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Conservation biology, husbandry, and captive breeding of the endemic Anatolia newt, *Neurergus strauchii* Steindachner (1887) (Amphibia: Caudata: Salamandridae)

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***Abstract.*—The long-term experiences of different private breeders on husbandry and breeding of the Anatolia newt, *Neurergus strauchii* are presented. This information is introduced and discussed in respect to the ecology, systematics, and conservation of *N. strauchii*. Our knowledge and data of husbandry and captive breeding is collated and compared with the literature. We present our experiences to provide information and advice for the successful long-term keeping, breeding, and raising of *N. strauchii* and also an example and model that may be used for privates' contribution to Conservation Breeding Programs for endangered *Neurergus* species and other semi-aquatic salamanders. *Neurergus strauchii* has proved relatively easy to keep in captivity under a range of aquatic and terrestrial housing and with adequate diet. However, although breeding is successful under a variety of conditions survival from egg to adult is low. Cold husbandry temperatures in winter increase reproduction. Eggs are laid very irregularly in time and number, and oviposition may depend on the condition of the female, particularly her nutritional condition through diet. There may be up to 285 eggs per female. The best temperature for egg laying is about 14.5 °C. Hatching success of eggs can vary enormously from 0% to 80%. Most larvae hatch from 11.5 to 14.5 mm. Larvae are easy to raise, with low mortality over a wide range of temperatures, and metamorphose in three to seven months, mostly from 55 to 63 mm and about 0.6 g. Several diseases are known to affect these newts and high temperature stress may exacerbate pathology.**

Key words. *Neurergus strauchii*, breeding, husbandry, ecology, conservation, private breeders, long-term maintenance, diseases, international cooperation

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Introduction

Since its description by Steindachner (1887), relatively little information has been collected on the Anatolia newt, *Neurergus strauchii*. Schmidtler and Schmidtler (1970) were the first to collect substantial information on this species. In 1982, the first captive breeding experiences were published by Fleck (1982). Haker (1985) described breeding an F2 generation and the appearance of a color mutant, later known as the "gold-dust" variety. Although Fleck and Haker both mentioned that it was not difficult to keep and breed *N. strauchii,* it is still relatively rare to find *N. strauchii* in captivity. Little information on the husbandry of *N. strauchii* has been published, perhaps due to a lack of husbandry and breeding success. Steinfartz (1995) was the first to report detailed information on the keeping and breeding of the subspecies *N. s. barani*, which had been described just two years prior (Öz 1994).

Inspired by the aquatic versus terrestrial rearing experiments on juvenile *N. s. strauchii* of Jennifer Macke (Macke 2006), the scattered Internet data sheets (see for instance Schultschik 2010; Sparreboom 2009), and the fact that Kristina Ernst is running a Studbook for this species for the AG Urodela, Sergé Bogaerts started collecting data and experiences from active and long-term breeders in order to establish some guidelines for successful husbandry of this species. In 2007, our common project was presented at the meeting of the Arbeitsgruppe

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[†]*We dedicate this paper to a passionate and experienced amphibian keeper and breeder, Patrick Wisniewski, who sadly passed away during the time of writing.*

Figure 1. Captive bred adult female of *Neurergus s. strauchii*. *Photo by Sergé Bogaerts*.

Figure 2. Adult female of *Neurergus strauchii barani* photographed at Kubbe mountain, Malatya. *Photo by Sergé Bogaerts*.

Urodela of the Deutsche Gesellschaft für Herpetologie und Terrarienkunde (DGHT) in Gersfeld, Germany (Bogaerts 2007). Not all authors have collected similar data for example, Henry Janssen has put an extraordinary effort in collecting data on reproduction between 1991 and 1997. However, through collating all husbandry knowledge and data, we can draw some general guidelines for successfully keeping and breeding *N. strauchii*. We will combine the information from both subspecies, as there appears to be few differences in their maintenance.

Distribution, description, and habitat

Neurergus strauchii is endemic to mountainous areas in eastern Turkey, roughly from Malatya to Lake Van. The subspecies *N. s. barani* is found only in the mountains southeast of Malatya. *Neurergus s. strauchii* has a wider distribution and is found east from the river Euphrates up onto the Lake Van area. Although there is a relatively high level of genetic differentiation at both the mitochondrial (12S and 16S rRNA) and nuclear levels between the subspecies (Steinfartz et al. 2002; Pasmans et al. 2006), it is not very easy to distinguish individuals of each subspecies, particularly as juveniles. Özdemir et al. (2009) found that *N. s. barani* is not strongly differentiated from *N. s. strauchii*, suggesting their distributions are either connected, or have been separated only recently.

The most obvious visual difference between *N. s. strauchii* and *N. s. barani* is the difference in the number and size of yellow spots on adults (Figs. 1 and 2). The main phenotypic difference between the subspecies is that the number of spots greatly increases during maturation in *N. s. strauchii*, but increases very little in *N. s. barani*. The *N. s. barani* subspecies keeps approximately its juvenile pattern of small spots in two rows dorsally,

Figure 3. Cloaca's of male (left) and female (right) of *N. s. barani* during breeding. *Photo by Sergé Bogaerts*.

whereas the number of spots on *N. s. strauchii* increases as it matures. Although this difference is very pronounced between the eastern populations of *N. s. strauchii* and *N. s. barani*, the westernmost *N. s. strauchii* are virtually indistinguishable from *N. s. barani* in this respect. Pasmans et al. (2006) found a geographically correlated increase in the number of spots on adult newts towards the eastern part of their distribution.

Neurergus strauchii are relatively large newts, measuring up to 19 cm (Steindachner 1887). Mean lengths in the wild are 14.3 cm for adult males and 15.2 cm for adult females (Table 1). The largest total length documented in the field was 18.1 cm for a female (n = 42) and 17.6 cm for a male (n = 21) (Pasmans et al. 2006). Males can be recognized by their slender body, shorter tale, larger cloaca, and the bluish-white colorations on the lateral sides of the tail, which can run through to the lateral sides of the body. These breeding colorations are often already visible in autumn. Females have an orange cloaca, relatively longer tails, and shorter legs, and appear more robust than males (Fig. 3).

Neurergus strauchii lives roughly between 1,000 and 1,900 m. above sea level. Its breeding habitats are mountain brooks, preferably with large, deep, slow running pools. A typical habitat is shown in Figure 4. Terrestrial habitats are often very bare, without much vegetation (Bogaerts et al. 2006). Water temperatures vary considerably seasonally and with stream length from springs. Pasmans et al. (2006) recorded water temperatures in breeding streams from 10.9 to 17.3 °C, although Schmidtler and Schmidtler (1970) recorded temperatures of 9 to10 °C in a flowing spring in which they found adults. Schneider and Schneider (2010) found water temperatures up to 21.9 °C, at the end of breeding season (June). Bogaerts et al. (2010) report of a temperature drop of 2.5 °C from 8.3 °C to 5.8 °C within one week at the start of the breeding season in April, which did not seem to change the breeding activity. From a spring, the water temperature was only 8.9 °C, but after flowing through a completely deforested and heavily grazed valley, the temperature rose about 2 °C per 100 meters up to 19 °C. Nevertheless, this wide temperature range is tolerated by *N. strauchii*, with

Table 1. Mean lengths and weights of adult *N. strauchii* (Adapted from Pasmans et al. 2006). Data were collected in the breeding season. There is no significant difference between the subspecies or males and females between the subspecies (t-test).

Subspecies	Sex and number	Mean total length (mm)	Min – max total length (mm)	Snout vent length (mm)	Tail length (mm)	Mean weight (g)
barani	Males (n = 11)	143	132-153	72	71	11.2
barani	Females (n = 25)	154	134-174	76	78	14.0
strauchii	Males (n = 10)	143	131-176	73	68	10.3
strauchii	Females (n = 17)	150	129-181	75	75	12.7

Figure 4. Habitat of *N. s. strauchii* near Bitlis. *Photo by Sergé Bogaerts*.

the warmer areas probably only increasing the development rate of larvae and shortening or shifting the aquatic phase in the adults. The streams in which the newts were found by Pasmans et al. (2006) were all slightly alkaline (pH 7-9) and soft to moderately hard, but these values can be strongly influenced by heavy rains or periods of prolonged drought.

