Prioritizing Conservation and Research Effort for Poorly Known Species: The Buttonquails (Turnicidae) as a Study Case

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Prioritizing conservation and research effort for poorly known species: the buttonquails (Turnicidae) as a study case

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Conservation status assessment of bird species is essential to prioritize conservation and monitoring efforts; however, this is not always possible to achieve due to lack of field data or scientific knowledge. In this context citizen science platforms can act as a data source to prioritize the conservation and research resources within a region or a given taxonomic group. Merging the available information on bird distribution areas from BirdLife International and field observations from eBird, the main citizen science birding app, we create a concern index, using the poorly known buttonquails (Turnicidae) as a case study. This concern index is based on two parameters: scarcity and uncertainty, which ultimately are based on two components, respectively. For every species, we defined scarcity as a combination of its frequency of occurrence (proportion of positive eBird checklists) and its relative range size, while uncertainty is a combination of the eBird effort (density of eBird checklists) and the range accuracy (proportion of positive eBird checklists within the BirdLife distribution area). We found a high correlation (Spearman $r = 0.74$) between our concern index and the IUCN threat categories for all buttonquail species. Then we apply this concern index to all buttonquail subspecies obtaining a ranked list for these non-assessed taxa, with some island endemic subspecies ranking very high together with the most endangered buttonquail species. Our approach is a very simple method to rank species within a given bird group and prioritize monitoring and conservation efforts. Moreover, it is also suitable for other taxonomic levels as subspecies or even for ecological units as populations, which normally lack a formal conservation status assessment.

Key words: distribution, citizen science, Turnicidae, eBird

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The assessment of the conservation status of species is an essential preliminary step in wildlife management and should largely be based on accurate scientific knowledge of trends in their distribution ranges and/or overall abundances (Dayton 2003, Groves *et al.* 2002). It enables the prioritization of resources and actions in biodiversity conservation (Wilson *et al.* 2009, Arponen 2012). While the coverage of formal assessments of conservation status by the IUCN may be still insufficient for several invertebrate, plant and fungi groups, vertebrates have a much better assessment level, birds being the first group to achieve a complete evaluation of extinction risk for all known species (IUCN 2022). However, even for these groups, it is not always possible to achieve sound assessments, due to the lack of both scientific knowledge and good field data (Papeş & Gaubert 2007, Martin & Molina 2013, Rueda-Cediel *et al.* 2018). Bird groups with very secretive habits are particularly difficult to study. This is particularly apparent in species for which field data are very difficult to obtain (Drew & Collazo 2012) as is the case for some nocturnal, marsh or forest bird species such as owls (Strigidae), crakes and rails (Rallidae), pittas (Pittidae) or tapaculos (Rhinocryptidae), resulting in classification as Data Deficient (Butchart & Bird 2010). In this sense, the buttonquail (Turnicidae) family is a good example of a group of very cryptic species, which very often pass unnoticed to bird observers. Buttonquails are one of the most understudied bird families (Yarwood *et al.* 2019, Winkler *et al.* 2020), whose unobtrusive behaviour makes them truly difficult to detect by both sight and voice being most notably detected by their tracks and other signs of activity (Gutiérrez-Expósito *et al.* 2011, Lees & Smith 1998). An exhaustive review of specific bibliographic references regarding all buttonquail species resulted in only 184 items, published between 1844 and 2019, in which the main study subject was a buttonquail species, of which only 104 were field-based studies (Gutiérrez-Expósito 2020). Only 78 of these publications are peer-reviewed articles and were mostly focused on endangered species found in economically developed areas: South Africa (Fynbos Buttonquail *Turnix hottentottus*), Europe (Common Buttonquail *T. sylvaticus*) or Australia (Black-breasted Buttonquail *T. melanogaster*), while most of the basic biological knowledge remains virtually unknown for most of them, even for some still common and widespread species (Gutiérrez-Expósito 2020).

Following del Hoyo & Collar (2014), the family Turnicidae is composed of 18 bird species, all belonging to the genus *Turnix*, except the Quail-plover *Ortyxelos meiffreni*. The Turnicidae is an Old-World bird family with distribution ranging from the West Palearctic and Sub-Saharan Africa to Australia and New Caledonia through South and East Asia and the islands of Malaysia, Philippines and Indonesia. Turnicidae are strictly ground dwellers found mainly in grassland, steppe and low shrub land, with some inhabiting low understory of wet and sclerophyll subtropical and tropical forests (Madge & McGowan 2002, del Hoyo & Collar 2014). While most of the species are monotypic or consist of two subspecies, three have much greater subspecific variation, most of them being island endemics (Table 3; del Hoyo & Collar 2014). Most of the species are listed as Least Concern in the IUCN Red List. However almost all other categories can be found within the family, with Black-breasted Buttonquail and Sumba Buttonquail *T. everetti* listed as Vulnerable, Buff-breasted *T. olivii* and New Caledonia Buttonquail *T. novaecaledoniae* as Critically Endangered and Luzon Buttonquail *T. worcesteri* as Data Deficient (del Hoyo & Collar 2014, IUCN 2022).

In this context, citizen science platforms can provide an opportunity to overcome the scarcity of scientific-based information on buttonquails and other poorly known bird groups through the participation of a huge number of observers reporting worldwide (Wiersma 2010, Wood *et al.* 2011). Among others, eBird, developed by the Cornell Lab of Ornithology, is the largest worldwide citizen science birding platform (Sullivan *et al.* 2014). These data are based on the creation of birding lists for a given location and date (hereafter checklist). Every checklist gives the option to record the number of individuals or just presence under different protocols. Up to July 2022, eBird has nearly 8 hundred thousand users who have contributed to this database with nearly 70 million complete checklists around the globe, which are reviewed by local expert reviewers, ensuring the correct identifications of birds listed by users.

In this paper, we will use the elusive buttonquails as a study case to provide a simple index to prioritize the study and conservation actions for all species and subspecies. This is performed through the combination of available distribution information already composed by BirdLife International and the field data provided by the eBird citizen science platform. This concern index has been estimated for every taxon as a combination of two parameters: (1) the scarcity of the taxon and (2) the uncertainty of the available data for the taxon, while each parameter is based on two components respectively. Relative range size and frequency of occurrence have been used as an approximation to the scarcity of the taxon, while range accuracy and eBird effort have been used to calculate the uncertainty parameter.

Table 1. Concern index parameters composition for each taxon with the definition of its respective components.

Index	Parameter	Component	Definition
Concern	Scarcity	relative range	Value between 0 and 1 resulting from a min-max normalization of the range size
		frequency of occurrence	Proportion of positive checklists within its BirdLife range
	Uncertainty	range accuracy	Proportion of positive checklists that fall out of its correspondent range
		eBird effort	Density of total eBird checklists within its range

The cryptic nature of buttonquails, the lack of scientific knowledge together with the small number of species with a high subspecific variation with all IUCN Red List categories represented, make the Turnicidae family a very good model avian group to evaluate a synthetic approach like this. Although using the same principles as those used in IUCN Red List assessments (IUCN Standards and Petiotions Committee 2022), the resulting index is based on a single dynamic continuously updated public database which has the potential to allow to prioritize the conservation and research needs not only for every bird family or group but also for lower taxonomical levels such as subspecies or even ecological units such as populations.

METHODS

We obtained data (hereafter observations) for all buttonquail species from the eBird platform, together with a global database of effort events (eBird 2019) from 1913 to May 2019 (eBird 2019). Buttonquails are terrestrial birds, so we used all eBird data available except those logged under the pelagic protocol (Sullivan *et al.* 2009), which means complete checklists, partial checklists and incidental observations. With these data, we created a spatially explicit point GIS layer file for every buttonquail species. Even when common, buttonquails are seldom seen so any sighting is highly appreciated by birdwatchers. Therefore we assumed that all buttonquails are equally difficult to observe and that they are always registered when an encounter with any of the species takes place. Consequently, we assumed that whenever buttonquails were not mentioned in a checklist the bird had not been spotted and thus, we treated those checklists as buttonquail absences. We used the spatially explicit shape files of buttonquail distribution maps provided by BirdLife International and Handbook of the Birds of the World (2018) to define the study areas for every buttonquail species. We calculated its range size, as the BirdLife extent of occurrence in km^2, by using the 'area' algorithm of QGIS in the World Cylindrical Equal Area coordinates reference system.

With these data, we created four components to be paired to obtain two parameters, which will be the base for the calculation of the concern index. As a proxy for species abundance, we named the first parameter 'scarcity' which is a combination of the relative range size of the taxon and its frequency of occurrence in the eBird data set, while as an approximation to the accuracy of the existing knowledge, we called the second parameter 'uncertainty', which results from the combination of the accuracy of its distribution area, hereafter range accuracy and the eBird survey effort, hereafter eBird effort.

The relative range value results from scaling the extension of the range sizes (km^2) of the species set, between 0 and 1, by min-max normalization, as:

$$\frac{x - m}{M - m}$$

where x is the range size of a given species, m is the range size of the most restricted species and M is the range size of the most widely distributed species. The frequency of occurrence is the proportion of eBird observations of a given species out of all the checklists made within its BirdLife distribution area.

