

Electronic Supplementary Materials:
Evolutionary pressures on primate intertemporal
choice

Jeffrey R. Stevens

April 13, 2014

Table S1: Species intertemporal choice, allometric, relative brain size, and group size data

| Species | Indifference | | Body mass | | Absolute brain size | | Relative brain size (residuals) | | Lifespan | | Home range | | Group size | |
|----------------------------|--------------|--------------------------|-----------|-------|-------------------------|----------------------|---------------------------------|--|----------|--|------------|--|------------|--|
| | point (s) | | (g) | | size (cm ³) | | size (residuals) | | (yrs) | | (ha) | | Group size | |
| <i>Eulemur macaco</i> | 14.8 [1] | 2330.8 [2-5] | 25.4 [6] | -0.22 | 28.0 [7] | 13.6 [4,8-10] | 8.2 [4,9,11,12] | | | | | | | |
| <i>Varecia rubra</i> | 16.6 [1] | 3313.6 [2,13,14] | 31.1 [6] | -0.31 | 35.0 [15] | 37.3 [16-18] | 9.5 [16-18] | | | | | | | |
| <i>Varecia variegata</i> | 17.9 [1] | 3485.9 [2,3,19] | 32.1 [6] | -0.31 | 34.0 [15] | 86.0 [20-23] | 5.3 [19,20,22-29] | | | | | | | |
| <i>Saguinus oedipus</i> | 7.9 [30] | 396.8 [30] | 9.7 [6] | 0.48 | 26.2 [15] | 8.5 [31] | 6.4 [31-33] | | | | | | | |
| <i>Callitrix jacchus</i> | 14.4 [30] | 323.4 [30] | 7.2 [6] | 0.24 | 23.0 [15] | 2.3 [34-38] | 9.2 [35,38-40] | | | | | | | |
| <i>Sapajus apella</i> | 55.6 [41,42] | 3167.5 [43] | 66.4 [6] | -0.26 | 45.1 [7] | 182.6 [44-49] | 15.6 [44,45,47-51] | | | | | | | |
| <i>Ateles geoffroyi</i> | 76.0 [41] | 7435.6 [43,52] | 107.3 [6] | 0.14 | 48.0 [7] | 129.4 [53-59] | 10.2 [53,57-63] | | | | | | | |
| <i>Macaca fascicularis</i> | 26.4 [41,64] | 4928.0 [65-68] | 64.4 [6] | 0.40 | 37.1 [69] | 54.6 [65,66,70,71] | 31.2 [65,66,70-79] | | | | | | | |
| <i>Macaca mulatta</i> | 19.3 [80,81] | 6624.0 [65,82-84] | 88.3 [6] | 0.20 | 40.0 [85] | 202.6 [65,86,87] | 27.0 [65,86-90] | | | | | | | |
| <i>Pongo pygmeus</i> | 49.6 [41] | 54416.4 [43,91,92] | 379.8 [6] | 0.04 | 59.0 [7] | 770.2 [93-97] | 1.9 [94,98,99] | | | | | | | |
| <i>Gorilla gorilla</i> | 44.0 [41] | 145331.6 [100] | 501.5 [6] | 0.38 | 54.0 [7] | 1777.5 [101-108] | 9.7 [103,104,109-115] | | | | | | | |
| <i>Pan paniscus</i> | 74.4 [116] | 36585.0 [100,117] | 344.3 [6] | 0.35 | 50.0 [15] | 3860.0 [118-121] | 54.6 [119-123] | | | | | | | |
| <i>Pan troglodytes</i> | 122.6 [116] | 39348.6 [43,100,124-127] | 367.6 [6] | -0.11 | 59.4 [7] | 8910.1 [108,128-140] | 48.0 [124,128-131,137,141-145] | | | | | | | |

