

## Crested newt (*Triturus cristatus* superspecies) populations in Salzburg, Austria, their distribution, size and conservation status (Caudata: Salamandridae)

Verteilung, Größe und Erhaltungszustand der Kammolch-Populationen  
(*Triturus cristatus* superspecies) in Salzburg, Österreich  
(Caudata: Salamandridae)

ANDREAS MALETZKY & ALFRED GOLDSCHMID & MARTIN KYEK

### KURZFASSUNG

Im Jahr 2003 war die Datenlage zum Status der vom Aussterben bedrohten und streng geschützten Kammolche (*Triturus cristatus*, *T. carnifex*) des Bundeslandes Salzburg (Österreich) völlig unzureichend für deren effektiven Schutz. Aus diesem Grund erfaßten wir alle bestehenden Daten, um ein Bild der früheren Verbreitung rekonstruieren zu können, und evaluierten den aktuellen Zustand durch intensive Kartierungstätigkeit zwischen 2004 und 2006. In neun Einzelpopulationen wurden mit Fang-Wiederfang-Methoden Abschätzungen der Populationsgröße durchgeführt. Weiters bestimmten wir den Erhaltungszustand von insgesamt 12 Populationen mithilfe einer standardisierten Matrix.

Zwischen 1923 und 2006 wurden insgesamt 85 Fundorte und 205 Einzelbeobachtungen von Kammolchen in Salzburg dokumentiert. Davon wurden im Laufe unserer Studie nur 33 (26 aquatische) Vorkommen bestätigt oder neu entdeckt. Die Vertikalverbreitung liegt zwischen 382 und 1282 m Seehöhe. Im Mittel liegen die rezenten Nachweise (nicht signifikant) in höheren Lagen als die älteren Vorkommen. Im Großteil des Salzburger Verbreitungsgebietes, welches sich erheblich verkleinert hat, besteht eine Kontaktzone mit Mischpopulationen der beiden Arten. Die meisten Populationen aus dem früheren Verbreitungszentrum in den Beckenlagen um die Stadt Salzburg sind verschwunden. Es bestehen keine aktuellen Nachweise aus Natura 2000 Gebieten (nach EU-FFH-Richtlinie). Die Populationsgrößenschätzungen lagen zwischen 32 und 101 Individuen, jedoch waren die Zahlen der Wiederfänge gering und die Konfidenzintervalle breit. Nur eine der zwölf evaluierten Populationen zeigte einen günstigen Erhaltungszustand ("A"), fünf Populationen sind derzeit in schlechtem Zustand ("C"), wofür hauptsächlich geringe Populationsgrößen und der schlechte Zustand der Landlebensräume verantwortlich sind.

Wir fordern die schnelle Durchführung von effektiven Maßnahmen zur Habitatverbesserung und -neuschaffung.

### ABSTRACT

In the province of Salzburg (Austria) only scarce information on the status of the critically endangered and strictly protected crested newts (*Triturus cristatus*, *T. carnifex*) was available. Therefore we collected existing data to outline the previous distribution and evaluated the current situation via extensive mapping between 2004 and 2006. In nine populations, size estimates were obtained by capture-mark-recapture studies. We also evaluated the conservation status of twelve populations using a standardized matrix.

A total number of 85 localities (205 single observations) from the province of Salzburg were documented between 1923 and 2006. Only 33 of these records (26 aquatic habitats) were confirmed or newly discovered in our study. The vertical distribution ranges between 382 and 1282 meters a.s.l. On the average, the recent records are at higher altitudes (not significant) than the older ones. The largest part of the province of Salzburg can be regarded as contact zone, inhabited by admixed populations. The range area of crested newts in Salzburg has been subject to considerable size reduction. Most populations in the former distribution centre, the basin areas surrounding the City of Salzburg, have disappeared. No current observations were recorded from any Natura 2000 site.

Estimated population sizes ranged between 32 and 101 individuals with wide confidence intervals due to low numbers of recaptures. Only one of twelve populations currently evaluated showed a favorable conservation status ("A"), five populations are in bad condition ("C"), mainly due to small population size and inadequate terrestrial habitat.

We urge for rapid and efficient protection measures in terms of habitat enhancement and creation.

### KEY WORDS

Amphibia: Caudata: Salamandridae; *Triturus cristatus*, *Triturus carnifex*, *Triturus cristatus* superspecies, favorable conservation status, conservation, distribution, Habitats Directive, population size, decline, Salzburg, Austria

## INTRODUCTION

Crested newts (*Triturus cristatus* superspecies) are distributed throughout large parts of Europe and small parts of Western Asia. In Central Europe these closely related taxa show parapatric distribution, whose contacts are characterized by narrow hybrid zones (ARNTZEN 2003). Crested newts have been subject to significant decline in many different parts of their distribution area during the latter half of the twentieth century (e.g. GASC et al. 1997; THIESMEIER & KUPFER 2000). Compared to other widespread amphibian species they appear to be more fastidious in their habitat requirements and therefore declined more severely. Among the main reasons of decline are the intensification of agriculture, traffic and land use, causing negative habitat development like destruction, fragmentation and manipulation (e.g. THIESMEIER & KUPFER 2000). Crested newt species are listed as endangered in the recently updated Red Lists of the German province of Bavaria [*Triturus cristatus* (LAURENTI, 1768); BEUTLER & RUDOLPH 2003] and Switzerland [*T. cristatus*, *T. carnifex* (LAURENTI, 1768); SCHMIDT & ZUMBACH 2005]. In the first regional Red List of Salzburg *T. cristatus* superspecies is considered critically endangered (KYEK & MALETZKY 2006), while in the updated Red List for Austria (GOLLMANN 2007) *T. cristatus* is classified in a higher category (endangered) than the more widespread *T. carnifex* (vulnerable).

These continuous negative trends are contrasted by the strong legal protection crested newts are subject to on the regional, federal and European scale. Crested newts are fully protected by conservation regulations in all Austrian provinces (RIENESL 2001). All three Austrian species - *T. cristatus*, *T. carnifex* and *T. dobrogicus* (KIRITZESCU, 1903) - are listed in Appendix II of the Berne Convention, which specifies several supraregional measures in a conservation action plan elaborated by its standing committee (EDGAR & BIRD 2005). Most important, they are species of Annexes II and IV of the EU-Habitats Directive (Council Directive 92/43/EWG 1992). Following Art. 3, species of Annex II should be pro-

tected in species specific areas of conservation (Natura 2000) and the conservation status of species of Annexes II and IV should be kept under surveillance by subsequent monitoring following Art. 11.

Conservation biology requires detailed knowledge about distribution, population size and trends of particular species which is the basis for adequate conservation measures. An appropriate evaluation of the conservation status has to assess population and habitat based parameters. While some recent information on basic habitat characteristics for crested newts in Austria and especially Salzburg is available (CABELA & GRILLITSCH 2001; MALETZKY et al. 2007), there is still a lack of knowledge concerning many other questions relevant for conservation and a sufficient obligatory report on the conservation status of the crested newt species in Austria in terms of Article 17 of the EU-Habitats Directive. The following preconditions must be met in order to achieve a sound basis for further investigations.

Firstly it is necessary to have the best information possible on the historical and recent distribution of the species. SCHEDL (2005) claims large gaps in knowing the precise distribution throughout most parts of Austria, including information on the vertical distribution. There is a necessity on surveys in little or barely studied areas, as well as a check-up on the status of sub-recently documented localities. In the province of Salzburg, precise historical data on the distribution of the two occurring species (*T. cristatus*, *T. carnifex*) are scarce (but see SCHÜLLER 1958, 1963; FREYTAG 1978). Most of the current information is based on unpublished mapping projects from the end of the last decade (e.g. KYEK et al. 1993; WERNER et al. 1993; KYEK 2001); they, however, did not include much of northern Salzburg (comp. CABELA et al. 2001). Two of the authors recently evaluated this area in the course of the current Atlas and Red List of Salzburg (KYEK & MALETZKY 2006) and provide precise results in the present paper.

