ACTA ZOOL. CRACOV.	27	4	61—72	KRAKÓW, 31. I. 1984

Włodzimierz JUSZCZYK, Marian ZAKRZEWSKI, Józef ŚWIERAD

The hibernation and survival of larvae of the Spotted Salamander *Salamandra salamandra* (LINNAEUS, 1758) in natural water reservoirs of the Carpathian Uplands and West Beskids in Poland

Zimowanie i przezimowywanie larw salamandry plamistej *Salamandra salamandra* (LINNAEUS, 1758) w naturalnych zbiornikach wodnych Pogórza Karpackiego i Beskidów Zachodnich, Polska

Abstract. In the Carpathian Uplands and West Beskids hibernating larvae of *Salamandra salamandra* were found in six water reservoirs (wells, springs, a pool), of which none was in the nature of a mountain brook. These larvae led active ways of living in winter as shown by analyses of their stomach contents. The larvae that survived the winter underwent a metamorphosis in the spring (in April) of the next year.

I. INTRODUCTION

It is generally known that in the uplands the spawning and egg hatching of amphibians is markedly delayed owing to prevailing climatic conditions and in this connection the larvae of some urodelans do not undergo a metamorphosis and remain for winter in water reservoirs. Descriptions of hibernation in literature most often concern the larvae of various species of newts (EGGERT, 1934; SMITH, 1954; GISLEN and KAURI, 1958; SEMBRAT and NOWAKÓWNA, 1959; MIELEWCZYK, 1964; SEMBRAT et al., 1965; JUSZCZYK, 1974; ŻYŁKA, 1975; ARNTZEN and SPARREBOOM, 1976; ŚWIERAD, 1980, 1983), but there are considerably fewer records of the hibernation of larval spotted salamanders in herpetological literature (SCHREIBER, 1912; EGGERT, 1934; JUSZCZYK, 1974).

Since we have found in the field that salamander larvae not only hibernate but outlive the winter and undergo a metamorphosis in the next year, it seems expedient to present the hydrobiological conditions of the water reservoirs and morphometric changes occurring in these larvae at the time of hibernation in them.

II. MATERIALS AND METHODS

In 1973—1978 a study was carried out on 22 permanent water reservoirs which were breeding sites of spotted salamanders year in year out, whereas observations of mountain brooks were conducted for 13 consecutive years.

The localities in which salamander larvae occurred in their first developmental stages in the winter were inspected once a month from November throughout April, more frequently only in the spring. In three of them all the larvae were then removed from the water so that we could determine the stage of their development acc. to the nomenclature given by JUSZCZYK and ZAKRZEWSKI (1981) and measure the overall length of their bodies. Then, after the larvae had been marked by cutting out a part of the dorsal fold of the caudal fin, they were released in the place of capture. Only a few larvae from two localities were fixed in 5% formalin so that their alimentary canals should be examined for their contents. At each inspection the general condition of water was determined, air and water temperatures were measured and samples of water taken in order that the amount of oxygen solved in the water might be determined by WINKLER'S method and the pH measured.

III. CHARACTERISTICS OF THE STUDY AREA

The most characteristic biotope in which the water reservoirs with hibernating larvae of spotted salamanders occur includes natural meadows overgrown with clumps of trees and shrubs and bordering upon mixed forests. The surface area of these little water reservoirs was between 0.7 and 2.0 sq.m. and the maximum depth was 30—80 cm. The wells were timbered, the springs steened and they formed basins filled with water, the pool had grassy borders. All these reservoirs were supplied from springs and they had outlets which constituted the sources of brooks.

The general climatological conditions in the study area, despite its altitudinal differentiation, were similar, because these localities were situated not far aparat. The mean and extreme temperatures of water and the oxygen content in it at the time of observation are given in Table I.

In the years 1973—1976 the winter seasons were particularly mild in the study area. Although snowfall occurred as early as mid-October, the snow thawed (in the 3rd decade of December) after spells of warmer weather and föhns. Only at altitudes above 700 m a.s.l. it persisted till the spring, which also brought some recurrences of winter weather. The winter seasons of 1976—1978 were more severe and richer in precipitation.