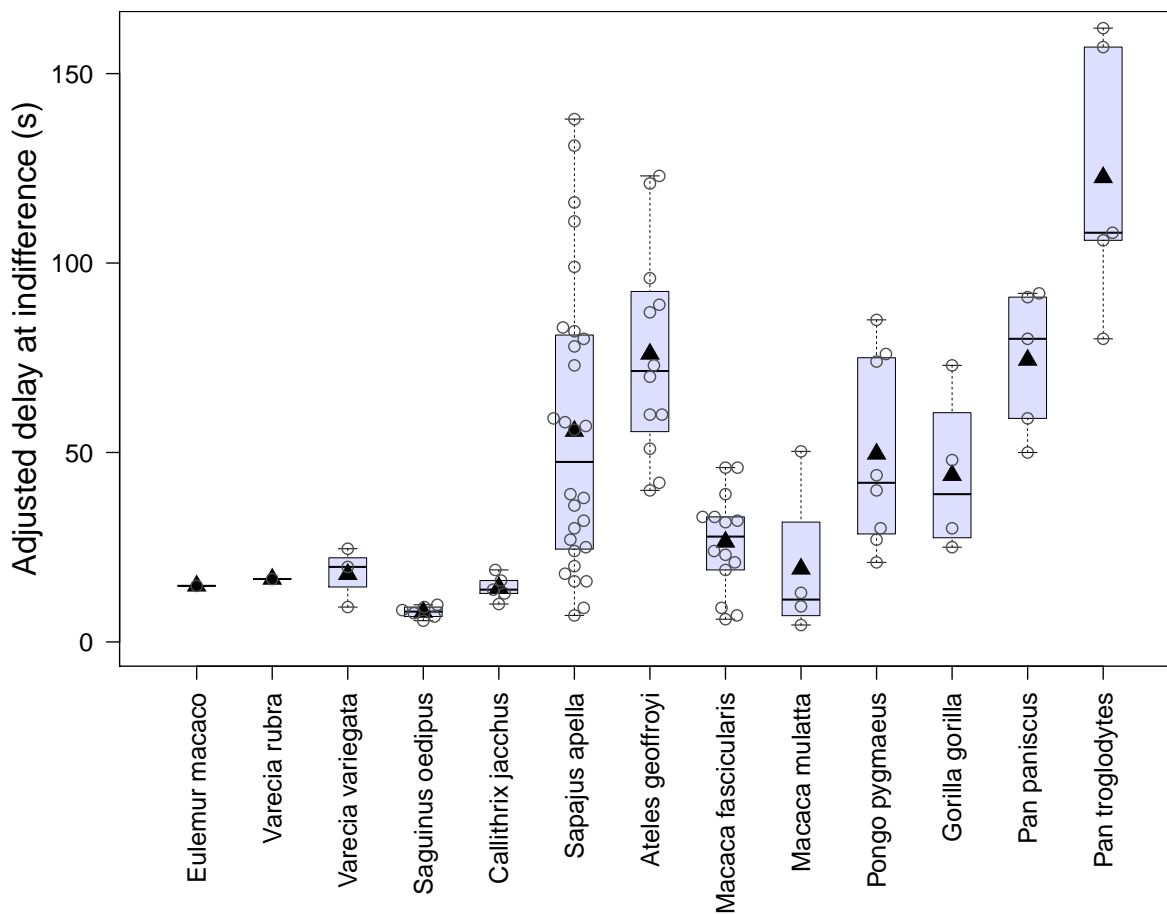


Figure S1: Intertemporal choice data. Thirteen species have been tested with adjusting intertemporal choice tasks: black lemurs (*Eulemur macaco*)^[1], red-ruffed lemurs (*Varecia rubra*)^[1], black-and-white-ruffed lemurs (*Varecia variegata*)^[1], cotton-top tamarins (*Saguinus oedipus*)^[30], common marmosets (*Callithrix jacchus*)^[30], brown capuchins (*Sapajus apella*)^[41,42], black-handed spider monkeys (*Ateles geoffroyi*)^[41], long-tailed macaques (*Macaca fascicularis*)^[41,64], rhesus macaques (*Macaca mulatta*)^[80,81], orangutans (*Pongo pygmaeus*)^[41], lowland gorillas (*Gorilla gorilla*)^[41], bonobos (*Pan paniscus*)^[116], and chimpanzees (*Pan troglodytes*)^[116]. The y-axis illustrates the indifference points representing the waiting time tolerated for three times as much food compared to an immediate reward. Circles represent data points for individual subjects, triangles represent the species mean, lines represent the median, boxes represent the interquartile range (25-75%), and whiskers represent the range.

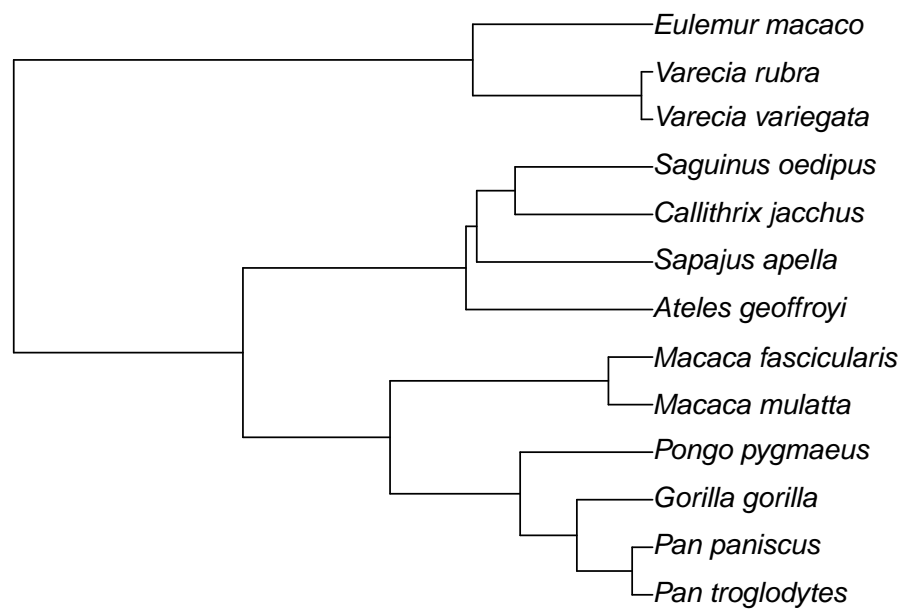


Figure S2: Phylogeny of species in comparative analysis. I used 10kTrees version 3^[146] to construct the weighted branch lengths of the primate phylogeny.

