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COMMENTARY

Commentary to biodiversity and conservation Upgrading Birgus: lessons for invertebrate conservation

Tim Caro[1]

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Abstract
Coconut crabs *Birgus latro* have recently been reclassified from Data Deficient to Vulnerable on the IUCN Red List. This is a somewhat unusual case of temporal and spatial information being used to change the IUCN status of an arthropod and it draws attention to the paucity of biological data on most invertebrate species. To be listed, two or more scientific criteria need to be documented but such data are unavailable for many invertebrates. This raises the question as to whether certain invertebrates receive more scientific attention and are hence more likely to be listed if, like the coconut crab, they are large, slow-reproducing or a dual-biome species (characteristics which make them inherently vulnerable) and whether being an indicator or a flagship species is important.

Keywords Arthropod conservation · *Birgus latro* · Coconut crabs · Flagship species · IUCN listing

Introduction

A terrestrial arthropod, well-known because of its size and strength, the robber or coconut crab (*Birgus latro*) (Laidre 2018), has just been upgraded from Data Deficient to Vulnerable on the IUCN Red List (Cumberlidge 2020) because it cannot respond easily to habitat change and direct exploitation (Caro et al. 2020; Cumberlidge et al. 2022). The species is slow to start to reproduce with males reaching sexual maturity only at 6 years, 7–9 years for females; it reproduces only once per year; incurs extremely high offspring mortality at sea; terrestrial adults are a delicacy and are easy to catch at night; and the species lives along coastlines with limestone karst and humic soils that are being destroyed or converted

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✉ Tim Caro
tmcaro@ucdavis.edu

[1] School of Biological Sciences, University of Bristol, Bristol BS8 1TQ, UK

at a rapid pace (Cumberlidge et al. 2022). Soon *B. latro*, the sole member of its genus, may additionally be vulnerable to rising sea levels and ocean acidification because the adult life stage lives near terrestrial coastlines and offspring develop a calcareous exoskeleton at sea. In spite of the coconut crab being an invertebrate, it has attracted an unusual amount of scientific attention and there are many research groups currently working on it. In part, this interest stems from it being the world's largest terrestrial arthropod with a leg-span reaching 1m and a body weight of up to 4kg (Brown and Fielder 1991) and it has the strongest pinch-force in the animal kingdom (Oka et al. 2016).

How do scientists know this species is in trouble? Despite its Indian and Western Pacific Ocean distribution being vast by any standards (81million km^2), Cumberlidge and colleagues had to calculate the real expanse on which the most geographically limited life stage is found: a small terrestrial area of occupancy of between 546km^2 and 75,000km^2 (0.000007–0.0009% of its global range). Next the researchers managed to document 14 different extinction locations and population declines on 12 separate island archipelagos (Cumberlidge et al. 2020). They also knew it had a very slow life history (Amesbury 1990; Fletcher et al. 1990). In summary, their coconut crab conservation study brought together the location of extant populations, of extinct populations, their life history, protection schemes and other details to make a case for upgrading (Cumberlidge et al. 2020, 2022). A very small percentage of arthropods receive this sort of scientific scrutiny and so it is worth examining some of the conservation questions raised by this detective work.

Results

Invertebrates are being lost from many ecosystems; as illustrations, molluscs (Régnier et al. 2009), insects (Fonseca 2009; Hallmann et al. 2017; Forister et al. 2019) and decapods (De Grave et al. 2015) are all in rapid decline (Eisenhauer et al. 2019). Yet the proportion of invertebrate species that is actually listed by IUCN is far lower than for vertebrates. For a species to be listed, detailed information is needed on some of these five criteria: (i) population size reduction (past, present and/or projected), (ii) geographic range size and fragmentation, or number, decline or fluctuations in certain locations, (iii) information to show a small and declining population size and its fragmentation, fluctuation, or there being a few subpopulations, (iv) information demonstrating a small population size or a very restricted distribution, and (v) a quantitative analysis of extinction risk notably a population viability analysis (IUCN Standards and Petitions Committee 2022). This raises the question of whether information for these listing criteria are more likely to be available for only a subsample of invertebrate species possessing certain characteristics. More specifically, was there something special about coconut crabs that made them easy to list in comparison to other arthropods or invertebrates.

