

9. Göttinger Freilandtage

The Sociality-Health-Fitness Link



December 3 - 6, 2013
Deutsches Primatenzentrum
– Leibniz-Institut für Primatenforschung –
Georg-August Universität
Göttingen, Germany

Editors: Prof. Peter M. Kappeler, Dr. Thomas Ziegler

Layout: Heike Klensang

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**Abteilung Verhaltensökologie & Soziobiologie
Deutsches Primatenzentrum (DPZ)**

and

**Abteilung Soziobiologie/Anthropologie
Georg-August Universität**

Göttingen, Germany

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Welcome!

On behalf of all colleagues at the German Primate Center and the Department of Sociobiology and Anthropology at the University of Göttingen, I welcome you to this conference on the sociality-health-fitness link!

This international meeting is part of a bi-annual series of meetings intended to provide a forum for thorough discussion of a selected topic in primate behavioral and evolutionary biology. From the outset, a second important goal of this meeting has been the stimulation of an exchange of ideas across taxonomic boundaries and disciplines with the goal of identifying general principles. This year's conference brings together students and professionals of animal and human behavior and health for a comprehensive analysis and syntheses of the social factors that affect health and pathogen transmission.

Strong links between sociality and fitness have long been identified in various taxa. However, the proximate behavioral and physiological mechanisms mediating these positive (direct or buffering) or negative effects remain largely unexplored. The diversity of animal social systems provides excellent opportunities for comparative studies of the effects of social variables, such as group size, dominance rank, social support and mating tactics on various aspects and indicators of health and physical condition, including levels of stress hormones, parasite load and physiological homeostasis. The transmission of emerging infectious diseases within and among social units is another relevant aspect of the interactions between sociality and health. Using a broad comparative and methodologically diverse approach, we hope to achieve significant insights into the various relationships between sociality, health and fitness.

I wish all of us an interesting and stimulating conference.

Peter M. Kappeler

Acknowledgements

It is a pleasure to thank the following agencies, institutions and people for making this conference possible:

Deutsche Forschungsgemeinschaft

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für Wissenschaft und Kultur**



**MPI für
biophysikalische Chemie**

Scientific Program

Tuesday, 3.12.2013

- 14:30 Optional: Tour of the German Primate Center
(*Deutsches Primatenzentrum, Kellnerweg 4*)
- 16:00 Arrival and Registration
(*Max Planck Institute for Biophysical Chemistry, Am Fassberg*)
- 18:00 Welcome and Introduction
Peter Kappeler
- 18:30 The adaptive value of social bonds for female baboons
Joan Silk (*Arizona State University, USA*)
- 19:30 Reception and Icebreaker (*Max Planck Institute for Biophysical Chemistry*)
- 21:00 *Departure conference shuttle bus*

Wednesday, 4.12.2013

Chair: Charles Nunn

- 9:00 Individual differences in sociability and health in rhesus monkeys:
from gene expression to the social context
John Capitanio
- 9:50 Social behavior, glucocorticoids, health and ornaments in male mandrills
(*Mandrillus sphinx*)
Joanna Setchell, Tessa Smith & Leslie Knapp
- 10:10 Social bonding as a stress buffer: linking cortisol, oxytocin and
social bonds in wild chimpanzees
Roman Wittig, Tobias Deschner & Catherine Crockford
- 10:30 *Morning coffee & tea*

Chair: John Capitanio

- 11:00 Social status, stress physiology, and health
Sonia Cavigelli

9. Göttinger Freilandtage: Program

- 11:50 Fecal glucocorticoids and gastrointestinal parasite infections in wild western lowland gorillas involved in ecotourism
Kathryn Shutt, Barbora Kalousova, Michael Heistermann, Adetayo Kasim, Klara Petrzekova, David Modry, Ilona Profosouva, Angeliqve Todd, Terrence Fuh, Jean-Francais Dicky, Jean-Bruno Bopalanognako & Joanna Setchell
- 12:10 The influence of dominance rank on the energy intake and expenditure of female Bwindi mountain gorillas
Edward Wright, Andrew Robbins & Martha Robbins
- 12:30 **Poster talks I**
- 13:00 *Lunch*
- Chair: Colin Chapman*
- 14:00 Ecological and social drivers of zoonotic disease transmission and emergence
Thomas Gillespie
- 14:50 Lethal and non-lethal microorganisms in wild great apes
Fabian Leendertz
- 15:10 Leaf swallowing behavior in captive great apes: rough surfaced leaves elicit leaf swallowing in naïve chimpanzees (*Pan troglodytes*) and bonobos (*P. paniscus*)
Claudia Menzel, Andrew Fowler, Claudio Tennie & Josep Call
- 15:30 *Afternoon coffee & tea with Poster Demonstrations*
- Chair: Peter Klopfer*
- 16:00 Primate self-medication
Michael Huffman
- 17:00 *Departure shuttle bus*

Thursday, 5.12.2013

Chair: Thomas Gillespie

- 9:00 Food for the masses: novel resources, sociality and disease
Sonia Altizer
- 9:50 Evaluating the synergy between nutrition, stress, and disease as determinants of primate abundance
Colin Chapman

9. Göttinger Freilandtage: Program

10:40 *Morning coffee & tea*

Chair: Michael Huffman

11:10 Sociality and parasitism: is it just a numbers game?
Charles Nunn

12:00 Investigating parasite spread through a lemur population
Andrea Springer, Claudia Fichtel, Fabian Leendertz, Sébastien Calvignac-Spencer, Alexander Mellmann, Charles Nunn & Peter Kappeler

12:20 Social learning as a conduit for parasite transmission in the evolution of primates
Collin McCabe, Simon Reader & Charles Nunn

12:40 **Poster talks II**

13:00 *Lunch*

Chair: Sonia Cavigelli

14:00 Socially-structured transmission of bacteria
Elizabeth Archie

14:50 Parasitism and sociality in a non-human primate
Clémence Poirotte & Marie Charpentier

15:10 *Afternoon coffee & tea* **with Poster Demonstrations and Press Opportunities**

Chair: Sylvia Cremer

16:00 Sociality and health: the effects of gregariousness on disease spread in orang-utans (*Pongo pygmaeus wurmbii*) and chimpanzees (*Pan troglodytes schweinfurthii*)
Charlotte Carne, Stuart Semple, Helen Morrogh-Bernard, Klaus Zuberbühler & Julia Lehmann

16:20 Infectious disease dynamics on wild animal contact networks
Meggan Craft

17:15 *Departure shuttle bus*

Friday, 6.12.2013

Chair: Elizabeth Archie

- 9:00 Parasites on the second pinnacle
Paul Schmid-Hempel
- 9:50 Disease defense in social networks of ants
Sylvia Cremer
- 10:40 *Morning coffee & tea*

Chair: Meggan Craft

- 11:10 The measurement of fitness and impacts of parasites: a rodent perspective
Stephen Dobson, Shirley Raveh, Peter Neuhaus & Dave Coltman
- 12:00 Can a closed host social system reduce the evolutionary potential of parasites?
Insights from the Bechstein's bat and two of its parasites
Jaap van Schaik, Daan Dekeukeleire & Gerald Kerth
- 12:20 Impact of social and ecological parameters on reproductive success in wild
female crested macaques
Antje Engelhardt
- 12:40 *Lunch*

Chair: Paul Schmid-Hempel

- 13:45 Perceived social connectedness and health: models, mechanisms, and evidence
Louise Hawkey
- 14:35 The behavioral immune system and human sociality
Mark Schaller
- 15:25 *Conference summary: Joan Silk*
- 16:15 *Departure shuttle bus*

19:30



Farewell party



(German Primate Centre, Kellnerweg 4)

Poster presentations

Posters will be displayed Wednesday until Friday outside the lecture hall

Klopfer PH, Krystal AD, Schopler B, Blanco MB, Yoder AD, Dausmann KH & Faherty SL
Sleep in a hibernating lemur

Pechousková E, Huchard E & Kappeler PM
On the track of diversifying selection: adaptive genetic divergence in Cheirogaleidae?

Hillyer A & Korstjens A
Observations of human disturbance in Abuko Nature Reserve, The Gambia, and threats to a wild population of Temminck's Colobus, *Procolobus badius temminckii*

Knauf S, Maciej P, Barnett U, Ndao I, Zinner D & Fischer J
Guinea baboons at Parc National du Niocolo Koba are sero-positive for *Treponema pallidum*

Martinez-Mota R
Effects of forest fragmentation on the parasitic infection of endangered black howler monkeys (*Alouatta pigra*) in Mexico

Kerth G, Zeus V, Kwasnitschka L, Fischer K, Balkema Buschmann A & Groschup M
Influence of bat social behavior on virus infection within and among three different bat species

Berghänel A, Schülke O & Ostner J
Social activity and developmental tradeoffs in wild Assamese macaques

Fürtbauer I, Heistermann M, Schülke O & Ostner J
Low female stress hormone levels are predicted by same- or opposite-sex relationships depending on season in wild Assamese macaques

Macdonald S, Sangmaneedet S, Schülke O & Ostner J
Parasite load in female Assamese macaques: a cost of sociality

Müller N, Ostner J, Schülke O & Walter L
Towards the non-invasive assessment of MHC genotype in wild primates

Young C, Majolo B, Heistermann M, Schülke O & Ostner J
Social influences on physiological stress levels in wild male Barbary macaques

Duboscq J, Sueur C & MacIntosh A
Social networks as a trade-off between optimal decision-making, information transmission and reduced disease transmission

Abstracts of Talks

The adaptive value of social bonds for female baboons

Silk J

School of Human Evolution and Social Change, Arizona State University, Tempe, USA

Natural selection favors traits that enable individuals to reproduce more successfully than other members of the population, and behavioral ecologists have devoted considerable effort to identifying the sources of variation in individual reproductive success. Much of this work has focused on the characteristics of individuals, such as their sex, age, parity, and physical condition. However, many animals live in social groups, and there is a growing body of evidence which demonstrates that the fitness of individuals depends at least in part on the outcome of their interactions with other group members. The most detailed evidence comes from long-term studies of yellow baboons in the Amboseli basin of Kenya and chacma baboons in the Okavango Delta of Botswana where females form strong, equitable, supportive, tolerant, and stable bonds with selected partners. The formation of close social bonds is associated with higher infant survival and greater longevity for females, which suggests that close social bonds enhance female fitness. I will consider the possible mechanisms underlying the linkage between sociality and fitness, explore the sources of individual variation in sociality, and consider the implications of these findings for understanding the role of social bonds in human health and wellbeing.

