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Why Have a Pet Amphibian? Insights From YouTube

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The desire to own a pet amphibian is growing, and with it a growth in amphibian trade and in negative impacts on native populations, including disease transmission and invasive amphibian populations. We know very little about how or why people choose amphibians as pets, but amphibian owners share large numbers of videos on freely accessible platforms, such as YouTube. We aimed to use videos of captive amphibians to determine which species are kept, their life-history stage and the types of videos uploaded. We watched and categorized 1,162 videos by video type, type of amphibian behavior and amphibian taxonomy (superfamily, family, and species). We used data on the amphibian trade from the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), on conservation status from the International Union for Conservation of Nature (IUCN) red list, and on potential environmental impact from published Environmental Impact Classification of Alien Taxa (EICAT) records, to determine potential conflicts of owning pet amphibians. We recorded 173 captive species in 847 videos with a taxonomic overrepresentation of salamandroids and pipoids, and an underrepresentation of ranoids and plethodontoids. When compared to videos of wild amphibian species, videos of captive animals featured disproportionate amounts of adults feeding, being handled and moving. The videos watched had a smaller proportion of threatened amphibian species, but a higher proportion of invasive species, than would be expected by chance, with the proportion present in CITES appendices (18%) being non-significant. We suggest that such data can be used to profile potential pets for trade and attempt to avoid conflicts with threatened and highly impacting alien species.

Keywords: Anura, Caudata, Gymnophiona, pet trade, invasive species, pathways

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INTRODUCTION

Few would deny that amphibians are fascinating animals. Metamorphosis intrigued Aristotle (350 BP; Thompson, 1907) and other early philosophers, and continues to draw major lines of inquiry (e.g., Laudet, 2011). The subject remains in the curricula of primary school students around the world. But amphibians draw interest from a wide section of society for many other reasons, including their diverse body forms, reproductive modes, striking colors, advertisement calls and amphibious nature (Burghardt, 2017). Documentaries show a bewildering array of species with diverse behaviors in naturalistic settings to an increasingly urban audience (Wigginton et al., 2016) detached from the natural world (Miller, 2005). Is it any wonder that a wider section of society is becoming interested in having their own pet frog, salamander, or caecilian?

Trade in amphibians for pets is rising (Schlaepfer et al., 2005; Carpenter et al., 2014; Herrel and van der Meijden, 2014), but such inferences are made on a small number of databases that actually record trade in select areas of the world (Auliya et al., 2016). Most of the world's trade in amphibians likely goes unrecorded (Herrel and van der Meijden, 2014). Trade drives the collection of wild amphibians, directly leading to decline of some species (Natusch and Lyons, 2012; Alroy, 2015), and this is the justification for trade bans and/or restrictions (e.g., CITES). Trade is often injurious to the animals traded, either during transport (Ashley et al., 2014) or as a result of malnutrition and poor husbandry (Pasmans et al., 2017; Warwick et al., 2018). Trade carries disease (Fisher and Garner, 2007; Peel et al., 2012; Kolby et al., 2014; O'Hanlon et al., 2018) and specimens in trade act as reservoirs for disease (Spitzen-van der Sluijs et al., 2011). Trade can lead to alien populations becoming invasive (Hulme et al., 2008; Kraus, 2008) and these can have a wide array of impacts (Bucciarelli et al., 2014; Measey et al., 2016). Like it or not, the amphibian trade is here to stay (Garner et al., 2009). Even in the face of regional bans (Gray et al., 2015; Yap et al., 2015), illegal trade likely continues to carry the same problems (e.g., Pistoni and Toledo, 2010; De Paula et al., 2012). Despite increasing calls for banning trade, the current consensus calls for the promotion and continuation of responsible pet ownership (Pasmans et al., 2017).

