AND DISCUSSION

Based on our analysis of conchological and morphological characters of the collected material we identified a single species, *Cerneuella (Cerneuella) virgata* (Da Costa, 1778), (syn. *Cochlea virgata* Da Costa, 1778, *Helix variabilis* Draparnaud, 1801, *Xerophila euxina* Clessin, 1883).

The species had not been listed in domestic taxonomic reference literature (Jovanović, 1995) or found in phytosanitary practice relying on potentially significant data in foreign reports, so that it had not been given a common name. It also lacks a common name in many other European countries in which it had probably been continually present for a very long time. Reflecting the invasive character that the species has in other parts of the world, outside Europe, many different names have appeared. In English-speaking countries it has various names, such as white snail, maritime garden snail, banded snail, striped snail or zoned snail.

Morphological characters of *C. (C.) virgata*

Description of the genus *Cerneuella* is based on the following main conchological and morphological characters: the shell is basically white and hairless; the snail has a single bursa teloris with a large internal conical papilla, and bursa teloris is not much larger than bursa copulatrix; penis innervation begins at the right pedal ganglion (Welter-Schultes, 2009). The subgenus *Cerneuella s.s.* is characterized by three frenula, or mussels that connect the basis of penial papilla to penial wall (Manganelli & Giusti, 1988).

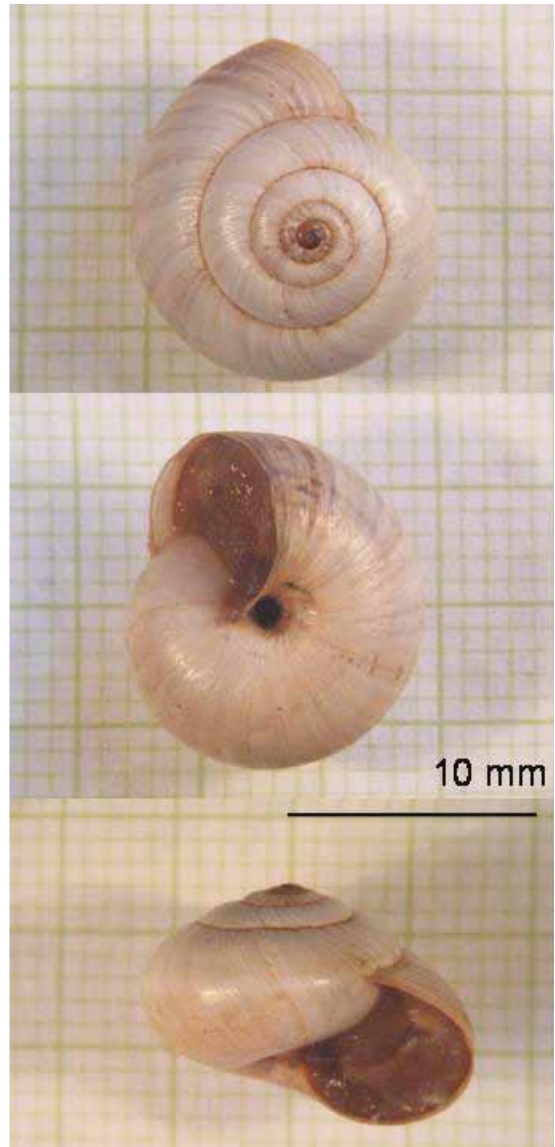


Figure 1. White snail, *Cerneuella (Cerneuella) virgata* (Da Costa, 1778) – shell

The main conchologic characters of *C. (C.) virgata* are: shell coloration, which is mainly different hues of white and yellow, possibly with a shade of red, and shell markings commonly including two brown bands on the apical side and several thin ones on the umbilical side. The shell may be without markings, or markings may form stains that are either separate or fused into wide dark-coloured zones. Some local forms have a single dark band along shell suture (Hausdorf & Sauer, 2009; Welter-Schultes, 2009). The shell is conical flat with fine transverse ribs across the surface behind the nucleus, and with slight and less regular striation at the

widest part of the whorl. Juveniles do not have visible striation on lower shell surface. It normally has 4.5–6.0 convex whorls, the last of which is slightly angular or rounded. Shell aperture is almost round and the inner wall may have either a paler white or redish shade along the lip, a property not found in subadult animals. The upper margin is weakly or perceptibly slanted. The margin is always sharp, and neither thickened nor arched. The umbilicus is narrow or medium wide, 1/10 to 1/6 of shell width, mildly excentric and not covered with the columellar extension. Shell sizes vary significantly among populations, shell height ranges between 8 and 15 mm and width between 12 and 23 mm (*ibid.*). Some shells may have up to 7 whorls, 19 mm height and 25 mm width (White-McLean, 2011).

