European population trends and current conservation status of an endangered steppe-bird species: the Dupont's lark *Chersophilus duponti*

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Background

Steppe-birds face drastic population declines throughout Europe. The Dupont's lark *Chersophilus duponti* is an endangered steppe-bird species whose European distribution is restricted to Spain. This scarce passerine bird could be considered an 'umbrella species', since its population trends may reveal the conservation status of shrub-steppes. However, Dupont's lark population trends of the whole Spanish (and therefore European) population are unknown, so an updated and rigorous assessment is needed.

In this work, we evaluated Dupont's lark population trends in Europe employing the most recent and largest compiled database until date (92 populations and 12 years). In addition, we assessed the species threat category according to current applicable criteria (approved in March 2017) in the Spanish Catalogue of Threatened Species (SCTS), which have never been applied to the Dupont's lark nor to any other Spanish species. Finally, we compared the resulting threat categories with current conservation status at European, national and regional level.

Methods

We fitted Switching Linear Trend models (software TRIM - *Trends and Indices for Monitoring data*) to evaluate population trends at national and regional scale (i.e. per Autonomous Community) during the period 2004 – 2015. In addition, the finite multiplicative annual rate (lambda) obtained from the TRIM analysis was employed to estimate the percentage of population size change in a 10-year period. In accordance, a threat category was assigned following A1 and A2 criteria applicable in the SCTS.

Results

Trends showed an overall 3.9% annual decline rate for the Spanish population (moderate decline, following TRIM). Regional analyses showed a high inter-regional variability. Andalusia and Castile-Leon showed a steep decline, experiencing over 5% annual declining change rate. Trends were classified as uncertain in Aragon, Castile-La Mancha, Catalonia, Community of Valencia, Navarre and Region of Murcia, due to variability in trends between years and populations, and to the high proportion of missing values.

On the other hand, we forecasted a 32.8% average decline during the next 10 years. Attending to these

results the species should be listed as ‘Vulnerable’ at national scale (SCTS). At the regional level, the conservation status of the species is of particular concern in Andalusia and Castile-Leon, where the species qualifies to be listed as ‘Endangered’.

Discussion

This work highlights the worrying conservation status of the European Dupont’s lark population, facing a 3.9% annual declining rate. Under this scenario, the urgent implementation of a wide-range conservation plan is vital to ensure the conservation of this steppe-bird species. Besides, the legal responsibility of administrations to law enforcement in matter of nature protection and cataloguing endangered species, is crucial to reverse declining population trends of this and other endangered taxa.

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Our results highlight the worrying conservation status of the European Dupont's lark population, facing a 3.9% annual declining rate. Under this scenario, the urgent implementation of a wide-range conservation plan is vital to ensure the conservation of this steppe-bird species. Besides, the legal responsibility of administrations to law enforcement in matter of nature protection and cataloguing endangered species, is crucial to reverse declining population trends of this and other endangered taxa.

Introduction

Steppes and pseudo-steppes are two of the most important habitats for preservation of bird diversity since 55% of European bird species listed in the IUCN Red List are highly dependent on these habitats (Burfield 2005). Moreover, 83% of steppe-bird species show an unfavorable conservation status in Europe (Burfield and Van Bommel 2004, Burfield 2005). This is a consequence of the accelerated process of land use changes faced by steppe-like habitats, with dramatic consequences on steppe-bird populations across Europe (Benton *et al.* 2003, Burfield

and Van Bommel 2004, Santos and Suárez 2005). Main habitat-related threats, and therefore drivers of steppe-bird populations decline are: (i) changes on land use (afforestation, new crops, infrastructure development, mining, rubbish dumps; Burfield 2005; Laiolo and Tella 2006a, Gómez-Catasús *et al.* 2016, 2018); (ii) agricultural intensification (landscape homogenization, irrigation, increase of agrochemicals; Donald *et al.* 2001, Benton *et al.* 2003, Brotons *et al.* 2004, Burfield 2005); and (iii) land abandonment and changes on agriculture and livestock management (Madroño *et al.* 2004, Burfield 2005).

Spain is the stronghold for steppe-birds in Western Europe, harbouring a major proportion of their total European breeding population (Burfield 2005). However, most of Spanish steppe-bird populations declined during the 1990 – 2000 period (Burfield 2005) and afterwards (BirdLife International 2015). A species of a particular conservation concern is the Dupont's lark *Chersophilus duponti* (Vieillot, 1820), identified amongst the 65 priority bird species inhabiting steppes (Burfield and Van Bommel 2004) and one of the scarcest passerine birds in Europe. The species is classified as 'Near Threatened' in the IUCN Red List (BirdLife International 2017) and as 'Vulnerable' in both the European Red List of Birds (BirdLife International 2015) and in the Spanish Catalogue of Threatened Species (Royal Decree 139/2011, 4th February). Its European geographic range is restricted to Spain spreading over 1,480 km^2 (Suárez 2010), and its population has been estimated at 1,300-2,400 breeding pairs (Garza *et al.* 2003, Tella *et al.* 2005, Suárez 2010). The European population of Dupont's lark qualifies to be considered as an Evolutionary Significant Unit (*sensu* Moritz 1994, Casacci *et al.* 2014), since they are isolated and genetically and morphologically differentiated from the African ones (García *et al.* 2008, Suárez 2010).

