Population Analysis & Breeding and Transfer Plan

Hooded Vulture (*Necrosyrtes monachus*)
AZA Species Survival Plan®
Red Program

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11 October 2022

PMC Population Management Center

LINCOLN PARK ZOO.

ASSOCIATION OF ZOOS & AQUARIUMS

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Acknowledgments

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Megan Victorino, SSP Coordinator and Studbook Keeper
John Andrews, Population Advisor

Cover photo courtesy of Gen Anderson

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Description of Population Status

Species Survival Plan® for the Hooded Vulture (*Necrosyrtes monachus*)

Introduction: The current SSP population consists of 47 animals (29.18.0) birds distributed among 10 facilities. The Raptor Taxon Advisory Group has set the target population size for this population to be 50 animals (2022 Regional Collection Plan). Following recommendations in this report, two new facilities are potentially joining the Program. Under AZA's current sustainability designations, this Program qualifies as a Red SSP, however, in 2023 will continue as a monitored Program in the TAG.

Genetic and demographic analyses of the population were performed in August 2022 resulting in the current Breeding and Transfer Plan (BTP); this is the third for this population following a plan in 2019. Recommendations contained in this Plan represent the results of these analyses. Analyses were performed on the AZA Regional Hooded Vulture Studbook (current to May 2, 2022) using ZIMS for Studbook (Aug 01, 2022 Release), PopLink 2.5.2, and PMX v1.6.4.20220303. The goal of these recommendations is to help ensure the genetic and demographic health of this population. Recommendations proposed in a Red Plan are non-binding; participation is voluntary.

Analytical Assumptions and Exclusions: The pedigree for this population is 100% known and no analytical studbook was needed for analysis. Nine (6.3) birds were excluded from genetic analysis due to veterinary concerns or ambassador use (Appendix C). Following exclusions, the potentially breeding population consists of 38 birds (23.15) with 100% known pedigree.

Demography: Records for hooded vultures in zoos begin in 1974 with the importation of 2 birds by Denver Zoo (Figure 1). The first zoo hatch eventually resulted from this pair in 1982, and hatches became relatively consistent thereafter. Additional imports of birds have been sporadic through the census with up to 30 birds entering the North American population from 1983 to 2007. Most recently in 2006/7, 10 birds were imported. The number of zoo hatched birds did not exceed that of wild birds until 2004. Recent growth in this population suggests positive growth over the last 5 years ($\lambda = 1.04$) with 25 hatches and 13 deaths during that time.

Maintaining the population at its current size will require around 2 – 3 hatches annually. Hatches above this number will allow for growth toward the target size of 50 animals.

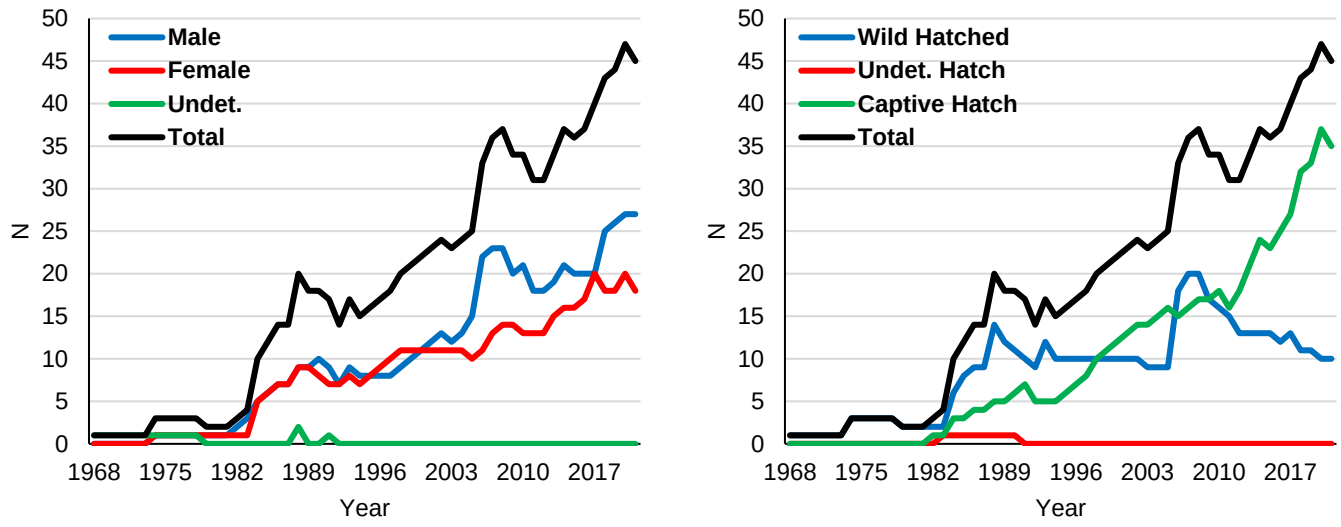

Figure 1: Census of the Hooded Vulture SSP from 1968 – 2021 by sex (left) and hatch type/origin (right).

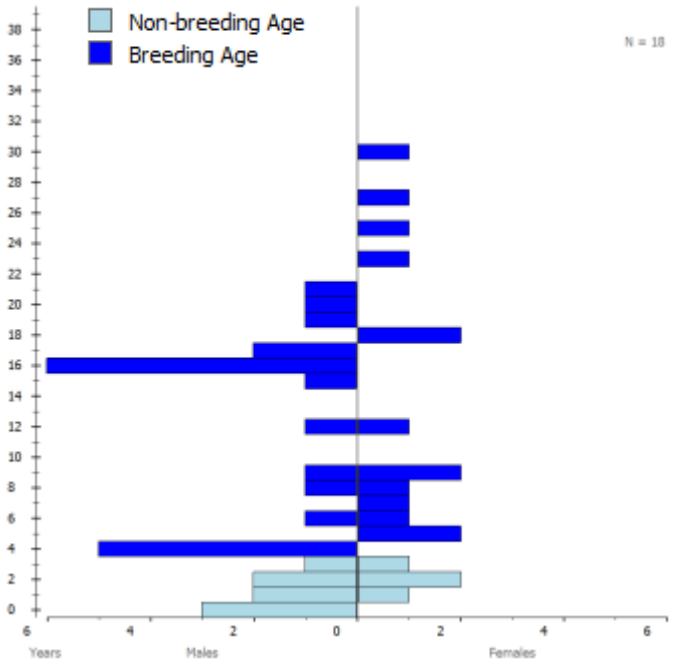

Figure 2: Age distribution of the total population in the Hooded Vulture SSP.