The external morphological characters of *C. (C.) virgata* include a gray, rusty or yellowish coloration of the foot, darker on the dorsum, redish brown mantle, and greyish and translucent tentacles (*ibid.*).

Regarding most conchological characters, the specimens of the population collected at Zemun Polje and Altina were found in our analysis to be similar to those of a „large form” population of *C. (C.) virgata* from Crete (Hausdorf & Sauer, 2009). The shell pattern, however, is different: unlike the Crete population, our population has none, so that its shell is of uniform colour. Predominantly unicoloured shell is not rare and other similar populations have been found elsewhere, e.g. in Ulcinj, Montenegro (Welter-Schultes, 2009) and in Varna, Bulgaria. Shell colour is highly variable in *C. (C.) virgata* and is considered a conchologic character of small reliance. On the other hand, conchologic characters of our population did not resemble the similar species *C. (C.) cisalpina*, which is characterized by smaller and flatter shell with more prominent growth ribs and proportionally wider umbilicus.

Distribution of *C. (C.) virgata*

The original distribution range of the genus *Ceruel-la* Schluter, 1838 (Pulmonata: Stylommatophora: Hygromiidae) includes most of Europe, reaching as far as Great Britain to the north, Turkey to the southeast, and North Africa to the south. The species *C. (C.) virgata* most probably originates in the western part of the Mediterranean, whence it was introduced into the Eastern Mediterranean region and Central Europe (Hausdorf & Sauer, 2009). Its known range of distribution includes: Albania, Andorra, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, France, Greece, Ireland, Italy, Macedonia, Malta, Montenegro, the Netherlands,

Portugal, Romania, Spain, Ukraine and the UK (Bank, 2011a). White snails have also been transferred to Australia (Baker, 1988) and the US (Michalak, 2010; White-McLean, 2011) in various shipments, and they have the status of invasive quarantine species there.

The genus *Ceruel-la* includes 10 species, of which only *C. (C.) virgata* (Welter-Schultes, 2009) had been detected in the former two-member state of Serbia and Montenegro, although the information more precisely referred to Montenegro alone (Bank, 2011b). Considering its known range of distribution, the species may be well present in Serbia, along with *Ceruel-la (C.) cisalpina* (Rossmassler, 1837), which has been detected in most other neighbouring countries (Bank, 2011a). The latter species is considered by some researchers to be a form of the former species, offering a lack of statistically significant anatomic differences as a basis for the assumption (Hausdorf & Sauer, 2009). In Croatia and Slovenia, the species *Ceruel-la (Xerocincta) neglecta* (Draparnaud, 1805) has also been detected (Bank, 2011b).

Bioecological properties of *C. (C.) virgata*

White snails inhabit arid parts of coastal Europe with sandy and limy soils. Synanthropic populations inhabit roadsides, areas along railway tracks and arable land. They are fairly tolerant of some cultural practices and stay on harvested land for a long time but they are affected by soil cultivation, upturn and calcium deficiency and by total lack of plant cover during hot periods (Pomeroy, 1968).

Aestivation occurs during winter and summer seasons with unfavourable environmental conditions, which helps snails reduce the loss of body fluids and energy. White snails restrict their daily activities to periods that are most favourable regarding temperature and humidity, which is a significant form of behavioral adaptation (Staikou, 1999), along with vertical migration. White snails climb various vertical structures and plants, forming cluster-like aggregations in order to reduce warming. Pomeroy (1968) proved that body temperature of *C. (C.) virgata* decreases significantly as snails get higher up and away from the warm soil. Morphological adaptation includes white-coloured shells to reflect light and a moderate size of shell aperture to reduce loss of body fluids. Morphological adaptation is accompanied by physiological adaptation. (Dittbrenner et al., 2009). Compared to the similar species *T. pisana*, *C. (C.) virgata* has shown a significantly higher tolerance of overheating, which results from its greater capability to

activate calcium cells in the digestive gland. Also, greater susceptibility to overheating has been detected in adults than in juveniles, which is associated with high energy losses during reproduction.