Table I

Mean and extreme temperatures, oxygen contents and pH of the water in the studied reservoirs

Locality (height above sea level)	Extreme and mean temperatures of water in °C in successive years												Mean contents of oxygen O_2/1	Oxygen saturation of water % O_2	pH
	min.	mean	max.	min.	mean	max.	min.	mean	max.	min.	mean	max.			
I. — well Kalwaria Lanc. 370 m	3,2	5,2	9,3	2,9	5,0	10	3,5	4,5	10,5	4,0	6,0	10	11,7	95,0	7,1
II. — spring Bystra Podh. 450 m	2,0	3,5	7,8	2,1	2,7	6,0	2,1	3,8	7,0	2,0	4,0	7,5	10,4	86,7	7,7
III. — spring Bystra Podh. 560 m	2,0	3,0	7,2	2,0	3,0	8,0	1,1	3,2	7,7	2,0	4,2	7,1	12,0	89,0	7,7
IV. — well Chrobacza Ł. 823 m	3,7	5,1	10	13	3,8	9,0	2,3	4,0	8,2	2,9	4,5	9,5	9,3	80,2	7,1
V. — spring Chrobacza Ł. 822 m	2,0	3,5	7,7	1,5	3,5	7,0	1,8	3,7	7,0	1,8	4,2	6,8	11,2	82,7	7,4
VI. — pool Chrobacza Ł. 820 m	2,0	3,0	4,1	2,0	4,5	9,3	2,3	4,0	8,7	2,0	4,0	8,9	8,7	79,0	7,1

Only the wells did not freeze in the study period, whereas the springs and brooks were partly covered with ice and the pool was frozen all over its surface as early as the beginning of winter in 1974 and in the first decade of December the ice reached to its very bottom.

During the period of hibernation of the larvae the percentage saturation of water with oxygen (Table I) in particular reservoirs was relatively high but did not exceed 100%, as it did in lowland water reservoirs in the summer, when the processes of photosynthesis were very intense in them owing to the abundant vegetation of plants (JUSZCZYK and ŚWIERAD, 1973). The lowest level of oxygen saturation was 79.0% and occurred in the pool.

The pH of the water at particular localities ranged from 7.1 to 7.5 and so between neutral and slightly alkaline. The mean temperatures of water at the time of hibernation were from 2.7 to 6.0°C.

IV. RESULTS

Out of the 22 water reservoirs examined hibernating larvae of the spotted salamander were found in 6 and these are:

locality I (well) — situated near Kalwaria Lanckorońska in the Carpathian Upland (46°06'N, 19°43'E; 370 m a.s.l.)

locality II (spring) — at Bystra Podhalańska in the West Beskids (49°39'N, 19°47'E; 450 m a.s.l.)

locality III (spring) — below the summit of Hyćkowa Góra at Bystra Podhalańska in the West Beskids (49°39'N, 19°47'E; 560 m a.s.l.)

locality IV (well) — below the summit of the massif of Chrobacza Łąka in the West Beskids (49°50'N, 19°11'E; 823 m a.s.l.)

locality V (spring) — below the summit of the massif of Chrobacza Łąka in the West Beskids (49°50'N, 19°11'E; 822 m a.s.l.)

locality VI (pool) — Chrobacza Łąka in the West Beskids (49°50'N, 19°11'E; 820 m a.s.l.).

The amphibian larvae, including those of *Triturus* and *Salamandra*, in the remaining 16 water reservoirs (5 wells, 5 brooks and 6 little ponds) underwent a metamorphosis before the beginning of the winter.

At locality I the larvae hibernated in four successive seasons. The number of the larvae staying in the water at this locality in the winter varied between 6 and 36 in particular years. The maximum length of the larvae was 56 mm. Four to six of these larvae underwent a metamorphosis in the spring, i.e. in April (Table III).

At localities II and III the larvae, respectively 17 and 22 in number, hibernated in only one season. They all underwent a metamorphosis in the second decade of April (Table II).

Table II

Number of hibernating larvae of *Salamandra salamandra* in each localities in successive years