(i) Was *Birgus* listed because it is such a big land crab and larger species are more likely to be exploited? Although human exploitation is a major threat to this species, it is also a problem for marine invertebrates that are often disproportionately targeted due to gear selectivity yet many of these are not listed (for example, the giant Pacific octopus *Enteroctopus dofleini*). While large size increases vulnerability (Purvis et al. 2000), it does not seem to be a factor in facilitating listing although it may counterintuitively be a benefit in attracting conservation attention.

(ii) Coconut crabs may be unusual because they are K-selected. R and K-selection are old concepts but, definitions notwithstanding, slow maturing, slow reproducing species find it hard to buffer anthropogenic insult. Interestingly, a surprising number of other invertebrates have these traits too, and some show extensive parental care (Trumbo 2012). Certainly, other slow growing invertebrates that are exploited are in also trouble although, again, they are often not listed: witness the historical exploitation of molluscs (e.g., Newell 1988), and the current harvesting of large clams and conch shells for the tourist trade (e.g., Lucas 1994; Theile 2001).

(iii) Is it fact that *B. latro's* life history encompasses both marine and terrestrial environments? Certainly, dual biomes are challenging. For example, sea turtles are notoriously prone to anthropogenic pressures due to bycatch, eating plastic waste, egg collection, and shrinking beach coastlines caused by development and rising sea levels (Butt et al. 2016). Another example comes from migratory birds using stopovers; they are subject to exploitation when airborne and habitat destruction at resting locations (Harris et al. 2009; Runge et al. 2014). Similarly, many invertebrates have aquatic larval and terrestrial adult stages such as shelled molluscs, crustaceans and diptera suggesting that the coconut crab is not necessarily special in this regard.

(iv) Was the coconut crab listed because it is an indicator species signaling environmental problems or species being in trouble at lower trophic levels (Caro 2010)? Coconut crabs may be an apex predator in some circumstances (Laidre 2017) but they are principally omnivores so are unlikely to particularly sensitive to changes in lower trophic levels, so it is difficult to argue that this species is an indicator of much other than coral rag forest destruction.

(v) Was *Birgus* listed because it is a flagship species chosen for its large size and strength (Barua et al. 2012), and has therefore attracted a lot of scientific study (Laidre 2018)? This is a strong possibility because the necessary data from many studies were available. Unfortunately, this is a worrying observation as many invertebrates will never be flagships simply because they are not seen as attractive, colourful, large and they are not homeotherms, all of which are important contributors to achieving flagship status (Clucas et al. 2008; Caro 2010; Barua et al. 2012).

Conclusion

Cardoso and colleagues (Cardoso et al. 2011) outlined seven impediments facing invertebrate conservation: public, political and scientific dilemmas, and Linnean (taxonomic), Wallacean (biogeographical), Prestonian (spatio-temporal abundance) and Hutchinsonian (resource limitation) shortfalls, and then went on to summarize how better marketing, red-listing, parataxonomy, inventorying and monitoring can overcome these hurdles. Coconut crab conservation science has cleared many of these obstacles because its taxonomy is understood, its life history is known, and its distribution is now partially documented, although it still falls far short on local public and political appreciation. Nonetheless, this case study of listing is instructive because it demonstrates that invertebrate conservation is a challenging discipline because disproportionately few scientists work on this topic. Many invertebrate species have both sedentary and mobile life stages, occupy several habitats, and live for long periods which not only make them vulnerable but also make monitor-

ing demanding and their population biology difficult to understand. Beyond that, invertebrates face the challenge of being taken seriously by the public and decision-makers. We need more good science and better public relations to give invertebrates the attention they deserve (Wilson 1987).

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