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SYMPOSIUM

A Guide for Successful Research Collaborations between Zoos and Universities

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Synopsis Zoos offer university researchers unique opportunities to study animals that would be difficult or impractical to work with in the wild. However, the different cultures, goals, and priorities of zoos and universities can be a source of conflict. How can researchers build mutually beneficial collaborations with their local zoo? In this article, we present the results of a survey of 117 personnel from 59 zoos around the United States, where we highlight best practices spanning all phases of collaboration, from planning to working alongside the zoo and maintaining contact afterward. Collaborations were hindered if university personnel did not appreciate the zoo staff's time constraints as well as the differences between zoo animals and laboratory animals. We include a vision for how to improve zoo collaborations, along with a history of our own decade-long collaborations with Zoo Atlanta. A central theme is the long-term establishment of trust between institutions.

Introduction

In this article, we present the results of a survey of collaborations between academic researchers and zoos. Zoos and universities have different goals, funding levels, and cultures, which can lead to conflict if not proactively addressed. We focus here on zoos, but our findings may be helpful for collaborations with aquariums and botanical gardens as well.

There are >350 zoos and aquaria throughout the United States and >2000 globally. Many zoos and aquaria have active research programs beyond conservation to include basic research on in-house animal care and physiology (Mason 2000). Moreover, the maintenance and husbandry of animals in zoos are often impractical for universities due to cost, space, and expertise limitations. Therefore, in a university setting, collaborating with zoos can significantly broaden research possibilities. The benefits can go both ways. Universities can bring technology, outside expertise, interdisciplinary research, and the media coverage and visibility that comes with making a scientific discovery.

Most previous studies on zoo collaborations have focused on enumerating popular research topics (Kleiman 1985; Minteer and Collins 2013; Loh et al. 2018; Hosey et al. 2019; Mendelson et al. 2019; Welden et al. 2020; Kögler et al. 2020; Escribano et al. 2021) or the research goals of the zoo (Fernandez and Timberlake 2008; Maple and Perdue 2013; Hopper 2017). Despite making a case for common interests and how research at each institution could benefit, these articles stopped short of providing suggestions for facilitating collaboration. We hope to fill this gap by writing for academics who will work with zoos and zoo staff who will advise new collaborations. The authors of this article include the combined perspectives of three university

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personnel, two zoo administrators, and an animal care specialist.

Universities often collaborate with industry (Pertuzé et al. 2010) to access cutting-edge tools or industry data. However, for fields like biology and bio-inspired design, which require access to plants and animals, collaborations with museums, zoos, and aquariums are more likely. Zoos are generally non-profit organizations and depend on trust-built relationships more than for-profit industries (Snavely and Tracy 2002; Murphy and Dixon 2012). The challenges associated with working with non-profit collaborators have been observed between academics and science journalists (Levy et al. 2014). The top factors that enable zoo employees to conduct research include the support of the zoo director, an atmosphere where staff have dedicated time to conduct research, well-defined and supported research, and adequate equipment and supplies (Anderson et al. 2010).

The study of biomechanics, physics of living systems, and bio-inspired design all depend on access to specialist species that have unique adaptations of body, behavior, or ecology (Helms and Goel 2014). Working with zoos will advance bio-inspired design and promote biodiversity research by helping lesser-known specialist species gain visibility. For example, much of our experience has been working with Zoo Atlanta, which has tremendous biodiversity boasting about 215 species. Figure 1 shows the phylogenetic relationships among 69 of these species, emphasizing the phylogenetic diversity available to researchers and the opportunities for comparative biological studies. Broadly stated, research collaboration with zoos allows research personnel to study animals in controlled conditions to advance various foundational questions in science.

We begin this guide with a glossary defining terms we will use throughout the paper. Then, we present our methods for survey writing, distribution, and analysis. Based on the survey responses, we will report the recommendations from survey respondents for successful research collaborations with zoos. We then provide quotes that highlight attitudes from zoo staff, relate our own experiences working with Zoo Atlanta, and close with thoughts for systematically improving zoo–university collaborations.

Introduction to zoological organizations and accreditation

Proposing collaborative research with zoos requires the submission of several protocols. In this section, we define the terms commonly used by zoological and accreditation organizations.

Roadside zoos are often small for-profit establishments that may offer close contact with the animals they keep (Moore 2008). With the emergence of roadside zoos that often exploit captive animals and are not grounded in traditional zoo culture, there has been a rise in zoological and conservancy accreditation (Winders 2017). Accreditation at its core evaluates zoos on animal welfare guidelines and housing conditions.

Many of the hundreds of zoos in the United States are accredited by various organizations such as the Association of Zoos and Aquariums (AZA) and the Zoological Association of America (ZAA). Of these institutions, there are a total of 238 zoos and aquariums that are accredited by the AZA (Gusset and Dick 2011). AZA accreditation is often costly, making it out of reach for zoos outside urban centers. Moreover, AZA does not dictate management style or day-to-day operations at every level that would be important to the researcher–zoo personnel relationship. AZA institutions also vary in their implementation of an Institutional Animal Care and Use Committee (IACUC) approval process, co-authorship requirements for zoo staff involved in collaborations, and the level of input of keepers and veterinarians when making research decisions.

