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Short communication

Intra-seasonal changes in local pattern of Corncrake *Crex crex* occurrence require adaptive conservation strategies in Alpine meadows

MATTIA BRAMBILLA and PAOLO PEDRINI

Summary

As a double-brooded species inhabiting grassland habitats subject to mowing and located at different elevations, the Corncrake *Crex crex* in the Alps is potentially affected by changes in its breeding habitat within a season, thus leading to shifts in occurrence and habitat association, with potentially relevant consequences for conservation. We investigated Corncrake abundance in four sites in Trento province (N Italy); two sites were defined as 'low elevation' (mean elevation 975 m and 976 m a.s.l., respectively) and two as 'high elevation' (mean elevation 1,173 m and 1,177 m). The number of calling males showed a clear variation in relative abundance between early and late periods of the breeding season; in particular, at low elevation sites, abundance decreased from the early to late periods, while the opposite was recorded at high elevation sites. A mixed model suggested that the number of males decreased in the second half of the breeding season and at high elevations, and changed according to mid-season altitudinal shifts. Conservation strategies for this species should take into account the mid-season territory shift.

Introduction

A poorly investigated topic of potential relevance in bird conservation is the intra-seasonal variation in ecological requirements and distribution patterns of species which breed more than once a season. Few studies have focused on within-season adjustments in site selection by multi-brooded birds (Betts *et al.* 2008, Brambilla and Rubolini 2009, Gilroy *et al.* 2010). However, within-season changes in ecological conditions could affect habitat selection, given variations in weather, vegetation and/or habitat structure, food abundance/availability, or changes in the bird community and hence in patterns of competition and predation. Habitat changes may cause declines in habitat quality through the breeding season within territory/home-range (Soderstrom 2001); birds experiencing multiple breeding opportunities during a season can react to these declines by moving to different sites or habitats, and such a strategy may potentially involve a large number of species (Gilroy *et al.* 2010). Species occurring along altitudinal gradients or occupying habitats undergoing within-season large modifications might be particularly involved. Agricultural habitats are most likely to be affected by intra-seasonal variation because of hay-making, seeding, sowing, which all take place also within the breeding period. As a consequence, vegetation height, density and appearance can change dramatically within the season (Gilroy *et al.* 2010).

In some multi-brooded passerines of agricultural landscapes, habitat suitability changes during the breeding season, causing territory shift (Stiebel 1997, Donald *et al.* 2002, Eraud and Boutin 2002, Brambilla and Rubolini 2009, Gilroy *et al.* 2010); within-season switches might maximize

the number of breeding attempts (Gilroy *et al.* 2010). When habitat/distribution changes are strong, they may have critical implications for conservation (Brambilla and Rubolini 2009).

The Corncrake *Crex crex* is potentially affected by within-season shifts in habitat association and distribution in central-western Europe, where it mainly breeds in grassland mown for hay (subjected to deep variations in e.g. sward height/density, soil humidity, invertebrate abundance, all affected by agricultural practices) and located at different elevations (in Italy, from a few meters to 1,800 m). Corncrakes usually raise two broods per season (Cramp and Simmons 1980), often changing singing and nest location between broods (Niemann 1995, Tyler and Green 1996, Green *et al.* 1997a). In this paper, we assess the variation in Corncrake abundance between early and late breeding season in grasslands mown for hay-making at different elevations in the Alpine region.

Methods

We investigated Corncrake occurrence in Trento province, northern Italy (6,206 km^2, elevations 67–3,769 m a.s.l. and with 50% of the area lying between 1,000 and 2,000 m). Valley floors are intensively cultivated and partly urbanised; mountainsides are covered by woodlands, interspersed with pastures and vineyards (<1,000 m) and with anthropogenic grasslands (1,000–2,000 m); highest areas (>2,000 m) are covered by alpine grasslands, rocks and snow. Rainfall mostly ranges from 700 to 1,500 mm/year. Human density is relatively low (76.3 inhabitants km^{-2}), especially in rural and mountain areas (PAT 2001).