Secondly, field identification of crested newt species according to morphological features is not reliable, particularly in con-

tact zones. Thus, such data must be handled cautiously, preferably at the super-species level. This problem is complicated by the lack of knowledge concerning the particular extension of hybrid zones (see also KLEPSCH 1994; MAYER 2001). A contact zone of *T. cristatus* and *T. carnifex* is located in the border area of south-eastern Bavaria (Germany) and Salzburg (Austria). The precise extensions of distribution areas and hybrid zones in this region were discussed in several publications, yet only using morphological data (e. g. SCHMIDTLER 1976; FREYTAG 1978; SOCHUREK 1978). Recent molecular studies on populations in the area between Bavaria and Upper Austria provided a basis for better understanding of the distribution of the crested newt species and the extension of contact zones with admixed populations (MALETZKY et al. in press). The findings for populations in Salzburg are summarized in the present study.

Thirdly, a reliable estimate of population size is a key component for the evalu-

ation of the conservation status and has a high practical importance in the course of obligatory reports concerning Article 17 of the EU-Habitats Directive (e.g. NEUKIRCHEN et al. 2005; SCHEDL 2005). Using population viability analysis, GRIFFITHS & WILLIAMS (2000) showed that low population size is a major parameter for increasing extinction risk particularly in isolated populations. Standardized data on status and trends of population size and structure are necessary to develop and implement monitoring procedures that produce comparable results achieved with reasonable effort.

This publication aims on reviewing and joining historical and current observation data to create an inventory of crested newt records in the province of Salzburg, and show changes between the recent and historical distributions. Moreover we present new size estimates for selected populations, combined with an assessment of the conservation status for these populations.

## MATERIALS AND METHODS

### Crested newt inventory

Historical and sub-recent data on the distribution of *T. cristatus* superspecies in the province of Salzburg (Austria) was gathered from published (WOLTERSTORFF 1925; SCHARLINSKI 1939; FREYTAG 1978; KYEK 2005), and “grey” literature (KYEK 1993, 2001; WERNER et al. 1993; LIEB & WERNER 1995; WEISSMAIR 2005) as well as the Biodiversity database of the Natural History Museum “Haus der Natur” Salzburg (Biodiv. Database Sbg.) and the herpetofaunal database of the Museum of Natural History in Vienna (NHMW Database). Additionally the collection of L. SCHÜLLER, located at the Natural History Museum in Salzburg, was analyzed. Geographical coordinates and habitat descriptions were attributed to each record with the highest precision possible ( $\pm 50$ - 250 m).

The current distribution was explored in the years 2004-2006 by extensive mapping of data deficient areas in the northern districts of the province of Salzburg, carried

out by the authors and trained volunteers from the Herpetological Study Group in Salzburg. A presence-absence monitoring of crested newt breeding ponds was carried out in northern Salzburg in 2005 (see MALETZKY et al. 2007 for precise detection methods).

We distinguished between observations made in aquatic, terrestrial and undetermined (historical observations) habitats, as well as individuals captured at drift fences. The assignment to one of two species or admixed populations was exclusively made for localities, in which newts were studied with molecular methods (see MALETZKY et al. in press).

For data acquisition and processing we used form sheets for mapping the Austrian herpetofauna (KYEK 1996), BioOffice<sup>®</sup> (BioGis<sup>®</sup>) software for databanking and ArcView<sup>®</sup> 9.1 (ESRI<sup>®</sup>) for GIS applications. Localities were assigned to coordinates, using the National grid of Austria (Bundesmeldenetz BMN: MGI M31), representing values for x and y in meters.

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### Population size estimates

Data on population size are available for two ponds in Fürweg (district “Salzburg-Umgebung”, SOMMER 1998), and a high altitude population at lake “Ameisen-see” (district “Hallein”, MALETZKY et al. 2004). In both studies population size was estimated during two consecutive years. These populations were not evaluated anew in the current study but appear stable at a high level (MALETZKY pers. observation). The size of nine more populations was estimated once during April/May 2005 (4 populations) and April/May 2006 (5 populations), using Seber’s unbiased modification of Petersen’s mark-recapture method (in KREBS 1989). Newts were captured with bottle traps, which are a very useful tool for studying ponds that are big or otherwise difficult to examine (GRIFFITHS 1985). We used a simple model described by SCHEDL & KLEPSCH (2003), with a minimum of 10 traps set at approximately every 5-10 meters shore line. In ponds where we did not capture a sufficient number of individuals with this method, we additionally used torching and dip-netting. Digital photographs of the ventral side were taken and individual belly patterns were used for identification (HAGSTRÖM 1973). For each pond a single recapture was carried out two or three days after the first capture.

### Assessment of conservation status

The conservation status of 12 selected populations was assessed following the criteria, indicators and threshold values in SCHEDL (2005). This evaluation includes data on population size and structure as well as terrestrial and aquatic habitat quality, combined and weighted according to an evaluation matrix. The conservation status is evaluated as favorable (“A”), inadequate (“B”) or bad (“C”). Population indicators contain both size estimates and data on population structure and frequency of reproduction, which require periodical monitoring. The herpetological value of aquatic habitats is given by the structural richness of the water body including its immediate surroundings (buffer = 50 m) and the presence or absence of fishes. The evaluation of the ambient terrestrial habitat should cover a 500 m wide annular buffer zone representing an area of at least 78.5 hectares. Within this area, parameters like human utilization, structure and potential summer and winter habitats, combined with the presence of roads or other migration barriers should be assessed.

As the geographical distance between pond Fürweg MM1 and MM2 is less than 50 m, the evaluations were merged. All other ponds were isolated due to high-traffic roads (Pabing) or geographical distance (nearest neighbor > 1.5 km).

## RESULTS

### Crested newt inventory

A total number of 205 individual observations of crested newts originating from 85 localities were registered in the three northern districts of the province of Salzburg (“Salzburg-Umgebung”, “Salzburg-Stadt” and “Hallein”) between 1923 and 2006 (Fig. 1). One additional record locality (Pfarrwerfen, district “St. Johann”), which according to subsequent studies (KASINGER 1999) very likely was based on misidentified larvae, was not included in the results. Thirteen record localities mentioned rather vaguely in the literature could be assigned to their geographic coordinates

with an accuracy of approximately  $\pm 250$  m only. Historical and sub-recent data recorded before 2004 contained a total of 78 individual observations from 52 localities (1.5 observations per locality), which could not be confirmed between 2004 and 2006 despite intensive search (Table 1, Fig. 1, see also MALETZKY et al. in press). The number of observations ranged between one and seven with a single observation in 38 localities and more than three observations in only two places (Table 1). The distribution area can be regarded as continuous along the Salzach river valley between Golling and St. Georgen with centers of distribution in the basin of the city of Salzburg and the

