

Selected studies supported by the German Primate Centre Endocrinology Laboratory using Non-invasive Hormone and Immune Marker Measurements

A) MONITORING FEMALE REPRODUCTIVE STATUS

Higham, J.P.; Heistermann, M.; Agil, M.; Perwitasari-Farajallah, D.; Widdig, A.; Engelhardt, A. (2021). Female fertile phase synchrony, and male mating and reproductive skew, in the **crested macaque**. *Sci. Rep.* 11: 4251.

Bernaldo de Quirós, E.; Wheeler, B.C.; Hammerschmidt, K.; Heistermann, M.; Tiddi, B (2018). Do sexual calls in female **black capuchin monkeys** (*Sapajus nigritus*) vary with fertility? An acoustic analysis. *Am. J. Primatol.* 80: e22920.

Hidayatik, N.; Agil, M.; Heistermann, M.; Iskandar, E.; Yusuf, T.L.; Sajuthi, D. (2018). Assessing reproductive status of **spectral tarsier** (*Tarsius tarsier*) using fecal steroid hormone metabolite analysis. *Am J. Primatol.* 80: e22917.

Tiddi, B., Wheeler, B., Heistermann, M. (2015). Female behavioural proceptivity functions as a probabilistic signal of fertility, not female quality, in a **New World primate**. *Horm. Behav.* 73: 148-155.

Fürtbauer, I., Heistermann, M.; Schülke, O., Ostner, O. (2013). Female fecal androgens prior to the mating season reflect readiness to conceive in reproductively quiescent wild **macaques**. *Am. J. Phys. Anthropol.* 151: 311-315.

Young, C.; Majolo, B.; Heistermann, M.; Schülke, O.; Ostner, O. (2013). Male mating behavior in relation to female sexual swellings, socio-sexual behavior and hormonal changes in wild **Barbary macaques**. *Horm. Behav.* 63: 32-39.

Higham, J.P., Heistermann, M., Saggau, C., Agil, M., Perwitasari-Farajallah, D., Engelhardt, A. (2012). Sexual signaling in female **crested macaques** and the evolution of primate fertility signals. *BMC Evol. Biol.* 12: 89.

Dubuc, C, Muniz, L., Heistermann, M., Widdig, A., Engelhardt, A. (2012). Do males time their mate-guarding effort with the fertile phase in order to secure fertilisation in Cayo Santiago **rhesus macaques**? *Horm. Behav.* 61: 696-705.

Fürtbauer, I.; Heistermann, M.; Schülke, O.; Ostner J. (2012). Fecal androgen excretion and fetal sex effects during gestation in wild **Assamese macaques** (*Macaca assamensis*). *Am. J. Phys. Anthropol.* 147: 334-339.

Engelhardt, A., Fischer, J., Neumann, C., Pfeiffer, J.-B., Heistermann, M. (2012). Information content of female copulation calls in wild **long-tailed macaques**. *Behav. Ecol. Sociobiol.* 66: 121-134.

Fürtbauer, I., Mundry, R., Heistermann, M., Schülke, O., Ostner, J. (2011). You mate, I mate: **Macaque** females synchronize sex not cycles. *Plos One* 6(10): e26144.

Mandalaywala, T.M., Higham, J.P., Heistermann, M., Maestripieri, D. (2011). Infant bystanders modulate the influence of ovarian hormones on female socio-sexual behaviours in free-ranging **rhesus macaques**. *Behaviour* 148: 1137-1155.

- Fischer, J., Semple, S., Fickenscher, G., Jürgens, R., Kruse, E., Heistermann, M., Amir, O. (2011). Do women's voices provide cues to the likelihood of ovulation? The importance of sampling regime. Plos One 6(9): e24490.
- Fürtbauer, I., Heistermann, M., Schülke, O., Ostner, J. (2011). Concealed fertility and extended female sexuality in a non-human primate (*Macaca assamensis*). Plos One 6(8):e:23105.
- Dubuc, C., Muniz, L., Heistermann, M., Engelhardt, A., Widdig, A. (2011). Testing the Priority-of-Access model in a seasonally breeding primate species. Behav. Ecol. Sociobiol. 65: 1615-1627.
- Pfefferle D., Heistermann, M., Pirow, R., Hodges, JK., Fischer, J. (2011). Estrogen and progestogen correlates of the structure of female copulation calls – a study in semi-free-ranging **Barbary macaques** (*Macaca sylvanus*). Int. J. Primatol. 32: 992-1006.
- Fürtbauer, I., Schülke, O., Heistermann, M., Ostner, J. (2010). Reproductive and life-history parameters of wild **Assamese macaques** (*Macaca assamensis*). Int. J. Primatol. 31: 501-517.
- Higham, J.P., Brent, L.J.N., Dubuc, C., Accamando, A.K., Engelhardt, A., Gerald, M., Heistermann, M., Stevens, M. (2010). Colour signal information content and the eye of the beholder: a case study in the **rhesus macaque**. Behav. Ecol. 21: 739-746.
- Dubuc, C., Brent, L.J.N., Accamando, A.K., Gerald, M.S., MacLarnon, A., Semple, S., Heistermann, M., Engelhardt, A. (2009). Sexual skin color contains information about timing of the fertile phase in free-ranging **rhesus macaques**. Int. J. Primatol. 30: 777-789.
- Higham, J., Semple, S., MacLarnon, A., Heistermann, M., Ross, C. (2009). Female reproductive signalling, and male mating behavior, in the **olive baboon**. Horm. Behav. 55: 60-67.
- Daspre, A., Heistermann, M., Hodges, K., Lee P., Rosetta, L. (2009). Signals of female reproductive quality and fertility in colony-living **baboons** (*Papio h. anubis*) in relation to ensuring paternal investment. Am. J. Primatol. 71: 529-538.
- Brauch, K., Hodges, J.K., Fuhrmann, K., Shaw, E., Heistermann, M. (2008). Sex-specific reproductive behaviours and paternity in free-ranging **Barbary macaques** (*Macaca sylvanus*). Behav. Ecol. Sociobiol. 62: 1453-1466.
- Higham, J., MacLarnon, A., Ross, C., Heistermann, M., Semple, S. (2008). **Baboon** sexual swellings: information content of size and color. Horm. Behav. 53: 452-462.
- Higham, J., Heistermann, M., Ross, C., Semple, S., MacLarnon, A. (2008). The timing of ovulation with respect to sexual swelling detumescence in wild **olive baboons**. Primates 49: 295-299.
- Pfefferle, D., Brauch, K., Heistermann, M., Hodges, J.K., Fischer, J. (2008). Female **Barbary macaque** copulation calls do not reveal the fertile phase but influence mating outcome. Proc. Roy. Soc. Lond. B 275: 571-578.
- Heistermann, M., Brauch, K., Möhle, U., Pfefferle, D., Dittami, J., Hodges, K. (2008). Female ovarian cycle phase affects the timing of male sexual activity in free-ranging **Barbary macaques** (*Macaca sylvanus*) of Gibraltar. Am. J. Primatol. 70: 44-53.
- Engelhardt, A., Hodges, J.K., Heistermann, M. (2007). Post-conception mating in wild **long-tailed macaques** (*Macaca fascicularis*): characterization, endocrine correlates and functional significance. Horm. Behav. 51: 3-10.