The species inhabits flat (<10-15% of slope) shrub-steppes, avoiding dry pastures and cereal fields (Garza *et al.* 2005, Seoane *et al.* 2006, Pérez-Granados *et al.* 2017a). Habitat fragmentation and land-use changes, common issues in steppe ecosystems, have been documented as the main threats for the species (Tella *et al.* 2005, Íñigo *et al.* 2008, Garza and Traba 2016, Pérez-Granados *et al.* 2016, Gómez-Catasús *et al.* 2018). Therefore, the Dupont's lark could be considered an 'umbrella species' (Frankel and Soulé 1981), since its population trends may reveal the conservation status of shrub-steppes.

Dupont's lark population trends have been previously addressed globally (Suárez 2010) or in a sample of populations (Tella *et al.* 2005, Pérez-Granados and López-Iborra 2013, 2014). Despite results of all these studies show declining population trends, none of them derived population change estimates using appropriate statistical methods. Moreover, current trends of the whole Spanish (and European) population are unknown, so an updated and rigorous assessment is needed. This updated information would allow assessing the conservation status of the species according to a formal set of criteria at two spatial scales: national and regional (i.e. per Autonomous Community where the species is present). The importance of both spatial scales relies on the competence of the Spanish Autonomous Communities in nature protection and, specifically, in listing and cataloguing endangered species (Law 42/2007, 13th December). The Spanish Ministry of Agriculture and Fisheries, Food and Environment has the jurisdiction to list the species at national scale in the Spanish Catalogue of Threatened Species (SCTS, Law 42/2007, 13th December) and to elaborate the National Conservation Strategy of endangered species. On the other hand, each Autonomous Community is legally bound to list species in its Regional Catalogue of Threatened Species (RCTS), at least with the same category than at the national level. Besides, they have the competence to elaborate and implement both Conservation

and Recovery Plans for those species classified as 'Vulnerable' and 'Endangered', respectively. Thus, regional population trends are crucial to assess whether species conservation status is especially worrying in specific regions and if the category of threat should be increased in the pertinent Catalogues.

Species included in the SCTS were listed in 2011 (Royal Decree 139/2011), but listing criteria applicable in the SCTS were modified in March 2017 (Royal Decree 139/2011, 4th February; Resolution 6th March 2017), to accommodate IUCN ones (IUCN 2012). However, conservation status of catalogued species in the SCTS has not been reviewed after this modification. To our knowledge, new criteria have never been applied to the Dupont's lark nor to any other Spanish species and, therefore, an assessment of the category of threat assigned under the new criteria is needed.

In this work, we aimed to evaluate Dupont's lark population trends during the 2004 - 2015 period at both national and regional scale (i.e. per region or also called Autonomous Communities), using the largest database ever compiled. We also carried out a comprehensive assessment of the conservation status of the Dupont's lark according to quantitative threshold criteria of reduction in population size (A1 and A2 criteria, see below) under current applicable criteria in the SCTS (Resolution 6th March 2017). Finally, we also aimed to assess whether the current threat category of the species at European (European Red List of Birds), national (SCTS) and regional levels (RCTS) agrees with Dupont's lark populations trends.

Materials and Methods

Data collection

The ethics committee of Animal Experimentation of the Autonomous University of Madrid as an Organ Enabled by the Community of Madrid (Resolution 24th September 2013) for the

130 evaluation of projects based on the provisions of Royal Decree 53/2013, 1st February, has
131 provided full approval for this purely observational research (CEI 80-1468-A229).
132 We compiled data for 92 Dupont's lark populations during the 2004-2015 period. We considered
133 a population as those habitat patches separated by less than 1 km (termed subpopulation in
134 Suárez 2010). Our dataset accounted for 41.6% of the 221 populations surveyed during the II
135 National Survey (2004-2006; Suárez 2010) and includes a temporal range between one and 12
136 years (mean ± SD = 5.36 ± 2.77 years). Besides, all the Autonomous communities where the
137 species occurs are included in the dataset (Fig. 1) (Suárez 2010).
138 The Dupont's lark population size is difficult to quantify due to the extremely shy and elusive
139 behavior of the species and the concentration of singing activity mainly before dawn. Therefore,
140 surveys of the species rely on auditory contacts. Bird censuses were carried out during the
141 breeding season (March-June depending on phenological differences; Garza *et al.* 2010)
142 approximately 1 hour before dawn, when singing activity peaks. Birds were counted by linear
143 transects (500 m inner belt width; Garza *et al.* 2010) or by territory mapping (Bibby *et al.* 2000),
144 since they produced similar population size estimates (Pérez-Granados and López-Iborra 2017).
145 A slightly different census method, consisting in a network of point counts, was performed in
146 Catalonia and Region of Murcia populations (comprising less than 5% of all populations).
147 Anyway, counting method remained constant throughout the study period within each region,
148 making inter-annual data comparable. Linear transects were designated to cover the whole
149 population (Suarez 2010), and were walked at constant speed georeferencing singing males with
150 a GPS and noting all males singing simultaneously. Transects were walked once under the linear
151 transect method and 2-4 times under the mapping method. Number of territories per population
152 was estimated by mapping all records and taking into account clusters of registrations and birds

