

GROUPS POPULATION MANAGEMENT WORKSHOP PROCEEDINGS
Woodland Park Zoo
16-18 May 2002

Compiled by Brandie Smith

Table of contents

- _ Introduction
- _ Records
- _ Demography
- _ Case Study: Flapping Critters
- _ Genetics: Group Management I
- _ Case Study: Straw Colored Fruit Bat
- _ Genetics: Molecular Analysis
- _ Genetics: Group Management II
- _ Case Study: Penguins
- _ Databases: ZIMS, AIMS & Tracks

Introduction

It is currently feasible to slow the loss of genetic diversity in animal populations through intense management where the entire pedigree is known and pairings can be controlled. This strategy is practical for many species in captivity, such as rhinos and vultures, but unrealistic for species for which there is insufficient information or over which we have less control. These include certain species of captive animals that are not maintained individually (e.g., herds, troops, flocks, tanks) and populations in the wild. Populations such as these, where detailed pedigree information is unknown, ages and individuals are difficult to identify, and/or specific pairings cannot reliably be made, are generally referred to as “groups”.

The second Groups Population Management Workshop was held at Woodland Park Zoo on 16-18 May 2002. Participants included Bruce Bohmke (Woodland Park Zoo), Nanette Bragin (Denver Zoo), Sue Dubois (Disney’s Animal Kingdom, IADISC Project Manager), Matt Gies (Shedd Aquarium), Ken Jones (University of Illinois at Chicago), Susie Kasielke (Los Angeles Zoo), Robert Lacy (Brookfield Zoo), Annarie Lyles (Medarex), Patty McGill (Brookfield Zoo), Andy Odum (Toledo Zoo), Dana Payne (Woodland Park Zoo), Michelle Schireman (Oregon Zoo), Brandie Smith (American Zoo and Aquarium Association), Wendy Wienker (Woodland Park Zoo), and James Williamson (National Aquarium in Baltimore). This workshop was a follow-up to one held by the Zoological Society of London (ZSL) in October 1998.

The meeting began on Thursday, May 16th, 2002 with a welcome by Bruce Bohmke, followed by an overview of the recent and current activities involving group population management by Brandie Smith. Brandie provided a working definition of groups (in reference to population management) as “populations where detailed pedigree information is unknown, ages and individuals are difficult to identify, and/or specific pairings cannot reliably be made” and encouraged the use of the term group management as opposed to colonial management. The term colony has its own, very specific biological implications. Of special interest was the first Group Population Management Workshop held in October 1998 at London Zoo. The summary of that meeting (Attachment A) was used to inform the participants at Woodland Park and to provide a starting point for new discussions. One of the most important things to come out of the ZSL workshop was a list of the different types of groups. Because the term group is so broad there is not one, best way to describe or manage groups. The London workshop began the process of

determining the characteristics that would affect population management and deciding how these different characteristics create different groups.

Records

Before talking specifically about genetic and demographic management, the Woodland Park workshop addressed records keeping issues. It is impossible to provide any type of population management without accurate records. AZA's definitive resource on capturing animal data is the *Standards for Data Entry and Maintenance of North American Zoo and Aquarium Animal Records Databases* (SDEMNAZAARD). The standards are available on the AZA Web site at http://www.aza.org/uploadedFiles/Animal_Care_and_Management/Animal_Management/Population_Management_Centers/standards-data-entry-na-databases.pdf. The section on *When and How to Enter Groups* is only slightly over three pages long and is most notable because the graphic chosen to represent the topic is a bespectacled duck about to smash his computer with a sledge hammer, along with a bolded statement that "Group records are only available within an institution's ARKS3 database and are not incorporated into the ISIS3 database." The Standards are in the process of being updated to incorporate information on ARKS4, but although there has been some improvement in recording group activities (Attachment B), it is still insufficient to meet management needs. There are efforts underway to improve the way zoos and aquariums manage their data and one of the primary reasons for the second groups workshop was to inform individual institutions, AZA, and the International Animal Data Information Systems Committee (IADISC) in their efforts to develop new animal databases (see below).

