frontiers | Frontiers in Ecology and Evolution

TYPE Mini Review
PUBLISHED 10 January 2023
DOI 10.3389/fevo.2022.1050191

OPEN ACCESS

EDITED BY
Artem Nedoluzhko,
European University at Saint Petersburg, Russia

REVIEWED BY
Reuven Yosef,
Ben-Gurion University of the Negev, Israel

*CORRESPONDENCE
Özgün Emre Can
✉ oecan@ankara.edu.tr

SPECIALTY SECTION
This article was submitted to Conservation and Restoration Ecology, a section of the journal Frontiers in Ecology and Evolution

RECEIVED 21 September 2022
ACCEPTED 16 December 2022
PUBLISHED 10 January 2023

CITATION
Can ÖE and D'Cruze N (2023) Cognitive biases can play a role in extinction assessments: The case of the Caspian tiger. *Front. Ecol. Evol.* 10:1050191. doi: 10.3389/fevo.2022.1050191

Cognitive biases can play a role in extinction assessments: The case of the Caspian tiger

Özgün Emre Can[1]* and Neil D'Cruze[2,3]

[1]Department of Biology, Faculty of Science, Ankara University, Ankara, Turkey, [2]World Animal Protection, London, United Kingdom, [3]Department of Natural Sciences, Ecology and Environment Research Centre, Manchester Metropolitan University, Manchester, United Kingdom

The premature declaration of a species as extinct has been reported across different taxonomic groups and is commonly referred to as Romeo's error or the Lazarus effect. In this study, based on a review of historical records and testimonies from local communities, we review the case of Caspian tiger (*Panthera tigris virgata*), a species we consider was prematurely declared globally extinct in 1950s. Considering that compelling evidence which suggests that Caspian tigers existed in Turkey perhaps up until early 1990s (some 40 years after international scientific community considered the species extinct) it is reasonable to posit that conservationists missed a historical opportunity to save the species. The case of the Caspian tiger demonstrates the cognitive bias of the Dunning-Kruger effect in action and the potential implications for conservation experts who are engaged in remotely evaluating contemporary species distributions. To mitigate these factors when assessing the global status of species threatened by extinction, we suggest that increased awareness of this type of cognitive bias could facilitate the introduction of additional measures in relevant conservation initiatives and in IUCN Red List assessments. For example, the formation of independent and specific teams to unearth implicit assumptions and weaknesses in assessments, and to question the group thinking of the species assessors. Against the backdrop of the current unprecedented rapid biodiversity decline, we recommend that researchers should be alert of the cognitive biases involved in species assessments and in conservation at large.

KEYWORDS

Caspian tiger, extinction, Romeo's error, Lazarus species, species assessments, IUCN Red List, IUCN

Introduction

The discipline of ecology and conservation is encumbered by a surprisingly large quantity of missing or incomplete information about the number of species, their distributions and status (Pimm et al., 2014). Even for popular and relatively large animals such as mammals, birds, and amphibians, taxonomic catalogues are still incomplete (Lees and Pimm, 2015). Since ecologists do not know what exists, they are obviously poorly placed to know what is being lost. This knowledge gap impedes conservation and increases extinction risk (Turvey et al., 2015). According to the IUCN, of the 71,576 species assessed,

only 860 have become extinct in the wild (Pimm et al., 2014). However, recent mathematical models confirm that this is a serious underestimate (Tedesco et al., 2014). The problem is not only that diagnosing extinction is difficult (Roberts, 2006) but also that an unknown number of species are becoming extinct before they have been described by science (Keith and Burgman, 2004).

Conservation has another problem. Declaring a species extinct prematurely is sufficiently common to have a name, indeed there are two: Romeo's error (Collar, 1998) and the Lazarus effect (Keith and Burgman, 2004). Rediscovery of species that are incorrectly considered to be extinct aren't limited to the minute or the obscure, for example non-vascular plants, invertebrates, fungi and microorganisms whose lack of "charisma" has denied them research focus. In fact, this effect even obscures the regional existence of charismatic carnivores such as striped hyaenas (*Hyaena hyaena*) and leopards (*Panthera pardus*; Can, 2001, 2002, 2004; Can and Lise, 2004; Table 1). In this study we review the case of Caspian tiger (*Panthera tigris virgata*), a species prematurely declared extinct in 1950s and make recommendations for minimizing such wrongful assessments in the future.