Snails are active only when soil is moist and relative air humidity high. After intensive cattle grazing in South Australia at the beginning of summer, *C. (C.) virgata* have been found to migrate from pastures to weedy roadsides, and to move back to pastures during autumn. On the average, they were able to cover a daily distance of 0.1-0.4 m. Some snails, however, travelled more than 25 m monthly during spring and summer, and up to 50 m in autumn and winter (Baker, 1988).

In our study, the main migration routes of white snails were noted based on specific conditions. Snail presence on vegetable plots was caused by accumulation and migration of snails from neighbouring weedy plots that had been planned for construction of private houses with gardens. More than 20% of the surrounding area was heavily weeded with 1.5 m high cover and some plants reaching over 2 m in height, while dense weed cover was also found along newly built roads around. Summer mortality caused by overheating and desiccation was therefore minimized in the population. A part of the population kept migrating or was carried away by wind together with dried plant material, so that snails spread across the entire area, including vegetable gardens. Conditions for snail activity and damage were favourable during a significant number of days in June and July.

White snail reproduction had been investigated in several other regions with climates different from ours and such data need to be regarded with caution. In France, the snail lays 30-80 ball-shaped eggs, 1.5 mm in diameter and with white membrane. Oviposition occurs mostly on rainy days over the period from September to November. Egg incubation lasts 15-20 days and the hatched juveniles become sexually mature during the following year (Welter-Schultes, 2009). In Australia reproduction occurs at the end of summer or beginning of a rainy period when snails lay 100-200 eggs in litters or slightly below soil surface (Baker, 1996). In the U.S., the species has been described in reports as being able to lay up to 60 eggs per cluster, and several clusters a year (White-McLean, 2011). Pomeroy (1969) proved experimentally that population density in Australia had grown up to a certain maximum point, and then the birth rate dropped along with the speed of juvenile maturation, while life span became shorter. This internal population control occurred as a result of growing population density as related to available food. Similarly, Baker (1996) reported a lower average fecundity during high population densities.

Pomeroy (1969) found that *C. (C.) virgata* normally had a single generation annually in Australia, which means massive egg hatching in autumn and fast juvenile growth until the next spring. Baker (2002) reported a biannual cycle of snails under pasture/small grains rotation and an annual cycle on permanent pastures. Reports from the State of Washington confirmed the existence of a biannual cycle of white snails (Michalak, 2010).

Pest significance and control of *C. (C.) virgata*

In our study, we observed large aggregations of *C. (C.) virgata* in the inspected vegetable plots, but snails were nonselectively present also in the surrounding areas, on ornamentals, fruit trees and densely packed along columns and fences. On a majority of infested plant species (e.g. potato, raspberry or rosemary) no visible feeding marks were found or chlorosis caused by aggregated snails. Negligible damage was found on pumpkins, cucumbers and beans. On the other hand, damage on green onions was more extensive and found on 80-95% of inspected plants. Besides an assumed pollution of green onions with excrements and slime that is not readily soluble in water, the plants were further damaged by biting and shortening of terminal green leaves. Interior leaf parts were additionally polluted by snails that got into the hollow leaves through bitten holes. Snails did not damage plants totally but the extent of biting and pollution rendered them unacceptable for consumption and sale.



Figure 2. White snails on green onions

In the original habitat, *C. (C.) virgata* snails feed on the topsoil and surface litter but avoid bare surfaces (Pomeroy, 1969). On arable plots, snails feed on cultivated plants. Godan (1983) reported damage in Germany on legume crops, i.e. alfalfa, clover and common sainfoin, and gave generalized information on damage caused to ornamentals in the Netherlands. Other data on the pest status of this species in Europe are not available but, based on its quarantine status in plant shipments into the U.S., it can be inferred that white snail populations are significant on cultivated plants in Italy and Spain (Michalak, 2010).

The most complete data on damage caused by white snails were collected in a study of introduced invasive populations in South Australia (Baker, 1986, 1996, 2002; Barker, 2002; Leonard et al, 2003). White snail causes significant economic damage on cereals in that country, developing populations of such density that yields are reduced, harvest machinery suffers clogging and grain becomes polluted. Besides, it damages seedlings of wheat, barley, oleiferous crops, carrot, annual medicinal plants, alfalfa, clover, pea, bean and ornamentals. On artificial pastures, cattle are repelled from grazing plants with contaminated slimy deposits. In the United States (Michalak, 2010; White-McLean, 2011), *C. (C.) virgata* is considered an important pest of cereals and nursery plants, a cause of contamination of cereal grains and damage of harvest machinery. Cereal pollution is caused by increased moisture during storage and stimulation of secondary infections with pathogens that release toxins.