Neurergus strauchii has been found overwintering on land, not far from streams (Schmidler and Schmidtler 1970). Adults, subadults, and juveniles have also occasionally been found under stones on land in April (Pasmans et al. 2006). As streams probably partly dry, it seems likely that *N. strauchii* spends most of the year on land under stones or underground, protected from high temperatures and arid summer conditions. Breeding animals in streams and pools are found during a relatively short period in spring from April to June (Steinfartz and Schultschik 1997; Bogaerts et al. 2010; Schneider and Schneider 2010).

Protection

Neurergus strauchii is a strictly protected species (Appendix II) by the Convention on the Conservation of European Wildlife and Natural Habitats (also known as the Bern Convention), which was ratified by Turkey in 1984. In Resolution No. 6 (1998) of the Standing Committee, *N. strauchii* is listed as a species requiring specific habitat conservation measures. The status of *N. strauchii* in Turkey is not clear, although the IUCN lists them as Vulnerable B1ab (iii) (Papenfuss et al. 2009). Their currently known distribution is much larger than previously thought, but the fact that they live in a habitat that is sensitive to human influences, and particularly climate change, makes them vulnerable. Habitat changes and destruction including overgrazing, pollution of breeding waters, cutting of trees, appear to currently be the major threats to the species (Bogaerts et al. 2006; Schneider and Schneider 2010).

Materials and methods

Origin of *N. s. strauchii*

The origin of the *N. s. strauchii* being kept by the authors has an interesting history, as it involves extensive co-operation between privates and the *N. s. strauchii* originated from a very small gene pool. Henry Janssen was one of the first people who succeeded in breeding F3 and F4 animals from captive breeding groups started by Fleck (F1) and Haker (F2) originating from Bitlis, near Lake Van, Turkey. These were distributed among other private breeders, including all authors on this article. Gunter Schultschik had several successful breedings (2000, 2001), and in 2003 Gunter bred a large group of offspring many of which were distributed within Europe, with a group being exported to the United States of America. All *N. s. strauchii* we have kept are direct descendants of the first breedings by Fleck. So we conclude that all animals of this subspecies kept by the authors originate from the same very small gene pool and we have bred to at least the F5 generation. Most *N. s. barani* that are in captivity originated from small private importations in 1997 and 1998, and two larger importations in 2002 and 2003.

Housing for adults in captivity

Adults may be housed under a wide variety of conditions. The first main variation in housing is whether they are kept in an aquatic habitat all year or kept terrestrially for part of the year. Although in nature they will probably spend the majority of the year on land away from the breeding waters, some are kept aquatic for most of the year, or permanently.

Different types of tanks are used for housing and relatively small: 30 × 40 cm to 50 × 120 cm. Individual carers use different furnishings for their terrariums. Terrestrial enclosures are often typical naturalistic terrariums with, for instance, a well-drained forest soil or loam and pieces of bark, moss, and plants to create shelter. Gunter Schultschik keeps his animals in a more sterile enclosure, on a five cm layer of synthetic foam, with shelters made out of pieces of bark. In this case, each tank is connected to a water system that drips cold water into the tank slowly, and seeps through the foam, running out again through a drain. This system works well in a warm and dry environment, but not in a relatively cold moist cellar or basement. When kept terrestrially, in a naturalistic enclosure, a water bowl is always present, and a gradation of humidity is offered so animals can choose from slightly humid to dry parts of the habitat.

When kept all year round in an aquarium or aquaterrarium, all carers provide the newts with an opportunity to climb to a dry area, which usually consists of stone plates that are above the water level (Fig. 5). These stones are often covered with cork bark or sometimes moss for hiding opportunities. The newts usually don't remain in the dry region for long periods, only for a few hours or occasionally for a few days, except when temperatures rise above 20-22 °C, then they escape the water. Henry Janssen notes that in colder periods, with temperatures below 10 °C, the newts spend most of their time on land. Temperatures can drop in winter to close to zero and in summer can rise up to 30 °C. Animals that are kept aquatic during summer will typically stay in the water until the temperature of the water exceeds 20-22 °C. Incidental high temperatures of up to 30 °C do not directly harm the newts, as long as the newts are healthy and can stay on land.

For lighting, natural light or fluorescent lamps are used. Temperatures in the tanks usually follow the season in order to mimic the animals' natural environment (Table 2). *Neurergus strauchii* are very good at escape and will soon notice any chance to escape and take it. Therefore, it is necessary to cover the aquarium or terrarium with a secure, well-ventilated cover.

Temperature cycling

A cold period occurs in nature from autumn to spring, in the snow covered mountain areas where these newts live. In captivity, this cold period is simulated using different methods as part of the natural reproductive cycle. Half of the current authors hibernate their animals in a refrigerator, approximately from mid-December to the end of February, at temperatures from 2 to 5 °C or at a constant 4.5 °C. Newts are kept in small boxes with wet paper towel(s) and bark with the sexes separated. The other half of the current authors keep newts under a regional temperature cycle at temperatures varying between 0-10

Figure 5. Aquarium constructed for *N. s. strauchii*. *Photo by Jennifer Macke*.

Table 2. Mean temperature ranges in the adult environment through the seasons and aquatic (a), aqua-terrestrial (a-t) or terrestrial (t) set up of the tank.

Keeper	Spring	Summer	Autumn	Winter
Steinfartz (1995)	14 °C (a)	Up to 23 °C (a)	10-14 °C (t)	10-14 °C (t)
Henry Janssen	10-17 °C (a)	up to 25 °C (a-t)	10-17 °C (a-t)	7-13 °C (a-t)
Jennifer Macke	16-17 °C (a)	18-22 °C (a)	16-17 °C (a)	2-12 °C (a)
Gunter Schultschik	16-17 °C (a)	up to 30 °C (t)	16 (t)	4.5 °C (t)
Kristina Ernst	12-18 °C (a)	18-27 °C (t)	8-18 °C (t) and more humidity	2-5 °C (t and a)
François Maillet	12-14 °C (a)	17-20 °C (a)	12-16 °C (a)	6-10 °C (t)
Christoph Bork	12-16 °C (a)	17-21 °C (a), max. 25	16-19 °C (a)	< 10 °C (t, for 2 months)
Sergé Bogaerts	12-16 °C (a)	Up to 30 °C (a-t)	15-20 °C (t)	5-10 °C in a refrigerator (t)
Patrick Wisniewski	10-15 °C (a)	15-25 °C (a)	15-20 °C (t)	10-15 °C (t)

°C in garages, basements, or garden sheds for one to three months. Fleck (1982), Haker (1986), and Steinfartz (1995) all kept these newts in an unheated room where temperatures could drop as well. This is either done in terrestrial or aquatic conditions, and both sexes are usually kept together. Newts can be transferred into another tank or stay in the same tank. Newts are mostly not fed during the cold period; only Jennifer Macke feeds them twice per week throughout the cold period and finds that they eat well, and are active even when their temperature is as low as 2 °C.

Diet and nutrition

Adult newts eat many types of living and non-living food. On land we offer them a wide variety of insects, including young crickets (*Acheata domesticus* or *Gryllus* sp.), mealworms (*Tenebrio molitor*), fungus beetle larvae (*Alphitobius laevigatus*), and larvae of wax moths; both the lesser (*Achroia grisella*) and greater (*Galleria mellonella*). We also feed earthworms (*Lumbricus* sp.), maggots, firebrats/silverfish (*Thermobia* sp.), and slugs. In water they are fed earthworms, black worms (*Lumbriculus variegatus*), *Tubifex* sp., bloodworms (*Chironimus* sp.), *Daphnia* sp., *Gammarus* sp., *Hyalella azteca*, white worms (*Enchytraeus albidus*), woodlice (*Asellus* sp.), etc. Amphibian eggs and larvae (*Rana* sp.) are eaten. Henry Janssen also saw them eat small fish (Guppies, *Poecilia reticulata*) at night when the guppies were sleeping. Non-living prey is accepted. Fleck (1982) fed them slices of liver, and Christoph Bork fed them, with tweezers, octopus that was cut into small worm-like strips.