The age structure of the population (Figure 2) deviates from a stable one with a male-skewed sex ratio. Several empty age classes suggest inconsistent reproduction. Therefore, more concerted efforts to consistently breed the zoo population are needed to maintain and grow to the population's target size. In the last 3 years, breeding seems more consistent, and increasing breeding rates will continue to grow this population.

Table 1: *Demographic status of the Hooded Vulture SSP population, according to studbook data.*

Demography Summary		
Current size of SSP population (N) – Total (Males.Females.Unknown Sex)	47 (29.18.0)	
Number of individuals excluded from genetic analyses	9 (6.3)	
Population size following exclusions	38 (23.15)	
Target population size (Kt) from *Raptor TAG 2022* RCP	50	
Mean generation time (T, years)	15.7	
Population growth rates (λ; lambda)*: Life Table / 5-year / Projected	1.014 / 1.04 / 1.009	
Percentage (%) of living population hatched ex situ	77.8	
Survival/Mortality	**Males**	**Females**
Observed first year mortality rate (Q_x)	32.1	42
Median life expectancy (MLE), excluding first year mortalities (years) (from PopLink Survival Statistics Report (https://www.aza.org/species-survival-statistics))	N/A	N/A
Observed maximum longevity (L_x)	29 (SB#3)	36 (SB#9)
Reproduction		
Observed reproductive age range	4 - 24	4 - 30
Incubation time	52 (48 – 54)	
Mean clutch size hatched	1	

* Life table (AZA – 1990 - present); 5-year from studbook census; Projected from PMx stochastic 20-year projections

First year mortality rates, breeding ranges and longevity values reported in Table 1 may be underestimated due to small sample sizes in the life tables. The full biological potential of these values for this species may not yet be realized due to the small sample sizes and relatively short time in human care compared to longevity.

The breeding age for both sexes has been recorded as 2 to 27 years of age, but all younger breeding individuals have been wild caught; ages are likely underestimates as other large vulture species typically do not produce until 5–7 years of age. Recently, a zoo hatched pair bred at age 4 with representing a new age at first breeding record. Breeding may be more likely before 5 in rarer cases when younger birds are paired very early.

Genetics: The studbook pedigree indicates that this SSP is descended from 11 founders with 5 potential founders remaining (Table 2; Figure 3). The gene diversity of the population is 90.33%, which is equivalent to that found in 5 founders (FGE = 5.17). Typical AZA program goals include thresholds for tolerance of gene diversity loss over time; 90% gene diversity retention for 100 years is a common management goal. Decreases in gene diversity below 90% of that in the founding population have been associated with reproduction increasingly compromised by, among other factors, lower birth/hatch weights, smaller litter/clutch sizes, and greater neonatal mortality in some species.

Based on current population parameters and recent growth rate trends, gene diversity is projected to decline to 77% over the next 100 years if the current population grows to the RCP target size of 50 at its projected growth rate of 1.4%. If we model a higher target size of 75, gene diversity will decline to 80.4% in 100 years. For a long-lived vulture species, the most impactful management strategy to retain gene diversity long term is making space for a larger population via a larger target size. Allowing for increased growth rate and increasing the effective size ratio (Ne/N) will also benefit retention of diversity in the long term.

Table 2: *Genetic status and projections for the Hooded Vulture SSP population.*

Genetics Summary*			
	2019	**2023**	**Potential**
Founders	*14*	11	5
Founder genome equivalents (FGE)	*5.24*	5.17	14.12
Gene diversity (GD %)	*90.46*	90.33	96.46
Population mean kinship (MK)	*0.0954*	0.0967	--
Mean inbreeding (F)	*0.000*	0.0022	--
Effective population size relative to population size (N_e/N)	*0.1905*	0.4037	--
Percentage of pedigree known before / after assumptions and exclusions	*100 / 100*	100 / 100	--
Percentage pedigree certain after assumptions and exclusions	*100*	100	--
Projections			
Years to 90% gene diversity	*3*	2	2
Years to 10% loss of gene diversity	*--*	75	105
Gene diversity at 100 years (%)	*6*	77	80.4
Gene diversity in 10 generations (%)	*--*	--	--
	Assuming λ = 1.01, Target size = 50, Generation length = 16, Starting population size = 47	λ =1.014, Target size = 50, T =15.7, Starting population size = 47	λ =1.014, Target size = 75, T =15.7, Starting population size = 47

*Genetic statistics may not be comparable across years due to changes in software and parameters used for projections from year to year.
**Pedigree assumptions were created for this population and may over- or under-estimate genetic statistics shown in this table.

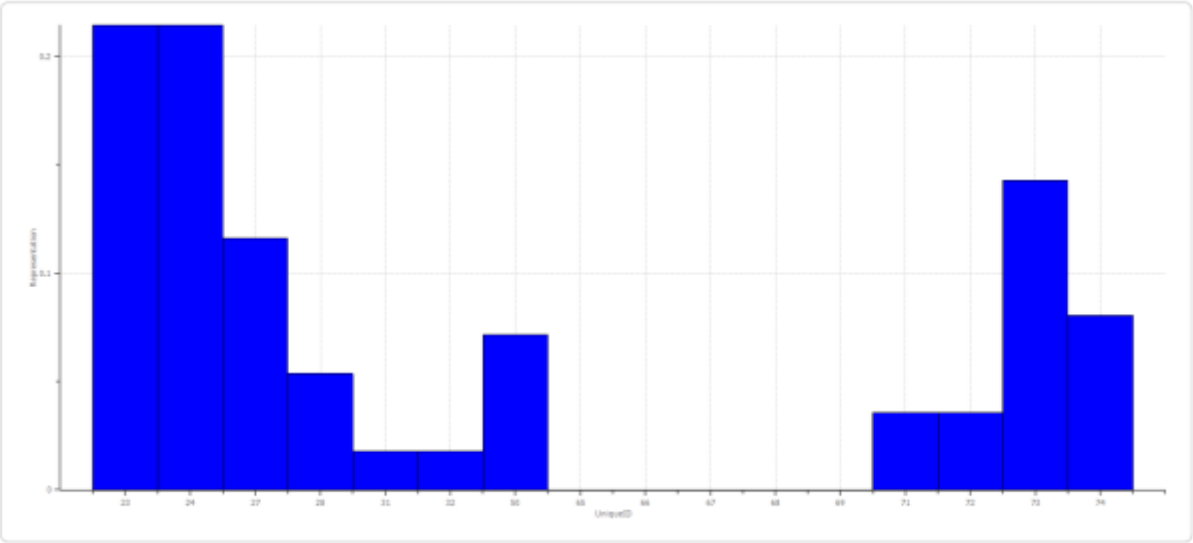

Figure 3: Founder representation distribution of the Hooded Vulture SSP population.

