HERPETOLOGICA ROMANICA
ISSN: 1842-9203
Vol. 5, 2011, pp.27-42
Article No. 111103

Water and ecological conditions of striped newt, *Triturus v. vittatus* (Urodela), breeding sites at various altitudes near the southern limit of its distribution

Oren PEARLSON[1,2,3] and Gad DEGANI[1,2,*]

1. MIGAL–Galilee Technology Center, P. O. Box 831, Kiryat Shmona 11016, Israel.
2. School of Science and Technology, Tel Hai Academic College, Upper Galilee 12210, Israel.
3. Institute of Evolution and Department of Evolutionary and Environmental Biology, University of Haifa, Haifa 31905, Israel.
* Corresponding author: G. Degani, Tel: 972-50-5586706; Fax: 972-4-6944980;
E-mail: gad@migal.org.il

Abstract. This paper examines the hypothesis that *Triturus v. vittatus* adapts to different breeding sites by changing the duration and rate of larval growth. Ecological and biological conditions of breeding sites inhabited by *Triturus v. vittatus* in northern Israel were studied for four years. Altitudes of the localities: 212-740m ASL. Longest larval growth period was found in Dovev pond (April to July), located at the highest elevation. Period of larval growth varied among sites and differed from year to year during the study. All sites possessed newt larvae along with various anuran larvae. *Salamandra infraimmaculata* larvae and adult newts inhabited two rain pools simultaneously, with very little overlap of the larval growth periods. Ponds water temperatures increased significantly from winter to spring (5-30 ºC). pH varied from 6.5-10, dissolved oxygen ranged between 2-27mg/L, generally between 5-10mg/L. Electrical conductivity varied between 150–800μs, with significant differences among the ponds during some periods ($P<0.05$). Ammonia (NH_4) and nitrite (NO_2) concentrations were low, generally less than 1 and 0.25mg/L respectively. Turbidity remained relatively constant, varying between 0-150NTU. In conclusion, among the different ponds, variations were found in the length of the newt larval growth period and the time required for the completion of metamorphosis, but no differences in the ecological parameters and water quality of the ponds were discovered during larval growth period. These results support the hypothesis that changes in the rate of larval growth and metamorphosis completion is the manner, by which *T. v. vittatus* adapt to unstable breeding sites. Based on the results of the investigation, the major factors affecting the habitat selected by *T. v.*

vittatus for breeding are the ecological conditions that allow for survival, growth and metamorphosis completion of the amphibian larvae.

Key words: adaptability; amphibian; larval growth period; *Triturus vittatus*; water quality.

INTRODUCTION

Six species of amphibians exist in northern Israel - the striped newt, *Triturus vittatus vittatus*; fire salamander, *Salamandra infraimmaculata* (Amphibia, Urodela, Salamandridae); and four anuran species, i.e., the tree frog, *Hyla savignyi*; green toad, *Bufo viridis*; water frog, *Rana bedriagae*; and the spadefoot, *Pelobates syriacus* (Degani 1982, Degani 1986). Israel offers mainly xeric habitats, unusual for most amphibians and represents the southeastern limit of distribution of these species (Steward 1969, Degani and Mendelssohn 1983). Hence, amphibian larvae occupy a very narrow and specific ecological niche in the region and are under intense pressure from predators and other biotic and abiotic factors (Degani and Mendelssohn 1983, Degani 1986, 1996). Amphibian larvae have been observed and studied in a variety of ephemeral pools, ponds and streams of hilly woodlands in northern Israel, as well as in the central coastal plains, during winter, spring and summer (Goldberg, et al. 2010).

Little is known about the ecological conditions of the natural habitats of the *Triturus vittatus.* Some aspects of the subspecies, *T. v. vittatus,* located in Israel, and its biology and life cycle in Europe and the Mediterranean region, have been described earlier by Olgun et al. (1997) and Raxworthy (1989).

Arntzen and Olgun, K. 2000 studied the number of rib-bearing vertebrae, eight morphometric characters and 36 protein loci in three subspecies of the banded newt, *Triturus vittatus* from the Near and Middle East. Significant differences in shape were observed comparing *T. vittatus* with *T. karelinii* and *T. montandoni*, but not among *T. v. vittatus*, *T. v. cilicensis* and *T. v. ophryticus*.

Until recently, it was thought that *Triturus vittatus* has three subspecies: *Triturus v. vittatus,* along the eastern edge of the Mediterranean Sea from Turkey to Israel, where it reaches its southern limit, *T. v. cilicensis*, found in areas bordering the east and northeast of the Mediterranean and *T. v. ophryticus* in the Caucasus, east and south of the Black Sea. Based on its trunk vertebrae count, genome size and allozyme data, Litvinchuk et al. (2005) suggested that the northern taxon, *T. v. ophryticus*, is subdivided into two geographic fragments, the "western group", with populations from western Anatolian Turkey, and the "eastern group", composed of populations from the remaining region of Pontic Turkey and the western Caucasus. Litvinchuk have allocated the western group of *T. ophryticus* to a separate subspecies, *Triturus ophryticus nesterovi*.

