Ex Situ Population Management Tools Working Group Report

2008 CBSG Annual Meeting, Adelaide, Australia

Participants

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Background

The population management methods, tools, and goals that are currently employed for the majority of *ex situ* conservation breeding programs for non-domestic species are an answer to the needs and circumstances of the period in which they were developed – the 1980s. We often take the specifics and characteristics of these management strategies for granted, because they are being used so frequently and across the regional zoo and aquarium associations. However, recently additional needs for population management are being expressed that cannot be met by our current methods and tools. In addition, there is a growing awareness that a substantial proportion of our programs do not seem able to reach the goals formulated for them, not only due to technical limitations but also due to logistic and socio-economic factors.

Over the last 20 years the zoo and aquarium world has made significant progress in its cooperative management of *ex situ* populations. There are very few 'industries' in the world that cooperate and share resources, data and experience to such a large degree and in service of conservation. If we make a critical evaluation, however, it also becomes clear that we must do even better and even more, for a much wider range of species. A recent assessment of the sustainability of 87 mammal species managed in captivity through AZA Species Survival Plans®, EAZA European Endangered Species Programmes, and ARAZPA Species Management Plans (Lees and Wilcken, Int. Zoo Yb. 2008, in press) indicated that 48% of the programs are breeding to replacement and 55% currently retain the levels of genetic diversity at or above the recommended threshold of 90%. Laurie Bingaman Lackey and Kristin Leus performed an assessment of EAZA avian studbooks to look at the sustainability of those captive populations and found a similar trend (pers. comm.). Out of 92 avian studbooks evaluated, 24 species were in excellent or fairly good shape in terms of population size, growth and meeting genetic diversity thresholds; 65 species were headed toward increasing difficulties; and 4 were in imminent danger. Looking at 924 electronic studbooks (all taxa) submitted to ISIS, the eye-opening fact was that 58% of species had fewer than 50 individuals in the living captive population.

Now is the time to take a step back and think about the way forward. Can we provide solutions to the current reasons for partial failure? Should we adapt our genetic and demographic goals? Can we develop new techniques, or increase the use of existing but so far underutilized techniques, to help solve our problems? What data do we need to analyze the situation and develop new strategies and tools for moving forward?

To address these issues, a wide range of individuals with varying perspectives on *ex situ* population management were invited to participate in this working group; those who were not able to attend were asked in particular to contribute their thoughts and relevant briefing materials for consideration at the working group sessions. The working group used this information as a basis to develop a more complete list of issues on the complexities, constraints and challenges of *ex situ* population management (PM). A list of current PM tools, and those under construction, was generated to identify which tools might be able to address some of the PM issues. With the limited time remaining, the working group discussed some initial action steps to address a few of these issues. Future electronic discussions and potentially additional meetings among working group members and other interested parties will continue to explore how existing goals and methods should be adapted, what new techniques or tools need to be developed, and what CBSG can do to help the *ex situ* community effectively manage their cooperative breeding programs for conservation.

Issues and Challenges

The working group identified problems and issues that define challenges for *ex situ* population management. These issues were categorized into one of three groups: Conceptual Issues, Technical Issues, or People Issues. Conceptual issues were identified but considered too large and complex a subject to tackle in this brief session. Technical

and People Issues were discussed, with some solutions offered and action steps developed (as time allowed). New tools that address the issue are noted in bold. Action steps are in *italics*.

Conceptual Issues

1. Plasticity – re-evaluate management units in the face of a changing environment. Considering the effects of climate change on wild populations (species having to migrate to find conditions within their temperature thresholds or to follow natural resources in the changing environment such that subspecies intermingle), the management practices to maintain pure subspecies in captivity may need re-evaluation (e.g., tigers).
2. Increasing need for PM – relating to climate change issue, sheer scale of species that might need captive management. Even without climate change issues, other extinction crises such as the amphibian crisis may need immediate attention. How can we deal with the need of literally thousands of species who may have no habitat to migrate to?
3. Founder availability – tools needed for linking *in situ* and *ex situ*, protecting habitats and increasing founder availability, with indigenous people involvement a necessity.
4. Recognition of expertise outside of the zoo industry – academics, wildlife researchers, government wildlife authorities, NGOs, indigenous people.
5. Optimizing the relationships between conservation partners for best outcomes in the wild.
6. Scale of problems in terms of captive propagation. Targeting flagship species for best outcomes.
7. Euthanasia as a management tool.
8. Limited funding, especially in certain regions, for *ex situ* management and for support of *in situ* conservation.
9. Lack of communication/insufficient accessibility of data between zoo and field.
10. Need to manage even more species to have sustainable captive populations even if there is no immediate conservation need (for exhibition or as insurance population in case the wild population goes into serious decline in the future).
11. Lack of awareness by visitors and public on role of *ex situ* management.
12. Exhibit design/size/capacity – not optimal for reproductive success (needs shift in thinking to change).
13. Differences in husbandry standards/practices within programs.
14. Insufficient founders – Many possible reasons. Most programs have insufficient founders. Big issue.
15. Inadequate population growth rates (may be mainly biological but could be combination of effects).
16. Insufficient carrying capacity.

