Global Ecology and Conservation 23 (2020) e01047

Contents lists available at ScienceDirect

Global Ecology and Conservation

journal homepage: http://www.elsevier.com/locate/gecco

Short Communication

China's online parrot trade: Generation length and body mass determine sales volume via price

Ru-Yi Yin [a], Yun-Chun Ye [a], Chris Newman [b], Christina D. Buesching [b], David W. Macdonald [b], Yi Luo [a], Zhao-Min Zhou [a, *]

[a] *Key Laboratory of Southwest China Wildlife Resources Conservation (Ministry of Education), China West Normal University, Nanchong, China*

[b] *Wildlife Conservation Research Unit, The Recanati–Kaplan Centre, Department of Zoology, University of Oxford, Oxford, UK*

ARTICLE INFO

Article history:
Received 10 January 2020
Received in revised form 27 March 2020
Accepted 1 April 2020

Keywords:
Animal welfare
Conservation
Phylogenetic path analysis
Price elasticity of demand
Wildlife trade

ABSTRACT

The wildlife trade threatens global biodiversity and animal welfare, where parrots are among the taxa most frequently traded, supplying exotic pets and captive breeders worldwide. Using phylogenetic path analysis, we examine how biological factors interact with price to influence online protected parrot trade volumes in China, using transactions recorded for 46 species ($n = 5862$ individuals). Trade was greatest in smaller, faster breeding species that commanded a lower price. This price effect followed the economic law of demand, with Relatively Inelastic Demand (−0.758), outweighing indicators of 'quality' such as body coloration, and conservation status. We identify two areas of concern: those larger, slower-breeding, rarer species, even though sold at lower numbers, may be at conservation risk if harvested from the wild. In contrast, the sheer numbers (over 90% of the individuals were under median generation length, body mass and/or price) and ready availability of smaller and more common species comprises a substantial overall animal welfare issue, given that the capture, importation, or captive breeding of many parrot species in China is illegal and thus unregulated. Our investigation highlights the importance of properly understanding the internal relations among drivers of wildlife trade to inform appropriate management.

1. Introduction

Wildlife trade threatens global biodiversity. Parrots are at particular threat because they are desirable as pets (Gonzalez, 2003; Drews, 2001; Pires, 2012). Wild parrot populations have declined over recent decades, with nearly 30% of 355 species currently threatened with extinction (Donald et al., 2010). Although among the most threatened bird orders in the world (Juniper and Parr, 1998), detailed studies on the (un-)sustainability of parrot harvesting and trading are lacking (Beissinger and Bucher, 1992; Gilardi and James, 2006), as are studies evaluating parrot welfare when held or bred in captivity, given that they are comparably intelligent and long-lived birds (Meehan and Mench, 2006; Engebretson, 2006), prone to traumatic stress (Yenkosky et al., 2010).

* Corresponding author. No. 1, Shida Road, Nanchong, 637002, China.
E-mail address: zhouzm81@gmail.com (Z.-M. Zhou).

https://doi.org/10.1016/j.gecco.2020.e01047

In Mexico, Europe and the USA, certain parrot species command a premium price, linked to striking coloration or rarity. This leads to a disproportionate number of these most expensive species being poached from the wild (Tella and Hiraldo, 2014). However, price creates a balance between supply and demand; when desirable goods are expensive, trade volumes are typically lower, causing sales volumes to self-regulate (Harris et al., 2015). For example, the price of pangolin products is increasing, seemingly due to desirability driving ever-greater consumer demand in China and Vietnam, with supply restricted by regulation and risk of prosecution (Challender et al., 2015). Consumer sensitivity to price (price elasticity of demand, PED) is quantified as the relative percentage change in quantities purchased in response to a one percent change in price (Walelign et al., 2019). PED further divides into Perfectly Elastic Demand (∞), Perfectly Inelastic Demand (0), Relatively Elastic Demand (>1), Relatively Inelastic Demand (<1), and Unitary Elasticity Demand (= 1). Phylogenetic path analyses enable a more expansive analysis of quality-quantity wildlife trade dynamics (Hardenberg and Gonzalez-Voyer, 2013; Gonzalez-Voyer and Von Hardenberg, 2014). This method can account for species non-independence due to shared ancestry, and describe dependencies within sets of variables.

Here we investigate the economics of online parrot sales in China, in relation to factors driving demand for these unconventional pets (Bush et al., 2014). This is despite all recorded sales likely being in contravention of China's Wild Animal Conservation Law (WACL) and CITES. We studied fixed–price classified transactions involving parrots over Taobao.com (a subsidiary of the Alibaba group; analogous to 'Ebay') that provides the largest domestic consumer to consumer (C2C) online platform in Mainland China. We then tested for possible correlations between sale volume per species across surveys (the dependent variable) as predicted by price, and indices relating to conservation status, extent of occurrence, morphological traits and breeding potential. Note: Su et al. (2015) found that song complexity was not a desirable trait motivating parrot sales. Based on pre-specified candidate path models, we used phylogenetic confirmatory path analysis to model how co-dependent factors influence sales volumes. We use these findings to comment on ways to improve parrot trade management.

