Using Wikipedia page views to explore the cultural importance of global reptiles

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Abstract

Modern conservation operates at the nexus of biological and social influences. While the importance of social and cultural factors are often mentioned, defining, measuring and comparing them remains a significant challenge. Here, we explore a novel method to quantify cultural interest in all extant reptile species using Wikipedia- a large, open-access online encyclopaedia. We analysed all page views of reptile species viewed during 2014 in all of Wikipedia's language editions. We compared species' page view numbers across languages and in relationship to their spatial distribution, phylogeny, threat status and various other biological attributes. We found that while the top three species with respect to page views are shared across major language editions, beyond these, page view ranks of species tend to be specific to particular language editions. Interest within a language is mostly focused on reptiles found in the regions where the language is spoken. Overall, interest is greater for reptiles that are venomous, endangered, widely distributed, larger sized and that have been described earlier. However, within individual families not all the above factors predict page views. Most families contain at least one species in the top 5% of page views, but 29 families (with 1450 species) have no 'high interest species' in them. Overall, our analyses elucidate novel patterns of human interests in nature over large geographical, cultural and taxonomic spectra using big-data techniques. Such approaches hold much promise for incorporating social perceptions in future conservation practices.

Keywords (max 6): big data, conservation, culture, endangered, language, flagship species.

Introduction

Various cultural elements exert a powerful influence on how conservation attention and resources are allocated. Challenges facing species conservation projects may even be primarily social rather than biological (Kellert 1985; Tisdell 2014). Thus, in order to secure better outcomes for conservation management schemes - in addition to biological attributes - social and cultural variables should also be incorporated in decision making (Ladle and Jepson 2008). Nevertheless, these attributes are often neglected in the conservation decision-making process (Gunnthorsdottir 2001; Kellert 1985; Stokes 2007).

Most global and regional conservation prioritization schemes rely on quantifiable differences in the geographic distribution, population size, ecological role, and evolutionary distinctness of species (Faith 1992; IUCN 2014; Mills et al. 1993; Vane-Wright et al. 1991). However, species are also unequal in their contributions to human culture – in how they are perceived by and attract attention from humans. While a few authors have addressed this point (Cristancho and Vining 2004; Garibaldi and Turner 2004), the extent to which species vary in their cultural importance or impact remains very poorly studied and how this potentially affects conservation practices is mostly unknown. Nevertheless, in order for conservation actions to be fruitful they need to incorporate both traditional conservation parameters and cultural values in local to global scales of the different actors and interventions attempted.

As with other human practices, conservation may suffer from biases due to the non-randomness in human interests and affections. For example we are more interested in the well-being and prolonged persistence of big, 'fluffy', attractive animals (Gunnthorsdottir 2001; Johnson et al. 2010; Ward et al. 1998), those with large, forward facing eyes (Macdonald et al. 2015), those who are more brightly coloured (Prokop and Fančovičová 2013; Stokes 2007) and preferably more phylogenetically (and thus morphologically) close to us (Gunnthorsdottir 2001), etc.

Reptiles as a group are usually less in the public eye when it comes to conservation when compared to the other groups of tetrapods, due to several potential biases and knowledge deficiencies.

Reptiles comprise about 30% of all extant land vertebrate species (Meiri and Chapple 2016, this issue), and are likely to have an even greater representation amongst threatened species (IUCN 2014). Nevertheless, their representation in targeted species conservation schemes is usually much lower (Clucas et al. 2008). Here we list reptiles' representation in targeted species programs of a few global conservation NGOs, acknowledging that local conservation schemes may have different representations of reptiles. Of the World Wildlife Fund's 36 priority species or species groups, only sea turtle and 'Asian tortoises and freshwater turtles' are reptilian (wwf.panda.org). Of the 1031 projects supported by the Mohamed bin Zayed Species Conservation Fund which incorporate tetrapods, only 17% include reptiles (http://www.speciesconservation.org). None of the African Wildlife Foundation's projects target reptiles (http://www.awf.org). Reptiles comprise 16% of the specific species of interest listed by the Defenders of Wildlife organization, but only 6.5% of their animals up for adoption (http://www.defenders.org). While 13 of the 36 species (36%) under management by the Durrell Wildlife Conservation Trust are reptiles, only one of the 14 species (7%) up for adoption on their website is a reptile (www.durrell.org). Furthermore, as compared with mammals and birds, the scientific knowledge of basic biological attributes of reptiles is much lower, and thus so is our ability to develop sound conservation practices addressing their prolonged survival (Böhm et al. 2013; Meiri and Chapple 2016, this issue). For example, while the distributions of all other groups of tetrapods has been known for a decade now (Grenyer et al. 2006; Orme et al. 2005), only recently has a parallel effort been completed for reptiles (www.gardinitiative.org).

Within the ~10 300 recognized species of reptiles (Uetz and Hošek 2015) there are great differences between species in the cultural representations (i.e. appearance at all in the public sphere) and importance in various cultural roles they play. Some reptile species (e.g., venomous snakes, geckos, tortoises) have potent roles across an array of cultural mediums – in the pet trade, as food objects, as fictional characters, as objects of fear or aspiration, etc. (Alves et al. 2009; Alves et al. 2008; Campbell 2009; Klemens and Thorbjarnarson 1995). Nevertheless very many species remain unknown beyond a few herpetology specialists. As such, there are potentially great differences in the contributions of individual reptile species to the various domains of human culture. If conservation hopes to preserve features such as the ‘aesthetic, historical, and recreational values’ of species (Millennium Ecosystems Assessment 2005), then identifying which species contribute to those values is of fundamental importance. Previous studies have examined cultural attitudes towards particular reptile species within local contexts (Ceríaco 2012; Ceríaco et al. 2011; Deb and Malhotra 2001; Jones et al. 2008; Ramstad et al. 2007), yet there have been no global efforts to compare the cultural significance of reptiles. Since many conservation policies and frameworks operate globally, considering cultural value at a global scale is potentially very useful.

‘Culture’ is one of the most widely used terms in the English language (Taras et al. 2009). In the context of conservation, ‘cultural value’ is frequently applied to defining ways in which humans assign value to different species. Though useful in the abstract, it creates challenges in measuring exactly what it means and creates confusion through the various meanings of value. Here we explore page view statistics (elaborated below) extracted from the Wikipedia online digital text archive for all extant reptiles in all language editions as a measure of the prominence of an entity or idea within a given cultural context (Yu et al. 2015).