In Israel, *T. v. vittatus* populations range from the north to the central coastal plains, where habitat conditions are most extreme. The biology and life cycle of *T. v. vittatus* populations in northern Israel and the Upper Galilee have been previously described (Degani and Mendelssohn 1983, Degani 1986, Pearlson and Degani 2008). Throughout their aquatic phase, adults and larvae of *T. v. vittatus* inhabit primarily winter pools, which contain water until the beginning of the summer, and sometimes throughout the year (Degani and Kaplan 1999, Pearlson and Degani 2008). The terrestrial adult newts reach the area of the pond at the beginning of the rainy season before the ponds fill up with water. Subsequently, they enter the water-filled ponds, during their aquatic phase. In the Upper Galilee, males inhabit the ponds from January to March and leave them after mating. Females may remain in the water until May, during which they deposit between 18-68 eggs on plants or rock surfaces, until they move into their terrestrial stage (Degani and Mendelssohn 1983). Afterwards, the larvae hatch, 19-29 days later, depending upon water temperatures.

The period of activity, population parameters and food habits of mature *T. v. vittatus* in central Israel have been studied by Geffen et al. (1987), who discovered that during November–December, adult newts appear on land and enter the water-filled ponds, remaining there until late February.

Very little information has been published on the effect of man on the water quality of breeding sites in northern Israel, especially with respect to the larval growth and metamorphosis of *T. v. vittatus* (Degani 1982, Degani 1986, Degani and Kaplan 1999).

Over the last 50 years, the Upper Galilee area has been, and still is, under intensive cultivation and urban use. It is possible that the breeding sites of *T. v. vittatus* have been affected by the intense agriculture and hydroperiod (Beja and Alcazar 2003).

In order to gain knowledge on the ecological conditions of habitats in the Galilee, where *T. v. vittatus* oviposite and larvae grow and reach metamorphosis, various winter pools were studied on the ecological and limnological level. The hypothesis of the study is that the ecological conditions of water bodies at various altitudes during the period of larval growth and through the completion of metamorphosis, are similar when *T. v. vittatus* larvae are present in the breeding sites, and this species adapts to the ecological conditions of different winter ponds by varying its growth rate and by changing the time necessary for metamorphosis to be completed.

The aim of the present study was to examine the ecological conditions and variables of different breeding sites located at various altitudes in northern Israel, where *T. v. vittatus* larvae grow and reach metamorphosis. Such a study may increase the understanding of the breeding site selection by species of which the breeding period is critical for survival.

MATERIALS AND METHODS

The breeding periods of *T. v. vittatus* in winter rain pools, i.e., ponds and rock pools, in northern Israel (Table 1) were studied over four years, 2001-2005. Five breeding sites from different locations were selected. We examined the pond areas from the beginning of October, as in a previous study (Degani and Mendelssohn 1983), which showed that terrestrial newts migrate to the pond area a few weeks before the rainy season. The elevations of these habitats ranged from 212- 740 m asl, with extreme ecological and physical conditions, such as temperature and hydroperiod. At the onset of the rainy season (autumn and winter in Israel), when natural pools fill up for the first time, and until the pools dry up, during the migration periods we monitored the mature newts, and recorded the water parameters every two weeks. We conducted in-situ measurements of temperature, pH, dissolved oxygen and electrical conductivity (EC), using a handheld pH meter, equipped with a digital thermometer (WTW, pH315i, Germany), a handheld oxygen meter (WTW, Oxi330 set, Germany) and a handheld EC meter (WTW, Multiline P4, Germany), respectively. We collected Water samples (0.5 L) from each breeding site and in the laboratory conducted further analysis of NH_4, NO_2, and turbidity, using ammonium and nitrite cell tests (Merck 1.14739 and 1.14547, Germany, respectively) with the Spectroquant Photometer NOVA 60 (Merck, Germany). Turbidity was determined with a turbidimeter (HACH- Loveland, Colorado, USA).

From each breeding site we collected larvae of all amphibian species, throughout the season, by a hand net (Degani and Mendelssohn 1983). Larvae were identified according to species.

Table 1. Various ponds in Israel colonized by *T. v. vittatus* and examined in the study.

Name of pond	Longitude	Latitude	Altitude m (ASL)
Dovev Pond (a)	239158	772801	740
Nahalit Pond (b)	243657	776401	665
Matityahu Q. Pond (c)	242783	774855	670
Pharaa Pond (d)	242784	774580	682
Amiad Waterholes (e)	251721	757994	212

We have calculated the differences in larval size and the duration of larvae in the pond until metamorphosis by 2^{nd} or 3^{rd} order polynomial regression. Regressions were conducted on data regarding larval size that had been recorded for all ponds. Differences in the growth trajectories were determined by comparing the slopes of the growth curves of newts from the different sites. We analysed the water parameters of the various ponds by two-way analysis of variance (ANOVA), followed by the Bonferroni post-test, with year and breeding sites as independent variables. The parameters of each year and pond were dependent variables. Analyses were conducted using the Graph-Pad Prism software (Graph Pad, San Diego, CA) with the level of significance among different groups set at $P < 0.05$.

