Zoo Research Guidelines

Research Using Zoo Records
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Introduction to Research Using Zoo Records

Effective management of species in zoos and aquariums requires considerable knowledge of the biology of each species including reproduction, behaviour, group dynamics, husbandry, nutrition, medical needs and so forth. Scientific investigations are the basis for understanding the animals in a zoo and assessing the way they are cared for. Through careful observations and well-planned studies, much can be learned about, for example, reproductive and social behaviour, growth and development, basic nutrition and dietary preferences and interactions with the physical environment.

Fundamental research analysing animal records is conducted much less frequently, yet due to the limited sample sizes in ‘living’ collections, adding a historical perspective has the potential to test more robust hypotheses. Basic and advanced biological data on up to two million individual animals and 10,000 taxa have already been gathered and recorded in scientifically sound ways in zoos and aquaria and entered into custom-built, dedicated electronic databases. Such large data sets allow studies of reproductive patterns, infant or adult mortality, and many other components of species’ life history, at both an institutional or population level.

These guidelines form part of a series designed to clarify the series of steps that are usually involved in developing a research project in a zoo environment. They discuss challenges which are characteristic for zoo research projects which may differ from those encountered in laboratory or field studies. Rather than repeat relevant advice offered elsewhere, the authors suggest reading this document in conjunction with:

- Project Planning and Behavioural Observations (Wehnelt et al., 2003)
- Statistics for typical zoo datasets (Plowman (ed.), 2006)
- Research by questionnaire (Plowman et al., 2006)

The Research Using Zoo Records Guidelines are divided into the following headings and it is advisable to read all sections before beginning a project:

1. What do we mean by Zoo Records?
2. What research questions can you ask?
3. What are the limitations?
4. How can I access the data?
5. Final considerations
6. Further reading and other resources
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What do we mean by Zoo Records?

Types of information
Zoos initially stored records of animal arrivals, departures, births and deaths as notes in diaries, ledgers or stock books. At minimum, the information contained within these volumes formed a current stock list and record of ‘transactions’ for each collection. A later development was the use of cards for individual animals, to note their date of arrival, place of origin, sex and name and species. The cards were updated when the animal died or departed.

Currently in the UK, the Secretary of State’s Standards for Modern Zoo Practice (SSSMZP) are designed to ensure that the welfare of animals in zoos is protected, that zoos are safe places for the public to visit and that zoos participate in appropriate conservation and public education measures. The Standards recommend best practice by which zoos are inspected and granted licenses by local authorities. Under Section 9 ‘Stock Records’ it is compulsory that an annual stocklist of all animals must be kept. All zoological collections in the UK are required to also keep and maintain records for all individually recognisable animals and groups.

The records should provide (wherever possible) the following information:
• identification and scientific name;
• origin (i.e. whether wild or captive-born, including identification of parents, where known, and previous location/s, if any);
• dates of entry into, and disposal from, the collection and to whom;
• date, or estimated date, of birth or hatching;
• sex (where known);
• any distinctive markings, including tattoos, freeze-brands, rings or microchips;
• clinical data, including details of and dates of any treatment given;
• behavioural and life history data;
• date of death and the result of any post-mortem examination and laboratory investigations;
• where an escape has taken place, or damage or injury has been caused to, or by, an animal to persons or property, the reason for such escape, damage or injury must be recorded and a summary of remedial measures taken to prevent recurrence should be provided;
• food and diets.

The SSMZP also stipulates that records must be kept up to date, and must be available on site for six years. After this time, provision should be made to archive the records in a secure format on a long-term basis. This means that every collection in this country holding a zoo licence should have up to date, detailed animal records for both individuals and groups, available on site going back at least six years.

Recording details for individual animals such as tigers is relatively straightforward, but becomes more complicated for group-living animals such as leaf cutter ant colonies, which can be made up of up to 40,000 inhabitants. In this instance a ‘colony’ would be recorded; similarly for some invertebrate and fish species a group record is kept.
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Having information in one place can assist the management of an individual animal and also provides insight into a species in general. Depending on the species concerned, many different levels of data are collected at each institution. Furthermore, this information is rarely managed independently, but forms the basis of managed conservation breeding programmes for species at a national, regional or international level.