Trade is fickle and subject to trends and fashions that are difficult to predict. Knowledge of what people want in a pet amphibian might help make predictions about which species may be future problems both in export and import areas. For example, the trade in dendrobatid frogs (poison arrow frogs) grew in the 1980s and 1990s (Gorzula, 1996; Carpenter et al., 2014), and was, at some point, considered unsustainable (Schlaepfer et al., 2005); however, trade in wild-caught dendrobatid frogs has now greatly diminished due to CITES and to the success in captive breeding of many of these species (Nijman and Shepherd, 2010). The African clawed frog was once exported from South Africa in large quantities (Van Sittert and Measey, 2016), but now animals are bred in and exported from China (Measey, 2017). Other examples are newts of the genus *Tylototriton* that have been exported in large numbers from Asia (Rowley et al., 2016), flooding the EU and USA markets, and consequently discouraging good husbandry (Auliya et al., 2016; Pasmans et al., 2017). Many amphibian species are difficult to keep and do not make good pets (Pasmans et al., 2017). However, we are still profoundly ignorant of what drives the amphibian pet trade, exactly what traits of species are desirable, and how can the future of trade be predicted (Reed and Kraus, 2010).

The upsurge in social media websites has been driven, in part, by the availability of cheap electronics that are able to capture sound, images, and video (Silvertown, 2009). The video-sharing website YouTube (www.youtube.com) has become extremely popular since its launch in 2005. Users can upload any video material and choose to have it available on a global platform. YouTube can censor content and users can take down videos, such that the website is somewhat dynamic. The massive potential of YouTube videos in elucidating animal behavior and human-animal interaction on a large scale (Nelson and Fijn, 2013) has spurred many studies in the last decade. These include studies on canine tail chasing (Burn, 2011), spontaneous motor entrainment to music (Schachner et al., 2009), yawning (Gallup et al., 2016) and behavior of true shrikes (Dylewski et al., 2017). Burn (2014) reviewed some of the caveats and advantages to using data from YouTube, including: non-random sampling, internal validity, large samples, and the free and ubiquitous availability. Video sharing platforms allow insight into how people perceive their pets inside their homes, and likewise the interactions that are commonly experienced with animals in the wild. So how can such data be used to assess the desire to have amphibians as pets?

We reasoned that people would upload videos of what they consider to be interesting aspects of pet amphibian ownership and wild amphibians, and that the videos uploaded would reflect amphibian taxa that are kept as pets, without reference to lists of species known to be traded. In order to gain insight into why people have amphibians as pets, we used YouTube videos to examine (i) which amphibians (species and life-history stages) members of the public are uploading videos on, (ii) whether there are conflicts for amphibians kept as pets with species that are trade restricted (listed in CITES appendices), considered threatened (according to the IUCN red list) or impacting invasive species (using the EICAT scheme), and (iii) the types of amphibian videos and behaviors that are most uploaded.

MATERIALS AND METHODS

We chose to use YouTube (www.youtube.com) as a source for prevailing interest in amphibians. We used broad search terms associated with amphibians (**Supplementary Table 1**), as well as those more specific to Anura, Caudata, and Gymnophiona, and translations of these terms in commonly used languages such as French, German, Italian, Portuguese and Spanish. Although we used search terms that were biased toward captive animals, the main subject of focus in this study, we also came across and scored videos of wild amphibians. This was done in order to understand and be able to compare behaviors found in videos of captive and wild amphibians. It was easy to determine whether videos were shot in captivity or wild scenarios, by referring to the setting in which the video was taken. However, we acknowledge that we have no information on how long any individual amphibians had been in captivity when they were filmed. To avoid dependence in searched videos, all searches were made in "incognito mode" using the Chrome browser (Davidson et al., 2010); using incognito mode allows searching without previous search history influencing the results.