When did the Caspian tiger become extinct?

Tigers (*Panthera tigris*) have been present in Turkey since time immemorial. The English naturalist Edward Blyth, about whom Charles Darwin mentions in the Origins of Species with respect, mentions his sighting of a tiger in Ağrı Mountain (the highest mountain in Turkey with an altitude of 5,137 meters a.s.l) in 1855. He described locals trapping live young tigers for trade and added that the mountain was "infested" with tigers even around the snow line (Burton, 1933; Schnitzler and Hermann, 2019). Some decades later, a tiger was also reportedly hunted by Enver Paşa (1882–1922) in Eastern Turkey (SonDakika, 2011). Yet, at the time the international scientific community considered the Caspian tiger globally extinct, following a field survey in the 1950s that failed to document them in neighboring Iran (Can, 2004; Can and Lise, 2004). This was in despite of the fact that in Turkey this species still possessed "pest species" status according to national legislation (Official Gazette, 1937). The international scientific community continued to disregard the possibility of tiger presence and only acknowledged the existence of tigers in Turkey only later in 1974 when Baytop (1974), a local botanist, published an account of a tiger killed in Uludere district in an international scientific journal (Can, 2004; Can and Lise, 2004). Subsequently, this date has been widely mentioned in the literature as the time of extinction of the species in Turkey (e.g., Driscoll et al., 2009; Chestin et al., 2017).

However, if this young male had not been killed by Şehit Şen (Baytop, 1974) in 1970, it would likely have lived until the late 1970s. Moreover, Baytop (1974) reported that local hunters in Eastern Turkey were aware of the presence of tigers in Hakkari and Siirt provinces while in Uludere district and Şırnak provinces, hunters were killing up to eight tigers a year. Baytop (1974) adds later, that actors involved in the fur trade in İstanbul confirmed that they were still receiving tiger pelts from Eastern Turkey, and that some pelts were sent to Iraq directly from the region (Figure 1A). Some 10 years later, Turan (1984) reported that tigers had survived in remote corners of eastern Turkey until the mid-1980s as evidenced by reports of a steady trickle of one or two being killed annually.

A more recent survey by Can and Lise (2004) revealed that locals were organizing tiger hunts in Şırnak up until 1970s, and that there were at least two credible tiger sightings and three tigers killed in Eastern Turkey between 1959 and 1984. However, this still wasn't the complete picture (see Figure 1A for all tiger records from Turkey), as the tiger might also have still had a presence in southwestern Turkey at that time. A local in Antalya, interviewed by one of us (ÖEC) in his 60s, described a childhood memory of how his father once hunted a "big cat with stripes" but failed to dry the enormous sized skin. Here, it must be noted that Baytop (1974), Turan (1984), and the local interviewed in Antalya in 2001 were likely reporting about tigers, and were not necessarily confused about leopards which were sometimes called "kaplan" in Turkish, also meaning tiger in English. So the Czech biologist Mazák (1981) may have been correct when stating, "possibly few tigers remain in south-eastern Turkey" in 1981.

Years later, during a field survey in Uludere district, the same area where a tiger was killed in 1970, a credible sighting of a "large cat with stripes" at 3000 metres above sea level was reported by military personnel to Can and Lise (2004) (Figure 1B). The locals also reported another "big cat with stripes" sighting to the military personnel in Güçlükonak district (about 80 km west of Uludere) in the same year (Can and Lise, 2004). After a brief meeting with U.S. Fish and Wildlife Service (USFWS) Division of International Conservation Rhinoceros and Tiger Conservation Fund officers in Washington, D.C. in 2004, one of us (ÖEC) prepared for an international workshop and a field survey of the area with the support of USFWS Division of International Conservation Rhinoceros and Tiger Conservation Fund. However, this workshop and survey could not be implemented due to security reasons (Can, 2004; Can and Lise, 2004).

Considering that Caspian tigers probably existed in Turkey perhaps up until early 1990s, some 40 years after international scientific community considered the species extinct, it is reasonable to posit that the complete absence of surveys throughout that period, as one symptom of national and international inertia, squandered a historical opportunity to save the species. Today, the continued presence of the Caspian tiger in some remote corner of eastern Turkey is less likely. However, it is important to note that a recent study elucidates the evolutionary and natural history of tigers (Sun et al., 2022). Specifically, the study indicates that the Caspian tiger may have originated from an ancestral Northeast Asian tiger population and then experienced gene flow from southern Bengal tigers (Sun et al., 2022). The study also suggests that Amur and Caspian tigers had a once-common ancestor in East or

TABLE 1 A selection of species from the literature which were prematurely considered extinct resulting in missed conservation opportunities.