153 heard simultaneously (Garza *et al.* 2010, Pérez-Granados and López-Iborra 2017). Population
154 size estimates refer to the minimum number of territories (mapping method), or minimum
155 number of males (line transect method) per population.
156 *Trend analysis*
157 Changes on population estimates were evaluated using the software TRIM (*Trends and Indices*
158 *for Monitoring data*. TRIM v. 3.54. Pannekoek and Van Strien 2006a). TRIM fits log-linear
159 models and was employed because: i) it allows to analyze time series with absence of data in
160 some years, a common issue in long-time series; and ii) it takes into account overdispersion and
161 serial correlation of data (Pannekoek and Van Strien 2005). TRIM calculates indices that
162 represent the effect of change between years, which indicates relative variation of the total
163 population size. From these indices, a mean annual change rate is estimated and a trend category
164 is assigned (Pannekoek and Van Strien 2006a). At the first time-point, the index value is 1 and is
165 taken as point-reference for quantifying the relative temporal trends in the subsequent years. This
166 technique has been broadly employed for the analysis of temporal series in bird populations (e.g.
167 Paradis *et al.* 2002, Wretenberg *et al.* 2007, Delgado *et al*. 2009).
168 We fitted Switching Linear Trend models to evaluate both national and regional Dupont's lark
169 trends during the period 2004 - 2015. TRIM employs a stepwise selection of change-points in
170 trends using Wald-tests for the significance of change-points. When the difference between
171 parameters before and after a change-point does not differ from zero (default significance
172 threshold: 0.2), the corresponding change-point is removed from the model attending to the
173 parsimony principle (Pannekoek and Van Strien 2005). The best-fit models were selected
174 according to Goodness-of-fit tests (Likelihood ratio test and Chi-squared) and Akaike
175 information criterion (AIC). A model with a significance value higher than 0.05 indicates that

data fit a Poisson distribution and, therefore, the model could be accepted. Indices, overall slope and Wald tests remain reliable in case of lack-of-fit (Pannekoek and Van Strien 2005). In case of overdispersion or serial correlation (default TRIM threshold: >3.0 and >0.4 respectively; Pannekoek and Van Strien 2006b) Wald-test for the significance of slope was employed (Pannekoek and Van Strien 2005). While the whole set of 92 populations was used to analyse national trends, regional subsets were subsequently extracted to analyse regional trends (see Table 1 for sample size in each region).

Threat category

We evaluated Dupont's lark category of threat according to A1 (population size reduction over the last 10 years or three generations, whichever the longer) and A2 (population size reduction within the next 10 years or three generations, whichever the longer) criteria applicable in the SCTS. We used recent trends to forecast future population trends of the species, since its geographic range reduction (Traba *et al.* 2016) and the lack of conservation measures (Tella *et al.* 2005, Suárez 2010, Pérez-Granados and López-Iborra 2014) predict similar population trends in the next years.

The finite multiplicative annual rate (λ) was obtained from the TRIM analysis. This value was employed to estimate the percentage of population size change in a 10-year period following the equation below:

$$\text{Percentage of change in a 10-year period (\%)} = (\lambda^{10} - 1) \cdot 100$$

We assigned a threat category according to population size reduction estimated over the last 10 years (A1 criterion; 'Endangered' ≥ 70% 'Vulnerable' ≥ 50%) and forecasted in the next 10 years (A2 criterion; 'Endangered' ≥ 50% 'Vulnerable' ≥ 30%) at both national and regional

198 scale. Lastly, categories were compared with the current threat categories for the Dupont's lark
199 in the European Red List of Birds, the SCTS and the RCTS.

200 Results

201 *Spanish (European) population trend*

202 The best Switching Linear Trend model for all Dupont's lark populations did not fit to a log-
203 linear distribution (Chi-square, $\chi^2 = 684.92$, df = 389, $p<0.001$; Likelihood Ratio, LR = 722.30,
204 df = 389, $p<0.001$; AIC = -55.70). Overdispersion and serial correlation values were relatively
205 low (1.70 and 0.34, respectively), but 55.8% of counts were missing values. The stepwise
206 procedure revealed six significant change-points in trends (Fig. 2; Table S1). Population size-
207 index experienced an overall 41.3% decline (95% CI, -50.2 to -32.5) from 2004 to 2015.
208 Besides, the extinction of 26 populations (hereafter local extinction events), which represents
209 28% of the set of study populations, was registered in this period (Table S2). The overall slope
210 parameter showed a 3.9% annual decrease (95% CI, -4.9 to -2.8%), which corresponds to a
211 moderate decline according to TRIM criteria (Pannekoek and Van Strien 2006a).

212 *Regional population trends*

213 Regional trends showed high variability between regions (Table 1; Fig. 3). Switching Linear
214 Trend models for Aragon (AR), Navarre (NA) and Region of Murcia (RM) populations fitted to
215 a log-linear distribution (χ^2 and LR p-values > 0.05), while goodness-of-fit tests for models of
216 Andalusia (AN) and Community of Valencia (CV) were near to acceptance values (χ^2 and LR p-
217 values > 0.01; Table 1). However, Castile-La Mancha (CM) and Castile-Leon (CL) models did
218 not fit to a log-linear distribution (χ^2 and LR p-values < 0.01; Table 1). Overdispersion and serial
219 correlation values were of less concern for all models except for Catalonia (CA; Table 1), so we
220 relied on Wald-tests for best-model selection. Proportion of missing values was higher than 50%