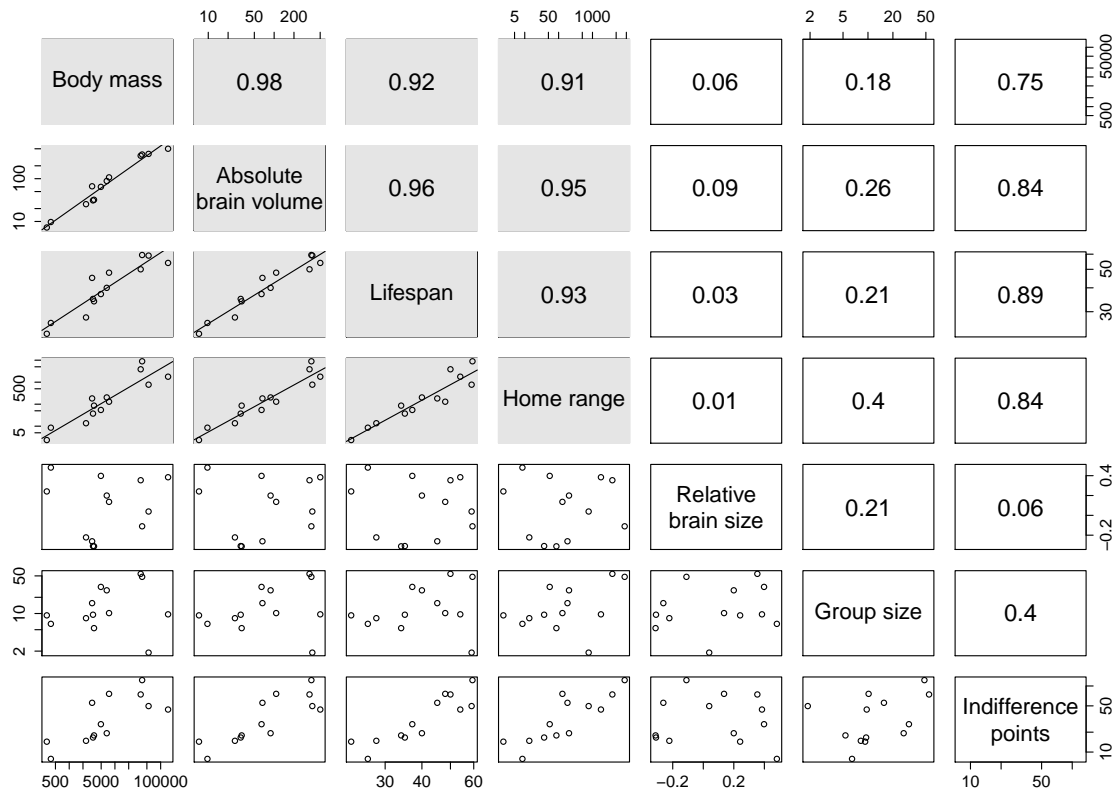


Figure S3: Correlation matrix for predictor variables and indifference points. All variables except relative brain size are plotted on log scale. Body mass, absolute brain volume, lifespan, and home range size (shaded panels) are highly intercorrelated. Upper panels show correlation coefficients.

References

- [1] Stevens, J. R. & Mühlhoff, N. 2012 Intertemporal choice in lemurs. *Behavioural Processes*, **89**(2), 121–127. doi:10.1016/j.beproc.2011.10.002.
- [2] Kappeler, P. M. 1991 Patterns of sexual dimorphism in body weight among prosimian primates. *Folia Primatologica*, **57**(3), 132–146. doi:10.1159/000156575.
- [3] Terranova, C. J. & Coffman, B. S. 1997 Body weights of wild and captive lemurs. *Zoo Biology*, **16**(1), 17–30. doi:10.1002/(SICI)1098-2361(1997)16:1<17::AID-ZOO4>3.0.CO;2-E.
- [4] Bayart, F. & Simmen, B. 2005 Demography, range use, and behavior in black lemurs (*Eulemur macaco macaco*) at Ampasikely, northwest Madagascar. *American Journal of Primatology*, **67**(3), 299–312. doi:10.1002/ajp.20186.
- [5] Junge, R. E. & Louis, E. E. 2007 Biomedical evaluation of black lemurs (*Eulemur macaco macaco*) in Lokobe Reserve, Madagascar. *Journal of Zoo and Wildlife Medicine*, **38**(1), 67–76. doi:10.1638/06-006.1.
- [6] Isler, K., Christopher Kirk, E., Miller, J. M., Albrecht, G. A., Gelvin, B. R. & Martin, R. D. 2008 Endocranial volumes of primate species: scaling analyses using a comprehensive and reliable data set. *Journal of Human Evolution*, **55**(6), 967–978. doi:10.1016/j.jhevol.2008.08.004.
- [7] Hakeem, A., Sandoval, G. R., Jones, M. & Allman, J. 1996 Brain and life span in primates. In *Handbook of the Psychology of Aging* (eds. J. E. Birren & K. W. Schale), pp. 78–104. Academic Press.
- [8] Jolly, A. 1972 *The Evolution of Primate Behavior*. New York: Macmillan.
- [9] Colquhoun, I. C. 1993 The socioecology of *Eulemur macaco*: a preliminary report. In *Lemur Social Systems and Their Ecological Basis* (eds. P. M. Kappeler & R. U. Ganzhorn), pp. 11–23. New York: Plenum Press.
- [10] Schwitzer, N., Randriatahina, G. H., Kaumanns, W., Hoffmeister, D. & Schwitzer, C. 2007 Habitat utilization of blue-eyed black lemurs, *Eulemur macaco flavifrons* (Gray, 1867), in primary and altered forest fragments. *Primate Conservation*, **22**(1), 79–87. doi:10.1896/052.022.0106.
- [11] Jolly, A. 1966 *Lemur Behavior: A Madagascar Field Study*. Chicago: University of Chicago Press.
- [12] Andrews, J. R. 1990 *A preliminary survey of black lemurs, Lemur macaco in north-west Madagascar: the final report of the Black Lemur Survey 1988*.
- [13] Vasey, N. 2003 *Varecia*, ruffed lemurs. In *The Natural History of Madagascar* (eds. S. M. Goodman & J. Benstead), pp. 1332–1336. Chicago: University of Chicago Press.
- [14] Dutton, C. J., Junge, R. E. & Louis, E. E. 2008 Biomedical evaluation of free-ranging red ruffed lemurs (*Varecia rubra*) within the Masoala National Park, Madagascar. *Journal of Zoo and Wildlife Medicine*, **39**(1), 76–85. doi:10.1638/06-062.1.
- [15] Weigl, R. 2005 *Longevity of Mammals in Captivity: From the Living Collections of the World*. Stuttgart: Schweizerbart.