- Barelli, C., Heistermann M., Boesch, C., Reichard, U. H. (2007). Sexual swelling in wild **white-handed gibbon** females (*Hylobates lar*) indicates the probability of ovulation. Horm. Behav. 51: 221-230.
- Brauch, K., Pfefferle, D., Hodges, J.K., Möhle, U., Fischer, J., Heistermann, M. (2007). Female sexual behavior and sexual swelling size as potential cues for males to discern the female fertile phase in free-ranging **Barbary macaques** (*Macaca sylvanus*) of Gibraltar. Horm. Behav. 52: 375-383.
- Higham, J., Ross, C., Warren, Y., Heistermann, M., MacLarnon, A.M. (2007). Reduced reproductive function in wild **baboons** (*Papio hamadryas anubis*) related to natural consumption of the African black plum (*Vitex doniana*). Horm. Behav. 52: 384-390.
- Engelhardt, A., Heistermann, M., Hodges, J.K., Nürnberg, P., Niemitz, C. (2006). Determinants of male reproductive success in wild **long-tailed macaques** (*Macaca fascicularis*) – male monopolisation, female mate choice or post-copulatory mechanisms? Behav. Ecol. Sociobiol. 59: 740-752.
- Nikitopoulos, E., Heistermann, M., de Vries, H., van Hooff, J.A.R.A.M., Sterck, E.H.M. (2005). A pair choice test to identify female mating pattern relative to ovulation in **long-tailed macaques** (*Macaca fascicularis*). Anim. Behav. 70: 1283-1296.
- Möhle, U., Heistermann, M., Dittami, J., Reinberg, V., Hodges, J.K. (2005). Endocrine correlates of anogenital swelling size during ovulatory cycles and early pregnancy in free-ranging **Barbary macaques** (*Macaca sylvanus*) of Gibraltar. Am. J. Primatol. 66: 351-368.
- Engelhardt, A., Hodges, J.K., Niemitz, C., Heistermann, M. (2005). Female sexual behavior, but not sex skin swelling reliably indicates the timing of the fertile phase in wild **long-tailed macaques** (*Macaca fascicularis*). Horm. Behav. 47: 195-204.
- Klinkova, E., Hodges, J.K., Fuhrmann, K., de Jong, T., Heistermann, M. (2005). Male dominance rank, female mate choice and male mating and reproductive success in captive **chimpanzees**. Int. J. Primatol. 26: 357-384.
- Deschner, T., Heistermann, M., Hodges, K., Boesch, C. (2004). Female sexual swelling size, timing of ovulation and male behavior in wild West African **chimpanzees**. Horm. Behav. 46: 204-215.
- Löttker, P., Huck, M., Heymann, E.W., Heistermann, M. (2004). Endocrine correlates of reproductive status in breeding and non-breeding wild female **moustached tamarins** (*Saguinus mystax*). Int. J. Primatol., 919-937.
- Engelhardt, A., Pfeifer, J.-B., Heistermann, M., van Hooff, J.A.R.A.M., Niemitz, C., Hodges, J.K. (2004): Assessment of female reproductive status by male **long-tailed macaques** (*Macaca fascicularis*) under natural conditions. Anim. Behav. 67: 915-924.
- Gerber, P., Moisson, P., Heistermann, M. (2004). Comparative studies on urinary progestogen and estrogen excretion during pregnancy in **Lemuridae**; *Eulemur macaco flavifrons*, *Eulemur rubriventer*, and *Hapalemur griseus occidentalis*. Int. J. Primatol. 25: 449-463.
- Heistermann, M., Ademmer, C., Kaumanns, W. (2004). Ovarian cycle and effect of social changes on adrenal and ovarian function in **Pygathrix nemaeus**. Int. J. Primatol. 25: 689-708.
- Ostner, J., Heistermann, M. (2003). Endocrine characterization of female reproductive status in wild **red-fronted lemurs** (*Eulemur fulvus rufus*). Gen. Comp. Endocrinol. 131: 274-283.

- Deschner, T., Heistermann, M., Hodges, J.K., Boesch, C (2003). Timing and probability of ovulation in relation to sex skin swelling in wild **chimpanzees**, *Pan troglodytes*. Anim. Behav. 66: 551-560.
- Reichert, K., Heistermann, M., Hodges, J.K., Boesch, C., Hohmann, G. (2002). What females tell males about their reproductive status: Are morphological and behavioural cues reliable signals of ovulation in captive **bonobos** (*Pan paniscus*)? Ethology 108: 583-600.
- Heistermann, M., Ziegler, T., van Schaik, C.P., Launhardt, K., Winkler, P., Hodges, J.K (2001). Loss of oestrus, concealed ovulation and paternity confusion in free-ranging **Hanuman langurs**. Proc. R. Soc. Lond. B 268: 2445-2451.
- Heistermann, M., Uhrigshardt, J., Husung, A., Kaumanns, W., Hodges, J.K. (2001). Measurement of faecal steroid metabolites in the **lion-tailed macaque** (*Macaca silenus*): A non-invasive tool for assessing ovarian function. Primate Report. 59: 27-42.
- De Vleeschouwer, K., Heistermann, M., Van Elsacker, L. (2000). Signaling of reproductive status in female **golden-headed lion tamarins** (*Leontopithecus chrysomelas*). Int. J. Primatol. 21: 445-465.
- Ziegler, T., Hodges, J.K., Winkler, P., Heistermann, M. (2000). Hormonal correlates of reproductive seasonality in wild female **Hanuman langurs** (*Presbytis entellus*). Am. J. Primatol. 51: 119-134.
- De Vleeschouwer, K., van Elsacker, L., Heistermann, M., Leus, K. (2000). An evaluation of the suitability of contraceptive methods in **golden-headed lion tamarins** (*Leontopithecus chrysomelas*), with emphasis on melengestrol acetate (MGA) implants: II) Endocrino-logical and behavioural effects. Animal Welfare 9: 385-401.
- Carosi, M., Heistermann, M., Visalberghi, E. (1999). Display of proceptive behaviors in relation to urinary and fecal progestin levels over the ovarian cycle in female **tufted capuchin monkeys**. Horm. Behav. 36: 252-265.
- Fieß, M., Heistermann, M., Hodges, J.K. (1999). Patterns of urinary and faecal progestin and estrogen excretion during the ovarian cycle and pregnancy in the **African elephant** (*Loxodonta africana*). Gen. Comp. Endocrinol. 115: 76-89.
- Aujard, F., Heistermann, M., Thierry, B., Hodges, J.K. (1998). The functional significance of behavioural, morphological and endocrine correlates across the ovarian cycle in semi-free ranging **Tonkean macaques**. Am. J. Primatol. 46: 285-309.
- Heistermann, M., Agil, M., Büthe, A., Hodges, J.K. (1998). Metabolism and excretion of oestradiol-17 β and progesterone in the female **Sumatran rhinoceros** (*Dicerorhinus sumatrensis*). Anim. Reprod. Sci. 53: 157-172.
- Küderling, I., Heistermann, M. (1997). Ultrasonographic and hormonal monitoring of pregnancy in the **saddle-back tamarin** (*Saguinus fuscicollis*). J. Med. Primatol. 26: 299-306.
- Heistermann, M., Trohorsch, B., Hodges, J.K. (1997). Assessment of ovarian function in the **African elephant** (*Loxodonta africana*) by measurement of 5 α -reduced progesterone metabolites in plasma and urine. Zoo Biology 16: 273-284.
- Thierry, B., Heistermann, M., Aujard, F., Hodges, J.K. (1996). Long-term data on basic reproductive parameters and evaluation of endocrine, morphological and behavioral measures for monitoring reproductive status in a group of semi-free ranging **Tonkean macaques** (*Macaca tonkeana*). Am. J. Primatol. 39: 47-62.

