

ORIGINAL PAPER

Newt decline in Western Europe: highlights from relative distribution changes within guilds

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Abstract

The recent increase in the number of monitoring schemes has formed the basis for high quality distribution atlases. This provides the opportunity of estimating global and specific decline patterns across regional and national borders. In this framework, this study focused on four sympatric newt species—including the great crested newt (*Triturus cristatus*), an Annex 2 European Habitats Directive species, over six geographic areas (five countries) in Western Europe. A relative comparison of distribution maps across time is used here and is based on more than twelve thousands occupied grid cells. It benefits from the definition of a guild, as these species are simultaneously detectable in wetlands. *T. cristatus* and the alpine newt (*Mesotriton alpestris*) were the most and the least threatened newt species, respectively, whereas the palmate (*Lissotriton helveticus*) and smooth newt (*Lissotriton vulgaris*) had an intermediate decline level at both coarse and fine grain resolutions. However, regional variations across Europe and scale effects were also found. On one hand, these results show that *T. cristatus* is not only regionally threatened but suffers from a global decline in Western Europe. On another hand, the results indicate that patterns of decline are not uniform within Europe and that species often considered as common and not threatened are, in fact, declining more than others. Finally, the proposed methodology, i.e. using guilds to assess relative decline, would be useful as a complement to other standardized methods in correctly advising conservation managers and policy makers, particularly for species with more subtle declines.

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Introduction

The distribution and conservation of amphibians has generated particular interest in the last few decades, culminating with world assessments which have revealed that more than 30 % of species are experiencing population decrease (Stuart et al. 2004). Among amphibians, newts and salamanders (Caudata) are the most endangered, with 47 % of threatened species occurring within this group (Stuart et al. 2008). In Europe, the reported extent of declines is different, particularly for pond-breeding newts. Most species have a least concern International Union for the Conservation of Nature (IUCN) global status (Stuart et al. 2008) but they also show decline over parts of their range. This is particularly the case for the great crested newt (*Triturus cristatus*), a flagship species at the European Union level, and one of the rare amphibians to be specially protected under the Habitats Directive (Edgar and Bird 2005; Jehle et al. 2011). Both monitoring programs (Maletzky et al. 2007) and regional assessments (e.g. Jacob 2007; Meyer et al. 2009) showed significant population decreases, causing

this species to be listed in several regional red lists as endangered. All the newt species that are sympatric with the great crested newt have usually a lower protection level and because of their relative commonness and least concern status, they often receive less attention in terms of conservation. However, some of them, such as the smooth newt (*Lissotriton vulgaris*), are already considered to be regionally threatened (Meyer et al. 2009) and monitoring programs have also flagged up local declines in the palmate (*Lissotriton helveticus*) and the alpine newts (*Mesotriton alpestris*) in Southern Europe (Denoël et al. 2005). In parallel to such assessments, many ecological studies have highlighted risks to populations due to an extensive array of anthropogenic pressures (Joly et al. 2001; Denoël et al. 2009; Rannap et al. 2009a; Hartel et al. 2010b). The main problem arising in relatively common species is that the large number of populations may hide declines (Gaston 2010). Recent studies have confirmed that common amphibian species are also declining (Bonnardi et al. 2011). In the light of these varied previously published reports, there is thus a need for additional overviews of decline patterns in Europe.

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Distribution atlases, i.e. projects that include a spatial mapping component of species occurrence, provide essential tools to monitor global biodiversity changes (Dunn and Weston 2008; Pomeroy et al. 2008; Robertson et al. 2010). Recent initiatives such as Natura 2000 in Europe (Mucher et al. 2009) or the convention on biological diversity (Balmford and Bond 2005) have produced a boost in data acquisition for many species. This has resulted in a higher and more accurate coverage of species distribution and in the dissemination of a plethora of distribution atlases starting to provide high quality maps (Donald and Fuller 1998; Soberon and Peterson 2004; Pomeroy et al. 2008). For instance, in the Netherlands and Switzerland, with respect to the historical herpetological atlases, the most recent editions have expanded their databases by a factor of nine in 20 years on average, with now more than half a million observations for these two countries alone (Creemers and Van delft 2009; Meyer et al. 2009).