We characterized the niche breadth for each pond inhabited by *T. v. vittatus* larvae, and determined the dimensions in a principle component analysis (Goldberg, et al. 2009), according to five important environmental water variables (which differed greatly among the breeding sites and during the year), i.e., temperature, electrical conductivity, ammonium, relative oxygen content (O_2) and pH.

RESULTS

The mature newts arrived at the pond area a short time before the beginning of the rains (November) and remained in the ponds until March, April or May (Table 2). They entered the breeding sites at the beginning of the winter, when the ponds were full of water, and remained in them for several months. The larval growth of the *T. v. vittatus* (n = 10 for each sample) is presented in Fig. 1. Immediately following hatching, the larvae were very small. The larval growth periods differed among the various ponds and over the years of the study. In all ponds, the larval growth periods were between 1.5-3 months. The longest growth period was observed in Dovev Pond, which was located at the highest elevation (Table 2). The calculations for larval growth using polynomial regression were: in Dovev Pond $y = (-0.000X^3) + (0.012X^2) + (0.018X) – (12.54)$, $R^2 = 0.986$; in Matityahu Q. Pond $y = (0.000X^3) – (0.016X^2) + (0.726X) + (22.30)$, $R^2 = 1$; in Pharaa Pond $y = (0.001X^2) + (0.226X) + (12.16)$, $R^2 = 1$; and in Nahalit Pond $y = (- 0.001X^3) + (0.064X^2) – (0.490X) + (15)$, $R^2 = 1$ (Fig. 1).

Table 2. Duration of *T. v. vittatus* larvae at the breeing sites studied.

Breeding Site	2001-2002		2002-2003		2003-2004		2004-2005	
	Months	Days	Months	Days	Months	Days	Months	Days
Matityahu Q. Pond			May-July	65	April-June	60	April-June	40
Dovev Pond	May-July	60	May-July	65	April-July	75	April-July	75
Pharaa Pond	May-July	60			May-July	50	April-May	50
Amiad Waterholes					June	35		
Nahalit Pond					April-June	60		

In all five breeding sites, where newt larvae grew and completed their metamorphosis other amphibian larvae were observed. There were anuran larvae *H. savignyi*, *B. viridis*, *R. bedriagae* and *P. syriacus,* which in most cases, appeared in the ponds only after the salamander larvae (*S. infraimmaculata*) completed metamorphosis and vacated the pools. Also *H. savignyi* and *B. viridis* tadpoles were found in all breeding sites, where newt larvae were present.

The size of the ponds varied from 78.5 - 1017 m^2, and their depth reached a maximum of 2.5 m. The temperatures in the various ponds increased significantly from winter to spring, ranging between 5 - 33.3 ± 6.22 °C. No significant