Technical Issues

1. Relative genetic contributions of siblings – under current system, contributions are rubber stamped as equal.
2. Unknown inaccuracies in pedigrees (assumption that pedigree records are correct). Import of molecular datasets would start to expose these inaccuracies.
3. Cumulative long-term effects of less than optimal genetic management – issues may include need for population growth vs maintaining genetic diversity, incorporating mate choice into management strategy, etc.
4. Need to optimize preparation of animals for life in the wild (reintroduction or re-release).
5. Managing biology – veterinary/health issues relevant to mortality and reproduction. **ZIMS r2**
6. Incorporating molecular genetic data. **PMx**
7. Incorporating genetic history of population into management strategy.
8. No guidance in relative importance of molecular data vs studbook data. **PMx might create a tool that does this.**
9. Relative concern with inbreeding and outbreeding in “naturally” inbred species or populations needs resolution.
10. Analysis of inbreeding depression for certain species or populations – identify effects of inbreeding.
11. Limited founder availability due to small wild population.
12. Group management issues
    a. Collecting the right data. **ZIMS r1**
    b. Dealing with unknown pedigree. **PMx**
    c. Genetic management of groups. **PMx**
    d. Incorporating known data into genetic management. **PMx**
    e. Better management guidelines and supporting tools for increasing gene diversity and decrease rate of inbreeding. **PMx**

Some tool development already by Paul Pearce Kelly and colleagues at London Zoo. Several other groups of individuals are also dealing with these problems. EAZA fish specialists are developing a simple spreadsheet that will feed into ZIMS group management.

Action: *ZIMS data specifications are needed so can start to collect data now. ZIMS – Excel import interface hopefully will be possible. The guidelines for amphibian population management (AArk guidelines) can be tweaked to create general group management guidelines (CBSG to facilitate).*

13. Genetics and demography
    a. Dealing with unknown pedigree. **PMx**
    b. More metapopulation management tools for dealing with global programs, wild-wild, captive-wild, etc. **PMx**
    c. Genetic adaptation to captivity.
14. Need to understand the consequences of incorporating founders over time.
15. Implications of mate choice on population management
    a. Mate choice as a different management strategy for genetic management
    b. Mate choice interference with breeding pair success (tradeoff between value of maintaining genetic diversity vs. successful reproduction and population growth, implications on demography).
    c. Effect of population management on altering mate choice
    d. Mate choice issues have interesting complications. One regional zoo association stated that considering mate choice was a bad idea since it makes our job harder. A number of people around the world, including a small group within AZA (led by Cheryl Asa at St. Louis Zoo), are interested in this topic and recognize the importance of mate choice. St. Louis Zoo had a meeting to start to identify issues and needed research. No identifiable collaboration among groups to date.

Action: *It would be valuable to bring those interested in mate choice together – could be a working/discussion group within CBSG or organized by CBSG. Cheryl Asa (Chair AZA Contraception Advisory Group, USA), Heribert Hoffer (Wildlife Institute, Germany), Jason Watters (Chicago Zoological Society, USA), and Lydia Költer (Zoo Köln, Germany) are among those who would be valuable participants. Other people are likely also interested. CBSG could promote mate choice issues as a trial for using the mass collaborative tool to find out what people are working on (maybe create working groups within collaborative tools – to carry on electronic forum on mate choice issues). Liaison with Onnie re: development of mass collaboration tools for this issue. Caroline Lees will initiate this – will talk to Cheryl Asa and Heribert Hoffer.*