From each video, we recorded the video URL, date posted, date accessed, and country of origin (**Supplementary Table 2**). Although "country of origin" was recorded as a variable, this information was present for only 42% of the dataset. We first identified the species of amphibian shown most prominently in the video, either by using information present on the video or by using expert knowledge of the authors. The video was then scored on the life-history stage of the amphibian shown, as egg, larvae, juvenile or adult. Video type was divided into

wild capture, showcasing/unboxing, behavioral, culinary, captive care, educational or advertising, and scored based on our perception of the main aim of the videographer for making the video. We further subdivided the behavior of the amphibian shown into the following categories: moving, molting, mating, laying eggs, immobile, hatching, handling, feeding, dead, calling, as prey and aggression. No videos that appeared to have been made professionally or that could have been reproduced from a previously broadcasted program were included. We also avoided any re-postings of existing videos and, in cases of doubt, the content with the oldest date of video posted was chosen. The sampled videos were uploaded between 2006 and 2016.

From our identification of the subject species, we obtained the Order, Superfamily and Family according to Frost (2018) and Pyron (2014). Videos that could not be ascribed to a confirmed genus or species by the viewer were removed from analyses that required species level data but, where known, were included in Superfamily and Family groupings. This means that the dataset size differed between analyses, with a full dataset of 1,162 videos available for comparisons between taxonomic representation, video type, behavior category, and potential conflicts.

DATA ANALYSES

Taxonomic Representation

To assess over- or under-representation of amphibian orders, superfamilies or families in videos, we compared the number of species at each taxonomic level with the total number of known amphibian species (Frost, 2018), assuming a random expectation generated using the hypergeometric distribution (see Van Wilgen et al., 2018) in R (3.4.0; R Core Team, 2018). Families outside the 95% confidence intervals were deemed either over- or under-represented in our sample of YouTube videos.

Trade, Conservation, and Invasive Status

We compared species names from videos of captive amphibians with their known CITES Appendices (I, II, and III on October 4, 2017). Although the list only has 45 entries, many are for entire genera. Using Frost (2018), we determined the current composition of each genus listed under CITES, totaling 163 species/entries. Because the genus *Rheobatrachus* only has two species that are both specifically excluded, we did not include this genus. We took the same approach with the IUCN red list status, comparing species on our list to the red list status of all amphibian species (Critically Endangered CR; Endangered EN, Vulnerable VU, Near Threatened NT and Least Concern LC on October 4, 2017). Lastly, we compared our list to species of recorded invasive amphibians with known EICAT scores [Massive MV, Major MR, Moderate MO, Minor, MN, Minimal MC, Data Deficient DD, using (Kumschick et al., 2017)]. We tested the proportion of animals in the categories named above from our list with the proportion of all amphibians using a paired Wilcoxon signed rank test in R.

Comparison of Behavior in Amphibians Filmed in Captivity and the Wild

We conducted a Wilcoxon signed rank test in R on numbers of video types (not including "Wild Capture") and behavioral categories, comparing videos of wild amphibians to those in captivity.

RESULTS

Taxonomic Representation in YouTube Videos

We identified 173 captive species from 847 videos, representing 33 amphibian families (22 families and 6 superfamilies of Anura; 6 families of 3 superfamilies of Caudata; and 5 families of 2 superfamilies of Gymnophiona). For the captive amphibian videos, the majority of superfamilies were represented proportionately, the only over-represented superfamilies being the Salamandroidea and Pipoidea, while Plethodontoidea and Ranoidea were both under-represented (**Figure 1**). Similarly, most families were proportionately represented, but that some, particularly urodeles (Ambystomatidae, Salamandridae) and caecilians (Siphonopidae, Caeciliidae), were overrepresented, while frogs were generally underrepresented (**Figure 1**). Of the frog families, Scaphiopodidae, Ceratophryidae, Dendrobatidae, Pipidae, and Bufonidae were all over-represented. Only two families appear to have been under-represented, the plethodontid salamanders and microhylid frogs (**Figure 1**). The majority of videos featured only adults (88.6%), with very small numbers of videos showing the remarkable metamorphic process of tadpoles turning into juveniles (0.3%). Of the 173 different species of captive amphibians in videos, the most widely videoed frog was the Argentine horned frog, *Ceratophrys ornata* (5.6% of all videos; **Table 1**) all of which were filmed in captivity.