for AR, CM, CA and NA models, and sample sizes were small for all regions (i.e. less than 15 populations) except for CM and CL (Table 1). Significant change-points in slope were incorporated in all models except for AR, CA and NA (Fig. 3; Table S3-S10), these three showing a constant slope throughout the study period. Trend analyses showed mean overall decreases in AN (70.0%), CL (50.8%), CM (59.0%), CV (26.8%) and NA (11.8%) during the 2004 – 2015 period (Table 2). However, mean overall trends were positive in AR (17.1%), CA (48.2%) and RM (37.4%) populations (Table 2). Average annual change rates showed a steep decline for AN and CL populations, higher than 5% per year (Table 1; Fig. 3). Population trends of AR, CA, CM, CV, NA and RM were classified as uncertain (Table 1; Fig. 3). Local extinction events were registered mainly in CL (9), AN (6), and CM (6) (Table S2). Frequency of local extinction events were higher in CA (100%, only one population under study which was ultimately recolonized in 2015), AN (50%), CV (37.5%), NA (33.3%), CL (31%) and CM (23.1%).

Threat category

According to estimated mean annual rate of change (-3.9%), Dupont's lark population size in Spain has been reduced on average by 32.8% over the last 10 years and will be reduced by the same percentage in the next 10 years (Table 2). This reduction in population size does not entail the classification of the Dupont's lark at any category of threat in Spain according to A1 criterion (Table 2). However, the Dupont's lark should be classified as 'Vulnerable' in the SCTS according to A2 criterion (Table 2).

Regional analyses showed that the species should classify as 'Vulnerable' in AN and CL according to past population trends (A1 criterion) and no category of threat is assigned in the rest of the Regional Catalogues (Table 2). Nevertheless, the species should classify at least as

244 'Vulnerable' in all the Regional Catalogues according to forecasted population declines (A2
245 criterion) and Spanish legislation (Table 2). Specifically, the species should be upgraded to
246 'Endangered' in AN and CL in agreement with A2 criterion (Table 2).

247 ## Discussion

248 Our results evidence the worrying trends of the Spanish Dupont's larks population, the only
249 bastion of this endangered steppe-bird in Europe. The species exhibited an estimated annual
250 decline rate of 3.9% during the last decade, which agrees qualitatively with previous work on
251 Dupont's lark population trends at particular areas of its Spanish distribution (Tella *et al.* 2005,
252 Pérez-Granados and López-Iborra 2013). Our results are also in concordance with declining
253 trends described for most of steppe-bird species in the Iberian Peninsula during the last decades
254 (Burfield 2005, BirdLife International 2015). Habitat loss and alteration (in terms of either
255 availability or quality) through agricultural intensification, abandonment of traditional extensive
256 livestock and other land use changes (e.g. ploughing and afforestation promoted by the Common
257 Agricultural Policy, tree crops, irrigated lands, infrastructure development), are some of the
258 anthropic activities known to impact on shrub-steppes (Santos and Suárez 2005), and have been
259 repeatedly cited as the main causes of Dupont's lark negative population trends (Tella *et al.*
260 2005, Íñigo *et al.* 2008, Garza and Traba 2016, Pérez-Granados *et al.* 2017b, Gómez-Catasús *et*
261 *al.* 2016, 2018).
262 In this study, we compiled the most exhaustive and updated database for Dupont's lark
263 population trends. We considered that our sampling coverage is representative of the Iberian
264 (European) distribution, leading to reliable results for the population trend analysis. Most regions
265 were significantly represented in this sample, ranging between 43% of the total regional
266 population for CL, 48% for CM and 100% for AN, CA, CV, NA and RM. However, we only

were able to compile data on 10 populations for AR (10.5% of the 95 populations surveyed in 2004-2006; Suárez 2010), the region that concentrates the majority of the Spanish Dupont's lark population (Suárez 2010). Thus, overall trends results (3.9% annual decline rate) may be somewhat biased due to absence of data in some important populations. Therefore, future population trend analyses incorporating a higher proportion of the regional populations in AR are needed. Accordingly, priority should be given to standardize long-term monitoring, particularly in those large populations in Aragon.

One additional precaution is related to the lack of fit in models, probably due to slight overdispersion in data (i.e. variance greater than the mean). This could be due to unknown factors not incorporated into the models, which could influence on trends (Quinn and Keough 2002, Crawley 2007). For instance, interannual variability in population trends encompassed by the significant change-points (Table S1; Table S3-S10) could be explained by natural stochasticity, either demographic or environmental (Lande 1987), as well as density-dependent interactions (Bjørnstad and Grenfell 2001). Demographic stochasticity may be an important driver of the observed oscillations between years, since Dupont's lark seems to fit to a metapopulation structure with local extinction events and colonization processes (e.g. Alfés population in CA; Bota *et al.* 2016). This produces high variability in TRIM yearly indices (i.e. overdispersion), and therefore hinders to obtain generalized population trends over time. On the other hand, interannual variability may be also associated to environmental stochasticity and fluctuations on abiotic factors such as climate (Delgado *et al.* 2009) due to its effects on food availability (Wiens 1989, Lemoine *et al.* 2007), reproductive success (Bolger *et al.* 2005, Van de Pol *et al.* 2010) or annual survival (Robinson *et al.* 2007), among others. Future research should focus on disentangling the mechanisms underlying variability on trends in order to incorporate