When the geographic range of a species has clearly shrunk or become fragmented when comparing historic and recent data bases, then red listing is made easily possible and special attention can be given to the most threatened species (IUCN 2001; Eaton et al. 2005; de Gramont and Cuarón 2006). However, in other cases, the increased sampling efforts may mask actual declines (Quayle and Ramsay 2005). A good way to address such an issue is to carry out long-term field monitoring on a representative fraction of the global population to determine status change (Denoël et al. 2005; Brotons et al. 2007). From this perspective, the large size or commercial interest of some species in particular have allowed the acquisition of good data on a long-term basis (Eaton et al. 2005). However, because of budgetary and time constraints (Naidoo et al. 2006), such data are not available for all species, particularly over the entire range of interest.

When herpetologists collect data, they usually survey habitat types that are inhabited by more than a single species. In amphibians, this is particularly true for newt guilds that share breeding habitat requirements, such as ponds (Joly and Giacoma 1992). As a consequence, they can be detected simultaneously by researchers and volunteers which contribute to the realisation of distribution atlases. Using such volunteer data has proved to be a straightforward way to enable a global overview of decline patterns (Bonardi et al. 2011). From this perspective, the aim of the present study is to use this detection specificity of organisms within a guild to rank them in terms of decline. Particularly, I expected that some species may suffer from hidden declines whereas others could be globally threatened in Western Europe. To this end, I analysed the past and recent distribution of four sympatric European newt species across five different countries for which detailed atlases were available. Because decline at a fine grain resolution could be masked at a coarser grain level (Böhning-Gaese 1997; Koleff and Gaston 2002; Rahbek 2005; Soberon et al. 2007), I analysed patterns at two different grain resolutions at both a regional and supra-regional level.

Methods

I selected four sympatric newt species (until recently classed in the Eurasiatic genus *Triturus*): *T. cristatus*, *L. vulgaris*, *L. helveticus*, and *M. alpestris*. These species are representative of assemblages in Europe where they can occur in syntopy and conform to the definition of guilds in sharing key ecological requi-

rements such as breeding in stagnant water habitats (Joly and Giacoma 1992; Denoël and Ficetola 2008). The four species are distributed sympatrically ranging from France to Germany and from North Sea coast to Switzerland (Gasc et al. 1997).

Over the sympatric range of these four species, six recent distribution atlases share similar characteristics of detailed grid size and historical and recent distribution: Belgium (Wallonia: Jacob et al. 2007, including the historical cartography of Parent 1984), Germany (Baden-Württemberg: Laufer et al. 2007 and Nordrhein-Westfalen: Hachtel et al. 2011), Grand-Duchy of Luxembourg (Proess 2003), Switzerland (Meyer et al. 2009), and the Netherlands (Creemers and Van Delft 2009). The analysis was based on the occurrence of newts in grid squares specific to each atlas. There were only two common features of these atlases, which allowed a similar analysis in each of them. These consisted of differentially marked squares (1) where no recent findings occurred but historical presence was known (hereafter, losses), and (2) where occurrence was found in the latest round of sampling (hereafter, recent data). Disparity between atlases prevents the use of additional metrics. The final dates of collection of historical and recent data were, respectively, 1984 and 2003 in Wallonia (Parent 1984; Jacob et al. 2007), 1989 and 2005 in Baden-Württemberg (Laufer et al. 2007), 1992 and 2010 in Nordrhein-Westfalen (Hachtel et al. 2011), 1996 and 2003 in Grand-Duchy of Luxembourg (Proess 2003), 1994 and 2009 in Switzerland (Meyer et al. 2009), and 1995 and 2007 in the Netherlands (Creemers and Van delft 2009).