Kristina Ernst reports that keeping females on land makes it easier to give high calorie food like wax worms, which seems to yield more eggs the next breeding period. Henry Janssen has noted that, with equal amounts of food offered, juveniles grow faster and adults gain more volume at lower temperatures (10-17 °C) than at higher temperatures (18-25 °C). *Neurergus strauchii* is not as voracious a feeder as, for instance, newts of the genus *Triturus*. *Neurergus strauchii* may be rather slow to catch prey. *Neurergus s. barani* seem to be more greedy for food and eat everything in greater portions, compared to *N. s. strauchii* in our experience; it is one of the few significant differences between keeping *N. s. strauchii* and *N. s. barani*. We find that feeding plenty of (high calorie) food during the breeding period is essential for females to produce many eggs.

Food items offered on land are typically dusted with a calcium vitamin powder. We have used, for example, Korvimin ZVT, Amivit A, Nutrobal Vitamin/Mineral powder, and ZooMed Calcium. Gut loading crickets with calcium rich plants, like dandelion, or nettles will enrich their food quality. Feeding crickets at temperatures below 10 °C is difficult as most crickets die. Individual newts can have very different preferences for food items.

Results

Breeding

For breeding purposes, the newts are placed into an aquarium. The tanks are furnished in various ways. Most of us use a layer of gravel on the tank floor, and various types of stones are placed on top of each other to provide places for hiding and egg deposition. Jennifer Macke uses turned over non-glazed ceramic flower pots with a cut out entrance, used by the females to deposit their eggs, which can easily be taken out with the eggs and replaced. Some of us have used no substrate or just a few flat stone plates, covering only part of the tank bottom. Tables 3 and 4 report the periods, temperatures, and other characteristics of the various breeding tanks.

Development of enlarged cloacas and the whitish-blue colorations on tails of males can already be observed in autumn. The smallest male in captivity bred measured 11.5 cm total length (TL) and 6.2 cm snout-vent length (SVL); the smallest female measured 12.8 cm TL and 6.5 cm SVL. Thus, animals start breeding at total lengths of around 12 cm TL. Breeding occurs within a water temperature range of 9-17 °C (mean 10-14 °C) and this seems to be independent of the time of the year (Table

Table 3. Aquarium conditions when breeding started. Included are only those years in which fertile eggs were deposited.

Keeper	Subspecies	Year	Starting	Temperature start breeding (°C)	Water level (cm)	Water circulation and/or air pump
Fleck (1982)	*strauchii*	1981	March	12	10	yes
Steinfartz (1995)	*barani*	1993-1994	Feb-March	14	25	yes
Jennifer Macke	*strauchii*	2005-2009 2011-2012	Dec-Jan	9-12	20	yes
Gunter Schultschik	*strauchii* & *barani*	2003-2004	Jan-Feb	16-17	28	yes
Kristina Ernst	*strauchii* & *barani*	2004 2005 2011 2012	May May April Feb	14 14 14 10-12	11-12	yes
François Maillet	*barani*	2005	March-April	12-14	12/15	yes and air pump
Christoph Bork	*strauchii* & *barani*	2001 2003 2005	Feb	13-15	24-28	yes
Patrick Wisniewski	*strauchii*	1996 1997	Feb-March	10-12	15	strong air pump only
Sergé Bogaerts	*strauchii*	2006	Feb	12-14	8	yes

3). Newts were bred in winter, early spring or even to the end of spring. The water level does not seem to be important. As these newts are stream dwellers, most of us have simulated this by using water circulation, sometimes with the addition of an air pump.

Breeding starts with male activity, typically at water temperatures of 10 °C. Males and females can be put in the water at the same time, but some of us prefer to introduce females to the water a few days or weeks later. After entering the water, males have been observed to start performing courtship the same evening. Within the courtship period, it is best to try and keep water temperatures below 14 °C. At 14 °C females start oviposition (Table 4 and Fig. 6).

Figure 6 shows oviposition in three of the most successful breeding years, in relation to the water temperature. Oviposition may take place during both day and night and may continue until water temperatures reach about 20 °C. Eggs are laid very irregularly in time and number, and oviposition may depend on the condition of the female, particularly her nutritional condition through diet. Occasional egg laying (one per day or less) can continue for up to two months after the main period of oviposition.

Henry Janssen measured the water temperatures at which oviposition took place for 1,225 eggs from different breedings over the years 1991-1997. He also noted which of these eggs hatched. Of all eggs, only six (0.48%) were laid at water temperatures below 14 °C. Most eggs (77.3%) were deposited at temperatures of 15-19 °C. Above 20 °C, production of eggs rapidly decreases. Figure 1 shows a dip at 16-17 °C, but we think this is an artifact of the combination of data from different years. Another finding of Henry Janssen is that of all eggs that were deposited, the ones laid between 14-16 °C had the best hatching rate (62.4% between 14-15 °C and

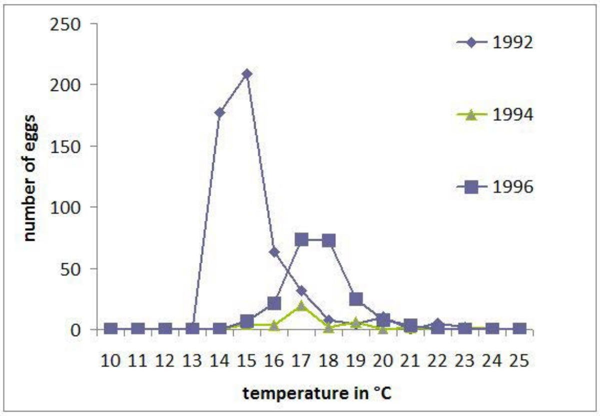

Figure 6. Oviposition (n = 760 eggs) in three successful breeding years in relation to water temperature. *Data by Henry Janssen.*

28.5% between 15-16 °C). There are several possible interpretations for these data. First, it may be related to the fecundity of the females; the first eggs laid are often of a higher quality than later eggs. Second, it could be related to the fertility of the males, which seem to be more active at lower temperatures. Jennifer Macke has also noted that egg fertility consistently decreases over time during the egg laying period (data not shown). Henry Janssen noted from the 1995 breeding season that when he separated females from males, after he discovered that males were eating some of the first eggs, most eggs laid afterwards were not fertilized. This seems to indicate that regular uptakes of spermatophores by the female, during the breeding period, are necessary for her to continue producing fertile eggs.

Table 4 records the aquarium conditions when females started oviposition—the number of eggs per female, and the percent of hatched eggs. As can be seen, large variations were found in number of eggs per female

Table 4. Conditions in the aquarium when females started oviposition, number of eggs per female (~ when more females are kept together), time to metamorphosis, and percent hatched. - No data available. # Average over the whole oviposition period. *Ten of these are 14 months old but still have not completed metamorphosis; they show no differences in length compared with their siblings.

Keeper	Subspecies	Year	Starting	T °C	Number of eggs per female	Time to metamorphosis (months)	Hatched
Fleck (1982)	*strauchii*	1981	April	17	~ 75	4.5	-
Haker (1986)	*strauchii*	1985	June	16	-	3	-
Steinfartz (1995)	*barani*	-	-	-	80-90	-	-
Jennifer Macke	*strauchii*	2005	Feb 16	14	152	-	~50%
		2006	Feb 19	13	150	-	~50%
		2007	Feb 27	-	104	-	-
		2008	March 4	-	246	-	-
		2009	Feb 27	-	285	-	-
		2011	Feb 26	-	238	-	mean 41% #
		2012	March 8	-	195	-	mean 78% #
Gunter Schultschik	*strauchii*	2004	May	14	11-12	yes	
		2005	May	14			
		2011	April	14			
		2012	Feb	10-12			
Kristina Ernst	*barani*	2004	June	16	~ 200	5-8	~ 50%
	barani	2005	May	20-21	~ 100	4-7	~ 25%
	strauchii	2005	May	17-19	~ 150	4-7	98%
	barani	2006	May	16	~ 250	-	~ 75%
	strauchii	2006	May	17	~ 200	-	97%
	strauchii	2011	April	15	~ 150	4-7*	88%
	strauchii	2012	March	15	~ 100	-	80%
	barani	2012	April	15	~ 100	-	90%
Christoph Bork	*strauchii* & *barani*	2001 2003 2005	March	14-16	-	~ 4	No counts, but never 100%
Henry Janssen	*strauchii*	1992	Mar-April	14-17	129	4-8	45%
	strauchii	1995	April-May	16-19	~ 120	4-8	10%
	strauchii	1996	April	16-17	~ 85	4-8	25%
Patrick Wisniewski	*strauchii*	1996	March	10-15	47	5-6	45%
	strauchii	1997	February	10-15	17	5-6	50%
Sergé Bogaerts	*strauchii*	2006	March	14-16	~ 40	5-10	70%

and hatching rates. However, the temperature conditions in which oviposition occurred were roughly the same for all of us, for both subspecies.

