Folia Primatologica

Preliminary comparisons of learning across four lemur genera at the Duke Lemur Center

Carly H. Batist[a,b,*], Jessica A. Mayhew[c,d]

[a]Department of Anthropology, Graduate Center of the City University of New York, 365 5th Ave, New York, NY 10016, USA

[b]New York Consortium in Evolutionary Primatology, New York, NY 10065, USA

[c]Department of Anthropology and Museum Studies, Central Washington University, 400 E. University Way, Ellensburg, WA 98926, USA

[d]Primate Behavior and Ecology Program, Central Washington University, 400 E. University Way, Ellensburg, WA 98926, USA

*Corresponding author; e-mail: cbatist@gradcenter.cuny.edu

ORCID iDs: Batist: 0000-0001-7320-2576; Mayhew: 0000-0001-9649-3513

Supplementary material

Table S1. Demographic data and individual results for the study population of 66 lemurs at the Duke Lemur Center. Total # of successes is taken using only experimental trials (none of the model's training trials). Proficiency rate is the number of successes/number of attempts and includes training trials for model individuals. Each individual's rate was averaged across 9 trials, so the number of training trials a model participated in was subtracted from the number of experimental trials included in the average

Name	**Species**	**Group size**	**Sex**	**Age (yrs)**	**Group type**	**Total # of successes**	**Overall proficiency rate**
Ma'at	*E. coronatus*	5	M	Infant	Experimental		
Kek	*E. coronatus*	5	M	1	Experimental	54	4.0 ± 3.6
Seshen	*E. coronatus*	5	F	2	Experimental	22	2.6 ± 1.9
Mosi	*E. coronatus*	5	M	7	Experimental		
Seshat[a]	*E. coronatus*	5	F	7	Experimental	103	7.5 ± 5.5
McKinnon	*E. flavifrons*	4	F	Infant	Control		

Murphy	*E. flavifrons*	4	M	1	Control	4	
Wiig	*E. flavifrons*	4	F	3	Control	60	4.8 ± 4.2
Hiddleston	*E. flavifrons*	4	M	4	Control	85	2.8 ± 2.0
Poehler	*E. flavifrons*	4	F	Infant	Experimental	1	
Lincoln	*E. flavifrons*	4	M	1	Experimental	40	4.3 ± 3.0
West[a]	*E. flavifrons*	4	F	6	Experimental	92	3.7 ± 4.3
Quinn	*E. flavifrons*	4	M	16	Experimental		
Iggy	*E. mongoz*	3	M	2	Control		
Mico	*E. mongoz*	3	M	3	Control	100	2.9 ± 1.7
Maddie	*E. mongoz*	3	F	11	Control	61	1.5 ± 1.2
Nacho	*E. mongoz*	5	M	Infant	Experimental		
Bonita	*E. mongoz*	5	F	1	Experimental	22	1.0 ± 1.7
Oscar	*E. mongoz*	5	M	3	Experimental		

Carolina[a]	*E. mongoz*	5	F	7	Experimental	69	1.4 ± 1.8
Duggan	*E. mongoz*	5	M	9	Experimental	62	5.0 ± 3.5
Lulu	*L. catta*	4	F	3	Control	11	
Stewart	*L. catta*	4	M	5	Control	60	4.8 ± 3.3
Jones	*L. catta*	4	M	5	Control		
Sprite	*L. catta*	4	F	16	Control	64	5.0 ± 3.8
Onyx	*L. catta*	4	M	4	Control	74	4.5 ± 4.0
Hibernia	*L. catta*	4	F	8	Control	53	2.3 ± 1.7
Justine	*L. catta*	4	F	12	Control		
Dorieus	*L. catta*	4	F	17	Control		
PJ	*L. catta*	4	F	2	Experimental	60	3.6 ± 3.2
Thea	*L. catta*	4	F	2	Experimental		
Narcissa	*L. catta*	4	F	1	Experimental	10	
Randy[a]	*L. catta*	4	M	11	Experimental	81	1.5 ± 2.7
Hedwig	*L. catta*	6	F	1	Experimental	8	