290 new covariates in models and improve their Goodness-of-fit. Anyway, the lack of fit would not
291 invalidate indices, overall slope and Wald tests (Pannekoek and Van Strien 2005), and
292 consequently main results about Dupont's lark population trends remain reliable.
293 We found large differences between regions in population trends; drastic declining trends
294 (annual declining rate higher than 5%) occurred in AN and CL, while trends were classified as
295 uncertain in the other regions (AR, CM, CA, CV, NA and RM). Uncertainty in trends may be
296 due to two typical handicaps in long-term databases: (i) high variability between years and
297 populations (within a region) that produces large Confidence Intervals (i.e. overdispersion); and
298 (ii) high proportion of missing values (Atkinson *et al.* 2006). As we stated above, overdispersion
299 was low except for CA, which could be explained by the extinction-recolonization process
300 undergone by the single population in this region (Bota *et al.* 2016). Besides, the percentage of
301 missing values (Table 1) exceeded the recommended threshold of 20-50% for TRIM analyses
302 (Pannekoek and Van Strien 2005). These two analytical constraints have negligible effects at
303 national scale but less reliable estimates are expected to be obtained with small-size samples (i.e.
304 regional analysis; Atkinson *et al.* 2006). This probably explains uncertain population trends for
305 AR, CA, CV, NA and RM. Consequently, results for some regional trends should be treated with
306 caution, especially when a low proportion of populations were included in the regional analyses
307 (e.g. AR; see above).
308 The comprehensive assessment of the conservation status of the Dupont's lark yielded a higher
309 category of threat according to A2 criterion (future population trends) than A1 criterion (past
310 population trends). The fulfillment of one criterion is enough to classify the species at the highest
311 category of threat. Thus, according to A2 criterion, the Dupont's lark is correctly listed as
312 'Vulnerable' in the European Red List of Birds, in the SCTS and in the Regional Catalogues of

CM, CV and RM. Of particular concern, however, are Dupont's lark populations in AN and CL, where the species qualifies to be listed as 'Endangered'. However, CL has not yet elaborated a RCTS, while the species is currently listed as 'Vulnerable' in AN. In the other regions (AR, CA and NA), the species should be classified as 'Vulnerable' according to the category of threat assigned in the SCTS (Law 42/2007, 13th December). If the same assessment would have been carried out using previous applicable criteria in the SCTS (before March 2017; Dirección General para la Conservación de la Naturaleza 2004), the cataloguing scenario would have changed drastically. Under the old criteria the Dupont's lark should have been listed as 'Endangered' (A2 criterion; population size reduction of ≥ 40% within the next 20 years), evidencing the effects that listing criteria modification may have on the management and conservation of threatened species.

In this study, we assessed the conservation status of the Dupont's lark according to A criteria, since we had no reliable data for including other criteria in our analyses. Therefore, a similar comprehensive assessment should be carried out considering the remaining listing SCTS criteria (reduction in area of occupancy and/or population viability analysis; Resolution 6th March 2017) to elucidate whether or not the species should be classified as 'Endangered', ensuring proper listing of the species at both European and national level. For instance, consensus among experts (D criteria; Resolution 6th March 2017) upon the need of its reclassification as "Endangered" exists (Tella *et al.* 2005, Pérez-Granados and López-Iborra 2014, Garza and Traba 2016). Future research should focus on accurately estimating the reduction in area of occupancy. Besides, a population viability analysis could be carried out to assess the risk of extinction in the coming years, although estimating reliable demographic parameters for the whole population of this secretive species is challenging.

Conclusions

Despite methodological constraints due to slight overdispersion, missing data, and low proportion of populations incorporated for AR, we believe that our results are conclusive. The European Dupont's lark population faces a 3.9% annual declining rate, entailing an expected average population decline of 32.8% within the next 10 years. The pressures faced by the species have not ceased during the last years (Tella *et al.* 2005, Íñigo *et al.* 2008, Garza and Traba 2016), and may be expected to increase in the future due to strong fragmentation and high vulnerability to stochastic factors (Laiolo and Tella 2006b, Vögeli *et al.* 2010, Méndez *et al.* 2011, Gómez-Catasús et al. 2018). Under this scenario, the implementation of a wide-range conservation plan within the Iberian distribution is vital to ensure the conservation of the species. According to Spanish legislation the elaboration of a Conservation Plan is mandatory for those species classified as 'Vulnerable', as the Dupont's lark since 2004 (Orden MAM/2784/2004), and this is within the competence of the Autonomous Communities. In addition, Autonomous Communities are legally obligated to comply with current legislation in cataloguing endangered species (Law 42/2007, 13th December). Therefore, the species should be classified as 'Endangered' in Andalusia and Castile-Leon, and as 'Vulnerable' in Aragon, Catalonia and Navarra. In this context, the legal responsibility of administrations to law enforcement is crucial to reverse declining population trends of this and other endangered taxa.

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Figure 1(on next page)

Dupont’s lark distribution in Spain according to Suárez, 2010 (light grey) and Dupont’s lark populations included in this study (black).

The names of the Autonomous Communities where the species is present, are shown. The arrow refers to an isolated region belonging to the Community of Valencia. AN: Andalusia. AR: Aragon. CA: Catalonia. CL: Castile-Leon. CM: Castile-La Mancha. CV: Community of Valencia. NA: Navarre. RM: Region of Murcia.