Recommendation Outcomes: The website PMCTrack calculates the outcomes fo SSP recommendations by comparing Breeding and Transfer Plan recommendations to births/hatches and transfers recorded in the studbook (Figure 4). There are many reasons that recommendations might not be fulfilled, including interim recommendations issued by the SSP Coordinator; these reasons can be captured using PMCTrack Outcomes Surveys. Note that starting in 2022, SSP Coordinators directly add interim recommendations to PMCTrack to improve the accuracy of recommendation outcomes. The fulfillment rates of any plan that had outcomes calculated in 2022 or after may reflect inclusion of these interim rates; in the graph, this may include the last plan before 2022, such as a 2021 plan, plus any plans with a date of 2022 or after.

Of the recommendations proprosed in the 2019 Breeding and Transfer Plan, 25% of the BREED WITH recommendations were fulfilled, and 27% of SEND TO recommendations were fulfilled as requested by 19 June 2022. SSP participants are always encouraged to attempt to fulfill recommendations and communicate sucesses and challenges to the SSP Coordinator.

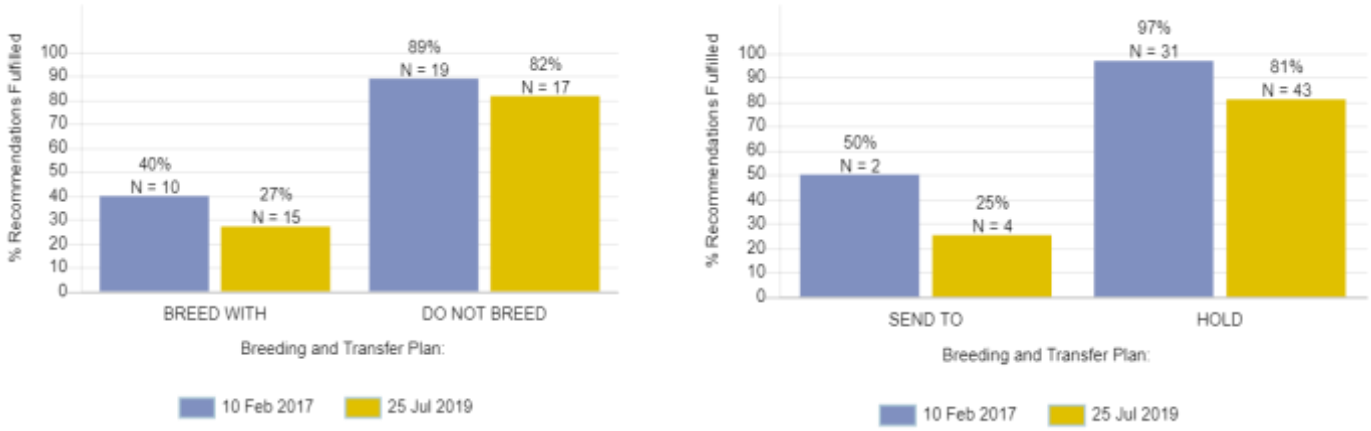

Figure 4: Recommendation outcomes by transfers (left) and breeding (right) for the past White-cheeked Turaco SSP Breeding and Transfer Plans. *N* represents the number of recommendations scored for each recommendation type, per plan, and the number represents the percentage recommendations fulfilled. Please visit PMCTrack.org or contact pmctrack@lpzoo.org for more information or with any questions.

Management Strategies: This is a 3-year plan (2022 - 2025). Interim recommendations will continue to be made as needed until another full set of recommendations are produced. Recommendations contained in this plan supersede all previous recommendations.

Table 3: *Historic reproduction and future population goals.*

Current Reproductive Goals Summary		
	Number of Hatches Needed per Year over the next 3 Years	**Target Population Size**
To maintain current population size (λ = 1.00)	2 - 3	47
To grow to the TAG's recommended target population size in 5 years to reflect the new RCP cycle (Kt =50; λ = 1.013)	4	50
Reproductive Goals Summary from the Last BTP (2019)		
Number of females recommended to breed	15	
Number of hatches since then	17 from 8 dams	
Average Number of Events in the SSP Population per Year over the Last Five Years		
Average number of hatches per year	5	
Average number of deaths per year	2.6	
Average number of imports per year	0.2	
Average number of exports per year	1	

At this time, the SSP:

1. **Recommends 14 females to breed at 8 facilities.** Institutions recommended to breed are expected to hold offspring for at least 1 year.

    a. Some genetically prioritized pairs may be asked to double clutch to promote underrepresented founders. Fostering of eggs with other pairs has been used successfully in this species and is a viable option to promote genetic priority breeding opportunistically. **Please contact the Coordinator if your pair may be good candidates to foster.**

2. **Recommends 5 transfers to establish new pairs and meet facility requests.**

    a. One transfer is a recommended import from a non-AZA to capture important genetic diversity.
    b. The remaining transfer recommendations are creating new pairs and recruiting new facilities to the SSP.

3. **Strongly requests that no animals be sent outside of the AZA population without consulting with the Coordinator.**

4. Requests that the Coordinator is consulted prior to assigning any new birds to show or ambassador roles. Please also share whether any birds are currently used in shows or ambassador programs that are not already designated as such.

    a. New ambassador animals can be recommended on a case by case basis, but the SSP is prioritizing breeding as many genetically important animals as possible and growing the population.

5. **The SSP is in need of new institutions to grow the population of this critically endangered bird.** Institutions interested in obtaining or placing Hooded Vultures should contact the SSP Coordinator.

Breeding and Transfer Recommendations by Facility

ATLANTA

Zoo Atlanta

800 Cherokee Ave. SE, Atlanta, GA 30315-1440, United States

Facility Note: Breeding is strongly discouraged for the current pair at this facility due to sibling relation. Potential exchanges can be proposed to continue breeding at this facility if desired. Contact the Coordinator during comment period for more detail. Additionally, egg fostering may become a more common practice in this population. Please let the Program know if this is of interest for your facility.

