Analysis and Breeding Recommendations

Toco Toucan

Ramphastos toco

Population Management Plan

POPULATION MANAGER/ Regional Studbook Keeper

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This report was prepared with assistance from the

American Zoo and Aquarium Association Population Management Center In Chicago

Executive Summary

Population Management Plan for Toco Toucan

The Piciformes TAG has set a target population size for toco toucans at 85 specimens. This is the second management plan for this species, following the first in 2001.

When gene diversity falls below 90% of that in the founding population, it is expected that reproduction will be increasingly compromised by, among other factors, lower birth weights, smaller litter sizes, and greater neonatal mortality. The current population structure allows maintenance of gene diversity above 90% (of that present in the wild population) for approximately 1year. Careful breeding resulting in equalization of founder representation and recruitment of existing potential founders, increasing the population growth rate, and improving the N_e/N ratio all could extend the time to 90%. This population, given its current size, number of unrepresented founders, and availability of new founders, has the foundation for meeting standardized genetic goals for captive populations under population management. Without management, projections are grim, with less than 1% gene diversity expected at 100 years from present.

DEMOGRAPHY

Current Population Size	75
Target Population Size	85
Specimens Excluded from Genetic Analyses	12
Mean Generation Time (years)	10.3
Projected Population Growth Rate (lambda)	0.9

GENETICS

	Current	***Potential***
Current Gene Diversity (% of Wild)	91.73	98.12
Founder Genome Equivalents	6.06	24.64
Number of Founders	17	13
% Pedigree Known	81.3	
Years To 90% Gene Diversity	1	
Gene Diversity at 100 Years From Present (%)	<1%	

The current population size is 75 distributed among 30 institutions; of these, 12 have been excluded from the genetic analyses because they come from unknown pedigrees. The known pedigree population of known pedigreed specimens can be grown to the TAG recommended target size in 10 years given a 1% annual growth rate while the unknown pedigreed portion of the population is phased out by attrition.

Of great concern to this population are the large number of unrepresented potential founders many of which are aged, the low N_e/N ratio, and the lack of population growth attributed to captive propagation relative to that from private sector acquisitions. It is crucial to the long-term management of this population that these concerns be addressed.

As with SSP populations, pairings recommended for this population are prioritized to maintain or increase gene diversity through considerations of mean kinship, avoidance of inbreeding, differences in sire and dam mean kinships, and the degree of uncertainty within a pedigree.

Summary Actions 2001-2002: The PMP will have no exportations, no importations of potential founders. Approximately 8 offspring are recommended for year 2003. Specific pairings have not been recommended in the PMP. **MateRx** Mate Suitability Indices are provided to assist participating institutions in establishing appropriate pairings.

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Description of Population Status

Introduction: Records indicate toco toucans first appeared in North American zoos as early as 1902 but were not commonly held until the 1960's. It was not until the mid-1970s that captive breeding became a source of captive specimens. Captive propagation of this species is still uncommon, and importation has become much more difficult since it was listed on CITES Appendix II. To further complicate genetic management, specimens frequently arrive in zoos from the private sector with unknown pedigrees.

Genetic and demographic analyses of the population were performed in October 2002 resulting in the current Population Management Plan for the AZA North American toco toucan population. Recommendations contained in this Population Management Plan represent the results of these analyses and superceed recommendations made in earlier plans. Population Management Plan analyses were performed on the North American Regional Toco Toucan Studbook (current to 1 August 2002) using SPARKS 1.5 and PM2000 1.17. The goal of these recommendations is to help insure the genetic and demographic health of this population. Recommendations proposed in a Population Management Plan are non-binding; participation is voluntary.

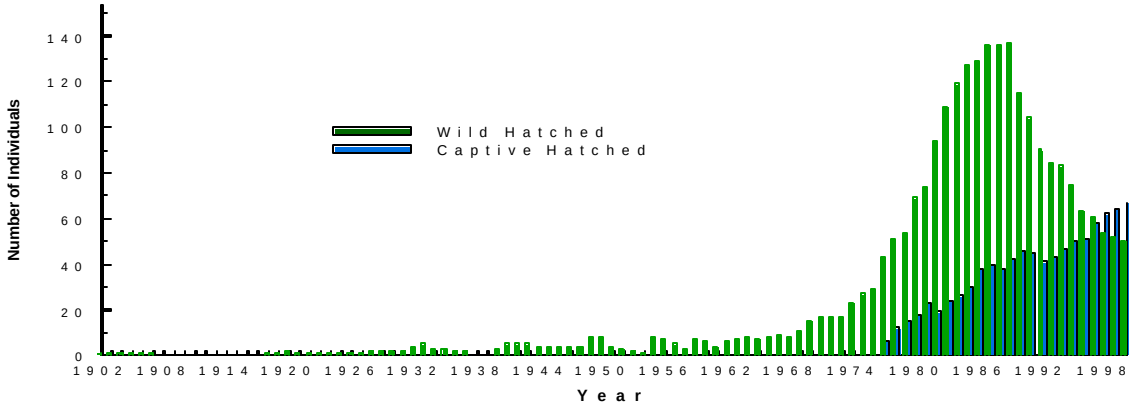

Figure 1. Population census of toco toucans in AZA zoos illustrating the reliance of the AZA population on wild caught specimens.