Some AZA zoos manage wildlife species in free contact. Free contact is the ability to touch an animal without barriers. For example, box turtles are often housed with free contact, and few zoos enforce protected contact with box turtles. In contrast, nearly all accredited zoos have only protected contact and no free contact with tigers, lions, and cheetahs. Protected contact involves barriers between the keepers and the animals, providing safety for both the animal and the keeper as well as preventing the animals from becoming accustomed to close contact with humans. Thus, one cannot assume that the techniques and processes from one AZA institution are applicable across institutions and species.

The paramount goal of zoos is to promote biodiversity conservation (Godinez and Fernandez 2019). While conservation as a field has adopted various definitions, zoos are particularly interested in research that aims to reduce threats to wildlife, reverse the effects of environmental degradation, and promote survival in natural habitats. These kinds of conservation actions and research are becoming more dependent on interdisciplinary partnerships akin to biotechnology and bio-inspired design, creating an increasingly collaborative space for zoos and academic institutions (Chiesa and Toletti 2004; Hashemi Farzaneh 2020). Zoos provide accessible and exciting opportunities for education research and public engagement in community conservation projects (Sloggett 2009; Falk 2014; Schulz et al. 2022).

Before contacting a zoo, it is helpful to be familiar with the organization of zoo staff. Zoos usually com-

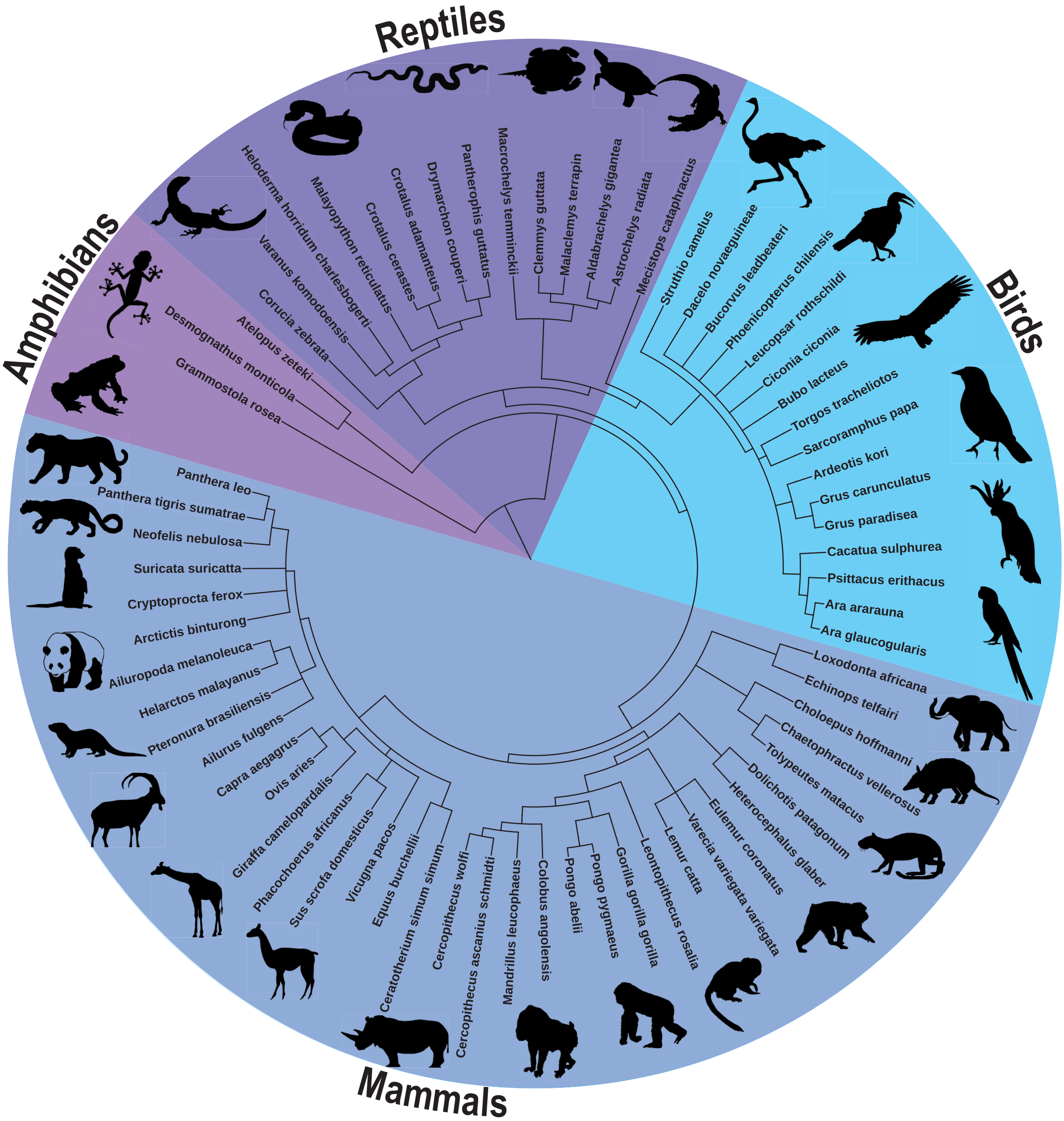

Fig. 1 A phylogenetic tree of the animals cared for at Zoo Atlanta. Phylogenetic tree generated on PhyloNet and all silhouettes are from PhyloPic's open source database.