Eggs

Eggs are mostly attached to the underside of stones (Fig. 7), but they can be laid almost anywhere, including on the filter, aquarium walls, and plants (Fig. 8), or specially prepared flower pots. Eggs may be found loose on the bottom of the tank, but this mainly occurs when there is too little space on the favorable places and, or eggs are not well attached. During oviposition the female lies on her back, often sandwiched between two layers of flat rock, depositing eggs on the underside of the upper rock. It is important that the habitat has enough space between the stone plates for the females to move around. Henry Janssen noted that out of a total of 560 eggs, 237 were deposited on the glass, 199 on stones, 83 loose on the substrate, 37 on plants, three on the filter system, and one was stuck to the hind leg of a female. No negative effects from exposure of developing eggs to indirect sunlight or artificial light could be observed when compared to eggs that developed under darker conditions.

In general, eggs were removed from the breeding tank, as the adults sometimes eat the eggs. Eggs were typically removed every few days. Some of us moved the eggs together with the stones they were attached to, others cut the eggs gently loose from the rocks with a razor blade or fingernail. There was no difference observed in the development of eggs that were cut loose versus eggs that were left on the stones they were laid upon.

Water parameters of the tank, where the eggs are put to hatch, do not seem to matter. Even an air stone is not really necessary for the development of the eggs. If the water is refreshed once a week this seems to be enough. It is, however, also possible to leave the eggs in the tank until they hatch, which some of us prefer.

In all our breedings, no clutch of eggs was 100% fertile. Unfertilized eggs and eggs that have died off, shrink in size and start decaying, resulting in the clear layers around the zygote becoming cloudy, starting with

Figure 7. Female *N. s. strauchii* depositing eggs. *Photo by Christoph Bork.*

the innermost layer and continuing outwards, followed by mould—growth on the outer surface (observations Henry Janssen; Fig. 9). It seems that a developing egg, attached to a moulding egg, can be infected with fungus too. Therefore, it is best to separate moulding eggs from developing eggs. Eggs can be eaten by the usual predators like snails and flat worms (*Planaria* sp.). Hatching success of eggs can vary enormously (Table 4). Jennifer Macke noted that in 2005 about 50% of eggs were fertile, and 10% began to develop but died as embryos. In 2006 about 80% were fertile and about 10% began to develop but died as embryos. Malformations seem to occur in all breedings. Kristina Ernst states that through feeding the females more often, more eggs are produced and in shorter periods. She observed up to about 15 eggs per day per female.

In 2005 Jennifer Macke had eggs laid from February until the beginning of March. After that animals were transferred to another location and they continued to lay eggs (about one a day), but all eggs produced in April and May were infertile. In 2009 Jennifer counted a total of 570 eggs from two females during the entire egg laying period (February-June). Henry Janssen measured the hatching success of all eggs deposited between 1991 and 1997, each year breeding occurred. Of the total of 1,413 eggs, 348 hatched (24, 62%).

Gunther Schultschik noted the exact water parameters in his rearing tanks. Larvae were raised at a water temperature of 16-19 °C, with no measurable organic ions in the water (NH_3, NO_2, NO_3), maximum of oxygen, minimum of CO_2. Water was treated by UV lamp. PH was 7.2 to 7.5. François Maillet maintains a pH of 7-8 and changed part of the water often to avoid nitrate development.

Henry Janssen measured the length at hatching for 283 specimens (Figure 10). About 45% of the measured larvae were between 12 to 14 mm at hatching. Fig. 11 shows a hatching larvae.

Henry Janssen measured the relationship between days of incubation and total length at hatching for 249 larvae. The shortest time to hatch was 15 days and the longest was 34 days. About 57.4% of all larvae hatch between 26 and 31 days after deposition. Consistent with this, Jennifer Macke found that from the time the first eggs were laid until the first larva hatched, exactly 30 days elapsed when the eggs were maintained at 16-17 °C.

The total length of the larvae becomes larger when hatching is delayed. Thus, the moment of hatching is not a fixed point in time. Moving the egg, for instance, can cause the larva to leave the egg shortly thereafter, whereas it would have stayed in place if the egg had been left undisturbed.

Larval rearing

All authors raised their larvae in more or less the same way, and all agreed it was not very difficult or problematic. For the first few days after hatching, the larvae live on their yolk. No food was added at this time, and some

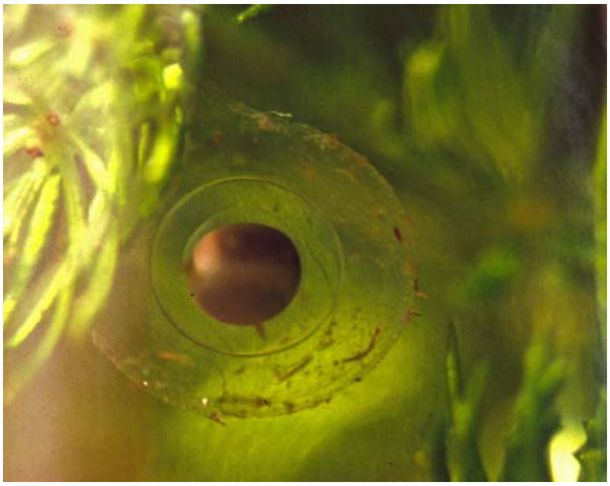

Figure 8. Fresh laid *N. s. strauchii* egg. *Photo by Henry Janssen.*

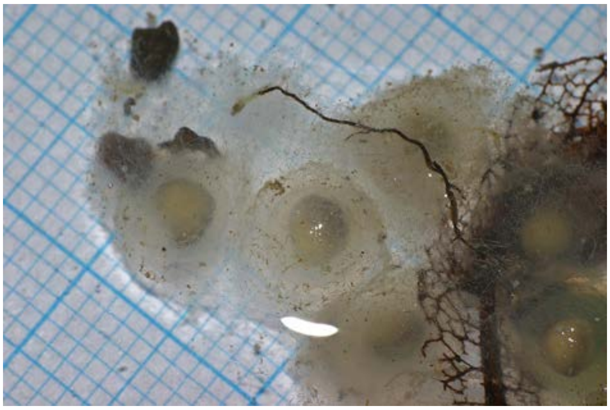

Figure 9. Moulding unfertilized eggs of *N. s. strauchii* on mm paper *Photo by Sergé Bogaerts*.