We calculated the range accuracy of the distribution areas as the proportion of all observations for a given species which lay within its BirdLife distribution area. Finally, we calculated the eBird effort as the checklist density within the BirdLife distribution area.

The same process was done when assessing at subspecific level, but taking into account all 47 described races of every buttonquail species, plus the 12 monotypic species (del Hoyo & Collar 2014). We used the subspecific distribution areas described by del Hoyo & Collar (2014), to split the specific BirdLife distribution areas into subspecific spatial files to calculate their respective range sizes.

Each parameter has been calculated as the geometric mean of its correspondent components. To avoid the skewness of results we used as parameters the absolute values resulting from a logarithmic transformation. To allow operations, all zero and zero/zero values have been approximated to 10^{-10}. Finally, in a bidimensional Euclidean space defined by the uncertainty and scarcity parameters, we calculated, for every taxon, the concern index as the distance to the origin from the point defined by its respective uncertainty and scarcity values as defined by the Pythagoras theorem as:

$$\text{concern index} = \sqrt{\text{uncertainty}^2 + \text{scarcity}^2}$$

The same data was extracted and calculated for every recognized buttonquail subspecies except for those of Barred Buttonquail *T. suscitator* in mainland Asia for which a clear barrier between subspecies cannot be defined. Consequently, the Indian Subcontinent subspecies *taigoor* and *bengalensis* have been treated together and the SE Asia races *blackistoni*, *pallescens*, *thai* and *plumbiceps* have also been treated jointly.

Excluding Data Deficient species, we assigned each IUCN category with a natural number, with lower values for non-endangered species and higher to critically endangered ones, where Least Concern = 1, Near Threatened = 2, Vulnerable = 3, Endangered = 4 and Critically Endangered = 5 (IUCN 2022). To validate our results, we did a Spearman correlation test between the obtained concern index and its parameters and the current IUCN Red List categories.

RESULTS

eBird data

We obtained a total of 21,511 buttonquail eBird observations from 8948 different localities worldwide (Table 2), comprising all buttonquail species except the Luzon Buttonquail and the New Caledonian Buttonquail, for which there were no sighting in the eBird database. Distribution maps and spatial distribution of eBird sightings of all buttonquails species can be consulted in Figure S1. More than half of the observations correspond to a single species, the Barred Buttonquail (n = 11,314) a common and widespread species found in South East Asia. The proportion of observations of a given species that fell within its distribution area as reported by BirdLife International ranged between 1 in Spotted Buttonquail *T. ocellatus* and Sumba Buttonquail to none in the Buff-breasted Buttonquail. The sampling effort made by birdwatchers within the distribution areas of the different buttonquail species was highly variable ranging from 2 checklists/100 km^2 for the Black-rumped Buttonquail *T. nanus* to 60 and 86 checklists/100 km^2 for the Black-breasted Buttonquail and the Buff-breasted Buttonquail, respectively (Table 2).

Together with the monotypic Luzon and New Caledonia Buttonquails, up to 26 buttonquail subspecies have not a single observation in the eBird database. In addition to the monotypic Little *T. velox* and Painted Buttonquails *T. varius*, three subspecies or subspecies groups of Barred Buttonquail had more than 1000 observations: Taiwan *T. s. rostratus* (n = 4289, 19.9%), Indian *T. s. taigoor* and *bengalensis* (n = 4185, 19.5%) and Indochinese *T. s. blackistoni*, *pallescens*, *thai* and *plumbiceps* (n = 1061, 4.9%), together with the Kurrichane Buttonquail *T. sylvaticus lepuranus* (n = 1327, 6.2%) (Table 3). Up to 13 subspecies or monotypic species (23.6%) have all their eBird observations within the BirdLife International corresponding distri-

Table 2. Number of total eBird observations (eBird total), buttonquail observations (eBird in BirdLife) and total checklists within the corresponding BirdLife International distribution area (eBird checklists). Extent of occurrence area in km^2 as defined by BirdLife (Range size), scarcity and uncertainty parameters and concern index for every buttonquail species, IUCN conservation status and number of subspecies by systematic order (del Hoyo & Collar 2014).

Species	eBird total	eBird in BirdLife	eBird checklists	Range size	Scarcity parameter	Uncertainty parameter	Concern index	IUCN categories	Number subspecies
T. olivii	11	0	1777	2066	8.68	5.03	10.03	CR	0
T. novaecaledoniae	0	0	1068	16,389	6.60	5.59	8.65	CR	0
T. worcesteri	0	0	10,801	105,070	6.17	5.49	8.26	DD	0
T. everetti	36	36	335	2065	5.48	0.39	5.50	VU	0
T. melanogaster	473	66	3627	5949	2.75	0.54	2.81	VU	0
O. meiffrenii	35	24	14,455	295,158	2.34	0.74	2.45	LC	0
T. hottentottus	51	40	16,221	333,360	2.22	0.71	2.33	LC	0
T. ocellatus	171	171	10,503	106,158	2.06	0.50	2.13	LC	2
T. castanotus	149	146	33,112	419,636	2.05	0.56	2.12	LC	0
T. maculosus	741	680	425,389	1,139,432	2.05	0.23	2.06	LC	14
T. pyrrhothorax	430	419	886,925	4,284,398	2.03	0.35	2.06	LC	0
T. nanus	211	138	125,697	6,616,766	1.75	0.95	1.99	LC	0
T. nigricollis	676	675	12,807	61,661	1.93	0.34	1.96	LC	0
T. tanki	537	492	958,809	9,316,208	1.84	0.51	1.91	LC	2
T. varius	2929	2858	906,111	2,276,774	1.75	0.21	1.76	LC	2
T. velox	1783	1743	761,408	6,979,269	1.58	0.49	1.65	LC	0
T. sylvaticus	1964	1857	1,531,808	22,843,450	1.46	0.60	1.58	LC	9
T. suscitator	11,314	8346	1,122,928	9,066,182	1.27	0.52	1.37	LC	18

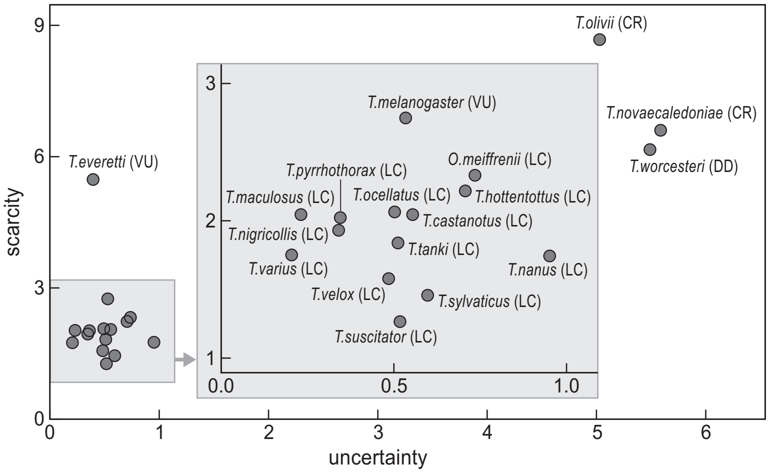

Figure 1. Bidimensional representation of the scarcity and uncertainty parameters to create the concern index of all buttonquail species. IUCN risk extinction category is shown in brackets. For a better understanding, the lower monitoring concern index zone has been enlarged.

bution area, while for the rest there exists much variation, ranging from 0% in the Buff-breasted Buttonquail to 99% in the Madagascar Buttonquail *T. nigricollis*. The highest density of checklists is found in the distribution area of the Taiwan Barred Buttonquail *T. s. rostratus* with up to 1323 checklists/100 km^2.

Concern index

The concern index ranked all buttonquail species between 1.37 and 10.03 (Table 1, Figure 1). As expected, when compared with the IUCN categories values, we found a highly significant positive correlation (r_s = 0.74; Figure 2). Equally, the correlation between the IUCN categories and the scarcity parameter was very high (r_s = 0.74), while correlation with the uncertainty parameter was low (r_s = 0.4). Lower values correspond to the commonest and widespread species such as Barred Buttonquail, Painted Buttonquail, Common Buttonquail, Red-backed Buttonquail *T. maculosus* or Little Buttonquail *T. velox*.

The highest values classified highly threatened species with a small distribution area, such as New Caledonian, Luzon and Buff-breasted Buttonquails, classified by IUCN as Critically Endangered, Data Deficient, and Endangered, respectively (Table 2, Figure 1).

At the subspecific level, the lower value was 1.81, while the highest concern index reached 14.14. The four subspecies which were found to be the rarest were the Bawean Barred Buttonquail *T. suscitator baweanus*, Savu Red-backed Buttonquail *T. maculosus savuensis*, Sulu Common Buttonquail *T. sylvaticus suluensis* and Banggai Red-backed Buttonquail *T. maculosus kinneari*. All of them are endemics of small islands in Indonesia and the Philippines (Table 3, Figure 3).

DISCUSSION

By using data from a single citizen science birding platform and the published distribution areas for every species and subspecies of buttonquails, we have been able to create a simple index to rank monitoring and conservation priorities.