prise distinct departments such as carnivores, primates, ambassador animals, or hoofstock. Instead of being aligned with taxonomy, departments may align with geography (e.g., Africa or The Tropics) or simply different locations in the zoo. Department members may be either biology-focused or education-focused, interfacing with the public and researchers in different capacities. Keepers are the primary personnel at the zoo who take care of the animals and are experts on individual animal personalities, behaviors, and daily patterns. Education staff are public-facing zoo personnel that present the biology and conservation challenges and programs to the public and engage in outreach at local K–12 schools. Curators are experts on the biology of different taxonomic groups, oversee the general direction and priorities of the department, and manage the personnel (e.g., the keepers) in each department. Zoo veterinarians maintain the health and well-being of species and perform surgeries, blood collections, and actions that require anatomical and physiological knowledge of the species at the zoo. Some zoos have animal-welfare specialists who assess and seek to steadily improve all aspects of the physiological and psychological well-being of the animals. Some zoos have dedicated research personnel.

To avoid misunderstandings and wasted effort, it is crucial to make early connections with the institutional animal welfare board at the researchers' academic institutions, which in the United States is called the IACUC. In some zoos, a university IACUC is all that is necessary to conduct research. However, an additional Zoo Research Application must be completed in other zoos, such as Zoo Atlanta. The Zoo Atlanta application requests specific information about the individual animals and biomaterials, the level of contact with the animals, and, crucially, how much time and effort by zoo staff is requested, all of which are shown in the Supplementary Material. The AZA has a similar research application form used in some zoos instead of a zoo-specific form included in the Supplementary Material (Ripple et al. 2021). Each academic institution may be different, and it is important to understand the timeline of research applications. For example, zoo approval may precede the university IACUC office approval or vice versa. Some universities will accept research approval from a zoo in place of their own IACUC review.

Methods

Survey creation and analysis

To evaluate how zoo personnel view collaborations with academic institutions, we created a 10-minute online survey using the Qualtrics software platform. The Institutional Review Board approved this human subjects research study at the Georgia Institute of Technology (Protocol Number: H21472). The survey was divided into three main sections: (1) acknowledgment of consent to participate in the research study, (2) background information, including job title, zoo affiliation, and experience with academic collaborations, and (3) opinions on the importance of different aspects of academic collaborations with regards to establishing and considering future partnerships. The survey concluded with an optional space for participants to provide additional thoughts.

We distributed the survey by emailing our contacts at zoos and professional lists from online zoo forums (e.g. AZA online forums). We asked our contacts to further distribute the survey to all working personnel and the zoo's weekly newsletters. Additionally, we sent the link to various online zookeeper communities, which likely contributed to the large percentage of zookeeper responses. We used Qualtrics reports to obtain distributions of answers, averages, and standard deviations, and then RStudio and Adobe Illustrator to visualize data distributions in divergent bar graph formats.

Phylogenetic tree

The list of animal species on the Zoo Atlanta website (https://zooatlanta.org/animals/) was used to generate a phylogenetic tree. Taxonomic representation is important to inform the responses from keepers to show the phylogenetic diversity represented in a medium-sized zoo such as Zoo Atlanta. We used the software PhyloT version 2 (NCBI taxonomy). The tree's 69 species (listed in Supplementary Fig. S1) were annotated with free silhouettes from Phylopic, indicating differences throughout the clades. Note that the species list is only a partial list of animals kept at the zoo.

Results

A total of 168 responses indicated "yes" to the consent form; one person said no to the consent form. Of the 168 consenting responses, 44 included only demographic and zoo information and therefore were removed from further analysis. Five respondents to the survey were from aquariums and two from non-animal housing organizations such as botanical gardens and zoo technology companies; these responses were removed from all analyses as the sample size was insufficient to merit any actionable results. Further surveys targeting such organizations are needed. Thus the data presented below are indicative of the 117 zoological responses.

Respondents represented 59 different zoological organizations, with 85% of respondents affiliated with AZA-accredited zoos and the other 15% of respondents affiliated with either international zoos or zoos accredited by other national organizations (e.g., ZAA). The largest response rate of any zoological organization was Zoo Atlanta, which comprised 38% of respondents.

With regards to job title, 26% of respondents identified as keepers, 17% as education staff, 19% as curators, 6% as veterinarians, 4% as administrators, and the remaining 28% as "other." The "other" category includes executive positions (president, manager, supervisor, board member), positions within conservation programs (director, researcher, program staff), and various staff involved in programming, research, or animal care. Of the total, 75 % of respondents indicated having prior experience collaborating with academic institutions on research, while 14% had no experience, and 11 % had engaged in research collaborations but were unsure if these were with academic institutions. Of those with prior experience, 41% had participated in 1–5 collaborations, 16% in 6–10 collaborations, 8% in 11–20 collaborations, and 9% in >20 collaborations.