To analyze and graphically represent distribution patterns, including losses and recent data, I scanned maps and georeferenced them using at least six control points and first order polynomial regression (QGIS 1.7). A similar projection (WGS 84) was used to insert regional and national maps of the six atlases in a global map of Western-Central Europe. Centroids (i.e., geometric centers) of distribution data were manually mapped as shapefiles and represented as grid cells. The resolution of six distribution atlases enabled work at two different grain resolutions (mean \pm SE): a coarse grain ($9.7 \pm 0.3 \times 9.8 \pm 0.4$ km) and a fine grain ($4.8 \pm 0.2 \times 4.9 \pm 0.2$ km). The coarser grain was used for mapping representation (cf readability and spatial standard at a scale encompassing several countries), using ArcGIS 10. The total number of squares with newt losses and recent data were obtained from an analysis of shapefiles, from counting tools within Adobe Photoshop CS5 and from data presented in the atlases. The two data sets (i.e., losses and recent observations) allowed to computation of a metric of relative distribution change (hereafter, decline index). This was obtained by dividing the number of squares with past but not recent occupancy by the number of occupied squares during the most recent sampling. The index ranged from 0 (no loss) to 100 % (full extirpation from the area concerned). Using this index relatively, i.e. among species that are sampled simultaneously, allowed freedom from the problem of increased of sampling efforts across time because this effort changed with time similarly for each studied species. Atlas data on species such as newts are indeed obtained from sampling in ponds where researchers and volunteers gathered data from all species at once.

I computed Chi-square tests in 4×2 matrices to account for relative differences between the number of grid cells with losses and recent data among the four newt species. Post hoc Chi-square tests were computed in 2×2 matrices to detect differences

between pairs of species with respect to loss and recent data. All tests were computed with Statistica10 (Statsoft-France 2011).

Results

Global patterns

Global distribution patterns (i.e. merging data from the six studied atlases) changed differently across time according to species (coarse grain: $\chi^2 = 209.6$, $df = 3$, $p < 0.0001$; fine grain: $\chi^2 = 390.6$, $df = 3$, $p < 0.0001$) (Fig. 1). At the coarse grain, *T. cristatus* losses (decline index: 26 %) were significantly more numerous than those of three other newt species (*M. alpestris*: 6 %, *L. vulgaris*: 12 %, *L. helveticus*: 11 %; all $\chi^2 > 63.93$, all $p < 0.0001$). *M. alpestris* was significantly less affected than *L. vulgaris* and *L. helveticus* (both $\chi^2 > 22.01$, both $p < 0.0001$). *L. vulgaris* and *L. helveticus* did not significantly differ ($\chi^2 = 0.06$, $p = 0.81$). Similar trends were obtained at the small grain: *T. cristatus* losses (decline index: 39 %) were significantly more numerous than those of the three other newt species (*M. alpestris*: 15 %, *L. vulgaris*: 22 %, *L. helveticus*: 23 %; all Chi-square tests > 118.82 , all $p < 0.0001$). *M. alpestris* was significantly less affected than *L. vulgaris* and *L. helveticus* (both $\chi^2 > 49.27$, both $p < 0.0001$). *L. vulgaris* and *L. helveticus* did not significantly differ ($\chi^2 = 0.87$, $p = 0.35$).

Regional patterns

Looking specifically at each of the six studied European areas at both a coarse and fine grain showed that distribution patterns changed across time differently according to species in each case (all $\chi^2 > 12.83$, all $p < 0.001$, Fig. 2).