Species Common Name	Scientific Name	(Re)discovery Date	Considered Extinct*	Red List Category	Country	References
Coelacanth	*Latimeria chalumnae*	1938	70 million years	CR	South Africa	Amemiya et al. (2013)
Sulawesi Coelacanth	*Latimeria menadoensis*	1997	70 million years	VU	Indonesia	Amemiya et al. (2013)
Bermuda petrel	*Pterodroma cahow*	1951	300 years	EN	Bermuda	Madeiros (2005)
Bocourt's terrific skink	*Phoboscincus bocourti*	2003	131 years	CR	New Caledonia	Caut et al. (2013)
Arakan forest turtle	*Heosemys depressa*	1994	119 years	CR	China	Hance (2015)
Red crested tree rat	*Santamartamys rufodorsalis*	2011	113 years	CR	Columbia	ProAves (2011)
Forest owlet	*Athene blewitti*	1997	113 years	EN	India	King and Rasmussen (1998)
Large luzon carpomys	*Carpomys melanurus*	2008	112 years	DD	Philippines	Heaney (2011)
Mahogany Glider	*Petaurus gracilis*	1989	103 years	EN	Australia	Jackson and Diggins (2021)
Brazilian arboreal mouse	*Rhagomys rufescens*	2002	~100 years	VU	Brazil	Pinheiro et al. (2004)
Gilbert's potoroo	*Potorous gilbertii*	1994	~100 years	CR	Australia	Sinclair et al. (1996)
Bornean rainbow toad	*Ansonia latidisca*	2011	87 years	EN	Borneo	Bryner (2011)
Woolly flying squirrel	*Eupetaurus cinereus*	1996	72 years	EN	Pakistan	Zahler (1996)
Cave splayfoot salamander	*Chiropterotriton mosaueri*	2010	69 years	CR	Mexico	Black (2010)
Leadbeater's possum	*Gymnobelideus leadbeateri*	1961	52 years	CR	Australia	Lindenmayer et al. (1991)
South Island takahe	*Porphyrio hochstetteri*	1948	50 years	EN	New Zealand	Maxwell (2013)
Mount Nimba reed frog	*Hyperolius nimbae*	2010	43 years	EN	Ivory Coast	Black (2010)
Naked-backed fruit bat	*Dobsonia chapmani*	2001	37 years	CR	Philippines	Waldien (2020)
Romer's tree frog	*Liuixalus romeri*	1984	31 years	EN	Hong Kong	Elbein (2017)
Jambato toad	*Atelopus ignescens*	2017	30 years	CR	Ecuador	Bello (2017)
Caspian tiger	*Panthera tigris virgata*	1970	~20 years	EX	Turkey	This study
Striped hyaena	*Hyaena hyaena*	2001	~20 years	VU	Turkey	Can (2002)

*Approximate number of years during which the species was considered/assessed to be extinct leading to the cease of research and conservation effort.

Northeast Asia (Sun et al., 2022). Moreover, similar to the tiger reintroduction programme in Kazakhstan (see WWF Russia, 2019 for details), reintroduction from the Amur tiger (*P. t. altaica*) stock to Turkey might be an option since "interruption of potential historical gene flow across the ancestral Eurasian distribution of *P. t. altaica* + *P. t. virgata* may have been too recent (<200 years) to accumulate sub-species level genetic differentiation" (Driscoll et al., 2009; see Chestin et al., 2017 for an assessment of tiger reintroduction in Central Asia).

Cognitive biases in species assessments

Researchers and practitioners working in monitoring and assessing conservation status of species are used to thinking about the quality and reliability of the data but less about their own cognitive biases. In fact, research has shown that cognitive biases affect pheasants, rats, capuchin monkeys and other animal species (e.g., Harding et al., 2004; Lakshminaryanan et al., 2008;