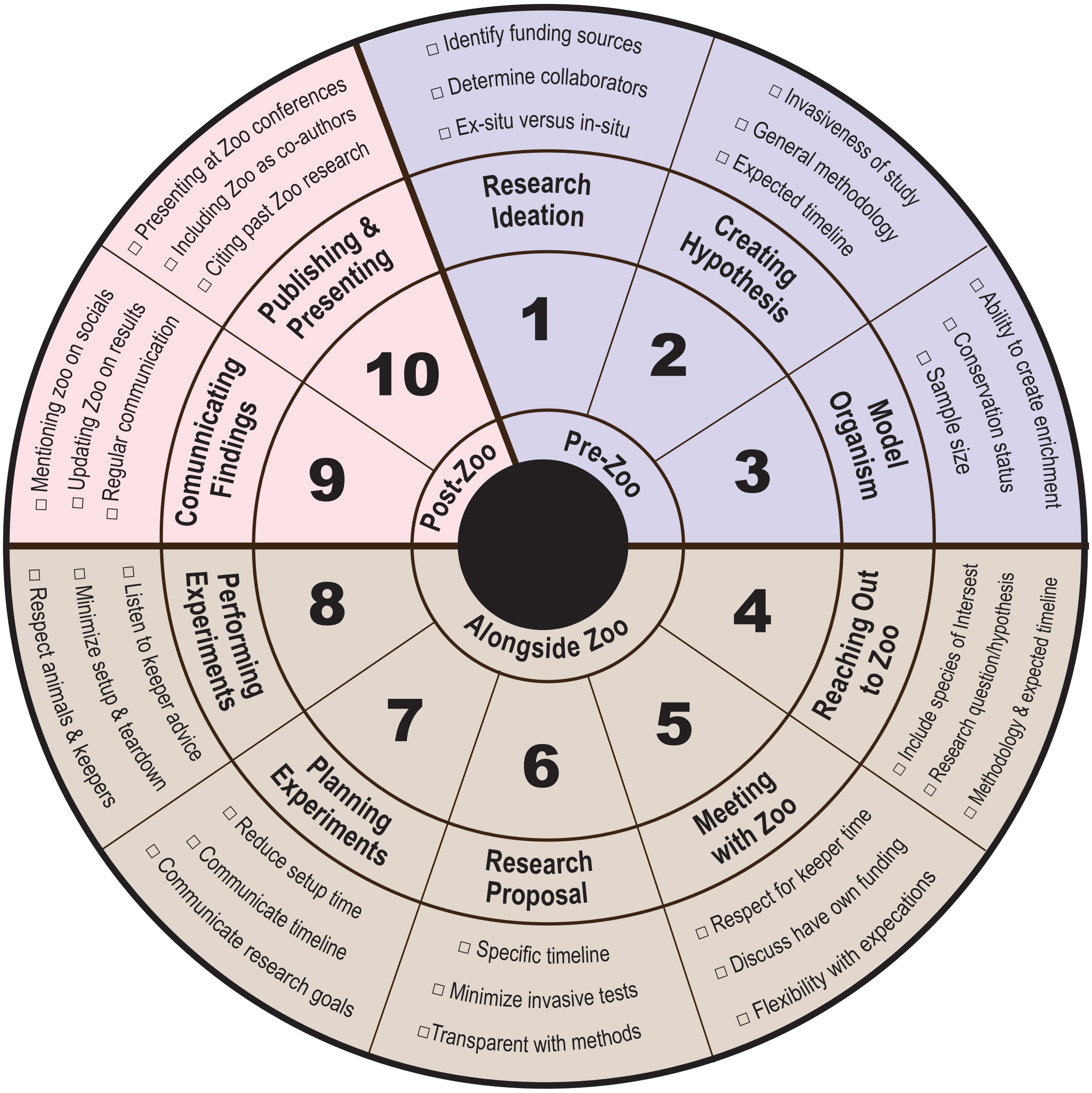

Fig. 2 Schematic of the zoo–university collaboration process. The inner ring displays the three phases of research collaborations with zoos. The middle rings display the steps within each phase. The outer ring displays a checklist of tasks that were most requested by zoo staff in our survey.

We then asked participants about their opinions on the importance of various aspects of collaboration with academics. We asked about the three phases of collaboration: the pre-zoo phase, alongside-zoo phase, and post-zoo phase. These phases may be further divided into the 10 steps shown in Fig. 2 beginning with the pre-zoo phase, which leads into the alongside-zoo phase and the post-zoo phase.

Pre-zoo phase

For most zoos, contact is first made by email or submission of a web-based form. Our survey results, as shown in Table 1 (Fig. 3, Supplementary Fig. S2), indicate that researchers should be aware of:

Table 1 The most important topics to include in an initial email to the zoo.

Topics	Number	%
Research question or hypothesis	114	97
Species of interest	111	95
Proposed methodology	100	85
Expected timeline	97	83
Conservation objective	75	64
Available research funding	66	56
Plans for citing zoo	42	36
Experience with species	32	27
Other	19	16

The percentage of respondents is taken from a total of $n = 100$ respondents.