Within the province, we identified four important areas for Corncrakes. All areas included suitable grassland habitats at similar elevation within each site (with the only exception of a small sub-area within Tesino, hosting 0-4 males per count). Two areas were classified as 'low elevation': Tesino (479 ha, average elevation 975 m, with grasslands interspersed with extensive cultivations and urbanised areas) and Alta Val di Non (807 ha, average elevation 976 m, with grassland patches interspersed with intensive apple orchards). The other two were classified as 'high elevation': Val di Gresta (356 ha, average elevation 1,177 m, with grassland flanked by small cultivated fields) and Altopiano Folgaria-Lavarone (520 ha, average elevation 1,173 m, with pastures and grassland, partly subjected to abandonment and urbanisation).

Management intensity is highest in Val di Non, lowest in Tesino and intermediate in the other two areas. Mowing takes place in all areas firstly around mid-June (exceptionally in late May in warmest years), and then in middle to late July, with a slight delay in high-elevation areas.

Each study area was divided into sectors which were simultaneously censused by different teams of observers. Calling males were counted by means of nocturnal surveys (23h00–03h00), listening to spontaneous vocalisations and using playback (broadcast call of male) if no male was singing. All areas were visited once in May–early June, according to weather (we avoided rainy and windy days) and always before the first mowing, and once in late June-July, between first and second mowing.

Censuses were carried out between 1997 and 2010, but not all areas were surveyed in all years; double censuses of the same site in the same season were available in 40 cases (Appendix S1).

We performed a mixed model analysis (Poisson regression) to investigate the effect of different factors on Corncrake abundance. The dependent variable was the number of calling males per area per census. We entered as factors the period (early vs. late) and elevation (low vs. high) and their interaction term: if a mid-season altitudinal change in relative distribution occurs, a significant interaction between the two factors should result. In the modeling procedure we included also year and area as random factors, to account for non-independence of data within the same study area or year, and a factor representing census date, expressed as progressive periods of 10 days (six different periods) since the earliest date of census (11^{th} May). Residual distribution was checked (Bolker *et al.* 2008). The analysis was performed in R 2.11.1, using the lme4 package. Parameter estimates are reported together with their standard errors.

Results

The mixed model analysis (intercept: 3.64 ± 0.88) showed a significant effect of elevation (for high-elevation sites: −1.18 ± 0.50, $z = -2.37$, $P = 0.017$), nearly significant effects of period (for late period: −0.50 ± 0.27, $z = -1.82$, $P = 0.069$) and of the sixth (latest) 10-day period (for latest period: −0.82 ± 0.46, $z = -1.78$, $P = 0.074$), and a highly significant positive effect of the interaction between elevation and period (0.51 ± 0.16, $z = 3.20$, $P = 0.001$). The full factorial model had by far the lowest AIC (Table S1). Residuals were normally distributed. The results suggest that the number of males decreases with late period, higher elevation, and in the last census period; the interaction effect strongly suggests mid-season altitudinal shifts.

Discussion

Mid-season changes in habitat selection and hence in the local/regional distribution of multi-brooded bird species are important for conservation of passerine species in agricultural landscapes (Brambilla and Rubolini 2009, Gilroy *et al.* 2010), but they also occur in non-passerines. Corncrake males showed clear within-season variation in local abundance. At low elevation, abundance decreased as the breeding season progressed, while the opposite happened at high elevation (Fig. 1). Despite the relatively small altitudinal difference between the two groups of sites, such a pattern seems more important than the negative effects of period and elevation. In Bulgaria, the second Corncrake brood is laid at a significantly higher altitude than the first, thus benefiting from delayed vegetation development and later hay mowing at higher altitudes (Niemann 1995, BirdLife International 2008). Without extensive capture/recapture, we cannot demonstrate that the same individuals moved from lower to higher sites, but it is at least conceivable that a similar pattern could occur also in our study areas. One ringed bird moved from Veneto (at the south-eastern boundary of our study province, where it was trapped at the end of May below 1,000 m) to our province (trapped at the end of June 40 km NNE, at 1,120 m), confirming the existence of mid-season movements in Italian Alps (Spina and Volponi 2008). In our study area, delayed vegetation growth and later mowing may be among the causes of the distributional shifts, as well as changes in prey abundance (peaking later at high elevation and also affected by vegetation growth and mowing). Mowing reshapes habitat structure and dramatically reduces habitat suitability, especially where management is intensive and unmown patches are scarcer. The within-season decline seemed highest in the most intensive area (Val di Non; see Fig. 1). Corncrakes could concentrate on low-elevation grasslands in the early season, and move to higher sites later (as apparently confirmed also by observations outside the study areas, which in July occur almost exclusively in high-elevation sites; P. Pedrini *et al.* unpubl. data), when these higher grasslands host a rich invertebrate fauna and a more suitable vegetation, than in spring (Pedrini *et al.* 2005).