At a coarse grain, *T. cristatus* had a higher score on the decline index than all the other species in three out of the six areas: Wallonia and both German regions (Chi-square tests, $df = 1$, all $p < 0.0001$), a higher score than two species in Luxembourg and Switzerland (*M. alpestris* and *L. helveticus*), and than one species in the Netherlands (*L. vulgaris*) (Chi-square tests, Fig. 2). *T. cristatus* never had a lower score than another species. *M. alpestris* had the lowest scores of all species in Wallonia and Baden-Württemberg, but only in comparison to *L. vulgaris* in the Netherlands and to both *T. cristatus* and *L. vulgaris* in Switzerland. *L. vulgaris* differed from *L. helveticus* in the Netherlands, in Baden-Württemberg and in Switzerland only (Fig. 2). Similar results were found at a fine scale, but more significant differences were outlined (Fig. 2): in addition to previously outlined differences, *T. cristatus* also differed from *M. alpestris* in the Netherlands, *L. vulgaris* from *M. alpestris* in the Netherlands, from *L. helveticus* in Nordrhein-Westfalen and from the three other species in Luxembourg, and *L. helveticus* from *M. alpestris* in Switzerland.

Discussion

The quantitative analysis of changes in distribution was able to pinpoint the most threatened newt species and to class the varied species in terms of decline in a large part of their sympatric area in Western Europe. In a broader perspective, the use of species guilds proved to be an effective tool to obtain such quantitative estimates. It had the advantage of getting additional resources from distribution maps in a way independent of changes in

sampling efforts, and thus was particularly suitable for situations in which knowledge of distribution coverage had improved in recent cartographies with respect to the historical ones. Specifically, the present results provided evidence that some species previously considered as non-threatened are, in fact, in decline. Because conservation efforts generally target the most threatened species (Naidoo et al. 2006), accurate rankings are of primary importance to ensure the proper and adequate allocation of conservation resources towards the species that are most at risk and are essential in improving decisions at the policy maker level (Mace et al. 2008; Butchart and Bird 2010).

One of the major problems in determining species status comes from the discrepancies in sampling efforts between historical and recent databases on the distribution of organisms. This is particularly the case for the Natura 2000 program (Mucher et al. 2009), but also relates to the increasing media coverage relating to importance of biodiversity conservation, both having huge increases in national databases, particularly in the European Union. Not only data on priority species, such as the great crested newt have been acquired, but also on their sympatric species (Proess 2003; Edgar and Bird 2005; Jacob et al. 2007; Laufer et al. 2007; Creemers and Van delft 2009; Meyer et al. 2009; Hachtel et al. 2011). The analysis of relative status change between species within guilds carried out in this study has shown that the great crested newt is the most threatened species at a global level in Western Europe. These results are in line with E.U. species ranking within the Habitats Directive, but not with the IUCN global ranking of this species. However, although its decline was never lower than the other sympatric species at a regional level, the great crested newt was in three countries not less threatened than either the palmate or the smooth newt, depending on the country. The studied area was limited to the area of sympatry of the four newt species, but encompassed a large part of Western Europe and five different countries. This thus indicates that a widespread decline is affecting the great crested newt. Other local reports within Europe are in line with these results (e.g. Maletzky et al. 2007) and highlight the need for more integrated analyses all over Europe.

In some areas such as in Wallonia (Belgium), the three smaller newt species were ranked at the same level, i.e. as least concern species (Jacob 2007). In the present study, however, the difference in distribution change between (1) the smooth and palmate newt and (2) the alpine newt was similar to the difference between the former species and the great crested newt. There is thus evidence of a decline in these species. These results suggest that more attention should be given to these species. Field monitoring of specific populations across time is needed to complement data gathered from the analysis of atlases and possibly help in re-assessing them regionally on a more quantitative basis (Denoël et al. 2005; Mattfeldt et al. 2009). On the other hand, ranking is not only a matter of distribution change, but also of population size. In the present case, it is also the most threatened species that has the smallest population (Jacob et al. 2007) but more work should be done on estimating population sizes of the different species in order to possibly fine tune ranking methods.

