



EGG RETENTION IN THE CLAUSILIID *BALEA (PSEUDALINDA) FALLAX* (ROSSMÄSSLER, 1836) FROM ROZTOCZE (S.E. POLAND)

ANNA SULIKOWSKA-DROZD¹, TOMASZ K. MALTZ², PRZEMYSŁAW STACHYRA³

¹Department of Invertebrate Zoology and Hydrobiology, University of Łódź, Banacha 12/16, 90-237 Łódź, Poland (e-mail: sulik@biol.uni.lodz.pl)

²Museum of Natural History, Wrocław University, Sienkiewicza 21, 50-335 Wrocław, Poland

³Base Station of the Integrated Monitoring of the Environment Roztocze in Roztocze National Park, Biały Szyp 16, 22-470 Zwierzyniec, Poland

ABSTRACT: Adults of *Balea fallax* sampled monthly from the Roztocze Upland were dissected to examine the occurrence of uterine egg retention. Developing eggs were found in snails collected between May and August. In June more than 60% of the studied individuals were gravid, while in other months egg-retaining snails constituted less than 10% of the sample. The number of retained eggs ranged from 3 to 17 (mean 12.3) and was not related to the adult shell size. In June the majority of eggs contained shelled embryos (maximum shell size 1.1 whorl). The reproduction mode of *B. fallax* is compared with those of other ovoviparous clausiliids of Central Europe.

KEY WORDS: Clausiliidae, land snails, life history, reproduction strategy, ovoviviparity, brooding

INTRODUCTION

The clausiliid *Balea (Pseudalinda) fallax* (Rossmässler, 1836) is included in the subfamily Baleinae (FALKNER et al. 2001) and sometimes classified in the genus *Alinda*, subgenus *Pseudalinda* (NORDSIECK 2007). It is a Carpathian-Balkan species (RIEDEL 1988). In Poland *B. fallax* occurs on the northern fringe of its distribution range: in the East Carpathians and the Roztocze Upland. An isolated population was recorded also in the Świętokrzyskie Mts. but it probably became extinct in the second half of the 20th century. At present *B. fallax* is abundant locally in the forested loess gorges of the Roztocze Upland, also in the Roztocze National Park (URBAŃSKI 1958, PIECHOCKI 1990). The species is red listed under the

near-threatened category (WIKTOR & RIEDEL 2002) but it is not protected according to the state nature conservation law.

The reproduction of *B. fallax* in a laboratory culture was analysed recently (SULIKOWSKA-DROZD & MALTZ 2012). Snails always laid eggs but, owing to the rather short interval before they hatched, ovoviparous reproduction (egg retention for a brief period) was hypothesised.

In this paper we aimed to ascertain whether *Balea fallax* from a natural population retains fertilised eggs in its reproductive tract, when and how many eggs are kept in the uterus, and what is the maximum developmental stage of the brooded eggs.

MATERIAL AND METHODS

For anatomical examination specimens of *Balea fallax* were collected from the Roztocze Upland near Szczebrzeszyn (Szperówka valley, 50°43.52'N, 022°54.53'E, 260 m a.s.l.). Snails were collected by

hand from leaf litter in a hornbeam forest that overgrows a deep loess gorge. Each sample consisted of ca. 30 adults with a fully developed clausilium and lip. They were collected every month from 1 May to 6 Oc-

tober 2011. The snails were killed in boiling water and preserved in 75% ethanol.

Each preserved adult was measured under a stereomicroscope with a graticule (shell height and breadth) and shell whorls were counted according to EHRMANN (1933). Then each snail had a part of the shell of the penultimate whorl removed (Fig. 1A). All eggs were extracted from the uterus, counted and

their developmental stage estimated. Two stages were distinguished: (I) egg filled with an amorphous substance or containing a small embryo without shell, (II) shelled embryo (Fig. 1B and C, respectively). In the latter case the size of the embryonic shell (number of whorls) was noted.

For statistical calculations Statistica 6.0 software was used.

RESULTS

Only 33 snails (13%), out of 250 dissected, had developing eggs in their uteri. Egg retention in *Balea fallax* was recorded in May–August, while in September and October no snails containing eggs were found (Fig. 2). The highest number of gravid snails ($N = 26$; 62%) was collected in June.