Notes:

Individual differences in sociability and health in rhesus monkeys: from gene expression to the social context

Capitanio JP

California National Primate Research Center and Department of Psychology, University of California, Davis, USA

Within a social species, members vary in their tendencies toward affiliation (i.e., Sociability), and this variation is associated with how animals cope with socially challenging situations. Variation in Sociability is also associated with differences in structure and function of stress-response systems that help regulate immunity, and both the sympathetic adreno-medullary and hypothalamic-pituitary-adrenal systems are implicated. I describe studies contrasting low- and high-Sociable adult male rhesus monkeys, and mechanisms by which corresponding differences in stress-response systems affect indicators of disease. I also present recent data suggesting that there are two types of low-sociable monkeys, those that may be relatively satisfied with their status (akin to human “introverts”) and those that may be dissatisfied with their status (akin to “lonely” humans). Among humans, only loneliness (and not introversion) is associated with poor health outcomes. Ongoing studies of “lonely” and “introverted” monkeys, which are examining genetic and physiological markers of inflammation, will also be discussed. The considerable plasticity in the physiological systems we have examined, however, suggests that changes in individuals’ dispositions might be associated with differences in risk for health-related outcomes.

Notes:

Social behavior, glucocorticoids, health and ornaments in male mandrills (*Mandrillus sphinx*)

Setchell JM¹, Smith TE² & Knapp LA³

¹Department of Anthropology, Durham University, UK, ²Biology Department, University of Chester, UK, ³Department of Biological Anthropology, University of Cambridge, UK

Social interactions can be important sources of stress, which may, in turn, be negatively associated with health and physical condition. The immunosuppressive effects of glucocorticoids underlie the stress-mediated immunocompetence handicap hypothesis, which holds that sexually selected traits honestly reflect individual quality by advertising the degree to which the bearer can tolerate these effects. We explored the relationships between fecal glucocorticoid levels and dominance rank, rank stability, the presence of receptive females, male sociality, gastro-intestinal parasite infection and ornamentation in 16 adult male mandrills (*Mandrillus sphinx*). Mandrills live in multi-male, multi-female groups in which reproduction is strongly skewed to the top-ranking male, and males possess a suite of exaggerated ornaments. We found that glucocorticoid levels did not vary systematically with dominance rank, but increased when the dominance hierarchy was unstable, and in the presence of receptive females. The relationship between dominance rank and glucocorticoid levels changed direction according to the stability of the dominance hierarchy: glucocorticoid levels were higher in subordinate males under stable conditions, but higher-ranking males had higher glucocorticoid levels under conditions of instability. The influence of dominance rank also interacted with the presence of receptive females: glucocorticoids were higher in dominant males than in subordinates, but only during mating periods. These results suggest that the relationship between dominance rank and glucocorticoid levels is dependent on the social environment. Males with higher glucocorticoids showed a higher diversity of gastrointestinal parasite infection, suggesting that elevated glucocorticoid levels are associated with poor health. However, we found no relationship between red color and glucocorticoid levels, suggesting that glucocorticoids do not play a simple role in translating social conditions or physical health into ornament expression in this species.

Notes:

Social bonding as a stress buffer: linking cortisol, oxytocin and social bonds in wild chimpanzees

Wittig RM, Deschner T & Crockford C

Max-Planck-Institut für Evolutionäre Anthropologie, Leipzig, D

There is increasing evidence that maintaining close social bonds can increase the reproductive success of social mammals. The mechanisms underlying this benefit, however, are not yet clear. A contributing factor maybe that maintaining close social bonds with others leads to buffering of the negative effects of stress. We examined this hypothesis by comparing urinary concentrations of cortisol and oxytocin in wild chimpanzees of Budongo Forest, Uganda, in the hours after grooming with a bond versus a non-bond partner. We found that chimpanzees showed higher urinary oxytocin levels and lower cortisol concentrations after grooming with a bond, compared with a non-bond partner. In contrast, possible confounding variables, like grooming duration or direction, showed no significant influences on hormonal levels. Oxytocin is known to have an inhibitory effect on cortisol secretion. Bond partner grooming, may thus be an effective mechanism for reducing cortisol release. This suggests that strong social bonds indeed act as a buffer against the negative effects of stress.

Notes:

Social status, stress physiology, and health

Cavigelli SA

Department of Biobehavioral Health, Pennsylvania State University, USA

Social species have relatively complex social repertoires and have been characterized as maintaining regular, albeit flexible, social status within groups. In an attempt to determine if/how/why social status is related to health outcomes, researchers have compared social status to specific physiological processes, particularly those associated with classical stress physiology (i.e. sympathetic, adrenal, and immune function). In the present talk, I present results of a recent literature review of studies on glucocorticoid (adrenal hormone) and immune functioning among high- vs. low-status individuals in a range of social species. The results indicate a highly variable relationship between glucocorticoid production and current social status, but glucocorticoid production is most closely related to social status during periods of social instability. In terms of immune function, high social status was associated with increased resistance to viruses and cancer development and increased cell-mediated immunity, whereas low status was associated with increased pro-inflammatory and humoral/antibody immunity. Comparable to glucocorticoid function, social status was more closely related to immune responses during periods of instability (i.e. experimentally-induced stressors). The most important results of the review suggest that early life social status, which can predict the nature of life-long social and immunological challenges, may be an important, and as of yet minimally-examined aspect of social status- and health-related physiology. To advance this field of study, I suggest specific areas for future research: (1) increased application of physiologically-appropriate measures in free-ranging animal groups, (2) assessment of specific aspects of social status and environmental conditions that influence physiological processes, and (3) examination of mechanisms that underlie early-life and potentially long-lasting influences of social status on physiology and health. Examination of context-specific, long-term processes are required to clarify complicated results on the relationship between social status and stress-related physiology.

Notes:

Fecal glucocorticoids and gastrointestinal parasite infections in wild western lowland gorillas involved in ecotourism

Shutt K¹, Kalousova B², Heistermann M³, Kasim A⁴, Petrzalkova K⁵, Modry D⁶, Profosouva I⁶, Todd A⁷, Fuh T⁷, Dicky J-F⁷, Bopalanognako J-B⁷ & Setchell JM¹

¹Department of Anthropology, Durham University, UK, ²Department of Pathology and Parasitology, Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences Brno & Department of Botany and Zoology, Masaryk University, Brno, Czech Republic, ³Hormonlabor, Deutsches Primatenzentrum, Göttingen, D, ⁴Wolfson Research Institute for Health and Wellbeing, Durham University, UK, ⁵Department of Mammal Ecology, Institute of Vertebrate Biology, Academy of Sciences of the Czech Republic, Brno & Liberec Zoo, Masarykova, Czech Republic, ⁶Department of Pathology and Parasitology, Faculty of Veterinary Medicine, University of Veterinary and Pharmaceutical Sciences Brno, Czech Republic, ⁷WWF-CAR, Bangui, Central African Republic

Wildlife ecotourism can offer a source of revenue which can simultaneously benefit local development and conservation. However, habituation can cause long-term elevation of glucocorticoid hormones which may suppress immune function and increase an animal's vulnerability to disease. We conducted the first study to combine measures of endocrine and immune function in the context of wildlife habituation and ecotourism. Over 12 months, we collected 1175 fecal samples from 3 groups of wild gorillas that are at different stages of habituation for ecotourism: a group undergoing habituation, a recently habituated group and a long-term habituated group. We analyzed all samples for glucocorticoid metabolites (FGCMs) and established the intensity of pathogenic parasite infection in a subset of 314 samples. The group undergoing habituation had the highest FGCMs, which increased up to 25 days following contacts, suggesting a cumulative FGCM response typical of hormonal adaptation to a chronic intermittent stressor. FGCMs in habituated groups were significantly associated with increasing frequency of violation of the 7 m distance rule by observers and a medical intervention study but not with other measures of human pressure. We found a positive relationship between FGCMs and the intensity of infection with strongylid parasites, suggesting that elevated glucocorticoids may reduce a host's ability to control the extent of parasitic infection. Monitoring endocrine-immune interactions may inform conservationists of any detrimental physiological effects that may be associated with habituation and ecotourism activities. Our findings provide critical information for the management of this, and other, species whose conservation depends on habituation for ecotourism.

Notes:

The influence of dominance rank on the energy intake and expenditure of female Bwindi mountain gorillas

Wright E, Robbins AM & Robbins MM

Max-Planck-Institut für Evolutionäre Anthropologie, Leipzig, D

According to socioecological theory, contest competition over contestable food resources, should lead to higher energy balance (energy intake minus energy expenditure) in favor of dominant individuals. We tested whether this was the case in a group of female Bwindi mountain gorillas, which are a folivorous-frugivorous species. We found that dominance rank was positively correlated with energy intake rate; this was predominantly due to dominant females feeding at faster rates than subordinate females, rather than feeding on foods with higher energy concentrations. Subordinate females did not compensate for having lower energy intake rates by spending more time feeding than dominant females. Moreover, dominance rank was not correlated with the time spent feeding on fruit, which suggests that dominant females cannot monopolize this resource. Dominance rank however, was negatively correlated with energy expenditure, as dominant females spent less energy on travel than subordinate females. Taken together there was a significant positive correlation between dominance rank and energy balance, which may have important implications in terms of reproductive success in this species. Our results differ from predictions of socioecological models for a species which predominantly feeds on abundantly distributed herbaceous vegetation and common female dispersal. Moreover, it further supports the concept that the distribution of herbaceous vegetation may not always be homogeneous, as the influence of dominance rank was the same when feeding on fruit versus non-fruit resources.

Notes:

Ecological and social drivers of zoonotic disease transmission and emergence

Gillespie TR

Program in Population Biology, Ecology and Evolution and Department of Environmental Sciences, Emory University, Atlanta, USA and Department of Environmental Health, Rollins School of Public Health, Emory University, Atlanta, USA

Pathogen emergence is disproportionately associated with the tropics and is often linked to anthropogenic change. Unique human and animal behaviors associated with this interface can also contribute to chronic zoonotic transmission and / or disease emergence. To better understand these transmission dynamics, we have used a mixed-methods approach in systems in tropical Africa and Latin America integrating epidemiology, molecular ecology, behavioral ecology, vector ecology, social and clinical survey, and spatially-explicit modeling. Using examples from our research in Madagascar, Mexico, Tanzania, and Uganda, I will demonstrate how key human behaviors, wildlife behaviors, ecological conditions, and landscape features in such systems increase the risk of interspecific disease transmission among people, wildlife, and domesticated animals.

Notes:

Lethal and non-lethal microorganisms in wild great apes

Leendertz F

Junior Research Group “Novel Zoonoses”, Robert-Koch-Institut, Berlin, D

Knowledge about pathogens affecting wild great apes often is an important piece of the puzzle when studying the sociality-health-fitness link in these species. Given the diversity of pathogens affecting humans, the closest phylogenetic relatives of apes, it is likely that only a small fraction of pathogens affecting wild great apes are known. Only two sets of diseases have been confirmed to cause significant mortality among wild great apes; respiratory diseases introduced by humans at research and tourism sites and Ebola viruses. The only documented non-acute disease causing pathogens to clearly affect wild great apes is SIV, which resulted in a population decline in the chimpanzees (*Pan troglodytes schweinfurthii*) of Gombe Stream Reserve. The impact of the plethora of other microorganisms described in wild great apes remains unknown. I will summarize what is known about lethal and non-lethal pathogens in wild great apes and point towards first candidate microorganisms which may be the basis for in depth studies of the link between sociality and health.