Mowing represents a major threat to the species (Broyer 1996, Crockford *et al.* 1996), and the effect of period suggests that mid-season mowing may cause a decline of Corncrakes, irrespective of elevation.

Whatever the main reasons for the distributional shifts, it is essential for a species with such a high mortality (Green 1999, 2004) to enhance breeding success by minimising losses during the entire season. To define suitable conservation measures, the mid-season distributional shift should be taken into account. In the early period, grasslands at lower elevation are of primary importance and hay-making should be planned (i.e. mowing date delayed) to allow Corncrakes to reproduce successfully (cf. Cramp and Simmons 1980, Broyer 1996, Crockford *et al.* 1996, Green *et al.* 1997b, Berg and Gustafson 2007). The same applies to higher elevation sites for the late period (and the mid-summer cutting). Voluntary measures for Corncrake conservation in the 2007–2013 Rural Development Programme require unmown grassland patches (≥ 2,500 m^2) to be kept between 5 May and 15 July below 1,000 m, and until 25 July above 1,000 m and impose outward mowing over these patches. Detailed studies on breeding phenology are required to define the best time for mowing, but it is possible that those dates should be postponed by 5–10 days.

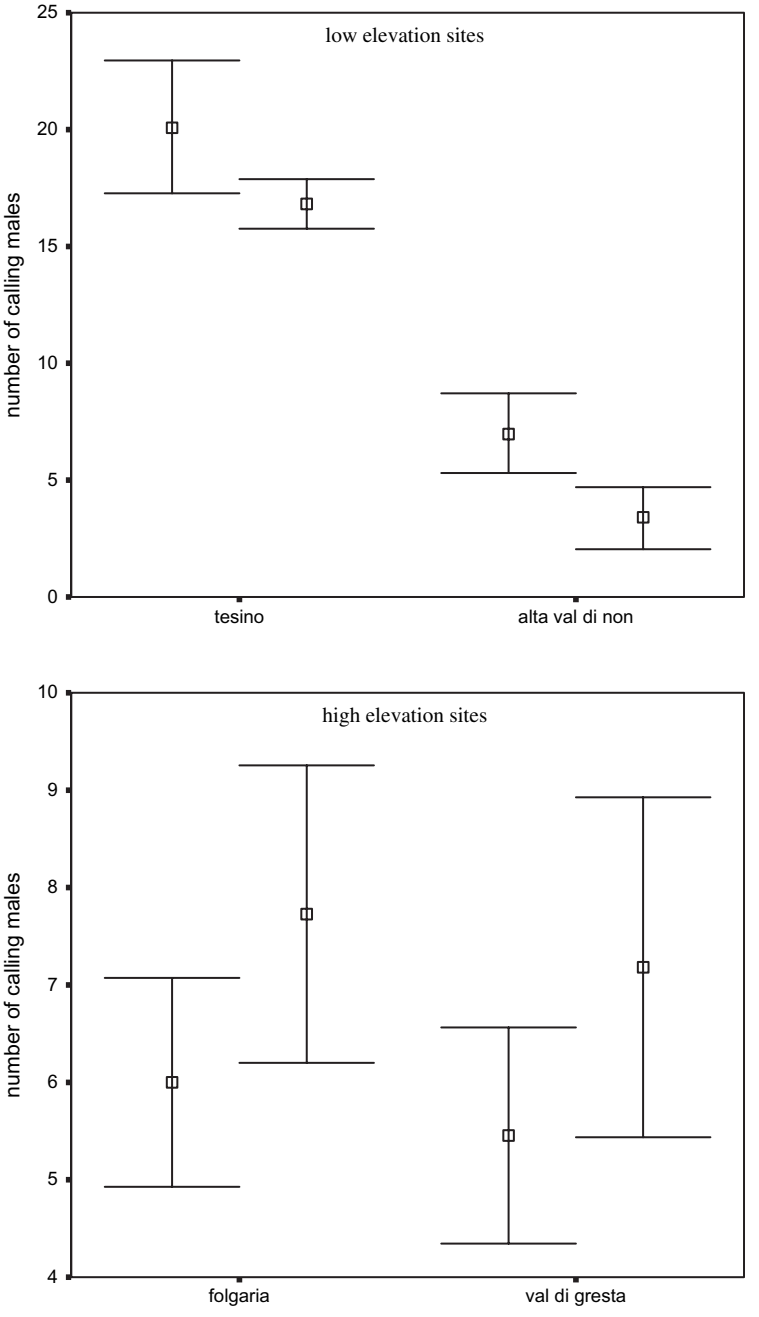

Figure 1. Mean number of calling males (± SE) during early (left value) and late (right value) periods, for low elevation (above) and high elevation areas (below).

Correct grassland management at middle/middle-high elevation in the Alps is required for the regional conservation of the species, which was abundant in lowland areas until the 1950s (AFC TN 1930, Pedrini *et al.* 2002) but is now confined to middle/middle-upper elevations (Pedrini

et al. 2002, 2005). Several important grasslands are now threatened by land abandonment. Similar to several other bird species in southern and eastern Europe (Brambilla *et al.* 2007, 2009a, b, 2010, Nikolov 2010), Corncrakes in the Alps rely on a delicate equilibrium between intensification and ceasing of farming, being threatened by both.

Supplementary Material

The supplementary materials for this article can be found at journals.cambridge.org/bci

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References