**Methods for recording/storing information**

Data may be recorded by many zoo staff including keepers, curators, and veterinarians. The information they generate is generally collated by one person, sometimes called a Record Keeper or Registrar, to a centralised records system. Note that for some collections, an alternative title may be 'ISIS Representative', for reasons which will become clear.

Originally all zoo records were paper-based using diaries, ledgers, stockbooks or index cards, which were stored in a secure place (e.g. a filing cabinet). Prior to the International Species Information System (ISIS) however, standards of record keeping were quite varied because there were no uniform record-keeping procedures among zoos.

Recognising that a system pooling all animal records in standardised format would enable more effective management of species, ISIS was founded in 1973 and continues to function as an international database to help zoos and aquariums accomplish long-term conservation management goals. To date (June 08) there are currently 760 ISIS member institutions in 76 countries on six continents and the ISIS central database contains information on 2 million animals – almost 15,000 taxa/10,000 species – held in zoological institutions, plus some animals in the wild. ISIS members use the basic biologic information (age, sex, parentage, place of birth, circumstance of death, etc.) collected in the ISIS system to manage genetic and demographic programs for their animal collections.

Initially data was submitted on paper, using duplicate pads (i.e. including carbon paper); one copy was sent to ISIS while the zoo kept the other on file. Pads were also preformatted to standardise the information being submitted. From 1985 an alternative to paper forms became available, namely the suite of software programmes now most widely used for records management within the zoo community. These guidelines are strongly biased towards records maintained using these programmes (ARKS, SPARKS, MedARKS etc.), therefore some explanation is necessary.

**ARKS - Animal Records Keeping System**

ARKS is the main computer program used by institutions in the UK to maintain animal records. All living specimens currently housed at an institution should be recorded (technically referred to as accessioned) and if historic data is available this may also be included in the ARKS database. The ARKS database is capable of rapidly retrieving data enabling an institution to review the overall management of an individual, group or species by using various reports as below:
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### Selected ARKS reports

<table>
<thead>
<tr>
<th>Report name</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPECIMEN REPORT</td>
<td>Individual specimen or group record</td>
</tr>
<tr>
<td>TAXON REPORT</td>
<td>All specimens of a selected taxonomic group during a selected time span</td>
</tr>
<tr>
<td>TRANSACTION REPORT</td>
<td>The number of transfers in/out of collection for a selected taxonomic group</td>
</tr>
<tr>
<td>COLLECTION INVENTORY</td>
<td>The number of transactions (births, deaths, transfer into/out of institution for a selected taxonomic group.</td>
</tr>
<tr>
<td>ENCLOSURE REPORT</td>
<td>Details of specimens maintained in a specified enclosure at the institution</td>
</tr>
<tr>
<td>PEAK HOLDING</td>
<td>The maximum number of specimens held by the institution</td>
</tr>
<tr>
<td>CENSUS REPORT</td>
<td>The number of specimen at the beginning of each year of a selected species over a selected date span</td>
</tr>
<tr>
<td>WEIGHT AND LENGTH</td>
<td>Recorded weights/lengths for a selected specimen</td>
</tr>
</tbody>
</table>

Additional data can be obtained relating to reproduction and demographics:

<table>
<thead>
<tr>
<th>Report name</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>AGE PYRAMID</td>
<td>Age of current population of selected taxonomic group</td>
</tr>
<tr>
<td>RELATIONSHIP REPORT</td>
<td>Ancestors, siblings and descendants of selected specimen</td>
</tr>
</tbody>
</table>

ARKS records are often held by the registrar, record keeper, or occasionally the curator or head keeper, designated as the ISIS Representative. Contact individual zoos for information on who keeps the records.

### SPARKS - Single Population Animal Records Keeping System

Studbooks are a positive exception to zoos’ otherwise historically patchy record keeping. Some were initiated as early as the 1930's (for a subspecies of European bison) and from 1965 studbooks became an integral part of managing endangered species living in zoos. Studbook keeping involves compiling genealogical and demographic data covering a species’ history in captivity, typically across an entire region (e.g. Europe) rather than just at a national level. This includes numerically identifying individual specimens so as to record permanently data on their origins, parentage, date of birth, gender, locally-assigned identifiers, dates of transfers to another collection. Captive population sizes and fecundity rates vary across species, thus the job of maintaining a studbook ranges from simple and easy, to complex and challenging. SPARKS is DOS-based software used by hundreds of studbook keepers worldwide which supports studbook management and species analysis. Examples of data that can be compiled in SPARKS reports are given below:

### Selected SPARKS reports

<table>
<thead>
<tr>
<th>Report name</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIVING ANIMALS</td>
<td>All individuals living at date criteria set (either during or at the end of a date span). Report can be ordered by studbook number or location</td>
</tr>
<tr>
<td>HISTORICAL</td>
<td>All individuals living or dead within the time the studbook data runs. Report can be ordered by studbook number or location</td>
</tr>
<tr>
<td>BIRTHS</td>
<td>Births over a selected date span</td>
</tr>
<tr>
<td>DEATHS</td>
<td>Deaths with death notes over a selected date span</td>
</tr>
</tbody>
</table>
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TRANSFERS | Transfers between zoos over a selected date span
MORTALITY (Qx) | Age specific mortality. The average proportion of animals that are expected to die within an age-class
SURVIVORSHIP (Lx) | Age specific survivorship. The probability of a newborn surviving to the beginning of age class x
REPRODUCTION | Details youngest parents, oldest parents, interbirth intervals, birth seasonality etc for both sires and dams. Reports on reproduction history for individuals can also be generated
AGE REPORT | Details oldest animals (living and dead)
PEDIGREE CHARTS | Details the sires and dams of individuals back to the population founders
DESCENDANT LISTS | Details offspring of an individual through all known generations (living and dead)

SPARKS records are kept by the studbook keeper or studbook coordinator. Details of the European studbook programmes (EEPs / ESBs) can be found on the EAZA website (www.eaza.net), along with the studbook keeper / coordinator’s information.

Example 1: Using records for evidence-based animal management

Although there is knowledge within zoos about husbandry practices for many species, much is anecdotal. Data within studbooks can be used to verify that knowledge, helping to establish guidelines for good practice with species and increase our knowledge of factors influencing animal welfare.

Within the European studbook for the white faced saki monkey (Pithecia pithecia) one question concerning husbandry practices is regularly asked:

At what age should animals be removed from their natal group?

From anecdotal evidence, saki monkeys moved from their natal group before they reach sexual maturity (at about two years of age) may have a reduced lifespan. Using historical data in the studbook (held on SPARKS) it’s possible to pull out when animals left their natal group and their age at death. In such a study, statistical analysis showed a positive relationship between the age an animal leaves the natal group and the age at which it dies, such that animals leaving below four years of age tend to die before reaching the age of 10 years.

Displaying this relationship graphically makes it easier for the studbook coordinator to demonstrate the rationale for why saki monkeys should stay within the natal group beyond the age of sexual maturity. Of course, individual recommendations must be considered in tandem with careful observations of social interactions of each group and the potential for interbreeding.

(Pullen, 2004)

MedARKS - Medical Animal Records Keeping System

MedARKS is DOS-based software which enables veterinary medical record keeping and collection management. Although part of the ISIS suite, its usage is far less consistent between collections and in many instances the software may be run alongside additional means of data recording, including paper records and other
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databases. Records will be for animals at that particular zoo only, both past and present although, on a regular basis (approximately every 6 months), all subscribers send their information to ISIS who compile this as a ‘Reference Values’ module for the software programme. A selection of reports are listed below – be aware that interpreting this data may require specialist knowledge.

Selected MedARKS reports

<table>
<thead>
<tr>
<th>Report name</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANAESTHETIC USE &amp; REGIMENS</td>
<td>Details physiological parameters (heart &amp; respiratory rates), drugs and dosages, recovery and survivalship</td>
</tr>
<tr>
<td>BLOOD NORMALS</td>
<td>Range values for specimen or selected species</td>
</tr>
<tr>
<td>HISTORICAL DISEASE INVESTIGATION</td>
<td>All incidences of an aetiology or diagnostic term, e.g. air sacculitis and staphylococcus over a selected date span</td>
</tr>
<tr>
<td>PATHOLOGY REVIEW</td>
<td>Causes of death for a species or time span, highlighting disease trends</td>
</tr>
<tr>
<td>PARASITOLOGY</td>
<td>Frequency of testing, subsequent findings and treatment</td>
</tr>
<tr>
<td>WEIGHT REPORT</td>
<td>Can be for an individual or species, for a selected date span</td>
</tr>
</tbody>
</table>

Within individual zoos, Medarks records will usually be kept by the vet or vet nurse. Many zoos do not have a dedicated vet and in these cases, the records may be kept by the curator or added into the ARKS database. Contact the individual zoos to find out where the records are kept.