Heistermann, M., Möhle, U., Vervaecke, H., van Elsacker, L., Hodges, J.K. (1996). Application of urinary and fecal steroid measurements for monitoring ovarian function and pregnancy in the **bonobo** (*Pan paniscus*) and evaluation of perineal swelling patterns in relation to endocrine events. *Biol. Reprod.* 55: 844-853.

Heistermann, M., Finke, M., Hodges, J.K. (1995). Assessment of female reproductive status in captive-housed **Hanuman langurs** (*Presbytis entellus*) by measurement of urinary and fecal steroid excretion patterns. *Am. J. Primatol.* 37: 275-284.

Heistermann, M., Hodges, J.K. (1995). Endocrine monitoring of the ovarian cycle and pregnancy in the **saddle-back tamarin** (*Saguinus fuscicollis*) by measurement of steroid conjugates in urine. *Am. J. Primatol.* 35: 117-127.

Heistermann, M., Tari, S., Hodges, J.K. (1993). Measurement of faecal steroids for monitoring ovarian function in New World primates, **Callitrichidae**. *J. Reprod. Fert.* 99: 243-251.

B) MONITORING MALE ANDROGEN STATUS

Rincon, A.V.; Heistermann, M.; Schülke, O.; Ostner, J. (2020). Testosterone and cortisol are negatively associated with ritualized bonding behavior in male **macaques**. *Psychoneuroendocrinology* 120: 104774.

Fürtbauer, I.; Brown, R.; Heistermann, M. (2020). Collective action reduces androgen responsiveness with implications for shoaling dynamics in **stickleback fish**. *Horm. Behav.* 119: 104636.

Kalbitzer, U., Heistermann, M., Cheney, D., Seyfarth, R.M., Fischer, J. (2015). Social behavior and patterns of testosterone and glucocorticoid levels differ between male **chacma and Guinea baboons**. *Horm. Behav.* 75: 100-110.

Marty, P. R., van Noordwijk, M.A., Heistermann, M., Willems, E.P., Dunkel, L.P., Cadilek, M., Agil, M., Weingrill, T. (2015). Endocrinological correlates of male bimaturism in wild **Bornean orangutans**. *Am. J. Primatol.* 77: 1170-1178.

Girard-Buttoz, C.; Heistermann, M.; Rahmi, E.; Agil, M.; Fauzan, P.A.; Engelhardt, A. (2015). Androgen correlates of male reproductive effort in wild male **long-tailed macaques** (*Macaca fascicularis*): A multi-level test of the challenge hypothesis. *Physiol. Behav.* 141: 143-153.

Barelli, C.; Mundry, R.; Heistermann, M.; Hammerschmidt, K. (2013). Cues to androgen and quality in male **gibbon** songs. *PLoS One* 8(12): e82748.

Higham, J.P.; Stevens, M; Pfefferle, D.; Heistermann, M.; Maestripieri, D. (2013). Signalling in multiple modalities in male **rhesus macaques**: sex skin coloration and barks in relation to androgen levels, social status and mating behavior. *Behav. Ecol. Sociobiol.* 67: 1457- 1469.

Higham, J.P., Heistermann, M., Maestripieri, D. (2013). The endocrinology of male **rhesus macaque** social and reproductive status: a test of the challenge and social stress hypotheses. *Behav. Ecol. Sociobiol.* 67: 19-30.

- Barelli, C., Heistermann, M. (2012). Socio-demographic correlates of fecal androgen levels in wild male **white-handed gibbons** (*Hylobates lar*). *Int. J. Primatol.* 33: 784-798.
- Weingrill, T.; Willems, E.P.; Zimmermann, N.; Steinmetz, H.; Heistermann, M. (2011). Species-specific patterns in fecal glucocorticoid and androgen levels in zoo-living **orangutans** (*Pongo spp.*). *Gen. Comp. Endocrinol.* 172: 446-457.
- Ostner, J., Heistermann, M., Schülke, O. (2011). Male competition and its hormonal correlates in **Assamese macaques** (*Macaca assamensis*). *Horm. Behav.* 59: 105-113.
- Ganswindt, A., Muenscher, S., Henley, M., Henley, S., Heistermann, M., Palme, R., Thompson, P., Bertschinger, H. (2010). Endocrine correlates of musth and the impact of ecological and social factors in free-ranging **African elephants** (*Loxodonta africana*). *Horm. Behav.* 57: 506-514.
- Girard-Buttoz, C., Heistermann, M., Krummel, S., Engelhardt, A. (2009). Seasonal and social influences on fecal androgen and glucocorticoid excretion in wild male **long-tailed macaques** (*Macaca fascicularis*). *Physiol. Behav.* 98: 168-175.
- Ostner, J., Kappeler, P.M., Heistermann, M. (2008). Androgen and glucocorticoid levels reflect seasonally occurring social challenges in male **redfronted lemurs** (*Eulemur fulvus rufus*). *Behav. Ecol. Sociobiol.* 62: 627-638.
- Huck, M., Löttker, P., Heymann, E.W., Heistermann, M. (2005). Characterization and social correlates of fecal testosterone and cortisol excretion in wild male **moustached tamarins** (*Saguinus mystax*). *Int. J. Primatol.* 26: 159-179.
- Ganswindt, A., Rasmussen, H., Heistermann, M., Hodges, J.K. (2005). The sexually active states of free-ranging **African elephants** (*Loxodonta africana*): Defining musth and non-musth using endocrinology, physical signals, and behavior. *Horm. Behav.* 47: 83-91.
- Ganswindt, A., Heistermann, M., Hodges, J.K. (2005). Physical, physiological and behavioural correlates of musth in captive **African elephants** (*Loxodonta africana*). *Physiol. Biochem. Zool.* 78: 505-514.
- Klinkova, E., Heistermann, M., Hodges, J.K. (2004). Social parameters and urinary testosterone level in male **chimpanzees** (*Pan troglodytes*). *Horm. Behav.* 46: 474-481.
- Sannen, A., van Elsacker, L., Heistermann, M., Eens, M. (2004). Urinary testosterone metabolite levels and dominance rank in male and female **bonobos** (*Pan paniscus*). *Primates* 45: 89-96.
- Sannen, A., van Elsacker, L., Heistermann, M., Eens, M. (2004). Urinary testosterone metabolite levels and aggressive behavior in male and female **bonobos**. *Aggr. Behav.* 30: 425-434.
- Sannen, A., van Elsacker, L., Eens, M., Heistermann, M. (2004). Urinary testosterone metabolite levels in captive **bonobos**: Relationship with age. *Folia Primatol.* 75: 107-110.
- Sannen, A., Heistermann, M., van Elsacker, L., Möhle, U., Eens, M. (2003). Urinary testosterone metabolite levels in **bonobos**: a comparison with chimpanzees in relation to social system. *Behaviour* 140: 683-696.
- Wich, S., van der Post, D.J., Heistermann, M., Möhle, U., van Hooff, J.A.R.A.M., Sterck, E.H.M. (2003). Life-phase related changes in male loud call characteristics and testosterone levels in wild **Thomas langurs**. *Int. J. Primatol.* 24: 1251-1265.