Trade, Conservation, and Invasive Status

The comparison of all amphibian species on CITES Appendices I–III with captive amphibians in YouTube videos was not significantly different ($V = 10$; $P = 0.125$; **Figure 2A**). Despite this, we found videos of two species listed on CITES Appendix I (*Atelopus zeteki* and *Andrias davidianus*), and we found that more than 15% of species videoed were listed on Appendix II. Proportions of threatened species (CR, EN, VU, NT) were lower in YouTube videos of captive amphibians than might be expected by chance ($V = 21$; $P = 0.031$; **Figure 2B**), although we did find videos of 13 Critically Endangered species in captivity. The number of invasive species with known impact levels (MV, MR, MO, MN, MC) in videos of captive amphibians was higher than might be expected by chance ($V = 36$; $P = 0.014$; **Figure 2C**), including species with Massive Impact (*Ambystoma tigrinum*) and some with Major Impact (*Rhinella marina, Xenopus laevis, Duttaphrynus melanostictus, Lithobates catesbeianus*). In fact, our list of captive amphibians accounts for 27.5% of alien amphibians with known impact, and 22% of all known alien amphibians.

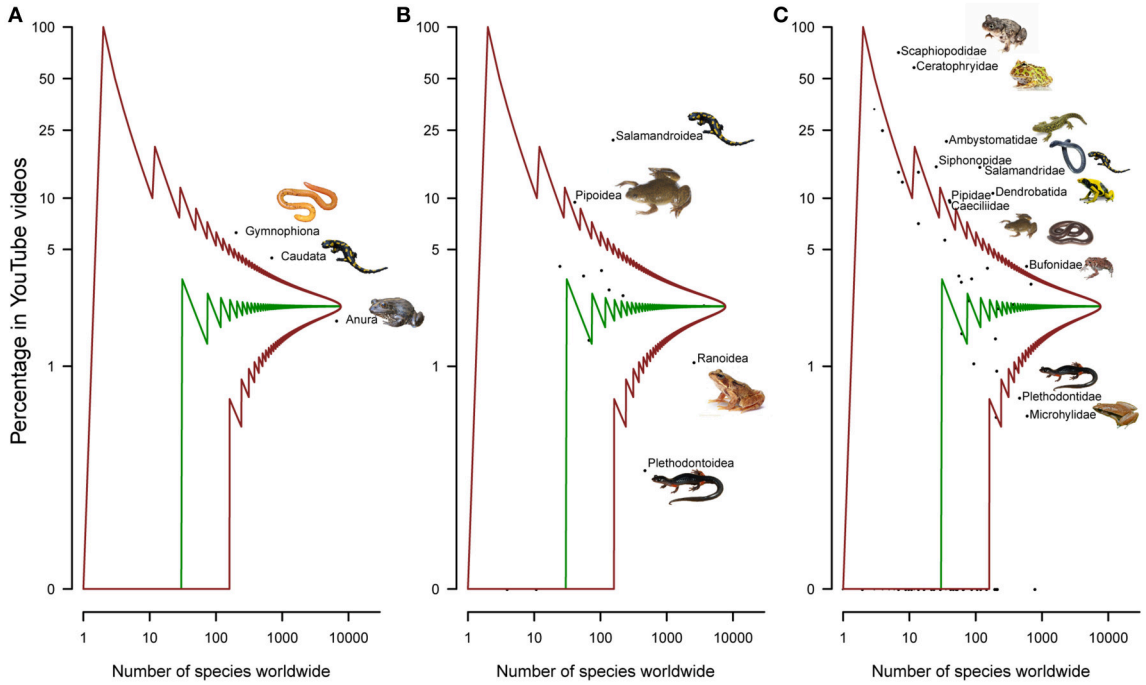

FIGURE 1 | Taxonomic patterns in amphibian **(A)** orders, **(B)** superfamilies, and **(C)** families present in the species identified in captive YouTube amphibian videos. The median (green line) and 95% confidence intervals (brown lines above and below), adjusted for multiple comparisons, were estimated from the hypergeometric distribution. The points that fall between the 95% confidence intervals are not significantly over or under-represented, relative to the number of amphibian species worldwide. Those labeled orders, superfamilies or families that fall above the 95% confidence intervals are over-represented and those below are under-represented in our sample of YouTube videos.

Comparison of Behavior in Amphibians Filmed in Captivity and the Wild

We watched 315 videos of wild amphibians, where we identified 133 species (from 22 families of the same 6 superfamilies of Anura; 8 families of the same 3 superfamilies of Caudata; and 5 families of the same 2 superfamilies of Gymnophiona). Types of videos were significantly different between wild and captive animals ($V = 70$; $P < 0.0001$; **Figure 3A**), with videos featuring different behaviors being the most frequent for both groups (49.1 and 46.8% for captive and wild videos, respectively). Behaviors of different categories were significantly different between wild and captive videos ($V = 76$; $P = 0.036$; **Figure 3B**), indicating that behaviors that could be filmed in captivity were not the same as those filmed in wild animals. For example, the most