The index correlates with the already published IUCN Red List categories for every species (IUCN 2022). Higher values match with the most endangered species: Buff-breasted, New Caledonia and Luzon Buttonquails. The Buff-breasted Buttonquail is listed as Critically Endangered by the IUCN (2022), and Endangered by the Australian environmental authorities (Mathieson & Smith 2009), remaining the only

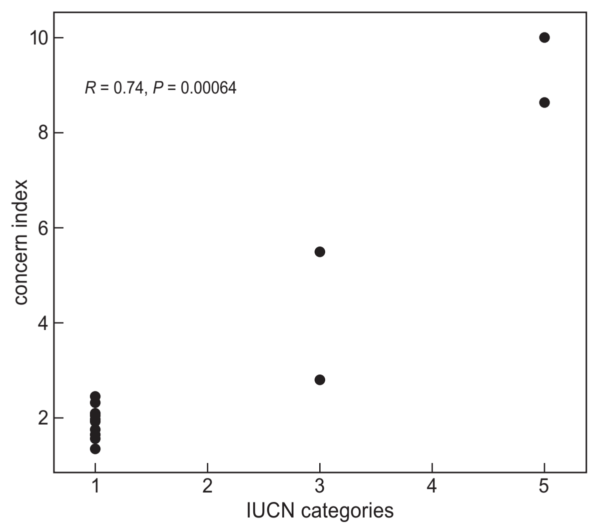

Figure 2. Scatter plot of the concern index and the IUCN categories for buttonquail species.

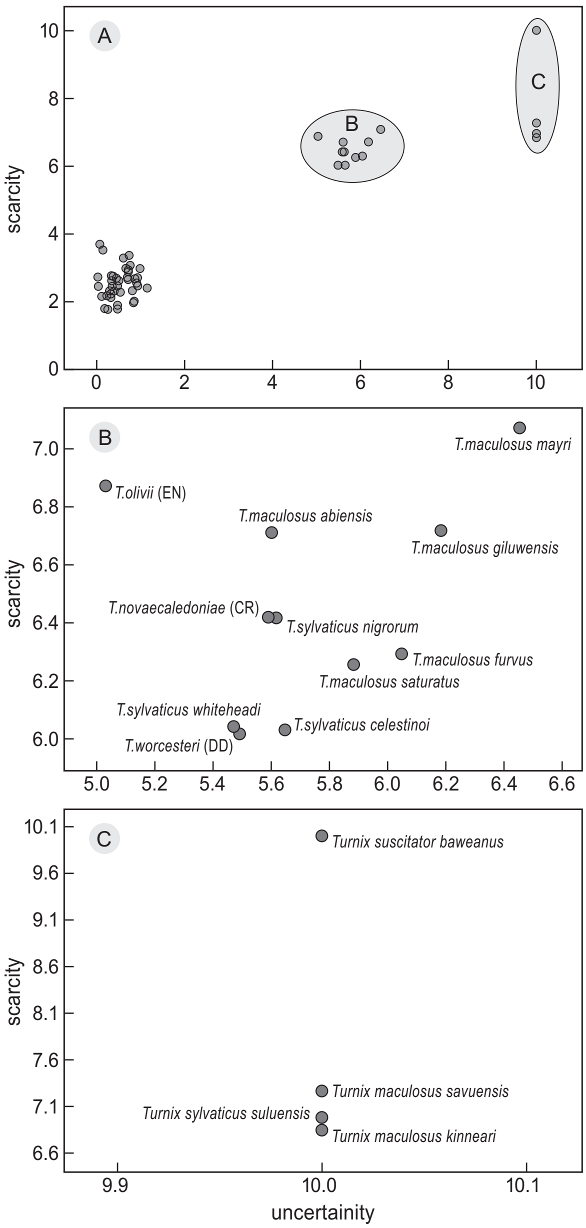

Figure 3. Concern status of (A) all buttonquail subspecies and monotypic species, with a detailed view of the (B) high and (C) very high concern index groups.

Australian bird species never photographed alive. Moreover, very recent research found that most probably all recent sightings should be better regarded as misidentifications with the commoner Painted Buttonquail (Webster *et al.* 2022) and thus proposing to change its Australian legal status to Critically Endangered. Caledonian Buttonquail is listed as Critically Endangered (IUCN 2022). The species is only known by the type specimen when the species was described in 1889 (Ogilvie-Grant 1889). In absence of intensive specific surveys (Elkstrom *et al.* 2002) and due to the absence of sightings, there is serious concern for the continued existence of this species (Butchart *et al.* 2018).

The Luzon Buttonquail is barely known from a few localities in the mountains of central Luzon, in the Philippines (Collar *et al.* 1999). Due to the lack of information, it is listed as Data Deficient (IUCN 2022). As expected, the uncertainty parameter is very high (Table 2). In 2009, after two nights of bird trapping in Dalton Pass, one bird was trapped and sold for food, being the only living specimen of this species ever photographed (Allen 2009), suggesting a viable population may still persist in this region. However, this is the only record in the 21st century. Historically the species is only known from six localities, and 79% of all 43 existing museum specimens were trapped at a single location: Dalton Pass, where there is very heavy hunting pressure by locals (Collar *et al.* 1999, Round & Allen 2010). Although more data are needed, the species should likely be better listed as Endangered or Critically Endangered. The South African fynbos endemic Fynbos Buttonquail, until recently, was listed as Endangered, However, Lee *et al.* (2018) found it to be more common and widespread than previously thought, thus proposing to down list the species to Vulnerable. This species ranks in our index with lower or similar values than other Least Concern species. Currently the species has been re-assessed and listed as Least Concern (IUCN 2022).

Due to the high diversity of living forms, these assessments are usually made only at the species level (IUCN 2022). Nevertheless, conservation status could also be evaluated at lower taxonomic levels, such as subspecies, and multiple ecologically or regionally defined units, such as populations (Gärdenfors *et al.* 2001, Phillimore & Owens 2006). In such cases, many taxa could be in decline before a formal assessment can be done or conservation measures and actions are taken. Based on the correlation between our concern index and the classification of the IUCN Red List we are confident that our concern index will work properly also at the subspecific level. We obtained very high values for highly unmonitored small island endemic subspecies such as Bawean Barred, Savu Red-Backed, Sulu Common and Banggai Red-backed Buttonquails (Table 3, Figure 3D). A possible explanation for these underreported taxa might be that birdwatchers visiting remote islands in search of endemic birds will pay low attention to somewhat less attractive habitats such as

Table 3. Concern index and uncertainty and scarcity parameters for all buttonquail subspecies, subspecies groups, and monotypic species sorted by concern index values with the proposed English names, mostly based on Gutiérrez-Expósito *et al.* (2011) and del Hoyo & Collar (2014).