2. Methods

2.1. Data collection and processing

Transaction information was extracted from Taobao.com, during four surveys (7 July - September 2, 2016, 19 September - October 22, 2016, 4–January 12, 2017 and 14 April - May 10, 2017). We applied the search criteria "parrot, living" (in Chinese). We amassed 44,597 screenshots of illegal advertisements of parrots listed in China's List of Fauna under Special State Protection (1989) and/or CITES Appendices I, II. Transaction information included 'species' (verified from the sellers' description and photographs), 'unit price' (i.e. price per single item) and 'successful transactions', which provided the number of individual animals traded and received during the 30 days preceding our survey (1 transaction = 1 animal traded; Ye et al., 2020; Liu et al., 2020) (Fig. 1). According to the annotations provided by some vendors, despite variations in size (and value) all

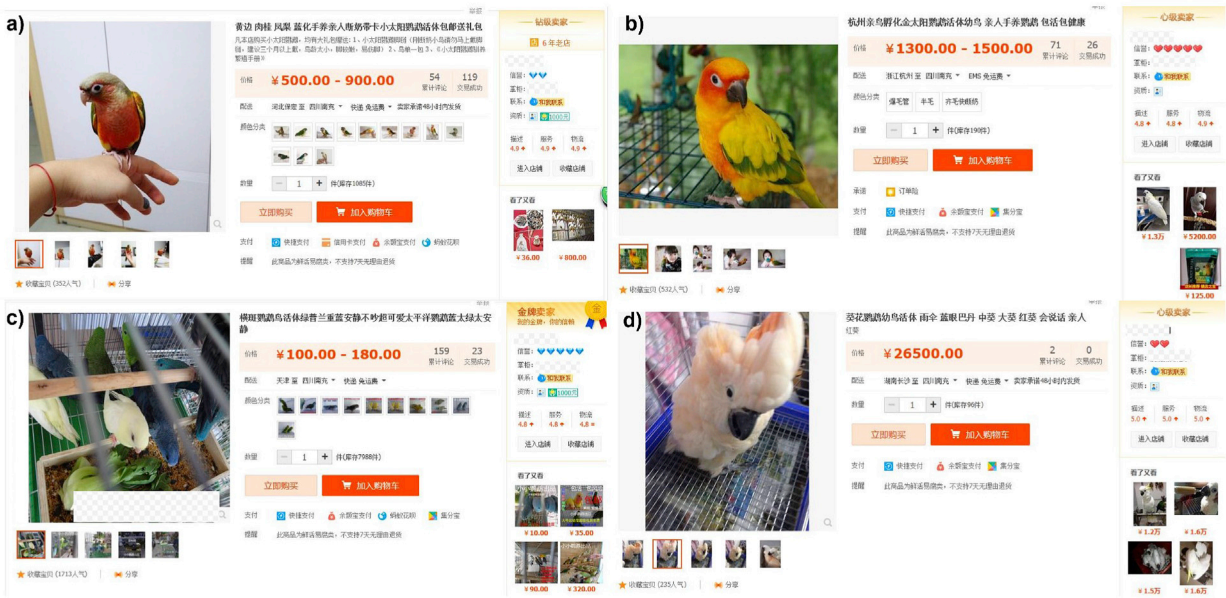

Fig. 1. Screenshots of four species featuring substantially across the surveys: a) Green–cheeked Parakeet (*Pyrrhura molina*); b) South American Sun Parakeet (*Aratinga solstitialis*); c) Barred Parakeet (*Bolborhynchus lineola*); d) Salmon-crested cockatoo (*Cacatua moluccensis*). The vender's names and the user names of the operators are hidden by mosaic. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

parrot species could be shipped to consumers across China via express delivery for a standard fee scaled by parcel size and shipping distance, except to buyers in remote areas in Tibet and Xinjiang, where more expensive charges applied. We selected price data randomly from no more than ten advertisements per species. Mean price per species was converted into US dollars (US$1:RMB¥6.759) and compared with trade volumes across surveys. We excluded species where fewer than 3 individuals were sold across surveys to increase the reliability of our dataset and ensure that general trends would not be skewed by the attributes of a few aberrant individuals.