The effect of grain resolution

The results of this study confirm the opinions of other authors: that the integration of varied resolution scales (i.e., grain resolution) is necessary for

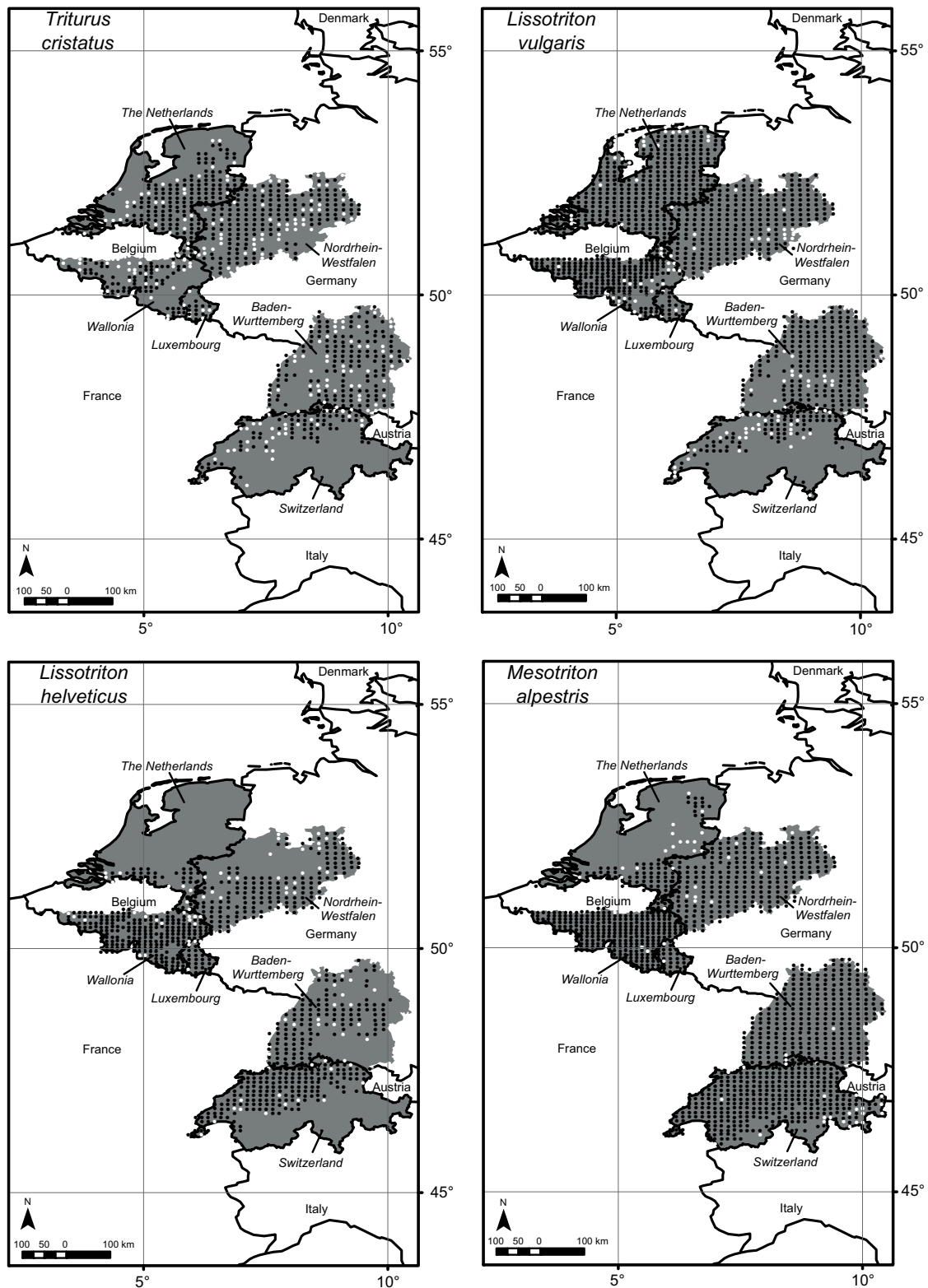


Fig. 1 Historical and recent distribution of four newt species in a large part of their area of sympatry in Western Europe. Italic texts refer to the six atlases, plain font to the countries. Circles represent grid cells of ca. 100 km². Open circles historical data only, closed circles recent observations. Maps were rebuilds on the basis of data extracted from detailed distribution maps published in three regional (Hachtel et al. 2011; Jacob et al. 2007; Laufer et al. 2007) and three national (Creemers and Van delft 2009; Meyer et al. 2009; Proess 2003) atlases