Notes:

Leaf swallowing behavior in captive great apes: rough surfaced leaves elicit leaf swallowing in naïve chimpanzees (*Pan troglodytes*) and bonobos (*P. paniscus*)

Menzel C¹, Fowler A², Tennie C³ & Call J⁴

¹Institut für Anatomie, Friedrich-Schiller-Universität Jena, D, ²African Wildlife Foundation, Kinshasa Office, Gombe, Kinshasa, Democratic Republic of Congo, ³School of Psychology, University of Birmingham, UK, ⁴Abteilung für Vergleichende und Entwicklungspsychologie, Max-Planck-Institut für Evolutionäre Anthropologie, Leipzig, D

Wild African great apes occasionally swallow rough (but not smooth) surfaced leaves without chewing for apparently self-meditative reasons (i.e. expelling intestinal parasites). Here, we provided 42 naïve captive great apes (24 chimpanzees, 6 bonobos, 6 gorillas and 6 orangutans) with both rough surfaced and smooth plants to investigate the acquisition and the underlying mechanisms of this behavior. The majority of chimpanzees (N=18) as well as all bonobos and orangutans were naturally infected with intestinal parasites during the study. Rough-surfaced leaves were spontaneously swallowed by two naïve chimpanzees and one bonobo. Later, when tested within their groups 6 more chimpanzees showed the behavior. Both, healthy and infected chimpanzees engaged in leaf swallowing. None of the gorillas or orangutans exhibited leaf swallowing. Since naïve animals acquired this behavior we conclude that it is latent in the behavioral repertoire of chimpanzees and bonobos. Though social learning is thus not necessary for leaf swallowing acquisition, it may still facilitate its expression. Because subjects always chewed leaves of smooth control plants (i.e. ate them), we conclude that the leaf surface is indeed a trigger for the leaf swallowing behavior. We also discuss other potential reasons for leaf swallowing.

Notes:

Primate self-medication

Huffman MA

Primate Research Institute, Kyoto University, Japan

Parasites cause a variety of diseases that affect the behavior and reproductive fitness of an individual. While the study of animal self-medication as a science is relatively new, to date, research has classified health maintenance and self-medicative behaviors into four levels: 1) optimal avoidance or reduction of disease transmission: 2) the dietary selection of items with a preventative or health maintenance affect: 3) ingestion of a substance for the curative treatment of a disease or the symptoms thereof: and 4) external application of a substance to the body for the treatment or control of disease bearing insects. Of any species studied thus far, chimpanzees have provided the most details for level 2 and 3 behaviors, exemplified by such behaviors as bitter pith chewing and whole leaf swallowing used in response to parasite infection. This presentation will review the progress to date in primates, and compare these strategies with examples from other animals to illustrate the wide and deep evolutionary origins of self-medication in the animal kingdom.

Notes:

Food for the masses: novel resources, sociality and disease

Altizer S¹, Becker D¹ & Streicker D^{1,2}

¹Odum School of Ecology, University of Georgia, USA, ²Institute of Biodiversity, Animal Health and Comparative Medicine, University of Glasgow, UK

Land-use changes such as urbanization and agricultural intensification have sent many wildlife populations into decline, but some species benefit from novel food resources available in human-altered habitats. Such provisioning is widespread and can be intentional, such as the use of bird feeders or handouts from tourists, or accidental, such as when animals consume agricultural products or household garbage. Predicting how infectious disease dynamics respond to resource provisioning is challenging because of opposing epidemiological and immunological mechanisms. On the one hand, resource provisioning can increase local host density, aggregation and contact rates, facilitating pathogen transmission; on the other hand, hosts might experience improved body condition and immune defenses owing to improved nutrition offered by novel resources. In this talk we provide a conceptual framework to address how human-driven changes in food resources interact with the dynamics of infectious diseases in wildlife and to identify key mechanisms by which this occurs. We will review findings from a meta-analysis to characterize the range of outcomes of resource provisioning, and analyze a modeling framework that captures the net effect of synergistic and opposing mechanisms. A growing number of case studies show how resource provisioning affects human health and wildlife conservation, and this is especially relevant when supplemental resources bring humans, domesticated animals, and wildlife into close contact. Last, we will highlight emerging research themes for future work, such as how dietary shifts influence the host microbiome with consequences for pathogenic species, as well as how resource-driven changes in host demography and contact behavior might affect virulence evolution.

Notes:

Evaluating the synergy between nutrition, stress, and disease as determinants of primate abundance

Chapman CA

Department of Anthropology and McGill School of Environment, McGill University, Montreal, Quebec, Canada

A fundamental issue in ecology is determining the factors affecting the density of animal populations and the importance of this issue has increased with the need to develop informed management plans for endangered species. There is ample evidence that finding single-factor explanations for complex biological phenomena, such as determinant of animal abundance, is unlikely. Thus, I examine if nutrition, stress, and disease interact to determine the abundance of primate populations. Using a system of forest fragments adjacent to Kibale National Park, Uganda and areas within the park, I demonstrate that in the fragments food availability has a strong direct effect on changes in population size, but population change is also indirectly affected by parasite infections. In contrast, in the national park, changes in population size appear to be determined solely by food availability. While there are few studies that simultaneously examine nutrition, stress, and disease, I present evidence indicating that nutritionally stressed primate populations often exhibit elevated disease levels and thus suggest that both of these factors generally interact to determine primate population size.

Notes:

Sociality and parasitism: is it just a numbers game?

Nunn CL

Department of Evolutionary Anthropology, The Duke Global Health Institute, Duke University, USA

Parasitism is thought to be one of the major costs of living in groups. Evidence for this effect is remarkably mixed, however, especially in one of the most social of mammals - the primates. In this talk, I consider the evidence for the “group size-parasitism effect” at both theoretical and empirical levels. Theoretical models typically show that rates of parasitism increase with group size. While some field studies have found support for a positive link between parasitism and group size, others have found no effects or even the opposite effect. Comparative studies across primates have also failed to find a compelling link between parasitism and group size. A meta-analysis of all mammals reveals a weak overall effect, substantial heterogeneity in effect sizes, and new insights into the drivers of that heterogeneity, with the largest effect sizes in studies that include larger groups. Additional research provides hints that contact patterns within groups could be more important than group size, including a new model that I will discuss. Collectively, it appears that group size on its own is a weak predictor of parasitism, with more substantial effects in large aggregations, including humans.

Notes:

Investigating parasite spread through a lemur population

Springer A¹, Fichtel C¹, Leendertz F², Calvignac-Spencer S², Mellmann A³, Nunn CL⁴ & Kappeeler PM^{1,5}

¹Abteilung Verhaltensforschung & Soziobiologie, Deutsches Primatenzentrum, Göttingen, D, ²Junior Research Group „Novel Zoonoses“, Robert-Koch-Institut, Berlin, D, ³Institut für Hygiene, Universitätsklinikum Münster, D, ⁴Department of Evolutionary Anthropology, The Duke Global Health Institute, Duke University, USA, ⁵Abteilung für Soziobiologie & Anthropologie, Universität Göttingen, D

Increased susceptibility to infectious disease is assumed to be one of the major costs of group-living. Exposure and susceptibility to parasites are influenced by a range of social and non-social factors affecting parasite species richness, prevalence and infection intensity. The aim of this study is to investigate the effects of group size, social contacts and habitat use on the spread of directly and indirectly transmitted parasites in a population of Verreaux's sifaka (*Propithecus verreauxi*) in their natural habitat in Madagascar. We present a transmission-relevant social network of the study population as well as data on home range use, home range overlap and intergroup contacts derived from GPS collars. Biomedical samples collected invasively and non-invasively allow us to investigate prevalences of *Plasmodium* spp., filarial worms, gastrointestinal helminths and ectoparasites, which represent different transmission modes. Additionally, a molecular epidemiological approach is applied to investigate genetic similarities between *Escherichia coli* bacteria from different individuals to infer transmission pathways. Our preliminary results demonstrate that integrative field studies on the health status of wild primate populations are feasible and that they can potentially shed light on central questions pertaining to primate sociality, ecology and conservation.

Notes:

Social learning as a conduit for parasite transmission in the evolution of primates

McCabe CM¹, Reader SM² & Nunn CL³

¹Department of Evolutionary Anthropology, The Duke Global Health Institute, Duke University, USA, ²Department of Biology, McGill University, Canada, ³Department of Evolutionary Anthropology, Duke University, USA

Social learning is one of the cornerstone behaviors of animal culture, and it is observed in diverse animal species, including most, if not all primate species. Understanding the costs of social learning is necessary to understand how and why some animals have relied so heavily on such behavioral plasticity, while others have not. We propose that one major cost of social learning is exposure to infectious disease. Although many measures of sociality, including population density and group size, may not be useful predictors of exposure to infectious organisms, we suggest that reliance on social learning may provide a more nuanced view of social interactions, indicating how frequently individuals interact. We predicted that higher frequencies of social learning would be associated with greater social contact and thus, more socially transmitted diseases. To test this prediction, we used phylogenetic comparative methods, controlling for sampling effort, body mass, group size, substrate use, and geographic range size. Among a dataset of 127 primate species, we found convincing evidence that socially contagious diseases were positively associated with rates of social learning. Thus, we propose that infectious disease exposure is a potential cost of social learning. These conclusions are relevant not only to the study of wildlife disease ecology (as they provide one of the first useful proxies for social parasite transmission dynamics), but also to that of human disease ecology: human evolution has been inextricably interwoven with the evolution of culture, which builds quite heavily upon the process of social learning.

Notes:

Socially-structured transmission of bacteria

Archie E

Department of Biological Sciences, University of Notre Dame, USA

Social structure is thought to be an important conduit for the transmission of infectious agents. Testing this idea is important because it has implications for the evolutionary costs and benefits of sociality, as well as for disease management in natural populations. However, to date, research on socially-structured transmission is limited by the fact that it is difficult to empirically track the movements of infectious agents within and between social groups of wild animals. Population genetic tools offer one approach to solving this problem. In this talk, I discuss results from two recent projects that used genetic tools to uncover patterns of socially-structured transmission. These projects explored: (1) the effects of social organization on the population genetic structure of *Escherichia coli* infecting wild African elephants, and (2) the effects of social relationships on the structure of the intestinal microbiome in wild savanna baboons. In the first project, we found little evidence for socially structured transmission on *E. coli* population genetic structure. In contrast, in the second project, we uncovered a striking signature of social group on the structure of bacterial communities in the microbiome. I discuss when and why patterns of socially-structured transmission of bacteria may emerge, focusing on interactions between social structure and other factors that also have strong effects on transmission patterns. In sum, interactions between bacterial transmission mode, the abiotic environment, and host traits, all play key roles in determining the degree to which social organization influences transmission patterns in a given host-bacteria system.