Digital text archives are an increasingly significant resource for the study of human culture and enable questions and scales of investigation that were unfeasible until recently (Aiden and Michel 2013; Lazer et al. 2009; Schich et al. 2014). The use of these resources for studying cultural patterns relevant to conservation is beginning to be recognized but remains low (Arts et al. 2015; Correia et al. 2016). The cultural salience of reptile species could theoretically be studied in a variety of digital archives. Within this context Wikipedia is particularly appealing for several reasons: 1) it is huge (> 35 million articles in English to date); 2) it is multilingual (287 languages including 12 with > 1 million articles); 3) it is open access and free to download; 4) it follows a standardized structure that groups information on a species together and thus avoids many of the challenges of unstructured text databases; and 5) a growing body of academic literature addresses aspects of Wikipedia’s coverage (Giles 2005; Halavais and Lackaff 2008; Messner and DiStaso 2013; Samoilenko and Yasseri 2014), credibility (Brown 2011; Miller and Murray

2010; Wilson 2014), contributor demographics (Wilson 2014) and user dynamics (Yasseri et al. 2014; Yasseri et al. 2012).

Wikipedia also has important limitations in the results it can produce and biases in whose cultural information it reflects. Unsurprisingly, Wikipedia skews heavily towards the Global North with respect to both content generation and usage, and African languages in particular are poorly represented (Graham et al. 2014). Wikipedia contributors also tend to be a highly skewed demographic from within the Global North: English-language Wikipedia contributors, for example, are primarily male, and mostly under 29 years old (Wilson 2014). As of 2013, 4.3 million registered users made at least one edit to all of Wikipedia, but only about 130 000 registered users made more than 100 edits (Wilson 2014). Another significant challenge in analysing Wikipedia from a cultural standpoint is that some of its contributors are not human. A proportion of Wikipedia articles are created or edited by specialized programs called ‘bots’. As an example, one of the most active bots, called ‘Lsjbot’, has contributed various types of information to over 2.7 million articles. Results obtained from Wikipedia therefore need to be considered within this context. We therefore want to emphasize that Wikipedia should not be seen as reflecting universal values nor representing the voices of groups such as indigenous people or individuals with limited internet access.

Wikipedia provides several potential referential metrics of cultural interest or saliency of different objects, each with potential benefits and flaws. Each Wikipedia page has been created at a particular date, been edited several times by a different number of editors, has a particular length, is linked to and from other pages (within and outside Wikipedia), appears in a set of different language editions, has been viewed a particular number of times, etc. Some of these metrics are potentially very information rich. Unfortunately, many of these metrics may suffer from inherent biases due to bot activity. Therefore – for our initial exploration of this data source for cultural attitudes towards nature – we limited our scope of reference only to the number of page views in different language editions of Wikipedia reptile pages. We suggest that page views within a given language measure the general interest that a page attracts from the public speaking that language (with the above biases in mind). We acknowledge that page views are recorded in a way that cannot account for page queries made by bots. Nevertheless, as most page views are made by humans (http://stats.wikimedia.org/archive/squid_reports/2014-12/SquidReportCrawlers.htm) we posit that they can provide some insight as to which reptiles attract more interest in the public sphere globally.

Here, we provide a novel approach to quantify and compare one aspect of the cultural interest associated with global reptile species - the number of times individual reptile pages are viewed, in a large, user-generated, multi-lingual, online encyclopaedia. We explore patterns at the species level, as many consider species the fundamental unit of biodiversity (Wilson 1992) and many conservation actions are designated towards individual species (Brooks 2010). This enables us to explore i) those species that may have greater conservation value because of their higher cultural interest, and ii) cross-cultural differences in interests towards reptile species, a key attribute in unravelling many conservation challenges. We address three questions relevant to the investigations of culture and conservation: 1) which reptile species are the most culturally salient at the global level, 2) what biological traits characterise those species, and 3) how does the relative cultural salience of species vary across languages.

Materials and Methods

We obtained cultural data on reptile species from two related sources: (i) DBpedia (http://wiki.dbpedia.org, version "Dataset 2014"), a repository of structured data, extracted and curated from Wikipedia, and (ii) Wikidata (http://www.wikidata.org, version 2015-07), a publicly editable repository of structured data, which aims to gather structured data from diverse sources including DBpedia, the Integrated Taxonomic Information System (ITIS - http://www.itis.gov), and many others. For both Wikidata and DBpedia, the full datasets were downloaded. For data processing scripts see the supplementary information.

To extract species-level entities within Wikidata, we utilised the fact that the global taxonomy of life via ITIS is fully integrated into this database. We therefore queried Wikidata for all entities marked as (i) having a 'taxon rank' property (https://www.wikidata.org/wiki/Property:P105) set to the value species (https://www.wikidata.org/wiki/Q7432), or (ii) having the property 'taxon name' (https://www.wikidata.org/wiki/Property:P225) set to some value (as opposed to no value). Our definition of a species was therefore anything with either a binomial or a 'species' label. Each species in the resulting list - 'Wikidata all species' corresponded to a unique URL within the Wikidata database. We identified reptiles in this list by matching them to Uetz and Hošek (2015) which served as the backbone taxonomy for this work. To obtain information on language editions and page views across languages, we cross-referenced our 'Wikidata reptiles' with DBpedia (data currently not found in Wikidata). DBpedia only includes a language edition for a species if a page for that species exists in a given language. The resulting list 'Wikipedia reptile URLs' contained every page title, in any language, for a species in Wikidata reptiles. We limited our analyses only to those pages that have been viewed at least once: as those that have not been viewed at all are most likely bot-generated pages.

Wikipedia page views and article traffic statistics are stored and made publically available at https://wikitech.wikimedia.org/wiki/Analytics/Data/Pagecounts-raw (a third party visualisation tool found at http://stats.grok.se). This dataset consists of files collated on an hourly basis for page views to all Wikipedia articles across all language editions. To extract page views for reptiles we downloaded page view files for the calendar year 2014 (collected per hour), and then matched page titles and their corresponding view counts to Wikipedia reptile URLs. Hourly view counts for each language edition of a species were summed to count total views per species. Altogether we identified 10 002 reptile species in Wikidata all species that were viewed in 2014.