In May, July and August eggs from the dissected snails were at developmental stage I (Fig. 1B). In the sample collected in June, the majority of eggs (65% of 317 eggs) were at stage II. Such eggs were found in 18 adults, of which only seven retained embryos larger

than 0.5 whorls. Most of the embryos were small and their shells were only just mineralized (approximate size: 0.3–0.5 whorl). The shells of the largest embryos consisted of 1.0–1.1 whorl (Figs 1C, D, 3).

The number of eggs in each uterus ranged from 3 to 17 (mean 12.3, SD 3.4). Most frequently 12–15 eggs were found (Fig. 4).

The shell size of the examined snails is presented in Table 1. No significant correlation was found between the number of retained eggs and any of the adult shell parameters (Spearman's r_s ; $p > 0.05$).

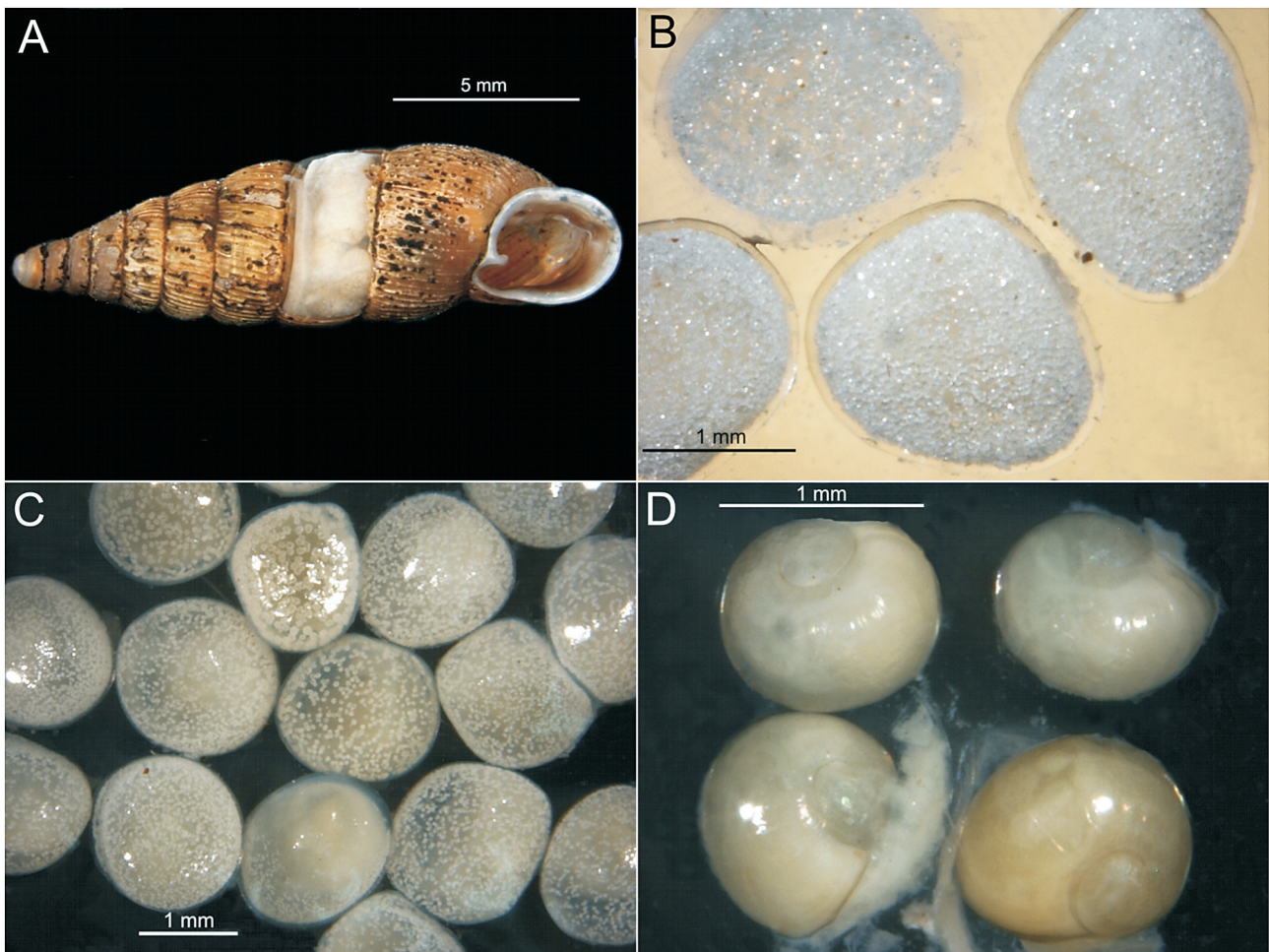


Fig. 1. *Balea fallax*: A – an adult with its shell partly removed to show eggs retained in the uterus; B – eggs (stage I) dissected from a snail collected on 1 May; C – eggs (stage II) dissected from a snail collected on 2 June; D – embryos removed from eggs found in a snail collected on 2 June

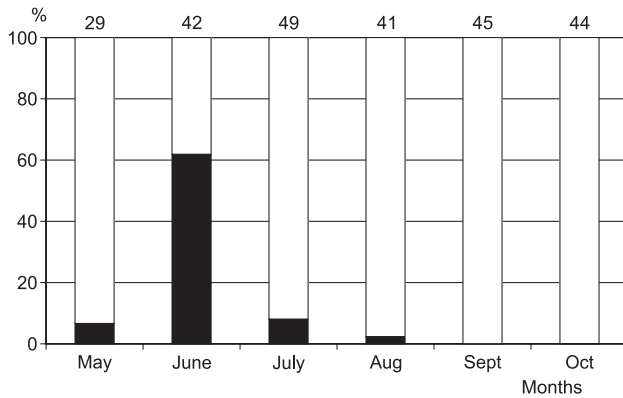


Fig. 2. *Balea fallax*: percentage of non-gravid (white) adults and gravid adults (black) during the vegetation season. Numbers above bars indicate the number of snails examined in each period

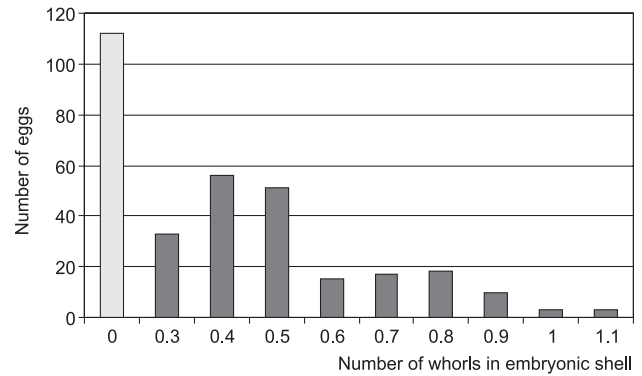


Fig. 3. *Balea fallax*: degree of development of eggs incubated in the uteri of snails sampled on 2 June 2011. Eggs containing amorphous substance or a small embryo without shell (light grey) and eggs containing a shelled embryo (dark grey)