Buttonquail subspecies		**Concern index**	**Uncertainty**	**Scarcity**
Bawean Barred Buttonquail	*T. suscitator baweanus*	14.14	10.00	10.00
Savu Red-backed Buttonquail	*T. maculosus savuensis*	12.36	10.00	7.27
Sulu Common Buttonquail	*T. sylvaticus suluensis*	12.20	10.00	6.98
Banggai Red-backed Buttonquail	*T. maculosus kinneari*	12.12	10.00	6.84
Louisiade Red-backed Buttonquail	*T. maculosus mayri*	9.58	6.46	7.08
Giluwe Red-backed Buttonquail	*T. maculosus giluwensis*	9.13	6.18	6.72
Obi Red-backed Buttonquail	*T. maculosus obiensis*	8.74	5.60	6.71
Huon Red-backed Buttonquail	*T. maculosus furvus*	8.73	6.05	6.29
New Britain Red-backed Buttonquail	*T. maculosus saturatus*	8.59	5.89	6.25
Negros Common Buttonquail	*T. sylvaticus nigrorum*	8.53	5.62	6.41
Buff-breasted Buttonquail	*T. olivii* (monotypic)	8.52	5.03	6.87
New Caledonia Buttonquail	*T. novaecaledoniae* (monotypic)	8.52	5.59	6.42
Visayan Common Buttonquail	*T. sylvaticus celestinoi*	8.26	5.65	6.03
Luzon Common Buttonquail	*T. sylvaticus whiteheadi*	8.15	5.47	6.04
Luzon Buttonquail	*T. worcesteri* (monotypic)	8.15	5.49	6.02
Abrolhos Painted Buttonquail	*T. varius scintillans*	3.69	0.08	3.69
Andalusian Buttonquail	*T. sylvaticus sylvaticus*	3.53	0.16	3.53
Sumba Red-backed Buttonquail	*T. maculosus sumbanus*	3.46	0.75	3.38
Guadalcanal Red-backed Buttonquail	*T. maculosus salomonis*	3.35	0.62	3.29
Indonesian Common Buttonquail	*T. sylvaticus bartelsorum*	3.17	0.78	3.08
Papuan Red-backed Buttonquail	*T. maculosus horsbrughi*	3.15	1.01	2.99
Visayan Barred Buttonquail	*T. suscitator nigrescens*	3.07	0.68	2.99
Flores Barred Buttonquail	*T. suscitator floresianus*	3.06	0.66	2.99
Northern Spotted Buttonquail	*T. ocellatus benguetensis*	3.04	0.73	2.95
Quail Plover	*O. meiffrenii* (monotypic)	2.93	0.74	2.84
Sulawesi Red-backed Buttonquail	*T. maculosus beccarii*	2.87	0.94	2.71
Fynbos Buttonquail	*T. hottentottus* (monotypic)	2.82	0.71	2.73
Sri Lanka Barred Buttonquail	*T. suscitator leggei*	2.82	0.89	2.67
Palawan Barred Buttonquail	*T. suscitator haynaldi*	2.79	0.36	2.76
Sumba Buttonquail	*T. everetti* (monotypic)	2.78	0.39	2.75
Dusky Barred Buttonquail	*T. suscitator powelli*	2.77	0.74	2.67
Sulawesi Barred Buttonquail	*T. suscitator rufilatus*	2.77	0.93	2.61
Timor Red-backed Buttonquail	*T. maculosus maculosus*	2.73	0.47	2.69
Okinava Barred Buttonquail	*T suscitator okinavensis*	2.72	0.04	2.72
Black-breasted Buttonquail	*T. melanogaster* (monotypic)	2.67	0.54	2.62
Greater Sundas Barred Buttonquail	*T. suscitator suscitator*	2.67	1.17	2.40
Kra Barred Buttonquail	*T. suscitator interrumpens*	2.64	0.37	2.62
Black-rumped Buttonquail	*T. nanus* (monotypic)	2.64	0.95	2.46
Luzon Barred Buttonquail	*T. suscitator fasciatus*	2.52	0.49	2.47
Siberian Yellow-legged Buttonquail	*T. tanki blanfordi*	2.47	0.82	2.33
Southern Spotted Buttonquail	*T. ocellatus ocellatus*	2.46	0.39	2.43
Chestnut-backed Buttonquail	*T. castanotus* (monotypic)	2.45	0.06	2.45
Indian Common Buttonquail	*T. sylvaticus dussumier*	2.35	0.42	2.32
Indian Yellow-legged Buttonquail	*T. tanki tanki*	2.35	0.30	2.33
Indochinese Common Buttonquail	*T. sylvaticus davidi*	2.35	0.56	2.28
Red-chested Buttonquail	*T. pyrrhothorax* (monotypic)	2.24	0.35	2.22
Indochinese Barred Buttonquail	*T. suscitator blackistoni*, *plumbipes*, *pallescens* and *thai*	2.20	0.87	2.02
Malay Barred Buttonquail	*T. suscitator atrogularis*	2.18	0.24	2.17
Australian Red-backed Buttonquail	*T. maculosus melanotus*	2.16	0.14	2.15
Kurrichane Buttonquail	*T. sylvaticus lepuranus*	2.15	0.85	1.98
Madagascar Buttonquail	*T. nigricollis* (monotypic)	2.14	0.34	2.11
Little Buttonquail	*T. velox* (monotypic)	1.97	0.49	1.91
Taiwan Barred Buttonquail	*T. suscitator rostratus*	1.85	0.49	1.78
Common Painted Buttonquail	*T. varius* (monotypic)	1.81	0.21	1.80
Indian Barred Buttonquail	*T. suscitator taigoor* and *bengalensis*	1.81	0.28	1.78

those usually preferred by buttonquails, and consequently those endemic buttonquails subspecies could be under-recorded in the eBird database. Although the lack of data could not confirm the scarcity of these subspecies, it does reveal a high uncertainty about their conservation status, consequently classifying them very high in our concern index. Together with New Caledonian and Buff-breasted Buttonquails, nine more subspecies have high concern index values and thus could be regarded as Endangered (Table 3, Figure 3C). Of these 15 taxa, the Buff-breasted Buttonquail is found in Australia and New Caledonian Buttonquail in New Caledonia, one of the overseas territories of France. Therefore, both species are under the protection of wealthy countries, which means that legislative and economic resources for monitoring and conservation are likely to occur. However, the remaining 13 taxa depend on just three countries: five in the Philippines and four in Indonesia and Papua New Guinea, respectively. In these countries, the conservation of those potentially highly threatened taxa is compromised by the lack of economic and human resources for population monitoring and the design and implementation of effective conservation measures. Among the subspecies with the lowest concern index values, three groups can be identified. Most of them show very low values for both uncertainty and scarcity, and consequently can be considered to be safe (Figure 3B). Among all taxa classified at the lower concern index values, those with higher values are Abrolhos Painted Buttonquail *T. v. scintillans* and the Andalusian Buttonquail *T. s. sylvaticus* (Table 3, Figure 3B). The first one is endemic of the Houtman Abrolhos Islands, a small archipelago in West Australia which is classified as Vulnerable by the Australian Government, while the second one is the only buttonquail species present in the Western Palearctic. Although there is no assessment of the entire taxon, the Andalusian Buttonquail has been classified as Critically Endangered at the European level (BirdLife International 2015). It has been recently considered extinct in Spain, its last stronghold in Europe, by the Spanish Government, with just a single population known to persist in west Morocco (Gutiérrez-Expósito *et al.* 2019).

A similar assessment should be undertaken at the population level, many of which could be highly endangered locally or on the verge of extinction. This could be the case for the Taiwan population of the Indochinese Common Buttonquail, where despite the very high eBird sampling effort made in the island (345,594 checklists), not a single sighting of this species has been obtained, while with the same effort, up to 4290 observations are found for the endemic Taiwan Barred Buttonquail.

The secretive habits of the buttonquails make them easily overlooked. As a consequence, silent extinction processes can occur, as happened with the Andalusian Buttonquail (Gutiérrez-Expósito *et al.* 2020), and this could be a risk for those taxa with a high concern index. However, as research on them continues, more detailed knowledge is coming to light, allowing the downlisting of the Black-breasted Buttonquail and the Fynbos Buttonquail from Endangered to Vulnerable (Lees & Smith 1999, Smyth & Pavey 2001, IUCN 2022) and Least Concern (Lee *et al.* 2017, 2018, IUCN 2022), respectively, giving some hope for those understudied species and subspecies.

Our approach is a very simple method to evaluate the monitoring and conservation priorities for taxa lacking a formal extinction risk assessment within a given avian group. Furthermore, as far as the concern index is based on two components, uncertainty and scarcity, it is also possible to prioritize focusing on research or conservation, or both, depending on the component's values obtained. Rather than a substitute of the formal assessments, this index is especially useful as it can be applied not only to bird species but also to other taxonomical levels as subspecies or even to ecological units as populations of a given species.

Of course, a simple approach like this is has limitations. Results in areas where eBird is not the primary birding tool should be taken with caution as data in these areas can underestimate bird occurrence. However, as when we examine buttonquail observation data we control for observation effort, we think that the results obtained should be comparable among taxa. We applied our novel approach just to one bird family, but future work could expand it to other bird groups or adapt it to the information available from different data sources for other taxa.

In summary, in a conservation landscape of perpetually limited funds, we propose a straightforward approach that can give managers, policymakers and ecologists an easy tool to prioritize conservation and research resources.

ACKNOWLEDGEMENTS

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SAMENVATTING

Het is door gebrek aan veldgegevens of wetenschappelijke kennis niet altijd mogelijk om bij de beoordeling van de staat van instandhouding van vogelsoorten aan te geven welke inspanningen op het gebied van bescherming of onderzoek prioriteit moeten krijgen. Burgerwetenschap ('citizen science') kan hiertoe binnen een regio of voor bepaalde taxonomische groepen een belangrijke gegevensbron zijn. We hebben als 'case study' de weinige veldwaarnemingen van alle soorten vechtkwartels (Turnicidae) op eBird samengevoegd met de beschikbare informatie over de door BirdLife International gehanteerde verspreidingsgebieden en vervolgens op basis van schaarste en onzekerheid een prioriteitsindex vastgesteld. Schaarste wordt hier gedefinieerd als een combinatie van de frequentie van voorkomen van een soort (aandeel positieve eBird checklists) en de relatieve grootte van het verspreidingsgebied. Onzekerheid is gedefinieerd als een combinatie van de eBird-inspanning (dichtheid van eBird checklists) en de nauwkeurigheid van het verspreidingsgebied (aandeel positieve eBird checklists binnen het verspreidingsgebied). Wij vonden voor alle soorten vechtkwartels een hoge correlatie (Spearman r = 0,74) tussen de berekende prioriteitsindex en de door de International Union for Conservation of Nature and Natural Resources (IUCN) gepubliceerde bedreigingsstatus. Vervolgens hebben we deze index toegepast op alle ondersoorten en een rangschikking voor deze niet-beoordeelde taxa gemaakt. Sommige endemische eilandondersoorten scoorden zeer hoog, samen met de soorten vechtkwartels die als meest bedreigd worden aangemerkt. De hier gevolgde aanpak is een eenvoudige methode om soorten binnen een bepaalde vogelgroep te rangschikken en prioriteiten voor monitoring en instandhoudinginspanning aan te geven. De methode is ook geschikt voor ondersoorten en zelfs voor populaties, die normaal gesproken geen formele beoordeling van de staat van instandhouding hebben.