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
64	14B050	M	17	HOLD	ATLANTA	DO NOT BREED		
87	13B066	F	9	HOLD	ATLANTA	DO NOT BREED		
88	13B067	M	9	HOLD	ATLANTA	DO NOT BREED		Excluded
126	21B041	F	1	HOLD	ATLANTA	DO NOT BREED		Excluded

CLEVELAND

Cleveland Metroparks Zoo

3900 Wildlife Way, Cleveland, Ohio 44109, United States

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
83	101208	F	12	HOLD	CLEVELAND	DO NOT BREED		Excluded

DALLAS

Dallas Zoo

Dallas Zoo, Dallas, Texas 75203, United States

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
35	959423	F	27	HOLD	DALLAS	BREED WITH	68	
50	13M527	F	23	HOLD	DALLAS	BREED WITH	57	Genetic priority pair
57	17W341	M	20	HOLD	DALLAS	BREED WITH	50	Genetic priority pair
68	14P262	M	16	HOLD	DALLAS	BREED WITH	35	Potential founder male
71	17W322	M	16	HOLD	DALLAS	BREED WITH	91	
91	14P215	F	8	HOLD	DALLAS	BREED WITH	71	
121	UNDETERMINED	M	1	HOLD	DALLAS	DO NOT BREED		Excluded
131	22F069	M	0	SEND TO	JACKSONVL	BREED WITH	117	Transfer recommended when age appropriate

HONOLULU

Honolulu Zoo

Honolulu Zoo, Honolulu, Hawaii 96815-4011, United States

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
109	220071	M	4	HOLD	HONOLULU	BREED WITH	113	
113	221008	F	3	HOLD	HONOLULU	BREED WITH	109	

HOUSTON

Houston Zoo, Inc.

1513 Cambridge St., Houston, Texas 77030, United States

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
107	34264	M	4	HOLD	HOUSTON	DO NOT BREED		
115	34265	M	2	HOLD	HOUSTON	DO NOT BREED		

JACKSONVL

Jacksonville Zoo and Gardens

370 Zoo Parkway, Jacksonville, Florida 32218-5769, United States

Facility Note: Welcome to the Hooded Vulture Program. A new pair is recommended to come to this facility per institutional requests. Breeding will likely occur later as animals mature, but this pair is genetically well matched for future breeding.

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
131	22F069	M	0	RECEIVE FROM	DALLAS	BREED WITH	117	Transfer recommended when age appropriate
117	4001669	F	2	RECEIVE FROM	SD-WAP	BREED WITH	131	

NATAVPGH

National Aviary in Pittsburgh

700 Arch Street, Pittsburgh, Pennsylvania 15212, United States

Facility Note: The SSP is recommending a female exchange to allow for a genetically important female to breed potential founders at this facility. Any breeding from males at this facility will be vital for future gene diversity in the population.

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
63	7326	M	17	HOLD	NATAVPGH	DO NOT BREED		Excluded
65	7496	M	16	HOLD	NATAVPGH	BREED WITH	95	potential founder, Genetic priority pairing
66	7497	M	16	HOLD	NATAVPGH	BREED WITH	100	Potential founder
67	7498	M	16	HOLD	NATAVPGH	DO NOT BREED		Potential founder
69	7500	M	16	HOLD	NATAVPGH	DO NOT BREED		Potential founder
96	8846	F	6	SEND TO	SAN ANTON	BREED WITH	103	
100	9163	F	5	HOLD	NATAVPGH	BREED WITH	66	Female can breed any male.
95	M15020	F	7	RECEIVE FROM	WORLDBIRD	BREED WITH	65	Genetic priority pairing, can breed any male

OAKLAND

Oakland Zoo

9777 Golf Links Rd, Oakland, California 94605, United States

Facility Note: Breeding may be delayed as the female matures but this pair is genetically well matched.

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
81	4329	M	12	HOLD	OAKLAND	BREED WITH	116	
116	4272	F	2	HOLD	OAKLAND	BREED WITH	81	

SAN ANTON

San Antonio Zoological Gardens & Aquarium

3903 N. St. Mary's Street, San Antonio, Texas 78212-3199, United States

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
96	8846	F	6	RECEIVE FROM	NATAVPGH	BREED WITH	103	
103	217079	M	5	RECEIVE FROM	TBD	BREED WITH	96	

SD-WAP

San Diego Zoo Safari Park

15500 San Pasqual Valley Rd, Escondido, California , United States

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
55	801311	M	21	HOLD	SD-WAP	BREED WITH	74	
73	807002	F	18	HOLD	SD-WAP	BREED WITH	76	
74	807003	F	18	HOLD	SD-WAP	BREED WITH	55	
76	807277	M	15	HOLD	SD-WAP	BREED WITH	73	
86	812115	F	9	HOLD	SD-WAP	BREED WITH	104	
104	818019	M	4	HOLD	SD-WAP	BREED WITH	86	
105	818021	M	4	HOLD	SD-WAP	DO NOT BREED		
117	4001669	F	2	SEND TO	JACKSONVL	BREED WITH	131	
118	4001659	M	2	HOLD	SD-WAP	DO NOT BREED		
130	4003964	M	0	HOLD	SD-WAP	DO NOT BREED		

ST AUGUST

St. Augustine Alligator Farm

999 Anastasia Blvd, St. Augustine, Florida 32080, United States

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
27	A0740	F	30	HOLD	ST AUGUST	BREED WITH	60	
39	A0829	F	25	HOLD	ST AUGUST	DO NOT BREED		Excluded
60	A0910	M	19	HOLD	ST AUGUST	BREED WITH	27	
97	A1707	M	6	HOLD	ST AUGUST	BREED WITH	99	Demographic pair
99	A1703	F	5	HOLD	ST AUGUST	BREED WITH	97	Demographic pair
122	A2102	M	1	HOLD	ST AUGUST	DO NOT BREED		
127	A2201	M	0	HOLD	ST AUGUST	DO NOT BREED		

WORLDBIRD

Natural Encounters, Inc.