Möhle, U., Heistermann, M., Palme, R., Hodges, J.K. (2002). Characterization of urinary and fecal metabolites of testosterone and their measurement for assessing gonadal endocrine function in male nonhuman primates. *Gen. Comp. Endocrinol.* 129: 135-145.

Ostner, J., Kappeler, P.M., Heistermann, M. (2002). Seasonal variation and social correlates of testosterone excretion in **red-fronted lemurs** (*Eulemur fulvus rufus*). *Behav. Ecol. Sociobiol.* 52: 485-495.

Ganswindt, A., Heistermann, M., Borragan, S., Hodges, J.K. (2002). Assessment of testicular endocrine function in captive **African elephants** by measurement of fecal androgens. *Zoo Biol.* 21, 27-36.

Von Engelhardt, N., Kappeler, P.M., Heistermann, M. (2000). Androgen levels and female social dominance in **Lemur catta**. *Proc. R. Soc. Lond. B* 267: 1533-1539.

Kraus, C., Heistermann, M., Kappeler, P.M. (1999). Physiological suppression of sexual function of subordinate males: A subtle form of intrasexual competition in **sifakas** (*Propithecus verreauxi*). *Physiol. Behav.* 66: 855-861.

C) ASSESSMENT OF STRESS HORMONE LEVELS

Shutt-Phillips, K.; Pafco, B.; Heistermann, M.; Kasim, A.; Petrzelkova, K.; Profousová-Psenková, I.; Modry, D.; Todd, A.; Fuh, T.; Dicky, J.-F.; Bopalanizognako, J.-B.; Setchell, J. (2021). Fecal glucocorticoids and gastrointestinal parasite infections in wild western lowland gorillas (*Gorilla gorilla gorilla*) involved in ecotourism. *Gen. Comp. Endocrinol.*, in press.

Touitou, S.; Heistermann, M.; Schülke, O.; Ostner, J. (2021). Triiodothyronine and cortisol levels in the face of energetic challenges from reproduction, thermoregulation and food intake in female macaques. *Horm. Behav.* 131: 104968

Sadoughi, B.; Girard-Buttoz, C.; Engelhardt, A.; Heistermann, M.; Ostner, J. (2021). Non-invasive assessment of metabolic responses to food restriction using urinary triiodothyronine and cortisol measurement in **macaques**. *Gen. Comp. Endocrinol.* 306: 113736.

Dinter, K.; Heistermann, M.; Kappeler, P.M.; Fichtel, C. (2021). Life on the edge: behavioural and physiological responses of **Verreaux's sifakas** (*Propithecus verreauxi*) to forest edges. *Primate Biol.* 8: 1-13.

Kunz, J.A.; Duvot, G.J.; van Noordwijk, M.A.; Willems, E.P.; Townsend, M.; Mardianah, N.; Atmoko, S.S.U.; Vogel, E.R.; Nugraha, T.P.; Heistermann, M.; Agil, M.; Weingrill, T.; van Schaik, C.P. (2021). The cost of association with males for Bornean and Sumatran female **orangutans**: A hidden form of sexual conflict? *Behav. Ecol. Sociobiol.* 75: 6.

Higham, J.P.; Kimmock, C.M.; Mandalaywala, T.M.; Heistermann, M.; Cascio, J.; Petersdorf, M.; Winters, S.; Allen, W.L.; Dubuc, C. (2021). Female ornaments: is red skin color attractive to males and related to condition in **rhesus macaques**? *Behav. Ecol.* 32: 236-247.

Rincon, A.V.; Heistermann, M.; Schülke, O.; Ostner, J. (2020). Testosterone and cortisol are negatively associated with ritualized bonding behavior in male **macaques**. Psychoneuroendocrinology 120: 104774.

Rudolph, K.; Fichtel, C.; Heistermann, M.; Kappeler, P.M. (2020). Dynamics and determinants of glucocorticoid metabolite concentrations in wild **Verreaux's sifakas**. Horm. Behav. 124: 104760.

Carrera, S.C.; Sharmi, S.; Heistermann, M.; Lu, A.; Beehner, J.C. (2020). Low rank and primiparity increase fecal glucocorticoid metabolites across gestation in **wild geladas**. Gen. Comp. Endocrinol. 293: 113494.

Hambrecht, S., Oerke, A.-K.; Heistermann, M.; Dierkes, P.W. (2020). Diurnal variation of salivary cortisol in captive **African elephants** (*Loxodonta africana*) under normal management conditions and in relation to a translocation event. Zoo Biol. 39:186-196.

Thompson, N.A.; Higham, J.P.; Heistermann, M.; Vogel, E.; Cords, M. (2020). Energy balance but not competitive environment corresponds with allostatic load during development in an **Old World monkey**. Horm. Behav. 119: 104664.

Rudolph, K.; Fichtel, C.; Schneider, D.; Heistermann, M.; Koch, F.; Daniel, R.; Kappeler, P.M. (2019). One size fits all? Relationship among group size, health, and ecology indicate a lack of an optimal group size in a **wild lemur** population. Behav. Ecol. Sociobiol. 73: 132.

Müller-Klein, N.; Heistermann, M.; Strube, C.; Morbach, Z.M.; Lilie, N.; Franz, M.; Schülke, O.; Ostner, O. (2019). Physiological and social consequences of gastrointestinal nematode infection in a **non-human primate**. Behav. Ecol. 30: 322-335.

McLennan, M.R.; Howell, C.P.; Bardi, M.; Heistermann, M. (2019). Are human-dominated landscapes stressful for **wild chimpanzees** (*Pan troglodytes*)? Biol. Conserv. 233: 73-82.