Notes:

Parasitism and sociality in a non-human primate

Poirotte C & Charpentier M

Centre d'Ecologie Fonctionnelle et Evolutive/Centre National de la Recherche Scientifique, Montpellier, F

Mammals are exposed to a diversity of parasites and infectious diseases, which can affect reproduction and host survival. Species which live in large groups at high density are especially exposed, and an increased risk of exposure to parasites is one of the major cost linked to sociality. Parasites are thought to represent a driving force of host social system, shaping specific behavioral patterns that enable animals to face these pressures. One specific behavior is the avoidance of parasitized conspecifics, which implies recognition of these individuals. Several studies have shown that in rodents, females prefer to mate with non-infected individuals, and individuals avoid the odor of parasitized conspecifics. In this study on a social mammal, we investigated the relation between parasitism and sociality as well as a possible proximal mechanism acting as a mediator of this relation. Specifically, we studied the influence of intestinal parasitism on social behavior (allo-grooming), and on odors produced by infected and non-infected individuals in a wild mandrill (*Mandrillus sphinx*) population in Gabon. Behavioral and coprological analyses of 40 individuals from all ages and both sexes were combined. We also performed chemical analyses in order to establish odor profiles from mandrill feces. The results obtained showed that the presence of some intestinal parasites, which are transmitted by physical contacts between individuals, was correlated with a decrease of sociality of infected individuals. Besides, some of the parasites associated with a reduction of sociality appear to modify odors of feces emitted by infected individuals. These results suggest that parasitism represents a selection force acting directly on social behavior: individuals could adapt to important parasitic pressures by elaborating odor recognition mechanisms of infected individuals, allowing the behavioral avoidance of infected individuals.

Notes:

Sociality and health: the effects of gregariousness on disease spread in orang-utans (*Pongo pygmaeus wurmbii*) and chimpanzees (*Pan troglodytes schweinfurthii*)

Carne C¹, Semple S¹, Morrogh-Bernard H², Zuberbühler K^{3,4} & Lehmann J¹

¹Centre for Research in Evolutionary and Environmental Anthropology, University of Roehampton, London, UK, ²The Orangutan Tropical Peatland Project, Centre for International Cooperation in Sustainable Management of Tropical Peatland, Universitas Palangka Raya, Central Kalimantan, Indonesia, ³School of Psychology & Neuroscience, University of St Andrews, UK, ⁴Cognitive Science Centre, University of Neuchâtel, CH

An increased risk of disease transmission has been hypothesized to be a major cost of sociality. However, little is known about how diseases spread within social groups or how individual variation in sociability affects the risk of becoming infected. Chimpanzees and orang-utans are both characterized by a fission fusion social system, but differ considerably in their level of gregariousness and thus are likely to differ in their susceptibility to the spread of diseases. In this study we use social network analysis to investigate vulnerability to disease in a population of 46 wild orang-utans and a community of 55 wild chimpanzees. Potential superspreaders, of disease - individuals with disproportionately strong relationships - were identified, and their influence on disease dynamics was assessed using simulations. Three resident female orang-utans were identified as potential superspreaders. By contrast, no superspreaders were identified in the chimpanzee network, although males had significantly stronger relationships than females. In both species, individuals with the strongest connections in the network affected disease spread disproportionately, but this effect was more pronounced for the orang-utans. The chimpanzee community was found to be far more susceptible to the spread of disease than the orang-utan population. Among orang-utans, even highly infectious diseases had limited transmission potential. Furthermore, the pattern of social bonds in the orang-utan population was not an important determinant of susceptibility to disease. Chimpanzees, on the other hand, were highly susceptible even to diseases with low infection rates, and the patterns of their social bonds had a noticeable impact on the predicted disease spread. These results highlight the role that certain individuals may play in the spread of disease and shed new light on the interactions between sociality and health, suggesting that - especially in chimpanzees - preventative diseases measures should be of high priority for researchers and eco-tourists.

Notes:

Infectious disease dynamics on wild animal contact networks

Craft M

Department of Veterinary Population Medicine, University of Minnesota, USA

Although contact network epidemiology has been increasing in popularity for studying transmission of infectious diseases in humans, it has generally been an underutilized approach for investigating disease outbreaks in wildlife populations. Efforts to construct realistic wildlife networks efforts can be hampered by a lack of detailed contact data; however, empirical data can be collected from direct observation of contacts, or through the use of rapidly developing technology. Network models are a flexible tool by which to simulate disease spread and test hypotheses and across a wide range of wild animal social systems. In this talk I will discuss how to construct contact network models for social species (i.e. African lion) and more solitary species (i.e. raccoons). I then will discuss the spread of canine distemper virus on the lion network and rabies on the raccoon network, and implications for control of these viral diseases.

Notes:

Parasites on the second pinnacle

Schmid-Hempel P

Institute of Integrative Biology, ETH Zürich, CH

Social insects represent one of the major evolutionary transitions to social life. As a group they have conquered most habitats and, accordingly, their biology is very varied. Invariably though, living in a nest with, typically, close relatives is an open invitation for parasites to catch on. Here, I will give a brief overview, and then illustrate some major points with our own work on bumblebees and their diseases. Among those, specific interactions, mating strategies, and maternal immune protection of offspring are especially intriguing. More recently, also the within-nest transfer of microbiota and its protective effects have become known.

Notes:

Disease defense in social networks of ants

Cremer S

Institute of Science and Technology Austria, Klosterneuburg, A

Colonies of social insects consist of hundreds to millions of closely related individuals, living together in high density. Depending on their age, workers either perform tasks in the nest center (queen and brood care), or in the periphery (nest maintenance and foraging). This spatial fidelity leads to an inherent substructuring of the social interaction network of the colony, with high contact rates within the central or peripheral group, but low interactions between them. Incoming diseased foragers are therefore predicted to spread any pathogen preferentially to other foragers, rather than the highly valuable queen and brood. Interaction rates change further upon pathogen entry into the colony. This is because (i) exposed individuals refrain from particular tasks such as brood care, and (ii) healthy nestmates take care of diseased nestmates by intensified allogrooming, a process during which infectious particles are removed from the body surface of the exposed individual. Grooming reduces the risk of infection of the exposed ant, but bears the risk of cross-infection to the previously healthy allogroomers. However, transfer of pathogens among group members through social contact can sometimes be beneficial, when nestmates only pick up sublethal micro-infections that stimulate the immune system and protect them against the pathogen upon secondary challenge (social immunization).

Notes:

The measurement of fitness and impacts of parasites: a rodent perspective

Dobson FS¹, Raveh S², Neuhaus P³ & Coltman D⁴

¹Centre d'Ecologie Fonctionnelle et Evolutive/Centre National de la Recherche Scientifique, Montpellier, France, ²Department of Environmental Sciences, Evolution & Zoology, University of Basel, CH, ³Department of Biological Sciences, University of Calgary, Canada, ⁴Department of Biological Science, University of Alberta, Edmonton, Canada

Diseases and parasites can have a major impact on fitness traits, such as growth, phenology, reproduction, and survival. However, the appropriate measure of fitness, particularly for long-lived organisms, is unclear. We conducted a field experiment on Columbian ground squirrels (*Urocitellus columbianus*), a diurnal rodent that occupies alpine and sub-alpine meadows in the northern Rocky Mountains of North America. These ground squirrels live for up to about 12 years of age, and they have been monitored since 1992. From earlier work on this species, we expected ectoparasites to have a significant detrimental influence on reproduction and survival of ground squirrels, at least for adult females. Ground squirrels were treated with parasite removal or kept in their natural state as controls. We examined measures of lifetime fitness, annual fitness, and reproductive output. We found no significant influence of parasites on any of these measures of fitness. Our use of several ways of estimating fitness increased our confidence in this surprising conclusion. Columbian ground squirrels may have come into an evolutionary equilibrium with ectoparasites where natural levels of infestation have little influence on fitness.

Notes:

Can a closed host social system reduce the evolutionary potential of parasites? Insights from the Bechstein's bat and two of its parasites

van Schaik J^{1,2}, Dekeukeleire D² & Kerth G²

¹Max-Planck-Institut für Ornithologie, Seewiesen, D, ²Ernst-Moritz-Arndt-Universität Greifswald, D

The genetic population structure, and thus the evolutionary potential, of a parasite is strongly influenced by its own life history and that of its host. However, how individual parasite life history variables interact with the host social system to shape parasite genetic population structure is poorly understood. In this study we compare the genetic population structure of two ectoparasites of the Bechstein's bat (*Myotis bechsteinii*): the mite *Spinturnix bechsteini* and the bat fly *Basilina nana*. Both species are highly specialized permanent ectoparasites of the Bechstein's bat, but differ in several key life history traits including their mode of reproduction and generation time. Using mtDNA sequences and nucDNA microsatellites, we found strongly differing genetic population structures in the two parasite species. The mite (*S. bechsteini*) was highly differentiated between demographically isolated host maternity colonies, whereas the fly (*B. nana*) was panmictic across the same host colonies. These results can be attributed to differences in effective population size, which are caused primarily by the different modes of reproduction in the two parasite species. Such differences in genetic population structure have substantial implications for the evolutionary potential of the parasites, thereby also affecting the risk and evolutionary pressure exerted by each parasite on its host. In conclusion, our study shows that a particular social system can affect the evolutionary potential of parasites with different life histories differently.

Notes:

Impact of social and ecological parameters on reproductive success in wild female crested macaques

Engelhardt A

Nachwuchsgruppe Sexuelle Selektion, Deutsches Primatenzentrum, and Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D

Sociality is supposed to bring fitness benefits, but also to carry costs of competition. Data on the positive and negative effects of sociality on individual reproductive success and offspring survival are, however, still scarce. Furthermore, even less is known about the interaction of ecological and social variables on direct fitness. I therefore investigated offspring production and survival in three large groups of wild crested macaques (*Macaca nigra*) over a period of five years. Crested macaques are known for their tolerant social style in which female social rank is of little importance for social relationships, females build extended social networks and show reduced aggression towards each other. The socio-ecological model predicts low effects of within-group competition and high effects of between-group competition on female fitness for this species. My results show that living with many females is beneficial for female reproductive success most likely due to increased competitive abilities of large groups. They further indicate that within-group competition brings reproductive costs to lower-ranking females even in a system of social tolerance. They furthermore suggest that male infanticide plays a role in crested macaques, which fits with the steep male reproductive skew found in this species. Finally, my results show that fitness determinants may vary between offspring production and survival and thus point out the importance of comprehensive studies when investigating parent fitness determinants.

Notes:

Perceived social connectedness and health: models, mechanisms, and evidence

Hawkley LC

NORC at the University of Chicago, USA

Feelings of social connectedness, or conversely, feelings of social isolation, have implications for physical and mental health and well-being. Perceived isolation is associated with increased morbidity and mortality even after adjusting for objective isolation, suggesting that construals of the social environment are central to its influence on health and well-being. According to a social cognitive model of perceived isolation, feelings of isolation can trigger implicit hypervigilance for social threat which, in turn, launches a cascade of cognitive biases and behavioral confirmation processes that can perpetuate and exacerbate feelings of loneliness and alter the activity of neurobiological and behavioral mechanisms that can influence health outcomes. Evidence shows that perceived isolation diminishes sleep quality, reduces the likelihood of engaging in physical activity, alters regulatory control of blood pressure, increases the circulating cortisol concentration on an acute basis, and alters regulation of gene expression toward a pro-inflammatory profile consistent with glucocorticoid resistance. Additional evidence supports a causal role for perceived isolation in mechanisms and health outcomes.

