

PERIODS OF OCCURRENCE AND FECUNDITY OF *ARION LUSITANICUS*
MAB. (GASTROPODA: PULMONATA) IN CROP PLANT HABITATS
IN POLAND

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Abstract. In the years 1997-1999, studies on the periods of *A. lusitanicus* development and on the occurrence of its developmental stages were carried out. Dates of overwintering, mating, egg-laying, hatching and population peaks of the slug were observed on six sites located in horticultural habitats, as well as in the isolation cage, where slugs were reared. It was ascertained that *A. lusitanicus* has a year-long life cycle. The slug overwinters in the form of eggs or juvenile stages and rarely as adult individuals. Young slugs leave their winter shelters by the end of February. The mating period starts in the second half of July and lasts from 6 to 10 weeks. Eggs are laid from mid-August till late autumn. Slug hatching occurs in spring and autumn at the time of plant sprouting.

Key words: slug, *A. lusitanicus*, life cycle

I. INTRODUCTION

The slug *Arion lusitanicus* Mab. occurs in many countries of central and western Europe, where it is a dangerous pest of cultivated plants (Altena van Regteren 1971; Chevallier 1972; Reischutz 1984; Davies 1987; Risch and Backeljau 1989; von Proshwitz 1992; 1994; Briner and Frank 1998). In the beginning of the 90's this species was introduced into Poland and became a troublesome pest of different plant species, especially vegetables (Kozłowski 1995; 1999; Kozłowski and Kornobis 1995; Kozłowski and Kozłowska 1998a; 1998b). This slug occurs very numerously in the area of Podkarpacie province (foothills of the Carpathian mountains), mainly in gardens and parks as well as in thickets on the river banks.

Most of the studies on that slug pertained to its morphology, occurrence and harmfulness (Schmid 1970; Reischutz 1984; Rish and Backeljau 1989; de Winter 1989; von Proshwitz 1992; 1994; von Proshwitz and Winge 1994). However, bionomy and the life cycle of this slug species have been only partially studied (Davies 1987; Briner and Frank 1998). In the case of such a dangerous plant pest, effective methods of its control should be developed. In this connection it was important to study the slug's life cycle, especially periods of its particular stage occurrence. Results of these studies are presented in the present paper.

II. MATERIALS AND METHODS

The studies were carried out in 1997-1999 at Łańcut and Wysoka located in south-eastern Poland. Gardens and their adjacent areas (plant crops, ditches, baulks, non-crop areas, thickets) were inspected 2-3 times a week from January till December. On 6 sites of the pest occurrence and at each observation date, the approximate age of the slugs was estimated on the basis of their appearance and size, which permitted to divide them into four age groups: juvenile stages; immature individuals; matured individuals; old individuals. After slug mating, the same sites were searched for the places of egg-laying and for the occurrence of juvenile stages. These places were marked with pegs and the dates of egg-hatching were observed in autumn, winter and spring. The duration of consecutive life periods of slugs, such as overwintering, emergence from shelters, mating, egg-laying, slug hatching and retreat of slugs to shelters were ascertained. Detailed observations concerning dates of mating, egg deposition and slug hatching were also conducted in the isolation cage placed in the garden at Łańcut. The isolation cage 50 × 70 × 50 cm in size made of metal angle bars, perforated metal sheets and mill gauze was filled with earth up to 1/3 and dug into the ground. Each year in May, 10 young, immature slugs were placed into cage to observe the dates of their development from mating to egg hatching. Air temperatures were determined with the use of electronic "Boneco" measuring instrument.

III. RESULTS

In 1997, the first young slugs hatched in the autumn of the preceding year emerged from their winter shelters in the third decade of February at the air temperature of 4°C (Tab.). Slug hatching from overwintered eggs began in the second decade of March at the temperature above 7°C and lasted for almost six weeks. In mid-May, juvenile stages of the slug (from 1.0 to 3.0 cm long) reached the population peak. During the next months the hatched slugs intensively fed and grew fast. The first mating pairs were observed at the beginning of the third decade of July. The slug mating lasted almost until the end of September. In mid-August the slugs began to lay eggs and the peak of their egg-laying fell on the first half of September.