Maag, N.; Cozzi, G.; Bateman, A.; Heistermann, M.; Ganswindt, A.; Manser, M.; Clutton-Brock, T.; Ozgul, A. (2019). Cost of dispersal in a **social mammal** – body mass loss and increased stress. Proc. R. Soc. B 286: 20190033.

Paschek, N.; Müller, N.; Heistermann, M.; Ostner, J.; Schülke, O. (2019). Subtypes of aggression and their relation to anxiety in **Barbary macaques**. Aggressive Behav. 45: 120-128.

Vlcková, K.; Shutt-Phillips, K.; Heistermann, M.; Pafco, B.; Petrzeková, K.J.; Todd, A.; Modrý, D.; Nelson, K.E.; Wilson, B.A.; Stumpf, R.M.; White, B.A.; Leigh, A.R.; Gomez, A. (2018). Stress impact on the gut microbiome of free-ranging **western lowland gorillas**. Microbiology 164: 40-44.

Kean, D.; Tiddi, B.; Fahy, M.; Heistermann, M.; Schino, G.; Wheeler, B.C. (2017). Feeling anxious? Feeding competition, anxiety, and the mechanisms of vocal deception in **tufted capuchin monkeys**. Anim. Behav. 130: 37-46.

Scott, K.; **Heistermann**, M.; Cant, M.A.; Vitikainen, E.I.K. (2017). Group size and visitor numbers predict faecal glucocorticoid concentrations in zoo **meerkats**. R. Soc. Open Sci. 4: 161017.

Marty, P.; Hodges, J.K.; Heistermann, M.; Agil, M.; Engelhardt, A. (2017). Is dispersal stressful? A study in male **crested macaques** (*Macaca nigra*). Horm. Behav. 87: 62-68.

Braga Goncalves, I.; Heistermann, M.; Santema, P.; Dantzer, B.; Mausbach, J.; Ganswindt, A.; Manser, M.B. (2016). Validation of a fecal glucocorticoid assay to assess adrenocortical activity in **meerkats** using physiological and biological stimuli. *PLoS One* 11 (4): e0153161.

Fürtbauer, I.; Heistermann, M. (2016). Cortisol coregulation in **fish**. *Sci. Rep.* 6: 30334

Berghänel, A.; Heistermann, M.; Schülke, O.; Ostner, J. (2016). Prenatal stress effects in a wild, long-lived **primate**: predictive adaptive responses in an unpredictable environment. *Proc. R. Soc. B.* 283: 20161304

Cannon, T.H., Heistermann, M., Hankison, S.J., Hockings, K.J., McLennan, M.R. (2016). Tailored enrichment strategies and stereotypic behavior in captive individually-housed **macaques** (*Macaca spp.*). *J. Appl. Anim. Welf. Sci.* 19: 171-182.

Kalbitzer, U., Heistermann, M., Cheney, D., Seyfarth, R.M., Fischer, J. (2015). Social behavior and patterns of testosterone and glucocorticoid levels differ between male **chacma and Guinea baboons**. *Horm. Behav.* 75: 100-110.

Marty, P. R., van Noordwijk, M.A., Heistermann, M., Willems, E.P., Dunkel, L.P., Cadilek, M., Agil, M., Weingrill, T. (2015). Endocrinological correlates of male bimaturism in wild **Bornean orangutans**. *Am. J. Primatol.* 77: 1170-1178.

Hämäläinen, A.; Heistermann, M.; Kraus, C. (2015). The stress of growing old: sex- and season-specific effects of age on allostatic load in wild **grey mouse lemurs**. *Oecologia* 178: 1063-1075.

Fürtbauer, I.; Pond, A.; Heistermann, M.; King, A. Personality, plasticity, and predation: linking endocrine and behavioural reaction norms in **stickleback fish**. *Funct. Ecol.* 29: 931-940.

Barelli, C., Rovero, F., Hodges, K., Araldi, A., Heistermann, M. Physiological stress levels in the endemic and endangered **Udzungwa red colobus** vary with elevation. *Afr. Zool.* 50: 23-30.

Young, C., Majolo, B., Heistermann, M., Schülke, O., Ostner, J. (2014). Responses to social and environmental stress are attenuated by strong male bonds in **wild macaques**. *P. Natl. Acad. Sci. USA* 111: 18195-18200.

Mandalaywala, T.M.; Higham, J.P.; Heistermann, M.; Parker, K.J.; Maestripieri, D. (2014). Physiological and behavioural responses to weaning conflict in free-ranging **primate infants**. *Anim. Behav.* 97: 241-247.

Girard-Buttoz, C.; Heistermann, M.; Rhami, E.; Agil, M.; Fauzan, P.A.; Engelhardt, A. (2014). Costs of mate-guarding in wild male **long-tailed macaques** (*Macaca fascicularis*): Physiological stress and aggression. *Horm. Behav.* 66: 637-648.

Balestri, M.; Barresi, M.; Campera, M.; Serra, V.; Ramanamanjato, J.P.; Heistermann, M.; Donati, G. (2014). Habitat degradation and seasonality affect physiological stress levels of **Eulemur collaris** in littoral forest fragments. *PLoS One* 9(9): e107698.

Girard-Buttoz, C.; Heistermann, M.; Rhami, E.; Agil, M.; Fauzan, P.A.; Engelhardt, A. (2014). Costs of and investment in mate-guarding in wild **long-tailed macaques** (*Macaca fascicularis*): Influences of female characteristics and male-female social bonds. *Int. J. Primatol.* 35: 701-724.

Fürtbauer, I.; Heistermann, M.; Schülke, O.; Ostner, J. (2014). Low female stress hormone levels are predicted by same- or opposite-sex sociality depending on season in wild **Assamese macaques**. Psychoneuroendocrinology 48: 19-28.

Wheeler, B.; Tiddi, B.; Heistermann, M. (2014). Competition-induced stress does not explain deceptive alarm calling in **capuchin monkeys**. Anim. Behav. 93: 49-58.

Shutt; K, Heistermann, M., Todd, A., Kasim, A., Kalousova B., Profosouva; I., Petrzekova, K., Fuh, T., Dicky, J.-F., Setchell, J.M. (2014). Effects of habituation, research and ecotourism on faecal glucocorticoid metabolites in wild western **lowland gorillas**: Implications for conservation management. Biol. Conserv. 172: 72-79.

Amrein, M.; Heistermann, M.; Weingrill, T. (2014). The effect of fission-fusion zoo housing on hormonal and behavioral indicators of stress in **Bornean orangutans** (*Pongo pygmaeus*). Int. J. Primatol. 35: 509-528.

Hämäläinen, A.; Heistermann, M.; Fenosa, Z.S.E.; Kraus, C. (2014). Evaluating capture stress in wild **grey mouse lemurs** via repeated fecal sampling: method validations and the influence of prior experience and handling protocols on stress responses. Gen. Comp. Endocrinol. 195: 68-79.

Rimbach, R.; Link, A.; Heistermann, M.; Gomez-Posada, C.; Heymann, E.W. (2013). Effects of human impact and forest fragment size on physiological stress levels in two sympatric **ateline primates** in Colombia. Conserv. Physiol. 1: cot031.