- [16] Rigamonti, M. M. 1993 Home range and diet in red ruffed lemurs (*Varecia variegata rubra*) on the Masoala Peninsula, Madagascar. In *Lemur Social Systems and Their Ecological Basis* (eds. P. M. Kappeler & J. U. Ganzhorn), pp. 25–39. New York: Plenum Press.
- [17] Vasey, N. 2007 The breeding system of wild red ruffed lemurs (*Varecia rubra*): a preliminary report. *Primates*, **48**, 41–54.
- [18] Martinez, B. T. 2010 Forest restoration in Masoala National Park, Madagascar: The contribution of the red-ruffed lemur (*Varecia rubra*) and the livelihoods of subsistence farmers at Ambatoladama. Ph.D. thesis, University of Minnesota, Minneapolis, MN.
- [19] Morland, H. S. 1991 Preliminary report on the social organization of ruffed lemurs (*Varecia variegata variegata*) in a northeast Madagascar rain forest. *Folia Primatologica*, **56**(3), 157–161. doi:10.1159/000156540.
- [20] White, F. J. 1991 Social organization, feeding ecology, and reproductive strategy of ruffed lemurs, *Varecia variegata*. In *Primate Today: Proceedings of the 13th Congress of the International Primatological Society* (eds. A. Ehara, T. Kimura, O. Takenaka & M. Iwamoto), pp. 81–84. New York: Elsevier.
- [21] Britt, A. 1996 Environmental influences on the behavioural ecology of the black-and-white ruffed lemur (*Varecia variegata variegata*, kerr, 1792). Ph.D. thesis, University of Liverpool, Liverpool, UK.
- [22] Balko, E. 1998 The behavioral plasticity of *Varecia variegata* in Ranomafana National Park, Madagascar. Ph.D. thesis, SUNY College of Environmental Science and Forestry, Syracuse, NY.
- [23] Baden, A. L. 2011 Communal infant care in black-and-white ruffed lemurs (*Varecia variegata*). Ph.D. thesis, Stony Brook University, Stony Brook, NY.
- [24] Petter, J.-J. 1962 *Recherches sur l'écologie et l'éthologie des lémuriers malgaches*. Paris: Editions du Muséum.
- [25] Pollock, J. 1979 Spatial distribution and ranging behaviour in lemurs. In *The Study of Prosimian Behaviour* (eds. G. A. Doyle & R. G. Martin), pp. 359–409. New York: Academic Press.
- [26] Welch, C. & Katz, A. 1992 Survey and census work on lemurs in the natural reserve of Betampona in eastern Madagascar with a view to restocking. *Dodo: Journal of the Jersey Wildlife Preservation Trusts*, **28**, 45–58.
- [27] Balko, E. A. & Underwood, B. H. 2005 Effects of forest structure and composition on food availability for *Varecia variegata* at Ranomafana National Park, Madagascar. *American Journal of Primatology*, **66**(1), 45–70. doi:10.1002/ajp.20127.
- [28] Overdorff, D. J., Erhart, E. M. & Mutschler, T. 2005 Does female dominance facilitate feeding priority in black-and-white ruffed lemurs (*Varecia variegata*) in southeastern Madagascar? *American Journal of Primatology*, **66**, 7–22.
- [29] Ratsimbazafy, J. 2007 Diet composition, foraging, and feeding behavior in relation to habitat disturbance: implications for the adaptability of ruffed lemurs (*Varecia variegata editorium*) in Manombo Forest, Madagascar. In *Lemurs* (eds. L. Gould & M. L. Sauther), pp. 403–422. New York: Springer.
- [30] Stevens, J. R., Hallinan, E. V. & Hauser, M. D. 2005 The ecology and evolution of patience in two New World monkeys. *Biology Letters*, **1**(2), 223–226. doi:10.1098/rsbl.2004.0285.

- [31] Neyman, P. F. 1977 Aspects of the ecology and social organization of free-ranging cotton-top tamarins (*Saguinus oedipus*) and the conservation status of the species. In *The Biology and Conservation of the Callitrichidae* (ed. D. G. Kleiman), pp. 39–71. Washington, DC: Smithsonian Institution Press.
- [32] Hershkovitz, P. 1977 *Living New World Monkeys (Platyrrhini), Volume 1: With an Introduction to Primates*. Chicago: University of Chicago Press.
- [33] Savage, A., Giraldo, L. H., Soto, L. H. & Snowdon, C. T. 1996 Demography, group composition, and dispersal in wild cotton-top tamarin (*Saguinus oedipus*) groups. *American Journal of Primatology*, **38**, 85–100.
- [34] Maier, W., Alonso, C. & Langguth, A. 1982 Field observations on *Callithrix jacchus jacchus* L. *Zeitschrift für Säugetierkunde*, **47**, 334–346.
- [35] Hubrecht, R. C. 1985 Home-range size and use and territorial behavior in the common marmoset, *Callithrix jacchus jacchus*, at the Tapacura Field Station, Recife, Brazil. *International Journal of Primatology*, **6**, 533–550.
- [36] Stevenson, M. F. & Rylands, A. B. 1988 The marmosets, genus *Callithrix*. In *Ecology and Behavior of Neotropical Primates* (eds. R. A. Mittermeier, A. B. Rylands, A. F. Coimbra-Filho & G. A. B. Fonseca), vol. 2, pp. 131–222. Washington, DC: World Wildlife Fund.
- [37] Alonso, C. & Langguth, A. 1989 Ecologia e comportamento de *Callithrix jacchus* (Primates: Callitrichidae) numa ilha de floresta Atlântica. *Revista Nordestina de Biologia*, **6**(2), 105–137.
- [38] Scanlon, C. E., Chalmers, N. R. & Monteiro da Cruz, M. A. O. 1988 Changes in the size, composition, and reproductive condition of wild marmoset groups (*Callithrix jacchus jacchus*) in north east Brazil. *Primates*, **29**(3), 295–305. doi:10.1007/BF02380953.
- [39] Stevenson, M. F. 1978 The behaviour and ecology of the common marmoset (*Callithrix jacchus jacchus*) in its natural environment. *Biology and Behaviour of Marmosets*, p. 298.
- [40] Koenig, A. 1995 Group size, composition, and reproductive success in wild common marmosets (*Callithrix jacchus*). *American Journal of Primatology*, **35**(4), 311–317. doi:10.1002/ajp.1350350407.
- [41] Amici, F., Aureli, F. & Call, J. 2008 Fission-fusion dynamics, behavioral flexibility, and inhibitory control in primates. *Current Biology*, **18**(18), 1415–1419. doi:10.1016/j.cub.2008.08.020.
- [42] Addessi, E., Paglieri, F. & Focaroli, V. 2011 The ecological rationality of delay tolerance: insights from capuchin monkeys. *Cognition*, **119**(1), 142–147. doi:10.1016/j.cognition.2010.10.021.
- [43] Smith, R. J. & Jungers, W. L. 1997 Body mass in comparative primatology. *Journal of Human Evolution*, **32**(6), 523–559. doi:10.1006/jhev.1996.0122.
- [44] Izawa, K. 1980 Social behavior of the wild black-capped capuchin (*Cebus apella*). *Primates*, **21**(4), 443–467. doi:10.1007/BF02373834.
- [45] Freese, C. & Oppenheimer, J. 1981 The capuchin monkey, Genus *Cebus*. In *Ecology and Behavior of Neotropical Primates* (eds. A. F. Coimbra-Filho & R. A. Mittermeier), vol. 1, pp. 331–390. Washington, DC: World Wildlife Fund.
- [46] Terborgh, J. 1983 *Five New World Primates: A Study in Comparative Ecology*. Princeton, N.J.: Princeton University Press.