Table

The time of *A. lusitanicus* development in the vegetation seasons of 1997-1999

Stages of development	1997		1998		1999	
	from	to	from	to	from	to
Emergence from winter shelters	22.02.	12.04	3.01	21.03	27.02.	20.03.
Hatching of winter egg	12.03.	19.04.	28.03.	25.04	2.03.	9.04.
Mating	20.07.	26.09	27.07.	11.10.	24.07.	18.09.
Egg-laying	18.08.	13.12.	10.08.	7.11.	16.08.	30.10.
Egg hatching before winter	16.09	7.12.	7.09.	15.11.	11.09.	2.11.
Coming down to winter shelters	15.12		15.11		20.11.	

Single eggs were laid even in December (13 December) at the time of warming up to 6°C, which lasted for several days. The first slug hatching from the eggs laid in August began in mid-September. The egg-hatching with large breaks in November lasted almost until the end of the first decade of December.

The eggs laid in the autumn wintered over. By the end of November, after a fall of the air temperature below 2°C, the juvenile stages and single adult individuals began to retreat to their shelters for overwintering. Slug retreat to the winter shelters lasted for about two weeks. In the winter period the slugs remained in the litter, under plant remnants, in soil and in the root layer of trees and bushes.

In 1998, the first young, 2-2.5 month-old slugs began to emerge from their winter shelters at the beginning of January, when the air temperature was over 4°C (Tab.). In the third decade of January, at the temperature drop below 0°C the slugs retreated to the shelters. In February there occurred warming up to 7°C, and the slugs left their shelters again and resumed feeding on leaves of dicotyledonous weeds, flowers and perennials. Slug hatching from overwintered eggs began by the end of March at the temperature of over 6°C. Most slugs hatched until the end of April. Young slugs fed on seedlings and plantlets of cultivated plants. Their number successively increased until the first days of May. By the end of July the slugs reached their sexual maturity and started mating. The first eggs were observed on 10 August. The slugs mated until the second decade of October and the egg-laying lasted until the first days of November.

The first slugs hatched from the laid eggs at the beginning of September. Slug hatching lasted until mid-November. In the beginning of November at the air temperature below 3°C the first slugs began to migrate towards their winter shelters. During the winter period (December – February), in the periods of increased air temperatures, young slugs resumed their activity. They fed on humus, plant remnants, roots or flower bulbs and retreated to their shelters.

In 1999, the first overwintering slugs left their shelters by the end of February following snow melting (Tab.). These were mainly juvenile stages hatched in the late autumn of the preceding year. Besides them, there occurred single larger specimens (about 3 cm long) as well as adult individuals. In the beginning of March at the air temperature over 6°C, the juvenile stages hatched from overwintered eggs began to appear. Their hatching lasted almost until the end of the first decade of April. The highest number of young slugs was observed in the first half of May. In that period the slugs migrated to the neighbouring sites in search of food; they intensively fed and grew. The first mating pairs were observed in the third decade of July and the first eggs were laid in mid-August. The slug mating lasted until the end of the second decade of September, whereas the last eggs were laid by the end of October. The first slugs from the eggs laid in August hatched at the beginning of the second decade of September.

The slug hatching lasted until the first days of November with a break in the first decade of October, when the temperature dropped to below 5°C. In the second half of November the slugs began to retreat to their shelters in soil, litter, composts, wells, irrigation ditches, cellars and so on. In that period, mainly juvenile stages were encountered in the shelters beside the eggs. The occurrence of adult individuals was not numerous and most of them died before winter. The last slugs were observed by the end of November, when abundant snowfalls covered their shelters.