Griselda	*L. catta*	6	F	1	Experimental	67	1.4 ± 0.9
Gretl[a]	*L. catta*	6	F	5	Experimental	75	4.9 ± 4.8
Liesl	*L. catta*	6	F	9	Experimental		
Shroeder	*L. catta*	6	F	25	Experimental	8	
Aracus	*L. catta*	6	M	26	Experimental	3	
Furia	*P. coquereli*	4	F	6mo	Experimental		
Hostilian	*P. coquereli*	4	M	1	Experimental	58	3.9 ± 2.8
Gisela[a]	*P. coquereli*	4	F	5	Experimental	47	1.6 ± 1.6
Rupert	*P. coquereli*	4	M	7	Experimental		
Calpurnia	*P. coquereli*	4	F	1	Control	11	
Aemilia	*P. coquereli*	4	F	3	Control	58	5.8 ± 4.5

Drusilla	*P. coquereli*	4	F	24	Control	68	3.8 ± 2.9
Julian	*P. coquereli*	4	M	24	Control	59	3.0 ± 2.0
Wenceslaus	*P. coquereli*	4	M	2	Experimental	1	
Eleanor	*P. coquereli*	4	F	3	Experimental		
Rodelinda[a]	*P. coquereli*	4	F	10	Experimental	79	3.0 ± 2.1
Marcus	*P. coquereli*	4	M	13	Experimental	16	0.9 ± 0.5
Buzz	*V. rubra*	4	M	6mo	Control	47	4.3 ± 3.2
Bode	*V. rubra*	4	M	2	Control	81	8.2 ± 3.5
Pyxis	*V. rubra*	4	F	22	Control	22	3.6 ± 2.1
Borealis	*V. rubra*	4	M	29	Control	42	5.8 ± 4.3
Kalani	*V. rubra*	5	M	1	Experimental	73	7.3 ± 3.5
Sally	*V. rubra*	5	F	1	Experimental	72	7.4 ± 2.6
Arche	*V. rubra*	5	M	2	Experimental	60	7.1 ± 3.2

Pandora[a,b]	*V. rubra*	5	F	6	Experimental	3	
Comet	*V. rubra*	5	M	33	Experimental		
AJ	*V. variegata*	3	M	4	Control	30	5.9 ± 4.8
Rees	*V. variegata*	3	M	4	Control	4	
Kizzy	*V. variegata*	3	F	12	Control	12	
Cosmo	*V. variegata*	3	M	1	Experimental	18	2.5 ± 1.7
Astro	*V. variegata*	3	M	1	Experimental	33	2.0 ± 1.0
Halley[a]	*V. variegata*	3	F	4	Experimental	78	3.8 ± 3.1

[a]Model individuals; [b]Pandora only had 3 successes across all experimental trials despite her trainings trials where she was proficient.

Table S2. Outputs from null hypothesis significance testing via Anova function in *car*. Bolded terms are the response variables, with rows beneath them being the set of composite models. Cells shaded grey represent the lowest AIC score (the "best-fitting" or most likely model)

	AIC	**logLik**	**deviance**	**Chisq**	**df**	**Pr(>Chisq)**
Latency to touch apparatus						
~ (1 |Ind)	545.35	-269.68	539.35	-	-	-
~ genus + (1 |Ind)	533.80	-260.90	521.80	17.55	3	<0.0005***
~ genus + trial# + (1 |Ind)	495.23	-240.61	481.23	40.58	1	<0.0001***
~ genus + trial# + group type + (1 | Ind)	491.68	-237.84	475.68	5.55	1	0.019*
Latency to success						
~ (1 |Ind)	490.34	-242.17	484.34	-	-	-
~ genus + (1 |Ind)	484.34	-236.17	472.34	12.00	3	0.007***
~ genus + trial# + (1 |Ind)	366.22	-176.11	352.22	120.12	1	<0.0001***
~ genus + trial# + group type + (1 | Ind)	363.96	-173.98	347.96	4.26	1	0.039*
Proficiency rate						
~ (1 |Ind)	87.24	-40.62	81.24	-	-	-
~ genus + (1 |Ind)	87.83	-37.91	75.83	5.41	3	0.144
~ genus + trial# + (1 |Ind)	44.68	-15.34	30.68	45.15	1	<0.0001***
~ genus + trial# + group type + (1 | Ind)	46.57	-15.29	30.57	0.11	1	0.746
Successes observed						