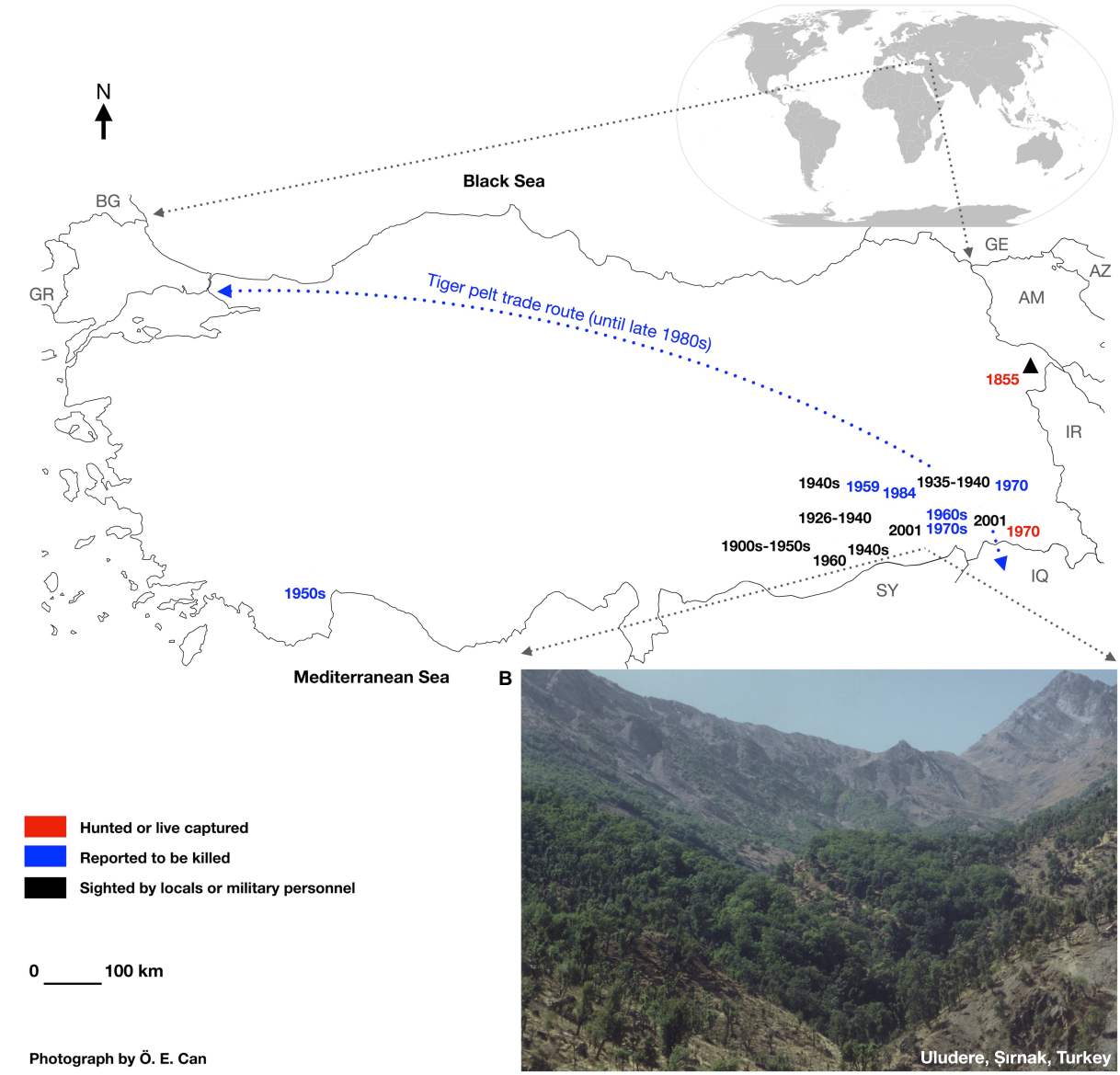

FIGURE 1
(A) Caspian tiger records for the period between 1855 and 2001 in Turkey (a tiger reported to be hunted by Enver Paşa (1882–1922) in Eastern Turkey is not shown as exact location of the hunt is unknown). **(B)** A view from Caspian tiger habitat, Uludere district, Turkey where a male tiger was killed in 1970 and another was one reported at 3000 meters in 2001. The region is still a stronghold of tiger prey species. The black triangle figure on map represents Ağrı Mountain (5,137 meters). The abbreviations used in the map are as follows; GR, Greece; BG, Bulgaria; GE, Georgia; AZ, Azerbaijan; AM, Armenia; IR, Iran; IQ, Iraq; SY, Syria. The world map from Wikimedia Commons is under Creative Commons CC0 1.0 Universal Public Domain. Map of Turkey was created with MapChart.