Notes:

The behavioral immune system and human sociality

Schaller M

Department of Psychology, University of British Columbia, Vancouver BC, Canada

Human anti-pathogen defense is characterized by proactive behavioral mechanisms that inhibit contact with pathogens. This “behavioral immune system” is comprised by psychological processes that infer infection risk from perceptual cues, and that respond to these perceptual cues through the activation of aversive emotions, cognitions, and behavioral impulses. These processes are engaged flexibly, producing context-contingent variation in the magnitude of these adaptive responses. I provide an overview of research documenting implications for human social cognition and social behavior (e.g., implications for social affiliation, sexual behavior, inter-group prejudice, social influence, and cultural values). I also discuss several health implications associated with these psychological outcomes.

Notes:

Abstracts of Posters

Sleep in a hibernating lemur

Klopfer PH^{1,2}, Krystal AD³, Shopler B¹, Blanco MB^{1,4}, Yoder AD^{1,2}, Dausmann KH⁴ & Faherty SL²

¹Duke Lemur Center, Durham, USA, ²Department of Biology, Duke University, Durham, USA, ³Duke University School of Medicine, Durham, USA, ⁴Abteilung Tierökologie und Naturschutz, Universität Hamburg, D

We obtained, for the first time, EEG, temperature, and metabolism recordings in the wild from two lemur species, *Cheirogaleus crossleyi* and *C. sibreei*. By comparing the findings to recordings obtained from other hibernators we sought to further our understanding of inter-species differences in hibernation. We also sought to better understand the significance of the spontaneous arousals that occur during hibernation in these animals and determine whether these fulfill a need for sleep that is not met during torpor. We observed a number of commonalities with non-primate hibernators including: 1) monotonous ultra-low voltage EEG during torpor; 2) the absence of sleep during torpor; and 3) the occurrence of spontaneous arousals out of hibernation with EEG Delta Power findings consistent with being sleep deprived. At the same time *C. crossleyi* and *C. sibreei* differed from their close relative *C. medius* in that they did not sleep during torpor (while *C. medius* did so) and had spontaneous arousals, though this difference may simply reflect differences in ambient temperature experienced during torpor (*C. medius* lives in a warmer area). This study highlights features of hibernation that are shared across species as well as some inter-species differences, though it is difficult to tease inter-species differences apart from environmental differences. The possibility of interspecies differences suggests that understanding factors related to the possibility of inducing hibernation-like states in humans may only be reliably derived from studies of primate hibernators and, even there, we may encounter some cross-species differences.

Notes:

On the track of diversifying selection: adaptive genetic divergence in Cheirogaleidae?

Pechousková E¹, Huchard E² & Kappeler PM^{1,3}

¹Abteilung Verhaltensforschung & Soziobiologie, Deutsches Primatenzentrum, Göttingen, D, ²Department of Zoology, University of Cambridge, UK, ³Abteilung Soziobiologie & Anthropologie, Universität Göttingen, D

Identification of selective forces acting on adaptive traits maintaining genetic divergence among populations is essential for understanding the ecological origins of reproductive barriers that may ultimately lead to speciation in sympatric populations. The major driving forces in the process of diversification among populations are considered to be sexual selection, acting on divergence of mating traits, and adaptations to local ecological pressures. Traits, that both respond to sexual selection and local ecological adaptations have been suggested as a possible mechanism facilitating selective divergence among populations. The potential for immune genes of the Major Histocompatibility Complex (MHC) to respond to both local ecological pressures (pathogen resistance) and sexual selection (mate choice) makes them ideal candidates to investigate a process of genetic diversification among closely related species. Using 454-sequencing technology (Roche), we genotyped two highly polymorphic MHC genes (DQB, DRB) in a sympatric community of four nocturnal lemur species of Cheirogaleidae to test whether i) MHC variability is affected by population density, and ii) allelic divergence and divergence in immunological repertoire (functional diversity) of MHC alleles reflects phylogenetic distances among species. We predicted that MHC variability would be higher in species with higher population density (*Microcebus murinus*, *Cheirogaleus medius*) than in two other species with lower population density (*Microcebus berthae*, *Mirza coquereli*) and that divergence in immunological repertoire will not reflect phylogenetic distances among species, as it is likely to be determined rather by similar ecological pressure exerted upon them. We found a higher level of MHC variability in species with higher population density and considerable divergence in immunological repertoire of MHC alleles in both genes among all four species. Our results also indicate that the allelic and functional proximity of MHC alleles does not reflect phylogenetic distances among species. In the next step, we will investigate whether richness of parasite communities predicts levels of MHC diversity and if overlaps in parasite communities predict proximities in MHC immunological repertoires.

Notes:

Observations of human disturbance in Abuko Nature Reserve, The Gambia, and threats to a wild population of Temminck's Colobus, *Procolobus badius temminckii*

Hillyer A & Korstjens A

School of Applied Sciences, Bournemouth University, UK

A pilot study was carried out from March to June 2013 to estimate the size of the *Procolobus badius temminckii* population in Abuko Nature Reserve, The Gambia, and assess any threats. Observations were made of different types of human disturbance or threats caused by management of the reserve that could threaten the health of the reserve itself and this endangered subspecies. Potential pathogenic sources which could be of significant threat included the presence of domestic animals, including dogs, one of which was seen chasing colobus, human defecation in the reserve, expectoration of phlegm by staff, ubiquitous litter including dangerous items such as razor blades, interaction between captive and wild primates and the presence of an abattoir next to the reserve. Individuals with missing hair and scabbing were seen in all followed troops, which may be indicative of ill health.

Notes:

Guinea baboons at Parc National du Niocolo Koba are sero-positive for *Treponema pallidum*

Knauf S¹, Maciej P², Barnett U², Ndao I³, Zinner D², Fischer J²

¹Abteilung Infektionspathologie, Deutsches Primatenzentrum, Göttingen, D, ²Abteilung Kognitive Ethologie, Deutsches Primatenzentrum, Göttingen, D, ³Direction de Park National de Niokolo-Koba, Tambacounda, Senegal

The bacterium *Treponema pallidum* is a human pathogen that, if untreated, can cause fatal disease. The bacterium is a highly clonal pathogen and its three ssp. *pallidum*, *pertenue*, and *endemicum* differ by less than 1 % of the genome. Nevertheless, they are known to cause distinctive clinical diseases in humans (syphilis, yaws, and endemic syphilis, respectively). In the late 60's, scientists discovered antibodies against *T. pallidum* in West African baboons and described associated lesions as small ulcers around the muzzle, eyelids and armpits. However, most sero-positive individuals were described asymptomatic and the simian strain isolated at that time, was only recently whole genome sequenced. The phylogeny indicates that it is most closely related to human yaws-causing strains. During a necessary management intervention (change of GPS collars) in 2013, we were able to test 13 adult Guinea baboons (*Papio papio*) at Parc National du Niokolo-Koba in South-Eastern Senegal for the presence of antibodies against *T. pallidum*. Even four decades after the description by Fribourg-Blanc and Mollaret in 1969, 92% of the tested individuals (n=13) showed a clear sero-reactivity against the *T. pallidum* outer-membrane proteins TpN47 and Tp15-17. All tested baboons were clinically healthy. Interestingly, *T. pallidum* infection is not restricted to West African baboons and is equally found in East African baboons, but so far, West Africa is the only known region where simian infection is not associated with a clinical disease. Based on the scarce phylogenetic data and the geographic overlap of human yaws and NHP *T. pallidum* infection, it is possible that NHPs serve as a natural reservoir for human infection. The identification NHPs as a natural reservoir for human *T. pallidum* infection would be revolutionary and could aid planning of the second, upcoming WHO yaws eradication campaign.

Notes:

Effects of forest fragmentation on the parasitic infection of endangered black howler monkeys (*Alouatta pigra*) in Mexico

Martinez-Mota R

Department of Anthropology, University of Illinois at Urbana-Champaign, USA

Alterations in disease transmission and parasite infection patterns in primates have been linked to changes in habitat conditions. Black howler monkeys (*Alouatta pigra*) in Southern Mexico inhabit fragmented landscapes characterized by different degrees of disturbance and anthropogenic activities, such as cattle ranching and expansive agriculture. In order to assess the health and viability of these primates, I examined the effects of forest disturbance on gastrointestinal parasitic infection of an endangered population of *A. pigra* inhabiting fragments of tropical deciduous forest in Campeche, Mexico. During 12 months (1,097 observation hours), I collected non-invasively 673 fresh fecal samples from individually recognized howlers including 15 adult males, 15 adult females, and 12 immatures, belonging to 7 social groups distributed in 5 fragments. Fragment characteristics and feeding trees were recorded. Parasite eggs and cysts were recovered using flotation and sedimentation techniques. Six parasite taxa were recovered: *Trypanoxyuris* sp., *Controrchis* sp., unknown nematode, *Parabronema* sp., *Entamoeba coli*, and *Entamoeba* sp. Generalized linear mixed models indicate that intrinsic factors such as individual sex and age, as well as ecological factors such as season and few forest attributes, differently affect the probability of infection, depending on the parasite taxon. For example, *Trypanoxyuris* infection was higher in males than in females and during the rainy season than in the “cooler” season, while *Controrchis* infection was higher in adults compared to juveniles and during the dry season than during the rainy season. These results highlight the complexity of parasite-host relationships and the need to avoid generalizations when analyzing patterns of parasitic infection.

Notes:

Influence of bat social behavior on virus infection within and among three different bat species

Kerth G¹, Zeus V¹, Kwasnitschka L², Fischer K¹, Balkema Buschmann A² & Groschup M²

¹Ernst Moritz Arndt Universität Greifswald, D, ²Friedrich-Loeffler-Institut, Greifswald, Insel Riems, D

Understanding the antagonistic nature and evolutionary dynamics of host-virus relationships requires information on the genetic covariation and ecological interactions of hosts and viruses. However, the interplay between the processes that influence covariation of hosts and viruses is largely unknown. Above all, it is unclear to what degree ecological conditions and social barriers affecting host dispersal and the degree of association among different host species influence virus transmission within and among host species. Understanding such processes will enable a risk evaluation for the transmission of viral agents within a given species as well as between different species under defined ecological conditions. We present a project that investigates the links between the ecology, behavior and genetic structure of three bat species and the genetic structures and prevalence of different viruses that infest bats. The aim is to understand the relationship between ecological conditions and life history traits, in particular host social systems, of the interacting species that may help viruses to overcome species barriers and colonize novel hosts. Bats provide an ideal model system to study co-variation of viruses with a given host and co-speciation with different hosts due to: 1) the variability of bat social systems, 2) bat species differ in how regularly they share roosts with each other and 3) their high level of social interaction (coloniality) and ease of mobility (flight) bats can spread viruses very rapidly.