Wheeler, B.; Tiddi, B.; Kalbitzer, U.; Visalberghi, E.; Heistermann, M. (2013). Methodological considerations in the analysis of fecal glucocorticoid metabolites in tufted **capuchin monkeys** (*Cebus apella*). Int. J. Primatol. 34: 879-898.

Rimbach, R.; Heymann, E.W.; Link, A.; Heistermann, M. (2013). Validation of an enzymeimmunoassay for assessing adrenocortical activity and evaluation of factors that affect levels of fecal glucocorticoid metabolites in two **New World primates**. Gen. Comp. Endocrinol. 191: 13-23.

Gillespie, T.; Barelli, C.; Heistermann, M. (2013). Effects of social status and stress on patterns of gastrointestinal parasitism in wild **white-handed gibbons** (*Hylobates lar*). Am. J. Phys. Anthropol. 150: 602-608.

Higham, J.P., Heistermann, M., Maestripieri, D. (2013). The endocrinology of male **rhesus macaque** social and reproductive status: a test of the challenge and social stress hypotheses. Behav. Ecol. Sociobiol. 67: 19-30.

Shutt, C., Setchell, J., Heistermann, M (2012). Non-invasive monitoring of physiological stress in the western **lowland gorilla** (*Gorilla gorilla gorilla*): Validation of a faecal glucocorticoid assay and methods for practical application in the field. Gen. Comp. Endocrinol. 179: 167-177.

Pirovino, M.; Heistermann, M.; Zimmermann, N.; Zingg, R.; Clauss, M.; Codron, D.; Steinmetz, H.W. (2011). Fecal glucocorticoid measurements and their relation to rearing, behaviour and environmental factors in the population of **pileated gibbons** (*Hylobates pileatus*) held in European zoos. Int. J. Primatol. 32: 1161-1178.

Hoffman, C.L.; Higham, J.P.; Heistermann, M.; Coe, C.L.; Prendergast, B.P.; Maestripieri, D. (2011). Immune function and HPA axis activity in free-ranging **rhesus macaques**. Physiol. Behav. 104: 507-514.

- Weingrill, T.; Willems, E.P.; Zimmermann, N.; Steinmetz, H.; Heistermann, M. (2011). Species-specific patterns in fecal glucocorticoid and androgen levels in zoo-living **orangutans** (*Pongo spp.*). *Gen. Comp. Endocrinol.* 172: 446-457.
- Brent, L.J.N., Semple, S., Dubuc, C., Heistermann, M., MacLarnon, A. (2011). Social capital and physiological stress levels in adult female **rhesus macaques**. *Physiol. Behav.* 102: 76-83.
- Ganswindt, A., Muenscher, S., Henley, M., Henley, S., Heistermann, M., Palme, R., Thompson, P., Bertschinger, H. (2010). Endocrine correlates of musth and the impact of ecological and social factors in free-ranging **African elephants** (*Loxodonta africana*). *Horm. Behav.* 57: 506-514.
- Higham, J.P., MacLarnon, A., Heistermann, M., Ross, C., Semple, S. (2009). Rates of self-directed behaviour and faecal glucocorticoid levels are not correlated in female wild **olive baboons** (*Papio hamadryas anubis*). *Stress* 12: 526-532.
- Girard-Buttoz, C., Heistermann, M., Krummel, S., Engelhardt, A. (2009). Seasonal and social influences on fecal androgen and glucocorticoid excretion in wild male **long-tailed macaques** (*Macaca fascicularis*). *Physiol. Behav.* 98: 168-175.
- Ostner, J., Heistermann, M., Schülke, O. (2008). Dominance, aggression and physiological stress in wild male **Assamese macaques** (*Macaca assamensis*). *Horm. Behav.* 54: 613-619.
- Ostner, J., Kappeler, P.M., Heistermann, M. (2008). Androgen and glucocorticoid levels reflect seasonally occurring social challenges in male **redfronted lemurs** (*Eulemur fulvus rufus*). *Behav. Ecol. Sociobiol.* 62: 627-638.
- Shutt, K., MacLarnon, A., Heistermann, M., Semple, S. (2007). Grooming in **Barbary macaques**: better to give than to receive. *Biol. Lett.* 3: 231-233
- Fichtel, C., Kraus, C., Ganswindt, A., Heistermann, M. (2007). Influence of reproductive season on fecal glucocorticoid levels in free-ranging male **Verreaux's sifakas** (*Propithecus verreauxi*). *Horm. Behav.* 51: 640-648.
- Laws, N., Ganswindt, A., Heistermann, M., Harris, M., Harris, S., Sherwin, C. (2007). A case-study: Faecal corticosteroid and behaviour as indicators of welfare during relocation of an **Asian elephant**. *J. Appl. Anim. Welf. Sci.* 10: 349-358.
- Heistermann, M., Palme, R., Ganswindt, A. (2006). Comparison of different enzyme-immunoassays for assessment of adrenocortical activity in **primates** based on fecal samples. *Am. J. Primatol.* 68: 257-273.
- Steinmetz, H.W., Kaumanns, W., Dix, I., Heistermann, M., Fox, M., Kaup, F.-J. (2006). Coat condition, housing condition and measurement of faecal cortisol metabolites: A non-invasive study about *Alopecia* in captive **rhesus macaques** (*Macaca mulatta*). *J. Med. Primatol.* 35: 3-11.
- Huck, M., Lötker, P., Heymann, E.W., Heistermann, M. (2005). Characterization and social correlates of fecal testosterone and cortisol excretion in wild male **moustached tamarins** (*Saguinus mystax*). *Int. J. Primatol.* 26: 159-179.
- Ganswindt, A., Rasmussen, H., Heistermann, M., Hodges, J.K. (2005). The sexually active states of free-ranging **African elephants** (*Loxodonta africana*): Defining musth and non-musth using endocrinology, physical signals, and behavior. *Horm. Behav.* 47: 83-91.

Ganswindt, A., Heistermann, M., Hodges, J.K. (2005). Physical, physiological and behavioural correlates of musth in captive **African elephants** (*Loxodonta africana*). *Physiol. Biochem. Zool.* 78: 505-514.

Heistermann, M., Ademmer, C., Kaumanns, W. (2004). Ovarian cycle and effect of social changes on adrenal and ovarian function in ***Pygathrix nemaeus***. *Int. J. Primatol.* 25: 689-708.

Ganswindt, A., Palme, R., Heistermann, M., Borragan, S., Hodges, J.K. (2003). Non-invasive assessment of adrenocortical function in the male **African elephant** (*Loxodonta africana*) and its relation to musth. *Gen. Comp. Endocrinol.* 134: 156-166.

Schmid, J., Heistermann, M., Gansloßer, U., Hodges, J.K. (2001). Introduction of foreign female **Asian elephants** (*Elephas maximus*) in an existing group, behavioural reactions and changes in cortisol levels. *Anim. Welf.* 10: 357-372.