Example 2: Using records to assess anaesthetic risk in great apes

Placing an animal under anaesthetic always carries an associated risk, particularly with exotic animals where details of their physiology may not be fully known. Zoos have had many situations where anaesthetics have been necessary for the treatment of their animals and therefore zoo records are an excellent source of information on the risks associated with anaesthetics.

Are the anaesthetic risks greater for great apes?

Records on all anaesthetic procedures from 16 zoos with great apes were examined. Some of these records were stored on MedARKS, others were stored in paper records within the zoo. Variables recorded included outcome at seven days (whether alive, dead or euthanized) and the physiological and anaesthetic characteristics. Multivariate analysis was carried out on the 1182 records collected.

It transpired that peri-operative and anaesthetic related mortality risks are significantly higher for the great apes than for domestic species. Major risk factors for anaesthetic-related mortality include health status and extremes of age; the major risk periods are during recovery, immediately post-recovery and within 24 hours of the anaesthetic. These results provided important information for the veterinary care of great apes in zoos.

(Masters et al. 2005)
ZIMS - Zoological Information Management System

There is a recognised lag in ISIS software development compared with general computing/IT advances, apparent from SPARKS and MedARKS still being DOS-based programmes. Furthermore, these individual programmes are not interlinked. ZIMS is the next generation of ISIS software and aims to be a unified global database on animal health and well-being, incorporating the functionality of ARKS, SPARKS and MedARKS in one programme, creating the first such database in the world. The 760 ISIS member institutions across the world will enter their data directly into this web-based global database. Any ISIS member (and others with permission) will be able to search the database and retrieve information they need (with appropriate security protections) for myriad purposes.

Example 3: Using records to look for sex ratio bias in avian breeding programmes

Recent studies have shown that egg sex ratios in many species of wild birds are not random. For example, in many species, sons are more ‘expensive’ (this may be measured in terms of energy, nutrition or developmental time) to produce than daughters. So, mothers may overproduce sons when they are in good condition, older and more experienced at rearing offspring, and/or when more food is available. The link between maternal condition and sex allocation shown in wild birds, suggests that captive breeding programmes in which individuals are kept on a high nutritional plane, are probably producing uneven sex ratios.

What factors influence the sex ratios of birds born within zoos?

Information available in studbooks and data on the life history in the wild and captivity, as well as diet and sexual size dimorphism, was compiled for 57 avian species. Overall the sex ratio across species was roughly 50%, but this ranged from 33 to 76% males. Such biases are likely to have important implications for the social dynamics and mating behaviour of captive populations. No significant correlations were found between sex ratio at hatching and any measured factors, not unsurprising since a third of these birds born in zoos were of unknown sex. Generalised linear models revealed that small, short-lived birds were less likely to be sexed, an observation likely explained by the perceived health risks associated with surgical sexing, the method most widely used by zoos. The proportion of unsexed offspring was high in species with a high mortality rate during the first month, suggesting that few nestlings are sexed post-mortem. In conclusion, it was not possible to determine from the existing data whether captive dietary regimes differentially influence the production and survival of sons or daughters. Understanding of the effects exerted by captive conditions on species’ management will remain limited if it is not possible to determine the sex of individuals.

(Ziach et al., 2004)

ZOOTRITION

An exception to the suite of software developed by ISIS, ZOOTRITION was initiated with a Federal grant from the USA’s Institute of Museum and Library Services. The programme’s content and design incorporated suggestions from zoo nutritionists, curators, and keepers, while nutrition scientists from five countries fine-tuned the first and second (current) working version.
Zootrition is a comprehensive electronic database that provides zoo and wildlife managers with a powerful tool to compare nutritional content of specific food items and calculate overall nutritional composition of diets. Potential nutritional deficiencies and toxicities can be identified. Users can also add additional information, specific to local regions (e.g. common name in native language; local currency).