127 Conservation Way, Winter Haven, Florida ,

SB ID	Local ID	Sex	Age	Disposition	Location	Breeding	With	Notes
90	M14001	M	8	HOLD	WORLDBIRD	DO NOT BREED		Excluded
95	M15020	F	7	SEND TO	NATAVPGH	BREED WITH	65	Genetic priority pairing
106	M18007	M	4	HOLD	WORLDBIRD	DO NOT BREED		Excluded
112	M19002	M	3	HOLD	WORLDBIRD	DO NOT BREED		Excluded

Appendices

A. Analytical Assumptions

No analytical pedigree assumptions used for this report

B. Summary of Data Exports

Studbook Name	Vulture, Hooded (Necrosyrtes monachus)
Studbook Currentness Date	2 May 2022
Studbook Software and version #	PopLink 2.5.2; ZIMS for Studbooks
Overlay Name	N/A
PMx version #	1.6.4.20220303
.fed file	AZA
Descriptive Survival Statistics Report	**1)** Report is archived with PMC/AZA and Median Life Expectancy can be viewed here: https://www.aza.org/species-survival-statistics

PMx Project: HOVO_0
Created: 2022-08-02 by PMx version 1.6.4.20220303
File: C:\PMxProjects\HOVO_0.pmxproj
Description: No assumptions

Primary data file
Data File Name: zims.zims
Common Name: Hooded vulture
Scientific Name: Necrosyrtes monachus
Data Source: ZIMS for Studbooks
Studbook Name: Vulture, Hooded (Necrosyrtes monachus)
Exported On: 2022-08-02
Software version: ZIMS for Studbooks 3.0
Current Through: 2022-05-02
Compiled By: Megan Victoriano
Scope: AZA
Dates: 1990-01-01 to 2022-08-02
Location:
Association: AZA / Association of Zoos & Aquariums (AZA)
Other Filters: Status = Living
User: John Andrews

Moves data file
Data File Name: genetic.csv
Common Name: Hooded vulture
Scientific Name: Necrosyrtes monachus
Data Source: ZIMS for Studbooks
Studbook Name: Vulture, Hooded (Necrosyrtes monachus)
Exported On: 2022-08-02
Software version: ZIMS for Studbooks 3.0
Current Through: 2022-05-02
Compiled By: Megan Victoriano
Scope: AZA
Dates: 1990-01-01 to 2022-08-02
Location:
Association: AZA / Association of Zoos & Aquariums (AZA)
Other Filters: Status = None
User: John Andrews

Moves data file
Data File Name: demographic.csv
Common Name: Hooded vulture
Scientific Name: Necrosyrtes monachus
Data Source: ZIMS for Studbooks
Studbook Name: Vulture, Hooded (Necrosyrtes monachus)

Exported On: 2022-08-02
Software version: ZIMS for Studbooks 3.0
Current Through: 2022-05-02
Compiled By: Megan Victoriano
Scope: AZA
Dates: 1990-01-01 to 2022-08-02
Location:
Association: AZA / Association of Zoos & Aquariums (AZA)
Other Filters: Status = None
User: John Andrews

Locations data file
Data File Name: location.txt

Demographic input files
Census1 file: Exchcens.txt

4 births to parents with unknown ages have been added in proportion to known aged parents.
This is 5% of TOTAL births (N=79)

C. Animals Excluded from Genetic Analyses

SB ID	Age	Sex	Location	Reason
63	17	M	NATAVPGH	Medical, Foot issues
83	12	F	CLEVELAND	Animal Ambassadors
90	8	M	WORLDBIRD	Animal Ambassadors
106	4	M	WORLDBIRD	Animal Ambassadors
112	3	M	WORLDBIRD	Animal Ambassadors
121	1	M	DALLAS	Medical exclusion
39	25	F	ST AUGUST	IMPRINTED
126	1	F	ATLANTA	Animal Ambassadors
88	9	M	ATLANTA	Animal Ambassadors

D. Life Tables

Px = survival; Qx = mortality; Lx = cumulative survivorship; Mx = fecundity; Ex = life expectancy; Vx = expected future reproduction,
At Risk (Qx and Mx) = number of animals corresponding values are estimated from.

MALES

Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Ex	Vx
0	0.68	0.32	33.29	1.00	0.00	33.29	16.97	1.19
1	0.97	0.03	36.39	0.68	0.00	36.39	20.02	1.51
2	0.97	0.03	33.80	0.66	0.00	33.80	19.56	1.57
3	0.94	0.07	31.25	0.64	0.00	31.25	19.46	1.67
4	1.00	0.00	26.75	0.60	0.02	26.76	19.09	1.75
5	1.00	0.00	26.65	0.60	0.08	26.65	18.09	1.75
6	0.96	0.04	26.96	0.60	0.06	26.97	17.42	1.73
7	0.93	0.08	25.32	0.58	0.09	25.33	17.39	1.79
8	0.96	0.04	24.76	0.53	0.04	24.76	17.39	1.82
9	1.00	0.00	22.74	0.51	0.07	22.74	16.72	1.84
10	1.00	0.00	21.52	0.51	0.10	21.53	15.72	1.79
11	1.00	0.00	20.93	0.51	0.09	20.94	14.72	1.72
12	1.00	0.00	20.37	0.51	0.13	20.38	13.72	1.65
13	1.00	0.00	20.00	0.51	0.15	20.01	12.72	1.55
14	1.00	0.00	20.17	0.51	0.20	20.18	11.72	1.41
15	1.00	0.00	20.19	0.51	0.15	20.20	10.72	1.22
16	0.95	0.05	16.81	0.51	0.17	16.82	9.97	1.11
17	0.92	0.08	10.61	0.49	0.13	10.62	9.57	1.01
18	0.91	0.09	10.30	0.45	0.19	10.31	9.35	0.98
19	1.00	0.00	9.33	0.41	0.26	9.34	8.77	0.84
20	1.00	0.00	8.57	0.41	0.23	8.58	7.77	0.59
21	0.88	0.13	6.65	0.41	0.00	6.65	7.22	0.39
22	1.00	0.00	6.00	0.36	0.09	6.00	6.67	0.42
23	1.00	0.00	6.00	0.36	0.17	6.00	5.67	0.34
24	1.00	0.00	6.00	0.36	0.17	6.00	4.67	0.17
25	1.00	0.00	6.00	0.36	0.00	6.00	3.67	0.00
26	1.00	0.00	6.00	0.36	0.00	6.00	2.67	0.00
27	0.67	0.33	4.85	0.36	0.00	4.85	2.00	0.00
28	0.75	0.25	3.06	0.24	0.00	3.06	1.43	0.00
29	0.00	1.00	1.27	0.18	0.00	1.27	1.00	0.00
30	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
31	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
32	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
33	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
34	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
35	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
36	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
37	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
38	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
39	0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00