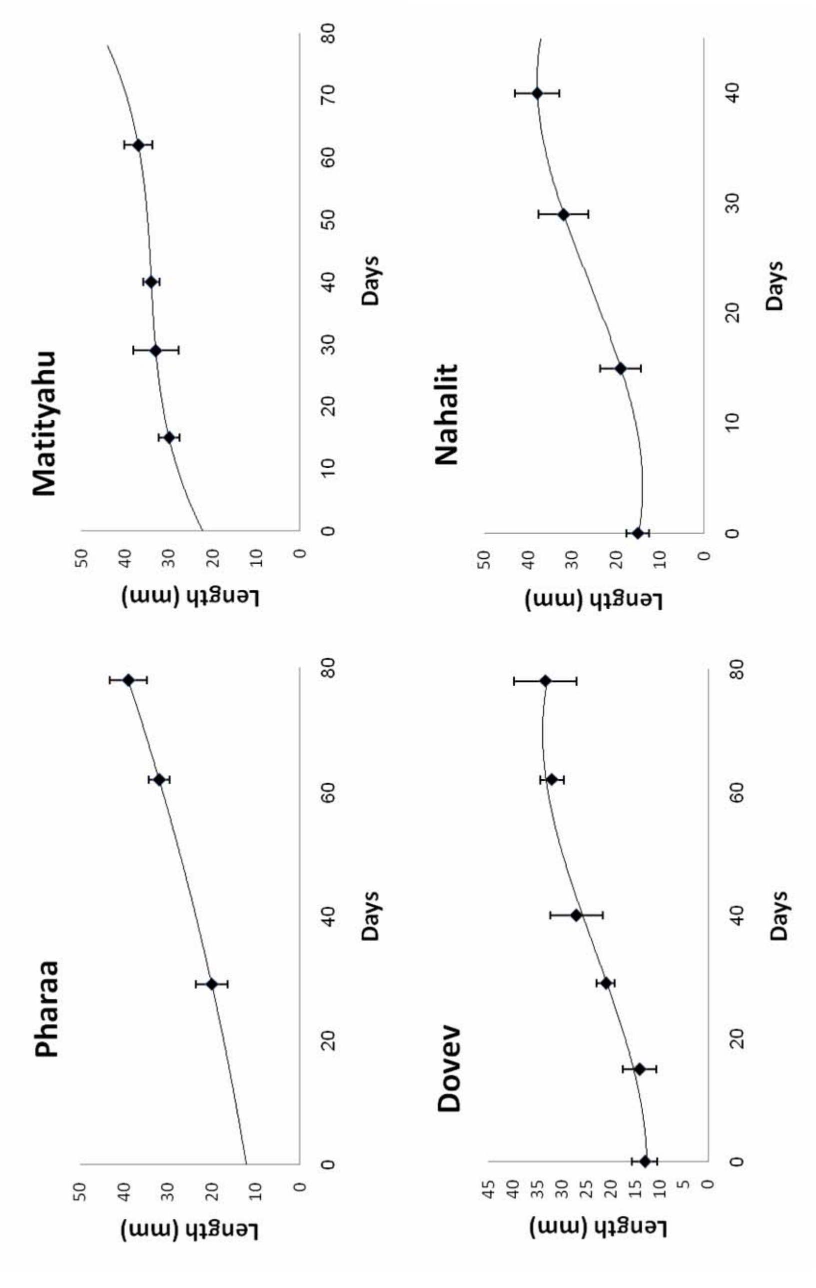

Figure 1. The growth curves of *T. v. vittatus* larvae from various breeding sites, as produced by polynomial regressions (2nd and 3rd degree).The sample size of each pond was 10 larvae (data is presented as mean ± SEM).