Managed Population: The current population is 75 distributed among 30 AZA institutions. Twelve animals were excluded from the managed population due to unknown pedigrees of 50% or greater. Where possible, assumptions were incorporated into the pedigree to include a greater number of individuals. The managed population that remains after these exclusions is 63. The target population (TAG RCP under review) size for toco toucan is 85. No exclusions were made for health or behavioral reasons. Individuals excluded from the managed (known pedigree) population as well as assumptions are listed in Appendix A.

Demography: Population growth still relies heavily on acquisitions from the private sector and many of those birds entering the AZA population are of unknown pedigree or may be wild caught. While occasional additions of wild caught specimens would benefit the population, those animals coming from private sources often have little documentation to support founder status. The captive population would derive greater benefit from successful propagation within the managed population than it would from a continued influx of unknown pedigree animals.

Population annual growth rates attributed to captive propagation within AZA institutions have varied greatly from year to year (annual range = 0.76 – 2.20) but the population has exhibited an overall trend of increase with a mean annual growth rate of 1.09 (Figure 1). The known pedigree population (n= 63) currently is below the target population size of 85 specimens,

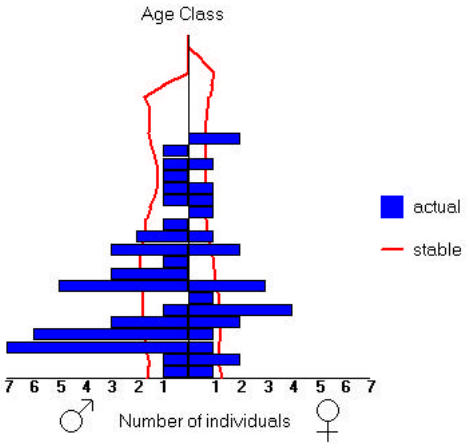

Figure 2. Age structure of known pedigree toco toucans in AZA zoos.

while the total population (including unknown pedigree animals) approaches the target size. Those animals of unknown pedigrees should be phased out of the population by attrition, while the known pedigree portion of the population should be grown to the target size. Given an annual growth rate of 1% the population could be grown to 85 specimens in 10 years. A 1% growth rate should be easily surpassed given the 10% mean growth rate observed over the past five years.

The age distribution approximates a stable distribution though it is columnar rather than pyramidal indicating a possible slowing of growth rates in the short-term future as few animals are entering the reproductive classes relative to the total population size. The age distribution also illustrates a male-biased sex ratio indicating a female-limited population growth (Figure 2). Captive toco toucans have lived until the age of 21 years but have failed to reproduce beyond the age of 17 years with the exception of a single male specimen that reproduced at 20 years of age. It is unknown whether other animals in the older age classes failed to reproduce due to reproductive senescence or lack of reproductive opportunity. Both males and females are reproductive at the age of about two years.

Genetics: The managed population is descended from 17 founders, with 13 potential founders remaining in the living population. Many of these potential founders, however, are of advanced age and it is unlikely that they will be recruited. Genetic diversity in the population is moderate relative to many other managed populations (91.73%), but the potential gene diversity remains high (98.12%).

Genetic Summary

	Living Descendants	Potential
Founder Genome Equivalents	6.05	26.60
Gene Diversity Retained (%)	91.73	98.12
Population Mean Kinship	.0807	
Mean Inbreeding	0.0495	
% Pedigree Known	81.3	

Gene diversity is likely to remain above 90% for less than 1 year. Long-term projections of gene diversity indicate less than 1% gene diversity at 100 years from present. Careful breeding targeted at the equalization of founder representation and recruitment of potential founders (Figure 3) will extend the time to 90% gene diversity. This level of gene diversity could be maintained for an estimated 6 years by recruiting existing potential founders. The recruitment of these potential founders combined with an increase in the population growth rate to 5% per annum (to a target size of 85) would extend time to 90% beyond 12 years.

Improving the N_e/N ratio (currently 0.17) of the population also could extend time to 90%, in addition to the above improvements, to beyond 25 years. Presently only 10 animals in the population have living offspring. A concerted effort to recruit breeders would likely improve the effective population size. Recruiting an additional 8 breeders would raise the N_e/N ratio to 0.30 (a value considered typical of managed populations) given the current population size.

Additionally, time to 90% gene diversity may be extended beyond 40 years given 2 additional founders (including the recruitment of additional potential founders) at approximately 10-year intervals beginning 10 years from present. Incorporating all of these improvements into toco toucan management could result in maintenance of more than 85% gene diversity at 100 years from present. Pairings have been determined with consideration of mean kinship, population change in gene diversity, maximum avoidance of inbreeding and the needs of individual institutions.