In order to carry out some first examinations of the patterns of page view activity across reptiles, we assembled various traits per species. Year of description was obtained from Uetz and Hošek (2015). Range sizes of the species as well as global gridded distribution maps on a 1^0 Behrmann equal area projection were obtained from the GARD initiative (www.gardinitiative.org), as was data on the presence of venom. Threat status, for assessed species, were obtained from the IUCN redlist (http://www.iucnredlist.org). Body-size measurements for lepidosaurs were taken from Feldman et al. (2015), and for crocodiles and turtles from Itescu (pers. comm.). Species with unknown or unassessed venomous or endangered variables were recorded as 'no'; for IUCN rating any species assessed as VU or above by the IUCN was recorded as 'yes'; any known venomousness of a species was recorded as 'yes'. All the variables were used as a predictor set for a model of page views in total across all language editions, and of the English language edition. Subset models of the total page views for several taxonomic groups were also explored.

We modelled page views using a negative binomial GLM, with the theta parameter estimated from the data by maximum likelihood, as a starting value from a Poisson error model showed problematic over-dispersion. Continuous variables were paired with a quadratic term. We restricted our analyses to those species with complete cases – i.e. without missing values in any of the data columns (for sample sizes see Table 2). Analyses were conducted in R (R-Core-Team 2015) using the glm.nb function in the MASS library (Venables and Ripley 2002). Model averaging was carried out using the MuMIn library (Barton 2015) by all-subsets searches of the complete model (models with only the quadratic term for continuous variables, and not the main term, were excluded). We restricted our analysis to those models within the top 4 AIC units of the best model (Burnham and Anderson 2002). We present coefficients, significance levels, and variable relative importance from the AICc weighted average model assuming a coefficient of zero for variables with no evidence weight in individual models (the "full" coefficient averages in MuMIn).

Initially we plotted the median value of the total page views for all the species in each 1^0 grid-cell. We then explored the global distribution patterns of page views in five main Wikipedia language editions, which are not known to have extensive bot edit histories, and are dominant in the countries where they are spoken (Graham et al. 2014) – English, Spanish, Portuguese, German and Japanese. For each language we calculated the total number of page views for each species. We then assigned to each grid cell all the page-views of the species that reside in it and divided this value by the total number of species in that cell with Wikipedia pages in that language. This gave us a measure of the relative visibility in Wikipedia, for each cell, correcting for global trends in species richness. For each reptile family we noted whether it included species found in the top 5 percentile of page views. We then indicated on a tree of reptile families based on Reeder et al. (2015) and Pyron and Burbrink (2014) those that do and do not have such 'high interest species'.

Results

Extracting page views for the year 2014 resulted in 67 062 pages of Wikipedia reptile URLs with at least a single view (138 pages or 0.2% had only a single view); reptile pages were viewed a total of 55.5 million times in that year. There were 146 different language editions of Wikipedia with reptile pages in them. Median total views per species is 828.3, and mean value is 5553.3 giving a very skewed distribution of page views with respect to the species of reptile in question (Figure 1). Eighty two (0.8%) species received over 50% of total views, and the top five species received 11.1% of all the views. The English version has many more page views than the other language editions and comprises 39.4% of all reptile page views. However, while in English there are about 1850 species with over 1000 page views, there are 3150 species that receive over 1000 page views when all languages editions' page views are combined (Figure 1). Furthermore, 67% of species with page views in other languages do not even have a Wikipedia page in English. For total page views, and to lesser degree also for English and Spanish, there is a set of several hundreds of species (at the tail end of the distribution) that receive very few views in Wikipedia. Table S1 in the supplement gives the total page view values for all species and for the five main language editions explored.

Table 1 displays the species with the most page views for all of Wikipedia combined and for five chosen Wikipedia language editions. Only three species of reptiles are found in the top 20 page views for all the five languages, *Varanus komodoensis* - Komodo dragon (top species in overall page views), *Crocodylus porosus* - salt-water crocodile (third overall) and *Dendroaspis polylepis* – the black mamba (fourth overall). All three of these species are also the three most visible pages in the English version of Wikipedia. Two more species: *Eunectes murinus* – the green anaconda (7th overall) and *Chelonoidis nigra* - the Galapagos tortoise (15th overall) are found in the top 20 of four of the five languages. *Vipera berus* - the common European adder, while being second in total page views is only found in the top 20 of page views of the German edition of Wikipedia (out of these five languages). Of the 63 species found in the top 20 of these five language editions only 20 species are shared between more than one language and the rest are unique to a single language.

Our modelling procedure for all reptiles combined, or for reptile groups that have more than 1500 species, highlighted a single model – the full model (with all the parameters included) as having all of the information (over 99% of the AIC weights). Thus for these groups we report only the results of this model (Table 2). For less speciose groups between 2-14 models contained most of the information (Table 3, for details on the contributing models to each groups' average see Table S2 in the Supplementary Information). Our modelling procedure was able to account for around 60% of the deviance in page views for all reptile page views in Wikipedia as well as just for the English version of Wikipedia (Table 2). Models for turtles and lizard families had around 10% less explanatory power (Tables 2, 3). None of the chosen predictors explained important variation in page views of Amphisbaenia. For the analyses of all reptiles, as well as for all lizards, all snakes, and all reptiles in the English version, all the terms we tested in our model proved significant (Table 2). For other subsets, we see that different predictors are highlighted as significant and important (Tables 2,3). The year of the description of the species is an important predictor for all groups, with earlier described species being more visible. Threatened species attract more page views for many groups. Beyond these being venomous is important globally. Body mass is an important positive predictor globally, and for skinks, agamids, chameleons, colubrids and elapids. The size of the distribution range of the species is positively related to page view numbers s for geckos, agamids, colubrids and vipers. We think it is important to note that the positive relationship between range size and page views is in the opposite direction to the relationship between threat status and page views, suggesting that the threat status relationship is not driven by the small range size of threatened species.