Bahr, N., Palme, R., Möhle, U., Hodges, J.K., Heistermann, M. (2000). Comparative aspects of the metabolism and excretion of cortisol in three individual **non-human primates**. *Gen. Comp. Endocrinol.* 117: 427-438.

D) ASSESSMENT OF IMMUNE STATUS

Behringer, V.; Deimel, C.; Stevens, J.M.G.; Kreyer, M.; Lee, S.; Hohmann, G.; Fruth, B.; Heistermann, M. (2021). Cell-mediated immune ontogeny is affected by sex but not environmental context in a long-lived **primate** species. *Front. Ecol. Evol.* 9: 629094.

Higham, J.P.; Stahl-Hennig, C.; Heistermann, M. (2020). Urinary suPAR: a non-invasive biomarker of infection and tissue inflammation for use in studies of large free-ranging mammals. *R. Soc. Open Sci.* 7: 191825.

Heistermann, M., Higham, J.P. (2015). Urinary neopterin, a non-invasive marker of mammalian cellular immune activation, is highly stable under field conditions. *Sci. Rep.* 5: 16308.

Higham, J.P., Kraus, C., Stahl-Hennig, C., Engelhardt, A., Fuchs, D., Heistermann, M. (2015). Evaluating non-invasive markers of **non-human primate** immune activation and inflammation. *Am. J. Phys. Anthropol.* 158: 173-184.

E) ASSESSMENT OF ENERGETIC STATUS

Touitou, S.; Heistermann, M.; Schülke, O.; Ostner, J. (2021). The effects of reproductive state on activity budget, feeding behavior and urinary C-peptide levels in wild female **Assamese macaques**. *Behav. Ecol. Sociobiol.*, in press.

Touitou, S.; Heistermann, M.; Schülke, O.; Ostner, J. (2021). Triiodothyronine and cortisol levels in the face of energetic challenges from reproduction, thermoregulation and food intake in female **macaques**. *Horm. Behav.* 131: 104968

Sadoughi, B.; Girard-Buttoz, C.; Engelhardt, A.; Heistermann, M.; Ostner, J. (2021). Non-invasive assessment of metabolic responses to food restriction using urinary triiodothyronine and cortisol measurement in **macaques**. *Gen. Comp. Endocrinol.* 306: 113736.

Fürtbauer, I.; Christensen, C.; Bracken, A.; O'Riain, J.; Heistermann, M.; King, A. (2020). Energetics at the urban edge: Environmental and individual predictors of urinary C-peptide levels in wild **chacma baboons** (*Papio ursinus*). *Horm. Behav.* 126: 104846.

Thompson, N.A.; Higham, J.P.; Heistermann, M.; Vogel, E.; Cords, M. (2020). Energy balance but not competitive environment corresponds with allostatic load during development in an **Old World monkey**. *Horm. Behav.* 119: 104664.

Girard-Buttoz, C., Heistermann, M., Rahmi, E., Marzec, A., Agil, M., Fauzan, P., Engelhardt, A. (2014). Mate-guarding constrains feeding activity but not energetic status of wild male **long-tailed macaques** (*Macaca fascicularis*). *Behav. Ecol. Sociobiol.* 68: 583-595.

Higham, J.P.; Heistermann, M.; Maestripieri, D. (2011). The energetics of male-male endurance rivalry in free-ranging **rhesus macaques**. *Anim. Behav.* 81: 1001-1007.

Higham, J., Girard-Buttoz, C., Engelhardt, A., Heistermann, M. (2011). Urinary C-peptide of insulin as a non-invasive marker of nutritional status: some practicalities. *Plos One* 6(7): e22398.

Girard-Buttoz, C.; Higham, J.P.; Heistermann, M.; Wedegärtner, S.; Maestripieri, D.; Engelhardt, A. (2011). A non-invasive method for the assessment of energetic condition in **monkeys**. *PloS One* 6(3): e18042.

F) METHOD VALIDATION PAPERS

Female reproductive status

Hidayatik, N.; Agil, M.; Heistermann, M.; Iskandar, E.; Yusuf, T.L.; Sajuthi, D. (2018). Assessing reproductive status of **spectral tarsier** (*Tarsius tarsier*) using fecal steroid hormone metabolite analysis. *Am J. Primatol.* 80: e22917.

Gerber, P., Moisson, P., Heistermann, M. (2004). Comparative studies on urinary progestogen and estrogen excretion during pregnancy in **Lemuridae**; *Eulemur macaco flavifrons*, *Eulemur rubriventer*, and *Hapalemur griseus occidentalis*. *Int. J. Primatol.* 25: 449-463.

Heistermann, M., Uhrigshardt, J., Husung, A., Kaumanns, W., Hodges, J.K. (2001). Measurement of faecal steroid metabolites in the **lion-tailed macaque** (*Macaca silenus*): A non-invasive tool for assessing ovarian function. *Primate Report.* 59: 27-42.

Heistermann, M., Agil, M., Büthe, A., Hodges, J.K. (1998). Metabolism and excretion of oestradiol-17 β and progesterone in the female **Sumatran rhinoceros** (*Dicerorhinus sumatrensis*). *Anim. Reprod. Sci.* 53: 157-172.

Heistermann, M., Trohorsch, B., Hodges, J.K. (1997). Assessment of ovarian function in the **African elephant** (*Loxodonta africana*) by measurement of 5 α -reduced progesterone metabolites in plasma and urine. *Zoo Biology* 16: 273-284.

Heistermann, M., Tari, S., Hodges, J.K. (1993). Measurement of faecal steroids for monitoring ovarian function in New World primates, ***Callitrichidae***. *J. Reprod. Fert.* 99: 243-251.

Male androgen status

Rincon, A.V.; Ostner, J.; Heistermann, M.; Deschner, T. (2019). Measuring urinary cortisol and testosterone levels in male **Barbary macaques**: A comparison of EIA and LC-MS. *Gen. Comp. Endocrinol.* 281: 117-125.

Barelli, C., Heistermann, M. (2012). Socio-demographic correlates of fecal androgen levels in wild male **white-handed gibbons** (*Hylobates lar*). *Int. J. Primatol.* 33: 784-798.

Weingrill, T.; Willems, E.P.; Zimmermann, N.; Steinmetz, H.; Heistermann, M. (2011). Species-specific patterns in fecal glucocorticoid and androgen levels in zoo-living **orangutans** (*Pongo spp.*). *Gen. Comp. Endocrinol.* 172: 446-457.

Ostner, J., Heistermann, M., Schülke, O. (2011). Male competition and its hormonal correlates in **Assamese macaques** (*Macaca assamensis*). *Horm. Behav.* 59: 105-113.

Girard-Buttoz, C., Heistermann, M., Krummel, S., Engelhardt, A. (2009). Seasonal and social influences on fecal androgen and glucocorticoid excretion in wild male **long-tailed macaques** (*Macaca fascicularis*). *Physiol. Behav.* 98: 168-175.