- [47] Robinson, J. & Janson, C. 1987 Capuchins, squirrel monkeys, and atelines: socioecological convergence with Old World primates. In *Primate Societies* (eds. B. Smuts, D. Cheney, R. Seyfarth, R. Wrangham & T. Struhsaker), pp. 69–82. Chicago: University of Chicago Press.
- [48] Di Bitetti, M. S. 2001 Home-range use by the tufted capuchin monkey (*Cebus apella nigritus*) in a subtropical rainforest of Argentina. *Journal of Zoology*, **253**(1), 33–45. doi:10.1017/S0952836901000048.
- [49] Izar, P., Verderane, M. P., Peternelli-dos Santos, L., Mendonça-Furtado, O., Presotto, A., Tokuda, M., Visalberghi, E. & Fragaszy, D. 2012 Flexible and conservative features of social systems in tufted capuchin monkeys: comparing the socioecology of *Sapajus libidinosus* and *Sapajus nigritus*. *American Journal of Primatology*, **74**(4), 315–331. doi:10.1002/ajp.20968.
- [50] Thorington, R. 1967 Feeding and activity of *Cebus* and *Saimiri* in a Colombian forest. In *Progress in Primatology* (eds. D. Stark, R. Schneider & H. J. Kuhn), pp. 180–184. Stuttgart: Gustav Fischer Verlag.
- [51] Fragaszy, D. M., Visalberghi, E. & Fedigan, L. M. 2004 *The Complete Capuchin: The Biology of the Genus Cebus*. Cambridge: Cambridge University Press.
- [52] Stephan, H., Frahm, H. & Baron, G. 1981 New and revised data on volumes of brain structures in insectivores and primates. *Folia Primatologica*, **35**(1), 1–29.
- [53] Dare, R. J. 1974 The social behavior and ecology of spider monkeys, *Ateles geoffroyi*, on Barro Colorado Island. Ph.D. thesis, University of Oregon, Eugene, OR.
- [54] Coehlo, A., Coehlo, L., Bramblett, C., Bramblett, S. & Quick, L. 1976 Ecology, population characteristics and sympatric associations in primates: a bioenergetic analysis of howler and spider monkeys in Tikal. *Yearbook of Physical Anthropology*, **20**, 96–135.
- [55] Fedigan, L. M., Fedigan, L., Chapman, C. & Glander, K. E. 1988 Spider monkey home ranges: a comparison of radio telemetry and direct observation. *American Journal of Primatology*, **16**(1), 19–29. doi:10.1002/ajp.1350160104.
- [56] Chapman, C. A. 1990 Association patterns of spider monkeys: the influence of ecology and sex on social organization. *Behavioral Ecology and Sociobiology*, **26**(6), 409–414. doi:10.1007/BF00170898.
- [57] Campbell, C. J. 2000 The reproductive biology of black-handed spider monkeys (*Ateles geoffroyi*): Integrating behavior and endocrinology. Ph.D. thesis, University of California, Berkeley, Berkeley, CA.
- [58] Ramos-Fernández, G. & Ayala-Orozco, B. 2003 Population size and habitat use of spider monkeys in Punta Laguna, Mexico. In *Primates in Fragments: Ecology and Conservation* (ed. L. K. Marsh), pp. 191–209. New York: Springer.
- [59] Wallace, R. B. 2008 Towing the party line: territoriality, risky boundaries and male group size in spider monkey fission–fusion societies. *American Journal of Primatology*, **70**(3), 271–281. doi:10.1002/ajp.20484.
- [60] Carpenter, C. R. 1935 Behavior of red spider monkeys in Panama. *Journal of Mammalogy*, **16**(3), 171–180. doi:10.2307/1374442.
- [61] Eisenberg, J. F. & Kuehn, R. E. 1966 The behavior of *Ateles geoffroyi* and related species. *Smithsonian Miscellaneous Collections*, **151**(1-63).

- [62] Milton, K. 1993 Diet and social organization of a free-ranging spider monkey population: the development of species-typical behavior in the absence of adults. In *Juvenile Primates* (eds. M. Pereira & L. Fairbanks), pp. 173–181. Oxford: Oxford University Press.
- [63] Estrada, A., Luecke, L., Belle, S. V., Barrueta, E. & Meda, M. R. 2004 Survey of black howler (*Alouatta pigra*) and spider (*Ateles geoffroyi*) monkeys in the Mayan sites of Calakmul and Yaxchilán, Mexico and Tikal, Guatemala. *Primates*, **45**(1), 33–39. doi:10.1007/s10329-003-0062-8.
- [64] Tobin, H., Logue, A. W., Chelonis, J. J. & Ackerman, K. T. 1996 Self-control in the monkey *Macaca fascicularis*. *Animal Learning and Behavior*, **24**(2), 168–174.
- [65] Roonwal, M. L. & Mohnot, S. M. 1977 *Primates of South Asia: Ecology, Sociobiology, and Behavior*. Cambridge, MA: Harvard University Press.
- [66] MacKinnon, J. & MacKinnon, K. 1978 Comparative feeding ecology of six sympatric primates in West Malaysia. In *Recent Advances in Primatology* (eds. D. Chivers & J. Herbert), vol. 1, pp. 305–321. New York: Academic Press.
- [67] Bakar, A., Amir, M. & Marshal 1981 Morphological studies on crab eating monkey in Indonesia. *Kyoto University Overseas Research Report of Studies on Indonesian Macaque*, **1**, 11–14.
- [68] Fooden, J. 1995 Systematic review of southeast Asian longtail macaques, *Macaca fascicularis* (Raffles, 1821). *Fieldiana Zoologica*, **81**, 1–206.
- [69] Jones, M. L. 1982 Longevity of captive mammals. *Zoologische Garten*, **52**(2), 113–128.
- [70] Kurland, J. A. 1973 A natural history of kra macaques (*Macaca fascicularis* Raffles, 1821) at the Kutai Reserve, Kalimantan Timur, Indonesia. *Primates*, **14**(2-3), 245–262. doi:10.1007/BF01730823.
- [71] van Schaik, C. P., van Noordwijk, M. A. v., de Boer, R. J. & den Tonkelaar, I. 1983 The effect of group size on time budgets and social behaviour in wild long-tailed macaques (*Macaca fascicularis*). *Behavioral Ecology and Sociobiology*, **13**(3), 173–181. doi:10.2307/4599622.
- [72] Furuya, Y. 1965 Social organization of the crab-eating monkey. *Primates*, **6**(3-4), 285–336. doi:10.1007/BF01730354.
- [73] Bernstein, I. S. 1967 A field study of the pigtail monkey (*Macaca nemestrina*). *Primates*, **8**, 217–228.
- [74] Medway, L. 1969 *The Wild Mammals of Malaya and Offshore Islands including Singapore*. Oxford University Press.
- [75] Fooden, J. 1971 Report on primates collected in western Thailand, January-April, 1967. *Fieldiana Zoology*, **59**, 1–62.
- [76] Poirier, F. E. & Smith, E. O. 1974 The crab-eating macaques (*Macaca fascicularis*) of Angaur Island, Palau, Micronesia. *Folia Primatologica*, **22**(4), 258–306. doi:10.1159/000155631.
- [77] Angst, W. 1975 Basic data and concepts on the social organization of *Macaca fascicularis*. *Primate Behavior*, **4**, 325–88.