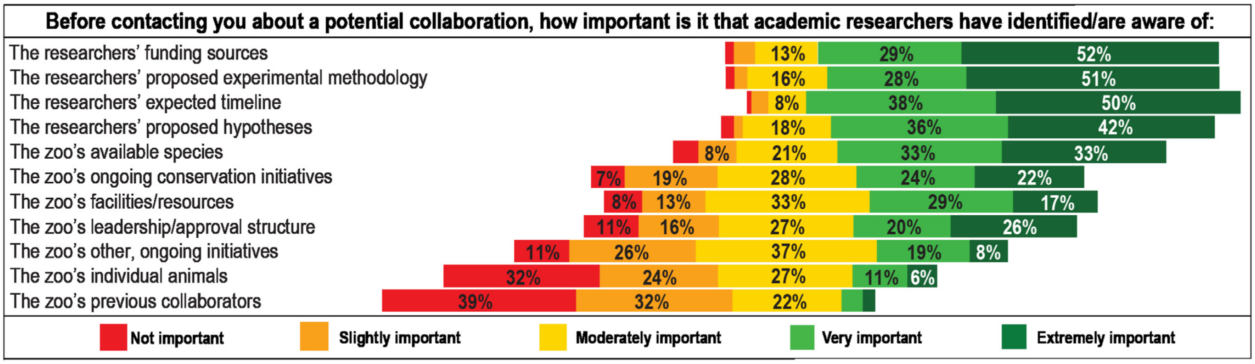

Fig. 3 Recommended knowledge requirements before initial contact with the zoo.

- research question or hypotheses
- species of interest
- proposed experimental methodology
- an expected timeline for research

Additionally, but of less importance, the researcher should be aware of the zoo's available species, the zoo's research approval structure, and the zoo's facilities and resources.

Critical to working with animals, the researcher should consider the ethical implications of their proposed research and plan to minimize invasive techniques with the animals. University IACUC proposals may need to be submitted, as well as zoo IACUC proposals. The order of these proposals depends on the institution. The primary information required in zoo proposals includes an application for research, project proposal, CVs of the principal investigator and co-investigators, guidelines on ownership of biomaterial and data, and specifics of biomaterial requests. We have included sample forms from Zoo Atlanta and the AZA research application questionnaire in the Supplementary Material (Ripple et al. 2021).

Alongside-zoo phase

After contacting the zoo, discussion of the proposed research may commence. The remaining steps of this phase include meeting with zookeepers, submitting the research proposal, and planning and performing experiments at the zoo. Iterative modifications to the proposed methodology are often made after conversations with keepers about the study's feasibility and timeline. When asked how important specific actions are for successful collaborations, most respondents identified the following themes as very important or extremely important (Fig. 4, Supplementary Fig. S3):

- transparency with methods and goals
- regular communication with the zoo
- updating the zoo on data analysis and conclusions
- citing the zoo in scientific publications
- discussing method design and improvements with keepers
- crediting the zoo on social media platforms and press releases

As with all collaborations, transparency and communication are common themes in working with the zoos. Attribution of credit is vital to zoo staff. The zoo personnel may provide several rounds of input in experimental planning. They may even perform much of the proposed experiment themselves. Expectations of how the zoo will be credited should be stated early by both parties, revisited during the collaboration, and confirmed before publication. Attribution of credit can vary from a mention in the "Acknowledgment" section to an offer of co-authorship.

While many zoos have conservation missions, we were surprised to find that conservation tie-ins were not considered more critical for research proposals. Zoo personnel were also not as concerned with researchers' previous experience with the species of interest or the use of jargon in their proposals. Zoo personnel have backgrounds in biology or animal behavior and will generally trust the researcher to perform data analysis and draw conclusions themselves. Nevertheless, keepers can often provide demographic information on the animals, including mass, age, sex, or other behavioral observations, and updates on metrics if they change during the study.

The zoo has years of experience dealing with the public and works pro-actively to present itself in the best possible light. Protecting the zoo's image protects its employees against negative comments, threats, and other responses from the public. Doing so involves screening any images, videos, or text descriptions of work done at the zoo. To that end, the researcher may be asked for their plans for disseminating the results of their study. Examples of such requests are in the Zoo Atlanta research application form and the AZA research

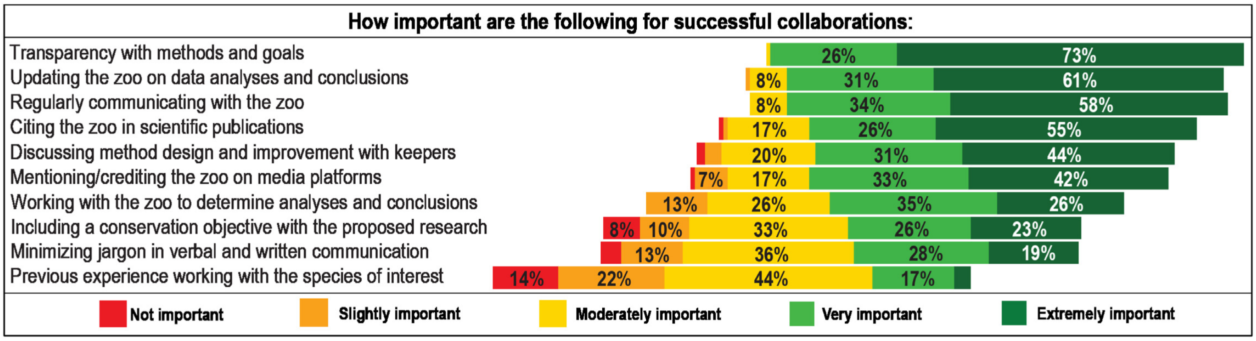

Fig. 4 Actions recommended by zoo personnel for successful collaborations.