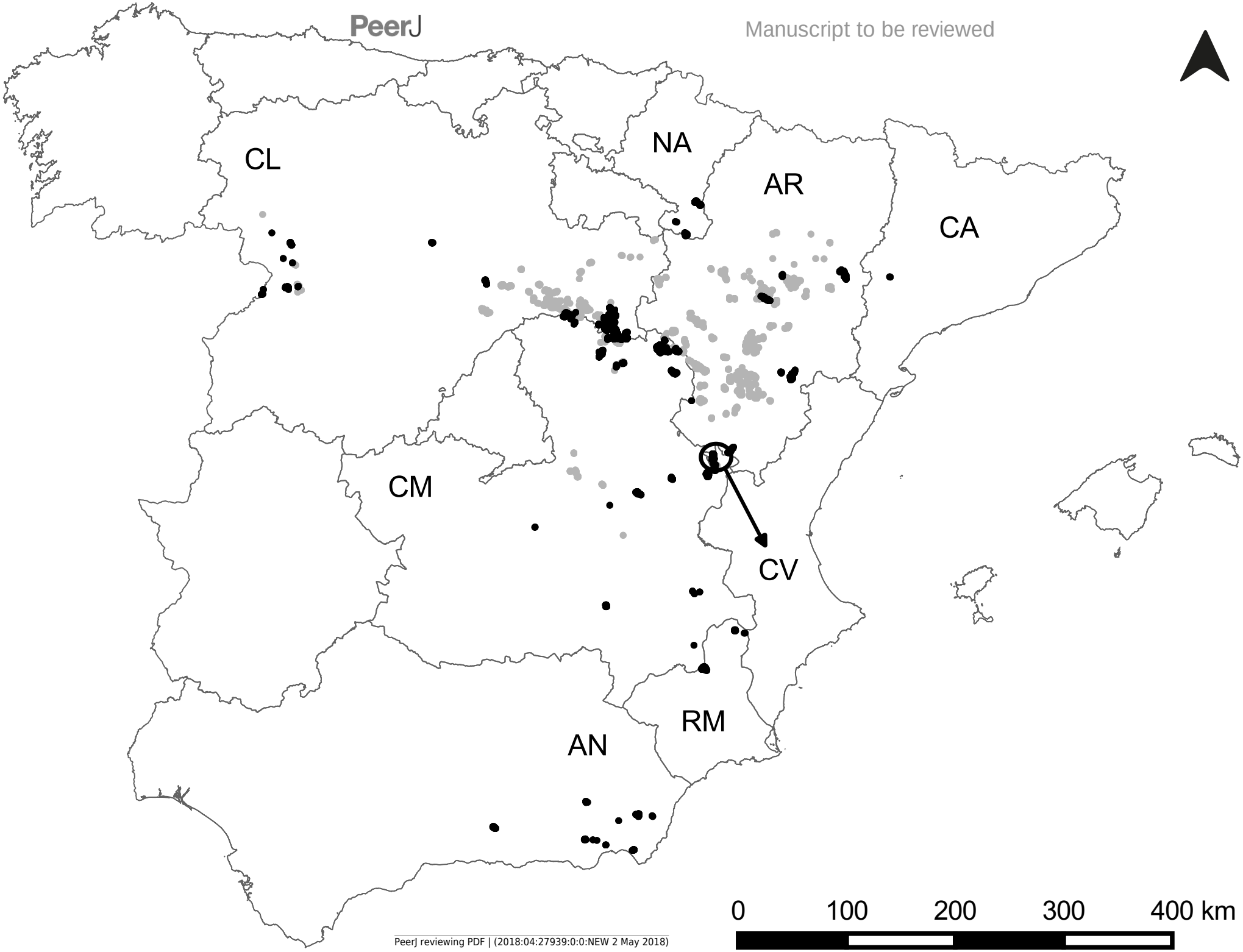
CL
NA
AR
CA
CM
CV
RM
AN
0
100
200
300
400 km

Figure 2(on next page)

Population size indices estimated by the Switching Linear Trend model for 92 Dupont's lark populations during the 2004 – 2015 period.

Time-points incorporated in the model as significant change-points on population trends are marked with asterisk (*).

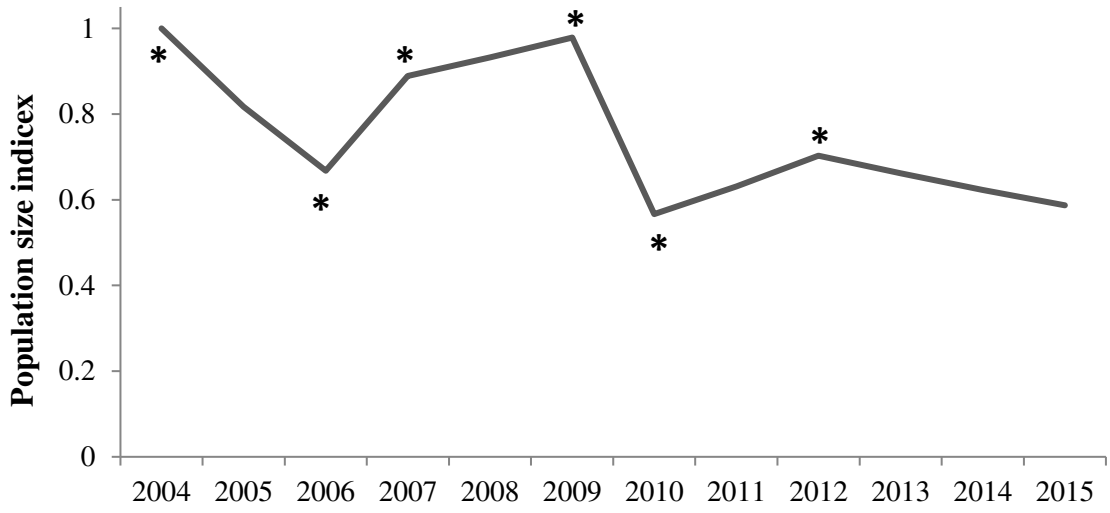
Population size indicex
1
0.8
0.6
0.4
0.2
0
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Figure 3(on next page)