popular behavior category in captive animals, feeding (31.4%), only made up 3% of videos of wild animal behavior; for the latter, the most popular behavior filmed was movement (29.5%), which featured in only 18.7% of captive amphibian videos. Indeed, there were more films of immobile captive amphibians (26.1%) than those showing movement. The next most popular video type was showcasing or unboxing (24.8% of all videos), videos that featured newly arrived species and equipment obtained from commercial suppliers (**Figure 3A**).

DISCUSSION

Why do people want to own amphibians? Our data suggest that captive amphibians afford their owners opportunities to observe behaviors that are not observed in wild amphibians. For example, the behavior most filmed in captive amphibians, feeding, was rarely captured in videos of wild animals. Additionally, amphibians included in YouTube videos emphasized that amphibian pet ownership may be in conflict with conservation, as many species were listed as protected or threatened, as well as invasive. Our amphibian video species list contained species in all IUCN Red List threat categories (except EX and EW) but, of more concern, is that they featured a disproportionately high number of invasive species, some of which with known Massive (MV) or Major (MR) impacts. This is generally not surprising, given the high numbers of known invasive species present in the pet trade (Herrel and van der Meijden, 2014). However, we found cane toads (*Rhinella marina*) to be popular captive pets which, given their known mjor impacts is especially concerning. More than 17% of species videoed were CITES listed, with two listed on Appendix I. Of four videos of the Panamanian golden frog, *Atelopus zeteki*, one of those species, two were shot in zoos, while the provenance of the other two could not be verified. The video of a Chinese giant salamander, *Andrias davidianus*, was

TABLE 1 | The 20 most frequent captive species with videos on YouTube.

Species name	No. videos	% Videos	CITES appendix	IUCN Red List	EICAT score
Ceratophrys ornata	65	7.70		NT	
*Typhlonectes natans**	53	6.28		LC	
Pyxicephalus adspersus	31	3.67		LC	
Litoria caerulea	29	3.32		LC	
*Anaxyrus americanus**	28	3.20		LC	DD
Ambystoma mexicanum	26	3.08	II	CR	
Ambystoma tigrinum	24	2.84		LC	MV
Anaxyrus sp.*	23	2.73			
Dendrobates tinctorius	23	2.73	II	LC	
*Hypselotriton orientalis**	22	2.61		LC	
Rhinella marina	22	2.61		LC	MR
*Bombina sp.**	20	2.37			
Xenopus laevis	19	2.13		LC	MR
Dendrobates leucomelas	15	1.78	II	LC	
Lithobates catesbeianus	13	1.54		LC	MR
Salamandra salamandra	13	1.54		LC	
Bombina orientalis	12	1.42		LC	DD
Hymenochirus sp.	12	1.42			
*Siren intermedia**	12	1.42		LC	
Agalychnis callidryas	11	1.30	II	LC	
Total	473	55.69			