IV. DISCUSSION

Arion lusitanicus occurring in Poland has a year-long life cycle (Fig.). Adults begin egg-laying in the second half of August. The eggs are laid by individuals mainly at the age of 6 to 9 months. The period of egg-laying lasts from 2.5 to 3.5 months, depending on temperature. The last eggs may be laid in December at the air temperature of over 5°C. Observations obtained in Poland and Great Britain as well as in Switzerland (Davies 1987; Briner and Frank 1998) indicate that the majority of slugs die after egg-laying. Under laboratory conditions (temperature of 17-19°C, RH 93%, 16 h day length) about 75% of slugs died after egg-laying before winter (Kozłowski and Sionek 2000). The remaining

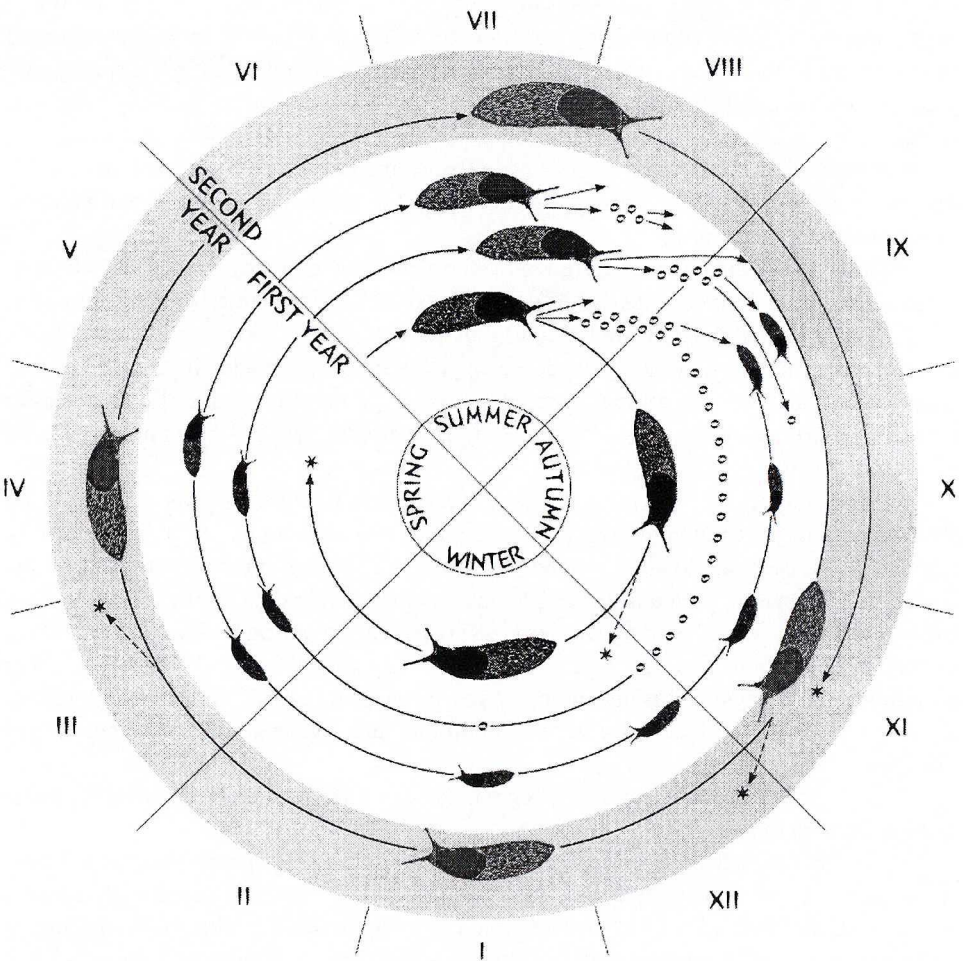


Fig. Life cycle of *Arion lusitanicus* Mabille, 1868
 (* death of slugs)

adult individuals die in winter or overwinter and die in the spring next year. However, single large individuals, which survived winter, may also occur in slug populations. These individuals grow all the time and reach sexual maturity only in summer, in the second year of their life. They are considerably larger than other adult slugs. In August and September the occurrence of a dozen or so exceptionally big slugs about 15 cm long was observed at Wysoka, whereas one-year-old adults reached the length of 12 cm. Similar large specimens were also found in Great Britain in the localities Devon, Kent and Sanderstead (Davies 1987). It, therefore, is possible that some individuals of *A. lusitanicus* can live to the age of two years.