We selected biological factors that potentially influence sales volume of each species:

i) Conservation status of species: The conservation status of each parrot species sold was obtained from the IUCN Red List of Threatened Species (IUCN, 2019). Our dataset included species classified as 'Least Concern' (Status = 1), 'near threatened' (Status = 2), vulnerable (Status = 3), and endangered (Status = 4), but did not include any species classified as 'Data Deficient', 'Critically Endangered', 'Extinct in the Wild' or 'Extinct'. Red List status is an ordinal categorization of an underlying continuous variable; however, our phylogenetic generalized least squares (PGLSs) analysis required continuous response variables (Martins and Hansen, 1997). We thus assumed that this status (coded as indicated above) reflected continuous variation in vulnerability to extinction (following Purvis et al., 2000; Fritz et al., 2009; Gonzalez-Voyer et al., 2016).
ii) Extent of occurrence (km^2): a measure was defined as the area contained within the shortest continuous boundary encompassing all the known, inferred, or projected sites of present occurrence of a taxon, excluding vagrancy, acquired from BirdLife International (2019).
iii) Morphological traits: Plumage color from scanned images of adult male parrots from *Parrots* (Juniper and Parr, 1998) was converted from RGB L*a*b* color mode to Lab color mode using Adobe Photoshop CS6 software, based on the human perception of color (Rathore et al., 2012). Body mass (grams) for each species was obtained from Iwaniuk et al. (2005) and the Handbook of the Birds of the World Alive (del Hoyo et al., 2019, HBW). Lengths of wing, tail, bill and tarsus were obtained from *Parrots* (Juniper and Parr, 1998) applying residuals from observed minus predicted lengths based on log-log regression controlling for body mass effect. Relative (allometrically scaled) brain size was taken from Sayol et al. (2018), as a proxy of ability to exhibit novel behavior (Lefebvre et al., 1997; Overington et al., 2009).
iv) Breeding potential: Clutch size (number of eggs per brood) and generation length (inter-cohort period, in years) were obtained from HBW and (Encyclopedia of Life, 2014) websites, respectively.

Data for relative brain size were available for 41 species (89%) and data for the other variables were available for all 46 species. All data on sales volume, price, EOO, L*a*b*, body mass, clutch size and generation length were log (x+1) transformed to meet normal distribution assumptions. For phylogenetic analyses we used the tree for birds proposed by Jetz et al. (2012), selecting a single random tree (Fig. S1) from the tree pool at http://birdtree.org, after we tested if the results vary with the tree selected and found the results consistent with each other.

2.2. Analyses

Sales volume and price are not evolved traits, but interact with inherent species traits, where shared ancestry could cause price/sales volume per species to vary non-independently (c.f. Fritz and Purvis, 2010). To address this, we constructed phylogenetic generalized least squares (PGLS) with a specified covariance matrix. Volume of species sold (response variable) was modeled against all 15 univariate predictor variables, using the *pgls* function in the R-package *caper* (Orme et al., 2015). PGLS models produced a phylogenetic scaling parameter λ, ranging from 0 (phylogenetic independence) to 1 (complete phylogenetic dependence) (Freckleton et al., 2002).

We then used phylogenetic path analysis (Hardenberg and Gonzalez-Voyer, 2013) to establish the most supported explanatory models. Only three variables influenced sales volume (see Results: generation length, body size and price) in these PGLS models, therefore we investigated four predictions: (1) body mass and generation length influence sales volume, via price; (2) body mass influences sales volume directly; (3) generation length influences sales volume directly; (4) the association of body mass and generation length influence sales volume directly. These resulted in 37 alternative models (Fig. S2), constructed as directed acyclic graphs. Using the R package *phylopath* (van der Bijl, 2018), we then tested the fit of a given path model, based on the C-statistic Information Criterion (CICc, Shipley, 2013; Hardenberg and Gonzalez-Voyer, 2013). CIC weights provided an estimate of the likelihood of each model (Burnham and Anderson, 2002). Support was taken ΔCICc $\leq$2 and the smallest CICc value, with C statistic $P > 0.05$ indicated the best candidate model. All analyses were conducted using R version 3.6.0 (R Core Team, 2019).

3. Results

3.1. Parrot species traded in China

From our four survey rounds, we recorded 5862 protected parrot transactions (46 species) (Table S1). Sales volume exceeded two for 29 species (n = 5853). Most traded was the Green−cheeked Parakeet (*Pyrrhura molina*; n = 2538); a South

American species of Least Concern, weighing just 71.5 g, with a relatively short generation length of 6 years, and cost only $111. Substantial numbers of Endangered parrots were also traded, notably the South American Sun Parakeet (*Aratinga solstitialis*; n = 495). Species price varied from US$21 per individual for the least expensive species sold, the Barred Parakeet (*Bolborhynchus lineola*), up to US$4073 per individual for the Salmon-crested Cockatoo (*Cacatua moluccensis*), weighing 850 g, with a generation length of 13 years and was traded much less ($n = 6$). Over 90% of individuals were under the median generation length of 7.9 years (n = 5346), the median body mass of 71.5 g (n = 5335) and/or the median price of $525.2 (n = 5325) of the 46 species. The total market value of the 46 sold parrot species on Taobao over these surveys exceeded US$1.19 million (US$1.18 million for the 29 species analyzed), of which 99% was attributable to alien species.