There are no reports as such but contents and features include:
- Over 3000 feedstuffs with published nutrient values, many unique to zoo and wildlife species.
- Comprehensive information covering nutrient recommendations for US domestic and zoo species, the latter largely based on AZA Species Survival Plan and Taxon Advisory Group nutrient specifications and recommendations for several species are from international husbandry guidelines.
- Energetics calculator to estimate energy needs based on animal taxonomy, food habits, physiological stage, and activity levels
- Standard Diet & Nutrient Reports

Published reference materials and protocols to assist with feeding program development and evaluation have undergone the most revision in Version 2.6 and the associated files (all in PDF format) are now split into:
- Forms/References – comprising resource materials including all the data citations and details of vitamin nomenclature.
- Animal Assessment - included are all the previous evaluation criteria (energy calculations, management food portions, intake, faecal scoring) but now also featuring hematology and nutrient SI conversion data for clinical assessors of nutrient status.
- Body Condition Scores, hopefully a stimulant for additions in the future.

Only data from peer-reviewed sources is considered for inclusion in the 'locked'global database embedded within Zootrition and most of the information on feedstuffs and nutrient recommendations is still of North American origin.

Zootrition addresses a gap within the current suite of animal records software provided by ISIS. Saint Louis Zoo, with financial support from the World Zoo Association (WAZA), has assumed technical user support and distribution of Zootrition. They will work in close association with ISIS staff on upgrade development as part of the ZIMS integration process.

**ISIS - International Species Information System**

In addition to the software resources already mentioned, the ISIS website details which species are held in which zoos and therefore provides invaluable data to ISIS members, studbook keepers and species programme managers, who require information for co-operative breeding programmes and animal acquisition. See Section 6. Further reading and resources for instructions on how to use the freely accessible Species Holdings feature.

The ISIS Specimen Reference DVD contains historical and pedigree information on 2 million specimens of approximately 10,000 species. The Specimen Reference DVD also contains historical zoological datasets, containing all data in the ISIS system. The Specimen Reference DVD is updated on a regular basis and available upon
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request to ISIS members. The ISIS/World Association of Zoos and Aquariums (WAZA) Studbook and Husbandry Manual CD-ROM contains almost 1,100 regional and international studbooks, husbandry manuals, related resources and reference documents pertaining to captive animal data records and population management. This product is produced annually and mailed to the ISIS representatives in member institutions and WAZA members.
2. **What types of questions could you ask?**

<table>
<thead>
<tr>
<th>Data stored electronically in &gt;</th>
<th>ARKS</th>
<th>SPARKS</th>
<th>MedARKS</th>
<th>Zootrition</th>
<th>ISIS</th>
</tr>
</thead>
<tbody>
<tr>
<td>I am interested in:</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Single species</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Multiple species</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Single institution</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Populations (multiple institutions)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>I want to know about:</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Genetic bloodlines (relatedness of individuals, kinship effects, descendants, pedigrees)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td></td>
</tr>
<tr>
<td>Life history parameters (longevity, developmental stages, dispersal ages, sexual maturity)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Fertility, fecundity &amp; reproductive parameters (birth rates, interbirth interval, litter / clutch sizes, infant survivorship rate, breeding success)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Mortality (mortality rates, infant mortality rates, causes of mortality)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Nutrition (feeding regimes, diet ingredients, nutritional content of diet)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Clinical data (health parameters, parasite checks, preventative health checks, anaesthetic procedures etc)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Transport data (moves between zoos, number / distance involved, ages at time of moves)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Behavioural data (mating, aggression, care of eggs, lekking / nesting behaviour, rearing / infant care)</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Who holds the data?</td>
<td>Registrar / Isis Representative</td>
<td>Studbook keeper / coordinator</td>
<td>Vet</td>
<td>Registrar</td>
<td>Keeper information sheets</td>
</tr>
<tr>
<td>Is there a hard copy equivalent</td>
<td>Arks records / daily diaries</td>
<td>Published studbook</td>
<td>Veterinary reports</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
What types of questions could you ask?

The table above provides a quick summary of the types of information present in zoo record keeping systems. Although the majority of zoos use the software programmes supplied by ISIS (i.e. ARKS, SPARKS etc), other population management programmes are in use. Also, direct access to electronic databases may well be limited. The number of 'users' within a zoo is usually restricted to ensure data quality and security, and also the programmes are not entirely intuitive and user-friendly. However, hard copies of database information will be held and these equivalents to databases are indicated wherever possible.