diversity metrics (Böhning-Gaese 1997; Koleff and Gaston 2002; Rahbek 2005; Soberon et al. 2007). I have shown that the resolution of atlases can affect the interpretation of apparent changes in the distribution of species across a landscape. At a global level, i.e. supra-regional and national, both the fine and coarse grains proved valuable, giving similar results, whereas at the level of regional atlases,

more significant differences were depicted at the finer than at the coarser grain. On the one hand, this shows that future broad scale atlases at a scale grid of about 100 km² would prove useful to depict global change. On another hand, this indicates that regional analyses need a finer resolution to detect more subtle and localized declines. As the coarse grain used in the present study was four times less

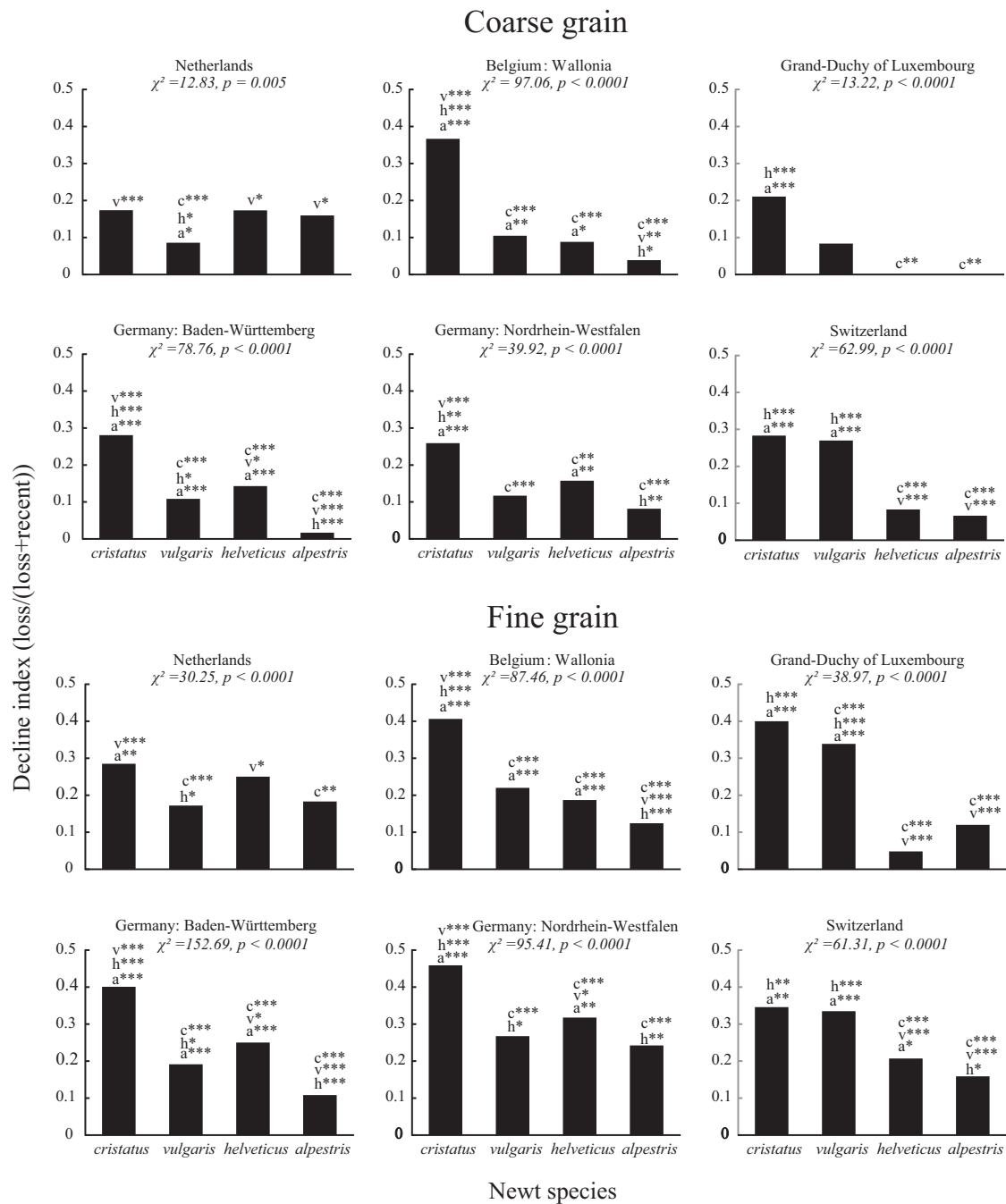


Fig. 2 Decline index [loss/(loss + recent)] atlas squares] in four sympatric newt species in six European areas (five countries) at two grain resolution: coarse (ca. 100 km²) and fine (ca. 25 km²). χ^2 are calculated in 2 × 4 matrices. Significant pairwise comparisons ($p < 0.05$) are indicated by the abbreviations of species names above the bars. c *T. cristatus*, v *L. vulgaris*, h *L. helveticus*, a *M. alpestris*

detailed than the finer grain, this indicates that declines may involve four times more local cases of extirpation before to be identified as losses in atlases publishing data at a coarser grain only. Such results highlights that both fine grain resolution (Rahbek 2005) and field assessment (Brotons et al. 2007) remain necessarily to look at a very fine scale such as the scale of the home range to identify population losses and to link such specific results to more global patterns, such as those presented here.

Fortunately, the trend for new atlases is towards using very large data sets and publishing detailed maps. This was the case in the six atlases used in this study, for which applying a new metric helped

increase the usefulness of the existing data. However, for the sake of clarity of illustrations, large countries often present maps at a coarse grain scale, which could make it more difficult to detect declines. Indeed, the smaller the scale, the more ponds are present within each grid cell and the more time is needed to detect local extirpations. While these data are useful (Böhning-Gaese 1997), they are most pertinent for highly threatened species that are disappearing at a broad scale level (Redford et al. 2003). The finest grain, i.e. 19 km² on average used in this study, was efficient enough to depict differences between species. Taken separately, this would mainly require action at a regional scale