3.2. Factors influencing species sales volume

Parrot sales volumes correlated negatively with mean species price ($\beta = -0.758$, $t = -3.500$, $P < 0.05$, $\lambda = 0.181^{0.58,<0.001}$), generation length ($\beta = -2.231$, $t = -2.291$, $P < 0.05$, $\lambda < 0.001^{1,<0.001}$) and body mass ($\beta = -0.923$, $t = -3.001$, $P < 0.05$, $\lambda < 0.001^{1,<0.001}$) (Fig. 2; Table S2). In contrast, other biological factors had no significant effect on sales volume ($P > 0.05$) (Table S2). There was also a positive interaction of price with generation length ($\beta = 2.525$, $t = 4.426$, $P < 0.001$, $\lambda = 0.734^{1,<0.001}$) and body mass ($\beta = 1.158$, $t = 7.802$, $P < 0.001$, $\lambda = 0.706^{0.014,<0.001}$), where generation length and body mass covaried ($\beta = 2.723$, $t = 11.173$, $P < 0.001$, $\lambda < 0.001^{1,0.003}$).

Corroborating prediction 1, the most supported path models indicated an internal association between body mass and generation length influencing sale volume, via price (Table S3; Fig. 3 and Fig. S2); i.e., larger parrot species with longer generation lengths were sold in lower numbers. In contrast, models not linking generation length and body mass provided a very poor fit (ΔCICc = 49.24). Models testing predictions 2–4, linking biological traits and sale volume directly, provided a relatively poor fit (respectively, ΔCICc ≥ 2.66; ΔCICc ≥ 2.78; and ΔCICc ≥ 6.60. Note: all path models with the best fit ΔCICc <2.00 had non-significant C statistic values, indicating all conditional independencies were met (Table S3).

4. Discussion

As one of the most popular bird groups in the international pet trade (Bush et al., 2014; Li and Jiang, 2014), even three decades ago the global trade in parrot species was estimated at $1.4 billion annually (Thomsen and Brautigam, 1991) and has likely continued to increase, although more recent studies are lacking.

The effect of price on sales volume we observed supports the law of demand (Walelign et al., 2019): more expensive parrots were traded less. Interestingly, however, consumer sales patterns had Relatively Inelastic Demand (Walelign et al., 2019), and, contrary to expectations, sales volumes did not decrease linearly in proportion to price increase – rather the market sustained higher prices in relation to trade volume [1: 0.758]. This is revealing of the leverage effect of price, which does not simply cause fewer more expensive parrots to be traded. A better understanding of these patterns requires further inclusion of socioeconomic covariates (i.e., household income and household size), offline trading and consumer preferences on biological traits, also substituting sales trends of other pets into models.

The majority of C2C trading we documented involved cheaper, smaller species with shorter generation lengths, and so we infer that these sales prices would only be profitable if these parrots were being bred in captivity. In support of the extensive role of captive breeding, Ye et al. (2020) reported that 43 of these 46 nationally and internationally protected parrot species (5798 of the 5862 individuals) traded on Taobao.com are not native to China, or even to Asia. Of these 46 species, 18 are indigenous to South America, and 14 to Australia and eastern Indonesia. Furthermore, Ye et al. (2020) reported that only 292 parrots (eight species) were seized by China's border authorities during the period 1976–2015; far too small a number to suggest trafficking was supplying consumer demand. Notably, however, in a further supply chain convolution, Australian

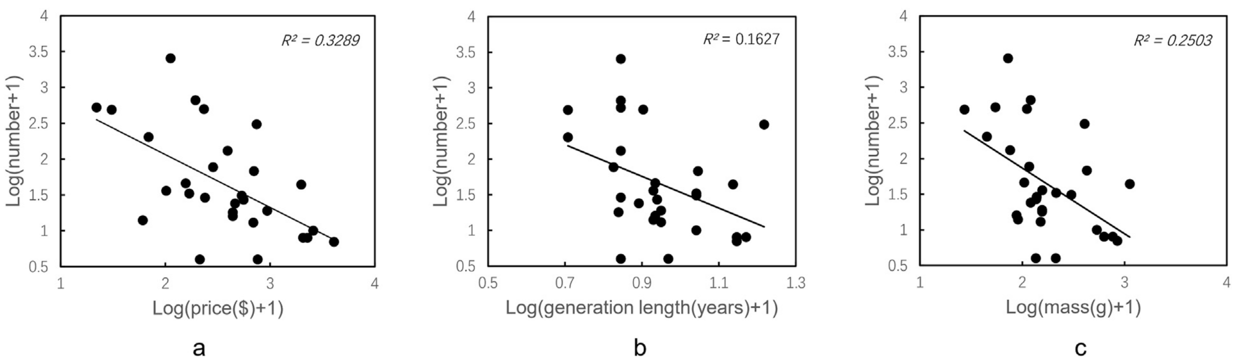

Fig. 2. The relationship between sale volume and price (a), body-mass (b) and generation length (c) recorded in China's online parrot trade.