Overall the species of interest to Wikipedia users are found predominantly in North America, Europe and Japan (Figure 2A). However, for individual language editions different patterns arise (Figure 2B-F). English language Wikipedia users predominantly view reptiles living in North America, northern

Europe as well as Indonesia and Eastern Africa (Figure 2B). The Spanish edition's page views highlights species in South America, southern Europe and Southeast Asia (Figure 2C). Portuguese Wikipedia users view species residing in South and Central America, Sub-Saharan Africa and Southeast Asia (Figure 2D). German Wikipedia users mostly view north Palearctic lizards (Figure 2E). Japanese language Wikipedia highlights reptiles from east and Southeast Asia as well as southeast North America, several other regions in eastern South America, the Nile Valley, eastern India and western Southern Africa (Figure 3F).

Several patterns arise when looking at the phylogeny highlighting families without representatives in the top five percentile of page views (Figure 3). 29 of the 88 families do not have a single species in the top fifth percentile. Furthermore, several of the unrepresented families – such as Liolaemidae, Gymnophthalmidae and Sphaerodactylidae are speciose (with 286, 243 and 208 species respectively). Altogether about 1450 species are found in sections of the tree without representation. All the families of crocodiles and turtles have at least one highly viewed species in them. However the tuatara (*Sphenodon punctatus*) is not found in the top five percentile of species' page views. There are three other small clades without any representatives in in the top five percentile. Nevertheless, we note that if we were to choose 5% of reptile species at random from our sample that would leave on average 33.8 families unsampled (standard deviation = 2.9, 10 000 randomizations).

Discussion

In recent years there has been a growing interest in people's attitudes towards nature while setting conservation priorities. In most cases, individual surveys were used to gain insight into people's perceptions, preferences and choices about nature (Macdonald et al. 2015; Taras et al. 2009). This approach is labour intensive, and usually limits the scope of the study. Here we utilize, for the first time, an online repository of user-generated content to gain insight into people's interests about an entire class – reptiles – over the entire globe and across many languages. We find interest is greater for reptiles that are venomous, endangered, widely distributed, large and that were described earlier. Furthermore, we show clearly that page views within a language edition increases for species found where that language is spoken. This approach holds much promise for the future in elucidating general trends in people's attitudes towards nature and conservation.

The first thing we were able to highlight were those species ranked top overall and top in the different languages (Table 1). It seems that, unsurprisingly, large, poisonous and potentially dangerous animals dominate the top spots: big fierce animals may be rare, but at least in reptiles they also receive disproportionally high internet interest (Figure 1). These are led by the Komodo dragon which alone attracts 3.6% of total page views, followed by salt-water crocodile and the black mamba. The potential – however overstated – for fatal interaction with people, and the associated folklore and cultural salience, is clearly a large determinant of page view activity. The same could also be true for the green anaconda (a top 20 species in 4 languages). However, this narrative is clearly not true for the Galapagos giant tortoise which shares prominence with the anaconda. Beyond the shared superstars, language-specific priorities emerge, however they are still driven strongly by venom and the potential for harm. 35 of the 63 top ranked species in the five languages we highlight could potentially be fatal. A large proportion of the top ranked species are also of unusual size. Of the 61 top ranked species in the five languages (with body mass data) 42 (68.8%) are found in the top 5% of body sizes of all reptiles. Nevertheless, as 82 top ranked species are generating more than half the total page views in our dataset, the vast majority of reptiles which are small, not dangerous and do not have a conservation narrative remain alarmingly invisible.

Greater interest or visibility in an online encyclopaedia is nevertheless no guarantee for greater support for targeted conservation of these species – especially for dangerous or venomous animals. However, greater interest could be harnessed to attract support by using both Wikipedia, other online tools and more traditional sources of information and campaigns to acknowledge the ecological roles and importance of these interesting, yet potentially dangerous species. Thus greater cultural interest could turn into greater cultural value. However, this will require a shift in our ideas of what makes a good flagship species – not just large, fluffy, big-eyed animals but potentially also mambas and dragons.

The overall 'heat-map' of reptile page views for all Wikipedia language editions combined, resembles that of content generation in Wikipedia in general (Graham et al. 2014). We find that more affluent societies with better internet connectivity, which are more represented in Wikipedia activity, are interested predominantly in the species that reside in their surrounding regions (Figure 2A). While the classical latitudinal gradients of species richness highlights tropical richness (Rosenzweig 1995), species of Wikipedia interest mostly inhabit higher latitudes. We present perhaps the first global map of the frequency of interactions with nature of a significant number of people. It is interesting to see its similarity with the general pattern of the Wallacean shortfall in other groups (Whittaker et al. 2005) and perhaps to speculate that they share a mechanism.

Apart from the absolute top 3-5 species, different language editions of Wikipedia highlight different top species of great interest. The local imprint of language becomes very evident when exploring the distributions of the species that receive most page views in the different language editions of Wikipedia (Figure 2B-F). By combining the knowledge of where a language is spoken with the unique page views of different language editions of Wikipedia, our approach enabled us to show that the reptile species people are most interested in, are those which are found where they live. While this phenomenon has been shown before at local scales, for few species (Campos et al. 2012; Lindemann-Matthies 2005; Shwartz et al. 2013), here we show it for an entire class of organism at a global scale. These findings further support the importance of regional conservation management plans which target the species considered important by those people most affected by and involved in their conservation (Miller 2005).

Our models were able to explain much of the variance in the interest people have in different species, using biological and other traits of the species (Table 2). The importance of description year perhaps highlights that similar mechanisms were at play for the selection of species to describe by the early reptile taxonomists as they are today for the general internet-using public. People are also more interested in large and venomous reptiles (Gunnthorsdottir 2001; Johnson et al. 2010; Ward et al. 1998; Woods 2000). Importantly, we find that species listed by the IUCN as threatened with extinction attract more interest (see also Johnson et al. 2010), irrespective of their body size, distribution or venomous status. This finding suggests that the IUCN red-listing process has intrinsic cultural impact, at least for reptiles (Ceballos and Ehrlich 2002). Models for selected reptile families and major groups show group-specific differences in the importance and significance of particular variables (but are always congruent in sign with each other and with the overall reptile models). Consequently, interest between particular reptile groups are likely to be influenced by different factors. This finding could be of value when searching for effective flagship species for conservation (Barua et al. 2011; Verissimo et al. 2011).