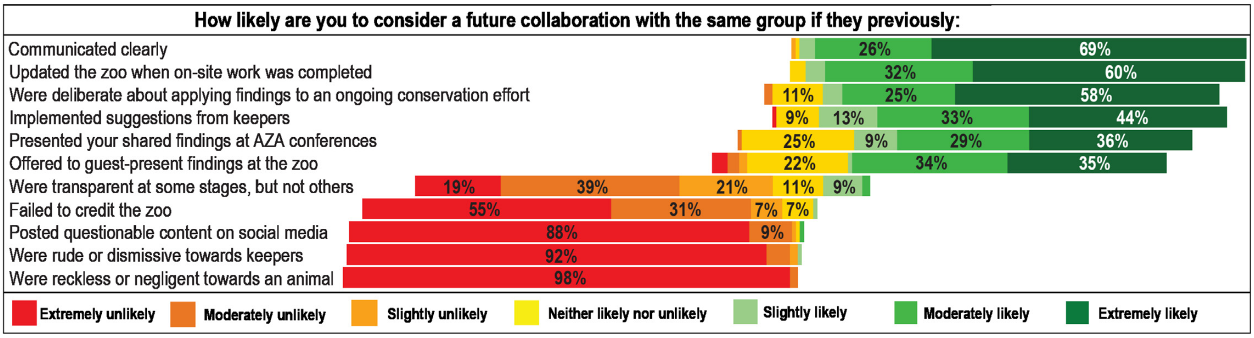

Fig. 5 Considerations by zoo personnel for continuing to work with a researcher.

form in the Supplementary Material. The researcher may need to request prior approval from the zoo before posting on social media or accepting interview requests.

In addition to the application forms, zoos may require more formalized, legally binding policies through memorandums of understanding to help foster long-term partnerships.

Post-zoo phase

Once experiments have been completed, research collaborators transition into the post-zoo phase. In this phase, researchers communicate results with zoo personnel and develop publications, presentations, and potential press coverage. Academic researchers set a precedent for what zoo personnel will expect in future collaborations. When asked how likely they would be to engage in future collaborations with academic researchers that performed certain actions, several themes stood out as largely positive (Fig. 5, Supplementary Fig. S4):

- clear communication
- updated the zoo when on-site work was completed
- were deliberate about applying their findings to an ongoing conservation effort
- implemented suggestions from keepers
- presented their shared findings at AZA conferences

In addition, we found several themes that stood out as largely negative (Fig. 5):

- were reckless or negligent toward an animal
- were rude or dismissive toward keepers
- posted questionable content on social media
- failed to credit the zoo
- were transparent at some steps, but not others

Overall, the choices made in this phase can make or break a relationship with the zoo. For continued collaborations, the most crucial aspect of post-zoo collaborations was clear communication. Across all three phases, respondents identified communicating a practical timeline, implementing suggestions, and crediting the zoo as important. Many zoos have dedicated public relations staff who review manuscripts and presentation files before they are presented at conferences or in journal publications. Close contact with public relations staff at zoos is even more crucial if media coverage is expected or solicited. While ties to conservation were not important in the pre- and alongside-zoo phases, they became critical in publishing and disseminating results.

Zoo Atlanta responses comprised 30% of the total responses analyzed. To test if there was a potential bias toward Zoo Atlanta in our data, we separated the Zoo Atlanta survey results from the entirety of the survey. We performed a two-tailed Mann–Whitney U test with outliers included with an $\alpha = 0.05$. The Mann–Whitney

U test showed that only three questions had been impacted by the Zoo Atlanta survey results including the zoos available species, the zoo's leadership structure, and discussing with keepers about methods (Supplementary Figs. S5–S7). Aside from those three questions, there was no significant difference between Zoo Atlanta ($n = 35$) and the total responses ($n = 117$).

We have now summarized the three phases of working with the zoo. Our survey also included several open-ended questions, whose most striking responses are given in the next section.

The perspective from the zoo on collaborations

The following quotes from zoo personnel summarize experiences from years of working with collaborators. We begin with quotes illustrating common misconceptions by academic researchers.

- *The biggest challenge I've personally faced with researchers is their belief that they can do whatever they want with the animals and that all methodologies will work on their given timeline. Bringing zoo staff into the discussion earlier can avoid establishing the usually unrealistic expectations that the animals will do what you want, when you want them to do it.*
- *It is important to note that zoo animals are never to be viewed as lab animals, but as individuals with high intrinsic value and emotional connections with zoo staff. These animals should be thought of as participants in research, rather than experimental subjects.*
- *...Understand that [the requested] level of manipulation of animals by staff will affect how likely we are to participate. Know that animals will not be put in adverse situations just to test something.*

These quotes underscore the mismatch between an outsider's expectations and research that is feasible at a zoo. Keepers generally do not make direct contact with the animals unless necessary for veterinary procedures such as blood draws. Thus, invasive experiments that are commonly performed with domesticated animals are often not feasible with zoo animals. This perspective highlights the difference between common lab animals, such as lab mice, and zoo animals.