Locality (height above sea level)	Year	Number of hibernating larvae	Stage of development at the beginning of hibernation	Date of 1st catching of larvae	Stage of development after hibernation	Remarks on hibernation of larvae
I — well	1973/4	19	I	20.IV.1974	III a	survived
Kalwaria	1974/5	11	I	28.IV.1975	III a	"
Lanc.	1975/6	36	I	25.IV.1976	III a	"
370 m	1976/7	9	I	2.IV.1977	III a i b	"
	1977/8	—	—	—	—	not survived
II — spring	1974/5	17	I, II	11.IV.1975	III a i b	survived
Bystra Podh.	1975/6	—	—	—	—	not survived
450 m	1976/7	—	—	—	—	"
	1977/8	—	—	—	—	"
III — spring	1974/5	22	I, II	11.IV.1975	III a i b	survived
Bystra Podh.	1975/6	—	—	—	—	not survived
560 m	1976/7	—	—	—	—	"
	1977/8	—	—	—	—	"
IV — well	1974/5	28	I	28.IV.1975	III b	survived
Chrobacza Ł.	1975/6	19	I	20.IV.1976	III b	"
823 m	1976/7	—	—	—	—	not survived
	1977/8	15	I	29.IV.1978	III b	survived
V — well	1974/5	14	I	28.IV.1975	III b	survived
Chrobacza Ł.	1975/6	—	—	—	—	not survived
822 m	1976/7	—	—	—	—	"
	1977/8	—	—	—	—	"
VI — pool	1974/5	18	I	14.XI.1974	—	not survived
Chrobacza Ł.	1975/6	—	—	—	—	"
820 m	1976/7	—	—	—	—	"
	1977/8	—	—	—	—	"

At locality IV the larvae hibernated for two successive seasons and next after an interval of a year they began to hibernate again. The number of larvae staying in the water ranged from 15 to 28 in particular years and their length was 31—58 mm. These larvae got metamorphosed towards the end of April (Tables 2 and 4).

At locality V the larvae, 14 in number, hibernated for only one season. Six of them survived and underwent a metamorphosis in April. The

Table III

Number of hibernating larvae of *Salamandra salamandra* in particular stages of development at locality 1

Date of catching of larvae	Number of caught of larvae	Stage of development	Observed range of body length
10.X.1973	19	I	27—38
18.X.1973	19	I	28—40
7.XI.1973	16	I	28—40
15.XII.1973	12	I, II	28—43
15.I.1974	10	I, II	28—44
9.II.1974	10	I, II	30—45
17.III.1974	8	I, II, III a	35—50
20.IV.1974	6	III a i b	48—56
15.IX.1974	11	I	23—30
2.XII.1974	11	I	23—31
18.I.1975	8	I	25—31
7.II.1975	8	I, II	28—41
25.II.1975	8	I, II	28—43
13.III.1975	4	II, III a	36—48
28.IV.1975	4	III a	45—51
25.XI.1975	36	I, II	28—33
8.XII.1975	32	I, II	30—33
13.I.1976	30	I, II	32—38
28.I.1976	24	I, II	32—39
10.II.1976	21	I, II	32—40
25.II.1976	18	I, II	35—45
18.III.1976	16	I, II	36—45
2.IV.1976	12	I, II	38—45
10.IV.1976	10	II, III a	43—50
25.IV.1976	8	III a i b	49—53
2.V.1976	—	—	—
18.X.1976	9	I	28—35
15.XI.1976	9	I, II	28—37
8.XII.1976	9	I, II	30—39
12.I.1977	7	I, II	30—41
23.II.1977	7	I, II	33—43
15.III.1977	7	II	35—44
2.IV.1977	3	II, III a	41—52
27.IV.1977	—	—	—
15.XI.1977	—	—	—
13.XII.1977	—	—	—
7.I.1978	—	—	—
21.II.1978	—	—	—

length of the larvae at the time of metamorphosis was 51—57 mm (Table V).

At locality VI 18 larvae hibernated for one season, but they did not live out the winter and all perished, because the water in the pool was frozen almost to the very bottom.

The numbers of hibernating larvae of the spotted salamander in particular localities are given in Table 2, whereas Tables 3—5 present the detailed rates of growth and development of larval salamanders in three (I, II and V) selected localities in the study period.

Table IV

Number of hibernating larvae of *Salamandra salamandra* in particular stages of development at locality IV during one season

Date of catching of larvae	Number of caught larvae	Stage of development	Observed range of body length
14. IX. 1974	28	I	31—35
19.X. 1974	25	I	32—35
1.XI. 1974	23	I	33—35
5.XII. 1974	20	I	33—35
4.I. 1975	17	I	33—35
22.II. 1975	12	I	33—35
9.III. 1975	9	I, II	33—37
16.III. 1975	7	I, II	34—37
1.IV. 1975	6	II	35—43
14.IV. 1975	5	III a	41—55
28.IV. 1975	4	III b	57—58
5.V. 1975	—	—	—