Notes:

Social activity and developmental tradeoffs in wild Assamese macaques

Berghänel A¹, Schülke O² & Ostner J¹

¹Arbeitsgruppe soziale Evolution von Primaten, Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D, ²Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D

Health is a status of physical integrity and unconstrained development. Physical integrity is often damaged by fights, which can be prevented by motoric and social skills. Skill acquisition is thought to be mediated by social play that may also affect social bonding and cooperation. Under energy restriction investments in social play may be traded off against growth and sexual maturation. We explored the strength of this tradeoff and how it will lead to individual and sex-specific strategies corresponding to diverging needs of adults. The study was conducted from May 2011 to December 2012 on all 17 infants (8 males, 9 females) in a wild group of Assamese macaques (*Macaca assamenis*) at Phu Khieo Wildlife Sanctuary in Thailand. Assamese macaques are characterized by male dispersal and female philopatry and strong male social bonds affect male fitness via cooperation in aggressive coalitions. We recorded behavioral data (1385.4 hours focal animal sampling), the first occurrences of 40 different motoric skills, and measured size photogrammetrically from the length of the lower arm from ~2500 pictures. We predicted that investment in social play speeds up motoric skill acquisition, but reduces growth rate, which might be positively correlated to time spent resting. We expect males to have higher needs for complex social skills (for social bonding with unfamiliar males after dispersal) and motoric skills (i.e. fighting competence) than females, who just need to integrate in their relatively stable matrilinear society. Thus, we expect male immatures to play socially more than female immatures, even for the price of reduced growth. Our first analyses suggest that male infants play socially more than females, and that social play speeds up motoric skill acquisition at the expense of growth. Thus animals may face a health tradeoff from birth between unconstrained physical development and their fighting competence and physical integrity as grownup.

Notes:

Low female stress hormone levels are predicted by same- or opposite-sex relationships depending on season in wild Assamese macaques

Fürtbauer I^{1,2}, Heistermann M³, Schülke O⁴ & Ostner J¹

¹Arbeitsgruppe soziale Evolution von Primaten, Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D, ²School of Psychology, University of Lincoln, UK, ³Hormonlabor, Deutsches Primatenzentrum, Göttingen, D, ⁴Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D

The social environment can have a powerful impact on an individual's stress response and thus affect health and fitness. This is particularly important in females of species living in complex societies like humans and non-human primates. Positive social relationships, particularly in unpredictable social environments, have been shown to alleviate the female stress response, resulting in lower glucocorticoid levels. Unfortunately, existing studies have mainly focused on female-female instead of same- and opposite-sex relationships simultaneously, and research for predictable social environments, such as seasonally recurring variation in social contact, is scarce. We test the hypothesis that female same- and opposite-sex social relationships predict fecal glucocorticoid levels (fGCs) in wild seasonally breeding Assamese macaques (*Macaca assamensis*). We found significant seasonal differences in same- and opposite-sex relationships which, depending on season, predicted female fGCs. In the mating season, females who spent more time close to males and more frequently groomed with them exhibited lower fGCs. In the non-mating season, when female-male interaction was infrequent, positive female-female interactions predicted lower fGCs. Our results indicate that both same- and opposite-sex relationships can moderate the female stress response during different reproductive life-history stages, which is likely to feedback positively on social preferences associated therewith.

Notes:

Parasite load in female Assamese macaques: a cost of sociality

Macdonald S¹, Somboon Sangmaneeet², Schülke O^{3*} & Ostner J^{1*}

¹Arbeitsgruppe soziale Evolution von Primaten, Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D, ²Faculty of Veterinary Science, Khon Kaen University, Thailand, ³Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D, *contributed equally

Sociality can be both a help and a hindrance to an individual's health. Socially well-integrated individuals, in both humans and non-humans, have been shown to fare better on various indicators of health and well-being, yet the increased social contact that comes with group living has also been shown to increase an individual's exposure to parasites and pathogens. In this study we aim to investigate to what extent sociality is a cost or benefit to the health of wild female Assamese macaques (*Macaca assamensis*). Data were collected from all adult females (N=15) from a fully habituated group of Assamese macaques living within Phu Khieo Wildlife Sanctuary, Thailand. Multiple fecal samples were collected from females during a month-long period in which parasite prevalence was particularly high. In addition over 400 h of focal data, including continuous recording of all social interactions, were collected during the four months leading up to sample collection. A network of female social relationships in the group was constructed based on three positive social behaviors, friendly approaches (<1.5 m), friendly body contact and grooming. We compared three measures of social integration within the network (strength centrality, eigenvector centrality and betweenness centrality) to female parasite load, assessed via fecal sample egg counts. Our analysis indicates that females who are the more socially integrated into the network have the higher loads of two long-lived intestinal parasites (*Entamoeba* sp. and *Trichuris trichiura*) but not a third potentially shorter lived intestinal parasite (*Strongyle* sp.). In particular females who occupy central "hub" positions within the network tended to have the highest parasite loads. We conclude that sociality, therefore, carries health costs for females in this group.

Notes:

Towards the non-invasive assessment of MHC genotype in wild primates

Müller N¹, Ostner J¹, Schülke O² & Walter L³

¹Arbeitsgruppe soziale Evolution von Primaten, Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D, ²Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D, ³Abteilung Primatengenetik, Deutsches Primatenzentrum, Göttingen, D

The major histocompatibility complex (MHC) plays an important role in the immune response and may thus crucially affect an individual's fitness, relevant also for studies on evolutionary ecology and wildlife conservation. Detailed knowledge on the genomic organization, polymorphism and diversity of the MHC has a narrow taxonomic focus and among macaques is only available for rhesus and long-tailed macaques, the species most commonly used for biomedical research. The lack of data on wild populations is mainly due to the difficulty to obtain blood or tissue samples necessary for genotyping approaches. Here, we aimed to analyze MHC-DRB from non-invasively collected fecal samples in wild Assamese macaques (*Macaca assamensis*). We analyzed the highly diverse microsatellite marker MHC-DRB-STR (D6S2878) and obtained results from 43 individuals including 35 members of previously identified families. Our results indicate that variability and diversity of MHC-DRB in Assamese macaques is comparable to that of other macaque species: We detected 28 distinct DRB-STR lengths, individual genotypes contained 1 to 9 MHC-DRB-STRs, and four haplotypes that segregated between families in Mendelian fashion were defined. As expected given the source of DNA, there were a number of methodological problems and thus we have to assume that for several individuals, genotypes are incomplete, calling for further improvement and evaluation of the current methods. As a first step in this direction, we developed a primer for the amplification of the marker D6S2878 based on Assamese macaque sequences, which improved the genotyping results. Generally, our results indicate that fecal samples can be used for non-invasive analysis of MHC genes after thorough method optimization, opening a number of opportunities for further MHC research on natural populations.

Notes:

Social influences on physiological stress levels in wild male Barbary macaques

Young C¹, Majolo B², Heistermann M³, Schülke O⁴ & Ostner J¹

¹Arbeitsgruppe soziale Evolution von Primaten, Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D, ²School of Psychology, University of Lincoln, UK, ³Hormonlabor, Deutsches Primatenzentrum, Göttingen, D, ⁴Courant Forschungszentrum Evolution des Sozialverhaltens, Universität Göttingen, D

Individuals living in social groups experience varying intensities of social stressors. The extent to which individuals can cope with both positive and negative interactions can affect their well-being and can lead to a rise in stress hormone (glucocorticoid; GC) production. An increase in GC secretion over prolonged periods can have deleterious health and fitness consequences for the individual. Individuals with strong social ties within a group have been shown, in both human and non-human primates, to exhibit lower physiological stress. In this study we investigate the effect of social factors on GC levels in male Barbary macaques (*Macaca sylvanus*) living in their natural habitat in the Middle Atlas Mountains, Morocco. Specifically, we predict increased levels of physiological stress to be associated with lack of strong social ties, lack of agonistic support and amount of received aggression. In addition, we predict that the loss of a close partner is associated with increased GC levels. We will present results based on the analyses of over 2,000 hours of focal observations collected on 14 males from two social groups and GC metabolites via assessment of 680 fecal samples using enzyme immunoassays. Social bond strength was measured using the Composite Sociality Index (Silk et al. 2003). By examining male stress responses to several social factors this study adds to the current literature on the value of social relationships in multi-male multi-female societies from the perspective of the dispersing sex.

Notes:

Social networks as a trade-off between optimal decision-making, information transmission and reduced disease transmission.

Duboscq J^{1,2}, Sueur C^{1,2} & MacIntosh A³

¹Département Ecologie, Physiologie & Ethologie, Centre National de la Recherche Scientifique, Strasbourg, F, ²Institut Pluridisciplinaire Hubert Curien, Université de Strasbourg, F, ³Kyoto University Primate Research Institute, CICASP, Inuyama, Japan

Within a group, each individual can be seen as part of a network of social interactions that vary in strength, type and dynamics. Social transmission of behavior and disease within a group can take many forms and may deeply affect an individual's fitness. In theory, the social network properties increasing decision accuracy and information flow should also increase the disease transmission rate, creating a trade-off between decision-making efficiency and infection risk. The aim of this study is to better understand this trade-off in Japanese macaques (*Macaca fuscata*), a highly social animal living in permanent stable groups and forming extended but highly differentiated social networks. For this purpose, we manipulate the environment of Japanese macaques to create conditions in which information and parasite transmission both vary. To study information transmission, we use a diffusion experiment where we train individuals with specific position in the social network (e.g. central/peripheral) to open food boxes in two ways (e.g. push/pull). At the same time, to study parasite transmission, we apply pseudoectoparasites (PEPs), made out of hypoallergenic colored wax, on the fur of the same "learner" individuals. We track the transmission of the PEPs and the diffusion of the novel behavior simultaneously. Specific questions we address are the patterns of interaction between informed/infected individuals and naïve/healthy ones, as well as the factors influencing both diffusion and transmission (position in the network, dominance rank, number/quality of bonds within the group, sex, or age). The use of social network analysis together with this experimental approach allows us to analyze and predict the efficiency of information transmission and the limitation of disease contagion. Ultimately, this study brings relevant information on decision-making trade-offs social individuals have to make.