The following quotes illustrate the conflicts that can arise in timelines and priorities between zoo staff and researchers:

- *Researchers also often seem surprised that our approval process can take a long time since we're usually weighing the benefits of the research with the cost of keeper time and sometimes animal welfare. We need to make sure the project is worth it!*
- *For us to dedicate resources (biomaterial, staff time, access) to a study, it needs to align with our priorities, which generally include improving husbandry/welfare, or [making discoveries] applicable to wildlife conservation. It is difficult for us to allocate resources to studies whose results don't have that applicability. It's often very evident that PIs don't understand the impact of their requests on husbandry. We often get requests requiring isolation of individuals for observation, or manipulation of social groupings...*
- *...Come prepared and transparent, be open minded and flexible, be prepared for it to take a long time for approval as zoos in general tend to move slowly and cautiously.*

These quotes underscore the importance of patience and understanding in working with the proposal approval process. Researchers should acknowledge their status as guests and understand that the zoo has the ultimate say in whether a study makes sense for the zoo.

We now turn to the zoo's suggestions for increasing a positive response or more engagement by the zoo. If a proposal initially did not receive traction, we encourage continuing conversations with the zoo. Conversations may lead to new rationale for the research that would not be initially known to investigators. For example:

- *Framing the research in terms of enrichment for the animals in question may produce positive responses from the zoo.*

Enrichment is the process of providing ex-situ housed animals with stimulation to encourage natural behaviors (such as foraging) that can help to improve or maintain health or fitness. For example, our experiments on feeding elephants different shapes and sizes of foods that would encourage the elephant to use its trunk were considered enrichment.

- *Mention other zoos that have already been or also will be approached for participation.*

If other zoos have rejected a proposal, the researcher should offer that information to reduce the zoo's effort as they track down the previous work. This procedure is in the same spirit as the cover letter of a journal paper when it is resubmitted to another journal.

- *Depending on subject matter, keeper staff might actually want to be more involved, so make the offer on how they can participate more fully.*

The researcher should be aware when the zoo staff would like to increase the level of collaboration. Zoos may have on staff entire educational teams that visit K–12 schools to discuss the importance of conservation and research at zoos. These programs provide additional collaborative opportunities for academic institutions to develop NSF-style broader impacts for their research.

Discussion

We found that topics of importance to the zoo depend on the phase of the collaboration. For instance, having research tied to conservation was very low for the research proposal phase but increased in importance in the post-zoo publication phase. Long-term collaborations may require more consistent applications to conservation or enrichment, even if singular or short-term collaborations do not prioritize them as much.

Researchers need to have their own funding plan if they collaborate with a zoo. Although many zoos have interns, and some now have research or animal welfare personnel, there is little to no funding for research for external members of the zoo. The primary resources that the zoo can offer are time and access. As shown by the quotes from participants, keepers and zoo personnel are likely not being compensated for any research being conducted, so researchers need to minimize the time required for zoo personnel to be actively assisting with experimental setup and data collection.

Although our survey results pertain to zoos in the United States, there are many parallels between collaborating with zoos and doing international fieldwork. “Parachute science” or “colonial science” are terms that refer to wealthy researchers going to economically challenged countries to do fieldwork but without proper citations or equitable collaborations (Roldan-Hernandez et al. 2020; Ruppert et al. 2021). Many journals now require publications of field studies to feature co-authors included from the place of study (Pérez-Espona 2021). This idea of parachute science is traditionally linked to biodiversity studies in tropical nations but also occurs in zoos (Stefanoudis et al. 2021). Biology journals that include authors affiliated with zoos tend to publish more descriptive literature on species and their behavior, providing more informative results (Anderson et al. 2008). Avoiding parachute science in zoo–university collaborations is as simple as providing due authorship, acknowledgment, and credit in premier journals. Including zoological personnel as co-authors can increase the descriptive nature of the publication, which will be useful to future workers and future collaborations with the zoo.

Personal experiences growing and learning with Zoo Atlanta

The Hu Lab for Biolocomotion has been working with Zoo Atlanta since 2010. We now have many collaborations on research projects proposed by either the Hu Lab or Zoo Atlanta. Our partnership has resulted in over six papers published with the involvement of graduate students (Hamidreza Marvi, Andrew Dickerson, Guillermo Amador, Alexis Noel, Patricia Yang, Marguerite Matherne, Andrew Schulz, and Cassie Shriver), a postdoc (Jia Ning Wu), and many undergraduates. We try to overlap the hiring of new graduate students because training to work with the zoo takes at least a year. This training is best when done one-on-one because the process of IACUC and research approval can be daunting at first. Moreover, having the veteran graduate student introduce the new graduate student to zoo staff helps facilitate future communication and research projects. Zoo Atlanta staff for example prefer in-person over online meetings, and building trust with that staff takes time. We keep records of approved research proposals on file for future graduate students in the group to reference as needed. The graduate students were the main point of contact with zoo staff.