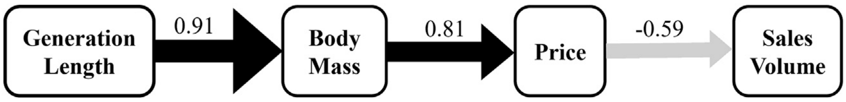

Fig. 3. Path diagram showing the empirical relationships described by the best supported model (Table S2). Arrow width depicts value of the standardized slope coefficient (higher values – wider arrows), with the value of the standardized slope coefficients given. Gray arrows indicate relationships that were included in all models.

species are frequently captive bred outside of Australia, either legally or illegally (Vall-llosera and Cassey, 2017). Nevertheless, the actual provenance of the parrots sold over Taobao.com in our sample remains uncertain.

In contrast, the longer generation length of the larger species would make them less profitable to breed and raise in captivity, potentially making them more vulnerable to poaching from the wild; although higher prices may obviate these captive husbandry costs (Su et al., 2015). This positive relationship between generation length and body mass is a generalized phenomenon among birds (Blueweiss et al., 1978), as well as mammals (Gaillard et al., 2005), because nearly all biological rates increase to an exponent of body mass (Gillooly et al., 2002).

This huge trade in protected parrots represents a transgression of China's wildlife protection legislation, even if demand is mainly met from captive-bred individuals. Under China's criminal law, any participants in illegal wildlife trade supply chains, to include hunters, sellers, buyer and/or transporters, could face up to 15 years fixed-term imprisonment accompanied by fines and/or the confiscation of property (see Zhou et al., 2016 for the detailed cascade of legal jurisdiction and penalties). Allowing parrot trading to continue in contravention of existing laws, emboldens other wild animal trade, and signals an unclear ethical position. The consequences of such failures to obey animal trading laws in China have, tragically, been brought into focus by the COVID-19 pandemic, with dire consequences for human health (Zhou et al., 2020). Indeed, parrots are susceptible to a number of infectious zoonotic diseases. For example, 35.37% of 311 parrots investigated from North China were *Chlamydia psittaci* seropositive (Zhang et al., 2015), causing psittacosis, or 'parrot fever' in humans (Eidson, 2002; Smith et al., 2005).

Notably, China has recently cracked-down on wild animal trading in response to COVID-19, and these new measures may help to curb parrot trade, where most species are already protected (except for the Budgerigar (*Melopsittacus undulatus*), Cockatiel (*Nymphicus hollandicus*) and Rosy-faced lovebird (*Agapornis roseicollis*)), but trade was formerly tolerated, all. Nevertheless, because the parrot trade is so pervasive in China, and volumes traded are so massive, a broad-scale ban on trading parrots, that would criminalize a substantial proportion of the Chinese population, would be untenable.

Aside from conservation implications, we must also be alert and respectful to the welfare of these birds. The low price and relatively easy husbandry of parrots makes them popular as companion animals, especially for children (Engebretson, 2006). But parrots are relatively intelligent birds (Pepperberg, 2006), and are prone to behavioural disorders, such as self-mutilation (Jenkins, 2001) if given insufficient stimulation or due to being neglected (Davis, 1991; Speer, 2014; Gaskins and Bergman, 2011).

Some of these traded species that are threatened in their native ranges also represent an invasive risk, if they escape to the wild (Cassey et al., 2004). For example, release of captive yellow-crested cockatoos (*Cacatua sulphurea*) in Hong Kong since the 1960s has resulted in damage to the few remaining large trees used by other resident species, and these cockatoos also compete with native birds for nesting resources such as tree cavities (Leven and Corlett, 2004).

For those species of parrot for which sales are illegal in China, logically, so is captive breeding. Consequently this is done covertly in unregulated facilities not subject to inspection, likely leading to poor welfare conditions. For example, Psittacine Beak and Feather Disease (PBFD) is a potentially deadly disease among parrots, cockatoos and lorikeets (non-zoonotic). This has been widely detected among wild, wild-caught captive and seized parrots across countries (Peters et al., 2014; Fogell et al., 2018) and can quickly spread through poorly kept parrot breeding facilities (Rahaus and Wolff, 2003). It seems probable that those more expensive parrot species, representing a considerable financial investment for breeders or consumers, may receive better welfare as a result of their value, where companion animals with a higher monetary value are often better cared for (Vermeulen and Odendaal, 1993); however, the cumulative compromised welfare of smaller, less valuable species may be considerable (Pires, 2012).