DISCUSSION

Dissection of *B. fallax* collected during the vegetation season in the Roztocze Upland confirmed its egg-retention strategy. The reproductive mode of the species was already suggested by SULIKOWSKA-DROZD & MALTZ (2012; for a general description of clausiliid reproductive strategy see MALTZ & SULIKOWSKA-DROZD 2008). However, life-history traits may vary between geographical regions and here we studied the reproduction of only a single population isolated from the main distribution range.

The results of the study can be compared with recently published data on other ovoviviparous clausiliids inhabiting Central Europe, namely *Vestia gulo* (E.A. Bielz, 1859), *V. elata* (Rossmässler, 1836), *V. turgida* (Rossmässler, 1836) (SULIKOWSKA-DROZD 2009) and *Ruthenica filograna* (Rossmässler, 1836) (SZYBIAK 2010). In *B. fallax*, specimens containing developing eggs were found through spring and summer months but only in early June was a significant part of the population gravid (62%). The highest percentage of egg retaining specimens was also observed in June in other ovoviviparous clausiliids (SULIKOWSKA-DROZD 2009, SZYBIAK 2010). In *V. gulo* and *V. turgida* egg retention was recorded from early May till August, with the maximum in June (50% and 72% of adults were gravid, respectively). In *R. filograna* the reproductive season was much longer and gravid adults were found between March and Oc-