Nanette Bragin gave the presentations on records keeping. As the registrar at Denver Zoo and Chair of the Zoo Registrars Association (ZRA), Nanette is very involved in furthering the science and art of records keeping. She reported on a survey she conducted asking (1) how are groups managed, (2) what census methods are used, (3) what databases are used and (4) what is needed and wanted in group management (Attachment C). Fifty-five percent of those surveyed said that they did have problems with all aspects of group management, including monitoring groups, recording information, and genetic management. Respondents also stated that they encounter group issues for almost all taxa (invertebrates, fish, mammals, amphibians, and water birds). Institutions monitored groups in a variety of ways including daily tracking, yearly or periodic census, grids and photos, and "guess-timation". Seventy-two percent said they use a computer database to record their group information (of those, 52% use ARKS, 4.5% use Excel, 4.5% use Access, and the rest use other means). In addition, they stated that the development of group management software should be a priority and that some of the capabilities they would like to see are enclosure tracking, environmental quality tracking and monitoring, group and enclosure management, life stage capabilities, photo and graphics capabilities, flexibility, ease of use, applicability to aquariums, and connectivity and information sharing capabilities. The survey demonstrated that there are a lot of variations in how zoos and aquariums track groups but one commonality is that very few are happy with the current situation. Nanette also reported that ZRA was working on a project to help with record keeping for groups by comparing taxa and looking for similarities (Attachment D). Involved in the project are Nanette, Gretchen Bickert (Phoenix Zoo), Pam Krentz (Cleveland Zoo), Lynn McDuffie (Disney's Animal Kingdom), and Alan Rost (Jacksonville Zoo). This project involves looking at individual species that represent the wide range of group types and detailing the information that should be recorded for each species.

Demography

After discussing records keeping issues, the meeting focused on demography with a presentation from Andy Odum (Attachment E). Demographic management is necessary for all captive species to determine group viability, prevent unneeded surplus and demographic decay, plan for the future, and discern parameters, such as generation time, necessary for genetic management. Andy used a slightly modified version of the group categories defined at the London workshop to organize the potential approaches for demographic management. The group categories he used are (1) individuals identified, parentage known, pairings cannot be controlled; (2) individuals identified, parentage unknown; (3) individuals indistinguishable, sex known, assignable to age/stage classes; (4) individuals indistinguishable, sex unknown, assignable age/stage classes;

(5) individuals indistinguishable, recruitment observable; (6) individuals indistinguishable and uncountable. As category numbers increase, available information decreases, along with available options for demographic management. Possible demographic modeling options could include sex segregated age-based models (currently used), unisex age-based models, sex segregated stage-based models, unisex stage-based models, census model with fecundity rates and a simple census model. Stage based models, though widely used in wildlife management, are not (or rarely) utilized in captive management. Andy reviewed the different stage-based models but warned that, with group management, each group is a sub-population with its own parameters and that each group may require its own model. In addition, zoos and aquariums must be able to record basic parameters for groups such as census, births, deaths, immigration, and emigration in addition to stages, ages, sex, size, reproductive status and location. Data standards for these parameters must also be developed (e.g., stages will vary across taxa). The goal of managers should be to “keep it simple”, but, again, simple is relative for groups where even a basic census could involve counting 3,000 toad eggs.

