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Abstract – Historically, Internet access has been linked to a country's wealth. However, starting a decade ago, this situation changed dramatically and Internet access became increasingly available in primate range countries. The rapid growth of smartphone use in developing nations has created new avenues to communicate conservation. Here we assess the potential of social media to promote primate conservation at the local level within primate range countries. We interviewed 381 people in communities associated with 18 conservation projects from 11 countries to assess their use of social media. We found that 91% of the people had at least one social media account and 95% of these people checked their accounts daily. The median number of contacts per person across all platforms was 453 and 300 considering only each person's most used platform. We also documented that local conservation projects had a diversity of information they wanted to relay to the local community through social media. Our research highlights the potential for social media to be an extremely useful communication tool for tropical conservation scientists. Thus, we encourage more conservation groups to explore using social media to communicate to local communities and to report on the impact it has on conservation.

Keywords – conservation education, conservation outreach, digital communication, environmental awareness, Internet access, primate conservation.

Introduction

The widespread adoption of social media globally was hard to anticipate just a decade ago. Social media now includes a huge number of websites and applications that allow users to create and share content or to participate in social networking. There are now 3.6 billion people using social media – almost half of the people on the planet – with 2.7 billion people alone having Facebook accounts (Wu *et al.*, 2018; Statista, 2020). Academics are no exception to this trend and social media use by scientists is growing rapidly. For example, the ResearchGate social network site has over 15 million users and is visited more than 150 million times a month (ResearchGate, 2020). Also, 13% of scientists use Twitter on a regular basis (Van Noorden, 2014).

The use of social media by scientists is particularly evident in conservation. Social media is used today as a tool for gathering data to address conservation issues, raise funding, and communicate with the public and policy makers to influence their actions to protect biodiversity (Vercammen *et al.*, 2020; Veríssimo *et al.*, 2020). Social media can be an effective way to collect digital data for conservation (Levin *et al.*, 2015; Forrester *et al.*, 2017). For example, Van Hamme *et al.* (2021) screened over 850 Instagram pictures associated with mountain gorilla (*Gorilla beringei beringei*) 'ecotourism', on which at least one human and one mountain gorilla were visible. They found that in only 3% of the pictures, tourists respected the 7+ m distance rule (Macfie and Williamson, 2010). In another study, Levin *et al.* (2015) used data from the Flickr photo-sharing website to identify natural areas that were not protected where a large number of photographs had been taken, such as the Pantanal of Brazil. The researchers suggested that such areas would have the public's support if they were to be suggested for protected area status. Musing *et al.* (2015) obtained online videos of slow lorises (*Nycticebus* spp.), which they supplemented with data from pet shops and informants, to

document the extent of this illegal trade and to propose way of curbing it. Researchers used Instagram posts of endangered Hawaiian monk seals (*Neomonachus schauinslandi*) to not only supplement traditional population monitoring, but also to assess the frequency of human-seal interactions and animal disturbances (Sullivan *et al.*, 2019). Google search trends have been use to map changes in the spatial distribution of invasive plants to aid in their control (Proulx *et al.*, 2014). By mining data from Instagram, researchers demonstrated that characteristics of the protected area (e.g., accessibility) determined social media usage and not charismatic species richness (*Hausmann et al.*, 2017). These examples clearly illustrate the potential for social media data to be used to advance conservation efforts.

Public enthusiasm to participate in conservation through social media is high, as demonstrated by the over 1.9 million registered volunteers in Zooniverse and over 1 million users of iNaturalist, two online citizen science platforms (Arts *et al.*, 2015). On these platforms, people in 2020 are particularly drawn to projects addressing conservation and biodiversity – 51 of the 56 projects tagged as "Most popular" on Zooniverse (accessed 16 March 2020) fit these categories. Building on this enthusiasm, researchers have started to use social media data to document trends in public interest in conservation issues (Ficetola, 2013; Soriano-Redondo *et al.*, 2017) and to monitor ecosystem services and trade (Galaz *et al.*, 2010). However, effective use of social media to drum up support for conservation is not always achieved. For example, Acerbi *et al.* (2020) obtained online interest data to evaluate the attention given to the publication of the "World's 25 Most Endangered Primates", finding that the release had only limited effect on the public.