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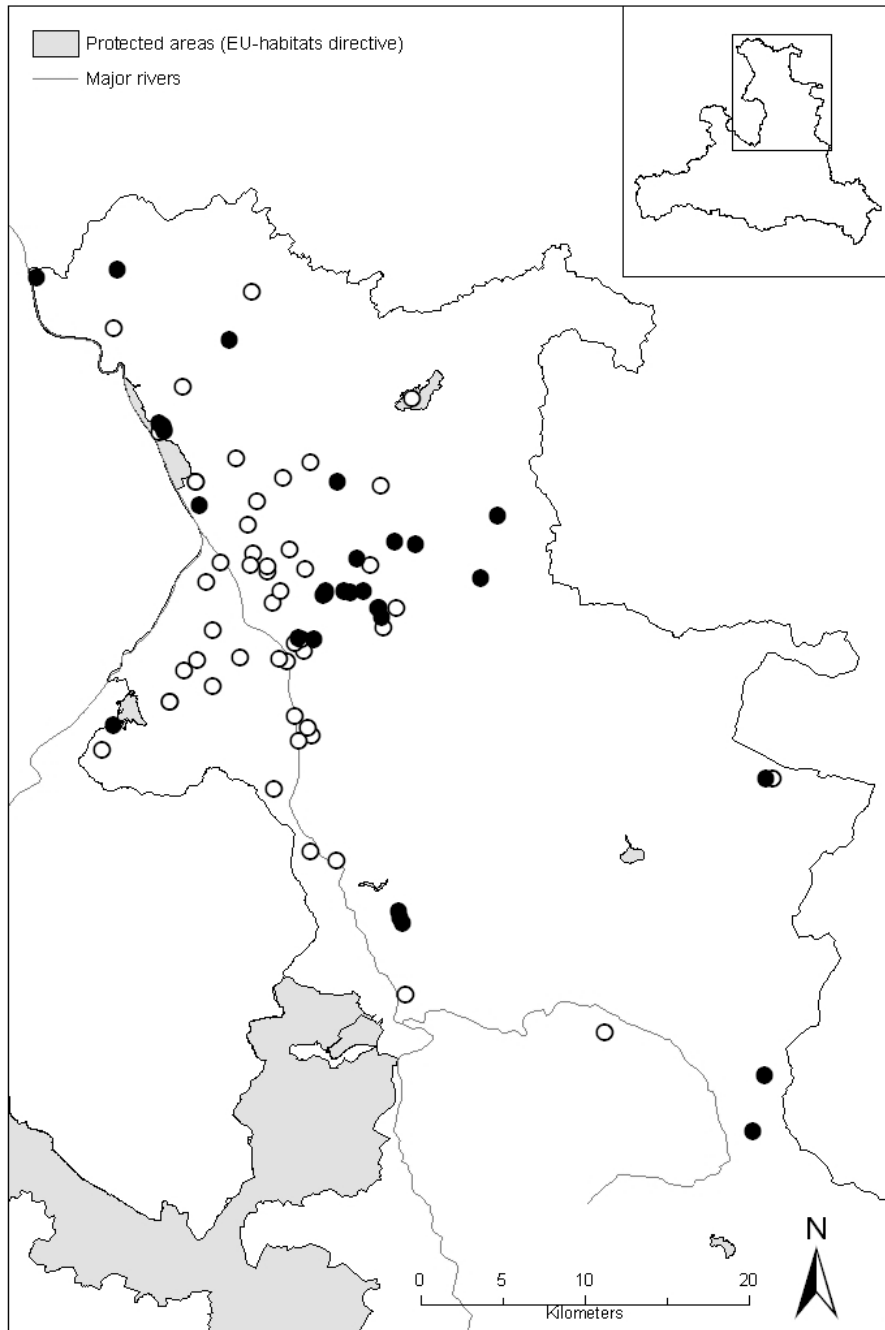


Fig. 1: Overall distribution of crested newts in the province of Salzburg (Austria);  
○ - records between 1923 and 2003, ● - records between 2004 and 2006.

Abb. 1: Die Verbreitung der Kammolche im Bundesland Salzburg (Österreich);  
○ - Nachweise von 1923 bis 2003, ● - Nachweise von 2004 bis 2006.

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Table 1: Record localities of *Triturus cristatus* superspecies in the province of Salzburg, unconfirmed after 2003. Coordinates following the Austrian national grid for Central Austria (BMN: MGI M31); habitat: a - aquatic, t - terrestrial, f - drift fence, ? - unknown.

Tab. 1: Zusammenstellung von seit 2004 unbestätigten Kammolch-Fundorten im Bundesland Salzburg. Koordinaten nach dem Österreichischen Bundesmeldenetz (BMN: MGI M31); Habitat: a - aquatisch, t - terrestrisch, f - Amphibienschutzzaun, ? - unbekannt.

#	Community Gemeinde	Locality Name Fundortname	First description by Erstbeschreibung	Coordinates (x,y) Koordinaten (x,y)
1	Salzburg	Maxglan	WOLTERSTORFF W.	426150 / 295500
2	Eugendorf	-	SCHÜLLER, L.	434320 / 303200
3	Wals-Siezenheim	Eichetsiedlung	MAHLER, F.	425150 / 293700
4	Salzburg	Mittermoos	MAHLER, F.	426100 / 292100
5	Puch	St. Jakob am Thurn	MAHLER, F.	432150 / 289100
6	Bergheim	-	MAHLER, F.	425100 / 304600
7	Wals-Siezenheim	Schweizersiedlung	MAHLER, F.	424400 / 293100
8	Salzburg	Liefering	MAHLER, F.	425750 / 298450
9	Salzburg	Salzachseen	MAHLER, F.	426600 / 299650
10	Elixhausen	-	MAHLER, F.	430400 / 304800
11	Salzburg	Aigen	SCHARLINSKI, H.	431700 / 294300
12	Nußdorf	St.Pankraz	SCHARLINSKI, H.	424300 / 310350
13	Strobl	Blinkingmoos	MÖLLER, J.	460250 / 286500
14	Salzburg	Schallmoos	SCHÜLLER, L.	429750 / 297200
15	Bergheim	Lengfelden	SCHÜLLER, L.	428600 / 300200
16	Köstendorf	Zeller Moor	SCHÜLLER, L.	438300 / 309700
17	Bergheim	Hochgitzten	SCHÜLLER, L.	428250 / 302000
18	Salzburg	Josefiau	SPERLING	430650 / 293600
19	Wals-Siezenheim	Untersberger Moor	SCHÜLLER, L.	423500 / 291200
20	Salzburg	Kasern	SCHÜLLER, L.	429500 / 299450
21	Hallein	-	MAHLER, F.	432100 / 282000
22	Salzburg	Itzling	SCHÜLLER, L.	499500 / 299100
23	Koppl	Winkl	SCHÖBERL, S.	436551 / 295732
24	Elixhausen	Moosham	ARNOLD, C.	428826 / 303412
25	Elsbethen	Zieglau	THOMASSER, H.	431148 / 290327
26	Anthering	Würmassing	ARNOLD, C.	427526 / 306037
27	Wals-Siezenheim	Walser Wiesen	PATZNER, A.-M.	423500 / 291200
28	Salzburg	Kleingmain	MAHLER, F.	430200 / 293800
29	Eugendorf	Pabenwang	PATZNER, A.-M.	435750 / 299500
30	Seekirchen	Mayerlehen	PATZNER, A.-M.	432100 / 305750
31	Berndorf	Schwandtl	Inst. of Ecology	428526 / 316207
32	Seekirchen	Unterhaging	Inst. of Ecology	436346 / 304352
33	Koppl	Koppler Moor	STÜBER, E.	436187 / 296910
34	Hallein	Gamp	HÖPFLINGER, R.	433700 / 281450
35	Golling	Rabenstein	SCHWEIGER, M.	437888 / 273334
36	Salzburg	Leopoldskron	SCHWEIGER, M.	427800 / 293855
37	Lamprechtshausen	Loipferding	BERGTHALER, G.	420071 / 313927
38	Hallein	Au	KYEK, M.	429839 / 285883
39	Salzburg	Josef Thorak Str.	KYEK, M.	431150 / 294750
40	Salzburg	Gänsbrunnstr.	KYEK, M.	431550 / 295000
41	Salzburg	Sam	BERGTHALER, G.	430250 / 297900
42	Anthering	Antheringer Au	Inst. of Ecology	425100 / 304600
43	Hallwang	Berg	ANZBÖCK, T.	430786 / 300480
44	Koppl	Gaisbergstrasse.	KYEK, M.	433000 / 297800
45	Großgmain	Kohlgraben, L 114	KYEK, M.	420000 / 289750
46	Hallwang	Esch-Mayrwies	KYEK, M.	431750 / 299260
47	Bergheim	Gagham	PREM, G.	428410 / 299500
48	Abtenau	Erlfeld	MALETZKY, A.	450020 / 270980
49	Puch	Gols	THOMASSER, H.	431916 / 289567
50	Nußdorf	Fürweg West	MALETZKY, A.	422900 / 307609
51	Koppl	Willischwandt	ACHLEITNER, S.	437336 / 296877
52	Puch	Urstein Au	Inst. of Ecology	431350 / 288790

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Table 1 (continued from opposite page): Record localities of *Triturus cristatus* superspecies in the province of Salzburg, unconfirmed after 2003. Coordinates following the Austrian national grid for Central Austria (BMN: MGI M31); habitat: a - aquatic, t - terrestrial, f - drift fence, ? - unknown.