Closing down animal markets risks merely transferring trade to the black market, making accountability, regulation and enforcement even harder, and so alternatively we advocate for interventions in China aimed at reducing and/or mitigating parrot suffering in unlicensed and unregulated breeding establishments, supplemented by effective enforcement. If consumers want to have parrots, their interest should be positively encouraged and fostered, educating them in how to care for their companion birds and fostering an interest that may transcend into concern for the conservation of these fascinating species in the wild. This combined hierarchical management approach is similar to that adopted in the USA and the EU, where the ownership of parrots has led to greater concern for parrot conservation (Anderson, 2003).

Author contributions

Z.M.Z. conceived the ideas and designed the study; R.Y.Y. and Y.C.Y. undertook the data gathering while R.Y.Y. and Y.L. led on the analysis, R.Y.Y., C.N., C.D.B., D.W.M. and Z.M.Z. interpreted the findings and wrote the paper. R.Y.Y. and Y.C.Y. contributed equally.

Declaration of competing interest

All authors have no competing interests to declare.

Acknowledgements

C.N. acknowledges support from the H.N. Southern Memorial Fellowship in Ecology; Z.M.Z. from the scientific research foundation of China West Normal University (16E013); and R.Y.Y. from the scientific research foundation of China West Normal University (cxcy2018280).

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.gecco.2020.e01047.