Table V

Number of hibernating larvae of *Salamandra salamandra* in particular stages of development at locality V during one season

Date of catching of larvae	Number of caught larvae	Stage of development	Observed range of body length
14.IX. 1974	14	I	31—33
9.X. 1974	12	I	31—33
1.XI. 1974	12	I	32—34
5.XII. 1974	10	I	31—35
4.I. 1975	8	I	31—36
22.II. 1975	7	I	32—35
9.III. 1975	6	I	32—36
16.III. 1975	6	I, II	33—38
1.IV. 1975	4	I, II	36—42
14.IV. 1975	2	III a	51—54
28.IV. 1975	2	III b	56—57
5.V. 1975	—	—	—

A comparison of the larvae living in streams during the vegetation season with those hibernating shows no essential differences in their morphological structure of body in successive developmental stages.

Only the time of the first stages of development (Stages I and II) was observed to be prolonged. With hibernating larvae it lasts from November throughout February and so four months, in which time in ordinary conditions the metamorphosis of these larvae would certainly have been completed. On the other hand, the time taken by the hibernating larvae for metamorphosis (Stages IIIa and b) resembled that of larvae undergoing it in ordinary conditions and lasted about 2 months (Tables III and IV).

A study of the stomach contents in 21 larval spotted salamanders in various developmental stages from 2 localities (I and VI) shows that in the hibernating season the larvae took food. Their food consisted chiefly of coleopteran larvae and also of members of the *Crustacea (Copepoda, Isopoda, Amphipoda).* Body fragments of other salamander larvae eaten up were found in the stomachs of two larvae derived from a well (locality I), which confirms the fact of adelophagy described in this species by JOLY (1968). Moreover, large pieces of larval *Triturus alpestris,* hibernating in the reservoir, were found in the stomachs of three salamander larvae from locality VI (pool). In the course of winter a regular decrease in the number of larvae was observed in all the localities examined and consequently only a few of them underwent a metamorphosis in the spring (Tables III, IV and V), which indicates, among other things, that in the severe periods of winter the larvae devoured each other.

V. DISCUSSION

In natural habitats of salamander larvae, like mountain streams, both the development and metamorphosis of these animals take place within one and the same vegetation season. Having undergone a metamorphosis, these larvae leave the stream at the latest in August (ZAKRZEWSKI, 1970). It is interesting that during the present study, carried out for 13 years, no salamander larvae were found hibernating in mountain streams, although these were not frozen over certain lengths in winter and the fauna of small organisms present in them constituted natural food for these larvae. On the other hand, in the water reservoirs which are not their characteristic habitats (well, spring, a pool), as shown by our study, they hibernate successfully. This may be explained by the fact that the larvae of salamanders are poor swimmers which avoid the current of the brook and stay in its shallows close to the banks or, generally speaking, only in places of a sluggish stream (JUSZCZYK, 1974). In the winter a considerable reduction in the water flow as a rule takes place in these streams, which in consequence leads to their shallowing and so the liquidation of windings and shallows just close to the banks. In this situation the larvae occurring in changed hydrological conditions

cannot stand the water current, being eventually drifted to the terminal portions of the streams, which causes their disappearance from their typical habitat.

All the cases of hibernation of spotted salamander larvae were generally observed in rather deep reservoirs of slow-flowing water, the parameter of which (pH, $^0/_{00}O_2$, temperature) resembled those of the water in mountain streams.

The causes of their hibernation in water reservoirs may be various. Here, we must above all mention the physiological aptitude of this species for delaying the term of ovulation (ZAKRZEWSKI, 1976) and also its ability to detain the larvae in the oviduct, which is most frequently connected with lack of suitable conditions for females to give birth to larvae, e.g. the lack of water in the reservoir, its remoteness, and, according to JOLY (1968), even its too great altitude above sea level. The larvae in the first developmental stage found in the autumn in various localities and in various years of study could not complete their metamorphosis before the onest of winter, because they take 3—5 month to go through a metamorphosis (PALUSHINA, 1966); this period may even be longer according to the water temperature and general climatological situation. When the water is too cold, i.e. below 10°C, the salamander larvae do not begin their metamorphosis but hibernate (SCHREIBER, 1912). The survival of the larvae till the spring depends chiefly on favourable ecological conditions in the given reservoir. And so the larvae in such localities as wells and springs survived to undergo a metamorphosis in April, whereas those in the pool all perished after the water had frozen.