Afc TN (Associazione Fascista Cacciatori della Provincia di Trento) (1930) Selvaggina nella Provincia di Trento. Risultati dell'inchiesta per l'anno 1929. Trento.

Berg, A. and Gustafson, T. (2007) Meadow management and occurrence of corncrake *Crex crex*. *Agr. Ecosyst. Environ.* 120: 139–144.

Betts, M. G., Rodenhouse, N. L., Sillet, T. S., Doran, P. J. and Holmes, R. T. (2008) Dynamic occupancy models reveal within-breeding season movement up a habitat quality gradient by a migratory songbird. *Ecography* 31: 1–9.

BirdLife International (2008) *Species fact-sheet*: Crex crex. Downloaded from http://www.birdlife.org on 22/11/2008

Bolker, B. M., Brooks, M. E., Clark, C. J., Geange, S. W., Poulsen, J. R., Stevens, M. H. H. and White, J. S. (2008) Generalized linear mixed models: a practical guide for ecology and evolution. *Trends Ecol. Evol.* 24: 127–135.

Brambilla, M. and Rubolini, D. (2009) Intra-seasonal changes in distribution and habitat associations of a multi-brooded bird species: implications for conservation planning. *Anim. Conserv.* 12: 71–77.

Brambilla, M., Casale, F., Bergero, V., Bogliani, G., Crovetto, G. M., Falco, R., Roati, M. and Negri, I. (2010) Glorious past, uncertain present, bad future? Assessing effects of land-use changes on habitat suitability for a threatened farmland bird species. *Biol. Conserv.* 143: 2770–2778.

Brambilla, M., Casale, F., Bergero, V., Crovetto, G. M., Falco, R., Negri, I., Siccardi, P. and Bogliani, G. (2009b) GIS-models work well, but are not enough: Habitat preferences of *Lanius collurio* at multiple levels and conservation implications. *Biol. Conserv.* 142: 2033–2042.

Brambilla, M., Guidali, F. and Negri, I. (2009a) Breeding-season habitat associations of the declining Corn Bunting *Emberiza calandra* – a potential indicator of the overall bunting richness. *Ornis Fennica* 86: 41–50.

Brambilla, M., Rubolini, D. and Guidali, F. (2007) Between land abandonment and agricultural intensification: habitat preferences of Red-backed Shrikes *Lanius collurio* in low-intensity farming conditions. *Bird Study* 54: 160–167.

Broyer, J. (1996) "Outward mowing", as a way of reducing losses of young corncrakes *Crex crex* and quails Coturnix coturnix. *Rev. Ecol. (Terre Vie)* 51: 269–276.

Cramp, S. and Simmons, K. E. L., eds. (1980) *The birds of the Western Paleartic*, 2. Oxford: Oxford University Press.