Population size indices predicted by Switching Linear Trend models during the 2004 – 2015 period for each Autonomous Community.

Time-points incorporated in models as significant change-points on population trends are marked with asterisk (*). AN: Andalusia. AR: Aragon. CA: Catalonia. CL: Castile-Leon. CM: Castile-La Mancha. CV: Community of Valencia. NA: Navarre. RM: Region of Murcia.

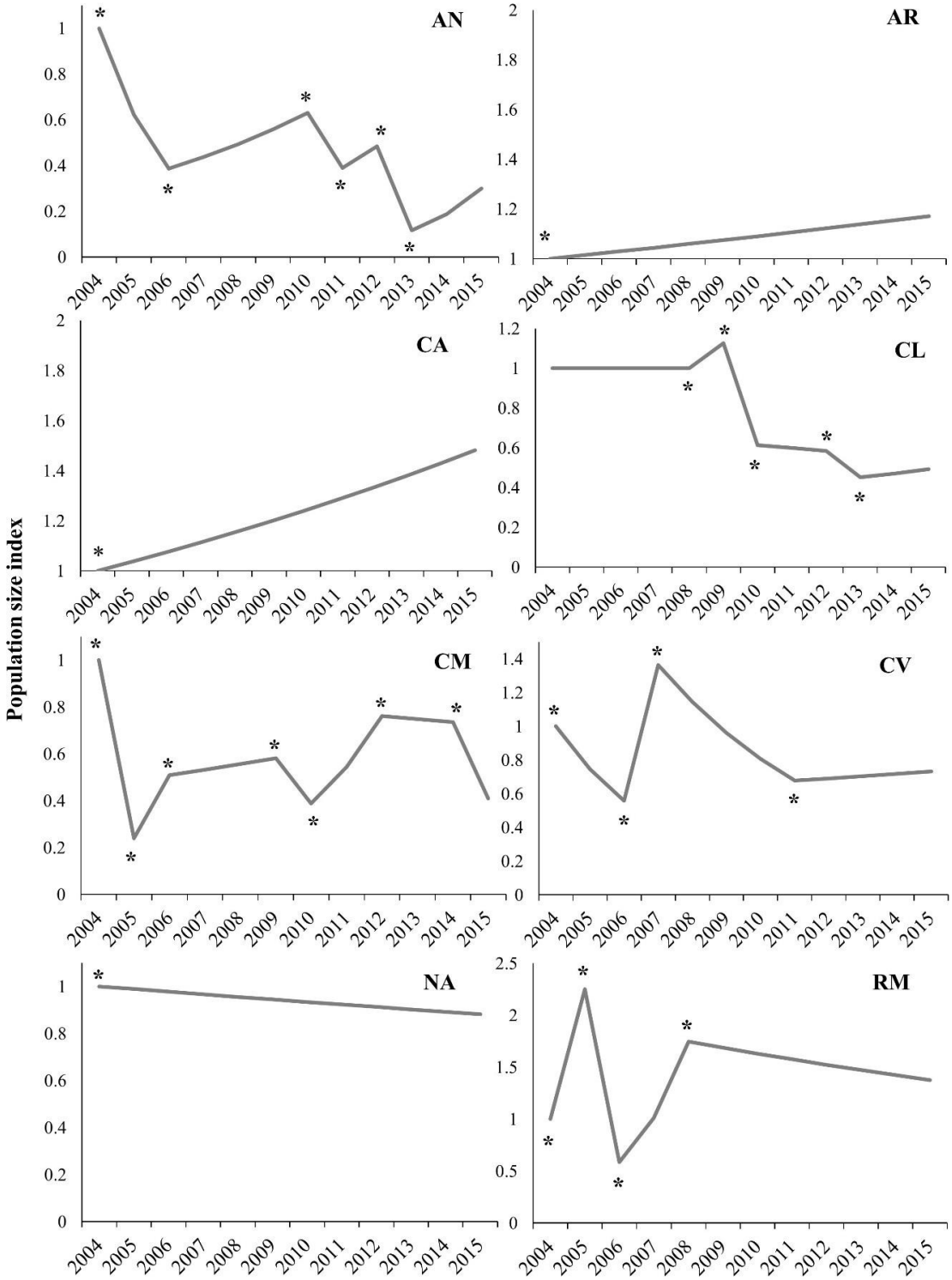
AN
AR
CA
CL
CM
CV
NA
RM
Population size index
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015

Table 1(on next page)

Results of regional Switching Linear Trend models through the time series 2004-2015.