*For each species, the CITES appendix (if any), IUCN red list status, and EICAT score are indicated. A * against the name denotes the absence of this species from recently published lists of traded species (see text for details).*

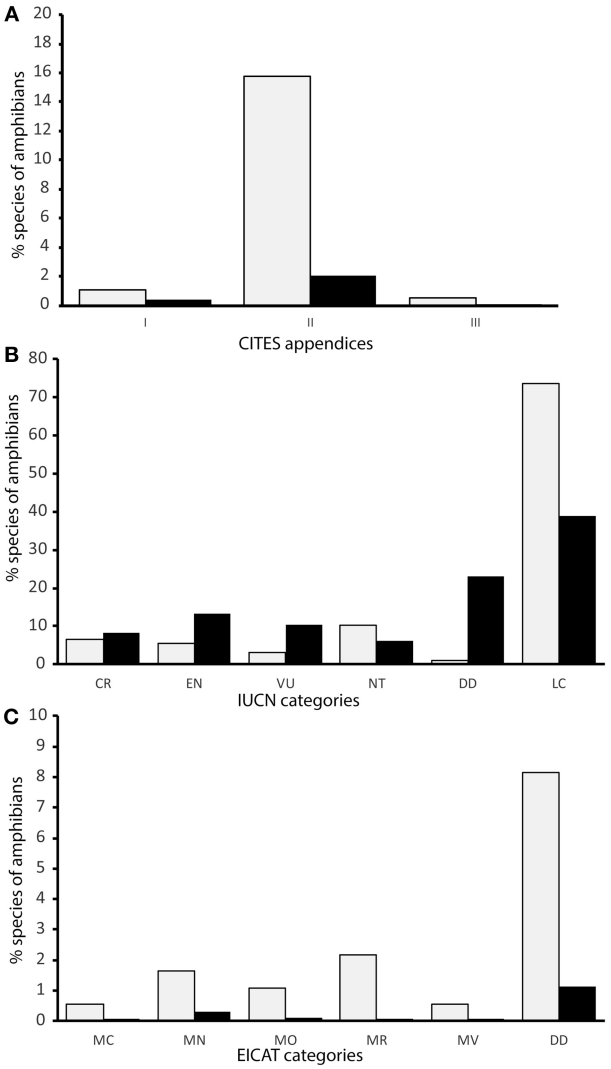

FIGURE 2 | Percentages of amphibian species identified in captive YouTube videos (gray bars) with **(A)** listed in CITES appendices, **(B)** IUCN Red List status, and **(C)** EICAT scores, compared to all amphibians (black bars). Note that in **(A)** categories "Extinct" (EX) and "Extinct in the wild" (EW) are not included, and in **(B)** the group "Not Alien" (NA) is not included, but represented 85.9% of species identified in YouTube videos ($n = 184$) and 98.3% of all amphibians. Similarly, in **(C)**, species not on a CITES appendix are not included and represented 82.6% of species identified in YouTube videos ($n = 184$) and 97.5% of all amphibians.

filmed in a Chinese kitchen and showed culinary preparation of a live animal, an act that does not contradict CITES regulations. That we found a relatively high proportion of videos with species listed in CITES Appendix II is not necessarily a conflict and may simply reflect the high numbers of these species present in the amphibian trade. Alternatively, there could be fewer CITES species in captivity because they are harder to obtain, or those that are in captivity could be filmed more frequently because of the greater interest in their rarity. However, we have no reason to think that either explanation is driving trends in our dataset.