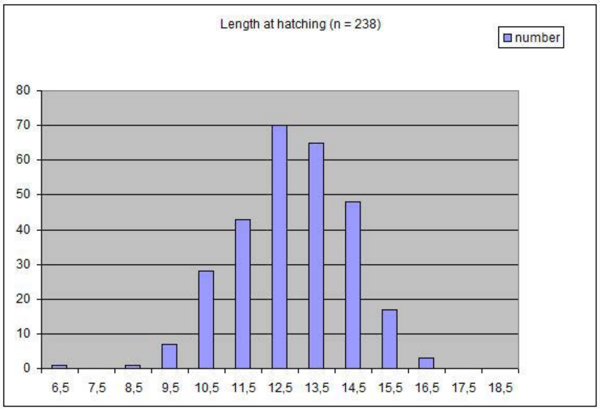

Figure 10. Total length of larvae at hatching in mm. *Data by Henry Janssen*, *n* = 283.

authors noted that micro-organisms, particularly water mites (*Hydracarina* sp.) and *Cyclops* sp. attacked newly-hatched larvae. After a few days the larvae begin to eat live food. Larvae are kept in tanks or tubs containing three to 20 cm of water, an air stone, and some pebbles and pots as hiding places. Aquatic plants are sometimes included. Larvae are fed first with *Artemia* (only the first one or two weeks), small live *Daphnia* sp., *Tubifex*/*Lumbriculus* (initially chopped, later whole), red mosquito larvae/bloodworms (*Chironimus* sp.), and white worms (*Enchytraeus albidus*). Gunter Schultschik gave *Artemia* until the larvae were 20 mm. When feeding *Daphnia*, care must be taken to avoid feeding other less harmless aquatic fauna. Water temperatures can range from 10 to 20 °C. Even if the temperature of the water rises up to 30 °C accidentally, it is not a serious problem, although larvae stop eating and become less active.

The larvae are not as aggressive toward each other as, for instance, *Triturus* larvae, but care must be taken to avoid overcrowding. Kristina Ernst noted cannibalistic behavior until the larvae were 1.5-2.0 cm, at which point the behavior disappeared. Several of us have never observed cannibalism and even kept larvae of different sizes together without a problem. Most of us have kept the larvae in small groups (15-30 larvae) in, for instance, plastic containers of various sizes with aquatic vegetation and shelters, like pieces of ceramic garden pots, as these salamanders hide during the day. Water is refreshed every week, or as often as required to avoid poor water quality.

In some cases, malformed larvae hatch. These larvae spin around when trying to swim, or are swollen. These larvae often lag far behind their siblings in growth, and euthanasia is the best option. Larvae of a few centimeters in size develop gold colored, shiny spots and dots that seem similar to the lateral line sense organs in fish used to detect movement and vibration in surrounding water (Fig. 12), which stay visible until metamorphosis (Fig. 13). After about three to four months the larvae de-

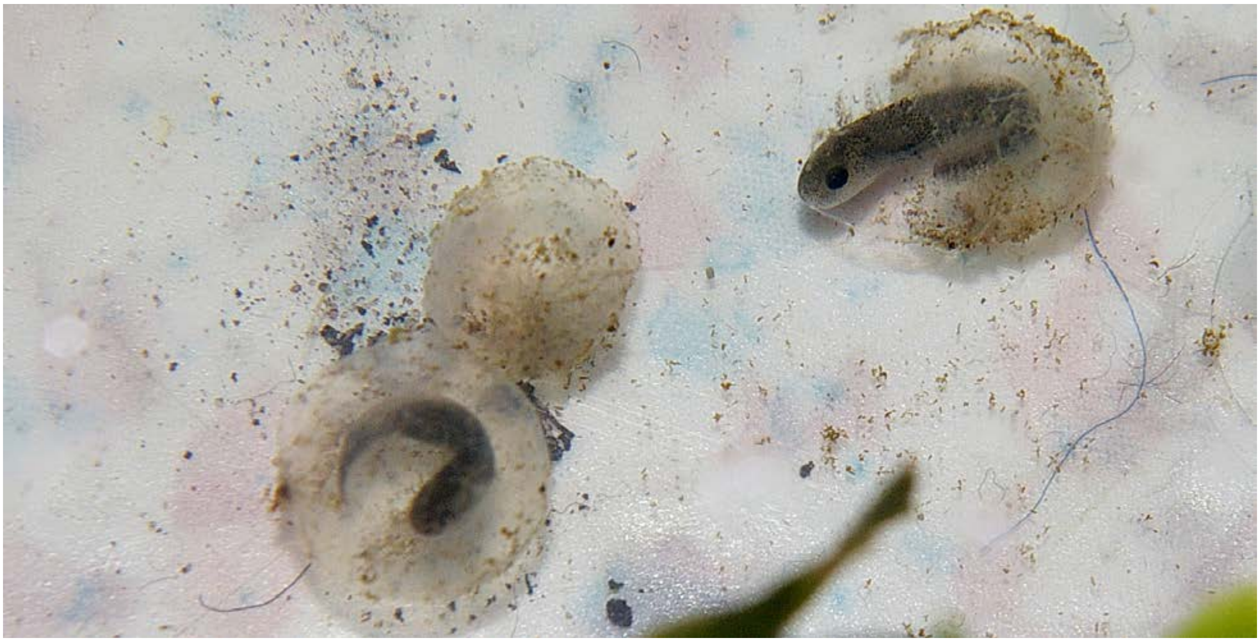

Figure 11. Hatching larvae of *N. s. strauchii. Photo by Sergé Bogaerts*.

Figure 12. Larva of *N. s. strauchii* few weeks old, the lateral line sense system visable in stripes on lateral sides and tail and in spots behind the eye. *Photo by Sergé Bogaerts*.

Figure 13. Larva of *N. s. strauchii* of approximately four months old. *Photo by Sergé Bogaerts*.

velop yellow spots and later become darker and darker developing their juvenile black pattern (Figs. 14, 15). Another one to three months may elapse before the gills are completely gone. Mortality of larvae is very low. Larvae become lighter in color at night. Depending on the water temperature and the amount of food, larvae metamorphosed in three to seven months, with a mean period of about five months (Table 4).

The first shedding takes place at around the time of metamorphosis, sometimes just before emergence from the water. They leave the water mostly at night and search for a hiding place, and if not provided, they try to hide again in the water. The first few weeks after metamorphosis, the juveniles can be kept in an aqua-terrarium with different hiding places from wet to dry, from which they can choose. Metamorphosis in this newt seems to be very gradual, such that juveniles continue to shift from water to land during a period of several weeks.

After metamorphosis the juveniles resemble their parents, although they have significantly fewer yellow spots, and spots are confined to two rows along their backs. The bellies are not completely black and show light-colored parts. The orange-red stripe on the belly is rose-orange and not as brilliant as in the adults. We are positive color intensity in captive-raised adults depends on the amount of carotenoid-rich food animals eat, like in the Japanese fire belly newt, *Cynops pyrrhogaster* (see Matsui et al. 2003).

Henry Janssen measured the total length of 108 specimens at the moment of metamorphosis (Figure 16). The

Figure 14. Larva of *N. s. strauchii* change its coloration to juvenile pattern. *Photo by Sergé Bogaerts*.

Figure 15. Larva of *N. s. strauchii* just before metamorphosis. *Photo by Sergé Bogaerts*.

data include only larvae that metamorphosed within the year eggs were laid. Metamorphosed *N. s. strauchii* weigh about 0.60 g (n = 11, with mean total length of 55 mm; data Sergé Bogaerts) which corresponds to Schultschik (data not shown) who gives 0.67 g for metamorphosed *N. s. strauchii*.

Henry Janssen measured the rate of metamorphosis of all eggs deposited between 1991 and 1997 in which breeding occurred each year. Of the total of 1,413 eggs, only 138 specimens reached metamorphosis (9.8%) (see Table 5).

Metamorphosis was considered as the moment the gills disappear, the black and yellow coloration are visible, and juvenile newt(s) come onto land for the first time. However, this is not a fixed moment. They can stay in a semi-aquatic stage for a while, with very short gills and full black and yellow coloration. The data of Henry Janssen show that there is a wide range of lengths at which metamorphosis can take place (Fig. 16). All of the measurements taken by other breeders have fallen within these ranges (Table 6).

"Overwintering" larvae

In both *N. s. strauchii* and *N. s. barani*, overwintering larvae are observed. Larvae that hatch later in the season, or stay behind in development, will remain larvae during the winter and metamorphose the next year. Fleck (1982) and Haker (1986) describe *N. s. strauchii* still found in larval form in January. Pasmans et al. (2006) describe this phenomenon for *N. s. barani*. During a field visit in May 2006, special attention was paid to this phenomenon at the type locality of *N. s. barani*, and many larvae that hatched in 2005 could be observed (S. Bogaerts, pers. obs.). The larvae keep their gills and fins, but develop characteristics of the juvenile coloration: black background color and yellow spots. Overwintering larvae seem to grow a bit larger than their siblings that

Table 5. Survival rate from egg laying until metamorphosis over seven years of breeding. *Data by Henry Janssen*.