When access to databases is limited, record keepers may be willing to provide hard copies of information on request. It is important to inform the record keeper fully of the search parameters necessary for the research (i.e. date criteria – within a date span, event type, location etc). Depending on accessibility of the information requested, a return rate of 50% should be expected. What might seem obvious information for zoo staff to have to hand, may not be so easy or be timely to pull out. If the key person is away, then the enquiry may not get answered, so polite reminders should be sent if no answer is received within three weeks.

It is essential that adequate preliminary work has been done to ensure questions are clear, sensible and answerable and DO NOT ask for information that could be easily obtained from published sources, websites etc. For more information on how to compose your query and tips on how to send it out, see 'Zoo Research Guidelines: Questionnaires'. Please ensure that these guidelines have been read and as much information as possible has been gathered BEFORE questionnaires are sent out.

Example 3: Using records to assess the effects of transportation of big cats

Part of the function of a studbook is to maintain genetic diversity within a population. To achieve this, animals may need to be transported from one zoo to another at appropriate points in their lives. The transportation and introduction of animals into new situations is assumed to be stressful but the potential effects of that stress have not been evaluated for the majority of species.

Is big cat reproductive success affected by age at transportation or by the number of transports in a lifetime?

Studbooks for Amur tigers and Amur leopards contained the data required to answer this question; age of animals at time of transports, number of times each animal was transported, number of offspring produced, number of offspring surviving to thirty days and to one year, lag time between transport and birth of consequent litter.

Using suitable statistical analyses, it was possible to conclude the number of transportation events in a lifetime did not affect reproductive success. Furthermore, as long as animals are sexually mature, the younger they are transported, the more offspring they have and these offspring are more likely to survive.

(Mitchell and Nevison, 2006)
3. What are the limitations?

Although zoo records provide an excellent opportunity for detailed and extensive research both on an applied and a theoretical basis, due to the extensive nature of the datasets there are some constraints that need to be borne in mind. These can be considered as data consistency, cleanliness and continuity.

Data consistency and cleanliness

Consistency of the data is potentially the biggest. The chain of data from collection to input into the programme can in some situations be quite large and extended. In many institutions data is collected by the keeper and passed on through the head of section to the curator before being handed over to the studbook keeper. This can lead to opportunities for inconsistencies to be included.

In addition the studbook keeper will often (in the case of transfers between zoos) receive information from both the sending and receiving zoo – this can lead to inconsistencies i.e. the animal may be recorded as leaving the donating zoo on the 1st September but may not arrive at the receiving zoo until the 2nd or 3rd September.

Part of the role of the studbook keeper and record keeper is to track down any of these inconsistencies and ensure that the data within the studbook/ARKS database is ‘clean’. The clean up process is now becoming vitally important as we move closer to the initiation of ZIMS, and once ZIMS has been initiated, many of these potential areas for inconsistency will be negated.

How to overcome data consistency limitations:

In the meantime it is important to bear in mind that the data is only as good as the person inputting it. ISIS has established a ‘reconciliation’ process to try and ensure that the data inputted to ARKS (through the institution) and SPARKS (through the studbook keeper) is consistent. The record keeper/studbook co-ordinator will be able to log onto the member’s area of the ISIS website and look for reconciliation values for their particular institution/studbook. These values (only visible to authorised personnel) will give you an indication of how ‘clean’ the data is i.e. ISIS’ average reconciliation rate = 84%, above this and the data is very ‘clean’, below this and you have to be aware that there may be some inconsistencies within the data set you are using.

Data continuity

Although data sets can be extensive and can provide answers to many questions, in some circumstances there are potential confounds to the data e.g. where the studbook has collected data over a long period of time (some studbooks have data for over three decades). It is worth remembering that zoo practices, including husbandry and housing knowledge, have changed quite dramatically in those times. This could have a strong influence on parameters such as mortality rate and breeding success. When looking at these sorts of parameters it may be worth investigating longitudinal variation within the dataset.

How to overcome data continuity limitations:

Filtering the data will prove to be a necessary step for the student working with a database. Filter criteria will depend on the questions being asked and potential
Research Using Zoo Records

influences / confounds on that data. e.g. if looking at factors affecting the longevity of an animal, the student may want to filter data by decade to assess whether this has an impact (potentially due to housing or husbandry improvements) before pooling the data to ask the research question. The researcher should accept that in some circumstances, some data may need to be excluded from the analysis or treated with caution.