Of course, social media is not just a data collection tool. The use of social media to communicate conservation messages has grown in popularity and takes many forms. For decades now large conservation groups have engaged in extensive and costly social media campaigns to raise awareness and to connect to potential donors. Recently, small conservation groups and individual researchers have also taken to social media to communicate messages about wildlife exploitation, their conservation activities, and to raise donations (e.g., https://www.sadabe.org, https://www.himaninautiyal.com, https://www.tce-programme.org/). However, most conservation communication efforts using social media are targeted to the public in high-income countries, particularly tailored towards raising awareness (Nekaris *et al.*, 2013) (e.g., https://www.facebook.com/ThePrimateCast/) and marketing (Harrington *et al.*, 2018; Thomas-Walters *et al.*, 2020) (e.g., https://kibalechimpanzees.wordpress.com/2018/06/12/get-your-kcp-t-shirt-for-world-chimpanzee-day/).

Communicating globally and using social media for fundraising in high-income countries is clearly valuable for conservation. However, given the proportion of the world's population on social media, one might expect that social media platforms could also be used to relay conservation messages to rural and often remote communities living next to and in primate habitats, as it has been done in the United States where 58% of rural people used social media in 2015 (Perrin, 2015). In their daily lives, these communities engage in activities that positively (e.g., wildlife monitoring, self-policing, environmental education) or negatively (e.g., bushmeat hunting, mining, logging) impact primate populations. Their behavior can be nudged towards positive actions through the social media they receive.

In this study, we assess the potential of using social media to promote primate conservation at the local level within primate range countries. Such efforts could target, for example, people living adjacent to protected areas with specific conservation messages. We explore a) the number of local people who could receive the message sent from the conservation group and b) the diversity of issues that could be targeted to specific communities, through the collection of two datasets. First, we asked people that our conservation programs interacted with (e.g., field assistants, cooks, village leaders), if they had social media accounts, and if so, what platforms they used and how many contacts they

had in their social media network (e.g., the number of Facebook Friends, TikTok followers, or WhatsApp contacts). The type, frequency, and nature of the use of social media platforms vary substantially among cultures and regions (Wang and Liu, 2019; Sheldon *et al.*, 2020). For example, the most widely known difference in the use of social media deals with the ban of Facebook and Twitter in China (Leetaru *et al.*, 2013; Mao and Qian, 2015). As a result, to ensure a diversity of perspectives and experiences in our evaluation, we gathered a team of academics from around the world who were from or had worked extensively with local communities in 11 primate-range countries. Second, we detailed the types of information that the local conservation projects wanted to provide the local community.

Methods

We targeted 18 conservation efforts where an academic was associated with a group that worked extensively with local communities in primate-range countries. To obtain a global perspective we included projects from Brazil, China, Colombia, Democratic Republic of the Congo, Ethiopia, India, Indonesia, Madagascar, Mexico, Rwanda, and Uganda. All of the communities had reliable access to the internet, which was typically used with smart phones. For none of the communities would it have been difficult to buy or repair a cell phone. The conservation groups were engaged in a diversity of activities including, education and outreach, conservation festivals, advance degree training, mobile health clinics, tourism, mitigating human-wildlife conflict (particularly crop raiding), reforestation, habitat restoration, teaching sustainable agriculture, park revenue sharing, and patrolling for illegal hunting, logging, or mining. Therefore, their local counterparts included a diverse array of players. While this between-study site diversity does not allow to treat the studies as replicas, their very heterogeneity meets our goal of characterizing the variety of scenarios in which social media can play a significant role in promoting biodiversity conservation.

We collected two types of data. First, to evaluate the potential reach that a social media post could have, we asked each project to communicate to people they worked with (e.g., farmers, herders, field assistants, local teachers, local village leaders, rangers, and residents living next to protected areas) and asked them to tell us all of the social media platform they used, if any. We then asked how many social contacts they had on each platform, and how often they checked social media. When doing this we informed the person of the purpose of the study, told them they should in no way feel pressured to participate, and told them we would not associate their name with the information. This was viewed as culturally acceptable and none of the local members of the 18 conservation groups could envision any risk associated with providing us this information (Villamar *et al.*, 2018). We asked each conservation group to interview all people they would want to communicate with, regardless of whether they thought the person would use social media. As some social media platforms notify members immediately if a message is received, often with audible and visual signals, we report the frequency of social media use (i.e., accessing the platform) as either daily or less than once a day. No one refused to answer our questions.

Second, to understand how the conservation projects might use social media, we asked each group to provide a short list of the type of information that they would envision relaying to the community. We emphasized that this list was not to be what their group had relayed, but simply the type of information they might want to share with the community.