Notes:

List of Participants

- Almeling, Laura:** DPZ, Göttingen, D; lalmeling@dpz.eu
- Altizer, Sonia:** University of Georgia, Athens, USA; saltizer@uga.edu
- Archie, Beth:** Notre Dame University, USA; earchie@nd.edu
- Behringer, Verena:** MPI für Evolutionäre Anthropologie, Leipzig, D;
verena_behringer@eva.mpg.de
- Berghänel, Andreas:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
aberghaenel@web.de
- Brett, Jacob:** School of Applied Sciences, Bournemouth University, UK;
jacob.brett90@hotmail.co.uk
- Brockmeyer, Timo:** DPZ, Göttingen, D; timo.brockmeyer@gmail.com
- Capitania, John:** University of California, Davis, USA; jpcapitania@ucdavis.edu
- Cavigelli, Sonia:** Pennsylvania State University, USA; s-cavigelli@psu.edu
- Chapman, Colin:** McGill University, Montreal, Canada; Colin.Chapman@McGill.ca
- Charpentier, Marie:** CEFE/CNRS, Montpellier, F; marie.charpentier@cefe.cnrs.fr
- Clutton-Brock, Tim:** University of Cambridge, UK; thcb@cam.ac.uk
- Craft, Meggan:** University of Minnesota, St. Paul, USA; craft004@umn.edu
- Cremer, Sylvia:** IST, Klosterneuburg, A; sylvia.cremer@ist.ac.at
- Cziommer, Anja:** DPZ & Universität Göttingen, D; acziommer@dpz.eu
- Dal Pesco, Federica:** DPZ, Göttingen, D; fdalpesco@dpz.eu
- de Paula, Valéria:** DEPE/IPHC, Strasbourg, F; romanodepaula@gmail.com
- Dobson, Steve:** CEFE/CNRS, Montpellier, F; stephen.dobson@cefe.cnrs.fr
- Dröschner, Iris:** DPZ, Göttingen, D; iris.droeschner@gmail.com
- Duboscq, Julie:** CNRS, Strasbourg, F; jduboscq@dpz.eu
- Engelhardt, Antje:** DPZ, Göttingen, D; aengelhardt@dpz.eu
- Fichtel, Claudia:** DPZ, Göttingen, D; claudia.fichtel@gwdg.de
- Fischer, Julia:** DPZ, Göttingen, D; jfischer@dpz.eu
- Fürtbauer, Ines:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
ifuertb@gwdg.de
- Gault, Colleen:** MPI für Evolutionäre Anthropologie, Leipzig, D;
colleen_gault@eva.mpg.de
- Gillespie, Thomas:** Emory University, Atlanta, USA; thomas.gillespie@emory.edu
- Glaschke, Christina:** DPZ, Göttingen, D; cglaschke@dpz.eu
- Goffe, Adeelia:** DPZ, Göttingen, D; agoffe@dpz.eu
- Gogarten, Jan:** McGill University & Robert Koch Institute, Montreal, Canada;
jan.gogarten@gmail.com
- Grützmaker, Kim:** Robert Koch Institut, Berlin, D; gruetzmacherk@rki.de
- Hammerschmidt, Kurt:** DPZ, Göttingen, D; khammerschmidt@dpz.eu

9. Göttinger Freilandtage: Participants

- Hawkley, Louise:** NORC at University of Chicago, USA; hawkley-louise@norc.org
- Heesen, Marlies:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
marlies.heesen@zentr.uni-goettingen.de
- Heymann, Eckhard:** DPZ, Göttingen, D; eheyman@gwdg.de
- Hillyer, Alison:** School of Applied Sciences, Bournemouth University, UK;
alisonhillier78@hotmail.com
- Huchard, Elise:** University of Cambridge, UK; ehuchard@gmail.com
- Hübner, Franziska:** DPZ, Göttingen, D; franzihuebner@gmx.de
- Huffman, Michael:** Primate Research Institute, Kyoto University, Japan;
huffman@pri.kyoto-u.ac.jp
- Kalbitz, Josefine:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
jkalbit@gwdg.de
- Kalbitzer, Urs:** DPZ, Göttingen, D; ukalbitzer@dpz.eu
- Kappeler, Peter:** DPZ & Universität Göttingen, D; pkappel@gwdg.de
- Kaumanns, Werner:** LTM Research and Conservation, Göttingen, D; silenus@t-online.de
- Kerth, Gerald:** Zoologisches Institut, Greifswald, D; Gerald.kerth@uni-greifswald.de
- Kittler, Klara:** DPZ, Göttingen, D; KKittler@dpz.eu
- Klopper, Peter:** Duke Lemur Center & Duke University, Durham, USA; phk@duke.edu
- Koch, Flávia:** DPZ, Göttingen, D; biokoch@gmail.com
- Kopp, Gisela:** DPZ, Göttingen, D; gkopp@dpz.eu
- Korstjens, Amanda:** School of Applied Sciences, Bournemouth University, UK;
akorstjens@bournemouth.ac.uk
- Kraus, Cornelia:** Universität Göttingen, D; ckraus1@gwdg.de
- Kubenova, Barbora:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
kubebear@seznam.cz
- Lahmann, Henning:** Universität Göttingen, D; hlahman1@gwdg.de
- Leendertz, Fabian:** Robert Koch-Institut, Berlin, D; leendertzf@rki.de
- Lehmann, Julia:** University of Roehampton, London, UK; j.lehmann@roehampton.ac.uk
- Lilie, Navina:** Universität Göttingen, D; navina_lilie@hotmail.com
- Marty, Pascal:** DPZ, Göttingen, D; pmarty@dpz.eu
- McCabe, Collin:** Harvard University, Cambridge, USA; mccabe@fas.harvard.edu
- Macdonald, Sally:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
sallymacd@gmail.com
- Martinez-Mota, Rodolfo:** University of Illinois at Urbana-Champaign, USA;
rmarti39@illinois.edu
- Menzel, Claudia:** Institut für Anatomie, Universität Jena, D; menzel.cl@gmail.com
- Morbach, Zina:** Universität Göttingen, D; zinamaria.morbach@stud.uni-goettingen.de
- Müller, Nadine:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
Nadine.Mueller@zentr.uni-goettingen.de

9. Göttinger Freilandtage: Participants

- Nevo, Omer:** DPZ, Göttingen, D; onevo@dpz.eu
- Nunn, Charles:** Duke University, Durham, USA; clnunn@duke.edu
- Ostner, Julia:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
jostner@gwdg.de
- Paschek, Nicole:** Universität Göttingen, D; N.Paschek@gmx.de
- Pechouskova, Eva:** DPZ, Göttingen, D; epechouskova@dpz.eu
- Pfefferle, Dana:** MPI für Evolutionäre Anthropologie, Leipzig, D; dpfefferle@eva.mpg.de
- Poirotte, Clémence:** CEFE/CNRS, Montpellier, F; c.poirotte@gmail.com
- Port, Markus:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
mport@gwdg.de
- Pozzi, Luca:** DPZ, Göttingen, D; lpozzi@dpz.eu
- Radespiel, Ute:** Institut für Zoologie, Hannover, D; ute.radespiel@tiho-hannover.de
- Rakotonirina, Hanitra:** DPZ, Göttingen, D; hrakotonirina@dpz.eu
- Randimbisoa, Annicka:** Université d'Antananarivo, Madagascar;
randy_annicka@yahoo.fr
- Runge, Jan-Niklas:** DPZ, Göttingen, D; jan.is.ping@gmail.com
- Rusk, Caroline:** Duke University, Durham, USA; caroline.rusk@duke.edu
- Schaeps, Franka:** MPI für Evolutionäre Anthropologie, Leipzig, D;
franka_schaeps@eva.mpg.de
- Schaller, Mark:** University of British Columbia, Vancouver, Canada; schaller@psych.ubc.ca
- Schloegl, Christian:** DPZ, Göttingen, D; cschloegl@dpz.eu
- Schmid-Hempel, Paul:** ETH, Zürich, CH; paul.schmid-hempel@env.ethz.ch
- Schneider, Tilman:** Universität Göttingen, D; tilman.carlo@gmail.com
- Schnoell, Anna:** DPZ, Göttingen, D; aschnoell@dpz.eu
- Schülke, Oliver:** CRC Evolution of Social Behaviour, Universität Göttingen, D;
oschuel@gwdg.de
- Setchell, Joanna:** Durham University, UK; joanna.setchell@durham.ac.uk
- Shedden, Aralisa:** School of Applied Sciences, Bournemouth University, UK;
arazitl@hotmail.com
- Shutt, Kathryn:** Durham University, UK; k.a.shutt@durham.ac.uk
- Silk, Joan:** Arizona State University, Tempe, USA; Joan.Silk@asu.edu
- Singh, Mewa:** University of Mysore, India; mewasinghltm@gmail.com
- Slana, Darja:** DPZ, Göttingen, D; darjuska.s@gmail.com
- Sperber, Anna:** DPZ, Göttingen, D; asperber@dpz.eu
- Springer, Andrea:** DPZ, Göttingen, D; aspringer@dpz.eu
- Székely, Tamás:** Universität Göttingen, D; T.Szekely@bath.ac.uk
- van Schaik, Jaap:** MPI für Ornithologie, Seewiesen, D; Jaapvanschaik@gmail.com
- Wadewitz, Philip:** DPZ, Göttingen, D; pwadewitz@dpz.eu
- Walbaum, Ulrike:** DPZ, Göttingen, D; uwalbaum@dpz.eu

9. Göttinger Freilandtage: Participants

- Wascher, Claudia:** Universidad de Valladolid, E; claudia.wascher@gmail.com
Weis, Marissa: DPZ, Göttingen, D; marissa@weis-richter.de
Widdig, Anja: MPI für Evolutionäre Anthropologie, Leipzig, D; anja.widdig@eva.mpg.de
Wittig, Roman: MPI für Evolutionäre Anthropologie, Leipzig, D; wittig@eva.mpg.de
Wright, Edward: MPI für Evolutionäre Anthropologie, Leipzig, D;
edward_wright@eva.mpg.de
Young, Christopher: CRC Evolution of Social Behaviour, Universität Göttingen, D;
christopher.young@zentr.uni-goettingen.de
Zeus, Veronika: Universität Greifswald, D; veronika.zeus@gmail.com
Ziegler, Thomas: DPZ, Göttingen, D; tziegler@dpz.eu
Zinner, Dietmar: DPZ, Göttingen, D; dzinner@gwdg.de

General Information

City map

Maps of Göttingen City are included in your conference package. Additional copies can be obtained at the registration/information desk.

Coffee breaks

Coffee, tea, mineral water and munchies are available free of charge to registered conference participants at the Foyer (outside the auditorium) during the official breaks.

Dinner

Dinner will be provided in the form of finger foods at the reception on Tuesday evening and at the conference party on Friday (see Social Program below).

Elevator

Elevator enabling easy access to the basement (= lunch) can be found in the lobby next to the Espresso Bar.

Internet

Free internet access is available at the computer terminal close to the Espresso Bar and at the computer pool, which is located inside the Max-Planck library (one floor below the auditorium). For Wi-Fi see below.

Lunch

Lunch will be available at the self-serve cafeteria located downstairs from the auditorium. You can choose from several warm and cold meals and pay in cash. Students presenting their student ID will be offered reduced fees. Conference participants will only be served after 13:00 h.

Parking

As there are no parking opportunities, please use the conference shuttle bus or public transportation to reach the Max-Planck campus.

Phone

You will be able to receive phone calls at the registration desk (+49-551-201-1132).

Photocopying

There are copy machines inside the Max-Planck library, located below the auditorium.

Posters

Poster authors can put their poster up between 08.00h and 09.00h on Wednesday (or during a subsequent break) on the designated boards outside the auditorium. Please follow the numbering system on the poster boards (alphabetical order). The necessary materials are available at the registration/information desk. Please remove your poster during the afternoon coffee break on Friday. Poster talks (Thursday morning) should be 3min max.

long and should not exceed 3 slides. During the poster session on Thursday afternoon, you are asked to stand next to your poster so that any delegates wishing to discuss your work can find you easily.

Questions?

For further questions, contact the registration/information desk or any member of the organizing committee wearing a red name tag.