~ (1 |Ind)	914.70	-455.35	910.70	-	-	-
~ genus + (1 |Ind)	885.36	-437.68	875.36	35.34	3	<0.0001***
~ genus + trial# + (1 |Ind)	882.22	-435.11	870.22	5.14	1	0.023*
~ genus + trial# + group type + (1 | Ind)	884.00	-435.00	870.00	0.22	1	0.64

Table S3. Candidate GLMM model sets for each learning variable analyzed against genus, group type, and trial number (with individual included as a random effect). Coefficients and estimates are averaged across only the model with the lowest AICc and all models within two AICc values (candidate models below this threshold are italicized). The weight of a model reflects AICc value and quantifies how good of a fit the model is at explaining variation in the dependent variable

	df	**logLik**	**AICc**	**ΔAICc**	**weight**
Latency to touch					
trial# + genus	7	-251.31	516.90	0	0.49
trial# + genus + group type	8	-250.44	517.24	0.34	0.41
trial#	*4*	*-256.29*	*520.68*	*3.79*	*0.07*
trial# + group type	*5*	*-256.19*	*522.52*	*5.62*	*0.03*
genus	*6*	*-267.50*	*547.21*	*30.31*	*0*
genus + group type	*7*	*-266.54*	*547.35*	*30.46*	*0*
(null)	*3*	*-271.89*	*549.84*	*32.95*	*0*
group type	*4*	*-271.58*	*551.45*	*34.56*	*0*
Latency to success					
trial#	4	-188.51	385.15	0	0.41
trial# + group type	7	-185.78	385.91	0.76	0.28
trial# + genus + group type	8	-185.29	387.03	1.88	0.16
trial# + group type	5	-188.42	387.04	1.89	0.16
(null)	*3*	*-244.20*	*494.48*	*109.33*	*0*
genus	*6*	*-241.92*	*496.11*	*110.96*	*0*
group type	*4*	*-244.17*	*496.47*	*111.32*	*0*

genus + group type	*7*	*-241.50*	*497.35*	*112.20*	*0*
Proficiency rate					
trial#	4	-24.85	57.82	0	0.95
trial# + group type	*5*	*-26.77*	*63.73*	*5.91*	*0.05*
trial# + genus	*7*	*-27.64*	*69.64*	*11.82*	*0*
trial# + genus + group type	*8*	*-29.55*	*75.57*	*17.75*	*0*
(null)	*3*	*-43.28*	*92.63*	*34.81*	*0*
group type	*4*	*-45.22*	*98.56*	*40.74*	*0*
genus	*6*	*-45.92*	*104.11*	*46.29*	*0*
genus + group type	*7*	*-47.85*	*110.05*	*52.23*	*0*
Successes observed					
trial# + genus	6	-435.11	882.49	0	0.59
trial# + genus + group type	7	-435.00	884.36	1.87	0.23
genus	*5*	*-437.68*	*885.55*	*3.06*	*0.13*
genus + group type	*6*	*-437.56*	*887.39*	*4.90*	*0.05*
trial#	*3*	*-453.31*	*912.70*	*30.21*	*0*
trial# + group type	*4*	*-453.29*	*914.71*	*32.22*	*0*
(null)	*2*	*-455.25*	*914.74*	*32.25*	*0*
group type	*3*	*-455.33*	*916.73*	*34.24*	*0*