We report social media use considering the whole sample and on a country-by-country basis. When comparing countries, interpretations should be made with caution as we have no assessment of within country variation in social media use. For example, a particular site in a country with high social media use could be remote with poor Internet access; thus, the single site would not represent the country as a whole. To assess the potential reach that a message could have if it was forwarded, we provide the average number of contacts across

all platforms and each person's most used platform. Considering the contacts across all platforms would represent the greatest reach a message could have, but assumes that the contact list on the different platforms are independent, which is unlikely to be the case. In contrast, considering the number of contacts on each person's most used platform is more conservative, but assumes that people will only forward messages from the one platform. To describe contact information we report the range, mean, and median. When considering the potential of a message that is reposted to reach an audience, the high values in a skewed distribution are meaningful, thus the range and average are meaningful.

Results

Eighteen conservation projects from 11 countries participated in our assessment of the potential of communicating conservation messages via social media to their local communities (table 1, fig. 1). In total, 381 individuals provided the requested information. Of this total, only 36 of these 381 individuals (9.5%) did not have a social media account. Of the 344 people with social media accounts, 327 (90.1%) check their accounts at least daily and only 17 (4.9%) did not. More than half (55.2%) of these individuals used more than one platform (1 platform = 44.8%, 2 = 26.5%, 3 = 21.2%, 4 = 6.4%, 5 = 1.2%).

As is common with social media data (Chapman *et al.*, in press), the number of contacts people had was highly skewed. Considering all platforms, 271 people had less than 1000 contacts, 95 people had more than 1000 contacts, other 10 had 5000 contacts and other 4 people had over 10 000 contacts. One person, a feeder of giant pandas in China, had 2 754 201 TikTok followers. The people with the second and third most contacts (168 031 and 40 200) were tour operators. The median number of contacts per person across all platforms was 453 and 300 considering only each person's most used platform.

Facebook (59.6% of those interviewed), WhatsApp (40.9%), and Instagram (24.9%) were the most used platforms in our sample. However, there were differences in the types of platforms available or preferred from region to region. In China for instance, only 2% of participants used Facebook (this site was banned in 2009), while 100% used WeChat, a platform no other participants in the study used. Furthermore, 51.2% of participants in China used TikTok and Kuaishou, platforms that participants from other countries did not use.

Table 1. Description of the use of social media of local community members neighboring conservation projects in 11 primate range countries. N = number interviewed. Note: These values should be interpreted with caution as we have no assessment of within country variation in social media use.

Country	# Interviewed	% Not using social media	Median all contacts	Median highest single platform
Brazil	32	9	457	275
China	41	0	309	309
Colombia	23	13	296	195
DR Congo	20	0	546	373
Ethiopia	16	38	393	163
India	25	0	782	782
Madagascar	20	35	568	342
Mexico	80	0	717	440
Rwanda	52	21	1432	308
Sulawesi	12	0	2035	1526
Uganda	60	0	50	50

Figure 1. The location the 18 conservation sites in the 11 countries that interviews were conducted concerning social media use.

The major reason that the conservation groups gave for using social media was categorized into six classes. The most common reason (34.0%) conservation groups gave for using social media was that they wanted to announce and advertise meetings or events. The nature of the events varied from social gatherings (e.g., party to celebrate Lemur Day or the showing of a nature film), to educational talks (e.g., how to improve local health), to organizational meeting (e.g., plans to dig a trench to deter elephant crop raiding). The second most common reason (20.8%) was to educate the community. The education messages were diverse, including improved farming methods, the risk of primate diseases, proper disposal of plastic bottles, and simply conveying the wonders of nature. Conservation groups also wanted to use social media to request help from the community (18.9%), such as asking for volunteer to plant seedlings, or gathering information about aspects of community life such as the frequency of crop raiding. The fourth most frequently given major reason to use social media (13.2%) was to inform the community about planned research or to present the findings of completed research. Fifth, conservation groups sometimes wanted to present news (9.4%). For example, to tell the community that another chimpanzee had been injured by a snare or that the project had planted some number of seedlings. Finally, conservation projects sometimes (3.8%) wanted to share good news about the community itself (e.g., a specific community member just graduated from nursing school, or which team won a football match).