Registration

Registration will take place on Tuesday, December 3, from 16.30 to 18.00 h at the Foyer of the Max-Planck-Institute for Biophysical Chemistry. On Wednesday, Thursday and Friday the registration/information desk will open at 08.30 h. In addition to the registration package, tickets for social events will be available there.

Sanitary facilities

Bathrooms are located next to the auditorium and downstairs across the cafeteria.

Snacks

Additional snacks can be purchased at the Espresso Bar open Mon-Thu: 12-16:30 h and Fri: 12-14:30 h.

Smoking policy

Smoking is prohibited in all public buildings. Smokers are kindly asked to smoke outside.

Social events

On Tuesday afternoon before at 14.30 h you will have the opportunity to join a guided tour of the facilities of the German Primate Center (DPZ). Meeting point for registered participants is at the main entrance of DPZ (Kellnerweg 4).

On Wednesday evening, you will have a chance to catch up with old friends, meet new ones, or explore the downtown Christmas market. No events will be organized that night to provide you with that flexibility. Optional meeting point is the big wheel at the Christmas market (close to St. Johannis church).

On Thursday evening (20.00 h), conference participants are invited to join an informal reception at the Divalounge Café/Bar/Lounge (Kurze-Geismar-Straße 9) to continue discussion in a more informal setting.

On Friday evening (19.30), the conference party will take place at the German Primate Center (Kellnerweg 4). Tickets (Euro 25) must be purchased at the registration/information desk by Wednesday noon. They entitle to ad lib access to a buffet with hot and cold local and seasonal specialties as well as drinks! Bring your dance shoes!

Taxis can be ordered by calling 0551-69300 or 0551-65000. You can ask for a "Großraum-taxi" to order a mini-van carrying up to 8 people!

Transport

In addition to the city bus number 5 and 51 (timetables available at registration desk), a free conference shuttle bus displaying the conference logo will pick up participants at several bus stops in town. Location of the bus stops and timetables can be found on the back cover of this program. About 30 minutes after the last talk each day, the same shuttle-bus will take you back into town (as announced in the scientific program).

Talks

To upload any visual or audio aids (PowerPoint, video etc.) used to accompany your presentation you will need to find Henning Lahmann (red name tag) to upload files. Items should be provided on a USB drive, and must be uploaded either the day before (if speaking in the morning) or on the morning of your presentation (if speaking in the afternoon). This ensures ample time to rectify any issues you may have with your visual aids files. Plenary speakers have 50 min for their talk (including discussion), all other oral presenters 15min + 5min discussion.

Wardrobe

Unattended wardrobes are located close to the reception desk and downstairs, outside the cafeteria.

Wi-Fi

Wireless internet access will be available for participants at the conference location throughout the meeting! To access this you will need to use a password that can be requested at the registration desk.

GFT proceedings

Following the previous Freilandtage conferences, we solicited representative contributions from invited speakers for a proceedings volume, each of them combining specific case studies, comprehensive reviews and theoretical analyses on the respective topic of the conference.

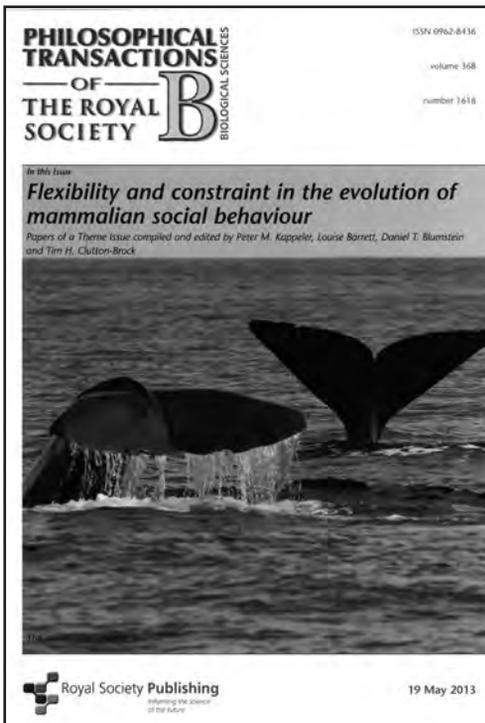
Kappeler PM (ed, 2000): Primate Males: Causes and Consequences of Variation in Group Composition. Cambridge University Press. ISBN: 0521658462.

Kappeler PM, Pereira ME (eds, 2003): Primate Life Histories and Socioecology. University of Chicago Press. ISBN: 0226424634.

Kappeler PM, van Schaik CP (eds, 2004): Sexual Selection in Primates: New and Comparative Perspectives. Cambridge University Press. ISBN: 052153738X.

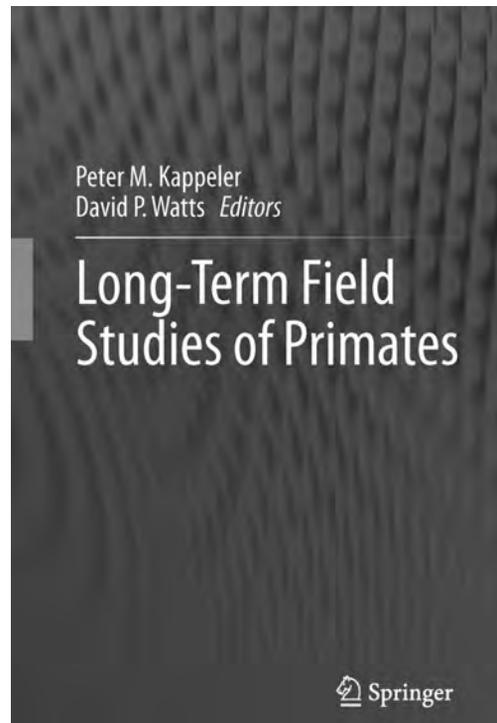
Kappeler PM, van Schaik CP (eds, 2006): Cooperation in Primates and Humans: Mechanisms and Evolution. Springer. ISBN: 3540282696.

Kappeler PM, Silk JB (eds, 2010): Mind the Gap: Tracing the Origins Of Human Universals. Springer. ISBN: 3642027245.



Flexibility and Constraint in the Evolution of Mammalian Social Behaviour
Edited by Peter Kappeler, Louise Barrett, Daniel Blumstein and Tim Clutton-Brock

Philosophical Transactions of the Royal Society B,
2013, ISBN: 3642027245

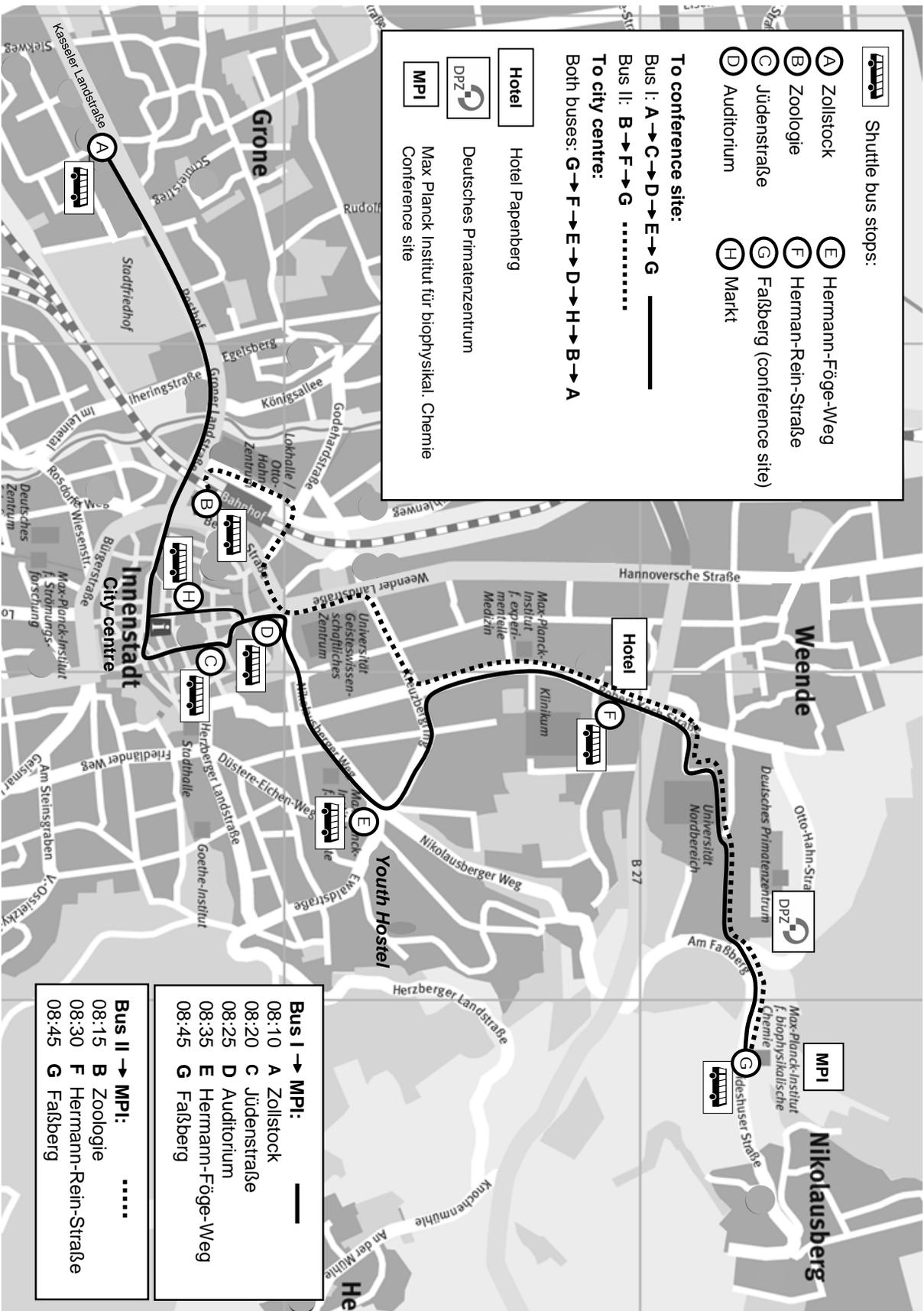


Long-Term Field Studies of Primates

Edited by Peter Kappeler and David Watts

Springer, 2012

ISBN: 3642225136



Shuttle bus stops:

- A Zollstock
- E Hermann-Föge-Weg
- B Zoologie
- F Herman-Rein-Strasse
- C Judenstraße
- G Faßberg (conference site)
- D Auditorium
- H Markt

To conference site:

Bus I: A → C → D → E → G ———

Bus II: B → F → G

To city centre:

Both buses: G → F → E → D → H → B → A

- Hotel** Hotel Papenberg
- DPZ** Deutsches Primatenzentrum
- MPI** Max Planck Institut für biophysikal. Chemie Conference site

Bus I → MPI:	—————
08:10 A Zollstock	
08:20 C Judenstraße	
08:25 D Auditorium	
08:35 E Hermann-Föge-Weg	
08:45 G Faßberg	
Bus II → MPI:
08:15 B Zoologie	
08:30 F Hermann-Rein-Strasse	
08:45 G Faßberg	