- [78] Crockett, C. M. & Wilson, W. L. 1980 The ecological separation of *Macaca nemestrina* and *M. fascicularis* in Sumatra. In *The Macaques: Studies in Ecology, Behavior and Evolution* (ed. D. G. Lindburg), pp. 148–181. New York: Van Nostrand Reinhold.
- [79] Wheatley, B. P. 1980 Feeding and ranging of East Bornean *Macaca fascicularis*. In *The Macaques: Studies in Ecology, Behavior and Evolution* (ed. D. G. Lindburg), pp. 215–246. New York: Van Nostrand Reinhold.
- [80] Louie, K. & Glimcher, P. W. 2010 Separating value from choice: delay discounting activity in the lateral intraparietal area. *Journal of Neuroscience*, **30**(16), 5498–5507. doi:10.1523/jneurosci.5742-09.2010.
- [81] Pearson, J., Hayden, B. & Platt, M. 2010 Explicit information reduces discounting behavior in monkeys. *Frontiers in Psychology*, **1**, 237. doi:10.3389/fpsyg.2010.00237.
- [82] Altmann, S. A. 1962 A field study of the sociobiology of rhesus monkeys, *Macaca mulatta*. *Annals of the New York Academy of Sciences*, **102**(2), 338–435. doi:10.1111/j.1749-6632.1962.tb13650.x.
- [83] Napier, P. H. 1981 *Catalogue of Primates in the British Museum (Natural History) and Elsewhere in the British Isles*. London: British Museum (Natural History).
- [84] Fitch, W. T. 1997 Vocal tract length and formant frequency dispersion correlate with body size in rhesus macaques. *Journal of the Acoustical Society of America*, **102**(2), 1213–1222. doi:10.1121/1.421048.
- [85] Mattison, J. A., Roth, G. S., Beasley, T. M., Tilmont, E. M., Handy, A. M., Herbert, R. L., Longo, D. L., Allison, D. B., Young, J. E. *et al.* 2012 Impact of caloric restriction on health and survival in rhesus monkeys from the NIA study. *Nature*, **489**(7415), 318–321. doi:10.1038/nature11432.
- [86] Neville, M. K. 1968 Ecology and activity of Himalayan foothill rhesus monkeys (*Macaca mulatta*). *Ecology*, **49**(1), 110–123. doi:10.2307/1933566.
- [87] Teas, J., Richie, T., Taylor, H. & Southwick, C. 1980 Population patterns and behavioral ecology of rhesus monkeys (*Macaca mulatta*) in Nepal. In *The Macaques: Studies in Ecology, Behavior and Evolution*, pp. 247–262. New York: Van Nostrand Reinhold.
- [88] Southwick, C. H., Beg, M. A. & Siddiqi, M. R. 1961 A population survey of rhesus monkeys in villages, towns and temples of Northern India. *Ecology*, **42**(3), 538–547. doi:10.2307/1932240.
- [89] Southwick, C. H., Beg, M. A. & Siddiqi, M. R. 1965 Rhesus monkeys in north India. In *Primate Behavior: Field Studies of Monkeys and Apes* (ed. I. DeVore), pp. 111–159. New York: Holt.
- [90] Seth, P. K. & Seth, S. 1986 Ecology and behaviour of rhesus monkeys in India. In *Primate Ecology and Conservation* (eds. J. G. Else & P. C. Lee), vol. 2, pp. 89–103. Cambridge, UK: Cambridge University Press.
- [91] Eckhardt, R. B. 1975 The relative body weights of Bornean and Sumatran orangutans. *American Journal of Physical Anthropology*, **42**(3), 349–350. doi:10.1002/ajpa.1330420303.
- [92] Rodman, P. S. 1984 Foraging and social systems of orangutans and chimpanzees. In *Adaptations for Foraging in Nonhuman Primates* (eds. P. S. Rodman & R. G. H. Cant), pp. 134–160. New York: Columbia University Press.