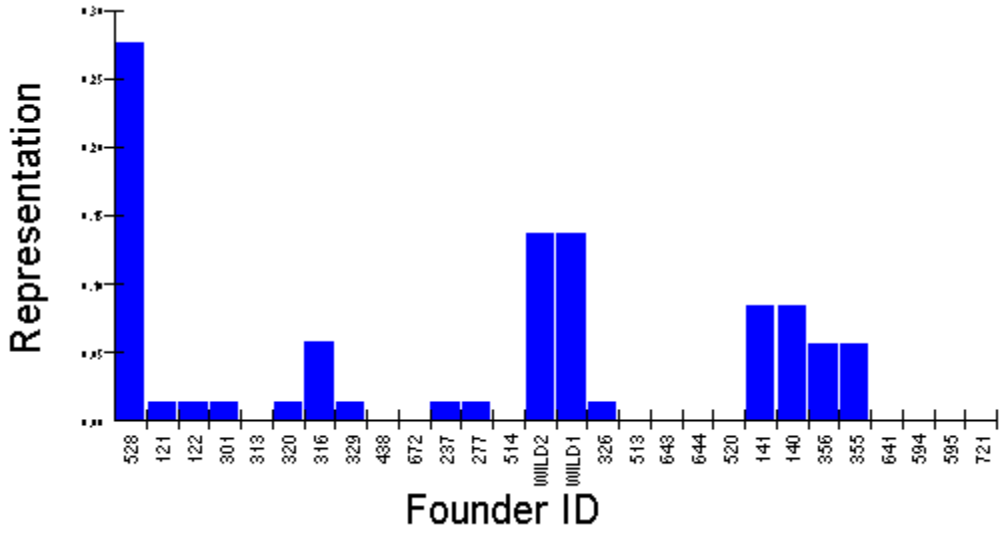

Figure 3. Founder representation in North American toco toucan illustrating the large number of unrepresented founders and inequality of founder representation.

Management Strategy: It is recommended that the population grow to the target size of 85 specimens at a rate of at least 1% per year. This will require 8 hatches in the coming year. In an effort to increase the effective population size (N_e) it is recommended that a concerted effort be made to recruit existing potential founders. It is also recommended that institutions consider the impact of adding unknown origin specimens to the population when acquiring specimens. To help achieve this goal, breeding recommendations have been provided in the form of a matrix that ranks all possible breeding combinations within the analytical population (sterile and unknown pedigree animals excluded) using software. A **MateR$_x$** matrix prioritizes pairs using a Mate Suitability Index (MSI). Participants with several animals are encouraged to use **MateR$_x$** to guide pairings within their institutions. *Whenever possible, managers should encourage pairings with MSIs of 1, 2, or 3 and discourage pairings of 5, 6, or "---". At the present time, pairings with MSIs of 4 are neither encouraged nor discouraged.* For more information on **MateR$_x$**, see below.

1. Recommend 8 offspring per year from pairs rating 1, 2, or 3 on **MateR$_x$**.
2. Grow the known pedigree population size to 85 specimens.
3. Make a concerted effort to determine parentage of unknown pedigree specimens.

Recommendations Using MateR$_x$

MateR$_x$ is analytical software developed jointly by the National Zoological Park and Lincoln Park Zoo. The primary output is a matrix of genetic ratings (Mate Suitability Indices = MSI) for every possible breeding pair in a population. MSIs allow managers to quickly discover how the genetic status of specimens in their collections compare to the rest of a managed population.

Each MSI represents the genetic consequences for the population if a given pair were to produce offspring. There are seven values for MSIs: offspring of pairs rated 1, 2, or 3 would benefit the population's genetic situation; pairs rated 4, 5, or 6 would be detrimental to the population's genetic situation. Pairs without an MSI value (i.e., a dash [--]) should not be considered under any circumstances without consulting an SPMAG advisor. These MSI values are defined as:

1 – very beneficial
2 – moderately beneficial
3 – slightly beneficial
4 – slightly detrimental
5 – moderately detrimental
6 – very detrimental

MateR$_x$ integrates four genetic factors to produce the Mate Suitability Index (MSI). These four components are currently used by SPMAG members to develop pairing recommendations for SSPs and PMPs. In decreasing order of "importance," they are:

1. the expected change in genetic diversity (increase, decrease) that would result if an offspring of a pair is added to the population;
2. the relative rareness or commonness of the parents genetic information (i.e., the relative dissimilarity of parental mean kinships);
3. the inbreeding coefficient of offspring that would be produced by a pair; and
4. the proportion, if any, of the dam and/or sire's pedigree that is of unknown origin.

Each **MateR$_x$** MSI value represents a continuous range of rankings which SPMAG advisors can use to fine tune recommendations for the maximum possible genetic benefits to a population.

Questions about the interpretation of **MateR$_x$** output should be directed to either Joanne Earnhardt at Lincoln Park Zoo or Jon Ballou at the National Zoological Park.