Of the well-recorded problems associated with amphibian trade (over-exploitation, poor husbandry, disease, etc.), our data highlights the conflicts with amphibian conservation and presence of invasive species. It is not necessarily problematic that captive amphibians have a threatened status, as many threatened species are legitimately bred in captivity with legal distribution. Indeed, it could be argued that *ex situ* breeding and successful captive populations are positive aspects of the amphibian trade (Zippel et al., 2011). Problems associated with captive species that are also invasive are of more concern, as each *ex situ* population may become a potential new invasion, if animals are released or escape (e.g., Kraus, 2008). Invasions are linked to the spread of disease to native amphibian populations (Daszak et al., 1999), hybridization with native species (Ryan et al., 2009), and it is well-established that pets support a reservoir of disease (Kolby et al., 2014). Indeed, stressed individuals are likely to be immunocompromised and thus more likely to harbor increased levels of disease (Titon et al., 2017; Assis et al., 2018).

YouTube videos may not represent all people who have amphibians as pets, although we know of no reason why our sample may be biased toward particular species or behavior types. We acknowledge that the high numbers of videos "showcasing" or "unboxing" amphibians are likely to have inflated the total

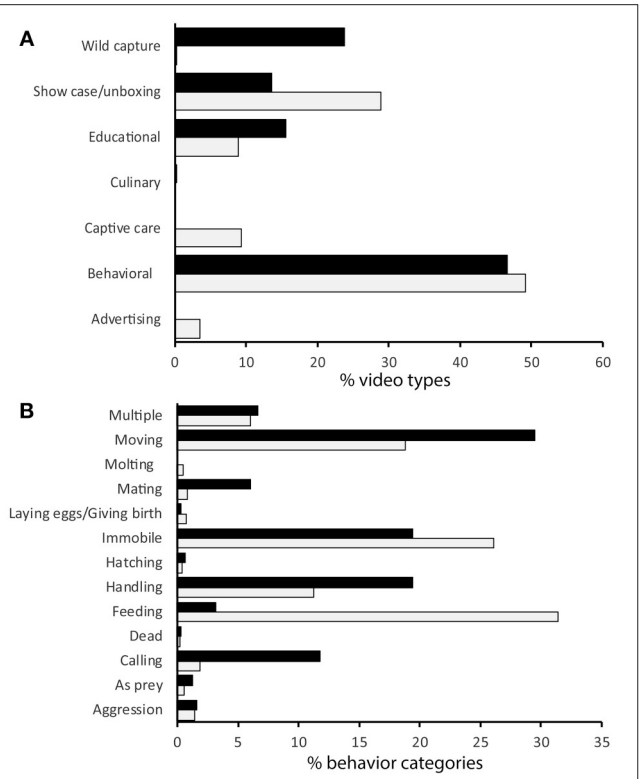

FIGURE 3 | Percentage values of **(A)** video types and **(B)** behavior categories exhibited by amphibians in captive (gray bars; $n = 847$) or wild (black bars; $n = 315$) YouTube videos.

number of species recorded, increasing the proportions of species that are rarely traded. However, these videos represented species in very low frequencies; 65% of species were only represented by one or two videos, suggesting that we could have missed a number of unusual species that are being kept in captivity. Videos featuring only the most frequent 15 captive species (video frequency >3) represented 75% of all videos watched. This species list included 10 out of the top 15 species imported live into the US (93% of individuals recorded in Schlaepfer et al., 2005; 92% of total numbers imported; Herrel and van der Meijden, 2014), 5 out of 11 species mentioned by Carpenter et al. (2014), and 11 of the 29 species available for sale in the UK (Tapley et al., 2011). The bias toward US imports may, to some extent, reflect the languages that were used in our search terms, which excluded Asian languages. Our list had only 14 of the 45 species exported live from Hong Kong (21.19% of total numbers exported; Rowley et al., 2016). Asia is clearly an important region for the amphibian trade, and conducting a comparative study on local video platforms there would be of great interest.