Following the notion of protecting unique evolutionary linages or phylogenetic diversity (PD) we plotted on a family-level tree of reptiles those families that have at least one representative species which is highly visible in Wikipedia (Figure 3). We find species in the top 5% of page views to be distributed widely across the phylogeny, leaving 33% of the 88 reptile families but only four distinct clades without a species of high interest. How interest, as measured by page views, relates to protection of phylogenetic diversity of course depends upon how we think interest influences conservation action. One conservative interpretation would simply be that a set of high-interest species exists which as passive recipients of conservation action, might effectively sample the phylogeny. At the other extreme, we could argue for direct use of page views as a measure of conservation importance. Page views in an online encyclopaedia are a quantifiable, omnipresent and easily obtainable metric of cultural interest, and could have obvious pragmatic benefits. Perhaps adopting such a metric together with other common conservation measures (threat, PD, function diversity etc) could bring about a more holistic suite of parameters for designating species for conservation.

Using large online repositories and big-data approaches holds much promise for conservation biology (Correia et al. 2016). We present an initial exploration of reptile species viewed in different language editions of Wikipedia. Interpreting these results should be done with caution as there are several known biases inherent to Wikipedia (Brown 2011; Graham et al. 2014; Miller and Murray 2010; Wilson 2014). As Arts et al. (2015) state, new technologies in conservation show “a need for rigorous evaluation [and] more comprehensive consideration of social exclusion”. Wikipedia page views, if applied uncritically as measures of conservation priority, would directly exclude the cultural values of the majority of humanity. Nevertheless, as an increasing amount of human activity is represented online and more tools for analysing this activity are being developed and tested, such approaches as ours become more useful and comparable. Exploring patterns of other metrics within Wikipedia, as well as other digital text corpuses with perhaps either more inclusive, or more targeted cultural salience, could be very useful. Trying to match these broad online survey techniques with more traditional surveys could prove useful, as theories and methods for the latter are much more robust. As challenges of protecting biodiversity are increasing, we need to develop new tools, approaches and mind-sets to tackle it (Sharman and Mlambo 2012) here we provide such an example.

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Conflict of Interest

All Authors claim no conflict of interest.

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Tables

Total	English	Spanish	Portuguese	German	Japanese		Binomial	# top
Varanus komodoensis (2014932)	Varanus komodoensis (845265)	Iguana iguana (196312)	Varanus komodoensis (110791)	Natrix natrix (251174)	Gloydius blomhoffii (191748)		Crocodylus porosus	5
Vipera berus (1059665)	Dendroaspis polylepis (520406)	Varanus komodoensis (155033)	Chelonoidis carbonaria (64113)	Vipera berus (223389)	Protobothrops flavoviridis (160635)		Dendroaspis polylepis	5
Crocodylus porosus (1055428)	Crocodylus porosus (478207)	Boa constrictor (97573)	Caretta caretta (59071)	Anguis fragilis (181409)	Elaphe climacophora (134282)		Varanus komodoensis	5
Dendroaspis polylepis (1042072)	Ophiophagus hannah (439853)	Eunectes murinus (86817)	Boa constrictor (45784)	Eunectes murinus (151228)	Gekko japonicus (127422)		Chelonoidis nigra	4
Ophiophagus hannah (1008676)	Heloderma suspectum (396522)	Crocodylus porosus (60603)	Caiman latirostris (39123)	Varanus komodoensis (130003)	Rhabdophis tigrinus (126388)		Eunectes murinus	4
Natrix natrix (949592)	Agkistrodon piscivorus (315207)	Dermochelys coriacea (57041)	Dendroaspis polylepis (37993)	Zamenis longissimus (88508)	Takydromus tachydromoides (97362)		Boa constrictor	3
Eunectes murinus (929057)	Alligator mississippiensis (266741)	Eretmochelys imbricata (52099)	Crocodylus porosus (34337)	Lacerta agilis (84408)	Varanus komodoensis (97124)		Crocodylus niloticus	3
Boa constrictor (629112)	Dermochelys coriacea (254229)	Dendroaspis polylepis (51405)	Bothrops jararaca (28880)	Testudo hermanni (80563)	Pelodiscus sinensis (94847)		Dermochelys coriacea	3
Anguis fragilis (616326)	Crocodylus niloticus (240528)	Caiman yacare (51215)	Bothrops alternatus (27771)	Dendroaspis polylepis (79740)	Trachemys scripta (72495)		Ophiophagus hannah	3
Crocodylus niloticus (613623)	Boa constrictor (240469)	Caretta caretta (49466)	Python regius (27680)	Crocodylus porosus (76318)	Elaphe quadrivirgata (63705)		Caiman yacare	2
Dermochelys coriacea (559746)	Eunectes murinus (233751)	Crocodylus acutus (47570)	Lachesis muta (27530)	Ophiophagus hannah (62606)	Ophiophagus hannah (61424)		Caretta caretta	2
Heloderma suspectum (521818)	Agkistrodon contortrix (225881)	Chelonia mydas (47417)	Bothrops insularis (25673)	Oxyuranus microlepidotus (62434)	Plestiodon japonicus (57898)		Chelonia mydas	2
Iguana iguana (498330)	Macrochelys temminckii (204320)	Chelonoidis carbonaria (41247)	Caiman yacare (23431)	Vipera aspis (55498)	Chelydra serpentina (55670)		Chelonoidis carbonaria	2
Caretta caretta (476772)	Crocodylus acutus (201540)	Caiman crocodilus (33843)	Spilotes pullatus (23058)	Chelonoidis nigra (55451)	Crocodylus porosus (55111)		Chelydra serpentina	2
Chelonoidis nigra (471396)	Chelonoidis nigra (200239)	Bothrops asper (32822)	Hemidactylus mabouia (21975)	Python molurus (52781)	Mauremys reevesii (47096)		Crocodylus acutus	2
Chelonia mydas (458579)	Gavialis gangeticus (199622)	Bothrops atrox (32577)	Bothrops jararacussu (20316)	Coronella austriaca (46730)	Dendroaspis polylepis (41840)		Eretmochelys imbricata	2
Malayopython reticulatus (432497)	Python bivittatus (198632)	Chelonoidis nigra (30041)	Dermochelys coriacea (19032)	Python regius (40647)	Macrochelys temminckii (40402)		Macrochelys temminckii	2
Alligator mississippiensis (425631)	Chelydra serpentina (190934)	Tarentola mauritanica (28872)	Melanosuchus niger (19027)	Crocodylus niloticus (40644)	Mauremys japonica (37894)		Oxyuranus microlepidotus	2
Gavialis gangeticus (393183)	Chelonia mydas (182412)	Vipera aspis (27377)	Eretmochelys imbricata (18853)	Oxyuranus scutellatus (39910)	Eunectes murinus (35703)		Python regius	2
Agkistrodon piscivorus (391239)	Oxyuranus microlepidotus (173869)	Crocodylus niloticus (27351)	Chelonoidis nigra (18212)	Emys orbicularis (37246)	Malayopython reticulatus (34727)		Vipera aspis	2