tober; in June more than 80% of adults retained eggs. The shells of the largest embryos removed from uteri of *B. fallax* had 1.0–1.1 whorl. This can be compared with 1.3 whorl in retained embryos of *V. gulo*, 1.8 in *V. elata*, and 2.9 in *V. turgida* (SULIKOWSKA-DROZD 2009). The largest embryonic shells of *R. filograna* have 2.5–2.7 whorls (SZYBIAK 2010). In ovoviviparous species neonates should hatch inside the parent or immediately after egg-laying (BAUR 1994), while in oviparous clausiliids the period between egg-laying and hatching lasts usually 10–16 days (MALTZ & SULIKOWSKA-DROZD 2008). It seems that *B. fallax* exhibits an intermediate reproductive strategy (short

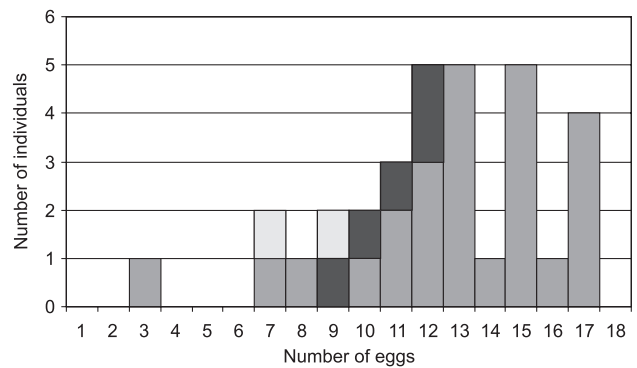


Fig. 4. *Balea fallax*: number of eggs found in the uterus. Adults collected in May (light grey), June (grey), July and August (black)

Table 1. *Balea fallax* from Szperówka (Roztocze Upland). Shell size, shape and Spearman's correlation coefficient (r_s) between shell parameters and number of retained eggs (data for 33 gravid individuals)

	n	mean (\pm SD)	range	r_s ($p > 0.05$)
Shell height (mm) (<i>H</i>)	205	17.03 (\pm 0.77)	14.8–19.4	0.21
Shell breadth (mm) (<i>B</i>)	210	4.57 (\pm 0.17)	3.7–4.9	–0.19
<i>H/B</i>	205	3.37 (\pm 0.22)	3.22–4.43	0.19
Number of whorls (<i>NW</i>)	208	10.74 (\pm 0.43)	9.5–11.9	0.09

egg retention): the eggs of *B. fallax* develop in the parental body only to a certain stage and the rest of embryonic development occurs outside. It remains unknown how long the eggs stay in the reproductive tract, while the interval between egg laying and hatching ranges from 8 to 10 days and the hatchling shell consists of ca. 2.5 whorls (SULIKOWSKA-DROZD & MALTZ 2012).

According to TOMPA (1979), ovoviviparous snails had significantly lower fecundity than oviparous species and most common cases involved the retention of 2–6 eggs in the reproductive tract. However, the number of eggs found in the uterus varies among clausiliids. For egg retaining species of the genus *Vestia* a negative correlation was observed between the number of eggs in the uterus and their ultimate size (SULIKOWSKA-DROZD 2009). In *R. filograna*, up to four embryos are simultaneously retained (SZYBIAK 2010), but other species, perhaps owing to their large shell sizes, contain larger broods: *V. turgida* up to 12 and *V. gulo* up to 21 eggs (SULIKOWSKA-DROZD 2009). *B. fallax* from Roztocze retains a mean of 12.3 eggs (maximum 17). The eggs in the uterus are more numerous than in an average batch laid in our laboratory culture of the studied species (mean 6.7, SD 3.61) (SULIKOWSKA-DROZD & MALTZ 2012). A similar difference between the numbers of retained and laid

eggs was observed previously in species of the genus *Vestia* (SULIKOWSKA-DROZD 2009). It may be advantageous in an unpredictable environment if not all eggs are laid at once.