Discussion

Our assessment of select conservation projects around the world demonstrates that most people in the communities neighboring primate conservation projects use one or more social media platforms and check their feeds daily. This suggests that conservation projects can use social media as an effective tool to communicate locally. Each of the 18 projects considered had information or news that they wanted to disseminate to these communities. For instance, frequently, foreign scientists are criticized for not conveying the research findings to the local communities and thus not being inclusive in

their research approach (Blair, 2019; Erondu *et al.*, 2021; Massey *et al.*, 2021). The local use of social media provides an effective way to communicate research findings. Often researchers only fully understand their data after they have left the field site and have returned to their universities and performed detailed analysis. Returning to the field site where the research was conducted can be difficult and expensive, particularly for international students. But once systems are established to convey information through social media, these difficulties are largely removed. Such systems can be as simple as a list of WhatsApp contacts or a Facebook group. It will be important that these systems involve local leaders moderating posts, and when researchers post, they would need appropriate ethical clearance.

Internet access and social media use are widespread, particularly in middle income countries, such as Brazil and Mexico (Poushter, 2016). Even in low-income countries 20-30% of the population are often connected to the Internet (fig. 2). In primate range countries the average percentage of the population that were Internet users in 2020 was 39% (fig. 2). This represents 3.4 billion people. Internet users are defined as people who accessed the Internet in the last 12 months from any device, including mobile phones. This level of social media usage offers an important and relevant channel to disseminate and maintain conservation efforts near protected areas. While low-income countries have a smaller percentage of Internet users, using social media to communicate with key actors presents the possibility to spread important information through traditional word of mouth networks. Furthermore, the percentage of internet users will increase as Internet penetration rate is typically high. We were able to obtain data from 89 primate range countries on the proportion of their population that had internet coverable https://ourworldindata.org/grapher/3g-mobile-network-coverage-of-population, Accessed November 22, 2021). We found that for 36% of the countries, 90% of their populations were in areas accessible to the Internet. Over half (51%) of the countries had 80% of their people in Internet accessible areas and for only 24% of the countries were less than 50% of the people covered. Unfortunately, social media will not be an effective communication tool in some key primate conservation areas, such as the Amazon and Congo basis, that have poor Internet coverage and may have

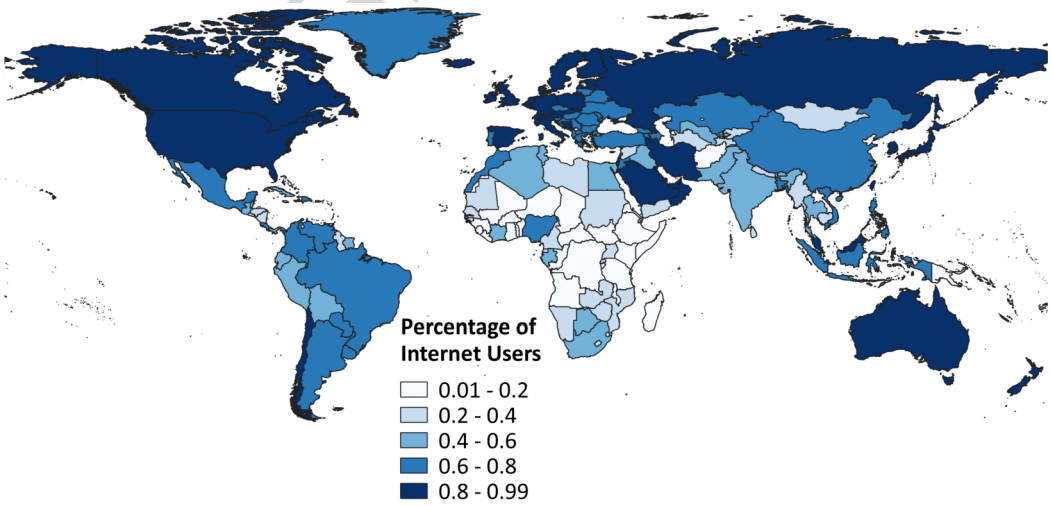

Figure 2. A global map of the intensity of Internet users in for 2020. Internet users are defined as people who accessed the Internet in the last 12 months from any device, including mobile phones. The estimates are derived either from household surveys or from Internet subscription data and the raw data and sources can be found at https://en.wikipedia.org/wiki/List_of_countries_by_number_of_Internet_users.

for some time. For example, there are only 29 towns larger than 25 000 people in the state of Amazonas (∼1.6 million km^2 = 19% of Brazil's territory), and Internet access usually terminates a few kilometers from the town (Carlos Peres, pers. comm., November 22, 2021).