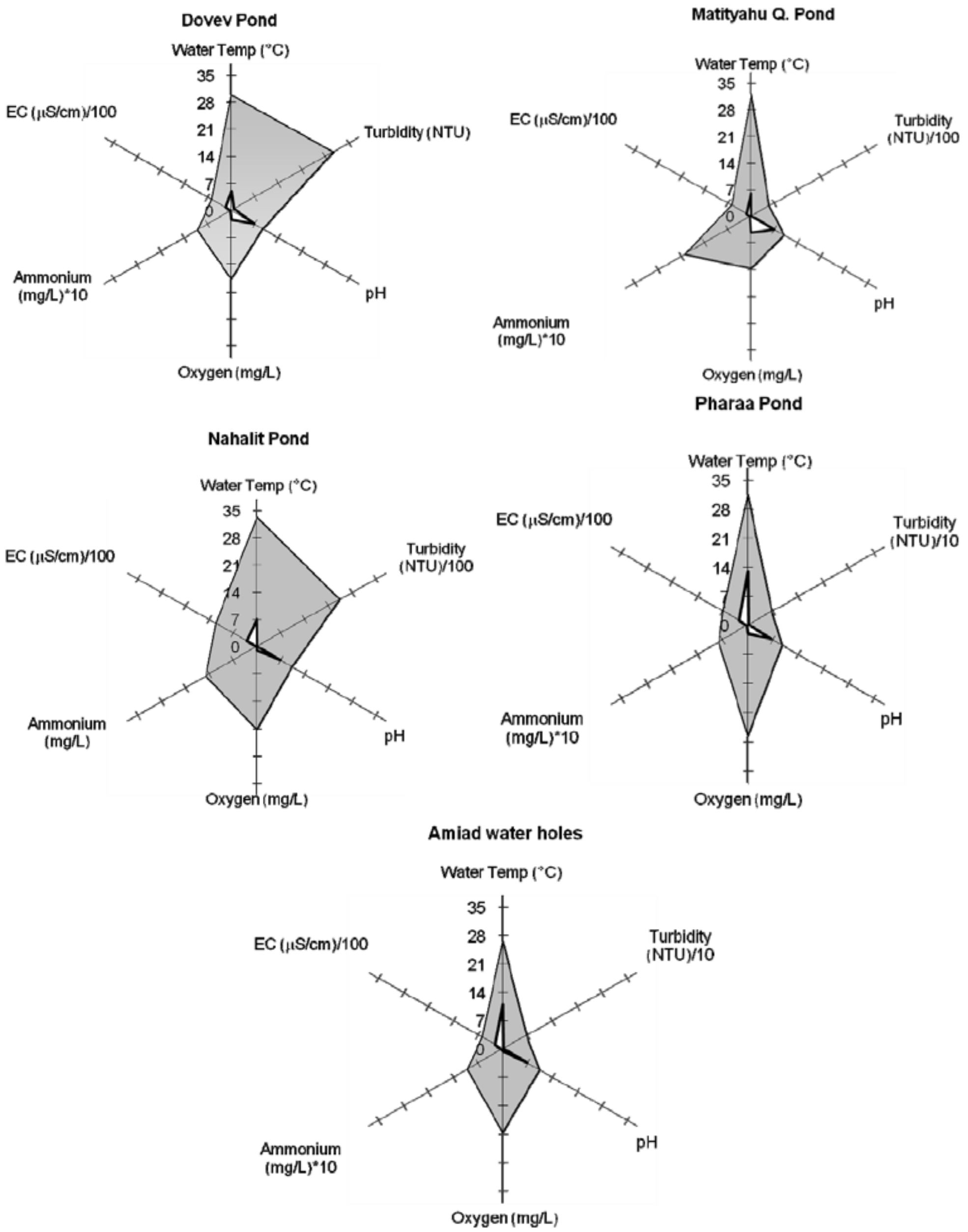

Figure 2. Presentation of five ecological characteristics (minimum and maximum) of *Triturus vittatus* larvae niches in northern Israel – oxygen (mg/L), ammonium (mg/L), temperature °C, conductivity (μS/cm) and pH. The figure has five axes, one for each of the five ecological variables.

differences were detected among the various ponds during periods that newt larvae occupied the ponds in this four year study (ANOVA in most of the parameters, $P > 0.05$). However, water temperatures in Dovev Pond were lower at the beginning of the growth periods, in 2001-2002, 2003-2004, and throughout most of the growth period in 2004-2005 (ANOVA, $P > 0.05$).

Dissolved oxygen concentrations ranged between 0.6 - 26.6 ± 4.55 mg/L in the different ponds, but most of the time they were constant, ranging between 5 - 10 mg/L, with significant differences observed only between Pharaa and Nahalit, during the winter of 2001-2002 ($P < 0.01$,). High oxygen concentrations were detected during the larval growth period and metamorphosis.

The pH varied from 6.5 – 10.4 ± 0.87, but most of the time, was lower, ranging from 7 - 9 in all breeding sites during the four years. Significant differences in pH were observed during the breeding season of 2002-2003 - between Amiad and Nahalit ponds ($P < 0.05$) and in 2004-2005 - between Pharaa (682 asl) and Nahalit (670 asl), Matityahu Q (685 asl) and Nahalit, Nahalit and Dovev (740 asl) ($P < 0.05$), Pharaa and Amiad, Matityahu Q. and Amiad and Dovev and Amiad (212 asl) ($P < 0.01$). The pH tended to mostly decrease during the first year of the study (2001-2002). This is in contrast to the pH in the other years, which increased. The relative pH levels during the larval growth periods tended to differ among the various ponds.

The EC of the pools at the various breeding sites varied between 130 – 1210 ± 176 μs, increasing slightly over the seasons. During some periods, in 2001-2002, 2003-2004 and 2004-2005, the EC among the ponds were significantly different. For example, during the season of 2001-2002, there was a significant difference between Pharaa and Matityahu Q., Pharaa and Nahalit ($P < 0.05$), Nahalit and Amiad ($P < 0.01$), Matityahu Q. and Nahalit and between Nahalit and Dovev ($P < 0.001$). In the season of 2003-2004, there were significances between Nahalit and Amiad ($P < 0.01$), Matityahu Q. and Nahalit and between Nahalit and Dovev ($P < 0.001$). In 2004-2005, there were significances between Pharaa and Matityahu Q. and between Matityahu Q. and Nahalit ($P < 0.05$).

The ammonia (NH_4) concentration was low in all ponds during the breeding season except from Nahalit pond. In most cases, concentrations were found to be less than 1 ± 0.26 mg/L. However, in Nahalit pond concentrations varied between 0-15 ± 3.7 mg/L. During some periods, the concentrations in a few ponds increased dramatically. Significant differences in the ammonia concentration were discerned during the season of 2003-2004 between Nahalit and Matityahu Q., Nahalit and Dovev and Nahalit and Amiad ($P < 0.001$).

The turbidity in the various ponds was relatively constant, varying between 0.73-2436 ± 328 NTU in the various breeding ponds. During some seasons (e.g., Matityahu Q. in 2001-2002 and Nahalit in 2003-2004 and 2004-2005), the turbidity dramatically increased. Significant differences were detected in 2001-2002 between Nahalit and Pharaa, Nahalit and Matityahu Q and between Nahalit and Dovev ($P < 0.01$) and in 2004-2005 between Nahalit and Dovev and between Nahalit and Amiad ($P < 0.05$).

The nitrite (NO_2) concentration was low during all years of the research at all breeding sites less than 1 ± 0.18 mg/L, generally varying between 0 - 0.25 mg/L. Significant differences were noted during the season of 2002-2003 between Pharaa and Matityahu Q. and between Pharaa and Amiad Q. ($P < 0.05$) and in 2004-2005 between Pharaa and Dovev ($P < 0.05$).