but if such data are available at broader scales, it would be possible to identify priority areas in which conservation actions could be launched (Naidoo et al. 2006). This idea connects with the identification of hotspots where smaller geographic areas are delineated to protect threatened species (Mittermeier et al. 2004; Cadotte and Davies 2010; Amori et al. 2011).

Directions for broad-scale integrated ecological research

It was not the aim of this study to identify the causes of the observed decline but to underline its generalities and specificities. In this way, this provides a basis for research on the causes of generalized decline, such as that of the great crested newt or more hidden ones such as those of the smooth and palmate newts in some parts of their range. These observations flag the need for global action plans throughout Europe. Previous research suggests that multiple mechanisms could be at the basis of newt decline in Europe but that both similar and different mechanisms could act on newts depending on European areas. The similar decline patterns found here across countries, such as for the great crested newts, suggest common causes or a high sensitivity for this species to varied causes that could occur over its distribution range (see also the action plan for the great crested newt: Edgar and Bird 2005). In contrast, the differences between countries for the smooth and palmate newts may indicate regional differences in habitat changes or varied local adaptations (see also Araujo et al. 2008; EEA 2010; Hartel et al. 2010b). They also reflect global differences in habitat composition and configuration as some kinds of habitats such as Alpine lakes, typically inhabited by Alpine newts in the absence of fish, are found only in one of the five studied areas (Switzerland) for instance (Meyer et al. 2009). In lowlands regions such as found in most of the studied area, particularly in Belgium and in the Netherlands, those species with plastic life-history habits such as the Alpine newt could also be maintained in numerous secondary aquatic habitats, such as forestry ruts or garden ponds for instance (Jacob et al. 2007). Replicated studies such as those done by Zanini et al. (2009) in Switzerland could prove particularly useful in this perspective. Moreover, as ecological processes may act differently on species communities according to scale (Böhning-Gaese 1997; Whittaker et al. 2001; Rahbek 2005; Soberon et al. 2007), the differences found here at the two spatial scales suggest that looking not only at one but at both fine and coarse scale could bring interesting findings on ecological determinants implied in species distribution and species decline. Altogether these results advocate for more collaborative projects across countries in determining species habitat requirements at different scales.