Examples of the use of social media to communicate to the local level in primate range countries are rare. However, in Morocco, Facebook proved to be an effective way to engage the public (Waters and El-Harrad, 2013). It was used to provide the public with information and to anonymously report the illegal wildlife trade of Barbary macaques (*Macaca sylvanus*) and animals being illegally used for tourist pictures. Facebook was also part of a campaign launched to inform the lay public and the mass media about the actual role played by howler monkeys (*Alouatta* spp.) as sentinels of the arrival of the yellow fever in a region in Brazil (https://www.facebook.com/Campanha-Proteja-seu-Anjo-da-Guarda-243621236063810/; Bicca-Marques, 2018). The conservation efforts with slow lorises (*Nycticebus* spp.) represents an example of taking social media from the local to global scale to promote primate conservation efforts (Nekaris and Campbell, 2012; Nekaris *et al.*, 2013; Nekaris *et al.*, 2015). The scarcity of published examples at the local level, suggests that the use of social media as a tool to communicate conservation messages at this level in primate range countries is underappreciated or under documented.

It would be unfair of us not to provide a few words of caution to academics seeking to promote conservation through social media. Academia is a very competitive profession (Chapman *et al.*, 2019). Using social media for scientific or conservation purposes demands considerable time commitments. Several online sites suggest that effective participation in social media aimed at an academic audience involves a full suite of activities, including having one's own blog, writing lay summaries to papers published, uploading data, images, PowerPoint presentations, and posters, reaching out to key bloggers in the field, working with the university's press office, and using a variety of social media outlets (Sugimoto *et al.*, 2017). Just the work to write a blog entry is estimated to take about 3.5 hours per week (Strong, 2018). This is a significant time commitment; thus, conservation scientists should consider when in their career they invest this time and likely invest in getting the training to be both effective and efficient.

At present, practicing conservation activities, such as holding community workshops, doing abundance surveys, or communicating to local communities over social media, is typically viewed as, at best, only nominally contributing to academic advancement (Chapman and Peres, 2021). Many of these endeavors are undervalued in the tenure and promotion process (Alperin *et al.*, 2019). This needs to be changed by academics established in the system. However, until it does, early career scientists wishing to most effectively promote conservation may wish to make a long-term career plan. This would involve deciding at what stage of their career it is best to invest in what activities to ensure the greatest conservation impact.

Historically, Internet access has been strongly linked to gross national per-capita income (Poushter, 2016). However, starting approximately a decade ago this situation changed rapidly, and Internet access became dramatically more available in primate range countries. For example, with the improvement of Internet access, social media networking became more popular in Latin America than in Europe or the United States (Poushter, 2016; Hagg *et al.*, 2018). In 2015, one third of the people in developing nations owned smartphones (Poushter, 2016) and the numbers are growing rapidly. This rapid growth of the use of smartphone in developing nations, including primate range countries, caught groups seeking to communicate to rural communities in low-income countries by surprise. In fact, in 2018 Hagg *et al.* stated that "descriptions of, and investigations into, the use of social media for health in low- and middle-income countries emerged only recently in the literature". Clearly the potential of this form of communication for a variety of endeavors, including primate conservation, has not yet been fully appreciated. Our data clearly demonstrates the potential for social

media to be a useful communication tool for tropical conservation scientists. Given this, and the current threats primates and their habitats face (Estrada *et al.*, 2017; Kalbitzer and Chapman, 2018; Chapman *et al.*, 2020), we encourage more groups to explore using social media to communicate to local communities and to report on the impact it has on conservation.

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Statement of ethics

This study adhered to the Code of Best Practice for Field Primatology.

Conflict of interest statement

The authors have no conflicts of interest to declare.

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Author contributions

Jorge Ramos Luna, Cate Twining-Ward, Juan Carlos Serio-Silva, and Colin Chapman conceived of the project. Janaína Paula Back, Joselyne Barakagwira, Júlio César Bicca-Marques, Mathilde Chavin, Nona Diko, Julia Duboscq, Pengfei Fan, Carmen Galán-Acedo, Songtao Guo, Diana Guzman-Caro, Rong Hou, Beth Kaplin, Addisu Mekonnen, Paulin Mungogo, Himani Nautiyal, Patrick Omeja, Nancia Raoelinjanakolona, Veronarindra Ramananjato, Onja Razafindratsima, Cécile Sarabian, Risma Yanti, and Juan Carlos Serio-Silva collected the information. The data was analyzed by Jan F. Gogarten, Urs Kalbitzer, Dipto Sarkar, and Colin Chapman. Colin Chapman led the writing but all authors contributed.

Data availability

All data generated or analyzed during this study are included in this article. Further enquiries can be directed to the corresponding author.

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