MateRx Matrix

Males		Females	637	615	207	485	514	609	618	528	719	652	672	688	708	706	622	607	595	320	458	610	741	472	643	641	668	465	742	744	526	613
			ALEXANDRI	AUDUBON	AURORA	CAPE MAY	CHICAGOBR	CHICAGOLP	COLUMBIA	COLUMBIA	COLUMBIA	DALLAS WA	FRESNO	GLEN OAK	HONOLULU	HONOLULU	HOUSTON	NZP-WASH	OMAHA	ORLANDO	PHOENIX	PHOENIX	PITTS CA	S BARBARA	SAN ANTON	SAN ANTON	SANDIEGOZ	ST AUG GA	ST AUG GA	ST AUG GA	TULSA	WINNIPEG
373	ALEXANDRI		6	2	1	-	1	1	3	4	4	-	1	1	-	-	4	3	1	1	2	-	4	2	1	1	6	-	6	6	3	1
301	AUDUBON		6	3	1	-	1	1	4	4	6	-	1	1	-	-	6	4	1	1	3	-	4	2	1	1	6	-	6	6	3	1
711	CAMDEN		4	-	2	-	3	1	3	4	4	-	3	1	-	-	4	3	3	2	2	-	4	-	3	3	4	-	5	5	2	3
316	CAPE MAY		4	2	1	-	1	1	3	4	4	-	1	1	-	-	-	3	1	1	2	-	4	1	1	1	4	-	6	6	-	1
529	CHICAGOLP		-	2	2	-	4	2	4	-	5	-	4	2	-	-	-	2	4	3	2	-	4	2	4	4	-	-	5	5	-	4
619	COLUMBIA		-	4	6	-	6	6	5	-	-	-	6	6	-	-	-	4	6	6	4	-	6	6	6	6	-	-	6	6	-	6
527	COLUMBIA		-	4	3	-	6	3	4	5	-	-	6	3	-	-	-	4	6	4	4	-	-	4	6	6	-	-	-	-	4	6
714	COLUMBIA		-	4	4	-	6	4	4	-	-	-	6	4	-	-	-	4	6	6	4	-	6	4	6	6	-	-	6	6	-	6
715	COLUMBIA		-	4	4	-	6	4	4	-	-	-	6	4	-	-	-	4	6	6	4	-	6	4	6	6	-	-	6	6	-	6
717	COLUMBIA		-	4	4	-	6	3	-	-	-	-	6	3	-	-	6	-	6	4	-	-	-	4	6	6	-	-	-	-	5	6
718	COLUMBIA		-	4	4	-	6	3	-	-	-	-	6	3	-	-	6	-	6	4	-	-	-	4	6	6	-	-	-	-	5	6
695	DALLAS WA		6	4	3	-	4	3	-	5	-	-	4	3	-	-	-	-	4	4	-	-	-	4	4	4	6	-	-	-	4	4
651	DALLAS WA		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
721	FRESNO		6	3	1	-	1	2	4	6	6	-	1	2	-	-	6	4	1	1	4	-	6	2	1	1	6	-	6	6	4	1
664	GLEN OAK		-	4	4	-	6	4	4	-	-	-	6	4	-	-	-	4	6	6	4	-	6	4	6	6	-	-	6	6	-	6
661	GREENVISC		-	4	4	-	6	4	4	-	-	-	6	4	-	-	-	4	6	6	4	-	6	4	6	6	-	-	6	6	-	6
587	HOUSTON		5	2	3	-	4	3	-	4	-	-	4	3	-	-	5	-	4	3	-	-	-	3	4	4	5	-	-	-	4	4
726	KNOXVILLE		4	-	2	-	3	1	3	4	4	-	3	1	-	-	4	3	3	2	2	-	4	-	3	3	4	-	5	5	2	3
532	LUFKIN		4	1	1	-	2	-	3	3	4	-	2	-	-	-	4	3	2	1	2	-	3	1	2	2	4	-	6	6	2	2
513	MEMPHIS		6	3	1	-	1	2	4	6	6	-	1	2	-	-	6	4	1	1	4	-	6	2	1	1	6	-	6	6	4	1
606	MEMPHIS		-	3	3	-	4	3	4	-	6	-	4	3	-	-	-	4	4	3	4	-	-	3	4	4	-	-	-	-	-	4
663	MINNESOTA		-	4	4	-	6	4	4	-	-	-	6	4	-	-	-	4	6	6	4	-	6	4	6	6	-	-	6	6	-	6
471	NZP-WASH		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
634	NZP-WASH		-	4	4	-	6	4	4	-	-	-	6	4	-	-	-	4	6	6	4	-	6	4	6	6	-	-	6	6	-	6
594	OMAHA		6	3	1	-	1	2	4	6	6	-	1	2	-	-	6	4	1	1	4	-	6	2	1	1	6	-	6	6	4	1
572	OMAHA		4	1	1	-	2	-	3	3	4	-	2	-	-	-	4	3	2	1	2	-	3	1	2	2	4	-	6	6	2	2
453	ORLANDO		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
329	ORLANDO		6	3	1	-	1	1	4	4	6	-	1	1	-	-	6	4	1	1	3	-	4	2	1	1	6	-	6	6	3	1
627	PHOENIX		-	4	4	-	6	4	4	-	-	-	6	4	-	-	-	4	6	6	4	-	6	4	6	6	-	-	6	6	-	6
533	PHOENIX		6	2	1	-	1	1	3	4	4	-	1	1	-	-	4	3	1	-	2	-	4	2	1	1	6	-	6	6	3	1
530	PITTS CA		4	2	3	-	4	3	-	4	-	-	4	3	-	-	4	-	4	3	-	-	-	3	4	4	4	-	-	-	2	4
313	QUEBEC		6	3	1	-	1	2	4	6	6	-	1	2	-	-	6	4	1	1	4	-	6	2	1	1	6	-	6	6	4	1
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473	S BARBARA		4	-	1	-	2	1	3	4	4	-	2	1	-	-	4	3	2	2	2	-	4	-	2	2	4	-	6	6	3	2
644	SAN ANTON		6	3	1	-	1	2	4	6	6	-	1	2	-	-	6	4	1	1	4	-	6	2	1	1	6	-	6	6	4	1
324	SAN ANTON		6	2	1	-	1	1	3	4	4	-	1	1	-	-	4	3	1	1	2	-	4	2	1	1	6	-	6	6	3	1
520	ST AUG GA		6	3	1	-	1	2	4	6	6	-	1	2	-	-	6	4	1	1	4	-	6	2	1	1	6	-	6	6	4	1
696	ST AUG GA		6	4	6	-	6	6	-	5	-	-	6	6	-	-	-	-	6	6	-	-	-	4	6	6	6	-	-	-	5	6
743	ST AUG GA		6	5	6	-	6	6	-	5	-	-	6	6	-	-	-	-	6	6	-	-	-	6	6	6	6	-	-	-	5	6
705	TULSA		4	2	3	-	4	3	-	4	-	-	4	3	-	-	4	-	4	3	-	-	-	3	4	4	4	-	-	-	2	4
612	WINNIPEG		6	3	1	-	1	2	4	6	6	-	1	2	-	-	6	4	1	1	4	-	6	2	1	1	6	-	6	6	4	1