The strategy of gradual release of eggs may obscure the correlation between the parent size and the number of eggs or embryos. Similarly, no relation between adult shell size and the number of young produced could be found in ovoviviparous *Balea perversa* (L.) (BAUR 1990).

In many respects the egg retention strategy found in *B. fallax* resembles the reproductive mode of the Carpathian clausiliid *V. gulo* (duration of the reproduction period, number of retained eggs and their degree of development). At present, all available data suggest that the ovoviviparity in *B. fallax* is obligatory rather than facultative and that it is not an artefact of laboratory conditions.

ACKNOWLEDGEMENTS

We are grateful to the anonymous referees for their valuable comments on the earlier version of the manuscript. The study of reproductive strategies in clausiliids was supported by the National Science Centre (N N 303 796740).

REFERENCES

- BAUR A. 1990. Intra- and interspecific influences on age at first reproduction and fecundity in the land snail *Balea perversa*. *Oikos* 57: 333–337. doi: 10.2307/3565962
- BAUR B. 1994. Parental care in terrestrial gastropods. *Experientia* 50: 5–14. doi: 10.1007/BF01992042
- EHRMANN P. 1933. Mollusca (Weichtiere). In: BROHMER P., EHRMANN P., ULMER G. (eds). *Die Tierwelt Mitteleuropas*, 2.1. Quelle & Meyer, Leipzig.
- FALKNER G., BANK R. A., PROSCHWITZ T. VON 2001. Checklist of the non-marine molluscan species-group taxa of the states of Northern, Atlantic and Central Europe (CLECOM I). *Heldia* 4: 1–76.
- MALTZ T. K., SULIKOWSKA-DROZD A. 2008. Life cycles of clausiliids of Poland – knowns and unknowns. *Ann. Zool.* 58: 857–880. doi: 10.3161/000345408X396783
- NORDSIECK H. 2007. *Worldwide Door Snails (Clausiliidae), recent and fossil*. ConchBooks. Hackenheim.
- PIECHOCKI A. 1990. Interesujące gatunki ślimaków lądowych (Gastropoda terrestria) na Roztoczu. *Przeegl. Zool.* 34: 267–274.
- RIEDEL A. 1988. *Ślimaki lądowe Gastropoda terrestria*. Katalóg Fauny Polski 46. PWN, Warszawa.
- SULIKOWSKA-DROZD A. 2009. Egg retention and ovoviviparity in clausiliids of the genus *Vestia* P. Hesse (Gastropoda: Clausiliidae). *J. Moll. Stud.* 75: 351–359. doi: 10.1093/mollus/eyp028
- SULIKOWSKA-DROZD A., MALTZ T. K. 2012. Reproduction of the clausiliid *Balea (Pseudalinda) fallax* (Rossmässler, 1836) (Gastropoda: Pulmonata: Clausiliidae) kept under laboratory conditions. *Folia Malacol.* 20: 27–34. doi: 10.2478/v10125-012-0007-1.
- SZYBIAK K. 2010. *Ruthenica filograna* (Rossmässler, 1836) (Gastropoda: Pulmonata: Clausiliidae). Structure, variation, life cycle, ecology and distribution. Wydawnictwo Kontekst, Poznań.
- TOMPA A. S. 1979. Oviparity, egg retention and ovoviviparity in pulmonates. *J. Moll. Stud.* 45: 155–160.
- URBAŃSKI J. 1958. Świdrzyk *Laciniaria (Pseudalinda) fallax* Rossm. (*Gastrop., Pulm.*) w Rezerwacie Bukowa Góra koło Zwierzyńca (Zamojszczyzna). *Pr. Kom. Biol. PTPN* 19: 13–18.
- WIKTOR A., RIEDEL A. 2002. Ślimaki lądowe Gastropoda terrestria. In: GŁOWACIŃSKI Z. (ed.). *Czerwona lista zwierząt ginących i zagrożonych w Polsce*. Nature Protection Research Centre of the Polish Academy of Science, Kraków, pp. 31–38.

Received: November 7th, 2011

Revised: December 19th, 2011

Accepted: December 31st, 2011