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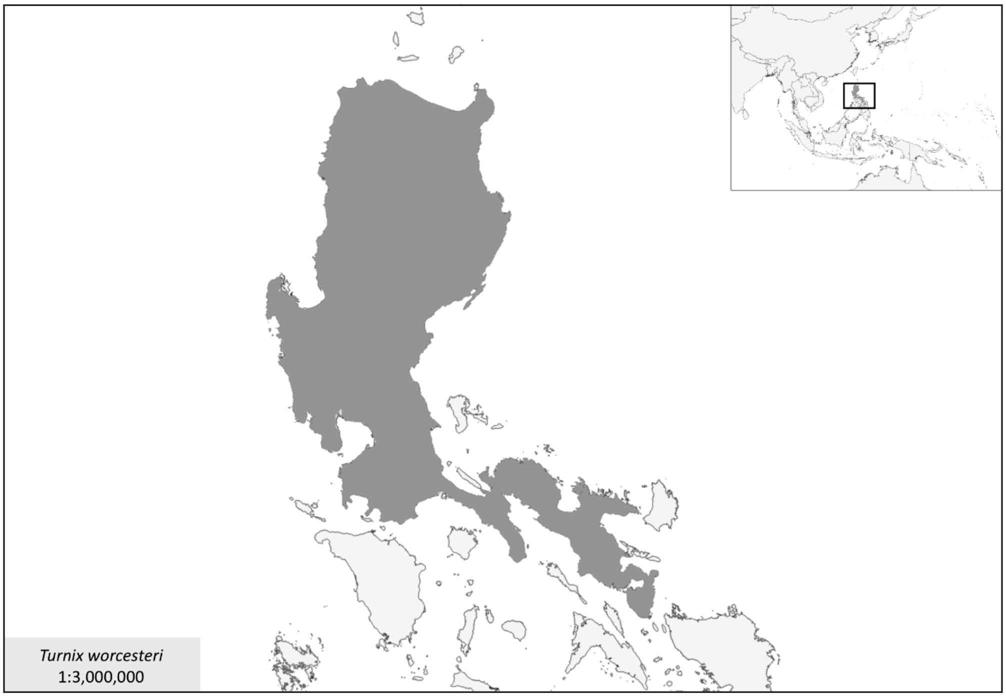
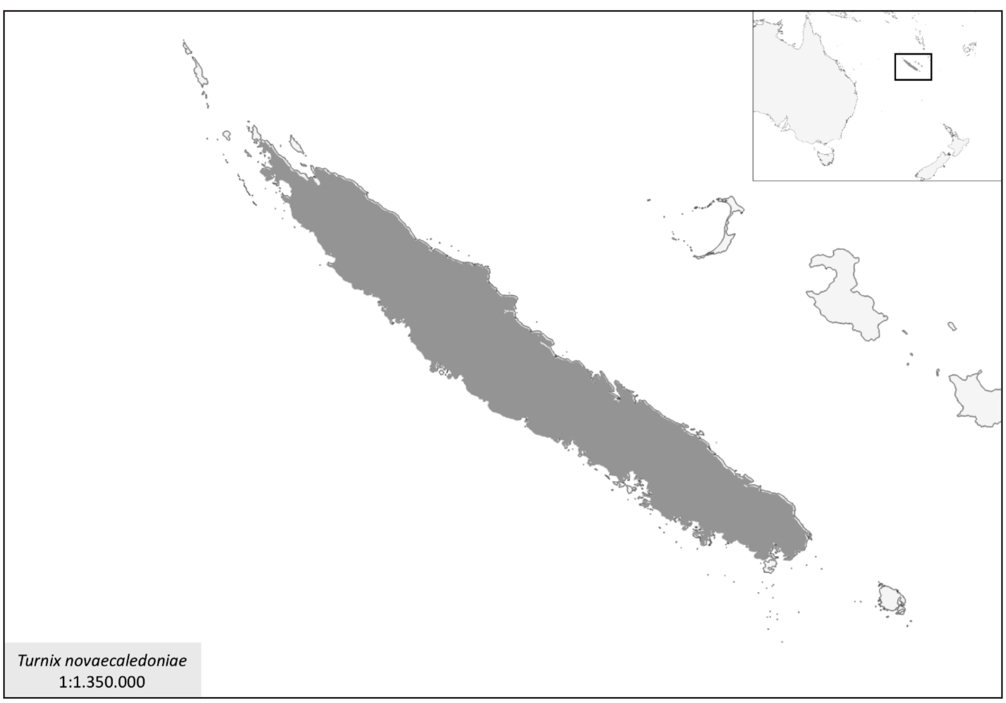
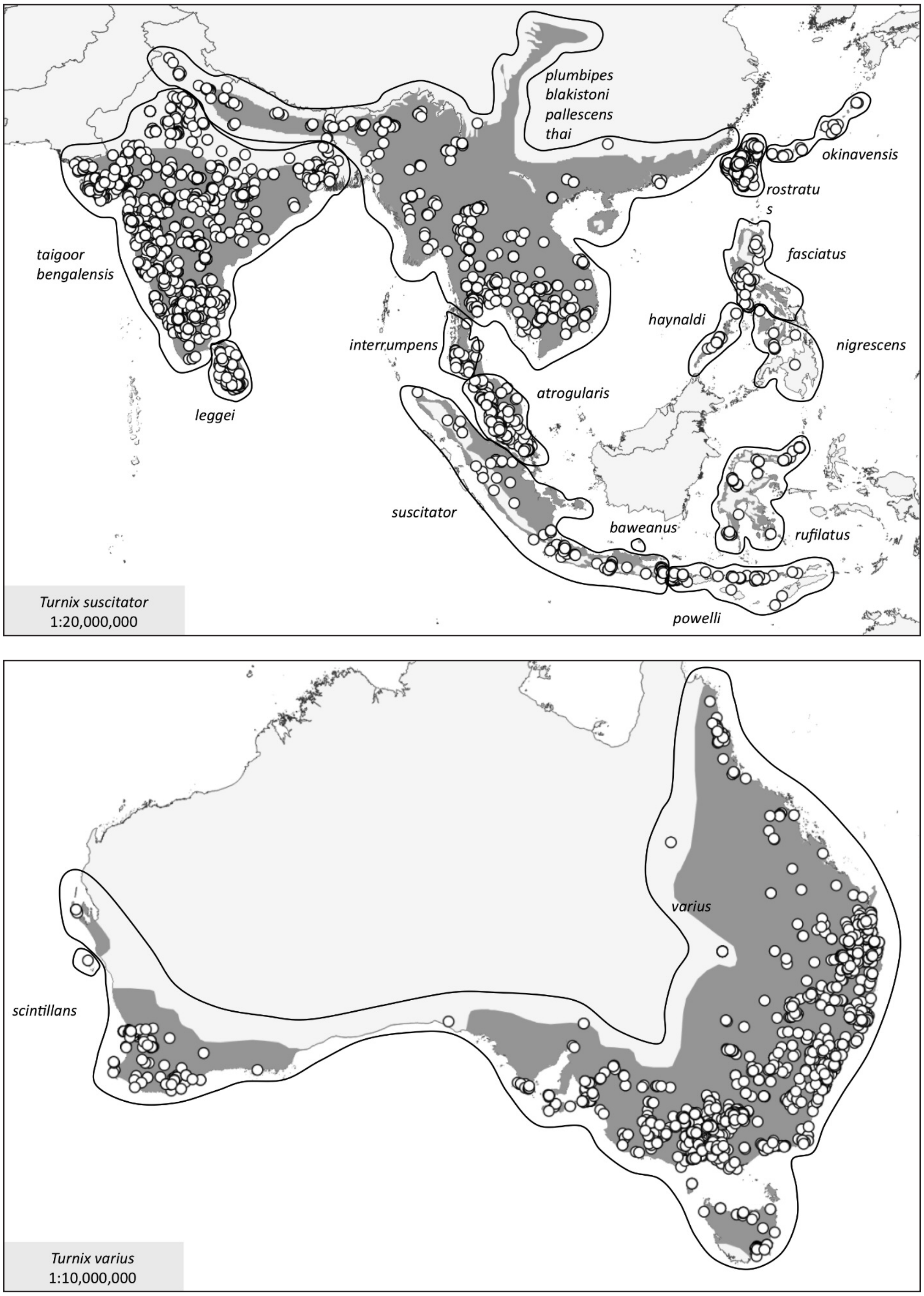
SUPPLEMENTARY MATERIAL

Figure S1. BirdLife distribution areas (grey shaded areas) and eBird available sightings (white dots) for all buttonquail species. For polytypic species, the subspecies name is given and the distribution is indicated with a black line.