Appendix A
Exclusions and Assumptions

Pedigree 50% or more Unknown: 453; 465; 471; 485; 610; 651; 652; 706; 708; 742; 743; 744

Assumptions: 527 – change parentage to Wild x Wild

Appendix B
Life Table

Males

AgeX	Px	lx	Mx	Vx	Ex	RiskQx	RiskMx
0	0.710	1.000	0.000	1.170	6.671	86.900	64.800
1	0.900	0.710	0.000	1.279	7.189	91.800	86.400
2	0.900	0.639	0.060	1.227	6.877	120.800	113.400
3	0.890	0.575	0.050	1.124	6.564	127.300	119.000
4	0.920	0.512	0.080	1.025	6.154	119.700	114.600
5	0.840	0.471	0.060	0.925	5.846	114.000	103.700
6	0.900	0.396	0.110	0.861	5.587	95.600	90.300
7	0.810	0.356	0.180	0.756	5.350	88.600	81.200
8	0.900	0.288	0.180	0.584	5.116	71.900	67.500
9	0.950	0.260	0.090	0.378	4.456	65.900	64.900
10	0.810	0.247	0.080	0.281	3.919	63.100	57.700
11	0.790	0.200	0.020	0.217	3.644	48.700	44.000
12	0.800	0.158	0.000	0.214	3.328	37.500	33.400
13	0.770	0.126	0.000	0.235	2.960	28.500	25.000
14	0.600	0.097	0.000	0.291	2.816	20.000	16.000
15	0.460	0.058	0.000	0.459	3.316	11.000	6.900
16	0.680	0.027	0.000	0.748	4.376	3.200	2.200
17	1.000	0.018	0.290	0.797	4.170	1.700	1.700
18	1.000	0.018	0.000	0.437	3.170	1.500	1.500
19	1.000	0.018	0.000	0.377	2.170	1.500	1.500
20	0.670	0.018	0.390	0.390	1.401	1.500	1.300
21	0.000	0.012	0.000	0.000	1.000	1.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000