Möhle, U., Heistermann, M., Palme, R., Hodges, J.K. (2002). Characterization of urinary and fecal metabolites of testosterone and their measurement for assessing gonadal endocrine function in male **nonhuman primates**. *Gen. Comp. Endocrinol.* 129: 135-145.

Ganswindt, A., Heistermann, M., Borragan, S., Hodges, J.K. (2002). Assessment of testicular endocrine function in captive **African elephants** by measurement of fecal androgens. *Zoo Biol.* 21: 27-36.

Stress hormone assessment

Carrera, S.C.; Sharmi, S.; Heistermann, M.; Lu, A.; Beehner, J.C. (2020). Low rank and primiparity increase fecal glucocorticoid metabolites across gestation in wild **geladas**. *Gen. Comp. Endocrinol.*, in press

Rincon, A.V.; Ostner, J.; Heistermann, M.; Deschner, T. (2019). Measuring urinary cortisol and testosterone levels in male **Barbary macaques**: A comparison of EIA and LC-MS. *Gen. Comp. Endocrinol.* 281: 117-125.

Braga Goncalves, I.; Heistermann, M.; Santema, P.; Dantzer, B.; Mausbach, J.; Ganswindt, A.; Manser, M.B. (2016). Validation of a fecal glucocorticoid assay to assess adrenocortical activity in **meerkats** using physiological and biological stimuli. *PloS One* 11 (4): e0153161.

Hämäläinen, A.; Heistermann, M.; Fenosoa, Z.S.E.; Kraus, C. (2014). Evaluating capture stress in wild **grey mouse lemurs** via repeated fecal sampling: method validations and the influence of prior experience and handling protocols on stress responses. *Gen. Comp. Endocrinol.* 195: 68-79.

Wheeler, B.; Tiddi, B.; Kalbitzer, U.; Visalberghi, E.; Heistermann, M. (2013). Methodological considerations in the analysis of fecal glucocorticoid metabolites in tufted **capuchin monkeys** (*Cebus apella*). *Int. J. Primatol.* 34: 879-898.

Rimbach, R.; Heymann, E.W.; Link, A.; Heistermann, M. (2013). Validation of an enzymeimmunoassay for assessing adrenocortical activity and evaluation of factors that affect levels of fecal glucocorticoid metabolites in two **New World primates**. *Gen. Comp. Endocrinol.* 191: 13-23.

Shutt, C., Setchell, J., Heistermann, M (2012). Non-invasive monitoring of physiological stress in the western **lowland gorilla** (*Gorilla gorilla gorilla*): Validation of a faecal glucocorticoid assay and methods for practical application in the field. *Gen. Comp. Endocrinol.* 179: 167-177.

Pirovino, M.; Heistermann, M.; Zimmermann, N.; Zingg, R.; Clauss, M.; Codron, D.; Steinmetz, H.W. (2011). Fecal glucocorticoid measurements and their relation to rearing, behaviour and environmental factors in the population of **pileated gibbons** (*Hylobates pileatus*) held in European zoos. *Int. J. Primatol.* 32: 1161-1178.

Weingrill, T.; Willems, E.P.; Zimmermann, N.; Steinmetz, H.; Heistermann, M. (2011). Species-specific patterns in fecal glucocorticoid and androgen levels in zoo-living **orangutans** (*Pongo spp.*). *Gen. Comp. Endocrinol.* 172: 446-457.

Fichtel, C., Kraus, C., Ganswindt, A., Heistermann, M. (2007). Influence of reproductive season on fecal glucocorticoid levels in free-ranging male **Verreaux's sifakas** (*Propithecus verreauxi*). *Horm. Behav.* 51: 640-648.

Heistermann, M., Palme, R., Ganswindt, A. (2006). Comparison of different enzyme-immunoassays for assessment of adrenocortical activity in **primates** based on fecal samples. *Am. J. Primatol.* 68: 257-273.

Ganswindt, A., Palme, R., Heistermann, M., Borragan, S., Hodges, J.K. (2003). Non-invasive assessment of adrenocortical function in the male **African elephant** (*Loxodonta africana*) and its relation to musth. *Gen. Comp. Endocrinol.* 134: 156-166.

Bahr, N., Palme, R., Möhle, U., Hodges, J.K., Heistermann, M. (2000). Comparative aspects of the metabolism and excretion of cortisol in three individual **non-human primates**. *Gen. Comp. Endocrinol.* 117: 427-438.

Energetic status

Higham, J., Girard-Buttoz, C., Engelhardt, A., Heistermann, M. (2011). Urinary C-peptide of insulin as a non-invasive marker of nutritional status: some practicalities. *Plos One* 6(7): e22398.

Girard-Buttoz, C., Higham, J.P., Heistermann, M., Wedegärtnert, S., Maestripieri, D.; Engelhardt, A. (2011). A non-invasive method for the assessment of energetic condition in **monkeys**. *PloS One* 6(3): e18042.

Immune marker assessment

Higham, J.P.; Stahl-Hennig, C.; Heistermann, M. (2020). Urinary suPAR: a non-invasive biomarker of infection and tissue inflammation for use in studies of large free-ranging mammals. *R. Soc. Open Sci.* 7: 191825.

Heistermann, M., Higham, J.P. (2015). Urinary neopterin, a non-invasive marker of mammalian cellular immune activation, is highly stable under field conditions. *Sci. Rep.* 5: 16308.

Higham, J.P., Kraus, C., Stahl-Hennig, C., Engelhardt, A., Fuchs, D., Heistermann, M. (2015). Evaluating non-invasive markers of non-human primate immune activation and inflammation. *Am. J. Phys. Anthropol.* 158: 173-184.

Miscellaneous

Gholib, G.; Heistermann, M.; Agil, M.; Supriatna, I.; Purwantara, B.; Nugraha, T.P.; Engelhardt, A. (2018). Comparison of fecal preservation and extraction methods for steroid hormone analysis in wild **crested macaques**. *Primates* 59: 281-292.

Nugraha, T.P.; Heistermann, M.; Agil, M.; Purwantara, B.; Supriatna, I.; Gholib, G.; van Schaik, C.P.; Weingrill, T. (2017). Validation of a field-friendly extraction and storage method to monitor fecal steroid metabolites in wild **orangutans**. *Primates* 58: 285-294.

Gholib, G.; Agil, M.; Supriatna, I.; Purwantara, B.; Heistermann, M.; Engelhardt, A. (2017). Repeated freeze-thaw cycles but not short-term storage of fecal extracts at ambient temperature influence the stability of steroid hormone metabolite levels in **crested macaques**. *J. Ked. Hewan (Indonesian Journal of Veterinary Sciences)* 11: 78-85.

Danish, L.M., Heistermann, M., Agil, M., Engelhardt, A. (2015). Validation of a novel collection device for non-invasive urine sampling from free-ranging animals. *PloS One* 10(11): e0142051.

Kalbitzer, U., Heistermann, M. (2013). Long-term storage effects in steroid metabolite extracts from **baboon** (*Papio sp.*) faeces - a comparison of three commonly applied storage methods. *Methods Ecol Evol* 4: 493-500.