AN: Andalusia. AR: Aragon. CA: Catalonia. CL: Castile-Leon. CM: Castile-La Mancha. CV: Community of Valencia. NA: Navarre. RM: Region of Murcia.

	AN	AR	CA	CL	CM	CV	NA	RM
Number of populations	12	10	1	29	26	8	3	3
Local extinction events	6	0	1	9	6	3	1	0
Missing values (%)	38.2	81.6	58.3	49.1	63.1	44.8	63.9	47.2
Annual change rate (%)	-10.9	+1.5	+3.6	-8.4	+1.5	-2.5	-1.1	+2.6
95% Confidence Interval	[-16.2; -5.7]	[-2.3; +5.2]	[-33.5; +40.8]	[-10.0; -6.7]	[-2.1; +5.1]	[-5.7; +0.7]	[-7.9; +5.6]	[-2.2; +7.5]
TRIM Trend[a]	Steep decline	Uncertain	Uncertain	Steep decline	Uncertain	Uncertain	Uncertain	Uncertain
Wald-test change rate	-	-	0.04	-	-	-	-	-
p-value	-	-	> 0.05	-	-	-	-	-
Goodness-of-fit test								
Chi-squared ($\chi 2$)	98.98	11.56	-	187.13	152.34	63.00	2.00	4.98
p-value $\chi 2$	0.0158*	**> 0.05**	-	< 0.01	< 0.01	0.0152*	**> 0.05**	**> 0.05**
Likelihood Ratio (LR)	100.81	11.85	-	211.67	139.36	63.53	2.24	5.44
p-value LR	0.0115*	**> 0.05**	-	< 0.01	< 0.01	0.0136*	**> 0.05**	**> 0.05**
AIC	-41.19	-10.15	-	-74.33	-24.64	-18.47	-3.76	-18.56
Overdispersion	1.39	1.01	6.67	1.29	1.69	1.43	0.66	0.23
Serial correlation	0.09	-0.18	-0.06	0.39	0.20	0.30	-	0.06

1 P-values of accepted models are marked in bold
2 P-values of models near to acceptance threshold are marked with asterisk (*)
3 [a] Trend classification attending to TRIM criteria (Pannekoek and Van Strien 2006b)

Table 2(on next page)

Assessment of Dupont's lark threat category.

Overall and average annual change rate obtained from trend analysis, and current threat category at National and Regional Catalogues of Endangered Species are shown. In addition, population size change in a 10-year period and corresponding threat category attending to A1 and A2 criteria applicable in the SCTS (Resolution 6th March 2017) are provided. The 95% Confidence Intervals are shown in brackets. Threat categories: Sensitive to Habitat Alteration (SHA), Vulnerable (VU) and Endangered (EN). AN: Andalusia. AR: Aragon. CA: Catalonia. CL: Castile-Leon. CM: Castile-La Mancha. CV: Community of Valencia. NA: Navarre. RM: Region of Murcia. SP: Spain.

	Overall change rate (%) from 2004 to 2015	Average annual change rate (%)	Current category of threat	Change rate for 10 years (%)	Category of threat – A1 criterion	Category of threat – A2 criterion
AN	-70.0 [-87.3; -52.7]	-10.9 [-16.2; -5.7]	VU[a]	-68.5 [-82.9; -44.4]	VU [EN; None]	EN [EN; VU]
AR	+17.1 [-30.2; +64.5]	+1.5 [-2.3; +5.2]	SHA[b]	+16.1 [-20.8; +66.0]	None [None; None]	VU* [VU*; VU*]
CA	+48.2 [-536.3; +632.6]	+3.6 [-33.5; +40.8]	-	+42.4 [-98.3; $+2.9 \cdot 10^3$]	None [EN; None]	VU* [EN; VU*]
CL	-50.8 [-60.8; -40.8]	-8.4 [-10.0; -6.7]	-	-58.4 [-65.1; -50.0]	VU [VU; VU]	EN [EN; EN]
CM	-59.0 [-78.9; -39.1]	+1.5 [-2.1; +5.1]	VU[c]	+16.1 [-19.1; +64.4]	None [None; None]	VU* [VU*; VU*]
CV	-26.8 [-55.3; +1.7]	-2.5 [-5.7; +0.7]	VU[d]	-22.4 [-44.4; +7.2]	None [None; None]	VU* [VU; VU*]
NA	-11.8 [-77.2; +53.6]	-1.1 [-7.9; +5.6]	SHA[e]	-10.5 [-56.1; +72.4]	None [VU; None]	VU* [EN; VU*]
RM	+37.4 [-53.6; +128.4]	+2.6 [-2.2; +7.5]	VU[f]	+29.3 [-19.9; +106.1]	None [None; None]	VU* [VU*; VU*]
SP	-41.3 [-50.2; -32.5]	-3.9 [-4.9; -2.8]	VU	-32.8 [-39.5; -24.7]	None [None; None]	VU [VU; none]

[a] Decree 23/2012 of 14 February 2012
[b] Decree 49/1995 of 28 March 1995
[c] Decree 33/1998 of 5 May 1998
[d] Decree 32/2004 of 27 February 2004
[e] Decree 563/1995 of 27 November 1995
[f] Law 7/1995 of 21 April 1995
* Minimum category of threat in accordance to the category of threat in the SCTS (Law 42/2007, 13th December)