Case Study: Scarlet Ibis and Rodrigues Fruit Bat

After the presentation and discussion on group demography, Annarie Lyles reviewed some actual attempts at group management for AZA’s Scarlet Ibis Population Management Plan (PMP) and Rodrigues Fruit Bat Species Survival Plan (SSP). Annarie began her talk, titled the “Flapping Critters Case Study” (Attachment F), by noting that the way zoos and aquariums usually manage groups is to simply try to force them into monogamy through means such as physical separation and/or contraception. For some species, this does work, but for others, such as many water birds and many species of bats, this is not always feasible. For example, the 1994 scarlet ibis studbook shows a population of over 900 individuals in 68 institutions. Less than 1% of the birds had a complete genealogy and one third were of unknown sex. Despite the lack of group management techniques, birds were still being bred and moved. What was known was that reproduction amongst colonies is highly uneven, with 6 of 70 institutions producing 75% of the chicks (most likely because bigger groups mean better breeders) and that stochastic events can and do take out entire groups. Some attempts were made at tracking birds from certain sources, but genealogy was mostly a fiction and a waste of time and resources, especially since difficulty in deciphering the pedigree was compounded by things like extra-pair copulation, egg-dumping and creching. Annarie said that attempts to manage the scarlet ibis population did generate some good general ideas for group management such as: forced monogamy isn’t a viable solution to the problem, colonies with rare founder lineages should try to avoid adding animals from over-represented lineages, and when the population is large but the conservation imperative isn’t, it may make sense to manage at a metapopulation level rather than on an individual level. Annarie then went on to discuss a working group meeting of the Rodrigues Fruit Bat SSP attended by Annarie, Kim Whitman (Species Coordinator, Philadelphia Zoo), Steve Wing (Riverbanks Zoo), Gary McCracken (University of Tennessee), and Sarah Long (AZA’s Population Management Center). The Rodrigues fruit bat population is young and numbers at about 300 individuals. There was a breeding moratorium for several years instituted so that the management group would have time to address the issues of group management. They determined that it might be possible to manage the SSP as individuals and use forced monogamy to control matings, but they first had to decipher the existing pedigree. Kim was awarded an IMLS grant to develop microsatellite DNA markers to determine paternity and relatedness. Unfortunately, there was not enough variation to construct a complete pedigree and, although the extra information gleaned can be of use, the SSP is still left to cope with large amounts of unknowness when making breeding recommendations. Annarie suggested that efforts at group management should consider group categories based on husbandry requirements such as:

- Socially facilitated breeders (need an orgy for libido, such as flamingos and ibis, fish that need to school, some bats)
- Gregarious species (can breed in pairs, but more naturally kept in groups, such as many ungulates and primate)
- Quasi-group animals (less gregarious but can be kept in multiple pairs in the same enclosure, such as waterfowl, small aviary birds)

- Eusocial organisms (obligately exist in large colonies and typically can't be tracked as individuals, such as ants)
- True colonial organisms (such as corals and bryozoans)

Annarie also reminded the group that, in August 1999, AZA's Ciconiiformes TAG suggested creating another management acronym to address their TAG's group management needs. ORGIES (Optimizing Reproductive Groups In *Ex Situ*) was a proposed category for "studbook" management that would use group monitoring rather than a SPARKS database. It was to be most appropriate for groups of large numbers (>250) and where parentage information is generally missing.

Genetics: Group Management I

The second day began with a presentation from Brandie on a research project she is conducting to compare genetic management strategies for groups (Attachment G). She began the presentation by reviewing the six types of groups recognized at the London workshop as well as another she had added as part of her research. Because there are many types of groups and because population management techniques may vary depending upon these types of groups, it is important that all of them be defined and addressed. After much discussion, the participants proposed that the number of these population management group types be expanded to nine (also listed in Attachment H):

1. Individuals can be identified and parentage is known. Pairings can be controlled. (The non-group.)
2. Individuals can be identified and parentage is known. Pairings cannot be controlled.
3. Individuals can be identified, but one parent most often is not known.
4. Individuals can be identified, but both parents are most often not known.
5. Individuals cannot be distinguished, but can be counted (or abundance accurately estimated) and classified into age/stage/size and sex classes
6. Individuals cannot be distinguished but can be counted (or abundance accurately estimated) and classified into age/stage/size groups. Sexes are unknown.
7. Individuals cannot be distinguished, but can be counted (or abundance accurately estimated) at the reproductive stage only.
8. Individuals cannot be distinguished, but a census of the population can be conducted. Life stages cannot be discerned.
9. Individuals cannot be distinguished or counted at any life stage (or only at non-reproductive stages).

Brandie then reviewed the genetic management techniques she is comparing in group management, including effective population size, founder important coefficients, maximum avoidance of inbreeding, proportional mean kinship, fixation indices, genetic distance, and molecular techniques, and reiterated how important the topic of group population management is to both captive and wild populations.