Table 1: Species rank for total page views across all languages and for five key language editions. The top 20 species for all of Wikipedia and five key language editions are shown and ordered from top to bottom, with page views given in parenthesis. Species appearing in more than one language edition are colour-coded according to the column on the right.

	All reptiles		All reptiles (English)		Snakes		Lizards		Scincidae	
	coeff.	P	coeff.	P	coeff.	P	coeff.	P	coeff.	P
Venomousness	0.346	***	0.397	***	0.667	***	1.685	***	n/a	
Threat	0.733	***	0.288	***	0.643	***	0.739	***	0.340	***
Body mass	-0.145	***	-0.092	***	-0.501	***	-0.072	***	0.061	
Body mass^2	0.052	***	0.036	***	0.088	***	0.051	***	0.021	**
Description year	-0.214	***	-0.116	***	-0.250	***	-0.205	***	-0.177	***
Description year^2	5.3E-05	***	2.9E-05	***	6.3E-05	***	5.1E-05	***	4.4E-05	***
Area	-0.117	***	-0.170	***	-0.111	***	-0.152	***	-0.105	***
Area^2	0.009	***	0.013	***	0.009	***	0.012	***	0.006	***
n	9701		3115		3353		5932		1557	
Adjusted D^2	0.671		0.579		0.670		0.623		0.470	

Table 2: Modelling page views with various traits. The results of modelling page views with negative binomial GLMs and quadratic terms for continuous variables. Models are for all page views for all species and English page view for all species. Models for snakes, lizards (includes *Sphenodon*) and Scincidae are for total page views. Results are for the global models of these groups which includes all terms (see text). coeff. denotes coefficients. Asterisks denote p values - ** <0.01, *** <0.001.

	Turtles			Amphisbaenia			Gekkonidae			Agamidae			Chamaeleonidae			Colubridae		
	coeff.	P	imp.	coeff.	P	imp.	coeff.	P	imp.	coeff.	P	imp.	coeff.	P	imp.	coeff.	P	imp.
Venomous		n/a			n/a			n/a			n/a			n/a		3.6E-06		0.91
Threat	5.8E-06	***	1.00	-1.0E-05		0.37	2.5E-05	***	1.00	1.7E-06		0.47	2.1E-07		0.21	3.8E-07	***	0.26
Body mass	1.3E-06		0.81	4.6E-05		0.62	6.2E-06		1.00	-2.9E-05	*	1.00	-8.0E-05	***	1.00	-1.0E-05		1.00
Body mass^2	5.9E-07		0.19	-6.8E-05		0.68	9.7E-06		0.63	5.7E-05	***	1.00	9.3E-05	***	1.00	3.0E-05	***	1.00
Description year	-2.4E-04	***	1.00	-1.7E-03		1.00	-1.1E-03	***	1.00	-8.7E-04	***	1.00	-6.7E-04	**	1.00	-1.0E-03		1.00
Description year^2	2.2E-04	**	1.00	1.6E-03		0.70	1.1E-03	***	1.00	8.5E-04	***	1.00	6.4E-04	**	1.00	1.0E-03	***	1.00
Area	-1.4E-05		0.81	4.7E-06		0.20	-2.9E-05	*	1.00	-2.9E-05	*	1.00	-2.3E-07		0.20	-9.6E-06		1.00
Area^2	1.6E-05		0.73	-3.2E-06		0.04	5.0E-05	***	1.00	5.5E-05	***	1.00		n/a		1.8E-05		0.87
n		206			187			1004			436			197			812	
Num. top models		6			14			2			2			3			4	
Adjusted D^2		0.532			0.293			0.528			0.542			0.584			0.633	

Table 3: Modelling total page views of reptile groups and key families with various traits. Results are for the top models in each group within 4 AIC units. coeff. are the averaged coefficients for each model and each term imp. are the importance values of the terms from the averaged modelled. Asterisks denote p values - * < 0.05, ** <0.01, *** <0.001.

Figure Captions

Figure 1: The abundance and frequency distribution of page views. The main pane shows the ranked abundance distribution for ln transformed total page views and views of five main families. The inset shows the frequency distribution of log transformed total page views.

Figure 2: Global distribution maps of page views of reptiles. Pane A displays the median value of the total page views for all the species, calculated per grid cell. Panes B-F show patterns of page views in five main Wikipedia language- English (B), Spanish (C), Portuguese (D), German (E) and Japanese (F). Each of these panes shows total number of page views per gridcell in that language divided by the number of species in that cell with Wikipedia pages in that particular language.

Figure 3: Phylogeny of reptile families. Family branches coloured red are those without a single species represented in the top 5 percentile of total page views.

Supplementary tables:

Table S1: Page views of reptiles pages in Wikipedia in the year 2014. The table displays the total page views from all 146 Wikipedia language editions, as well as, those for five key languages: English, Spanish, Portuguese, German and, Japanese (Portug.). Reptile binomial names follow the August 2015 Uetz and Hošek taxonomy.

Table S2: Details on individual model contributing to the model averaging for the different groups.