This collection of data makes it possible to estimate the major parameters of the ecological niche in which *T. v. vittatus* larvae grow and complete metamorphosis (Fig. 2). The differences among the ecological niches are mainly in the ammonia concentration, EC and turbidity in Nahalit Pond and turbidity in Matityahu Q. pond.

DISCUSSION

The distribution of *T. v. vittatus*, as is true of many other amphibian species (Herrmann et al. 2005) is related to environmental parameters of the aquatic and terrestrial habitats, such as elevation, water temperature, pH, dissolved oxygen and turbidity, pool depth, width and length, vegetation and others (Lecis and Norris 2004, Goldberg et al. 2009). The effects of these environmental factors are more important at the borders of the amphibians' distribution, where the conditions are more extreme. In the present study, we examined various breeding sites of this endemic subspecies, *T. v. vittatus*. Some water bodies of a given type contained only one urodele species, *T. v. vittatus*, together with other anuran species, while in other water bodies of the same type, larvae of all six amphibian species were found together. This finding is in agreement with results of previous studies on amphibians in Israel (Degani 1986, Blaustein and Margalit 1994;

Blaustein and Margalit 1996, Degani 1996, Degani and Kaplan 1999) and in other parts of the world (Pavignano 1990, Warkentin 1992, Wassersug and Wake 1995). *T. v. vittatus* only breeds in rain pools, where water is available for only a few months a year, i.e., during winter and spring (Degani and Kaplan 1999; Goldberg et al. 2009). In some breeding sites, other amphibian larvae may be observed together with *T. v. vittatus,* due to the fact that the conditions of the breeding sites are suitable for larval development and growth of more than one species (Degani 1986).

The results of the present study support those of investigations conducted previously in the Upper Galilee, by Degani & Kaplan (1999) and Degani & Mendelssohn (Degani and Mendelssohn 1983), and in the coastal plains of Israel, by Geffen et al. (1987). They demonstrate, that in Israel, the period when *T. v. vittatus* is present in water bodies, is between December and April. This is in contrast to *T. v. ophryticus* in northern Turkey. The adults of *T. v. ophryticus* usually stay in the water from early March to late October, and sometimes until November, depending on the climate and altitude (Kutrup et al. 2005).

Kutrup et al. (2005) studied the food of the banded newt, *T. v. ophryticus*, at different sites in Trabzon in northern Turkey and discovered that the newts consume a wide variety of invertebrates during their aquatic phase. In Israel, the food of *S. infraimmaculata* and *T. v. vittatus* is very similar, being composed of various invertebrates (Degani and Mendelssohn 1978, Geffen, et al. 1987). Nevertheless, Degani (1982, 1986), who studied in detail the growth periods of various larvae, including salamander and newt larvae, reported that no competition existed between the two species. We also observed that in breeding sites, where newt and salamander larvae were found, newt larvae hatched and developed in the ponds usually after the *S. infraimmaculata* larvae had completed their metamorphosis.

In this study, larvae of *S. infraimmaculata* were detected in habitats, where the water temperature was below 15 °C. During this period of time in northern Israel, only mature newts were observed in the ponds, as has been reported, previously (Degani 1982, Degani 1986). *T. v. vittatus* larvae, as well as anuran tadpoles (*H. savignyi*, *B. viridis*, *R. bedriagae* and *P. syriacus*), have been observed in water in Israel at temperatures between 15 °C and 30 °C. This is in agreement with the temperatures recorded in the present study. According to our results, it seems that breeding sites, consisting of newt larvae, are more suitable for tadpoles of *H.*

savignyi and *B. viridis,* than for tadpoles of other amphibians common to Israel. These two species adapt to unpredictable habitats and breeding sites, where water is available for a relatively short time (Degani and Kaplan 1999). The explanation for the coexistence of newt larvae together with anuran tadpoles, as was observed in the present study and also confirmed in previous ones (Degani 1986), is that all species, residing in the same pond, occupy different ecological niches (especially with regard to temperature, swimming behaviour, duration in the pond and food). Evidence for competition between anuran species has been reported to occur in Israel (Degani 1996), as well as in other parts of the world [for review see (Smith 2005)].

Very few factors, related to the habitats of *T. v. vittatus* (e.g., water temperature and hydroperiods) and affecting the aquatic phase of adult newts or growth duration of larvae, have been quantified formerly (Degani 1986, Geffen, et al. 1987, Degani 1996, Degani and Kaplan 1999). The results of the present study, which support the findings of Degani & Kaplan (1999) and Degani & Mendelssohn (1978), reveal that the breeding site size has a very minor effect on newt breeding, and that newt larvae can grow in breeding sites of various sizes.

The water quality range in *T. v. vittatus* breeding sites is relatively wide. However, very few studies have been conducted on water quality with regard to *T. v. vittatus.* This is in spite of reports on the effects of environmental changes and pollution on amphibian distribution and survival (Lecis and Norris 2004, Herrmann et al. 2005). The range in water quality of ponds, where larvae of *T. v. vittatus* grow and develop, was very similar to that of other ponds in Israel, occupied by other amphibians (Degani 1986), and to ponds in other parts of the world (Beja and Alcazar 2003, Herrmann, et al. 2005). In the present study, most breeding sites of *T. v. vittatus* were located in areas that were subjected to intense agricultural use, which may have affected the conditions and water quality of the habitat.