r = -0.1475
lambda = 0.8629
T = 10.15
N = 33.50
N(at 20 yrs) = 1.75

Females

AgeX	Px	lx	Mx	Vx	Ex	RiskQx	RiskMx
0	0.700	1.000	0.000	1.176	6.154	84.500	62.700
1	0.930	0.700	0.000	1.287	6.486	99.500	95.200
2	0.860	0.651	0.060	1.249	6.120	141.300	130.800
3	0.930	0.560	0.060	1.159	5.738	137.700	132.800
4	0.860	0.521	0.100	1.066	5.286	128.600	121.500
5	0.870	0.448	0.070	0.972	4.958	113.800	106.600
6	0.870	0.390	0.110	0.902	4.549	101.400	93.900
7	0.790	0.339	0.140	0.827	4.261	92.600	81.900
8	0.760	0.268	0.120	0.769	4.199	75.400	66.900
9	0.840	0.203	0.070	0.710	4.026	57.500	52.200
10	0.770	0.171	0.070	0.689	3.745	48.800	41.700
11	0.740	0.132	0.090	0.711	3.626	38.100	32.900
12	0.720	0.097	0.040	0.739	3.590	26.600	24.300
13	0.820	0.070	0.060	0.798	3.400	19.000	18.000
14	0.590	0.058	0.170	0.895	3.350	14.800	11.500
15	0.880	0.034	0.460	0.904	3.369	8.000	7.600
16	0.850	0.030	0.230	0.446	2.735	6.500	6.400
17	0.780	0.025	0.230	0.230	2.122	4.500	4.400
18	0.390	0.020	0.000	0.000	1.842	1.600	1.000
19	1.000	0.008	0.000	0.000	1.500	0.500	0.500
20	0.000	0.008	0.000	0.000	1.000	0.500	0.300
21	0.000	0.000	0.000	0.000	0.000	0.000	0.000
22	0.000	0.000	0.000	0.000	0.000	0.000	0.000
23	0.000	0.000	0.000	0.000	0.000	0.000	0.000

r = -0.1396
lambda = 0.8697
T = 10.46
N = 20.50
N(at 20 yrs) = 1.26

Appendix B
Ordered Mean Kinship

Males

SB#	MK	%Known	Age	Location
313	0.000	100.0	17	QUEBEC
513	0.000	100.0	11	MEMPHIS
520	0.000	100.0	10	ST AUG GA
594	0.000	100.0	7	OMAHA
612	0.000	100.0	10	WINNIPEG
644	0.000	100.0	11	SAN ANTON
721	0.000	100.0	3	FRESNO
301	0.006	100.0	18	AUDUBON
329	0.006	100.0	15	ORLANDO
324	0.011	100.0	14	SAN ANTON
373	0.011	100.0	12	ALEXANDRI
533	0.011	100.0	7	PHOENIX
316	0.021	100.0	16	CAPE MAY
532	0.028	100.0	7	LUFKIN
572	0.028	100.0	9	OMAHA
473	0.051	100.0	10	S BARBARA
711	0.057	100.0	3	CAMDEN
713	0.057	100.0	3	RIO GRAND
726	0.057	100.0	2	KNOXVILLE
529	0.071	100.0	8	CHICAGOLP
530	0.080	100.0	7	PITTS CA
705	0.080	100.0	8	TULSA
587	0.088	100.0	7	HOUSTON
606	0.097	100.0	5	MEMPHIS
695	0.102	100.0	2	DALLAS WA
696	0.102	100.0	2	ST AUG GA
527	0.108	100.0	8	COLUMBIA
717	0.110	100.0	2	COLUMBIA
718	0.110	100.0	2	COLUMBIA
627	0.114	100.0	4	PHOENIX
634	0.114	100.0	3	NZP-WASH
661	0.114	100.0	3	GREENVISC
663	0.114	100.0	4	MINNESOTA
664	0.114	100.0	3	GLEN OAK
714	0.114	100.0	2	COLUMBIA
715	0.114	100.0	2	COLUMBIA
739	0.114	100.0	0	COLUMBIA
619	0.123	100.0	4	COLUMBIA

Females

SB#	MK	%Known	Age	Location
514	0.000	100.0	14	CHICAGOBR
595	0.000	100.0	7	OMAHA
613	0.000	100.0	10	WINNIPEG
641	0.000	100.0	7	SAN ANTON
643	0.000	100.0	11	SAN ANTON
672	0.000	100.0	15	FRESNO
320	0.006	100.0	17	ORLANDO
207	0.011	100.0	19	AURORA
609	0.028	100.0	5	CHICAGOLP
688	0.028	100.0	4	GLEN OAK
472	0.051	100.0	10	S BARBARA
458	0.057	100.0	13	PHOENIX
615	0.057	100.0	5	AUDUBON
526	0.071	100.0	7	TULSA
607	0.080	100.0	6	NZP-WASH
618	0.088	100.0	5	COLUMBIA
741	0.102	100.0	1	PITTS CA
622	0.106	100.0	5	HOUSTON
528	0.109	100.0	19	COLUMBIA
719	0.110	100.0	2	COLUMBIA
637	0.114	100.0	4	ALEXANDRI
668	0.114	100.0	3	SANDIEGOZ
736	0.114	100.0	1	COLUMBIA
737	0.114	100.0	1	COLUMBIA
738	0.114	100.0	0	COLUMBIA

Appendix C
Summary of Data Exports

Report compiled under SPARKS V. 1.5 & Population Management 2000, V. 1.15

Data exported on: 28 October 2002
Data compiled by: Bob Seibels
Data current thru: 1 August 2002

Filter Conditions In Effect:

Genetics: Locations: N.AMERICA/Association: AZA/Dates: As of End of date <= 28/10/2002 / Status: Living by 28/10/ 2002

Demography : Locations: N.AMERICA//Association: AZA/ Dates: During 01/01/1977 <= date .and. date <= 28/10/2002

Appendix D
Definitions

Management Terms

SSP Complete Analysis and Breeding and Transfer Plan - The document resulting from a Master planning Session and a 30 day comment period of a draft plan providing breeding and transfer recommendations for a Species Survival Plan. Full Participation is required of all AZA member institutions. MOPs are required of all AZA non-member institutions.