References

Anderson, P., 2003. A bird in the house: an anthropological perspective on companion parrots. Soc. Anim. 11 (4), 393–418.
Beissinger, S.R., Bucher, E.H., 1992. Can parrots be conserved through sustainable harvesting? Bioscience 42 (3), 164–173.
BirdLife International, 2019. IUCN Red List for Birds. Downloaded from. http://www.birdlife.org. (Accessed 26 July 2018).
Blueweiss, L., Fox, H., Kudzma, V., Nakashima, D., Peters, R., Sams, S., 1978. Relationships between body size and some life history parameters. Oecologia 37 (2), 257–272.
Burnham, K.P., Anderson, D.R., 2002. A Practical Information-Theoretic Approach. Model Selection and Multimodel Inference, second ed. Springer, New York.
Bush, E.R., Baker, S.E., Macdonald, D.W., 2014. Global trade in exotic pets 2006–2012. Conserv. Biol. 28 (3), 663–676.
Cassey, P., Blackburn, T.M., Russell, G.J., Jones, K.E., Lockwood, J.L., 2004. Influences on the transport and establishment of exotic bird species: an analysis of the parrots (Psittaciformes) of the world. Global Change Biol. 10 (4), 417–426.
Challender, D.W., Harrop, S.R., MacMillan, D.C., 2015. Towards informed and multi-faceted wildlife trade interventions. Glob. Ecol. Conserv. 3, 129–148.
Davis, C.S., 1991. Parrot psychology and behavior problems. Vet. Clin. Small Anim. Pract. 21 (6), 1281–1288.
del Hoyo, J., Elliott, A., Sargatal, J., Christie, D.A., Kirwan, G. (Eds.), 2019. Handbook of the Birds of the World Alive. Lynx Edicions, Barcelona retrieved from. http://www.hbw.com/on. (Accessed 29 July 2018).
Donald, P., Collar, N., Marsden, S., Pain, D., 2010. Facing Extinction: the World's Rarest Birds and the Race to Save Them. Bloomsbury Publishing.
Drews, C., 2001. Wild animals and other pets kept in Costa Rican households: incidence, species and numbers. Soc. Anim. 9 (2), 107–126.
Eidson, M., 2002. Psittacosis/avian chlamydiosis. J. Am. Vet. Med. Assoc. 221 (12), 1710–1712.
Encyclopedia of Life. Available from: http://eol.org. (Accessed 1 November 2017).
Engebretson, M., 2006. The welfare and suitability of parrots as companion animals: a review. *Anim. Welf.* 15, 263–276.
Fogell, D.J., Martin, R.O., Bunbury, N., Lawson, B., Sells, J., McKeand, A.M., et al., 2018. Trade and conservation implications of new beak and feather disease virus detection in native and introduced parrots. Conserv. Biol. 32 (6), 1325–1335.
Freckleton, R.P., Harvey, P.H., Pagel, M., 2002. Phylogenetic analysis and comparative data: a test and review of evidence. Am. Nat. 160 (6), 712–726.
Fritz, S.A., Purvis, A., 2010. Selectivity in mammalian extinction risk and threat types: a new measure of phylogenetic signal strength in binary traits. Conserv. Biol. 24 (4), 1042–1051.
Fritz, S.A., Bininda-Emonds, O.R., Purvis, A., 2009. Geographical variation in predictors of mammalian extinction risk: big is bad, but only in the tropics. Ecol. Lett. 12 (6), 538–549.
Gaillard, J.M., Yoccoz, N.G., Lebreton, J.D., Bonenfant, C., Devillard, S., Loison, A., et al., 2005. Generation time: a reliable metric to measure life-history variation among mammalian populations. Am. Nat. 166 (1), 119–123.
Gaskins, L.A., Bergman, L., 2011. Surveys of avian practitioners and pet owners regarding common behavior problems in psittacine birds. J. Avian Med. Surg. 25 (2), 111–118.
Gilardi, James, D., 2006. Captured for conservation: will cages save wild birds? a response to cooney & jepson. Oryx 40 (1), 24–26.
Gillooly, J.F., Charnov, E.L., West, G.B., Savage, V.M., Brown, J.H., 2002. Effects of size and temperature on developmental time. Nature 417 (6884), 70–73.
Gonzalez, J.A., 2003. Harvesting, local trade, and conservation of parrots in the Northeastern Peruvian Amazon. Biol. Conserv. 114 (3), 437–446.
Gonzalez-Voyer, A., Von Hardenberg, A., 2014. An introduction to phylogenetic path analysis. In: Modern Phylogenetic Comparative Methods and Their Application in Evolutionary Biology. Springer, Berlin, Heidelberg, pp. 201–229.
Gonzalez-Voyer, A., González-Suárez, M., Vilà, C., Revilla, E., 2016. Larger brain size indirectly increases vulnerability to extinction in mammals. Evolution 70 (6), 1364–1375.
Hardenberg, A.V., Gonzalez-Voyer, A., 2013. Disentangling evolutionary cause-effect relationships with phylogenetic confirmatory path analysis. Evolution 67 (2), 378–387.
Harris, J.B.C., Green, J.M., Prawiradilaga, D.M., Giam, X., Hikmatullah, D., Putra, C.A., Wilcove, D.S., 2015. Using market data and expert opinion to identify overexploited species in the wild bird trade. Biol. Conserv. 187, 51–60.
IUCN, 2019. The IUCN Red List of Threatened Species. Version 2019-3. Downloaded on. http://www.iucnredlist.org. (Accessed 3 December 2019).
Iwaniuk, A.N., Dean, K.M., Nelson, J.E., 2005. Interspecific allometry of the brain and brain regions in parrots (Psittaciformes): comparisons with other birds and primates. Brain Behav. Evol. 65 (1), 40–59.
Jenkins, J.R., 2001. Feather picking and self-mutilation in psittacine birds. Vet. Clin. Exot. Anim. Pract. 4 (3), 651–667.
Jetz, W., Thomas, G.H., Joy, J.B., Hartmann, K., Mooers, A.O., 2012. The global diversity of birds in space and time. Nature 491 (7424), 444–448.
Juniper, T., Parr, M., 1998. Parrots: A Guide to Parrots of the World. Yale University Press, New Haven.
Lefebvre, L., Whittle, P., Lascaris, E., Finkelstein, A., 1997. Feeding innovations and forebrain size in birds. Anim. Behav. 53 (3), 549–560.
Leven, M.R., Corlett, R.T., 2004. Invasive birds in Hong Kong, China. Ornithol. Sci. 3 (1), 43–55.
Li, L.L., Jiang, Z.G., 2014. International trade of CITES listed bird species in China. PloS One 9 (2), e85012.