Laposata & Dunson (2000) examined three species of temporary pond-breeding amphibians: the wood frogs (*Rana sylvatica* LeConte), Jefferson salamanders (*Ambystoma jeffersonianum* Green) and spotted salamanders (*A. maculatum* Gravenhorst). The results of their study showed that the wastewater-irrigated ponds had a significantly higher median EC, pH, Na, K, Ca, Mg and $N+NO_3$, and a low level of dissolved oxygen. In our study, some fluctuation was found in parameters, such as NH_4, NO_2, EC and turbidity, which may have been affected by agriculture in the areas located near the ponds.

In most sites, an increase in the EC from winter to summer was discovered, when the ponds were in the process of drying up. This result is in agreement with Degani (1982, 1986), who studied the parameters of ponds where all six amphibian species in Israel exist.

In conclusion, all of the newt breeding sites, monitored in the study (temporary winter ponds), were comprised of unstable ecological conditions (as opposed to streams with stable conditions), and as a result, were going through changes during the larval growth period. The water parameters of the different breeding sites only occasionally varied significantly from pond to pond, and only in a few of the years, where larvae were present in the water.

Newt larval inhabitation occurred in ponds at various altitudes and at different times, during the winter and spring. Larvae at sites of the highest altitudes had longer growth periods. Moreover, the conditions of the sites at the high altitudes in the spring time and at the beginning of summer were similar to the conditions of the sites at the lower altitudes at the end of the winter and the beginning of spring. We propose that the long term adaptation of larval growth to the various breeding sites occurs from the moment they hatch in the pond until the time they reach metamorphosis.

The present study concurs with Goldberg et al. (2009), who reported that there were no significant differences in the ranges of the abiotic parameters of aquatic habitats among winter ponds inhabited by the species, *T. v. vittatus*, *H. savignyi*, *P. syriacus* and *B. viridis* (ANOVA, $p>0.05$). Here, also, no significant differences were found among the niches of *T. v. vittatus,* which were detected in breeding sites at various altitudes. In addition, the niches of *T. v. vittatus* were very similar to those of *H. savignyi*, *P. syriacus* and *B. viridis* (Goldberg, et al. 2009). All of these species breed in very similar winter ponds. On the other hand, the ranges of the water temperature, soluble oxygen, EC and ammonium concentrations in the aquatic habitats of *S. infraimmaculata* and *R. bedriagae* larvae, which grow not only in winter ponds, but also in springs and streams (Degani and Kaplan 1999), were significantly higher than those of *T. v. vittatus*, as was discovered by Goldberg et al. (2009) (ANOVA $p < 0.05$).

The statistical comparison among the parameters of the water of the breeding sites, using ANOVA, supports our hypothesis that the ecological conditions of the water, during larval growth, are similar in the breeding sites. However, the time suitable for breeding differs from breeding site to breeding site. Moreover, the larval growth rate and metamorphosis duration change according to these ecological conditions. In winter ponds, where water is available for only a short time, the larvae grow faster and complete metamorphosis within a shorter time than those in ponds, where water is available longer. Based on present and previous studies in Israel (Degani 1982, Degani 1986, Degani and Kaplan 1999, Goldberg et al. 2010), we have suggested that this is one manner by which *T. v. vittatus* adapts to unstable breeding sites in the southern border of this subspecies' distribution. In areas, where the water conditions change rapidly and ponds dry up at different rates, the duration of larval growth and metamorphosis completion is short. In contrast, at the breeding sites, where suitable conditions persist for longer periods, the duration of larval growth is longer.

In conclusion, all sites possessed newt larvae inhabited rain pools and pits. Based on the results of the investigation, the major factors affecting the habitat selected by *T. v. vittatus* for breeding are the ecological conditions that allow for survival, growth and metamorphosis completion of the amphibian larvae.

ACKNOWLEDGEMENTS. We thank Leon Blaustein for constructive comments on an earlier draft of the manuscript.

REFERENCES

Arntzen, J.W., Kurtulus, O.K. (2000): Taxonomy of the banded newt, *Triturus vittatus*: morphological and allozyme data. Amphibia-Reptilia 21: 155-168.

Beja, P., Alcazar, R. (2003): Conservation of Mediterranean temporary ponds under agricultural intensification: an evaluation using amphibians. Biological Conservation 114: 317-326.

Blaustein, L., Margalit, J. (1994): Mosquito larvae (*Culiseta longiareolata*) prey upon and compete with toad tadpoles (*Bufo viridis*). Journal of Animal Ecology 63: 841-850.

Blaustein, L., Margalit, J. (1996): Priority effects in temporary pools: nature and outcome of mosquito larva-toad tadpole interactions depend on order of entrance. Journal of Animal Ecology 65: 77-84.