Case Study: Straw Colored Fruit Bat

Brandie concluded with a case study of the Straw-colored Fruit Bat PMP. The Population Manager (Anna Michel, Oregon Zoo) had worked with a graduate student to determine the pedigree of the population using microsatellite and mitochondrial DNA analysis. Although some pedigree information was obtained from the study, it was not enough to manage the population through traditional non-group methods. Anna was attending a meeting of the Bat Taxon Advisory Group (TAG) and need some quick analyses done to determine how a few bats should be moved between institutions. Brandie composed a diagram (Attachment I) of previous imports into the population and movements of founder stock to offer a few suggestions for future movement based on a very rough attempt to minimize F_{ST} . F_{ST} is one of Sewall Wright's F-statistics, also called a fixation index. These values are useful for comparing the effect of substructure in a population. F_{ST} describes the decrease of heterozygosity among subpopulations relative to the total population. Attempts to minimize the value could help reduce the detrimental effect of having large populations divided among several institutions.

Genetics: Molecular Analysis

It has been suggested that one of the ways in which the pedigree unknowness may be solved or alleviated is through molecular analyses such as DNA fingerprinting. Ken Jones gave a brief lecture called DNA 101 to bring the workshop participants up to speed on all the molecular techniques available for pedigree determination. Ken began by talking about the different kinds of DNA analyses and their utility. Some of the most well-known methods are no longer the best. Isozymes are relatively inexpensive, but usually not very informative unless you know there are some protein variants and use them to monitor the population. DNA fingerprinting requires a lot of DNA material and uses radioactive markers, but does not indicate heterozygosity. More useful techniques include analyses of Microsatellite DNA and AFLPs (Amplified Fragment Length Polymorphisms). The biggest drawback to a molecular study is the cost. Ken estimated the cost of a microsatellite study on a single population to be in the tens of thousands, though it is likely that the cost will drop significantly over the next few years. Because of the expense in determining the pedigree for every individual, other molecular management options include analyzing the pedigree of populations or subpopulations to determine gene flow or fixation indices. Ken then talked about his research on genetic management of the whooping crane population. He was able to add pedigree information to the studbook by using microsatellite DNA profiles. The study has recently been published in *Conservation Biology*, Pages 789-799, Volume 16 (3).

Genetics: Group Management II

Bob Lacy continued the genetics theme with his talk on strategies for genetic management of animal groups (Attachment J). The reason we manage the genetics of our animal populations is to maintain individual animal health, avoid inbreeding, retain evolutionary flexibility, preserve representation of the wild species, and ensure a source of animals for conservation actions and programs. This is true of group-living animals as well as non-group living animals. Animals are currently managed by minimizing mean kinship (MK). The key word is kinship – without knowing an animal's pedigree, its kinship, or genetic value, cannot be calculated. Instead of managing kinship on an individual level, one solution to group management may be to manage the kinship between groups, with the formulas for calculating group kinship dependent upon the type of group. Example of different types of groups include known pedigree with uncontrolled breeding, unknown pedigree, and even unknown numbers of sires and dams and maybe unknown numbers of animals. Group kinships can be managed by monitoring loss of gene diversity (1-MK) within and for all groups, identifying when to outcross a group, identifying which animals to move, and identifying the best sources for new groups. MK is also related to F_{ST} , a measure that may be valuable to group population management. This between-group kinships would be a measure of the similarity between groups, relative to initial source population. PM2000, a population management program developed by JP Pollack (Cornell University), Jon Ballou (National Zoological Park), and Bob already has capabilities for managing captive populations at a metapopulation level. The PM2000 metapopulation module uses pedigree information to show kinships among groups and has already been used to help manage some species. The software can be downloaded at <http://home.netcom.com/~pm2000/pm2000.html>. Bob concluded by mentioning the need to immediately begin tracking group data that could be relevant such as founder stock information, imports to and exports from each group, and potential parents and their probabilities of contributing to the population. In addition to developing new methods to genetically manage groups, new software is needed to track and analyze these populations.