r = 0.012, λ = 1.012, Ro = 1.196, T = 14.7, N@20 = 27

FEMALES

Age	Px	Qx	Risk Qx	Lx	Mx	Risk Mx	Ex	Vx
0	0.58	0.42	21.36	1.00	0.00	21.36	---	1.27
1	0.96	0.04	20.56	0.58	0.00	20.56	---	1.79
2	0.90	0.10	19.69	0.56	0.00	19.69	---	1.96
3	1.00	0.00	19.21	0.50	0.00	19.21	---	2.10
4	1.00	0.00	19.00	0.50	0.03	19.00	---	2.14
5	1.00	0.00	18.96	0.50	0.06	18.96	---	2.14
6	1.00	0.00	20.35	0.50	0.03	20.35	---	2.12
7	0.90	0.10	17.65	0.50	0.05	17.65	---	2.24
8	1.00	0.00	16.38	0.45	0.16	16.39	---	2.35
9	0.94	0.06	15.41	0.45	0.10	15.41	---	2.30
10	1.00	0.00	14.00	0.42	0.07	14.01	---	2.32
11	1.00	0.00	14.00	0.42	0.11	14.00	---	2.28
12	1.00	0.00	13.33	0.42	0.19	13.35	---	2.20
13	1.00	0.00	12.59	0.42	0.20	12.59	---	2.04
14	1.00	0.00	12.16	0.42	0.17	12.17	---	1.87
15	1.00	0.00	13.00	0.42	0.12	13.00	---	1.73
16	1.00	0.00	13.00	0.42	0.20	13.01	---	1.63
17	0.92	0.08	13.22	0.42	0.12	13.22	---	1.52
18	0.92	0.08	13.19	0.39	0.07	13.19	---	1.54
19	0.91	0.09	10.58	0.36	0.14	10.59	---	1.63
20	1.00	0.00	10.00	0.32	0.05	10.01	---	1.59
21	1.00	0.00	10.00	0.32	0.16	10.01	---	1.57
22	1.00	0.00	10.00	0.32	0.31	10.02	---	1.43
23	1.00	0.00	8.75	0.32	0.34	8.76	---	1.14
24	0.88	0.13	7.32	0.32	0.07	7.34	---	0.87
25	1.00	0.00	6.39	0.28	0.16	6.40	---	0.86
26	1.00	0.00	6.00	0.28	0.26	6.02	---	0.71
27	0.80	0.20	5.15	0.28	0.30	5.16	---	0.51
28	1.00	0.00	4.00	0.23	0.13	4.02	---	0.24
29	1.00	0.00	4.00	0.23	0.00	4.00	---	0.11
30	0.75	0.25	2.80	0.23	0.13	2.80	---	0.13
31	1.00	0.00	2.00	0.17	0.00	2.00	---	0.00
32	1.00	0.00	2.00	0.17	0.00	2.00	---	0.00
33	0.50	0.50	2.00	0.17	0.00	2.00	---	0.00
34	1.00	0.00	1.00	0.09	0.00	1.00	---	0.00
35	1.00	0.00	1.00	0.09	0.00	1.00	---	0.00
36	1.00	0.00	1.00	0.09	0.00	1.00	---	0.00
37	1.00	0.00	0.00	0.09	0.00	0.00	---	0.00
38	1.00	0.00	0.00	0.09	0.00	0.00	---	0.00
39	1.00	0.00	0.00	0.09	0.00	0.00	---	0.00

r = 0.016, λ = 1.016, Ro = 1.308, T = 16.8, N@20 = 27

E. Ordered Mean Kinship List

These lists are current to August 2022 and values are subject to change with any hatch, death, import, export, inclusion, exclusion, or changes in pedigree or pedigree assumptions.

Population MK = 0.0967
(as indicated by the black line)

Male					Female				
Stbk#	**MK**	**Known**	**Age**	**Location**	**Stbk#**	**MK**	**Known**	**Age**	**Location**
65	0	1	16	NATAVPGH	35	0.0179	1	27	DALLAS
66	0	1	16	NATAVPGH	95	0.0268	1	7	WORLDBIRD
67	0	1	16	NATAVPGH	50	0.0357	1	23	DALLAS
68	0	1	16	DALLAS	74	0.0402	1	18	SD-WAP
69	0	1	16	NATAVPGH	27	0.058	1	30	ST AUGUST
71	0.0179	1	16	DALLAS	116	0.0614	1	2	OAKLAND
81	0.0268	1	12	OAKLAND	73	0.0714	1	18	SD-WAP
109	0.0614	1	4	HONOLULU	100	0.0971	1	5	NATAVPGH
127	0.0614	1	0	ST AUGUST	117	0.0971	1	2	SD-WAP
131	0.0614	1	0	DALLAS	99	0.1083	1	5	ST AUGUST
57	0.0692	1	20	DALLAS	86	0.1205	1	9	SD-WAP
104	0.0971	1	4	SD-WAP	87	0.1205	1	9	ATLANTA
97	0.1016	1	6	ST AUGUST	91	0.1205	1	8	DALLAS
107	0.1038	1	4	HOUSTON	96	0.1205	1	6	NATAVPGH
115	0.1038	1	2	HOUSTON	113	0.1205	1	3	HONOLULU
122	0.1138	1	1	ST AUGUST					
64	0.1161	1	17	ATLANTA					
105	0.1205	1	4	SD-WAP					
118	0.1205	1	2	SD-WAP					
130	0.1205	1	0	SD-WAP					
60	0.1317	1	19	ST AUGUST					
55	0.1362	1	21	SD-WAP					
76	0.1518	1	15	SD-WAP					

F. Definitions

Management Terms (as of December 2021)

Green Species Survival Plan® (Green SSP) Program – A Green SSP Program has a population size of 50 or more animals and is projected to retain 90% gene diversity for a minimum of 100 years or 10 generations. Green SSP Programs are subject to AZA's Full Participation and Sustainability Partner Policies.

Yellow Species Survival Plan® (Yellow SSP) Program – A Yellow SSP Program has a population size of 50 or more animals but cannot retain 90% gene diversity for 100 years or 10 generations. Yellow SSP participation by AZA facilities is voluntary. Yellow SSP Programs are subject to AZA's Sustainability Partner Policy.

Red Species Survival Plan® (Red SSP) Program – A Red SSP Program has a population size of twenty or more animals managed among three or more participating AZA facilities. If a population does not meet these minimum criteria, but has an IUCN designation of Critically Endangered, Endangered, or Extinct in the Wild, and the TAG has developed three goals to sustain this population, then the population will be considered a Red SSP Program. Red SSPs cannot retain 90% gene diversity for 100 years or 10 generations and participation by AZA facilities is voluntary. Red SSP Programs are subject to AZA's Sustainability Partner Policy.

Candidate Program – A Candidate Program either has a population size of fewer than twenty individuals and/or found at fewer than three AZA facilities or it does not yet have a completed studbook so the population size is unclear. A Candidate Program is overseen by the TAG, with no additional AZA accountability requirements.