Tab. 1 (Fortsetzung der gegenüberliegenden Seite): Zusammenstellung von seit 2004 unbestätigten Kammolch-Fundorten in Salzburg. Koordinaten nach dem Österreichischen Bundesmeldenetz (BMN: MGI M31); Habitat: a - aquatisch, t - terrestrisch, f - Amphibienschutzzaun, ? - unbekannt.

#	Altitude (m a.s.l.) Seehöhe (m ü. M)	Last observ. (year) Jahr der letzten Beobachtung	Data source Datenquelle	Nr. of observ. Anzahl Beobachtungen	Habitat
1	424	1923	WOLTERSTORFF (1925)	1	?
2	560	1926	Collection L. SCHÜLLER	1	?
3	430	1928	FREYTAG (1978)	1	?
4	435	1928	FREYTAG (1978)	1	?
5	515	1929	FREYTAG (1978)	1	?
6	408	1929	FREYTAG (1978)	1	?
7	434	1929	FREYTAG (1978)	1	?
8	417	1929	FREYTAG (1978)	1	?
9	441	1929	FREYTAG (1978)	1	?
10	579	1929	FREYTAG (1978)	1	?
11	436	1929	SCHARLINSKI (1939)	1	?
12	497	1931	SCHARLINSKI (1939)	1	?
13	560	1949	Collection L. SCHÜLLER	1	a
14	430	1949	Collection L. SCHÜLLER	1	a
15	432	1950	Collection L. SCHÜLLER	2	a
16	510	1950	Collection L. SCHÜLLER	1	a
17	500	1952	Collection L. SCHÜLLER	1	t
18	424	1953	Collection L. SCHÜLLER	2	a
19	445	1954	Collection L. SCHÜLLER	3	a
20	440	1955	Collection L. SCHÜLLER	3	a
21	450	1956	FREYTAG (1978)	1	?
22	450	1957	Collection L. SCHÜLLER	7	a
23	720	1977	Biodiv. Database Salzburg	3	a
24	550	1977	Biodiv. Database Salzburg	1	a
25	430	1980	Biodiv. Database Salzburg	1	a
26	526	1981	NHMW Database	2	a
27	440	1981	NHMW Database	2	a
28	430	1981	FREYTAG (1978)	2	?
29	730	1981	Biodiv. Database Salzburg	1	a
30	565	1982	Biodiv. Database Salzburg	1	a
31	593	1983	NHMW Database	1	a
32	570	1984	NHMW Database	2	a
33	759	1984	NHMW Database	5	a
34	447	1989	Biodiv. Database Salzburg	1	a
35	479	1990	Biodiv. Database Salzburg	1	a
36	431	1992	KYEK et al. (1993)	1	a
37	437	1992	KYEK et al. (1993)	1	a
38	440	1992	KYEK et al. (1993)	1	a
39	425	1993	KYEK et al. (1993)	1	t
40	436	1993	KYEK et al. (1993)	1	a
41	430	1993	KYEK et al. (1993)	1	a
42	408	1994	LIEB & WERNER (1995)	3	a
43	530	1995	Biodiv. Database Salzburg	1	a
44	630	1996	KYEK (2005)	1	f
45	480	1996	KYEK (2005)	1	f
46	479	1997	Biodiv. Database Salzburg	1	a
47	460	1999	Biodiv. Database Salzburg	2	a
48	731	1999	Biodiv. Database Salzburg	1	a
49	478	2002	Biodiv. Database Salzburg	1	t
50	405	2003	Biodiv. Database Salzburg	1	a
51	715	2003	Biodiv. Database Salzburg	1	a
52	430	2003	KYEK et al. (2007)	2	t

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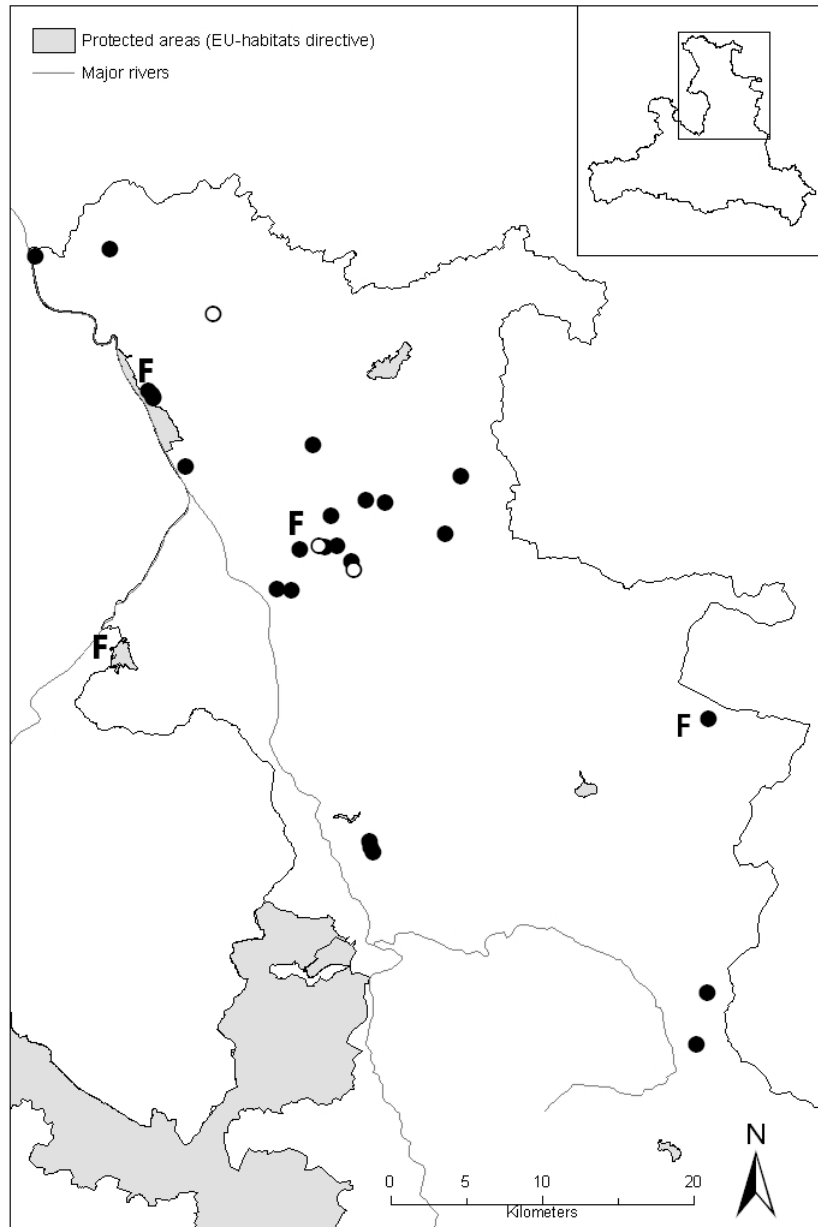


Fig. 2: Habitat types at the current (2004-2006) crested newt record localities in the province of Salzburg; records from ○ - terrestrial habitat, ● - aquatic habitat, F - drift fences.

Abb. 2: Lebensraumtypen an den aktuellen (2004-2006) Kammolchfundorten im Bundesland Salzburg; Funde im/am ○ - terrestrischen Lebensraum, ● - aquatischen Lebensraum, F - Amphibienschutzzaun.