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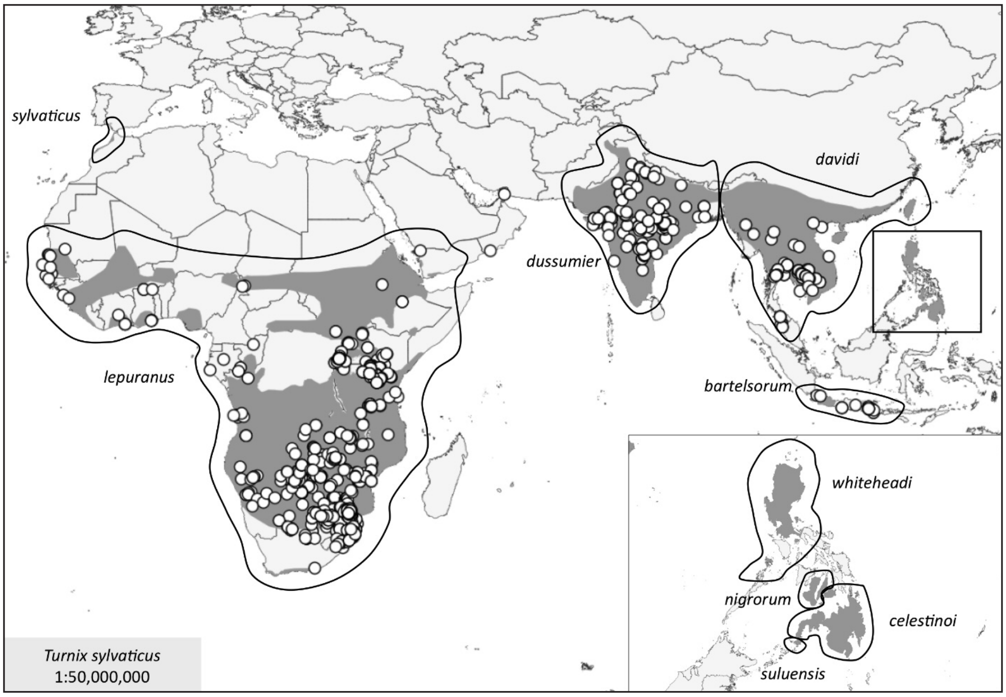
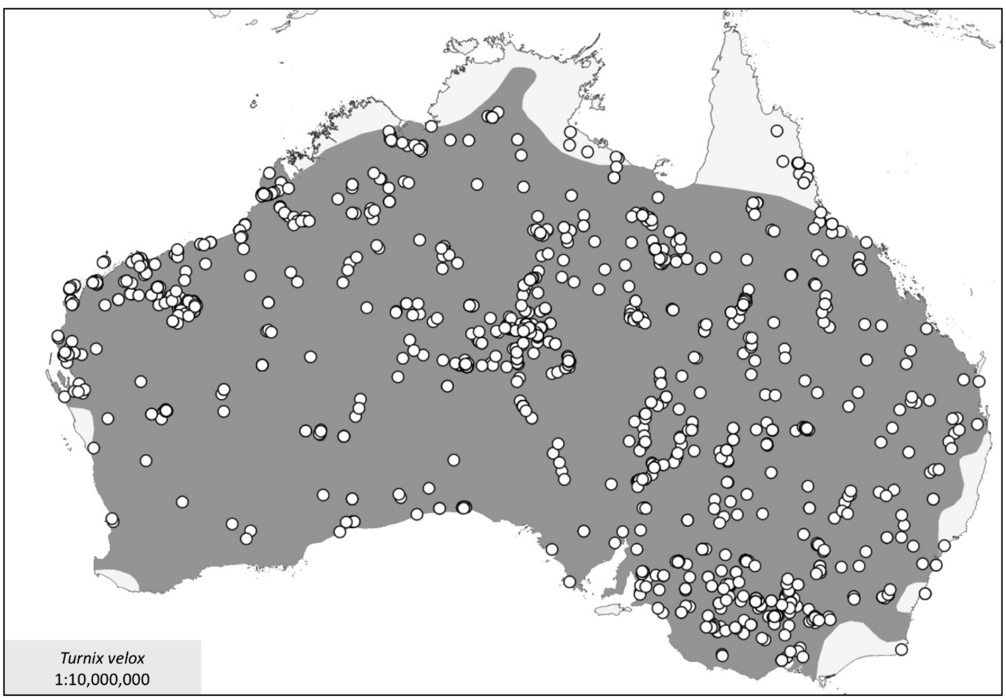
pallescens
thai
okinavensis
rostratu
s
fasciatus
taigoor
bengalensis
haynaldi
nigrescens
interrumpens
atrogularis
leggei
suscitator
baweanus
rufilatus
powelli
Turnix suscitator
1:20,000,000
varius
scintillans
Turnix varius
1:10,000,000


sylvaticus
davidi
dussumier
lepuranus
bartelsorum
whiteheadi
nigrorum
celestinoi
suluensis
Turnix sylvaticus
1:50,000,000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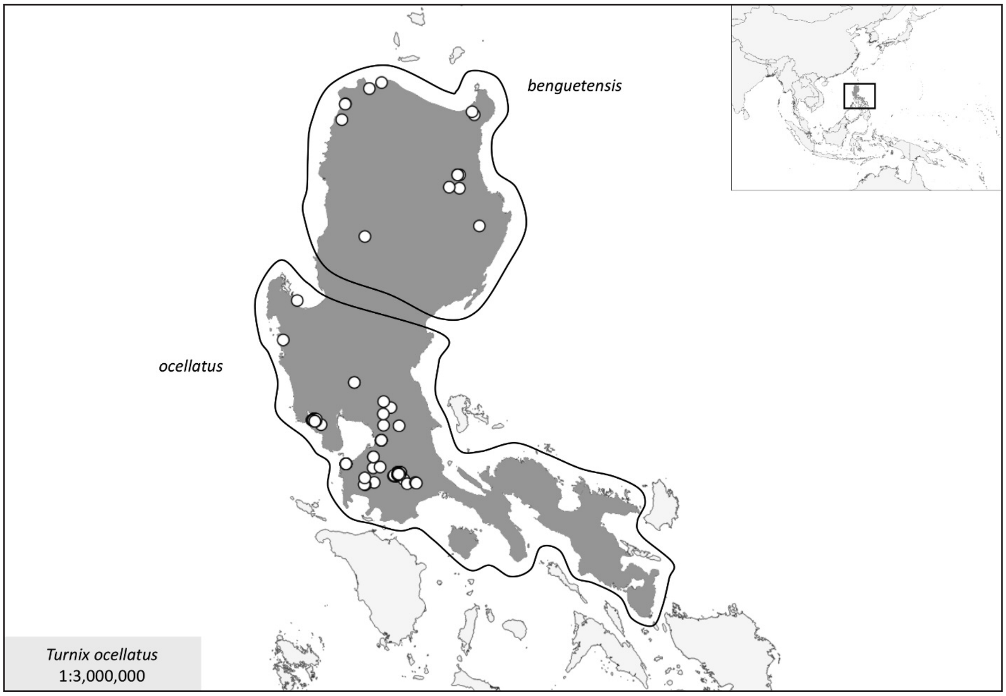
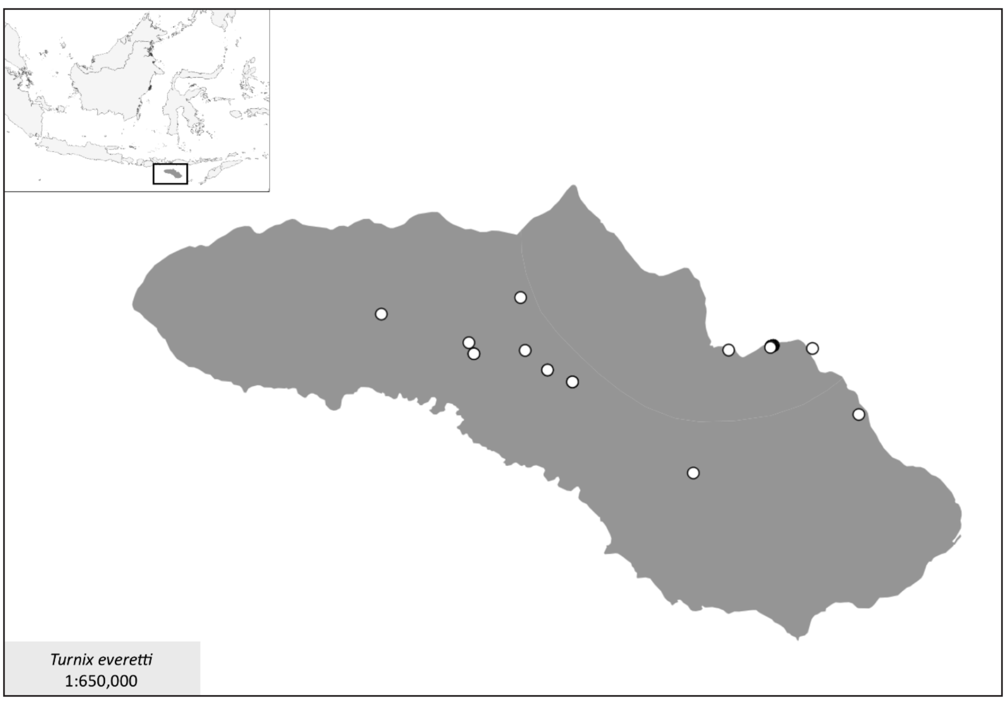
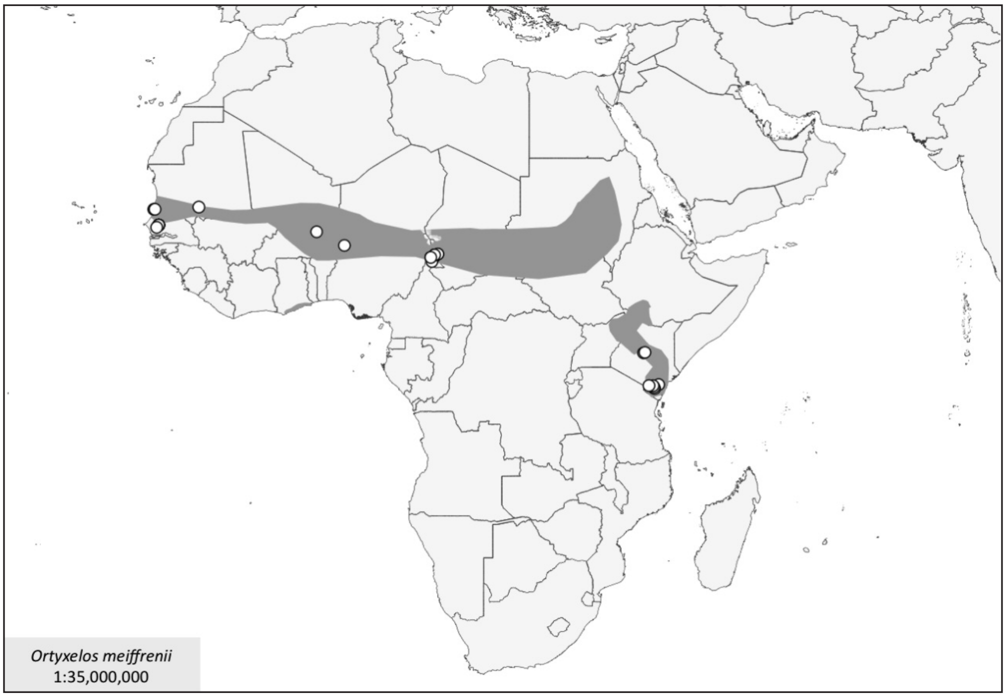