Full Participation - AZA policy stating that AZA member institutions proclaim a level of participation (Breeding, Holding, Support) to each SSP in which the institution participates, and that AZA member institutions implement the SSP Complete Analysis and Breeding Plan once the institution has been given the opportunity to respond to a draft plan. Further explanation can be found in the AZA Resource Center at www.aza.org.

MOP, Memorandum of Participation - A document to be secured by each SSP Coordinator from every AZA non-member institution participating in the SSP. This document ensures that the SSP Complete Analysis and Breeding Plan will be implemented by the non-member institution. Further explanation can be found in the AZA Resource Center at www.aza.org.

PMP Complete Analysis and Breeding and Transfer Recommendations – The document resulting from a Master planning Session and a 30 day comment period of a draft plan providing breeding and transfer recommendations for a Population Management Plan. Full Participation is NOT required of all AZA member institutions; participation is voluntary. MOPs are NOT required of all AZA non-member institutions. Recommendations involving non-AZA institutions do not imply endorsement of the non-member by the AZA or the SPMAG Advisor.

Demographic Terms

Age Distribution -- A two-way classification showing the numbers or percentages of individuals in various age and sex classes.

Population Growth Rate (Lambda, ?) -- The proportional change in population size from one year to the next. Lambda can be based on life-table calculations (the expected lambda) or from observed changes in population size from year to year. A lambda of 1.11 means a 11% per year increase; lambda of .97 means a 3% decline in size per year.

Px, Age-Specific Survival – The probability that an individual of age *x* survives one time period; is conditional on an individual being alive at the beginning of the time period. Alternatively, the proportion of individuals which survive from the beginning of one age class to the next.

Qx, Mortality – Probability that an individual of age *x* dies during time period. Qx = 1-Px
The proportion of individuals that die during an age class. It is calculated from the number of animals that die during an age class divided by the number of animals that were alive at the beginning of the age class (i.e.-"at risk").

lx, Age-Specific Survivorship – The probability that a new individual (eg., age 0) is alive at the *beginning* of age *x*. Alternatively, the proportion of individuals which survive from birth to the beginning of a specific age class.

Mx, **Fecundity** – The average number of same-sexed young born to animals in that age class. Because SPARKS is typically using relatively small sample sizes, SPARKS calculates Mx as 1/2 the average number of young born to animals in that age class. This provides a somewhat less "noisy" estimate of Mx, though it does not allow for unusual sex ratios. The fecundity rates provide information on the age of first, last, and maximum reproduction.

Vx, **Reproductive Value** – The expected number of offspring produced this year and in future years by an animal of age x.

Ex, Life Expectancy – Average years of further life for an animal in age class x.

Risk (Qx or Mx) – The number of individuals that have lived during an age class. The number at risk is used to calculate Mx and Qx by dividing the number of births and deaths that occurred during an age class by the number of animals at risk of dying and reproducing during that age class.

Genetic Terms

Current Gene Diversity (GD) -- The proportional gene diversity (as a proportion of the source population) is the probability that two alleles from the same locus sampled at random from the population will be identical by descent. Gene diversity is calculated from allele frequencies, and is the heterozygosity expected in progeny produced by random mating, and if the population were in Hardy-Weinberg equilibrium.

Effective Population Size (Inbreeding N_e) -- The size of a randomly mating population of constant size with equal sex ratio and a Poisson distribution of family sizes that would (a) result in the same mean rate of inbreeding as that observed in the population, or (b) would result in the same rate of random change in gene frequencies (genetic drift) as observed in the population. These two definitions are identical only if the population is demographically stable (because the rate of inbreeding depends on the distribution of alleles in the parental generation, whereas the rate of gene frequency drift is measured in the current generation).

Founder – An individual obtained from a source population (often the wild) that has no known relationship to any individuals in the derived population (except for its own descendants).

Founder Genome Equivalents (FGE) – The number wild-caught individuals (founders) that would produce the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Founder Genome Surviving – The sum of allelic retentions of the individual founders (i.e, the product of the mean allelic retention and the number of founders).

Founder Representation -- Proportion of the genes in the living, descendant population that are derived from that founder. I.e., proportional Founder Contribution.

Founder Contribution -- Number of copies of a founder's genome that are present in the living descendants. Each offspring contributes 0.5, each grand-offspring contributes 0.25, etc.