Year	Number of eggs	Hatched eggs	Metamorphosed	Success rate per year (%)
1991	40	0	0	0
1992	514	229	48	9.3
1993	85	30	24	28.2
1994	39	2	2	5.1
1995	476	43	30	6.3
1996	171	43	34	19.8
1997	88	1	0	0

Table 6. Lengths of larvae at metamorphosis.

Keeper	Subspecies	Length (mm)	Remarks
Schmidtler and Schmidtler 1970	*strauchii*	54-61	
Fleck 1982	*strauchii*	54-55	
Steinfartz 1995	*barani*	56	
Henry Janssen	*strauchii*	47-75	
Gunter Schultschik	*strauchii*	45-50	
Kristina Ernst	*barani & strauchii*	40-60	
Jennifer Macke	*strauchii*	60-65	Still with gills
François Maillet	*barani*	55-60	

completed metamorphosis the previous year (up to 75, 25 mm; data Henry Janssen).

Raising juveniles

Fleck (1982) writes that raising juveniles is not problematic, as they easily switch between aquatic and terrestrial living, and can be kept and raised in an aqua-terrarium. Most of us raise the juveniles terrestrially. This method of rearing is most like their natural conditions, where juveniles live terrestrially until reaching reproductive age. A small terrarium (50 × 20 × 15 cm) is often used, with a leaf litter soil (typically from beech or oak forest), or a mixture of substrates (soil, coconut fibre, etc.) and some pieces of bark, which the newts use as shelter. A more sterile option with moist paper towel(s) and some pieces of bark also works well, but needs cleaning at least once a week. The juveniles are fed at a minimum of once a week, or usually more (further details above under the "Diet and nutrition" section on page 14). Tanks should provide a range of dry and moist places (Fig. 17). Frank Pasmans raised juveniles on wet Kleenex kitchen towel paper, with pieces of ceramic roof tiles piled up, creating gradients from moist to dry.

Foods are prepared similar as for the adults and are typically small crickets, small wax worms, slugs, fruit flies (*Drosophila* sp.), woodlice (*Asellus* sp.), firebrats/silverfishes (*Thermobia* sp.), etc. Further, bloodworm (*Chironimus* sp.), *Tubifex* sp., or chopped earthworms and blackworms can be fed from a small bowl or on a wet paper towel. They can be kept in the same temperature ranges as adults. Our captive bred animals have reached at least the age of 12 years.

Jennifer Macke tested the difference between terrestrial and aquatic raising of juveniles. In March 2004, four of the juveniles obtained in October 2003 were adapted to water at a size of about 7-8 cm total length. This was accomplished by placing them, one at a time, into an 18-liter (five gallon) tank containing two cm (one inch) of water, a thick layer of aquatic plants, and an ample supply of live blackworms (*Lumbriculus variegatus*), and chopped earthworms. Each animal adapted to hiding beneath the plants within one day. Once adapted to water, they were moved to a larger tank (60 × 30 × 30 cm) containing 25 cm of water, large river rocks, clay pots, and a mini canister filter providing a bit of current. Local tap water comes from ground water that is alkaline and moderately hard (GH 70 ppm, KH 90 ppm, pH 8). Both the aquatic and terrestrial animals appeared healthy and grew well. Feeding regimens were, of necessity, dif-

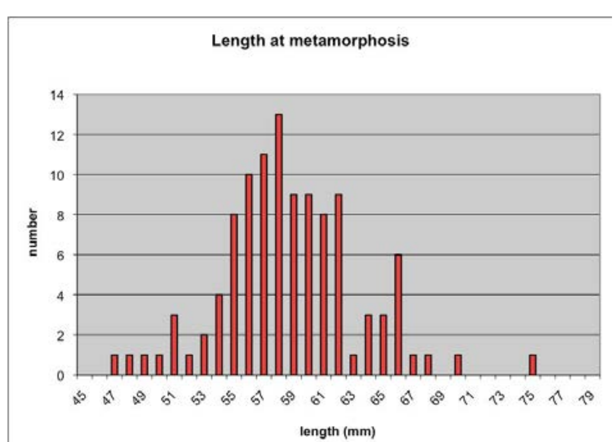

Figure 16. Length at metamorphosis (n = 108; *data by Henry Janssen*).

Figure 17. Set up for raising juvenile *N. s. strauchii*. *Photo by Jennifer Macke*.

ferent for the two groups. The terrestrial group was fed as described above, including live blackworms *ad libitum*. The aquatic group was hand fed almost every day with chopped earthworms and occasional fly larvae or crickets. They were also given some live blackworms during the first months. However, when a large population of leeches was discovered in the tank (and one leech was observed briefly attached to one of the newts), no more blackworms were given. By August 2004, the typical size of the terrestrial animals was 10 cm, while the aquatic animals were approximately 12 cm and more heavily spotted. The aquatic group mated and bred the following winter, while the terrestrial animals showed no sign of breeding readiness. By August 2005, the aquatic animals were all 12-13 cm, while the terrestrial group had reached 11-12 cm, and males of both groups had enlarged cloacas and some white highlights on the tail. Thus, it can take just two years between egg and breeding adult (at least for males). In our experience, females need one year more to become adult, and when raised more slowly (given less food), they take three to four years to mature.

Gold dust variety

Haker (1986) first bred some aberrant color morphs, known as the "gold dust" variety—originated because of their appearance of being sprinkled with gold dust and a black line along the dorsal side (Fig. 18). This form occasionally still occurs in breedings directly derived from Haker through Henry Janssen. The number of individuals is very low, noted Patrick Wisniewski. In the first breeding of 35 metamorphs, two were "gold dust," and in the second batch of nine metamorphs, only one. This form has not appeared since the breedings of Henry Janssen, in any of the other breeding groups, that are involved in this article.

Diseases

Very little is known regarding diseases occurring in newts of the genus *Neurergus*. As in most urodelans, inadequate husbandry (including poor water quality) and/or nutrition are probably the most important predisposing factors for disease. More specifically, for *Neurergus*, most disease cases appear to occur during summer months, suggesting this species to be sensitive to higher temperatures (>20 °C). A six week quarantine period is recommended when having first obtained animal(s). During this period, the newly acquired animal should be assessed by a qualified veterinarian for the presence of infectious and non-infectious diseases. We strongly recommend every newly acquired animal to be tested for the presence of ranaviruses and *Batrachochytrium dendrobatidis*. The presence of both agents can be assessed by detection of their respective DNA in skin swabs (less sensitive for the detection

Figure 18. Adult of *N. s. strauchii* of "Gold-dust" form. *Photo by Henry Janssen*.

Figure 19. Metabolic bone disease in an adult female *N. s. strauchii*. Note the malformation of the lower jaw. *Photo by Frank Pasmans*.

of ranaviruses) or tail clips. Trade derived animals have indeed been identified as important carriers of both infectious agents and may spread diseases to native amphibian populations. Both diseases have been listed by the Office International des Epizooties or World Organisation for Animal Health (OIE) as notifiable diseases since 2008. The following disorders have been diagnosed in *Neurergus* (in part by F. Pasmans, pers. observ.):

1) Metabolic bone disease (MBD, Fig. 19). MBD comprises a number of metabolic disorders affecting skeletal calcification. In urodelans, most cases of MBD can probably be attributed to relative lack of calcium and/or vitamin D in the feed, and would thus be more appropriately named, nutritional secondary hyperparathyroidism. Clinical signs are most obvious in young, terrestrial specimens, and include backbone and head malformations (e.g., shortening of the lower jaw), and abnormal movements. MBD can be prevented by supplying feed items (e.g., crickets) with extra calcium through the insect diet ("gut loading") and topically applying calcium containing powder on the feed insects. However, this is only applicable for juveniles raised on land and for terrestrial adults. Feeding calcium supplementation for aquatic newts is much more difficult to achieve and may in part be met by providing calcium supplemented pellet feed (e.g., turtle pellets, if accepted by the newt).