benguetensis
ocellatus
Turnix ocellatus
1:3,000,000


Turnix everetti
1:650,000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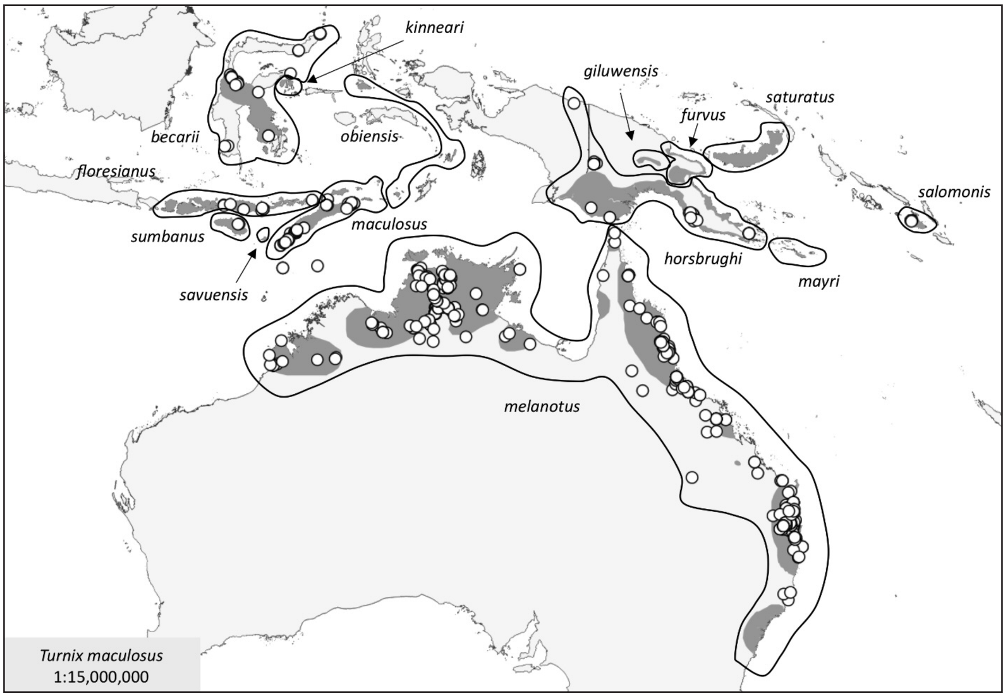
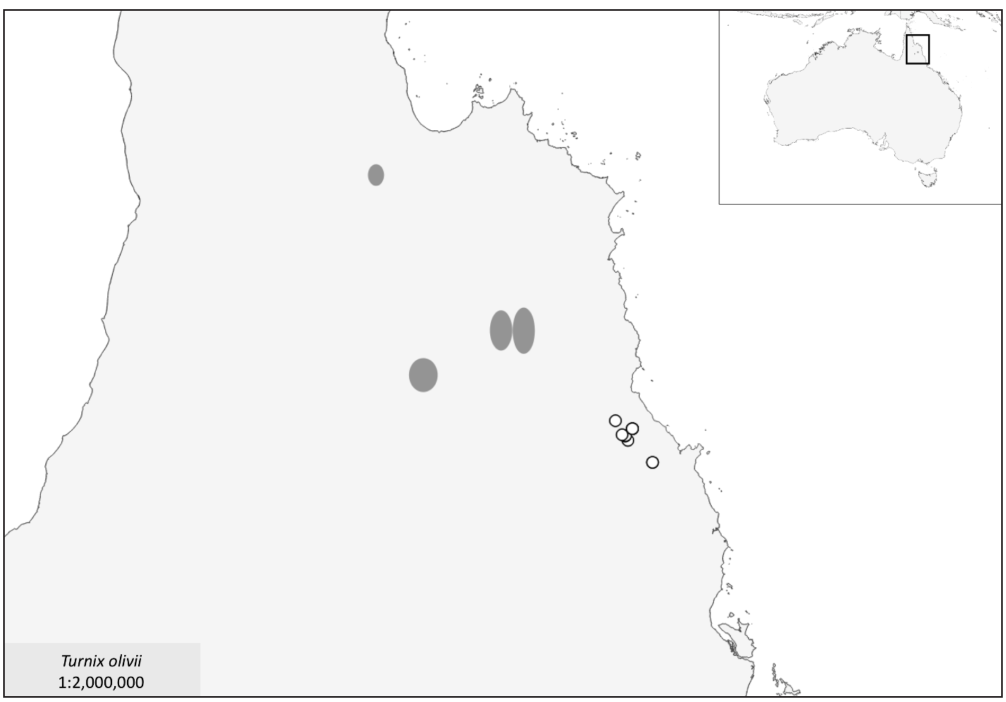
1:35,000,000