16. Tradeoffs of demographic growth and genetic management.
17. Problems related to aggression.
18. Mating systems issues providing challenges for genetic management – sperm competition, parthenogenesis (e.g., Komodo monitors), extra pair copulations (differential parentage within litter), chimeras – mosaic genetic cells (e.g., tamarins). **PMx can use probabilities with possible parents. In future, planned specifications can be set by a choice of genetic mechanism (clone, parthenogenesis, triploid). ZIMS data standards for sex and parents are that complex. If known, there will be mechanism for recording it. Partula snail program, which handles groups, does take into account selfing or sexual reproduction.**
19. Hybrids discovered too late – how to handle, how to prevent situation (currently do not check for hybrids early). **ZIMS – will trace back taxonomy in pedigree.**

Action (CBSG): *Develop a process to determine this before too late. Think about guidelines for insurance populations or rescue populations. Guidelines for confirming taxonomy (ask Heribert Hofer) and for breeding management. Amphibian ARK could be approached for a model for this and develop guidelines for starting a new captive population of a taxon, including taxonomic assessment, reference issues, and databank. Population-specific and species-specific. Guidelines on what to do has not been done.*

20. Interpretation of molecular results not clear cut.
21. Lack of husbandry knowledge/experience.
22. Measuring breeding success – inadequate records. **ZIMS.**

Action: *Need to compile information on who is doing this (including which regions) and disseminate this information. Good route would be to go through the regional conservation management committees – ARAZPA put together a body of text on tracking breeding success within ASMP programs (Roz). Also need to find out how ZIMS will be doing this. CBSG (Kathy) to approach the WAZA Committee on Population Management (former CIRCC) for interest in coordination of this project.*

23. Contraception (problems)
24. Problems associated with age and reproduction (long-term limits on reproduction, consequences of delaying reproduction)
25. Temperament issues – aggression
26. Behavioral adaptation to captivity

People Issues

1. Lack of monitoring, measuring and reporting to the right people.
2. Project management skills and capacity to deliver.
3. Initiating future programs: initiating monitoring and reporting early on.
4. Insufficient use of ISIS Studbook Reconciliation and other data validation tools – data quality and integrity between institutional data and studbook data is deficient. Bob stated, "This is not just theoretically unfortunate that data are different; it's critical to rectify for future population management when ZIMS comes out."

Action: *Kathy and Bart will take this issue to WAZA CPM. CPM has the authority to require clean-up for inclusion in the WAZA/ISIS studbook library. This issue also can be highlighted in Records and Population Management Training Programs (such as AZA Institutional Records-Keeping Course). Karin (as a Co-Administrator for AZA IRK course) will find out about other regional records-keeping courses and open a collaborative discussion on course content.*

5. Euthanasia as a management tool (also under Conceptual Issues). Will not discuss here in WG.
6. Lack of communication and sharing and analysis of information – among institutional records (registrars), studbooks (studbook keepers), and management programs (species coordinators and TAG chairs). **ZIMS – records will all be in one database.**
7. Language communication problems (e.g., EAZA countries, globally). **ZIMS available in different languages (major languages at roll-out)**
8. Lack of understanding or acceptance of population management principles.
9. Wavering commitment to collection plans.
10. Non-compliance with breeding management program recommendations.
11. Unreasonable or misguided recommendations from population managers (untrained).
    Training Courses for Population Managers: AZA requires population managers to attend AZA courses: Population Management I: Data Acquisition and Processing; and Population Management II: Data Analysis and Breeding Recommendations. New EAZA population managers (i.e., EEP coordinators and ESB keepers) are required to take the EAZA Academy's Basic Breeding Programme Management Course. For the experienced population managers EAZA also offers the Advanced Breeding Programme Management Course as part of the EAZA Academy. Other regional zoo associations are beginning to offer training in studbook and population management (e.g., JAZA, SEAZA).
12. Tradeoff between the need for more programs/managers and the expertise to deal with complexities.
13. Program managers not communicating with or listening to institution's problems/needs.
14. Differences in training opportunities and status of current programs among regions (husbandry standards and practices coordinated between regions).
15. Lack of global programs/global coordination – **WAZA CPM will be taking on.**
16. Atypical (to natural system in the wild) social groupings – management-related.
17. Barriers to international/inter-state transfers
18. Quarantine/disease risk management measures limiting movements
19. Inadequately trained coordinators
20. Too few professional coordinators
21. Inappropriate species prioritization (changing thinking on what is important)
22. Inappropriate/inadequate institutional plans – poor exhibit design/inadequate capacity/lack of flexibility

23. Buy in from zoo administrative staff that records-keeping is important.

Current Tools

These include institutional animal data and population management software used for population analyses and breeding recommendations.