Case Study: Penguins

Patty McGill gave a presentation on what it's actually like to manage a group population. Patty is Species Coordinator for the Humboldt Penguin SSP. The population's pedigree is known but, due to the biology of the species, suggested pairings are difficult to make happen. Until recently, Patty has been managing her population using the complicated simplicity of Post-it Notes (i.e., Post-its simulate individuals. When one individual is moved to a new group, it is checked against all the individuals in the new group to ensure that all potential pairings are acceptable). Fortunately, this process has been automated in PM2000's metapopulation module. This module

permits genetic calculations of individuals with respect to an entire group and comparisons of one entire group to another (see above).

Databases: ZIMS, AIMS, and Tracks

Sue Dubois began the last day of the meeting with an overview of the AZA' Animal Data Information Systems Committee (ADISC), its international counterpart (IADISC) and the Zoological Information Management System (ZIMS) (Attachment K). Managing the welfare of a diverse collection of animals requires timely access to a complex set of data from multiple sources. An integrated database contains medical, behavioral, nutritional, environmental, reproductive, life history, regulatory, and other data from sources such as veterinarians, keepers, nutritionists, endocrinologists, curators, registrars, and researchers. The complexity is compounded because data must be pooled across institutions throughout the association and around the world to successfully manage our animal collections. The mission of the ZIMS Project is to develop, deploy and maintain a comprehensive information system to support a wide range of animal management and conservation activities associated with zoological institutions and the zoological community. Products of the first phase of the project are a project charter and mission, a technology assessment, defined work processes, and a conceptual data model. Much of the visioning and planning work has been done for the system and an RFP (request for proposals) developed for the next phase of analysis, design, and construction.

One of the primary goals for ZIMS is to develop a system that it has an ability to handle groups and is equally useful to both zoos and aquariums. Currently, problems arise if individual animals are unidentifiable at all or some stages of their life, if animals are kept in large groups or colonies, if one or both parents are not identifiable, if gender or gender changes are not identifiable, if animals are asexual, parthenogenetic, hermaphroditic, haploid, or polyploid, or if they have complex life cycles (e.g., neotony, metamorphosis, diapause). Not only must we be able to determine and record into what group an animal fits, but also to decide if it is obligatively or facultatively in that group.

Several hours at the end of the workshop were reserved for Sue to lead the group through a modified Joint Application Development (JAD) session to determine how groups would fit into the new international database and what the system requirements would be. Extensive information on the project is available at <http://www.zims.org>.

Following Sue, there were presentations from representatives from two AZA aquariums that are in the process of developing new record keeping systems. Because the current software does not have the ability to handle groups its use for aquariums is severely limited. Because of this, aquariums have helped lead the charge to develop new software that meets the needs of all taxonomic groups.

Matt Gies, from Shedd Aquarium, spoke first about the Animal Information Management System (AIMS). AIMS is a cooperative effort, with input from Shedd, New England Aquarium, and National Aquarium in Baltimore. The goal of the system is to record information that will allow individuals to search and subsequently analyze recent or long-term institutional animal histories in association with environmental monitoring, animal health, husbandry, training, research and science activities within a specific enclosure. The National Aquarium in Baltimore has gone on to work on a new system called Tracks, but continues to work in close association with the AIMS development group. James Williamson demonstrated Tracks (Attachment L), a database that is a collaborative development project between the National Aquarium in Baltimore and Denver Zoological Gardens. In Tracks, the following can be tracked for groups: Acquisition/disposition information, birth information, life stage information, rearing information, sex information, parent information, identifier information, census data, location information, and notes. Very importantly, Tracks has the ability to merge and split groups as well as track two groups in the same enclosure, things that will be necessary for genetic management.

Sue Dubois led the group through last discussion of the meeting, which was aimed at trying to determine what the system requirements would be for groups in a new information management system. The results of that discussion are summarized in Attachment M. Most important, these results are part of the beginning of the development of groups capabilities in ZIMS and will enable zoos and aquariums to begin collecting and analyzing data on groups.

The meeting closed with discussions of plans for the future. It was decided that periodic group population management workshops were necessary to bring together people who are interested in the topic to generate discussions and new ideas and to serve as the impetus for new research. The workshop participants decided that it might be necessary to form an official AZA Scientific Advisory Group (SAG) called the Groups Advisory Group and are currently exploring the feasibility of the new SAG.