Our collaboration began with work that was noninvasive and most likely to be approved by the zoo. For example, in 2012, we conducted studies involving sprinkling animals with water to watch them shake off water on a hot summer day (Dickerson et al. 2012). One of the reasons we have been able to collaborate in the long run was that the zoo was willing to work with us while we were in the learning phases of collaborating with the zoo. We advise new principal investigators to set up meetings with their universities’ IACUC committees to discuss the timeline of processes. At Georgia Tech, we had two Georgia Tech IACUC staff reach out we began. On the phone, they patiently explained places where I could improve my efficiency and effectiveness in proposal writing. In the long-run, such advice helped tremendously over the years and continues to inform my research today. One mistake we made early on was not communicating to a new graduate student that citations of the zoo should still be made when animals are photographed from the public area (Amador et al. 2015). We have improved our communication in the group to prevent such mistakes in the future. We progressed in 2014 to studying mammal urination (Yang et al. 2014) and tail-swinging (Matherne et al. 2018). These studies were primarily observational and noninvasive, involving little of the zoo personnel’s time and not affecting the animals or their routines in any way. Thus, acknowledgment of the zoo was sufficient to give credit.

When assigning credit to zoo staff, one must keep in mind the organizational structure of the zoo and the complexity of the study. We conducted studies on venomous side-winding snakes that involved zoo staff for safety reasons. We also constructed a unique facility for creating prepared mixtures of sand with fluidized beds on zoo grounds (Marvi et al. 2014). Similarly, studies with elephants involving picking up barbells or different-sized foods required regular planning meetings and the assistance of zoo staff during the experiment (Schulz et al. 2021). These experiments were more complex and required a higher degree of active collaboration with the keepers. Thus, these publications resulted in co-authorship with zoo staff. In addition to research collaboration, graduate students from the Hu Lab often participate in a number of other volunteer events at the zoo, such as presenting at AZA conferences, organizing Biomechanics Day events, giving tours to guests, giving guest lectures, and fund-raising. These activities were often suggested by zoo staff, and our involvement has indicated the level of trust between our two groups.

Ideas for improving zoo–academic collaborations

Currently, collaborations with zoos are too often ad hoc: they emerge from historical contingencies such as longstanding relationships between key individuals. Starting such relationships is a big commitment. In this article, we discussed ways to make this process more efficient when such relationships already exist. In this section, we propose ways to make zoo–university collaborations more common and systematic.

We recommend that researchers who are first-time collaborators with a local zoo should seek mentors who have successfully navigated collaboration before. Mentors can offer to share their IACUC and other zoo protocols, make introductions to zoo staff, and help interpret waiting times and responses by the zoo. Most universities have trained staff that can assist with writing IACUC proposals and making connections. A few minutes on the phone can save several iterations on proposals, and it is often in the IACUC committee's interest to reduce the number of proposal re-submissions.

Conferences are also an excellent way to meet researchers who have successfully collaborated with a zoo. Zoological organizations have annual AZA conferences where they discuss advances in their protocols for working with animals. The Society of Integrative & Comparitive Biology (SICB) as a community might consider providing travel scholarships and other incentives to encourage students to present their work at AZA conferences. Guidance on working with zoos is particularly relevant now that the public can interact with zoos through social media and the web. These new digital sources make it especially important for researchers to present their work and findings with the varying constraints of the zoo and university in mind.

To form long-lasting and systematic collaborations, both parties need equal commitment, effort, and consent. Zoos throughout the world now have educational departments to help engage in outreach. One way to improve rapport with a zoo is to volunteer to do scientific and conservation outreach as an extension of the research.

Conclusion

There are thousands of zoos and aquariums that can provide opportunities for advanced scientific discoveries. Although research collaborations may bring about challenges, this article highlighted a few simple steps to create more equitable partnerships. We proposed three phases of zoo research and walked researchers through the 10 steps of a successful zoo–university collaboration (Fig. 2). We highlight the importance of transparent communication, acknowledging zoo personnel through co-authorship and acknowledgements, and treating the zookeepers with respect as behavioral experts and collaborators. We hope that the results of this study will improve not just zoo research, but animal conservation as a whole.

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Author contributions statement

A.S. came up with the idea and hypothesis for this study as well as assisted in survey creation, data analysis, figure making, and manuscript writing. C.S. created and submitted the IRB protocol and also assisted in survey creation, data analysis, figure making, and manuscript writing. C.A. reviewed the survey and advised from a keeper perspective in addition to helping write the manuscript. E.W. contributed to the survey design and analysis. J.M. III led the zoo research arm of this survey and distribution of the survey to various zoo personnel. D.H. is the corresponding author for this study and assisted with manuscript edits, methodology, and ideation of the survey.

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Supplementary data

Supplementary data available at *ICB* online.

Conflict of interest

J.M. III was the director of research at Zoo Atlanta during this survey. The survey was distributed in a daily zoo email blast without indication that J.M. III would be the corresponding author. There could potentially be a conflict of interest as we have three zoological personnel on this publication and the point of this publication is to advance zoo–academic research collaborations.

Data availability

The authors currently have reported all statistical values of each survey in the Supplementary Material. Individual survey results will require Institutional Review Board (IRB) approval from Georgia Institute of Technology and Zoo Atlanta to be shared with interested parties.

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