International Species Information System software (accessible by ISIS members only)

ARKS – Animal Records Keeping System (institutional animal records software)
MedARKS – Medical Animal Records Keeping System (institutional medical records software)
SPARKS – Single Population Analysis and Records Keeping System (studbook software)
REGASP – Regional Animal Species Collection Plan (regional collection planning software)

Population Management / Analysis Software

PM2000 – software package that provides tools for genetic and demographic analyses and management of pedigreed animal populations. Freeware available from Chicago Zoological Society. Developed by JP Pollack, Bob Lacy, and Jon Ballou.

MateRx – software that uses genetic data from PM2000 to calculate a Mate Suitability Index that indicates the relative value/impact of every potential breeding pair in a population relative to several measures of genetic importance. Developed by Jon Ballou, Joanne Earnhardt, and Steve Thompson.

MetaMK – software that analyzes the genetic impacts of transfer of individuals between 2 populations. Developed by Jon Ballou.

Vortex – stochastic simulation population modeling software that can be used to project the long-term viability of *in situ* and/or *ex situ* populations under various management scenarios. Copyright Chicago Zoological Society; available for free download. Developed by JP Pollack, Maxim Borbat, and Bob Lacy.

Software developed at Lincoln Park Zoo (free downloads at www.lpzoo.org), with assistance from the AZA Population Management Center:

PopLink – software used for collection and analysis of studbook data.

ZooRisk – provides a quantitative assessment of a population's risk of extinction due to the demographic, genetic and management processes that affect captive populations based on a population's history, the science of the biology of small populations, and the ability to manage captive populations.

New Tools

New tools that are under development include PMx (to replace PM2000) and ZIMS (to replace the various ISIS software programs).

PMx

Bob Lacy discussed a new tool called PMx, population management software currently under development to provide methods and tools to address some of the issues surrounding analysis of population data. PMx will replace the PM2000 software that has been used for the past 8 years. The program will have a new interface and new underlying code, and will accept data from SPARKS, ZIMS, PopLink, and Excel. PMx runs well with Vista and Word 2007 (PM2000 does not). PMx will have enhanced demographic analysis, genetic analyses, reporting and graphing tools. New features include:

Genetic tools – has all of the tools in PM2000, plus:

Kinship options: PMx can factor in probabilistic parents and MULTs. PM2000 does not handle MULTs well (cases in which multiple animals are recorded as possibly being the parent), either requiring the user to create a hypothetical pedigree to represent the MULT parent, or allowing PMx to convert MULT to UNK. For uncertain or unknown (UNK)

parents, PMx will provide options to omit, consider parents as WILD, use weighted probabilities for possible parents, or use most likely listed parent. There will be the option to use all of the information available. If genetic relationships are measured (e.g., by DNA assays), these empirically determined relationships can replace the values calculated from the pedigree information. Subsequent calculations in the pedigree will then be based on the empirical knowledge of the measured relationships.

Pairing options: PMx will provide the option to list the 10 best genetic pairings, given some defined rules. PM2000 was only able to display optimal matings one by one. Automated pairings will be based on one of 4 different pairing strategies:

1. Static Mean Kinship (MK) – Selects the best pairs using a static MK list, starting from the top of the ranked MK list (no adjustment for successful reproduction of selected pairs).
2. Dynamic MK – Selects the best pair, then recalculates mean kinships on the assumption that the pair will successfully reproduce before choosing the next best pair, etc., until the desired number of pairs are created.
3. Ranked MK – Removes the worst pair, then recalculates the list until the desired number of pairs remain.
4. Simultaneous MK – Examines (nearly) every set of pairings, testing for the best set. Takes a very long time even on a fast computer.

Demographic tools – has all of the tools in PM2000, plus:

Error estimates (bootstrapping): Provides measures of the accuracy of the demographic rates.

Stochastic projections: Gives a fan of possible trajectories depending on the amount of uncertainty in the demographic rates.

Projection of lifetime breedings – indicates how many offspring an animal should produce over its lifetime (in a perfect world). Gives indication of which animals should produce the most offspring.