Our results featured groups of amphibians that, to our knowledge, are not traded, but presumably obtained directly from the wild, like the American toad, *Anaxyrus americanus*. Given that this was one of the most popular species videoed, taking amphibians directly from the wild to keep as pets may be an underappreciated aspect of amphibian captive activities. Although such instances may appear benign, releasing of immunocompromised animals from captivity back into the wild could increase prevalence of disease in natural communities (see Assis et al., 2018). The movement of wild amphibians into captivity without involving trade was given as a reason for the decline of native European species in the past (e.g., Beebee, 1973; Spellerberg, 1976). It could be an indication of the classic reason for keeping amphibians as pets: witnessing metamorphosis. We are certain that this still happens (e.g., Vigni, 2013), but does not appear to be a popular subject for YouTube videos, perhaps because it is not an easy process to film. That so few videos featured life-history stages other than adults suggests that there is proportionately little breeding of captive amphibians or, at least, being filmed. Further, if observing metamorphosis would be a prime motivation for keeping non-traded amphibians, we would expect to see a higher proportion of videos than the 8% that featured larvae and or metamorphosing amphibians.

Our search terms probably influenced our results in terms of the over-representation of salamanders and caecilians. Because it was not possible to search for amphibians and continue to find sufficient videos on which to conduct a study, we were forced to use more specific search terms. Nevertheless, the inclusion of these groups in our study does provide an opportunity to show that there are many species in captivity that were not previously considered (Schlaepfer et al., 2005; Tapley et al., 2011; Carpenter et al., 2014; Herrel and van der Meijden, 2014; Rowley et al., 2016). In future, it would be interesting to conduct a similar exercise on captive salamander videos to determine the effect of recent trade bans (Yap et al., 2015), especially to answer whether sufficient policy actions have taken place (Gray et al., 2015). Another potential source of bias in our analysis could be geographical origin of videos (Brodersen et al., 2012). However, given the lack of location information for more than 50% of the dataset (Dylewski et al., 2017), we did not investigate such patterns further. The stability of the observed patterns, in the face of the rapid growth of YouTube (Cheng et al., 2008), is a concern. However, a year-wise analysis of sampled videos does not reflect a drastic increase from 2010 to 2016, leading us to infer that the observed patterns will hold for the near future.

SUMMARY

There has been a marked increase in research into the size and effect of the pet trade, but very little attempt to explain what drives it. In this novel approach, which reaches into the homes of the owners of pet amphibians, we found that people are most interested in amphibian behavior, especially feeding. We find that behaviors filmed in captive amphibians are different from those that YouTube contributors are able to film in the wild, which we think provides insight into why people want pet amphibians: to watch feeding and movements, as well as being able to handle individuals. Our data also upholds the validity of a previously documented trend (Beebee, 1973; Spellerberg, 1976) that has received little or no recent attention: collecting native amphibians to keep as pets. Such habits may have important repercussions as these captive animals have a propensity for harboring disease (e.g., Titon et al., 2017; Assis et al., 2018), as well as other implications for conservation. Whether recent restrictions in trade will augment the collection of individuals from the local environment as pets remains to be seen. However, we caution

that even in the absence of trade, keeping local amphibians as pets is still hazardous for wild populations. Lastly, our study contributes to the rapidly emerging stream of using social media to quantitatively understand human-animal interactions and further predict motivations for future interactions.

AUTHOR CONTRIBUTIONS

All authors conceived the ideas and collected the data. JM analyzed the data and led the writing.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fevo.2019.00052/full#supplementary-material

Supplementary Table 1 | Search terms used in 'incognito mode' of Chrome to search YouTube for videos of amphibians.

Supplementary Table 2 | Videos watched (URL), date posted, date accessed, and country of origin. Species are identified (with Order, Superfamily, Family and Species). Videos are divided into type and subdivided into behavior.

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