Crockford, N., Green, R., Rocamora, G., Schäffer, N., Stowe, T. and Williams, G. (1996) *Action plan for the Corncrake (Crex crex) in Europe*. BirdLife International/European Commission.

Donald, P. F., Evans, A. D., Muirhead, L. B., Buckingham, D. L., Kirby, W. B. and Schmitt, S. I. A. (2002) Survival rates, causes of failure and productivity of

Skylark *Alauda arvensis* nests on lowland farmland. *Ibis* 144: 652–664.

Eraud, C. and Boutin, J. M. (2002) Density and productivity of breeding Skylarks *Alauda arvensis* in relation to crop type on agricultural lands in western France. *Bird Study* 49: 287–296.

Gilroy, J. J., Anderson, G. Q. A., Grice, P. V., Vickery, J. A. and Sutherland, W. J. (2010) Mid-season shifts in the habitat associations of Yellow Wagtails *Motacilla flava* breeding in arable farmland. *Ibis* 152: 90–104.

Green, R. E. (1999) Survival and dispersal of male Corncrakes *Crex crex* in a threatened population. *Bird Study* 46 (Suppl.): 218–229.

Green, R. E. (2004) A new method for estimating the adult survival rate of the Corncrake *Crex crex* and comparison with estimates from ring-recovery and ring-recapture data. *Ibis* 146: 501–508.

Green, R. E., Rocamora, G. and Schäffer, N. (1997a) Populations, ecology and threats to the Corncrake *Crex crex* in Europe. *Vogelwelt* 118: 117–134.

Green, R. E., Tyler, G. A., Stowe, T. J. and Newton, A. V. (1997b) A simulation model of the effect of mowing of agricultural grassland on the breeding success of the corncrake (*Crex crex*). *J. Zool.* 243: 81–115.

Niemann, S. (1995) *Habitat management for corncrakes*. Draft report. Sandy, UK: RSPB.

Nikolov, S. C. (2010) Effects of land abandonment and changing habitat structure on avian assemblages in upland pastures of Bulgaria. *Bird Conserv. Int.* 20: 200–213.

PAT (Provincia Autonoma di Trento) (2001) *Rapporto sullo stato dell'ambiente* 2001 *n.*4/1. *Aggiornamento degli indicatori*. Trento: Agenzia Provinciale per la Protezione dell'Ambiente.

Pedrini, P., Caldonazzi, M. and Zanghellini, S. (a cura di) (2005) Atlante degli uccelli nidificanti e svernanti in provincia di Trento. Museo Tridentino di Scienze Naturali, Trento. *Studi Trentini di Scienze Naturali, Acta Biologica* 80(2003): 1–674.

Pedrini, P., Rizzolli, F., Cavallaro, V., Marchesi, L. and Odasso, M. (2002) Status e distribuzione del Re di quaglie (*Crex crex*) in provincia di Trento (Alpi centro-orientali, Italia). *Studi Trentini di Scienze Naturali, Acta Biologica* 78(2000): 55–60.

Soderstrom, B. (2001) Seasonal change in Red-backed Shrike *Lanius collurio* territory quality – the role of nest predation. *Ibis* 143: 561–571.

Spina, F. and Volponi, S. (2008) *Atlante della migrazione degli uccelli in Italia. 1. Non-Passeriformi*. Roma: Ministero dell'Ambiente e della Tutela del Territorio e del Mare e ISPRA.

Stiebel, H. (1997) Habitat selection, habitat use and breeding success in the Yellow Wagtail *Motacilla flava* in an arable landscape. *Vogelwelt* 118: 257–268.

Tyler, G. A. and Green, R. E. (1996) The incidence of nocturnal song by male Corncrakes *Crex crex* is reduced during pairing. *Bird Study* 43: 214–219.

MATTIA BRAMBILLA*
Museo Tridentino di Scienze Naturali, Sezione di Zoologia dei Vertebrati, Via Calepina 14, I-38122 Trento, Italy. Fondazione Lombardia per l'Ambiente, Settore Biodiversità e Aree protette, Piazza Diaz 7, I-20123 Milano, Italy

PAOLO PEDRINI
Museo Tridentino di Scienze Naturali, Sezione di Zoologia dei Vertebrati, Via Calepina 14, I-38122 Trento, Italy.

**Author for correspondence; email: brambilla.mattia@gmail.com*

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