Beardsworth et al., 2021). Similarly, humans including academics, conservationists, and wildlife managers are hardwired for cognitive biases. Cognitive biases play a role when people assessing a species' status notice evidence in the first place; how they interpret it, and how they make conclusions during the process of species assessments.

The case of the Caspian tiger demonstrates the cognitive bias of the Dunning–Kruger effect (Kruger and Dunning, 1999) in action and the potential implications for conservation. The Dunning–Kruger effect, a phenomenon known in psychology, prevails when people overestimate their competence and underestimate their incompetence in social and intellectual domains. As a result, people not only reach erroneous conclusions and make unfortunate choices, their incompetence prevents them from critically evaluating their own thinking (Kruger and Dunning, 1999). Characteristics of this effect appear to have bedevilled the foregoing account of prematurely announcing the extinction of Caspian tiger. If such a mishap was avoided in the case of the Caspian tiger between 1950s and 1980s, and much needed research effort was spent, the Caspian tiger might probably

still roam in Turkey today. The case of Caspian tiger demonstrates how experts that are remotely evaluating contemporary species distributions can fall prey to the Dunning–Kruger effect. So how can this bias be prevented in the future?

Minimizing expert bias in extinction assessments

Conservationists, like physicians, judges and experts in geopolitics, are typically "highly educated groups making high-stakes decisions" (Hallsworth et al., 2018) that are also hardwired for biases. Acknowledging this fact, would possibly make the conservation community aware and facilitate the introduction of additional measures in relevant conservation initiatives. Moreover, a species assessment mostly requires the work of an established expert group, but group work has inherent risks (Hallsworth et al., 2018). Research has shown that in group discussions, individuals are very sensitive to what others think; rather than challenging, they reinforce each other and conform to the group majority view by self-censoring due to group enforcement (Hallsworth et al., 2018). Also, groups tend to focus on what most group members already know; initial contributions can strongly sway group opinion and discussions within the group can make the group's view extreme (Hallsworth et al., 2018). Therefore, to mitigate these factors, when assessing the global status of species such as the IUCN Red List of Threatened Species, independent "Red Teams," as used in military, intelligence agencies and private sector, could be formed to unearth implicit assumptions and weaknesses in assessments and to question the group thinking of the species assessors.

Nevertheless, even the best possible assessments reflecting the opinions of academics sitting in some other corner of the world cannot replace the necessity of field surveys by local biologists; conservation needs more boots on the ground (Wilson, 2017). Mathematical models can now inform extrapolations from sightings, or even rumors, of rare species (e.g., see Rivadeneira et al., 2009; Lee, 2014; Boakes et al., 2015; Turvey et al., 2015 for information) and this can indicate what steps need to be taken on the ground when designing field surveys (to search for signs, tracks and environmental DNA) by trained personnel, particularly in remote regions. However, it must be noted that when searching for rare species, not all researchers are equal. An often unremarked determinant of the success of field surveys, and one that is elusive to describe, is the aptitude and skill of field staff (Scott et al., 2008). When reviewing records about the presence of elusive and rare species, or reading reports about the presence or absence of such species, the reader should think critically about the competence and the field skills of the reporter, and attempt not to be biased by authority or status. Moreover, as the recent discovery of a clouded leopard (*Neofelis nebulosa*) population at 3500 meters a.s.l. (a world record altitude for the species) in Langtang Himalayas (Can et al., 2020) demonstrated, local information is not always reliable, locals may not be aware of rare and elusive species. Therefore, local information or expert opinion cannot fulfil the role of carefully designed field research (Can and Togan, 2009). In brief, we recommend that decision about extinctions, as for all conservation focused initiatives, should be based on the consensus of trained local conservation biologists, local authorities and locals rather than solely on the opinions of a subjectively selected elite group of experts operating remotely.

The pace of biodiversity decline is unprecedented and has been dubbed the sixth mass extinction (e.g., Leakey and Lewin, 1995; Ceballos and Ehrlich, 2018), with habitat loss, and exploitation of wildlife, highlighted as being among the greatest threats to global diversity (IPBES, 2019). Against this backdrop of rapidly declining biodiversity, we hope this article inspires further research in cognitive biases involved in species assessments and in conservation at large.