Liu, S., Newman, C., Buesching, C., Macdonald, D., Zhang, Y., Zhang, K.J., Li, F., Zhou, Z.M., 2020. E-commerce promotes trade in invasive turtles in China. Oryx 1–4.
Martins, E.P., Hansen, T.F., 1997. Phylogenies and the comparative method: a general approach to incorporating phylogenetic information into the analysis of interspecific data. Am. Nat. 149 (4), 646–667.
Meehan, C., Mench, J., 2006. Captive parrot welfare. Manual of parrot behavior 301–318.
Orme, D., Freckleton, R., Thomas, G., Petzoldt, T., Isaac, N., Pearse, W., 2015. Caper: Comparative Analyses of Phylogenetics and Evolution in R. R Package. Version 0.5.2. http://CRAN.R-Project.org/package=caper.
Overington, S.E., Morand-Ferron, J., Boogert, N.J., Lefebvre, L., 2009. Technical innovations drive the relationship between innovativeness and residual brain size in birds. Anim. Behav. 78 (4), 1001–1010.
Pepperberg, I.M., 2006. Grey Parrot (*Psittacus erithacus*) numerical abilities: addition and further experiments on a zero-like concept. J. Comp. Psychol. 120 (1), 1–11.
Pires, S.F., 2012. The illegal parrot trade: a literature review. Global Crime 13 (3), 1–15.
Peters, A., Patterson, E.I., Baker, B.G., Holdsworth, M., Sarker, S., Ghorashi, S.A., Raidal, S.R., 2014. Evidence of psittacine beak and feather disease virus spillover into wild critically endangered orange-bellied parrots (*Neophema chrysogaster*). J. Wildl. Dis. 50 (2), 288–296.
Purvis, A., Gittleman, J.L., Cowlishaw, G., Mace, G.M., 2000. Predicting extinction risk in declining species. *Proc. Royal Soc.* B. 267 (1456), 1947–1952.
R Core Team, 2019. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/.
Rahaus, M., Wolff, M.H., 2003. Psittacine beak and feather disease: a first survey of the distribution of beak and feather disease virus inside the population of captive psittacine birds in Germany. *Thai. J. Vet. Med.* Series B 50 (8), 368–371.
Rathore, V.S., Kumar, M.S., Verma, A., 2012. Colour based image segmentation using L*a*b* colour space based on genetic algorithm. Int. J. Emerg. Technol. Adv. Eng. 2, 156–162.
Sayol, F., Downing, P.A., Iwaniuk, A.N., Maspons, J., Sol, D., 2018. Predictable evolution towards larger brains in birds colonizing oceanic islands. Nat. Commun. 9 (1), 2820.
Shipley, B., 2013. The AIC model selection method applied to path analytic models compared using ad-separation test. Ecology 94 (3), 560–564.
Smith, K.A., Bradley, K.K., Stobierski, M.G., Tengelsen, L.A., 2005. Compendium of measures to control Chlamydophila psittaci (formerly Chlamydia psittaci) infection among humans (psittacosis) and pet birds. J. Am. Vet. Med. Assoc. 226 (4), 532–539.
Speer, B., 2014. Normal and abnormal parrot behavior. J. Exot. Pet Med. 23 (3), 230–233.
Su, S., Cassey, P., Vall-Llosera, M., Blackburn, T.M., 2015. Going cheap: determinants of bird price in the Taiwanese pet market. PloS One 10 (5), e0127482.
Tella, J.L., Hiraldo, F., 2014. Illegal and legal parrot trade shows a long-term, cross-cultural preference for the most attractive species increasing their risk of extinction. PloS One 9 (9), e107546.
Thomsen, J.B., Brautigam, A., 1991. Sustainable Use of Neotropical Parrots. Neotropical Wildlife Use and Conservation. The University of Chicago Press, Chicago, pp. 359–379.
Vall-llosera, M., Cassey, P., 2017. 'Do you come from a land down under?'Characteristics of the international trade in Australian endemic parrots. Biol. Conserv. 207, 38–46.
van der Bijl, W., 2018. phylopath: easy phylogenetic path analysis in R. PeerJ 6, e4718.
Vermeulen, H., Odendaal, J.S., 1993. Proposed typology of companion animal abuse. Anthrozoös 6 (4), 248–257.
Waleligm, S.Z., Nielsen, M.R., Jacobsen, J.B., 2019. Price elasticity of bushmeat demand in the Greater Serengeti Ecosystem: insights for management of the bushmeat trade. Front. Ecol. Evol. 7, 162.
Ye, Y.C., Yu, W.H., Newman, C., Buesching, C.D., Xu, Y.L., Xiao, X., Macdonald, D.W., Zhou, Z.M., 2020. Effects of regional economics on the online sale of protected parrots and turtles in China. Conserv. Sci. Pract. 2 (3), e161.
Yenkosky, J.P., Bradshaw, G.A., McCarthy, E., 2010. Post-Traumatic Stress Disorder among parrots in captivity: treatment considerations. In: Association of Avian Veterinarians, p. 17.
Zhang, N.Z., Zhang, X.X., Zhou, D.H., Huang, S.Y., Tian, W.P., Yang, Y.C., et al., 2015. Seroprevalence and genotype of *Chlamydia* in pet parrots in China. Epidemiol. Infect. 143 (1), 55–61.
Zhou, Z.M., Buesching, C.D., Macdonald, D.W., Newman, C., 2020. China: clamp down on violations of wildlife trade ban. Nature 578 (7794), 217.
Zhou, Z.M., Newman, C., Buesching, C.D., Meng, X., Macdonald, D.W., Zhou, Y., 2016. Revised taxonomic binomials jeopardize protective wildlife legislation. Conserv. Lett. 9 (5), 313–315.