Slug hatching from the laid eggs begins at the turn of the first/second decades of September and lasts 50 to 80 days. After the temperature decrease below 2°C the slugs come down to their winter shelters. Only eggs laid in August and in the first days of September hatch before winter. They constitute from 25% to 39% of all laid eggs. Eggs laid in the period from mid-September till December overwinter and hatch in the spring next year (Kozłowski and Sionek 2000). From this it follows that overwintering stages of *A. lusitanicus* are eggs or juvenile individuals. Overwintered adult individuals of the slug are encountered less frequently. According to Briner and Frank (1998) slugs of this species occurring in Switzerland lay eggs in late summer and in autumn and hatch like in Poland – in late autumn and in spring.

Young slugs which overwintered leave their winter shelters by the end of February. At favourable air temperatures (>4°C) the process of leaving winter shelters may start considerably earlier, even at the beginning of January, as it took place in 1998 (Tab.). Hatching of the majority of slugs from the eggs wintered over begins in mid-March and lasts from 4 to 6 weeks. A small percentage of slugs may hatch significantly earlier (January-February), when the air temperature is over 6°C. The last slugs hatch even by the end of April.

In mid-May to July the juvenile stages reach their population peak. In the period from May to July the juvenile slugs intensively feed and grow. In the third decade of July the first slugs reach sexual maturity and start mating. The slugs copulate at the age of 5 to 8 months. The mating period lasts for 1.5 to 2.5 months, depending on the temperature of the environment. As reported by Davies (1987), the mating period of *A. lusitanicus* slugs occurring in Glasgow in Great Britain lasts from July until the first days of September (for about 30-40 days) and is considerably shorter than in Poland. This probably results from the influence of different climatic conditions and higher autumn temperatures in Glasgow.

The slugs 2-4 weeks after mating begin to lay eggs, after which their entire life cycle is completed in this way.

A. lusitanicus occurring in Poland, similarly to other slug species from the family *Arionidae* – *Arion rufus* (Linnaeus), displays a stable life rhythm related with the year seasons (Riedel and Wiktor 1974). The period of its maturation and fecundity falling on warm summer months may last until late autumn at suitable air temperatures. Its eggs hatch in autumn or after a period of warming up in spring. The extension of the time of slug development at low temperatures enabled its egg stages and juvenile individuals to survive winter. A decrease in the air temperatures in late autumn caused that the majority of

slugs from the preceding generation died after egg-laying. Probably the observed overwintering of few adult individuals is not of large importance for the development of slug population. Such life cycle determines numerous slug occurrences in spring and early autumn, in the periods of cultivated plant emergence, when the crops are the most susceptible to slug feeding.

Arion lusitanicus, like other species of harmful slugs, feed most readily on plants and seedling sprouts (Briner and Frank 1998; Kozłowski and Kozłowska 1998a; b). The dependence of the slug mass occurrence on the stage of cultivated plant emergence creates suitable conditions for slug development, among others, due to the presence of an adequate food required by the pest. Numerous occurrence of slugs in the period of plant emergence constitutes a serious danger to plant crops and may cause significant yield losses.