Author contributions

ÖC: conceived, wrote the original manuscript, and created the figures. ÖC and ND'C: contributed, reviewed, and edited the manuscript for publication. All authors contributed to the article and approved the submitted version.

Funding

The open access publication fee was kindly covered by Manchester Metropolitan University.

Acknowledgments

We thank Angie Elwin and Özge Balkız for providing feedback on the manuscript. ÖC thanks George Schaller for visiting him in the field in Turkey in 2003 and for sharing insights and historical knowledge on Caspian tigers. ND'C thanks World Animal Protection and Manchester Metropolitan University for supporting his research.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

References

Amemiya, C. T., Alföldi, J., Lee, A. P., Fan, S., Philippe, H., MacCallum, I., et al. (2013). The African coelacanth genome provides insights into tetrapod evolution. *Nature* 496, 311–316. doi: 10.1038/nature12027

Baytop, T. (1974). La Présence du Vrai Tigre, Panthera tigris (Linné, 1758) en Turquie. *Säugetierkd. Mitt* 22, 254–256.

Beardsworth, C. E., Whiteside, M. A., Laker, P. R., Nathan, R., Orchan, Y., Toledo, S., et al. (2021). Is habitat selection in the wild shaped by individual-level cognitive biases in orientation strategy? *Ecol. Lett.* 24, 751–760. doi: 10.1111/ele.13694

Bello, L. D., (2017). Boy finds "extinct" frog in Ecuador and helps revive species [WWW document]. Available at: https://www.newscientist.com/article/2140098-boy-finds-extinct-frog-in-ecuador-and-helps-revive-species/#:~:text=Aschool%2Dageboyhasnowsuccessfullybredincaptivity (Accessed September 14, 2022).

Black, R., (2010). "Lost" frogs found after decades [WWW document]. BBC News. Available at: https://www.bbc.com/news/science-environment-11385774 (Accessed September 9, 2022).

Boakes, E. H., Rout, T. M., and Collen, B. (2015). Inferring species extinction: the use of sighting records. *Methods Ecol. Evol.* 6, 678–687. doi: 10.1111/2041-210X.12365

Bryner, J., (2011). "Lost" rainbow toad rediscovered after 87 years [WWW document]. Live Science. Available at: https://www.livescience.com/15038-lost-rainbow-toad-rediscovered-borneo.html (Accessed September 9, 2022).

Burton, R. G., (1933). *The Book of The Tiger*. Boston: Houghton Mifflin.

Can, Ö. E., (2001). Anadolu leoparı yaşıyor. Atlas 16–17.

Can, Ö. E., (2002). Large Carnivores in Turkey. IUCN Species.

Can, Ö. E., (2004). Status, conservation and Management of Large Carnivores in Turkey (no. T-PVS/Inf 2004 8), Convention on the conservation of European wildlife and natural habitats Strasbourg: Council of Europe.

Can, Ö. E., and Lise, Y., (2004). Distribution of large mammals in southeastern Anatolia: recommendations & priority areas for their conservation (in GAP biodiversity research project 2001-2003 final report). Turkish Society for the Conservation of nature (DHKD), Istanbul, Turkey.

Can, Ö. E., and Togan, İ. (2009). Camera trapping of large mammals in Yenice Forest, Turkey: local information versus camera traps. *ORX* 43:427. doi: 10.1017/S0030605308000628

Can, Ö. E., Yadav, B. P., Johnson, P. J., Ross, J., D'Cruze, N., and Macdonald, D. W. (2020). Factors affecting the occurrence and activity of clouded leopards, common leopards and leopard cats in the Himalayas. *Biodivers. Conserv.* 29, 839–851. doi: 10.1007/s10531-019-01912-7

Caut, S., Holden, M., Jowers, M. J., Boistel, R., and Ineich, I. (2013). Is Bocourt's terrific skink really so terrific? Trophic Myth and Reality. *PLoS ONE* 8:e78638. doi: 10.1371/journal.pone.0078638

Ceballos, G., and Ehrlich, P. R. (2018). The misunderstood sixth mass extinction. *Science* 360, 1080–1081. doi: 10.1126/science.aau0191

Chestin, I. E., Paltsyn, M. Y., Pereladova, O. B., Iegorova, L. V., and Gibbs, J. P. (2017). Tiger re-establishment potential to former Caspian tiger (*Panthera tigris virgata*) range in Central Asia. *Biol. Conserv.* 205, 42–51. doi: 10.1016/j.biocon.2016.11.014