Inbreeding Coefficient (F) -- Probability that the two alleles at a genetic locus are identical by descent from an ancestor common to both parents. The mean inbreeding coefficient of a population will be the proportional decrease in observed heterozygosity relative to the expected heterozygosity of the founder population.

Mean Generation Time (T) -- The average time elapsing from reproduction in one generation to the time the next generation reproduces. Also, the average age at which a female (or male) produces offspring. It is not the age of first reproduction. Males and females often have different generation times.

Mean Kinship (MK) -- The mean kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. The mean kinship of a population is equal to the proportional loss of gene diversity of the descendant (captive-born) population relative to the founders and is also the mean inbreeding coefficient of progeny produced by random mating. Mean kinship is also the reciprocal of two times the founder genome equivalents: MK = 1 / (2 * FGE). MK = 1 - GD.

Percent Known -- Percent of an animal's genome that is traceable to known Founders. Thus, if an animal has an UNK sire, the % Known = 50. If it has an UNK grandparent, % Known = 75.

KV, Kinship Value – The weighted mean kinship of an animal, with the weights being the reproductive values of each of the kin. The mean kinship value of a population predicts the loss of gene diversity expected in the subsequent generation if all animals were to mate randomly and all were to produce the numbers of offspring expected for animals of their age.

GU, Genome Uniqueness – Probability that an allele sampled at random from an individual is not present, identical by descent, in any other living individual in the population. GU-all is the genome uniqueness relative to the entire population. GU-Desc is the genome uniqueness relative to the living non-founder, descendants.

Prob Lost – Probability that a random allele from the individual will be lost from the population in the next generation, because neither this individual nor any of its relatives pass on the allele to an offspring. Assumes that each individual wil produce a number of future offspring equal to its reproductive value, Vx.

FOKE, First Order Kin Equivalents – The number of first-order kin (siblings or offspring) that would contain the number of copies of an individuals alleles (identical by descent) as are present in the captive-born population. Thus an offspring or sib contributes 1 to FOKE; each grand-offspring contributes 1/2 to FOKE; each cousin contributes 1/4 to FOKE. FOKE = 4*N*MK, in which N is the number of living animals in the captive population.

Allele Retention – The probability that a gene present in a founder individual exists in the living, descendant population.

Appendix E
Directory of Institutional Representatives

Contact	Institution	Address	City, State Zip Code
Dale Thompson	Roeding Park Zoo	894 W Belmont Ave.	Fresno, CA 93728-2891
Kevin Wright	Phoenix Zoo	455 N Galvin Pky	Phoenix, AZ 85008-3431
Alan Varsik	Santa Barbara Zoo	500 Ninos Dr.	Santa Barbara, CA 93103-3798
Gail Worth	Aves International	PO Box 2863	Rancho Palos Verdes, CA 90274
Jerry Jennings	Emerald Forest Bird Farm	Rt 6, Box 14	Fallbrook, CA 92028
Sherry Branch	Sea World of Florida, Inc.	7007 Sea World Dr.	Orlando, FL 32821-8097
Amanda Whittaker	St. Augustine Alligator Farm	P.O. Box 9005	St Augustine, FL 32085-9005
Linda Santos	Honolulu Zoo	151 Kapahulu Ave.	Honolulu, HI 96815-7173
Megan Ross	Lincoln Park Zoo	2001 N. Clark St.	Chicago, IL 60614
Dawn Petefish	Glen Oak Zoo	2218 N Prospect Rd.	Peoria, IL 61603-2193
Leslie Whitt	Alexandria Zoo	P.O. Box 71	Alexandria, LA 71301-4240
Mark Myers	Audubon Park Zoo	P.O. Box 4327	New Orleans, LA 70178-4327
Jim Pichner	Minnesota Zoo	13000 Zoo Blvd.	Apple Valley, MN 55124-8199
Steve Martin	S. Martin Natural Encounters	9014 Thompson Nursery Rd.	Lake Wales, FL 33853
Dan Cassidy	Henry Doorly Zoo	3701 S 10th St.	Omaha, NE 68107-2200
Bill Aragon	Rio Grande Zoo	903 Tenth St. SW	Albuquerque, NM 87102-4098
Diane Fell	Tulsa Zoo	5701 E 36th St. N	Tulsa, OK 74115
James Majeur	National Aviary in Pittsburg	Allegheny Commons West	Pittsburgh, PA 15212
Robert Wilson	Greenville Zoo	150 Cleveland Park Dr.	Greenville, SC 29601
Herb Roberts	Memphis Zoo	2000 Galloway Ave.	Memphis, TN 38104
Lee Schoen	Houston Zoo	1513 N MacGregor	Houston, TX 77030
Celia Falzone	Ellen Trout Park Zoo	402 Zoo Circle	Lufkin, TX 75904
Josef San Miguel	San Antonio Zoo	3903 N. St. Mary's Street	San Antonio, TX 78212-3199
Jan Raines, DVM	Dallas World Aquarium	1801 N. Griffin St.	Dallas, TX 75202
Robert Seibels	Riverbanks Zoo	PO Box 1060	Columbia, SC 29202