The body length of the hibernating larvae did not differ from that of the larvae met with in streams during vegetation seasons. It was found that the growth rate of the body length of hibernating larvae started to accelerate in the 3rd decade of March, being very slow up to that time. It should be stated on the basis of our observations that at the time of metamorphosis all the larvae that live out till the spring showed the length of body characteristic of this population in Poland, that is, 58 mm.

WILBUR and COLLINS (1973) write that the physiological processes which start the metamorphosis are associated with the last developmental stages of the specimen, whereas the larvae in the initial stages of development are only able to grow in size. This growth however brings about the senescence of the tissues and so the salamander larvae may become less sensitive to thyroid hormones, which as a result leads to the development of neotenic forms. Also low water temperatures are sometimes responsible for the origin of neotenic forms, but then their body size is larger than that of adult specimens. SCHREIBER (1912) claims that under laboratory conditions it is possible to obtain salamander larvae of a larger body size (70—75 mm) but not neotenic forms.

Hormonal factors have also an effect on lingering metamorphosis (KUHN, 1925; EGGERT, 1934; DOOD and CALLA, 1955), which phenomenon also takes place in overcrowded populations of larvae, where it is due the secretion by their members of metabolites, termed inhibitors (ROSE S.M., 1959a, b; ROSE S.M. and ROSE F.C., 1961, 1965; WEST, 1960; RICHARDS, 1962). Under some circumstances and notably when the exchanging of water in the reservoir is impossible, these inhibitors may slow down the development of the larvae living in it. However, in the cases observed by us this hypothesis must be excluded, for in all the reservoirs examined the outflow and influx of water was stable and the larvae staying in them were not numerous.

Translated into English
by Jerzy ZAWADZKI

Instytut Biologii WSP
Zakład Zoologii
Podbrzezie 8
31-054 Kraków, Poland

REFERENCES

ARNTZEN, J. W., SPARREBOOM, M., 1976. Enekele waanemingen aan de ampibienfauna Tatra en de Beskiden (Polen). Lacerta, **34** (2): 146—148.

DODD, J. M., CALLAN, H. G., 1955. Neoteny with goitre in *Triturus helveticus*. Quart. J. Micr. Sc., (96): 121—128.

EGGERT, B., 1934. Zur Überwinterung der Larven von *Molge alpestris* (Laur.) unter besonderer Berücksichtigung des Verhaltens der Schilddrüse. Z.f. wissensch. Zool., (145): 399—424.

GISLEN, T., KAURI, H., 1959. Zoogeography of the Swedish Amphibians and Reptiles with notes on their growth and ecology. Acta Vertebr., **1** (3): 193—397.

JOLY, J., 1968. Données écoiogiques sur la Salamandre tachetée *Salamandra salamandra* (L.). Annal. Sc. Natur. Zool., Paris, ser. 12 (10): 301—366.

JUSZCZYK, W., ŚWIERAD, J., 1973. Wpływ hydrobiologicznych właściwości zbiorników wodnych na rozwój kijanek żaby trawnej (*Rana temporaria* L.). Rocz. Nauk.-Dydak., WSP Kraków, Zool. (50): 47—66.

JUSZCZYK, W., 1974. Płazy i gady krajowe. PWN, Warszawa, 1—721.

JUSZCZYK, W., ZAKRZEWSKI, M., 1981. External morphology of larval stages of the spotted salamander, *Salamandra salamandra* (L.). Acta Biol. Cracov., Ser. Zool., (23): 127—135.

KUHN, O., 1925. Schilddrüsenfunktion und Neotenie bei Urodelen. Biol. Zbl., (45): 483—495.

MIELEWCZYK, S., 1964. Zimowanie traszki górskiej (*Triturus alpestris* [LAUR.]) w Karkonoszach. Przeg. Zool., **8** (4): 347—348.

POLUSHINA, N. A., 1966. Reproduction of *Salamandra salamandra* L. and its relation to the environment. Zool. Jurnal, (45): 144—146.

RICHARDS, C. M., 1967. The control of tadpole growth by algalike cells Physiol. Zool., (35): 285—296.

ROSE, S. M., 1959a. Failure of survival of slowly growing members of a population. Science, (129): 1026.

ROSE, S. M., 1959b. Population control in grupies. Amer. Migl. Nat., (62): 474—481.

ROSE, S. M., 1960. A fedbac mechanisms of growth control in tadpoles. Ecology, (41): 188—199.