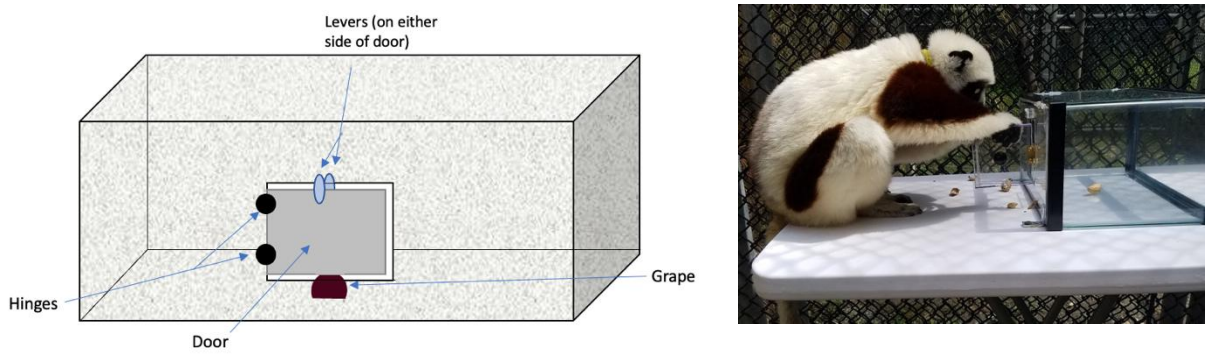

Fig. S1. Two-action apparatus used in this study at the Duke Lemur Center.

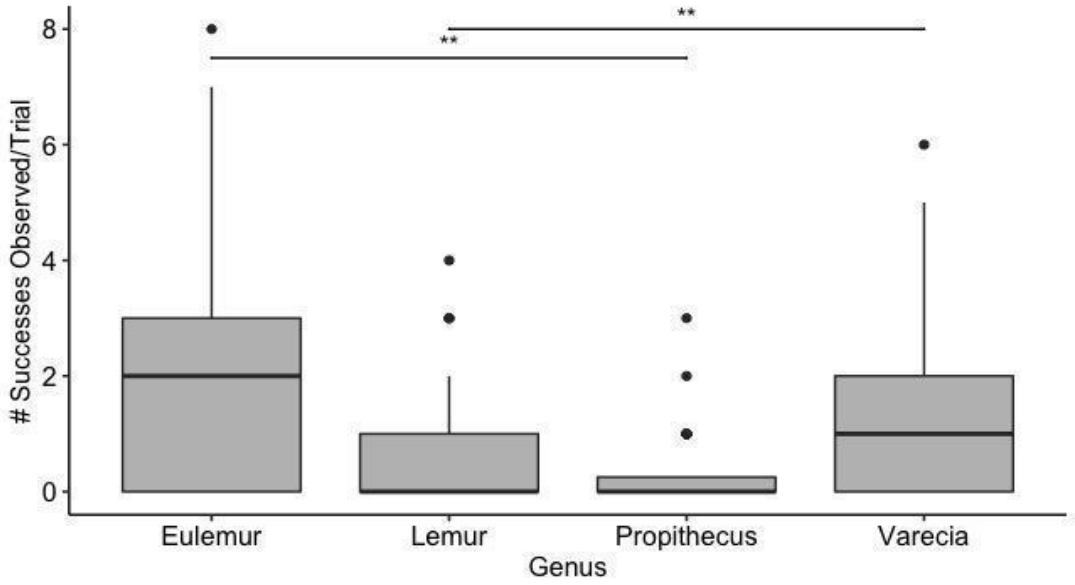

Fig. S2. Differences in the number of successes an individual observed per trial by genus. *Eulemur* and *Varecia* each observed more successes than either *Propithecus* or *Lemur* (** indicate significant differences). The shaded boxes represent the inter-quartile range, thick midline shows the median. Lines extend out from the shaded boxes to show maximums, and the dots are outliers.