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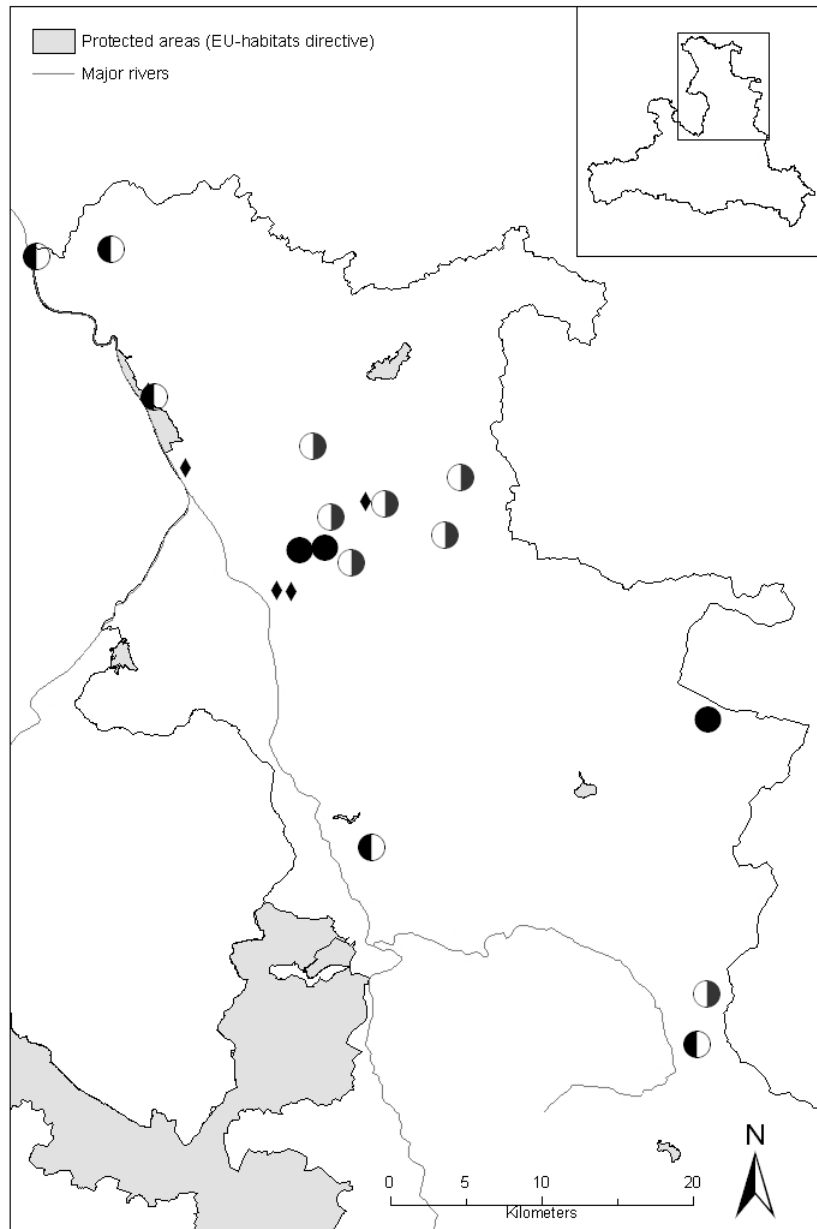


Fig. 3: Current distribution of *Triturus cristatus* and *T. carnifex* in the province of Salzburg according to molecular data, modified from MALETZKY et al. (in press); ● - *T. carnifex*, right half filled - *T. carnifex*-like admixed populations, left half filled - *T. cristatus*-like admixed populations, ◆ - no molecular data available.

Abb. 3: Aktuelle Verbreitung von *Triturus cristatus* und *T. carnifex* im Bundesland Salzburg unter Berücksichtigung molekularbiologischer Untersuchungen, verändert nach MALETZKY et al. (in Druck); ● - *T. carnifex*, rechte Hälfte schwarz - Mischpopulation, mehrheitlich *T. carnifex*, linke Hälfte schwarz - Mischpopulation, mehrheitlich *T. cristatus*, ◆ - keine genetischen Daten vorhanden.

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Table 2: Recently (2004-2006) confirmed record localities of *T. cristatus* superspecies in the province of Salzburg. Coordinates following the Austrian national grid for Central Austria (BMN: MGI M31); habitat: a - aquatic, t - terrestrial, f - drift fence.

Tab. 2: Zusammenstellung aktueller Kammolch-Fundorte aus dem Bundesland Salzburg zwischen 2004 und 2006. Koordinaten nach dem Österreichischen Bundesmeldenetz (BMN: MGI M31); Habitat: a - aquatisch, t - terrestrisch, f - Amphibienschutzzaun.

#	Community Gemeinde	Locality Name Fundortname	First observation by Erstbeobachtung durch	Coordinates (x, y) Koordinaten
1	Eugendorf	Sommeregg	PATZNER, A.M.	434865 / 299907
2	Seekirchen	Ried	Inst. of Ecology	433696 / 304582
3	St. Georgen	Irlacher Au	PATZNER, A.M.	415330 / 317030
4	Thalgau	Achleiten	TEUFL, H.	442400 / 298750
5	Annaberg	Scheffer	KLEPSCH, L.	459000 / 265000
6	Kuchl	Freimoos	KYEK, M.	437453 / 277996
7	Nußdorf	Fürwag LB 156	KYEK, M.	423000 / 308000
8	Koppl	Guggenthal	KYEK, M.	432830 / 297700
9	Nußdorf	Fürwag, MM1	SOMMER, R.	423094 / 307755
10	Nußdorf	Fürwag, MM2	SOMMER, R.	423110 / 307700
11	Abtenau	Ameisensee	KYEK, M.	459760 / 268340
12	Thalgau	Zecherl	KYEK, M.	443420 / 302550
13	Bürmoos	Zehmoos	KAISER, R.	420220 / 317565
14	Koppl	Guggenthal LB 158	KYEK, M.	432940 / 297950
15	Koppl	Steinbruch	MALETZKY, A.	434451 / 297812
16	Kuchl	Doser	KYEK, M.	437660 / 277640
17	Eugendorf	Neuhofen	ARMING, C.	438461 / 300787
18	Großgmain	Hinterreit L 114	KYEK, M.	419350 / 288200
19	Nußdorf	Fürwag-Auersperg	MALETZKY, A.	423070 / 307920
20	Nußdorf	Haßberg	MALETZKY, A.	427056 / 313232
21	Strobl	Nestner LB 158	PULIDO, C.	458880 / 286070
22	Bergheim	Siggerwiesen A	WEIBMAIR, W.	425285 / 303191
23	Bergheim	Siggerwiesen B	WEIBMAIR, W.	425273 / 303275
24	Eugendorf	Reitberg-Burgstall	MALETZKY, A.	437138 / 300923
25	Koppl	Flugfeld	MALETZKY, A.	436187 / 296910
26	Koppl	Koppler Moor	MALETZKY, A.	436356 / 296302
27	Kuchl	Modermühl	MALETZKY, A.	437451 / 278417
28	Salzburg	Stöcker	MALETZKY, A.	432216 / 294952
29	Strobl	Marienhof	MALETZKY, A.	459816 / 286472
30	Koppl	Unterkoppl	MALETZKY, A.	435260 / 297947
31	Koppl	Gniglerbauern	MALETZKY, A.	434116 / 297937
32	Nußdorf	Pabing	RIEDER, W.	422783 / 308159
33	Salzburg	Aigen, Kastner	KYEK, M.	431318 / 295037

surrounding areas further north and east. Only one historical record ("Wenger Moor", 1950) refers to a current Natura 2000 site.

Between 2004 and 2006 we documented 127 observations from 33 localities. The number of observations per locality ranged between one and eight (mean = 3.85). 17 of these represented new record localities for crested newts. In 26 localities newts were found in aquatic habitats, three localities concerned single subadult individuals in terrestrial habitats and four localities represented individuals captured at drift fences during breeding migration (Table 2, Figs. 1 and 2).

The current situation can be described as follows: there is one larger contiguously populated area in the Flysch region east of the City of Salzburg, while populations appear scattered and geographically isolated in the rest of the study area (Figs. 1 and 2).

According to molecular data from 15 populations, the largest part of the province of Salzburg can be regarded as contact zone between two closely related crested newt species (see also MALETZKY et al. in press). In 12 out of 15 genetically surveyed populations, genotype characteristics from both species were detected (Fig. 3). *Triturus cristatus*-like populations were found along the Salzach river and *T. carnifex*-like popu-

## Inventory, population size and conservation status of crested newts

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Table 2 (continued from opposite page): Recently (2004-2006) confirmed record localities of *T. cristatus* superspecies in the province of Salzburg. Coordinates following the Austrian national grid for Central Austria (BMN: MGI M31); habitat: a - aquatic, t - terrestrial, f - drift fence.

Tab. 2 (Fortsetzung der gegenüberliegenden Seite): Zusammenstellung aktueller Kammolch-Fundorte aus dem Bundesland Salzburg zwischen 2004 und 2006. Koordinaten nach dem Österreichischen Bundesmeldenetz (BMN: MGI M31); Habitat: a - aquatisch, t - terrestrisch, f - Amphibienschutzzaun.