2) Ranavirosis. Recently, ranavirosis has been described in *N. crocatus*, imported from Iraq (Stöhr et al., in prep.). Clinical signs of this viral disease include reddening of the skin (erythema), skin ulceration, edema, anorexia, and death. The course of a *Ranavirus* infection may vary from subclinical (without clinical signs) to mass mortality. This virus is one of two known infectious threats to amphibian biodiversity worldwide. Prevention consists of quarantine measures of newly acquired animals and preferably testing of a tail clip or skin swab for the presence of the viral DNA. It is of utmost importance to prevent any contact of *Ranavirus*-infected newts or their environment (e.g., aquarium water) with the environment, to prevent spread of the virus to native amphibian populations. Ranavirosis cannot be treated.

3) Chytridiomycosis. This fungal disease is caused by *Batrachochytrium dendrobatidis* and is considered the most important infectious driver of worldwide amphibian declines. For this reason, it is of utmost importance that (as for ranavirosis), captive populations of *Neurergus* are negative for the fungus. It is at present not clear whether this fungus causes clinical problems in newts of the genus *Neurergus*. In other amphibians, the course of a *B. dendrobatidis* infection may vary from asymptomatic to apathy, skin disorders, and death. Recently, *B. dendrobatidis* infection was demonstrated in *N. kaiseri* (Spitzen van der Sluijs et al. 2011) but no clinical signs of disease were noticed. As a preventative measure, all newly acquired *Neurergus* should be tested for the presence of the fungus using a skin swab. If positive, infected animals and their captive environment should be treated appropriately. *Neurergus kaiseri* was treated successfully using voriconazole (F. Pasmans, pers. observ.; Martel et al. 2011). As for ranaviruses, all contact of *B. dendrobatidis* infected animals and their captive environment with the outside environment should be strictly prevented.

Figure 20. Ascites ("bloating") in an adult female *N. s. strauchii* with a severe enteritis, associated with high numbers of flagellates. *Photo by Frank Pasmans.*

4) Chlamydiosis. For more than a decade, enigmatic mortality in captive *N. crocatus* and *N. strauchii* newts was observed by several breeders. This mortality even impaired the establishment of successful breeding programs in for example *N. crocatus*. In the nineties of the past century, entire captive breeding groups of this newt were lost. Keepers reported non healing wounds on the tail. Recently, the cause for this mortality was suggested to be a bacterium: *Candidatus* Amphibiichlamydia salamandrae (Martel et al. 2012). The disease presents as anorexia, lethargy, edema, markedly abnormal gait, and death. Secondary bacterial or mycotic infections (e.g., with *Aeromonas* sp. or *Mucor* sp.) appear to be common. Urodelans can be very probably latent carriers of *Chlamydia* bacteria, with possible reactivation of the infection during stress periods. Indeed, *Chlamydia* infections are probably widely spread in urodelan collections and clinical signs are possibly provoked by suboptimal conditions, for example, elevated temperatures during summer months. Until now, clinically infected animals invariably die but therapy may consist of the use of, for example, tetracyclines to cure the infection. Preventative measures consist solely of quarantine measures and optimal husbandry (including temperatures <20 °C).

5) Intestinal parasitosis (Fig. 20). As in all amphibians, intestinal parasitosis may occur in *Neurergus* newts and appears to be mostly provoked by suboptimal husbandry. Several cases of severe enteritis, coinciding with very high numbers of flagellate protozoa were diagnosed in *N. strauchii* and *N. crocatus*. Clinical signs were anorexia, loss of condition to cachexia, and in some cases ascites (bloating). Treatment using metronidazole and optimizing husbandry was successful in cases with an early diagnosis.

Conclusions

In addition to their beauty, *N. strauchii* are interesting newts in captivity. Although our data are still scattered and incomplete, the results of this project presents good indications for long-term captive maintenance and gives direction for further studies especially, when our experiences differ, or have revealed new topics to study.

Our main goal in keeping this newt has been its successful breeding. We vary in our opinions about the importance of a terrestrial period as part of the yearly breeding cycle. Although, it is in their natural cycle to have a terrestrial period both Fleck (1982) and Steinfartz (1995) write that a terrestrial phase is necessary to initiate breeding. Fleck kept his animals from 1975 to 1979 in an aquatic enclosure, but males and females were not synchronized in their breeding behavior. He gave three animals a terrestrial phase in 1980 and then both sexes got into breeding condition at the same time. However, Jennifer Macke has bred the same group of animals for eight years without any terrestrial periods, while most of us experienced that animals were less willing to breed when they were not given a terrestrial period.

Thus, if keeping adults aquatic or not, the whole year round is not of major importance in breeding these animals, we show that a dramatic change in temperature, often combined with an abrupt shift from land to water is probably more important. Steinfartz (1995) reported that in his opinion it is not a low temperature in winter that is necessary for successful breeding, but a strong temperature difference between summer and winter period. However, our findings indicate a strong correlation between specific temperatures and the specific phases of reproduction. A period with temperatures below 10 °C

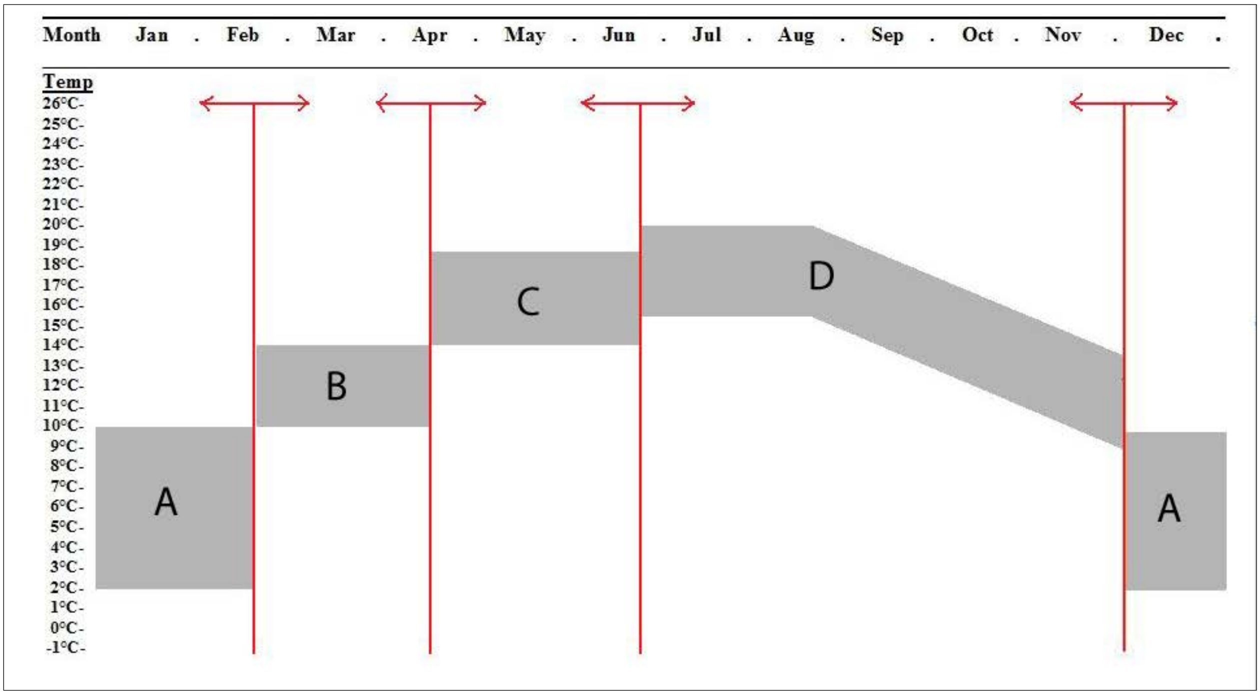

Figure 21. Proposed yearly temperature-curve for the captive breeding of *Neurergus strauchii*.

prior to the breeding season proves essential to realize the temperature curve that stimulates breeding (Fig 21). Hence, a terrestrial period may help to synchronize the sexes and breeding behavior. Adults can be kept all year round aquatic and will still breed, but need to at least undergo a change in temperatures. Keeping animals in a terrestrial phase makes it easier to change temperatures by, for instance, placing them in a refrigerator or outdoors. Another advantage of a terrestrial period is that one can provide more differentiation in food items (e.g., crickets, wax worms, and other insects) which increased diet quality.