- [93] Horr, D. A. 1975 The Borneo orang-utan: population structure and dynamics in relationship to ecology and reproductive strategy. *Primate behavior*, **4**, 307–323.
- [94] Rijksen, H. D. 1978 *A Field Study on Sumatran Orang-utans (Pongo pygmaeus abelii Lesson 1827)*. *Ecology, Behaviour and Conservation*. Wageningen: H. Veenman & Zonen.
- [95] Rodman, P. S. & Mitani, J. C. 1987 Orangutans: sexual dimorphism in a solitary species. In *Primate Societies* (eds. B. Smuts, D. Cheney, R. Seyfarth, R. Wrangham & T. Struhsaker), pp. 148–154. Chicago: University of Chicago Press.
- [96] Galdikas, B. M. F. 1988 Orangutan diet, range, and activity at Tanjung Puting, Central Borneo. *International Journal of Primatology*, **9**(1), 1–35. doi:10.1007/BF02740195.
- [97] Singleton, I. & van Schaik, C. P. 2001 Orangutan home range size and its determinants in a Sumatran swamp forest. *International Journal of Primatology*, **22**(6), 877–911. doi:10.1023/A:1012033919441.
- [98] Rodman, P. S. 1973 Population composition and adaptive organisation among orang-utans of the Kutai Reserve. In *Comparative Ecology and Behaviour of Primates* (eds. R. P. Michael & J. H. Crook), pp. 171–209. New York: Academic Press.
- [99] MacKinnon, J. 1974 The behaviour and ecology of wild orang-utans (*Pongo pygmaeus*). *Animal Behaviour*, **22**(1), 3–74. doi:10.1016/S0003-3472(74)80054-0.
- [100] Jungers, W. L. & Susman, R. L. 1984 Body size and skeletal allometry in African apes. In *The Pygmy Chimpanzee* (ed. R. L. Susman), pp. 131–177. New York: Springer.
- [101] Remis, M. J. 1994 Feeding ecology and positional behavior of western lowland gorillas (*Gorilla gorilla gorilla*) in the central african republic. Ph.D. thesis, Yale University, New Haven, CN.
- [102] Tutin, C. E. G. 1996 Ranging and social structure of lowland gorillas in the Lopé Reserve, Gabon. In *Great Ape Societies* (eds. W. C. McGrew, L. F. Marchant & T. Nishida), pp. 58–70. New York: Cambridge University Press.
- [103] Yamagiwa, J., Maruhashi, T., Yumoto, T. & Mwanza, N. 1996 Dietary and ranging overlap in sympatric gorillas and chimpanzees in Kahuzi-Biega National Park, Zaire. In *Great Ape Societies* (eds. W. C. McGrew, L. F. Marchant & T. Nishida), pp. 82–98. New York: Cambridge University Press.
- [104] Bermejo, M. 2004 Home-range use and intergroup encounters in western gorillas (*Gorilla g. gorilla*) at Lossi forest, North Congo. *American Journal of Primatology*, **64**(2), 223–232. doi:10.1002/ajp.20073.
- [105] Cipolletta, C. 2004 Effects of group dynamics and diet on the ranging patterns of a western gorilla group (*Gorilla gorilla gorilla*) at Bai Hokou, Central African Republic. *American Journal of Primatology*, **64**(2), 193–205. doi:10.1002/ajp.20072.
- [106] Doran-Sheehy, D. M., Greer, D., Mongo, P. & Schwindt, D. 2004 Impact of ecological and social factors on ranging in western gorillas. *American Journal of Primatology*, **64**(2), 207–222. doi:10.1002/ajp.20075.
- [107] Robbins, M. M., Nkurunungi, J. B. & McNeilage, A. 2006 Variability of the feeding ecology of eastern gorillas. In *Feeding Ecology in Apes and Other Primates* (eds. G. Hohmann, M. M. Robbins & C. Boesch), vol. 48, pp. 25–47. Cambridge, UK: Cambridge University Press.

- [108] Yamagiwa, J. & Basabose, A. K. 2006 Diet and seasonal changes in sympatric gorillas and chimpanzees at Kahuzi-Biega National Park. *Primates*, **47**(1), 74–90. doi:10.1007/s10329-005-0147-7.
- [109] Fay, J. M. 1989 Partial completion of a census of the western lowland gorilla (*Gorilla g. gorilla* (Savage and Wyman)) in southwestern Central African Republic. *Mammalia*, **53**(2), 203–215. doi:10.1515/mamm.1989.53.2.203.
- [110] Tutin, C. E. G., Fernandez, M., Rogers, M. & Williamson, E. 1992 A preliminary analysis of the social structure of lowland gorillas in the Lopé Reserve, Gabon. In *Topics in Primatology: Behavior, Ecology, and Conservation* (eds. N. Itiogawa, Y. Sugiyama, G. P. Sackett & R. K. R. Thompson), vol. 2, pp. 245–254. Tokyo: University of Tokyo Press.
- [111] Mitani, M., Yamagiwa, J., Oko, R., Moutsambote, J., Yumoto, T. & Maruhashi, T. 1993 Approaches in density estimates and reconstruction of social groups in a western lowland gorilla population in the Ndoki forest, northern Congo. *Tropics*, **2**, 219–229.
- [112] Nishihara, T. 1994 Population density and group organization of gorillas (*Gorilla gorilla gorilla*) in the Nouabale-Ndoki National Park, Congo. *Africa Kenkyu*, **44**, 29–45.
- [113] Remis, M. J. 1993 Nesting behavior of lowland gorillas in the Dzanga-Sangha Reserve, Central African Republic: implications for population estimates and understandings of group dynamics. *Tropics*, **2**(4), 245–255.
- [114] Magliocca, F., Querouil, S. & Gautier-Hion, A. 1999 Population structure and group composition of western lowland gorillas in North-Western Republic of Congo. *American Journal of Primatology*, **48**(1), 1–14. doi:10.1002/(SICI)1098-2345(1999)48:1<1::AID-AJP1>3.0.CO;2-2.
- [115] Parnell, R. J. 2002 Group size and structure in western lowland gorillas (*Gorilla gorilla gorilla*) at Mbeli Bai, Republic of Congo. *American Journal of Primatology*, **56**(4), 193–206. doi:10.1002/ajp.1074.
- [116] Rosati, A. G., Stevens, J. R., Hare, B. & Hauser, M. D. 2007 The evolutionary origins of human patience: temporal preferences in chimpanzees, bonobos, and adult humans. *Current Biology*, **17**(19), 1663–1668. doi:10.1016/j.cub.2007.08.033.
- [117] Deschner, T., Kratzsch, J. & Hohmann, G. 2008 Urinary C-peptide as a method for monitoring body mass changes in captive bonobos (*Pan paniscus*). *Hormones and Behavior*, **54**(5), 620–626. doi:10.1016/j.yhbeh.2008.06.005.
- [118] Kano, T. 1982 The social group of pygmy chimpanzees (*Pan paniscus*) of Wamba. *Primates*, **23**(2), 171–188. doi:10.1007/BF02381159.
- [119] Badrian, A. & Badrian, N. 1984 Social organization of *Pan paniscus* in the Lomako Forest, Zaire. In *The Pygmy Chimpanzee: Evolutionary Biology and Behavior* (ed. R. L. Susman), pp. 325–346. New York: Springer.
- [120] Kano, T. & Mulavwa, M. 1984 Feeding ecology of the pygmy chimpanzees (*Pan paniscus*) of Wamba. In *The Pygmy Chimpanzee: Evolutionary Biology and Behavior* (ed. R. L. Susman), pp. 233–274. New York: Springer.
- [121] Hashimoto, C., Tashiro, Y., Kimura, D., Enomoto, T., Ingmanson, E. J., Idani, G. & Furuichi, T. 1998 Habitat use and ranging of wild bonobos (*Pan paniscus*) at Wamba. *International Journal of Primatology*, **19**(6), 1045–1060. doi:10.1023/A:1020378320913.