Collar, N. J. (1998). Extinction by assumption; or, the Romeo error on Cebu. *Oryx* 32, 239–244. doi: 10.1046/j.1365-3008.1998.d01-51.x

Driscoll, C. A., Yamaguchi, N., Bar-Gal, G. K., Roca, A. L., Luo, S., Macdonald, D. W., et al. (2009). Mitochondrial Phylogeography illuminates the origin of the extinct Caspian Tiger and its relationship to the Amur Tiger. *PLoS One* 4:e4125. doi: 10.1371/journal.pone.0004125

Elbein, A., (2017). Bright lights, big city, tiny frog: Romer's tree frog survives Hong Kong [WWW document]. Mongabay Available at: https://news.mongabay.com/2017/02/bright-lights-big-city-tiny-frog-romers-tree-frog-survives-hong-kong/ (Accessed September 9, 2022).

Hallsworth, M., Egan, M., Rutter, J., and McCrae, J., (2018). *Behavioural Government: Using Behavioural Science to Improve How Governments make Decisions*. London, UK: The Behavioural Insights Team.

Hance, J., (2015). Locals lead scientists to a new population of near-extinct reptile [WWW document]. Mongabay. Available at: https://news.mongabay.com/2015/02/locals-lead-scientists-to-new-population-of-near-extinct-reptile/ (Accessed September 9, 2022).

Harding, E. J., Paul, E. S., and Mendl, M. (2004). Cognitive bias and affective state. *Nature* 427:312. doi: 10.1038/427312a

Heaney, L., (2011). Dwarf cloud rat re- discovered after 112 years [WWW document]. Blog. Available at: https://www.fieldmuseum.org/blog/dwarf-cloud-rat-re-discovered-after-112-years (Accessed September 11, 2022).

IPBES, (2019). *Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services*. Bonn, Germany: IPBES secretariat.

Jackson, S., and Diggins, J., (2021). *National Recovery Plan for the Mahogany Glider (Petaurus gracilis)*. Canberra: Australian Government.

Keith, D. A., and Burgman, M. A. (2004). The Lazarus effect: can the dynamics of extinct species lists tell us anything about the status of biodiversity? *Biol. Conserv.* 117, 41–48. doi: 10.1016/S0006-3207(03)00261-1

King, B. F., and Rasmussen, P. C. (1998). The rediscovery of the Forest owlet. *Forktail* 14, 53–55.

Kruger, J., and Dunning, D. (1999). Unskilled and unaware of it: how difficulties in recognizing one's own incompetence lead to inflated self-assessments. *J. Pers. Soc. Psychol.* 77, 1121–1134. doi: 10.1037/0022-3514.77.6.1121

Lakshminaryanan, V., Keith Chen, M., and Santos, L. R. (2008). Endowment effect in capuchin monkeys. *Phil. Trans. R. Soc. B* 363, 3837–3844. doi: 10.1098/rstb.2008.0149

Leakey, R., and Lewin, R., (1995). *The Sixth Extinction: Biodiversity and its Survival* New York: Doubleday.

Lee, T. E. (2014). A simple numerical tool to infer whether a species is extinct. *Methods Ecol. Evol.* 5, 791–796. doi: 10.1111/2041-210X.12227

Lees, A. C., and Pimm, S. L. (2015). Species, extinct before we know them? *Curr. Biol.* 25, R177–R180. doi: 10.1016/j.cub.2014.12.017

Lindenmayer, D. B., Nix, H. A., McMahon, J. P., Hutchinson, M. F., and Tanton, M. T. (1991). The conservation of Leadbeater's possum, Gymnobelideus leadbeateri (McCoy): a case study of the use of bioclimatic Modelling. *J. Biogeogr.* 18:371. doi: 10.2307/2845479

Madeiros, J.L., (2005). *Recovery Plan for the Bermuda Petrel (CAHOW) Pterodroma Cahow*. Hamilton: Bermuda Government.

Maxwell, J. M. (2013). "South island takahe | takahē" in *In New Zealand Birds Online [WWW document]*. ed. C. M. Miskelly (Wellington: New Zealand Birds Online)

Mazák, V. (1981). *Panthera Tigris. Mammal Species* Wellington, The American Society of Mammalogists.

Official Gazette (1937). Terrestrial hunting law. Law No: 3167. Turkey: Turkish Republic Prime Ministry, Ankara.