#	Altitude (m a.s.l.) Seehöhe (m.ü. M.)	First and last years of observation Jahre der ersten und letzten Beobachtung		Data source Datenquelle	Nr. of observ. Anzahl Beobachtungen	Habitat
1	812	1981	2006	NHMW database	8	a
2	526	1981	2005	NHMW database	6	a
3	382	1981	2006	KYEK et al. (1993)	7	a
4	720	1984	2005	NHMW database	6	a
5	934	1992	2005	KLEPSCH (1994)	4	a
6	467	1992	2005	KYEK et al. (1993)	3	a
7	400	1992	2006	KYEK (2005)	6	f
8	626	1996	2006	KYEK (2005)	6	a
9	415	1996	2006	SOMMER (1998)	8	a
10	415	1996	2006	SOMMER (1998)	5	a
11	1282	1998	2006	Biodiv. Database Sbg.	7	a
12	750	1999	2005	KYEK (2001)	8	a
13	437	2001	2006	Biodiv. Database Sbg.	7	a
14	610	2001	2006	KYEK (2005)	3	f
15	701	2003	2006	Biodiv. Database Sbg.	4	a
16	470	2003	2005	KYEK et al. (2007)	3	a
17	645	2004	2006	MALETZKY et al. (2007)	8	a
18	550	2004	2004	KYEK (2005)	1	f
19	420	2004	2006	MALETZKY et al. (2007)	4	a
20	669	2004	2004	-	1	t
21	556	2004	2004	KYEK (2005)	1	f
22	403	2005	2006	WEISSMAIR (2005)	5	a
23	403	2005	2006	WEISSMAIR (2005)	2	a
24	701	2005	2005	MALETZKY et al. (2007)	3	a
25	763	2005	2005	MALETZKY et al. (2007)	1	a
26	760	2005	2005	-	1	t
27	470	2005	2005	MALETZKY et al. (2007)	1	a
28	562	2005	2005	MALETZKY et al. (2007)	1	a
29	539	2005	2005	MALETZKY et al. (2007)	3	a
30	675	2006	2006	MALETZKY et al. (2007)	1	a
31	675	2006	2006	-	1	t
32	397	2006	2006	-	3	a
33	430	2006	2006	-	1	a

lations in the Flysch-zone east of the City of Salzburg. Three genetically unadmixed populations of *T. carnifex* (Strobl, Guggenthal and Unterkoppl) were detected, two of which are located in close vicinity to admixed populations (Fig. 3).

In none of Salzburg's Natura 2000 sites, designated according the EU-Habitats Directive, crested newts were observed. While some *T. cristatus*-like populations are located in close vicinity of protected areas, *T. carnifex* is presently not included in the Natura 2000-network of Salzburg at all.

The vertical distribution of *Triturus cristatus* superspecies in Salzburg ranges between 382 m a.s.l. (Irlacher Au) and 1.282

m a.s.l. (Ameisensee) (Fig. 4). Comparing the mean altitude of all localities recorded between 1923 and 2003 ( $n = 70$ , median = 462 m, mean $\pm$ SD = 524.1 $\pm$ 150.0 m) with the mean altitude of recent records from 2004-2006 ( $n = 33$ , median = 556 m, mean $\pm$ SD = 593.3 $\pm$ 191.8 m), a trend to higher elevations may be assumed (Fig. 4). Still, the difference between these two groups is not statistically significant (Mann-Whitney U:  $T = 1933$ ,  $P = 0.126$ ).

#### Population size estimates

The estimated population sizes ranged between 32 and 101 individuals. Four pop-

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Table 3: Size estimates and 95 % confidence intervals (C. I.) for nine populations of crested newt in the province of Salzburg, plus data from three localities recorded in previous studies: \* - MALETZKY et al. (2004), \*\* - SOMMER (1998).

Tab.3: Populationsgrößen-schätzungen und 95 % Konfidenzintervalle für neun Populationen im Bundesland Salzburg, sowie Daten von drei weiteren Populationen, die in früheren Studien erhoben wurden: \* - MALETZKY et al. (2004), \*\* - SOMMER (1998).

Locality Name Fundortname	Nr. of Individuals Anzahl Individuen	95 % C. I. 95 % Konfidenz- intervall	Capture 1 Fang 1	Capture 2 Fang 2	Recaptures Wiederfänge	Year Jahr
Guggenthal	101	31-193	11	16	1	2006
Irlach	43	13-83	7	10	1	2006
Strobl	32	12-72	8	10	2	2006
Neuhofen	76	23-145	16	8	1	2006
Pabing	47	18-105	11	11	2	2006
Ried	93	29-177	16	10	1	2005
Sommereg	52	20-117	9	15	2	2005
Zeherl	33	13-76	12	7	2	2005
Zehmemoos	79	36-166	21	17	4	2005
Ameisensee *	805 / 327	353-1772 / 165-634	61 / 55	51 / 40	3 / 6	2000 / 01
Fürwag MM1 **	78 / 89	-	-	-	-	1996 / 97
Fürwag MM2 **	22 / 36	-	-	-	-	1996 / 97

ulations showed less than 50 individuals, four ranged between 51 and 100 and only one ("Guggenthal") was larger than 100 individuals according to our estimation. However, the number of captures (range 7-21) and recaptures (range 1-4) was low producing wide 95 % confidence intervals (Table 3, Fig. 5).

#### Conservation status

Presently only one out of 12 evaluated crested newt populations ("Ameisensee") in the province of Salzburg turned out to be in "favorable conservation status" ("A"). In

five cases the conservation status was rated inadequate ("B"), five populations had to be characterized as in bad status ("C"). The conservation status of populations estimated at less than 100 individuals but with wide confidence interval was rated as "B". Population size was still crucial for a negative evaluation in many cases. While the aquatic habitat indicators mainly accounted for status "A" and "B" (except Zeherl and Zehmemoos), terrestrial habitat indicators were rated inadequate or bad in most cases. Only three populations showed a favorable result when pooling terrestrial and aquatic habitats (Table 4, Fig. 5).

## DISCUSSION

### Crested newt inventory

We present the first inventory of observation records for crested newts in the province of Salzburg. It may be incomplete for various comprehensible reasons and calls for additional information to be supplied by further studies and the well-disposed reader. Despite prevalent concern about publishing precise localities which may support illegal capture, we chose this form of presentation, as this will substantially facilitate future studies (e.g. monitoring).

The current distribution pattern of crested newts in Salzburg and the results from molecular studies on 15 populations (MALETZKY et al. in press) show good agreement with earlier considerations of semi-species "*in statu nascendi*" (e.g. MAYER 2001). As the largest part of the province of Salzburg appears to be a contact zone and formerly extensive hybrid zone, populated by variably admixed populations, we propose to apply the name "*Triturus cristatus* superspecies" to the crested newt taxon in this contact zone for the future, as implemented in KYEK & MALETZKY (2006).

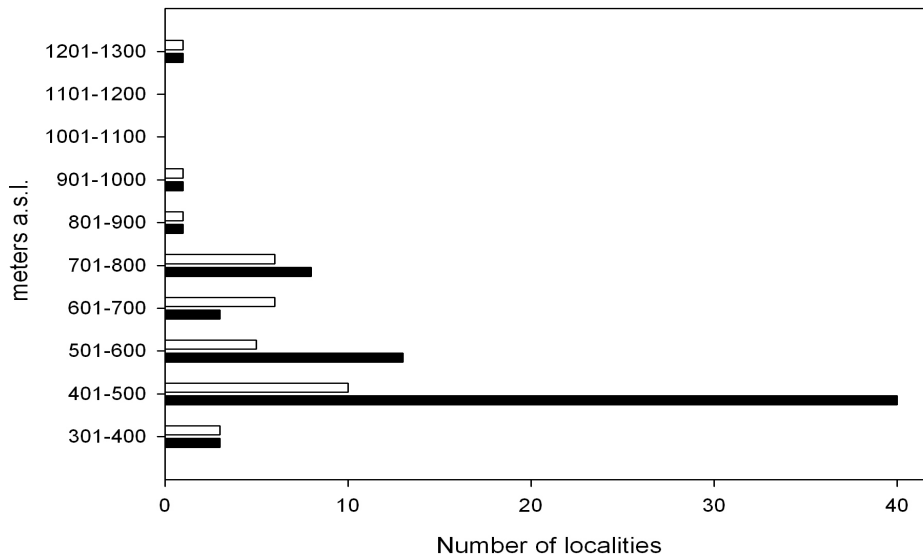


Fig. 4: Vertical distribution of crested newts (*Triturus cristatus* superspecies) in the province of Salzburg displayed in 100 m classes; empty bars - all record localities from before 2004 (n = 70), filled bars - all record localities from between 2004 and 2006 (n = 33).