Sustainability Partners – AZA Animal Population Management (APM) Committee approved wildlife facilities that regularly exchange animals with AZA-accredited facilities and certified related facilities, typically as part of the Species Survival Plan® (SSP) Program Breeding and Transfer Plan or other SSP Program management process.

Full Participation – AZA policy stating that all AZA accredited facilities and certified related facilities having a Green SSP animal in their collection are required to participate in the collaborative SSP planning process (e.g., provide relevant animal data to the AZA Studbook Keeper, assign an Institutional Representative who will communicate facility wants and needs to the SSP Coordinator and comment on the draft plan during the 30-day review period, and abide by the recommendations agreed upon in the final plan).

All AZA member facilities and Animal Programs, regardless of management designation, must adhere to the AZA Policy on Responsible Population Management and the AZA Code of Professional Ethics. For more information on AZA policies, see https://www.aza.org/board-approved-policies-and-position-statements.

Currentness Date – The date when the entire studbook is updated. This equates to the first date you received an update after requesting updates from all the facilities included in your studbook.

Demographic Terms

Age Distribution – A visual representation of the numbers or percentages of individuals in various age and sex classes.

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

Lambda (λ) or Population Growth Rate – The proportional change in population size from one year to the next. A lambda of 1.11 means an 11% per year increase; a lambda of 0.97 means a 3% decline in size per year. The three lambdas highlighted in this BTP are: 1) Life Table, from the PMx life tables, the change in the population based on the demographic regional and date window exported from the studbook, the life table lambda is the rate at which the population would be expected to grow (in the future) given the birth and death rates reported in the life tables and assuming a stable age distribution (does NOT factor in imports or exports); 2) 5-year, from the studbook census, the 5-year lambda is calculated from observed changes in population size over the last 5 years and includes births, deaths, imports and exports; and 3) Projected, from the PMx stochastic 20-year projections (includes confidence intervals), models how the population is predicted to grow or decline over the next 20 years given the birth and death rates from the life tables and the age structure of the current population.

lx, Age-Specific Survivorship – The probability that a new individual (e.g., 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.

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.

Median Life Expectancy (MLE) – The 'typical' age at which an average animal is expected to live; 50% will die before the median life expectancy and 50% die after. The MLE reported in Breeding and Transfer Plans (BTPs) and Survival Stats Reports, does excludes individuals that did not survive to their first birthday. The MLE obtained from population management software (PM2000, PMx, ZooRisk) or from life tables in BTPs (e.g., where Lx = 0.5) will be lower because they include those individuals that did not survive to their first birthday in order to project the correct number of births needed. A Survival Statistics Library is maintained for most AZA Animal Programs on the AZA website: https://www.aza.org/species-survival-statistics.

Maximum Longevity – The maximum age at which we have observed a species to live. If the oldest observed animal is currently living, we do not yet know the maximum longevity.

Mx, Fecundity – The average number of same-sexed offspring born to animals in that age class. Because studbooks typically have relatively small sample sizes, studbook software calculates Mx as 1/2 the average number of offspring 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.

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

Qx, Mortality – The probability that an individual of age *x* dies during an age class (Qx = 1-Px). Alternatively, 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").

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.

Target Population Size (TPS) – The desired number of SSP animals to be held across AZA and approved partner facilities over a specific, stated timeframe. This number is determined with consideration for program roles and goals (genetic, demographic, and others), logistical constraints, spatial competition with other TAG-managed species, and other population-specific concerns. Target Population Size is determined by the Taxon Advisory Group (TAG) and published in their Regional Collection Plan (RCP).

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

Genetic Terms

Allele – Alternate forms of DNA at a particular position in a genome (genetic locus). Alleles represent the most basic form of genetic diversity.

Gene Diversity (GD) – The probability that two alleles randomly sampled from the same genetic locus across a population are not identical by descent. Gene diversity is calculated relative to a population’s founders, which are assumed to be unrelated and not inbred, and is the proportional diversity retained by the current, descendant population.

Effective Population Size (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 allele 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 allele frequency drift is measured in the current generation). More specifically, PMx software uses the definition as the size of the current population that have produced offspring, assuming that there are current breeders, that these current breeders have a Poisson distribution of family sizes, that none of the current breeders are now post-reproductive, and none of the not-yet-breeding adults will breed.

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 of wild-caught individuals (founders) that represent the same amount of gene diversity as does the population under study. The gene diversity of a population is 1 - 1 / (2 * FGE).

Founder Representation – The proportion of the alleles in the living, descendant population that are derived from that founder.

Inbreeding Coefficient (F) – The probability that the two alleles present at an individual’s genetic locus are identical by descent (i.e., both alleles originated from an ancestor common to both the individual’s parents).

Mean Kinship (MK) – The mean (or average) kinship coefficient between an animal and all animals (including itself) in the living, captive-born population. An individual’s mean kinship is a measure of how well its alleles are represented within a population. Animals with low mean kinships have few relatives, are from under-represented founder lineages, and have transmitted few of their alleles to the next generation; these individuals should be prioritized for breeding to slow a population’s gene diversity loss.

Percent Known – The percentage of an animal's genome that is traceable to known founders. Thus, if an animal has an UNK sire, its % Known = 50. If it has an UNK grandparent, its % Known = 75.

Percent Certain – The percentage of the living individuals' pedigree that can be completely identified as *certain:* (exact identity of both parents is known) and traceable back to known founders. Individuals that are 100% *certain* do not have any MULTs or UNKs in their pedigree. *Certainty* represents a higher degree of knowledge than *Known* and therefore is always less than or equal to *Known.*

G. AZA Animal Population Management (APM) Committee Disclaimers

as of June 2019

This Animal Program is currently a Red SSP and recommendations proposed are non-binding – participation is voluntary. Transfers to non-AZA facilities must comply with each facility's acquisition/transfer policy, in accordance with the AZA Policy on Responsible Population Management. APM Committee-approved Sustainability Partners are expected to agree and abide by AZA's Code of Professional Ethics, SSP Full Participation Policy, Policy on Responsible Population Management, and Accreditation Standards related to animal care and welfare.