Figures

Figure 1

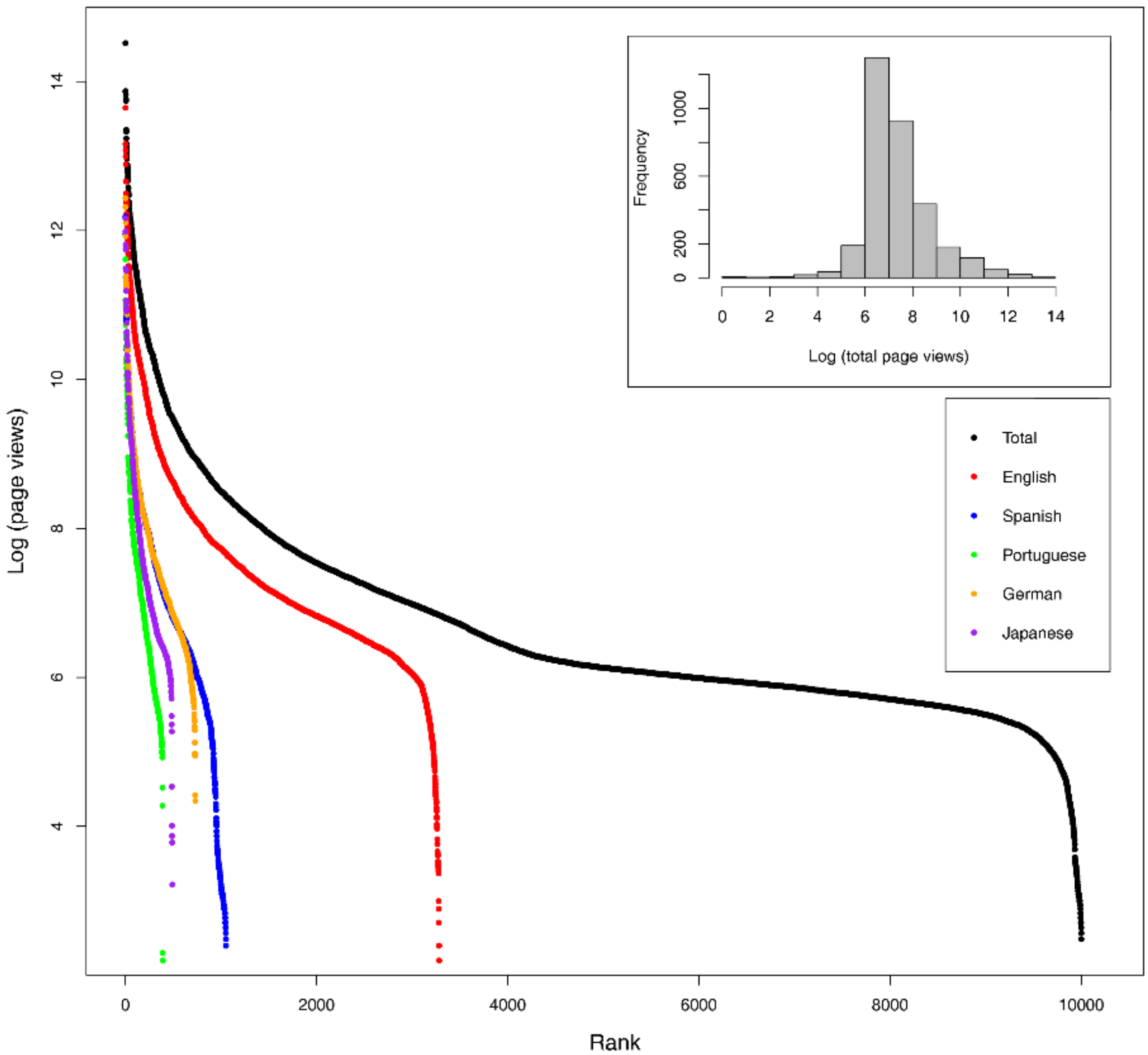


Figure 2

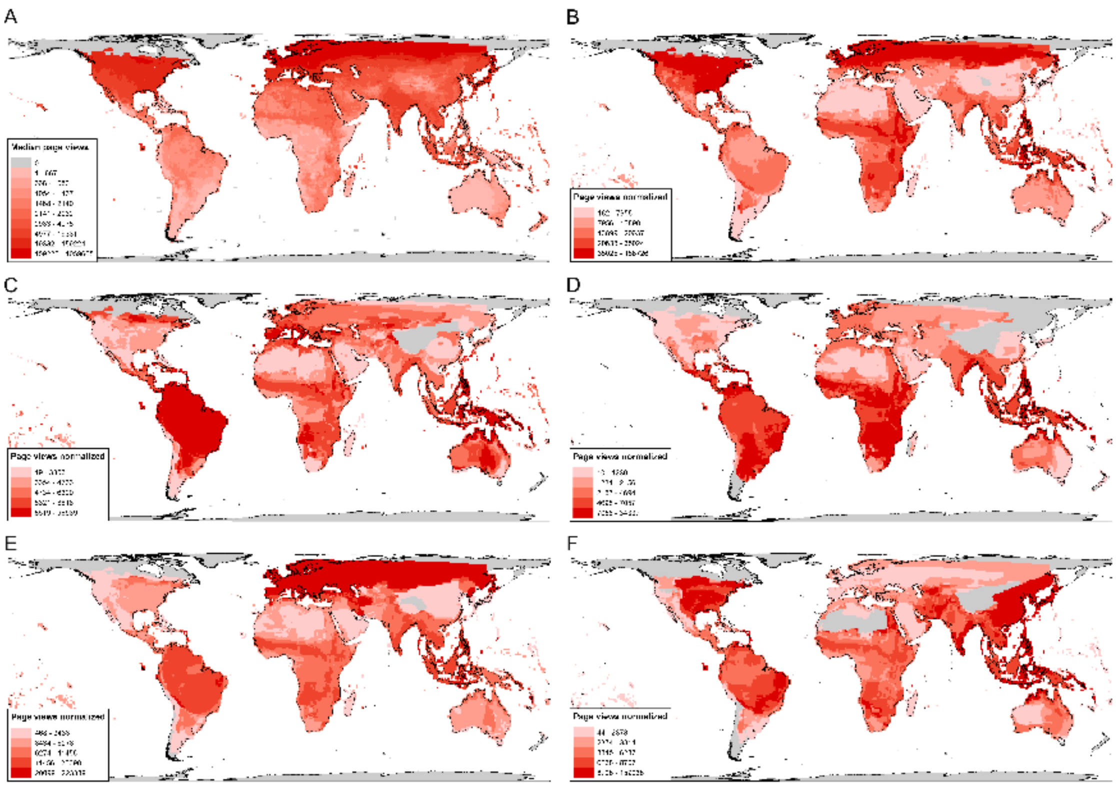
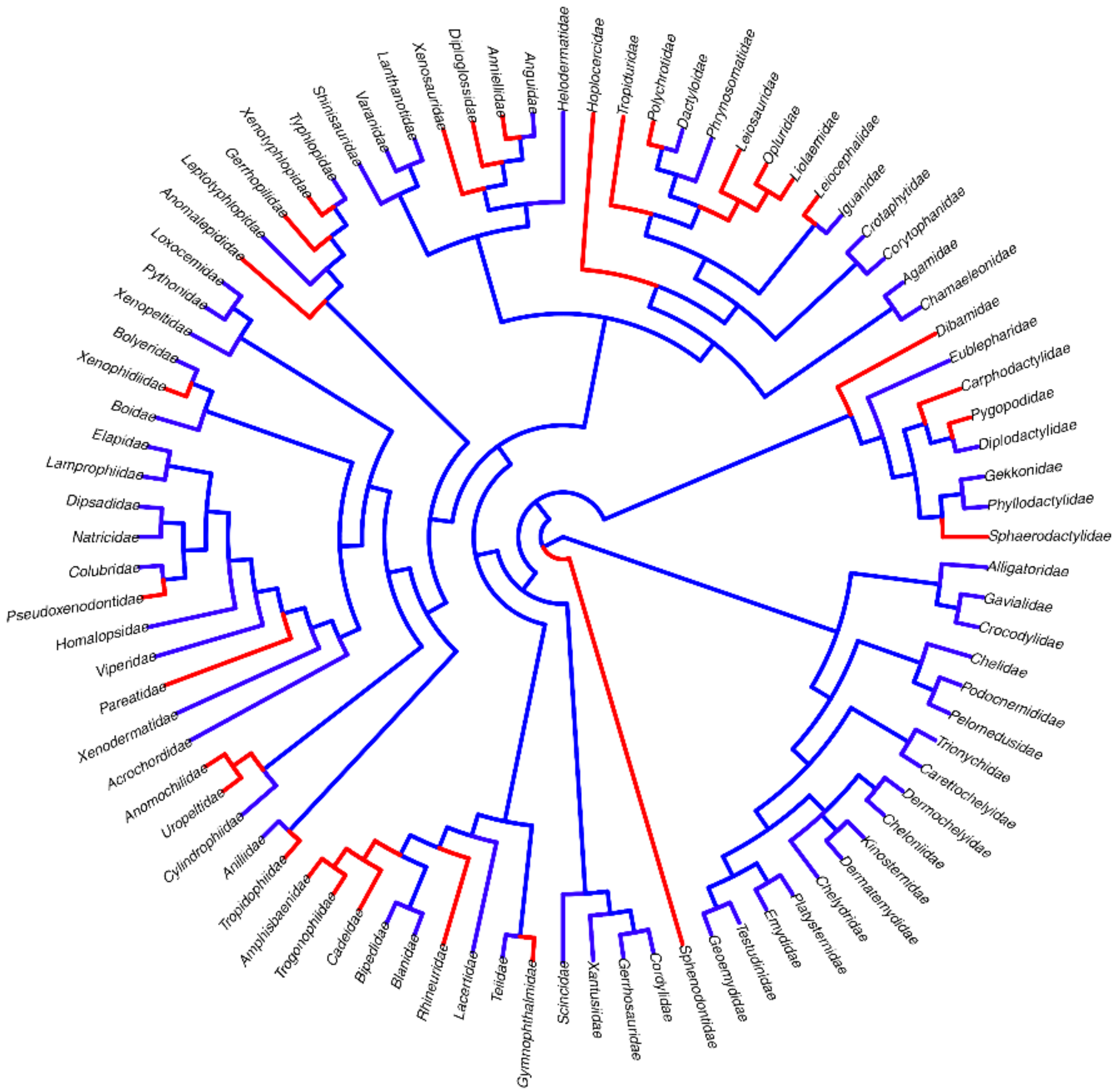

A
B
C
D
E
F
Median page views
Page views normalized
Page views normalized
Page views normalized
Page views normalized
Page views normalized

Figure 3:



Helodermatidae
Hoplocercidae
Tropiduridae
Polychrotidae
Dactyloidae
Phrynosomatidae
Leiosauridae
Opluridae
Liolaemidae
Leiocephalidae
Iguanidae
Crotaphytidae
Corytophanidae
Agamidae
Chamaeleonidae
Dibamidae
Eublepharidae
Carphodactylidae
Pygopodidae
Diplodactylidae
Gekkonidae
Phyllodactylidae
Sphaerodactylidae
Alligatoridae
Gavialidae
Crocodylidae
Chelidae
Podocnemididae
Pelomedusidae
Trionychidae
Carettochelyidae
Dermochelyidae
Cheloniidae
Kinosternidae
Dermatemydidae
Chelydridae
Platysternidae
Emydidae
Testudinidae
Geoemydidae
Sphenodontidae
Cordylidae
Gerrhosauridae
Xantusidae
Scincidae
Gymnophthalmidae
Teiidae
Lacertidae
Rhineuridae
Blanidae
Bipedidae
Cadeidae
Trogonophidae
Amphisbaenidae
Tropidophiidae
Aniliidae
Cylindrophiidae
Uropeltidae
Anomochilidae
Acrochordidae
Xenodermatidae
Pareatidae
Viperidae
Homalopsidae
Pseudoxenodontidae
Colubridae
Natricidae
Dipsadidae
Lamprophiidae
Elapidae
Boidae
Xenophidiidae
Bolyeridae
Xenopeltidae
Pythonidae
Loxocemidae
Anomalepididae
Leptotyphlopidae
Gerrhopilidae
Xenotyphlopidae
Typhlopidae
Shinisauridae
Varanidae
Lanthanotidae
Xenosauridae
Diploglossidae
Anniellidae
Anguidae