It seems that changing the newts between enclosures is not a drawback. When animals are kept the whole year in the same tank, with just gradual changes of temperature, they will not breed, but if they have a dramatic change of environment (or change of temperature), they are likely to initiate breeding behavior. We all agree that giving the newts a cold winter period is the best way to have a successful breeding.

Although Sparreboom et al. (2000) noted interfering males when a couple is mating, it does not seem to decrease the success rate of breeding, but if undisturbed breeding is the goal, one should keep one male together with one or more females during the breeding period.

For successful initiation of oviposition, it seems that a shift in temperature from 12-14 °C (courtship behavior and development of eggs) to 16-18 °C is important. A temperature stable environment where the tank is placed (basement) or refreshing the water can help provide this. The period of egg laying seems to depend on the gradual rising of temperature. If temperature rises quickly this can reduce, or even eliminate, the period of egg laying. Henry Janssen noted such negative influences on his breeding results, caused by rapid and unwanted temperature changes, typical for the sea climate where he lives. It seems therefore important for the breeder to have some control over water temperature. In nature, depending on the weather, mating season starts approximately at the end of April to beginning of May for both subspecies (Bogaerts et al. 2006) and continues into June (Schmidtler 1994). In captivity, temperature is of more influence than the time of the year and newts are preparing to breed when temperatures rise above 10 °C.

Although eggs are mostly "spawned" on the underside of stones, they can be laid anywhere, as described. Bogaerts et al. (2006) found some eggs of *N. s. barani* on tree branches and at the bottom of water bodies, but concluded it was an artifact due to the lack of other suitable sites. This might also be true for captive populations. Eggs laid or kept in lighter environments develop in the same manner, and we have not found any differences in development. Development of eggs does not seem to be influenced by taking them out of the breeding tank or cutting them loose from stones. The eggs are not delicate. One can choose the way that suits the breeder best. Taking the eggs out of the tank gives the breeder more control.

Our data show total number of eggs per female can be much higher, up to 285, than previously reported (Schmidtler and Schmidtler 1970; Fleck 1982; Steinfartz 1995). It seems likely the amount of food given to females adds to production of more eggs. Even young females can lay many eggs, thus size of the female does not seem to be a major factor determining the amount of eggs laid, but the amount of food given probably is a contributing factor as well; however, we do not have enough data to support this claim. There doesn't seem to be a difference between the two subspecies in the number of eggs.

Steinfartz (1995) stated that in his opinion the larvae of *N. s. barani* are more pond-type, in comparison to stream-type larvae of *N. s. strauchii*, based on minor differences. In the experience of the authors that have kept both subspecies, it is impossible to tell larvae apart. However, perhaps *N. s. barani* grows a little larger and more robust before metamorphosis. But we do not have data to support this.

Rearing of the larvae and juveniles was relatively unproblematic in all cases, as long as water quality is checked regularly. Raising juveniles can be done in a terrestrial environment or in an aqua-terrarium. In nature, juveniles certainly grow up terrestrial, as aquatic juveniles have never been observed in the field. Raising them in an aqua-terrarium gives the opportunity to feed them more varied types of food. The newts are able to switch easily from land to water and vice versa, and they adapt quickly to water without skin problems. Jennifer Macke showed a slightly faster growth of aquatically-raised animals. But as the number of animals is very small and because the feeding regime and types of food differed, it is not possible to draw straightforward conclusions. It seems likely that growth depends more on quality and availability of food and temperature, than on the type of housing. In the past, whole groups of captive bred *N. strauchii* have collapsed; also among the authors. Several possible and proven candidates have been described above. We strongly advise to avoid stress (e.g, high temperatures >20 °C) and provide optimal husbandry and feeding.

We hope our successful long-term keeping, breeding, and raising of *N. strauchii* is an example and model that may be used for private contributions to conservation breeding programs, for endangered *Neurergus* species and other semi-aquatic salamanders. Future studies on captive specimens will provide more data on the captive breeding of this, and other newts. According to the Studbook (Molch-Register) by Kristina Ernst it seems this species is still available in good numbers, but consistent breeding every year is still rare, even among the authors. Hopefully, this paper can contribute to greater captive breeding efforts and to a better understanding of the ecology of this fascinating newt but also can be seen as a valuable example of privates' contribution to conservation breeding programs for endangered *Neurergus* species and other semi-aquatic salamanders.

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Sergé Bogaerts has been fascinated by salamanders and newts since the age of seven. He studied biology at Raboud University Nijmegen, specializing in herpetology and animal ecology. He works as advisor on ecology and nature law for infrastructure projects for the Ministry of Infrastructure and Environment, while he continues herpetological studies as a hobby. Both through field work and captive care, he is striving to learn more about the ecology and behavior of newts and salamanders, particularly those of the Mediterranean and Middle East, and he publishes the results of these studies whenever possible.

Henry Janssen started out as a turtle enthusiast in the early 1970s. Gradually his interest shifted to newts, in particular to the genus *Paramesotriton*. Over the years he was able to build up a significant collection of *Paramesotriton* and other newt species, and has bred and raised at least one generation of most of these. By keeping detailed records of his observations and through the systematic gathering of data, he has acquired a thorough knowledge about the species he works with.

Jennifer Macke has had a life-long fascination with animals. Her interest in newts began with an undergraduate research project on limb regeneration, and she has kept and bred caudates ever since. She is particularly interested in newts of the genera *Cynops* and *Neurergus*. She is currently employed as a molecular biologist and also volunteers her time to manage the care of the reptiles, amphibians, and invertebrates at a local nature center.

Günter Schultschik started keeping newts and salamanders as a boy and still considers himself just an enthusiast. After getting in contact with AG-Urodela of DGHT in 1989, his collection grew rapidly. J. F. Schmidtler (Munich) was his teacher when he began to travel through Anatolia and the Middle East searching for amphibians and reptiles. As a member of the Austrian Herpetological Society, he founded "Urodela-Austria" a working group which has a meeting once a year, the "Molchlertag." After some publications together with W. Grosse, they started a project called "Captive Care Management" for threatened species of tailed amphibians, which will be published soon in the DGHT series *Mertensiella*.

Kristina Ernst has been interested in all kinds of animals since she was a small child. Her fascination for newts and salamanders started in 1993 with her first newts of the genus *Cynops*. In 2000 she became a member of AG-Urodela of the DGHT and discovered, and developed a special interest in the genus *Neurergus*. Since then, she has focused on this genus and is responsible for the studbook of *Neurergus strauchii* at AG-Urodela.

François Maillet has been keeping and breeding salamanders and newts as long as he can remember. Together with Jean Raffaelli and Arnaud Jamin, he forms the core of the French Urodela Group (FUG), whose goals are to bring together knowledge and experience regarding captive bred animals, and to keep stable long-term populations of many species of newts and salamanders in captivity.

Christoph Bork has been interested in amphibians since he was six years old. He especially loves newts and salamanders, which he has kept seriously for at least 25 years now. He got his start with *Triturus* species, and mainly keeps *Neurergus* species nowadays. As a hobby newt enthusiast he has been a member of the AG Urodela for many years. Additionally he is fascinated by poison dart frogs. Several of these species decorate his living room.

Frank Pasmans has been fascinated by urodelans since he was a young boy, and he has kept and bred several species. As a veterinarian, he is currently head of a research group that studies amphibian diseases at Ghent University, Belgium.

Patrick (Pat) Wisniewski (1954-2008) was an all-round natural historian and the longest serving curator of Martin Mere in Lancashire, one of the nine UK Wildfowl & Wetland Trusts centres. He was "the newt man's newt man," said to be ahead of his time in amphibian husbandry. He kept and bred a great range of amphibians, especially newts and salamanders—mainly European and Asian species. A vast collection of captive animals covered every inch of several rooms and part of the garden. Pat wrote the booklet "Newts of the British Isles" published in 1989.