Example 4: Using records to investigate ‘purging’ in zoo populations

It is generally agreed that inbreeding produces offspring which are less fit than their non inbred counterparts. As a consequence, current captive breeding management plans aim to minimise inbreeding whenever possible. However, since the expression of deleterious genes is increased during inbreeding, selection against such genes is also increased meaning that, in theory, a population could perhaps be ‘purged’ of its mutations. Indeed, laboratory experiments have shown that, in some cases, intensive continued inbreeding can raise fitness levels.

Is purging occurring in zoo populations and, if so, how strong are the effects?

Whilst purging of detrimental genes might be thought to be advantageous to the conservation of threatened species, it must be remembered that purging will always result in a loss of genetic diversity. Genes that might be detrimental to species in captivity could actually prove to be advantageous in the wild. If purging was found to be occurring, it would be important to assess whether it was advantageous or detrimental to future reintroduction programmes and whether breeding programmes might need adjusting to incorporate its effects.

This PhD investigation would have been impossible without the vast wealth of studbook data and the co-operation of studbook holders. 136 populations which had experienced inbreeding over 2 or more generations were identified and contained sufficient known ancestry to be included in the analysis although permission was only granted to use 119 of these studbooks. Using regression models and meta-analyses, there was a significant trend of both inbreeding depression and purging across populations. However, the change in inbreeding depression due to purging averaged across the 119 populations was <1%, suggesting the fitness benefits of purging are rarely appreciable. The study therefore re-emphasises the necessity to avoid inbreeding in captive populations and shows that purging cannot be relied upon to remove deleterious genes from zoo populations.

(Boakes and Wang, 2006)
How can I access the data?

Throughout the BIAZA region there is a variation in the way records are maintained at each institution thereby restricting their research value. In conjunction with this, in order for records to be of value at institutional level there is a need for continuity in the way in which data is entered (e.g. if the same code is not used for specific data or if wording is not consistent then full data extraction cannot be successfully carried out). Often these issues only become evident when data quality/retrieval is carried out. BIAZA have recently developed a ‘Records Group’ who are developing management procedures that will guide best practice and create uniformity throughout the BIAZA region, thereby improving the quality of records overall for both archival and research purposes.

One of the greatest limitations with zoo research is that of small sample size. In many situations methodology and experimental design as well as statistical analyses need to be tailored to meet the specific requirements of small sample sizes and single case situations (re: stats research guidelines). However zoo records research can give access to multi-institutional data through the use of studbooks and SPARKS data sets. Although there are limitations that must be taken into consideration, using the records of a European breeding programme (either EEP or ESB) will dramatically increase the sample size of your research and allow access to a wider range of statistical tests.

Within the EEP there are 170 EEPs and 157 ESBs (current to the end of 2007 these numbers are continually updated) each of which are required to update data on a yearly basis. In some cases this can provide more than three decades of information which, at the most basic level of data extraction will include births, deaths and transfers between groups; at a more advanced level of data extraction will allow the analyses of pedigrees of known individuals.

Information on the co-ordinator / studbook keeper and which institution supports them can be found on the EAZA website (www.eaza.net), although contact details are not included.

Write to BIAZA or EAZA explaining why you want to make contact with a specific programme co-ordinator (see Online Resources for web addresses). They will forward your request on to the relevant person and it will be up to them to decide whether to follow-up. Your initial contact should give brief details of research objectives, what you require from the breeding programme and how you think the programme will benefit from participating.

Remember, adequate preliminary work must have been done to ensure questions are clear, sensible and answerable and you should NOT ask for information that could be easily obtained from published sources, websites etc. For more information on how to compose your query and tips on how to send it out, see ‘Zoo Research Guidelines: Questionnaires’.
Final considerations

Multi zoo research
For research that is done across a number of BIAZA collections, BRG suggests that you get support in the form of a letter from BIAZA. In order to get this support, please see the BRG home page (for web page see section 6. Further reading and resources).