Abb. 4: Vertikalverbreitung der Kammolche (*Triturus cristatus* superspecies) im Bundesland Salzburg in Intervallen von 100 Metern; leere Balken - alle vor 2004 dokumentierten Fundorte (n = 70), schwarze Balken - alle zwischen 2004 und 2006 dokumentierten Fundorte (n = 33).

Our data substantiated a remarkable shrinkage of the distribution area of *Triturus cristatus* superspecies in the province of Salzburg which led to the classification “critically endangered” in the current regional red list (KYEK & MALETZKY 2006). Most crested newt populations have disappeared from their former Salzburgian distribution centre in the basin areas surrounding the City of Salzburg. The ever-growing pressure on natural habitats within the main human settlement area of Salzburg, combined with the specific requirements of the crested newt expose its populations to a high risk of progressive local extinction. Bearing in mind the current situation of the Adder *Vipera berus* (LINNAEUS, 1758), which to the best of our knowledge has become functionally extinct in the lowlands of Salzburg (with only two recently confirmed records below 800 m altitude - KYEK & MALETZKY 2006), one might expect a comparable scenario for crested newts. There is, however, an important difference between these two cases in that *V. berus* is

still not rare in high altitude regions, while crested newts barely inhabit localities above 1000 m altitude in Austria (e.g. CABELA & GRILLITSCH 2001; MALETZKY et al. 2004). They literally appear to be stuck “between a rock and a hard place” with most localities showing strong geographical isolation. Tendencies of genetic isolation were already detected in most populations (MALETZKY et al. unpublished data).

#### Population sizes

The assessment of population size should be carried out with appropriate precision and standardised methods, simultaneously with or subsequent to mapping procedures. In most previous surveys and reports heterogeneously collected presence-absence data were considered sufficient, while quantitative approaches like mark-recapture methods were rejected as too time consuming and costly. As a consequence, sufficient data on population sizes of crested newts are missing for most areas and all species

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Table 4: Evaluation matrix of the conservation status of 12 crested newt populations in Salzburg following SCHEDL (2005): A - favorable, B - inadequate, C - bad.  
 Tab. 4: Matrix zur Evaluierung des Erhaltungszustandes bei 12 Kammolch-Populationen in Salzburg nach SCHEDL (2005): A - günstig, B - inadäquat, C - schlecht.

Locality Fundort	Habitat indicators / Lebensraumindikatoren											
	Population indicators Populationsindikatoren			Aquatic habitat aquatischer Lebensraum			Terrestrial habitat terrestrischer Lebensraum			Habitats Lebensräume		
	Size Größe	Structure Struktur	Total	Structure Struktur	Vicinity Nähe	Fish presence Fischvorkommen	Total	Structure Struktur	Road impact Straßenverkehr	Total	Total	Con- serva- tion status
Ameisensee	A	A	A	A	A	A	A	A	A	A	A	A
Fürwag MM1 & MM2	B	A	B	A	B	B	A	C	B	B	B	B
Guggenthal	C	B	C	A	A	A	A	A	A	A	A	C
Irlach	C	B	C	A	A	A	B	A	A	A	A	C
Strobl	C	B	C	A	A	A	B	A	A	A	B	C
Neuhofen	B	A	B	B	B	A	B	B	B	C	B	C
Pabing	C	A	C	A	A	A	B	B	C	C	B	C
Ried	B	A	B	A	B	A	A	B	B	C	B	B
Sommeregg	C	A	C	A	A	A	A	A	A	A	A	C
Zeherl	C	B	C	B	C	A	C	B	B	C	C	C
Zehemoos	B	A	B	B	B	A	B	B	B	B	B	B

throughout Austria (SCHEDL 2005). Two long-term studies on population dynamics of crested newts in Austria are currently on hand. The first was carried out with a population of *T. dobrogicus* in Vienna ("Danube-Island") between 1986 and 1995. The total number of individuals fluctuated widely and ranged between 203 and 949 (ELLINGER & JEHL 1997). A second study showed population size estimates and trends for *T. carnifex* from the northern foothills of the Alps in Upper Austria, where a slightly positive development was detected between 1985 and 1999, and the number of observed adults ranged between 1 and 25 per pond (SCHUSTER 2004). Furthermore population size data are available for the Natura 2000 site "Upper Drau" river in Carinthia (K. MICHOR pers. comm.), where the authors estimated between 251 and 500 adult individuals to populate five ponds. Finally *T. cristatus* population of 500-700 individuals from Unterpinswang near Reutte (North Tyrol).

In Salzburg two studies on population ecology of crested newts were carried out in the last decade. SOMMER (1998) enclosed two neighboring ponds in Weitwörth (Flachgau) with drift fences during two years and found a total of 100 and 125 individuals respectively. The high altitude population at the lake "Ameisensee" (Tennengau) is the largest known from Salzburg. In the years 2000 and 2001, the numbers of individuals were estimated at 327 and 805 by mark-recapture studies (MALETZKY et al. 2004).

Our study on nine additional populations in Salzburg was carried out in combination with the assessment of their conservation status. Many if not most surveyed populations consisted of less than 100 adult individuals. In Westphalia and Rhineland-Palatinate (Germany) only 1 % of 496 surveyed populations comprised more than 100 individuals (in THIESMEIER & KUPFER 2000). Population sizes may fluctuate to a certain extent as long term studies have shown (e.g. ELLINGER & JEHL 1997; MEYER et al. 1998). Our results obviously are snap-shots and can only give a notion about size classes. Nevertheless, methods like permanent drift fences and/or PIT-tags, as used in the Danube-Island study (JEHL 1997) are too

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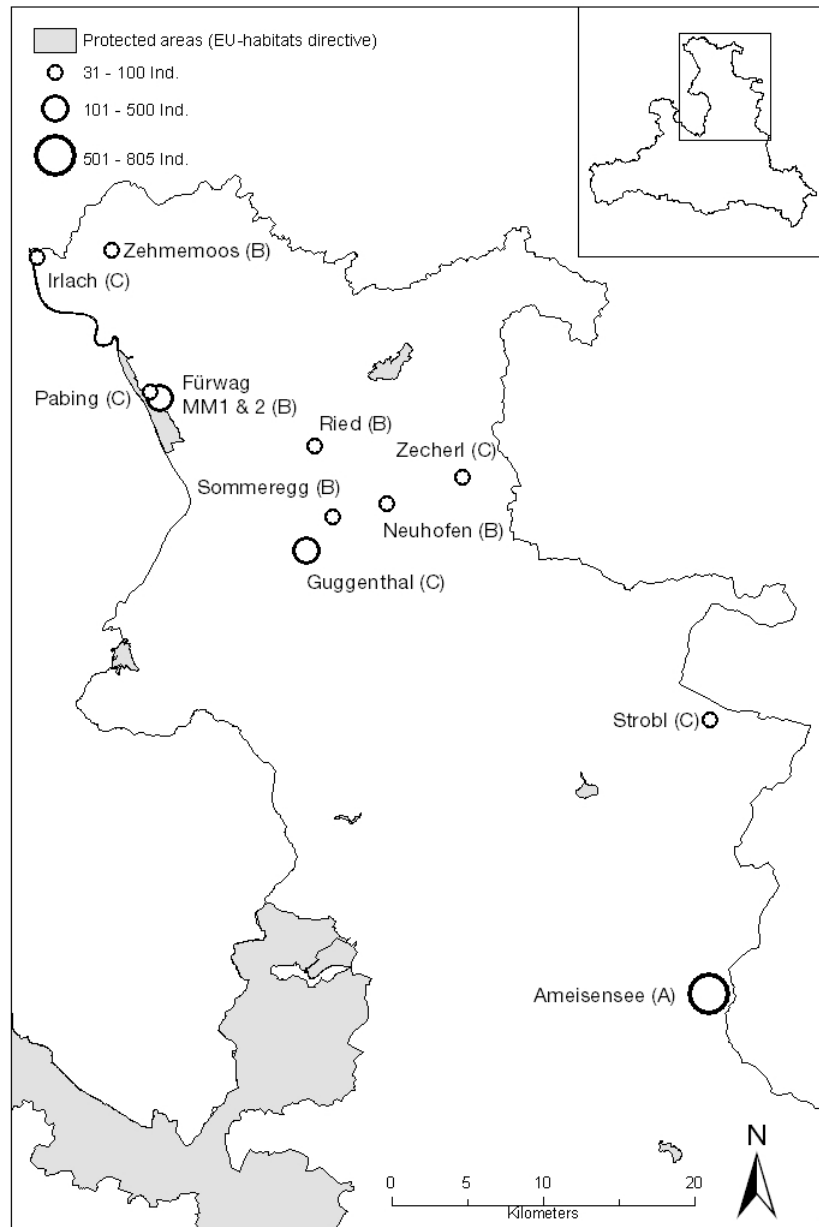