Figure 3. Bites and infiltration of white snails into green onion leaves

The result is grain that is unacceptable on the market for being toxic both as food and forage. In Australia, thresholds have been defined for white snails on large areas: 5 snails/m² in leguminous and oleiferous crops, 20 snails/m² in cereals and 80 snails/m² on artificial pastures (Leonard et al., 2003).

White snails become unintentionally incorporated in shipments of plant materials in international trading. In Israel, a shipment of 23 tonnes of apples has been sent back to France after several live white snails were discovered (Mienis & Rittner, 2010). The species *C. (C.) virgata* is on quarantine lists in the U.S. and Canada (Cowie et al., 2009). Michalak (2010) systematized data on intercepted shipments arriving in the U.S. over the 1985-2009 period that contained the invasive quarantine species *C. (C.) virgata*. Over the period of 25 years, white snails were discovered in 455 shipments of crops belonging to 21 plant genera originating from 16 countries. Seeding materials on substrates, pot plants and bulk plant materials in transport containers are the most risky types of shipments for transferring the species. The most risky countries of origin include Italy, Spain and Australia. Many grain shipments have been returned from the U.S. to Australia when white snails were found in them (White-McLean, 2011).

Besides being a potential threat to cultivated plants, *C. (C.) virgata* is also an important vector of causative agents of zoonoses. It may host and spread lung nematodes (Protostrongylidae) among domestic ungulates. Studies conducted in Spain and on pastures in Southern Bulgaria (Lopez et al., 1998; Georgiev et al., 2003) have proved infection of white snails with the nematodes *Muellerius capillaris* (Müller, 1889), *Cystocaulus ocreatus* (Railliet & Henry, 1907), *Neostromylus linearis* (Marotel, 1913) and species in the genus *Protostrongylus*.

Several methods of control of white snails would be appropriate in vegetable plots in Serbia. Physical methods practiced across the world include: knocking snails onto the hot soil surface, cutting and burning of weed vegetation, ploughing and drilling of soil and continued removal of plant debris that contains snails. Cleansing of plot margins from overgrowing weeds, rolling of plants to prevent vertical migration of snails, which is needed for their summer aestivation, and formation of 2 m wide belts of bare ground along both sides of a fence would be sound preventive measures. On the hottest summer days, it is recommendable to knock snails down to the ground from various pillars and fences or from plants on which they stay immobile. The optimum temperature for this action is 35°C when soil

is also warm. Snails quickly become overheated on such soil or move in search of shelter, which makes them prone to desiccation. The efficacy of this method is 50-90%, depending on general conditions (Leonard et al., 2003).

Under moderate temperatures and humidity, caused by preceeding rainfall or dew, it is most appropriate to lay granular and pellet molluscicide baits. Small-sized baits of around 2 mm diameter should be laid underneath plants at a rate of 20-30 granules/m², and especially densely at plot margins and along fences, 40-50 granules/m², while the application rates of larger baits should be lower, 10-12 pellets/m² and 20-24 pellets/m², respectively (Leonard et al., 2003).

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Štete na mladom luku od belog puža, *Cernuella virgata* (Da Costa)

REZIME

Tokom leta 2011. i 2012. godine prvi put je dokumentovana štetnost belog puža, *Cernuella virgata* (Da Costa, 1778), na povrtarskim biljkama u Srbiji. U našoj zemlji značajne štete na povrću izazivaju prvenstveno golači, a veće štete od puževa sa ljušturom nisu uobičajene. Kada se radi o izrazito kserofilnim vrstama puževa rodova *Cernuella*, *Xerolenta* i *Theba*, ispoljavanje štetnosti je još ređe, jer su one ograničene na spontanu floru neobrađenih i ruderalnih površina, sa lokalnim masovnim pojavama samo na površinama pod krmnim leguminozama. Tokom produženih perioda izrazito toplih i suvih uslova, uočena je po prvi put štetnost vrste *C. virgata* na većem broju povrtarskih biljaka, dok je na parceli mladog luka šteta bila potpuna.

Ključne reči: Štete; beli puž; povrće