Alternative assumptions – allows the user to change selection or assumptions as they go along. For every screen, the user will have the opportunity to change assumptions about how UNKs and other problematic data are handled (in PM2000, you must restart at the beginning for every change).

Groups – has built-in genetic algorithms to take into account relationships among groups. Can show the best way to transfer animals between groups to maximize genetic diversity.

Goal setting – PMx will have same capabilities as PM2000 in determination of target population size (still deterministic, no uncertainty measures).

MateRx – will be integrated into PMx (currently it is a separate program from PM2000).

Metapopulation – provides the capability to analyze 2 or more populations (MetaMK can only handle two). Can be used for 2 or more regions or populations within a region. Will develop a matrix to show which populations are most alike or dissimilar (kinship between populations). Can show which transfers would optimize overall genetic diversity

Graphics – includes improved graphs, tables, and displays. Will be able to select what information is included on graphs and tables.

Lineage – will provide a pedigree graphing screen and tools to show relationships among individuals and groups.

Data imports – will import data directly from ZIMS as well as SPARKS. This may be problematic for non-studbook species, since there may be many errors in the data. Also, data integrity in the current ISIS database between studbook data and institutional data takes on increased importance, as all data will be within

one database in ZIMS. Will also be able to import pedigree data from PopLink and other programs.

Zoological Information Management System (ZIMS)

Nate Flesness gave an update on ZIMS. ZIMS is a huge project that experiments in unprecedented collaboration. It will encompass institutional records management, population management and people management. It also is unprecedented on veterinary side, with shared medical records. The past vendor (CGI) did not meet its contract agreement, and has financially reimbursed ISIS and withdrawn from the project. A new vendor has been selected and will be tested. All prior work to develop data standards and scientific background will still be used. The CGI product was too complex – there were 1000 screens designed. New screen designs are simpler and cleaner, with all required fields on Screen 1. Anticipated timeline for ZIMS releases is:

Release 1 – Animal Management

Expected to be available to the early adopters by the end of 2009, and is divided into 7 Sprints:

Sprint 1: Institution (begin date: 13-Oct-08)
Key Functionality: Institution administration, including contact methods, staff, and ISIS Membership data; and User Administration, including roles and access rights.

Sprint 2: Taxonomy (begin date: 22-Dec-08)
Key Functionality: Taxonomic hierarchy, local synonyms, and taxon-related rules.
New: Hybrids – will show history of taxonomic names in pedigree, and how it was classified at each institution.

Sprint 3: Enclosures/Tanks and Life Support Systems (New) (begin date: 16-Feb-09)
New: Key Functionality: Enclosure/Tank hierarchy, enclosure/tank characteristics, enclosure/tank observations, and life support components.

Sprint 4: Animal Husbandry (begin date: 13-Apr-09)
Key Functionality: Accessioning of individuals and groups, identifiers, transponders, morphometrics and measurement types (e.g. live animal weight, shell length).

Sprint 5: Animal Management (begin date: 8-Jun-09)
Key Functionality: Animal observations, census, death/disposition, group split/merge, quarantine, contraception.
New: ARKS for aquariums – group data models to meet data standards in PMx.

Sprint 6: Complex Transactions (begin date: 3-Aug-09)
Key Functionality: External transfers, pedigree, role/team responsibilities, and inventory reconciliation.

Sprint 7: System Functionality (begin date: 28-Sep-09)
Key Functionality: ARKS/ZIMS data migration, data fragmentation, and data quality metrics.

User Acceptance Testing of ZIMS Release 1: Begin 21-Dec-2009

Release 2 – Animal Health Care

Medical records will represent about one-half of the entire system. When available, users will be able to query what treatment, drugs, dosages, etc. have been found to be effective.
New: sample banking system. Currently, MedARKS has the capacity to store simple sample information, such as what is in the inventory and where it is stored. The new sample system will be able to include much more information.

Release 3 – Population Management

Studbook and population management analysis module. Studbook keepers will not have to re-enter data. Changes in individual animal records (such as sex) will be automatically updated in studbook. Changes will

be flagged as of yesterday for studbook keepers. Discrepancies between records and studbooks will be moved into ZIMS as “differences”. Reports will include choice.

Release 4 – Information Management System

This module will include protocols (husbandry), regional association plans (e.g., SSP, EEP, ASMP, collection plans), tasks and tests. Advanced sampling (1000 data fields – but maybe roll out 50).

Ex Situ Population Management Tools Working Group Actions

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