- [122] Kuroda, S. 1979 Grouping of the pygmy chimpanzees. *Primates*, **20**(2), 161–183. doi:10.1007/BF02373371.
- [123] White, F. J. 1988 Party composition and dynamics in *Pan paniscus*. *International Journal of Primatology*, **9**(3), 179–193. doi:10.1007/BF02737400.
- [124] Rahm, U. 1967 Observations during chimpanzee captures in the Congo. In *Progress in Primatology* (eds. D. Stark, R. Schneider & H. J. Kuhn), pp. 195–207. Stuttgart: Gustav Fischer Verlag.
- [125] Pusey, A. E. 1978 The physical and social development of wild adolescent chimpanzees: (*pan troglodytes schweinfurthii*). Ph.D. thesis, Graduate Division Special Programs, Ethology, Stanford University, Palo Alto, CA.
- [126] Wrangham, R. W. & Smuts, B. B. 1980 Sex differences in the behavioural ecology of chimpanzees in the Gombe National Park, Tanzania. *Journal of Reproduction and Fertility*, **Suppl 28**, 13–31.
- [127] Uehara, S. & Nishida, T. 1987 Body weights of wild chimpanzees (*Pan troglodytes schweinfurthii*) of the Mahale Mountains National Park, Tanzania. *American Journal of Physical Anthropology*, **72**(3), 315–321. doi:10.1002/ajpa.1330720305.
- [128] Goodall, J. 1965 Chimpanzees of the Gombe Stream Reserve. In *Primate Behavior: Field Studies of Monkeys and Apes* (ed. I. DeVore), pp. 425–473. New York: Holt.
- [129] Reynolds, V. & Reynolds, F. 1965 Chimpanzees of the Budongo Forest. In *Primate Behavior: Field Studies of Monkeys and Apes* (ed. I. DeVore), pp. 368–424. New York: Holt.
- [130] Sugiyama, Y. 1968 Social organization of chimpanzees in the Budongo Forest, Uganda. *Primates*, **9**(3), 225–258. doi:10.1007/BF01730972.
- [131] Izawa, K. 1970 Unit groups of chimpanzees and their nomadism in the savanna woodland. *Primates*, **11**(1), 1–45. doi:10.1007/BF01730674.
- [132] Kano, T. 1971 The chimpanzee of Filabanga, western Tanzania. *Primates*, **12**(3-4), 229–246. doi:10.1007/BF01730413.
- [133] Kano, T. 1972 Distribution and adaptation of the chimpanzee on the eastern shore of Lake Tanganyika. *Kyoto University African Studies*, **7**, 37–129.
- [134] Nishida, T. & Kawanaka, K. 1972 Inter-unit-group relationships among wild chimpanzees of the Mahali Mountains. *Kyoto University African Studies*, **7**, 131–169.
- [135] Nishida, T., Uehara, S. & Nyundo, R. 1979 Predatory behavior among wild chimpanzees of the Mahale Mountains. *Primates*, **20**(1), 1–20.
- [136] Baldwin, P. J., McGrew, W. C. & Tutin, C. E. G. 1982 Wide-ranging chimpanzees at Mt. Assirik, Senegal. *International Journal of Primatology*, **3**(4), 367–385. doi:10.1007/BF02693739.
- [137] Tutin, C. E. G., McGrew, W. C. & Baldwin, P. J. 1983 Social organization of savanna-dwelling chimpanzees, *Pan troglodytes verus*, at Mt. Assirik, Senegal. *Primates*, **24**(2), 154–173. doi:10.1007/BF02381079.
- [138] Ghiglieri, M. P. 1984 *The Chimpanzees of the Kibale Forest: A Field Study of Ecology and Social Structure*. New York: Columbia University Press.

- [139] Boesch, C. & Boesch, H. 1989 Hunting behavior of wild chimpanzees in the Tai National Park. *American Journal of Physical Anthropology*, **78**, 547–573.
- [140] Newton-Fisher, N. E. 2003 The home range of the Sonso community of chimpanzees from the Budongo Forest, Uganda. *African Journal of Ecology*, **41**(2), 150–156. doi:10.1046/j.1365-2028.2003.00408.x.
- [141] Kortlandt, A. 1967 Experimentation with chimpanzees in the wild. In *Neue Ergebnisse der Primatologie* (eds. D. Stark, R. Schneider & H. J. Kuhn), pp. 208–224. Stuttgart: Fischer.
- [142] Nishida, T. 1968 The social group of wild chimpanzees in the Mahali Mountains. *Primates*, **9**(3), 167–224.
- [143] Suzuki, A. 1971 Carnivory and cannibalism observed among forest-living chimpanzees. *Journal of Anthropological Society of Nippon*, **79**(1), 30–48. doi:10.1537/ase1911.79.30.
- [144] Wrangham, R. W. 1977 Feeding behavior of chimpanzees in Gombe National Park, Tanzania. In *Primate Ecology: Studies of Feeding and Ranging Behaviour in Lemurs, Monkeys, and Apes* (ed. T. H. Clutton-Brock), pp. 503–538. New York: Academic Press.
- [145] Nishida, T. & Hiraiwa-Hasegawa, M. 1987 Chimpanzees and bonobos: cooperative relationships among males. In *Primate Societies* (eds. D. L. Cheney, R. M. Seyfarth, B. B. Smuts, T. T. Struhsaker & R. W. Wrangham), pp. 165–177. Chicago: University of Chicago Press.
- [146] Arnold, C., Matthews, L. J. & Nunn, C. L. 2010 The 10ktrees website: a new online resource for primate phylogeny. *Evolutionary Anthropology*, **19**(3), 114–118. doi:10.1002/evan.20251.