Fig. 5: Estimated population sizes (in three classes) of 12 crested newt populations in the province of Salzburg and their current conservation status (in parentheses) computed following SCHEDL (2005):  
 A - favorable, B - inadequate, C - bad.

Abb. 5: Geschätzte Größen (in drei Klassen) von 12 Kammolch-Populationen im Bundesland Salzburg und deren aktueller Erhaltungszustand (in Klammern) berechnet nach SCHEDL (2005):  
 A - günstig, B - inadäquat, C - schlecht.

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labor-intensive and costly for applied studies, whereas sight counts of adults or egg counts can only be used for presence-absence studies and have little significance for population size estimates (e.g. COOKE 1995). Funnel traps (e.g. ORTMANN et al. 2005) or bottle traps (e.g. BEEBEE 1990) have proved to be equally or more efficient than complex methods. MINTEN & FARTMANN (2001) proposed the use of mark-recapture for population size estimation using funnel traps and individual recognition of belly patterns.

It can be assumed that very large populations like in the lake "Ameisensee" are exceptional cases in the region at the foothills of the Alps. As amphibians with low dispersal ability are assumed to form metapopulations (SMITH & GREEN 2005), low population sizes and local extinctions are natural phenomena as long as dynamic pond networks enable dispersal between and (re-)colonisation of ponds (e.g. GRIFFITHS 1997). Most populations in the province of Salzburg are currently profoundly isolated due to geographical distance and habitat fragmentation. According to population viability analyses by GRIFFITHS & WILLIAMS (2000), extinction risk in such isolated populations steadily declined as population size and carrying capacity of the habitat increased, reaching 27.5 % within 50 years for populations with less than 200 individuals.

#### Conservation status

The aim of the EU-Habitats Directive (following Article 2, Directive 92/43/EEC) is to preserve or re-establish the "favorable conservation status" (FCS) of species listed in Annexes II, IV and V. Presently none of the Natura 2000 sites in the province of Salzburg is explicitly designated for the needs of the amphibian species of Annex II (KYEK & MALETZKY 2006). Crested newts (*Triturus cristatus* superspecies) are subject to explicit protection only in the Natura 2000 site "Salzachauen", where, however, a crested newt population is currently not known to occur. The largest part of this site consists of habitats suboptimal for amphibians due to intensive silvicultural utilisation, low groundwater level and high numbers of wild boars. Nevertheless, some crested newt populations extant in close vicinity to

the protected area, render its re-colonization possible after implementation of specific enhancement measures. Up to now, surveillance of this area was conducted solely on voluntary basis by members of the Herpetological Study Group (KYEK unpublished data). As proposed additional designations of Natura 2000 sites were rejected by authorities within the provincial government, alternative solutions have to be discussed and implemented as soon as possible.

We evaluated most extant populations in the province of Salzburg, following the procedure published by SCHEDL (2005). Eleven out of twelve populations currently show inadequate or bad conservation status. In most cases small population size of less than 100 adult individuals was responsible for the bad conservation status. Only the high altitude population in the lake "Ameisensee" was evaluated as favorable in all categories. Suitable measures for enhancement and protection have already been proposed by SCHABETSBERGER et al. (2004) to maintain this status and partially implemented by the land owners. Still the population is threatened by exploitation due to the weak legal protection of the locality ("landscape conservation area"), and to stochastic events connected with the high degree of isolation and the lack of other suitable breeding ponds in the surrounding area. The locality "Zehme-moos" will most probably reach "favorable conservation status" in the next years due to subsequent implication of habitat enhancement measures. In this EU bird-protection area colonization of newly created and enhanced ponds was already observed but these data were not yet published (T. HERMANN pers. comm.).

We consider the evaluation matrix of SCHEDL (2005) useful in its current form. The biggest advantage is the standardized procedure which facilitates objective results and allows comparability. Still, high quality data are needed for its application as most surveys only provide presence-absence results which are insufficient for the evaluation of population structure or trends.

#### Implications, future studies and measures

As the quality of the existing data is heterogeneous, they cannot be used for



upcoming standardised evaluations of population trends. The next years will bring about the necessity of monitoring procedures as demanded in the Habitats Directive (Article 11). For this challenge minimum standards for additional data acquisition in poorly surveyed areas and standardised monitoring procedures are urgently needed. For crested newts methods for presence-absence surveys with high detection probability are proposed in MALETZKY et al. (2007). Regarding monitoring standards the Field Herpetologist Working Group of the Austrian Herpetological Society (ÖGH) prepared a publication on this item (GOLLMANN et al. 2007) in which the use of identical procedures is suggested for all three crested newt species. Within a six-year period each locality should be moni-

tored twice (i.e. every three years). Each assessment should include three visits between March and July. The presence of adults should be detected via night counts and/or using funnel or bottle traps. The presence of larvae should be evaluated by standardised dip-netting combining area and time intervals. We consider the assessment of population trends an unconditional element of the monitoring of Appendix II species. This can be achieved with comparatively little effort using simple mark-recapture models using ventral pattern recognition (e.g. HAGSTRÖM 1973). Populations at the edge of the distribution area, fragmented populations and areas with sympatric occurrence of two or three crested newt species should be treated with special intensity.

#### ACKNOWLEDGMENTS

We would like to thank the Federal Government of Salzburg for funding and especially M. JERABEK for cooperation. E. STÜBER and A. CABELA from the Natural History Museums of Salzburg and Vienna gave permission to study historical collections and supplied data. H. SCHEDL (Vienna) provided valuable comments on the use of bottle traps. Thanks also to all active members of the Herpetological Study Group Salzburg, D. & S. ACHLEITNER (Mattsee), C. ARMING (Seekirchen), M. BACHLER (Innsbruck), R. MYSLIWIETZ (Bad

Ischl), G. NOWOTNY (Grödig), R. PÖCKL (Salzburg), R. & W. RIEDER (Großmain) and the SCHARINGER family (Bürmoos) provided observation data and helped in the field. H. ACKERL, T. EBERL, R. FUCHS and R. KAISER from the University of Salzburg contributed to the graphical design and F. WEBSTER gave valuable comments on style and language. The permission for capture of protected amphibian species was granted by the Federal Government of Salzburg (Nr. 21301-RI-548/9-2003).

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DATE OF SUBMISSION: July 16, 2007

Corresponding editor: Heinz Grillitsch

AUTHORS: Andreas MALETZKY, Alfred GOLDSCHMID, University of Salzburg, Department of Organismic Biology, Hellbrunnerstraße 34, A-5020 Salzburg, Austria; Martin KYEK, Institute of Ecology, Haus der Natur, Johann Herbst Strasse 23, A-5061 Elsbethen, Austria