H. Directory of Institutional Representatives

Facility	Facility Mnemonic	Institutional Representative	IR Email
Zoo Atlanta	ATLANTA	Justin Eckelberry	jeckelberry@zooatlanta.org
Cleveland Metroparks Zoo	CLEVELAND	Travis Vineyard	tgv@clevelandmetroparks.com
Dallas Zoo	DALLAS	Sprina Liu	sprina.liu@dallaszoo.com
Honolulu Zoo	HONOLULU	Kelly Reno	kelly.reno@honolulu.gov
Houston Zoo, Inc.	HOUSTON	Kelly Pardy	kpardy@houstonzoo.org
Jacksonville Zoo and Gardens	JACKSONVLE	Danielle Minkus	minkusd@jacksonvillezoo.org
National Aviary	NATAVPGH	Cathy Schlott	cathy.schlott@aviary.org
Oakland Zoo	OAKLAND	Madison Brandon	mbrandon@oaklandzoo.org
San Antonio Zoological Society	SAN ANTON	Josef San Miguel	josef.sanmiguel@sazoo.org
San Diego Zoo Safari Park	SD-WAP	Andrew Stehly	astehly@sdzwa.org
St. Augustine Alligator Farm	ST AUGUST	Megan Victoriano	mvictoriano@alligatorfarm.com
Natural Encounters, Inc.	WORLDBIRD	Rob Bules	r.bules@naturalencounters.com

Exported from PMCTrack as of 8/2/2022

I. Descriptive Survival Statistics Report

Hooded vulture Studbook, Necrosyrtes monachus, North American Regional Studbook

Studbook data current as of 5/2/2022 12:00:00 AM

Compiled by, Megan King, MVictoriano@alligatorfarm.com

PopLink Studbook filename: HoodedVulture_2022
PopLink User Who Exported Report: JAndrews
Date of Export: 8/2/2022 12:00:00 AM
Data Filtered by: Association = AZA.FED AND StartDate = 1/1/1980 AND EndDate = 8/2/2022
PopLink Version: 2.5.2

REPORT OVERVIEW:

Data for Hooded vulture were not of sufficient robustness to analyze and report survival statistics. See the body of the report for further details.

BACKGROUND ON ANALYSES:

These analyses were conducted using animals that lived during the period 1 January 1980 to 2 August 2022 at institutions within AZA. The analyses mainly focus on survival statistics from 1 year (e.g. excluding any individuals that did not survive past their first birthday). These statistics most accurately reflect typical survival for animals which can be seen on exhibit in zoos and aquariums.

This report summarizes survival records of individuals housed at zoological facilities for a specific geographic range and time period; these records trace an individual's history from birth or entry into the population to death, exit out of the population, or the end of the time period. As such, this history only reflects standard practices - including management, husbandry, and acquisition/disposition practices - for the specified time period and geographic range. Thus, the report contents should be viewed with some caution as they may not fully reflect current and newly emerging zoo and aquarium management techniques or practices. For example, if the population has not been maintained in zoos and aquariums long enough to have many adults living into old age, median life expectancy will likely be an underestimate until more data accrue in older age classes. Thus, users of these reports should recognize that the results produced will likely vary over time or depending on the subset of data selected.

SUMMARY OF ANALYSES:
SURVIVAL STATISTICS

Unfortunately, **data were not robust enough to analyze and report survival statistics**[1] (see Data Quality section). The dataset used for analysis includes partial or full lifespans of 86 individuals, 31 (36.1%) of which had died by 2 August 2022. These data are not sufficient for further analysis.

For general reference, data are provided on the oldest individuals in the dataset defined with the analysis window. Please note that these are the individual's ages as of the end date of the demographic window (2 August 2022); for the most up-to-date ages of the oldest animals in this population, you should contact the studbook keeper for this species directly.

10 Oldest Censored Individuals[2]

Studbook ID	Sex	Birth Type	Age at Censoring	Birth Date Est.	Exit Method
9	Female	Captive Hatch	37.5	None	exported out of window
27	Female	Wild Hatch	30.6	None	alive at end of window
35	Female	Captive Hatch	27.3	None	alive at end of window
39	Female	Captive Hatch	25.4	None	alive at end of window
50	Female	Wild Hatch	23.6	None	alive at end of window
46	Male	Captive Hatch	23.5	None	alive at end of window
43	Female	Captive Hatch	23.1	None	exported out of window
55	Male	Captive Hatch	21.5	None	alive at end of window
57	Male	Captive Hatch	20.6	None	alive at end of window

60	Male	Captive Hatch	19.3	None	alive at end of window

10 Oldest Dead Individuals

Studbook ID	Sex	Birth Type	Age at Death	Birth Date Est.
11	Female	Wild Hatch	34.0	None
31	Female	Wild Hatch	30.2	None
3	Male	Captive Hatch	29.5	None
15	Male	Captive Hatch	29.0	None
17	Male	Wild Hatch	28.0	None
5	Male	Captive Hatch	27.7	None
12	Male	Wild Hatch	27.1	None
18	Female	Wild Hatch	24.3	None
32	Male	Wild Hatch	21.1	None
13	Female	Captive Hatch	19.6	None

The PopLink Age Outliers report can give further information on these and other 'old' individuals within the studbook dataset.

DATA QUALITY

The PopLink Survival Tool uses five data quality measures to determine whether data are robust enough to make reliable estimates of key survival parameters. **This population failed at least one of the following tests:**

1. Can the median life expectancy be calculated? **PASS**
2. Is the sample size (number of individuals at risk) greater than 20 individuals at the median? **FAIL**
3. Is the 95% Confidence Interval (CI) bounded? **PASS**
4. Is the sample size in the first age class of analysis (e.g. the first day of analysis) greater than 30 individuals? **PASS**
5. Is the length of the 95% CI < 33% of the maximum longevity? **PASS**

PopLink data validation was last run on 6/20/2022. This validation found 59 errors, including 0 high priority errors, 3 medium priority errors, and 56 low priority errors. These errors may or may not directly affect the data in this analysis.

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[1] The statistics analyzed for this report (median life expectancy, 95% confidence limits, and age to which 25% of individuals survive) exclude any individuals who did not survive to their first birthday; these individuals are excluded because this Report is focused on providing median survival estimates for the typical individual that survives the vulnerable infant stage. In other words, this report answers the question, 'how long is this species expected to live once it has reached its first birthday?' For this studbook, 33 individuals died before their first birthday and were excluded from these analyses.

For all animals that survive to their first birthday, 50% will die before the median life expectancy in this report and 50% die after. Note that the median life expectancy obtained from population management software (PM2000, PMx, ZooRisk) or from life tables in Breeding and Transfer Plans (e.g. where Lx = 0.5) will be lower because it includes these individuals that did not survive to their first birthday in order to project the correct number of births needed. See the PopLink manual for more details.

[2] Censored individuals are individuals whose deaths have not been observed as of the end of the analysis window, including individuals who 1) are still alive as of the end date, 2) exited the geographic window before the end date (through transfer or release), or 3) were lost-to-follow up before the end date.