Turnix melanogaster
1:3,000,000


kinneari
giluwensis
saturatus
furvus
becarii
obiensis
floresianus
salomonis
sumbanus
maculosus
horsbrughi
mayri
savuensis
melanotus
Turnix maculosus
1:15,000,000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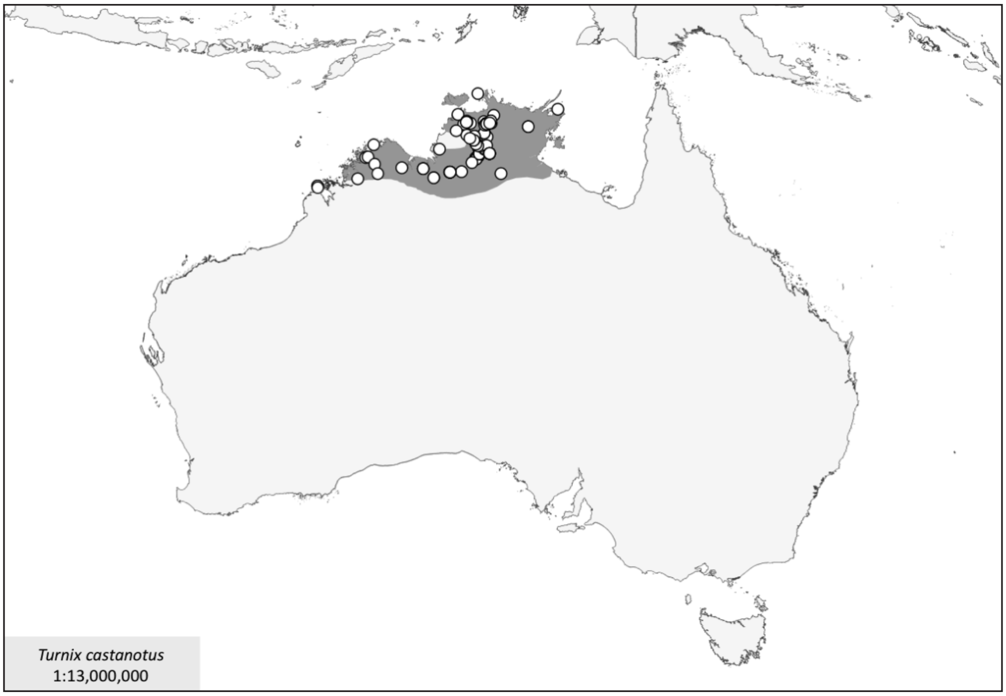
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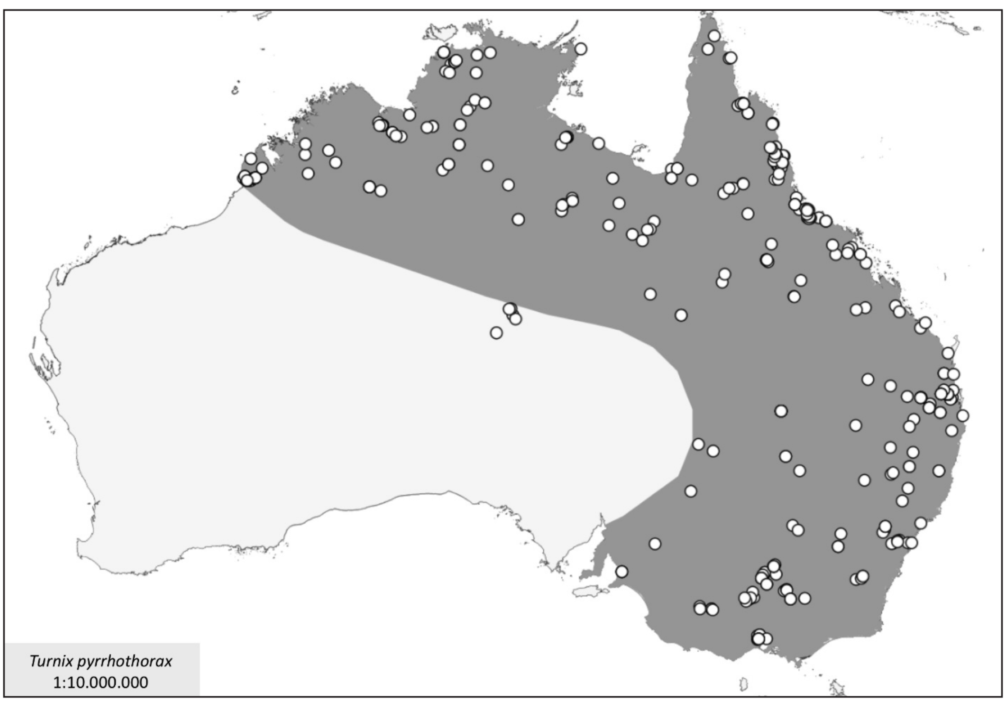
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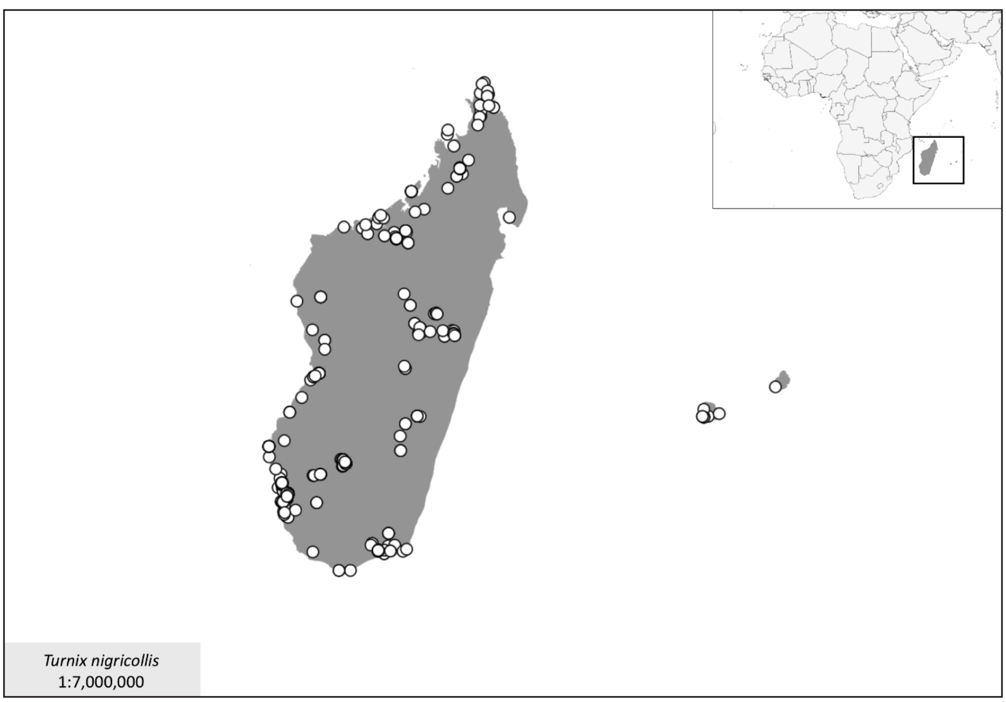
1:10.000.000


tanki
blanfordi
Turnix tanki
1:15,000,000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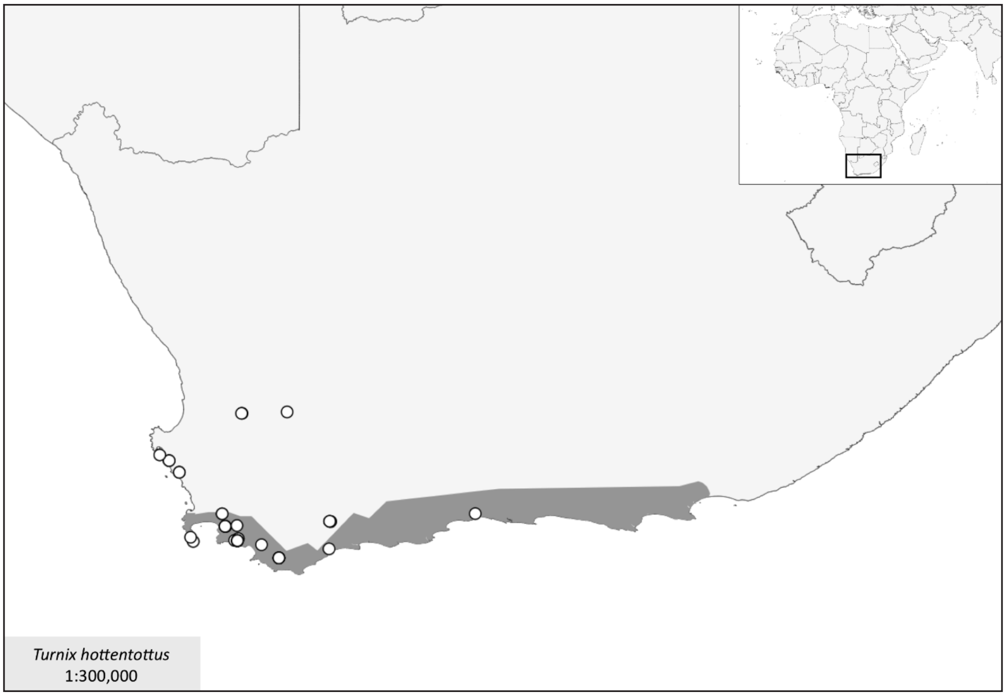
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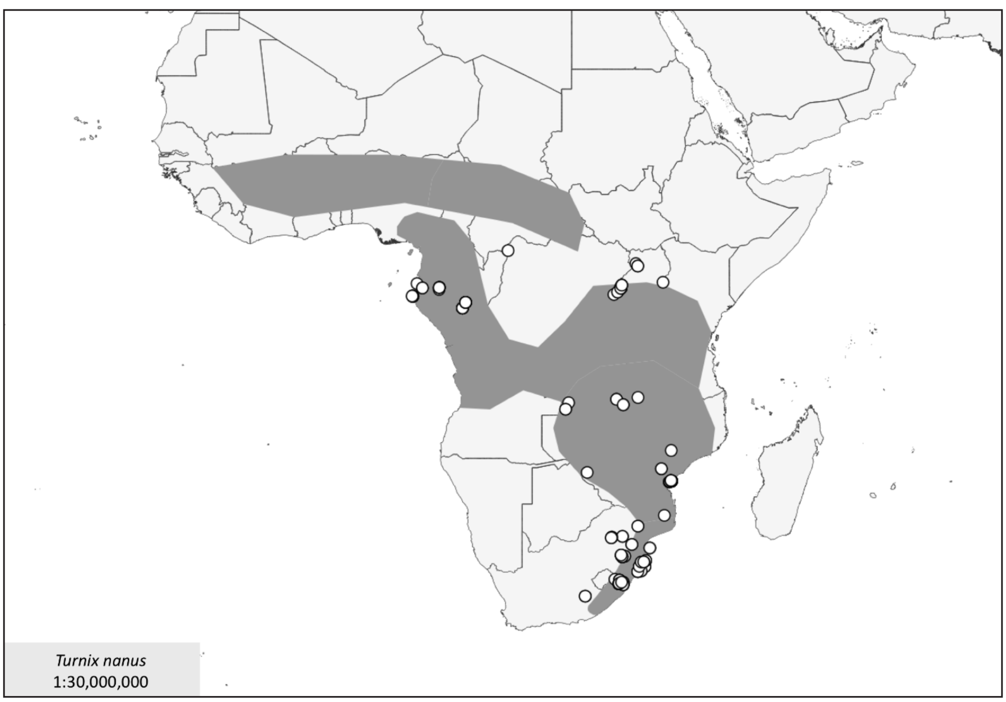
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