Previous work on pond restorations (Rannap et al. 2009b) and landscape ecology in European newts (Joly et al. 2001; Karlsson et al. 2007; Rannap et al. 2009a; Hartel et al. 2010a) also indicate that the great crested newt particularly needs networks of favourable permanent ponds surrounded by a mosaic of varied terrestrial landscapes. This is unfortunately a configuration of habitats which is less and less available in Western Europe (Gent 2001; Wood et al. 2003), contrary to some areas such as in Eastern Europe where traditionally managed rural landscapes are still well represented, providing a valuable habitat for amphibian communities (Hartel et al. 2010b). The smooth newt is also typical of open landscapes and thus could be particularly affected by the large decrease of ponds in open

landscapes, due to the expansion of agriculture, wetland pollution (Denoël and Ficetola 2008) and road traffic (Hartel et al. 2010b). The palmate newt has also high scores for decline (this study). It is typical of forested areas or lives close to them (Denoël and Lehmann 2006; Denoël and Ficetola 2007). Woodland cover has not been very negatively affected and these areas are usually devoid of pollution. In common with the other species, the palmate newt is also affected by fish introductions (Denoël et al. 2005; Denoël and Ficetola 2008; Rannap et al. 2009a). Urbanisation and associated factors such as the paving of roads can be particularly detrimental to the palmate newt because they prevent the formation of forestry ruts, which are one of its usual secondary habitats in forests (Denoël 2007). The large variety of causes requires future studies to encompass a simultaneously large number of ecological processes. Linking distribution data to global environmental features across varied landscapes is the next challenge to understand the reasons behind declines and, most particularly, why species decline differently across regions. This is not an easy task because of the large variety of environmental processes involved, the complexity of spatial analyses and the need for large amounts of data. However, altogether global digital atlases projects (e.g. SEH 2009) and new statistical tools combined to GIS data (Ficetola et al. 2010; Pautasso et al. 2011) are expected to make this possible at broad scale and be of high informative value for conservation managers and policy makers.

Conclusions and perspectives

Detailed distribution atlases are essential parts of conservation assessments and complement data from field studies (Dunn and Weston 2008; Robertson et al. 2010), which together provide critical information necessary to accurately classify biodiversity risks. Future atlases should include both historic and recent distribution maps, with clear definitions as to scale and effort, to allow the computation of varied diversity indexes. There is currently no uniform way of presenting distribution maps. Whereas some atlases use the worldwide UTM grid system, many continue to use national grids which differ in grid cell sizes. This makes it sometimes difficult to compare regions or countries and thus prevents some analyses, which could be very informative at supranational scales, i.e. at the scale of species ranges (Gregory et al. 2005; Lengyel et al. 2008). Three recent advances on this matter are the creation of continental atlases (see e.g., Gasc et al. 1997; SEH 2009), the development of GIS databases (Sillero et al. 2005), and the availability of open access on-line cartographies, for example in the Netherlands and Switzerland. Such on-line systems are particularly valuable because they can be customized according to time, thus giving up-to-date situations on declining species. As long as resolution is good enough, atlases can thus easily allow large scale coverage to efficiently monitor species status outside political boundaries.

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