Degani, G. (1982): Amphibian tadpole interaction in winter pond. Hydrobiologia 96: 3-7.

Degani, G. (1986): Growth and behavior of six species of amphibian larvae in winter pond in Israel. Hydrobiologia 140:5-10.

Degani, G. (1996): The salamander at the southern limit of its distribution. Laser Pages Publishing. Israel.

Degani, G., Kaplan, D. (1999): Distribution of amphibian larvae in Israeli habitats with changeable water availability. Hydrobiologia 405: 49-56.

Degani, G., Mendelssohn, H. (1978): The food of Salamandra salamandra (L.) tadpoles in Israel in different habitats. Israel Journal of Ecology C19-C45.

Degani, G., Mendelssohn, H. (1983): The habitats, distribution and life history of *Triturus vittatus vittatus* (Jenyns) in the Mount Meron Area (Upper Galilee, Israel). British Journal of Herpetology 6: 317-319.

Geffen, E., Gafny, S., Gasith, A. (1987): Contribution to the knowledge of the biology of the banded newt, *Triturus vittatus vittatus*, in rainpools in Israel. Israel Journal of Zoology 34:213-223.

Goldberg, T., Nevo, E., Degani, G. (2009): Breeding site selection according to suitability for amphibian larval growth under various ecological conditions in semi-arid zone of northern Israel. Ecologia Mediterranea 35: 65-74.

Goldberg, T., Nevo, E., Degani, G. (2010): Genetic variation in Salamandra infraimmaculata from various breeding sites – a model for habitat selection. Asian Herpetological Research 1: 1-21.

Herrmann, H.L., Babbitt, J., Baber, M.J., Congalton, R.G. (2005): Effects of landscape characteristics on amphibian distribution in a forest-dominated landscape. Biological Conservation 123: 139-149.

Kutrup, B., Akir, E., Yilmaz, N. (2005): Food of the banded newt, Triturus vittatus ophryticus (Berthold, 1846), at different sites in Trabzon. Turkish Journal of Zoology 29: 83-89.

Laposata, M.M., Dunson, W.A. (2000): Effects of spray-irrigated wastewater effluent on temporary pond-breeding amphibians. Effects of boron and nitrate on hatching success of amphibian eggs. Ecotoxicology and Environmental Safety 46: 192-201.

Lecis, R., Norris, K. (2004): Population genetic diversity of the endemic Sardinian newt *Euproctus platycephalus*: Implications for conservation. Biological Conservation 119: 263–270.

Litvinchuk, S.N., Zuiderwijk, A., Borkin, L.J., Rosanov, J.M. (2005): Taxonomic status of *Triturus vittatus* (Amphibia: Salamandridae) in western Turkey: Trunk vertebrae count, genome size and allozyme data. Amphibia-Reptilia 26: 305-323.

Loehle, C., Wigley, T.B., Shipman, P.A., Fox, S.F., Rutzmoser, S., Thill, R.E., Melchiors, M.A. (2005): Herpetofaunal species richness responses to forest landscape structure in Arkansas. Forest Ecology and Management 209: 293-308.

Loehle, C., Wigley, T.B., Shipman, P.A., Fox, S.F., Rutzmoser, S., Thill, R.E., Melchiors, M.A. (2005): Herpetofaunal species richness responses to forest landscape structure in Arkansas. Forest Ecology and Management 209: 293-308.

Mazerolle, M.J., Desrochers, A., Rochefort, L. (2005): Landscape characteristics influence pond occupancy by frogs after accounting for detectability. Ecological Applications 15: 824-834.

Olgun, K., Tok, V., Arntzen, J., Turkozan, O. (1997): The taxonomic status of the banded newt (*Triturus vittatus*) in southern Turkey. Herpetological Journal 7: 169-171.

Pavignano, I. (1990): Niche overlap in tadpole populations of *Pelobates fuscusinsubricus* and *Hyla arborea* at a pond in northwestern Italy. Bollettino di Zoologia 57: 83-87.

Pearlson, O., Degani, G. (2008): The Life History of *Triturus v. vittatus* (Urodela) in Various Habitats. Asiatic Herpetological Research 11: 91–95.

Raxworthy, C. (1989): Courtship, fighting and sexual dimorphism of the banded newt, *Triturus vittatus ophryticus*. Ethology 81: 148-170.

Smith, K. (2005): Effects of nonindigenous tadpoles on native tadpoles in Florida: evidence of competition. Biological Conservation 123: 433-441.

Steward, J. (1969): The tailed amphibians of Europe. David & Charles Publishers. Plymouth.

Warkentin, K. (1992): Microhabitat use and feeding rate variation in green frog tadpoles (*Rana calamitans*). Copeia 3: 731-740.

Wassersug, R., Wake, D.B. (1995): Fossil tadpoles from the Miocene of Turkey. Alytes 12: 145-157.