V. LITERATURE

1. Altena C. O. van Regteren. 1971. Neue Fundorte von *Arion lusitanicus* Mabille. Arch. Moll., 101: 183-185.
2. Briner T., Frank T. 1998. The palatability of 78 wildflower strip plants to the slug *Arion lusitanicus*. Ann. Appl. Biol., 133: 123-133.
3. Chevallier H. 1972. *Aronidae (Mollusca, Pulmonata)* des Alpes et du Jura français. Haliotis, 2: 7-23.
4. Davies M. J. 1987. *Arion flagellus* Collinge and *A. lusitanicus* Mabille in the British Isles: A morphological, biological and taxonomic investigation. J. Conch., 32: 339-354.
5. Kozłowski J. 1995. Ślimaki *Arion lusitanicus* Mab. i *Arion rufus* (L.) – nowe groźne szkodniki w Polsce południowo-wschodniej. Ochrona Roślin nr 9: 3-4.
6. Kozłowski J. 1999. Ślimaki (*Gastropoda: Stylommatophora*) – niedoceniane szkodniki roślin uprawnych w Polsce. Post. Nauk Roln., 6: 39-50.
7. Kozłowski J., Kornobis S. 1995. *Arion lusitanicus* Mabille, 1868 (*Gastropoda: Arionidae*) w Polsce oraz nowe stanowisko *Arion rufus* (Linnaeus, 1758). Przegl. Zool., 39 (1-2): 79-82.
8. Kozłowski J., Kozłowska M. 1998a. Food preferences of the slug *Arion lusitanicus* Mab. (*Gastropoda: Stylommatophora*), in south-east part in Poland. J. Plant Protection Res., 38 (1): 81-83.
9. Kozłowski J., Kozłowska M. 1998b. Podatność nasion i siewek roślin uprawnych na żerowanie *Arion lusitanicus* Mab. (*Gastropoda: Stylommatophora*). Prog. Plant Protection/ Post. Ochr. Roślin 38 (2): 420-423.
10. Kozłowski J., Sionek R. 2000. The rate of egg laying and hatching of the slug *Arion lusitanicus* Mabille, a pest of arable crops. J. Plant Protection Res., 40 (2): 162-167.
11. Proschwitz T. von. 1992. Spanska skogssnigeln – *Arion lusitanicus* Mabille – en art i snabb spridning med människan i Sverige. Göteborgs Naturhistoriska Museum, Arstryck, 35-42.
12. Proschwitz T. von. 1994. *Oxychillus cellarius* (Müller) and *Oxychillus draparnaudi* (Beck) as predators on egg-clutches of *Arion lusitanicus* Mabille. J. Conch. Lond., 35: 183-184.
13. Proschwitz T. von, Winge K. 1994. Iberiasnigeln – en art på spridning i Norge. Fauna 47: 195-203.
14. Riedel A., Wiktor A. 1974. *Arionacea* – ślimaki krawałowate i ślimakowate (*Gastropoda: Stylommatophora*). Fauna Polski – Fauna Poloniae, T. 2, PWN, Warszawa.
15. Reischütz P. L. 1984. Zum massenhaften Auftreten von *Arion lusitanicus* Mabille in den Jahren 1982 und 1983. Mitt. Zool. Ges. Braunau 4: 253-254.
16. Risch P., Bacheljau T. 1989. On the occurrence of *Arion lusitanicus* Mabille, 1868, in Belgium. Ann. Soc. Zool. Belgique 118 (1): 25-38.
17. Schmid G. 1970. *Arion lusitanicus* in Deutschland. Arch. Moll., vol.100: 95-102.
18. Winter A.J. de. 1989. *Arion lusitanicus* Mabille in Nederland (*Gastropoda, Pulmonata, Arionidae*). Basteria 53: 49-51.

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OKRESY POJAWU I ROZRODU ŚLIMAKA *ARION LUSITANICUS* MABILLE (GASTROPODA: PULMONATA) W SIEDLISKACH ROŚLIN UPRAWNYCH W POLSCE

STRESZCZENIE

W latach 1997-1999 w rejonie Łañcuta prowadzono badania nad cyklem życiowym ślimaka luzytańskiego – *Arion lusitanicus* Mab. W siedliskach upraw ogrodniczych oraz w izolatorze z hodowlą ślimaka obserwowano terminy: zimowania, kopulacji, składania jaj, wylęgania ślimaków i szczytów liczebności.

Ustalono, że *A. lusitanicus* ma roczny cykl życiowy, ale w populacji ślimaka mogą także występować pojedyncze osobniki o dwuletnim cyklu życiowym. Zimują jaja lub stadia młodociane, rzadziej osobniki dorosłe. Młode ślimaki opuszczają kryjówki zimowe pod koniec lutego. Wyląg ślimaków z jaj zimujących trwa od połowy marca do końca kwietnia. W połowie maja stadia młodociane osiągają szczyt liczebności. Okres kopulacji rozpoczyna się w drugiej połowie lipca i trwa od 1,5 do 2,5 miesiąca. Jaja składane są od połowy sierpnia do późnej jesieni. Ze złożonych jaj wyląg ślimaków rozpoczyna na początku drugiej dekady września i trwa od 50 do 80 dni. Przed zimą wylęga się do 30% jaj. Reszta jaj zimuje i wylęga się wiosną następnego roku.

Liczne pojawy *A. lusitanicus* przypadają wiosną i wczesną jesienią, w okresach wzrostu i wschodów roślin uprawnych najbardziej wrażliwych na żerowanie ślimaka.