Publications
More people can benefit from the hard work that researchers have done if it is published, even in grey literature. The BIAZA Annual Zoo Research Symposium is a good, friendly place to present papers, and the Research Newsletter publishes abstracts and gets sent to zoo professionals and academics around the world. For a list of peer reviewed publications that have publish zoo-based research and Guidelines on how to publish zoo research see the BIAZA Research Group home page.

Acknowledgements
This is where researchers get the opportunity to thank all the people that facilitated or contributed to the research. Acknowledgements should be no longer than half a page and more in depth lists could be put in an appendix if need be.

Say thank you!!!!
By their nature, research projects involving zoo records may involve substantial input from zoo staff. Saying ‘Thank You’ to those who have taken time out of their already busy jobs to give information or data to a research project is very important and means you are more than likely to get the help you want.
Further reading and resources

This section contains a selection of relevant references, but the main resources are online. A short guide to using the ISIS Species Holding tool is also provided.

References


Online Resources

<table>
<thead>
<tr>
<th>ARKS</th>
<th>Animal Records Keeping System software distributed by ISIS</th>
<th><a href="http://www.isis.org">www.isis.org</a></th>
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<tbody>
<tr>
<td>BIAZA</td>
<td>British and Irish Association of Zoos and Aquariums</td>
<td><a href="http://www.biaza.org.uk">www.biaza.org.uk</a></td>
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<tr>
<td>EAZA</td>
<td>European Association of Zoos and Aquaria</td>
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<td>EEP</td>
<td>European Endangered species Programme</td>
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<td>ESB</td>
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<tr>
<th><strong>ISIS</strong></th>
<th>International Species Information System</th>
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<tr>
<td><strong>MedARKS</strong></td>
<td>Medical Animal Record Keeping System software distributed by ISIS</td>
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<tr>
<td><strong>SSSMZP</strong></td>
<td>Secretary of State’s Standards for Modern Zoo Practice</td>
<td><a href="http://www.defra.gov.uk/wildlife-countryside/gwd/zooprac/index.htm">http://www.defra.gov.uk/wildlife-countryside/gwd/zooprac/index.htm</a></td>
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<td><strong>SPARKS</strong></td>
<td>Single Population Animal Record Keeping System software distributed by ISIS</td>
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<tr>
<td><strong>TAG</strong></td>
<td>Taxonomic Advisory Group</td>
<td><a href="http://www.eaza.net">www.eaza.net</a></td>
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<tr>
<td><strong>WAZA</strong></td>
<td>World Association of Zoos Aquariums</td>
<td><a href="http://www.waza.org">www.waza.org</a></td>
</tr>
<tr>
<td><strong>ZIMS</strong></td>
<td>Zoological Information Management System</td>
<td><a href="http://www.zims.org">www.zims.org</a></td>
</tr>
<tr>
<td><strong>Zootrition</strong></td>
<td>Diet management software</td>
<td><a href="http://www.zootrition.org">www.zootrition.org</a></td>
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</table>
ISIS Species Holdings

This tool will help you find out how many animals of each type are currently living in ISIS member institutions. From the ISIS home page (www.isis.org) click on ‘animals’ then ‘find animals’ (see screenshot below):

This takes you to the ISIS Species Holdings page. To use this tool:
On the left side of the screen, click to expand the category of the animal for which you would like to search.

- Mammalia – mammals (e.g. elephants, tigers, dolphins)
- Aves – birds (e.g. doves, owls, hawks)
- Reptilia – reptiles (e.g. snakes, lizards, turtles)
- Amphibia – amphibians (e.g. frogs, salamanders, newts)
- Other – everything else (e.g. fish, sealife, insects)

After the selected category expands, click to expand the appropriate subcategory to search by “common” or “taxonomic” name.
(Note: if you are not able to find the animal for which you are searching by common name, use this tool: http://www.itis.gov to find the taxonomic name for that animal.)

Choose the letter with which the name of the animal for which you are searching begins (e.g. choose “T” for “tiger”).

Now you can select your animal from the alphabetical list displayed in the right column. (Both the common name and the scientific name for each animal are displayed.)

Clicking on the name of the animal will display tables, which are divided by different types of that animal. For example, clicking on “tiger” will display separate tables for each kind of tiger.

In these tables, clicking on the blue text will show you the name of the institution that cares for those animals. Note: to obtain the full count of a particular species held by all ISIS members, you must add the totals from each table.)