Pimm, S. L., Jenkins, C. N., Abell, R., Brooks, T. M., Gittleman, J. L., Joppa, L. N., et al. (2014). The biodiversity of species and their rates of extinction, distribution, and protection. *Science* 344:1246752. doi: 10.1126/science.1246752

Pinheiro, P. S., Hartmann, P. A., and Geise, L. (2004). New record of Rhagomys rufescens (Thomas 1886) (Rodentia: Muridae: Sigmodontinae) in the Atlantic forest of southeastern Brazil. *Zootaxa* 431:1. doi: 10.11646/zootaxa.431.1.1

ProAves, (2011). Spectacular mammal rediscovered after 113 Years! [WWW document]. ProAves. Available at: https://proaves.org/en/spectacular-mammal-rediscovered-after-113-years/ (Accessed September 9, 2022).

Rivadeneira, M. M., Hunt, G., and Roy, K. (2009). The use of sighting records to infer species extinctions: an evaluation of different methods. *Ecology* 90, 1291–1300. doi: 10.1890/08-0316.1

Roberts, D. L. (2006). Extinct or possibly extinct? *Science* 312, 997–998. doi: 10.1126/science.312.5776.997c

Schnitzler, A., and Hermann, L. (2019). Chronological distribution of the tiger Panthera tigris and the Asiatic lion Panthera leo persica in their common range. *Asia. Manag. Rev* 49, 340–353. doi: 10.1111/mam.12166

Scott, J. M., Ramsey, F. L., Lammertink, M., Rosenberg, K. V., Rohrbaugh, R., Wiens, J. A., et al. (2008). When is an "extinct" species really extinct? Gauging the search efforts for Hawaiian Forest birds and the ivory-billed woodpecker. *ACE* 3:art3. doi: 10.5751/ACE-00254-030203

Sinclair, E. A., Danks, A., and Wayne, A. F. (1996). Redṁovery of Gilbert's Potoroo, Potorous tridactylus, Western Australia. *Aust. Mammal.* 19. 69–72. doi: 10.1071/AM96069

SonDakika, (2011). Enver Paşa'nın Avladığı Anadolu Kaplanı, Işıklar Askeri Lisesi'nde Sergileniyor [WWW Document] Available at: https://www.sondakika.com/haber/haber-enver-pasa-nin-avladigi-anadolu-kaplani-isiklar-3059182/ (Accessed September 14, 2022).

Sun, X., Liu, Y.-C., Tiunov, M. P., Gimranov, D. O., Zhuang, Y., Han, Y., et al. (2022). Ancient DNA reveals China as a historical genetic melting pot in Tiger evolution. bioRxiv [Preprint]. doi: 10.1101/2022.09.14.507899

Tedesco, P. A., Bigorne, R., Bogan, A. E., Giam, X., Jézéquel, C., and Hugueny, B. (2014). Estimating how many Undescribed species have gone extinct: estimating Undescribed species extinctions. *Conserv. Biol.* 28, 1360–1370. doi: 10.1111/cobi.12285

Turan, N., (1984). *Türkiye'nin Av ve Yaban Hayvanları Memeliler*. Ongun Kardeşler Matbaacılık Sanayii, Ankara.

Turvey, S. T., Trung, C. T., Quyet, V. D., Nhu, H. V., Thoai, D. V., Tuan, V. C. A., et al. (2015). Interview-based sighting histories can inform regional conservation prioritization for highly threatened cryptic species. *J. Appl. Ecol.* 52, 422–433. doi: 10.1111/1365-2664.12382

Waldien, D. L. (2020). Dobsonia chapmani. The IUCN red list of threatened species 2020: e.T6773A2203397 [WWW document]. IUCN Red List. doi: 10.2305/IUCN.UK.2020- 3.RLTS.T6773A22033978.en

Wilson, E. O. (2017). Biodiversity research requires more boots on the ground. *Nat. Ecol. Evol.* 1, 1590–1591. doi: 10.1038/s41559-017-0360-y

WWF Russia (2019). Tiger reintroduction programme in Kazakhstan [WWW document]. Available at: https://wwf.ru/upload/iblock/f57/TigerProgrKaz_2019_Engl.pdf (Accessed December 12, 2022).

Zahler, P. (1996). Rediscovery of the woolly flying squirrel (*Eupetaurus cinereus*). *J. Mammal.* 77, 54–57. doi: 10.2307/1382708