ROSE, S. M., ROSE, F. C., 1961. Growth-controlling exudates of tadpoles. In "Mechanisms in Biological competition". F. L. Milthrorpe ed., Symp. Soc. exp. Biol., (15): 207—213.

ROSE, S. M., ROSE, F. C., 1965. The control of growth and reproduction infreshwater organisms by specific products. Mitt. Intern. Verein. Limnol., (13): 21—32.

SCHREIBER, E., 1912. Herpetologia Europea. Jena, 1—960.

SEMBRAT, K., NOWAKÓWNA, J., KOŚCIELSKI, B., 1965. Kilka uwag w sprawie zimowania larw traszek. Przegląd Zool., **9** (1): 51—53.

SEMBRAT, K., NOWAKÓWNA, J., 1959. Zimowanie larw traszki górskiej *Triturus alpestris* (LAUR.) i traszki karpackiej *Triturus montandoni* (BLGR.) w Stawie Toporowym Niżnim w Tatrach. Przeg. Zool., **3** (1): 56—60.

SMITH, M., 1954. The British Amphibians and Reptiles. London.

ŚWIERAD, J., 1980. Vertical ranges of four species of newts in West Beskid Mountains. (Carpathian Mountains — South Poland). Acta Biol. Cracov., Ser. Zool., (1): 35—48.

ŚWIERAD, J., 1983. Wintering of newt larvae (*Triturus* RAF.) in small lakes in the Western Beskid Mountains (Poland). Folia Biol., **31** (1): 79—92.

WEST, L. B., 1960. The nature of growth inhibitory material from crowded pipiens tadpoles. Physiol. Zool., (33): 231—239.

WILBUR, H. M., COLLINS, J. P., 1973. Nonormal distributions of cometitive ability reflect selection for facultative metamorphosis. Science, (182): 1305—1313.

ZAKRZEWSKI, M., 1970. Dates of the appearance and development of larvae of the spotted salamander (*Salamandra salamandra* L.) in a natural habitat. Acta Biol. Cracov., (13): 161—173.

ZAKRZEWSKI, M., 1976. Development of the female reproductive organ nominal form of the spotted salamander *Salamandra s. salamandra* (L.), in the West Beskid region (Poland) in the annual cycle. Acta Biol. Cracov., (19): 23—39.

ŻYŁKA, A., 1975. Zimowanie larw traszki zwyczajnej *Triturus vulgaris* (LINNAEUS 1758) w Oświęcimiu. Przeg. Zool., **19** (2): 227—230.

STRESZCZENIE

Badania nad zimowaniem i przezimowywaniem larw salamandry plamistej *Salamandra salamandra* (L.), przeprowadzono w ciągu 5 lat w 22 nie wysychających zbiornikach wodnych (studnie, źródła, strumienie, stawki) Pogórza Karpackiego i Beskidów Zachodnich. Zimowanie larw stwierdzono w 6 zbiornikach wodnych (2 studniach, 3 źródłach, 1 stawku), przy czym żaden z nich nie miał charakteru górskiego strumienia. W czasie przeprowadzonych szczegółowych obserwacji w ciągu 13 lat w górskich strumieniach tych regionów nie stwierdzono zimujących larw salamandry plamistej. Spotykane w wymienionych zbiornikach zimujące

larwy były w różnych stadiach rozwojowych. Larwy, które przetrwały niekorzystne warunki zimowe, przeobrażały się dopiero na wiosnę przyszłego roku. Badania morfologiczne zimujących larw wykazały bardzo wolny wzrost długości ciała. Przyspieszenie zaś tempa wzrostu larw salamandry oraz ich przeobrażenie następowało na wiosnę, w kwietniu. Analiza treści pokarmowej zimujących larw wykazała, że prowadzą one aktywny tryb życia. Pokarm ich stanowiły głównie larwy *Coleoptera*, jak również przedstawiciele *Crustacea (Copepoda, Isopoda, Amphipoda)*. W dwu przypadkach stwierdzono w żołądkach larw salamandry fragmenty ciała larw tego gatunku, jak również larw *Triturus*, które wspólnie z nimi zimowały. Dowodzi to zjawiska kanibalizmu u larw tego gatunku, jak również wyjaśnia sukcesywne zmniejszanie się liczebności zimujących larw w danym zbiorniku wodnym.

Redaktor pracy: prof. dr M. Młynarski