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# References

## Aktuell


Alonso-Mora 2017

Javier Alonso-Mora, Samitha Samaranayake, Alex Wallar, Emilio Frazzoli & Daniela Rus, *On-demand high-capacity ride-sharing via dynamic trip-vehicle assignment*. PNAS **114** (2017), 462–467.

Ride-sharing services are transforming urban mobility by providing timely and convenient transportation to anybody, anywhere, and anytime. These services present enormous potential for positive societal impacts with respect to pollution, energy consumption, congestion, etc. Current mathematical models, however, do not fully address the potential of ride-sharing. Recently, a largescale study highlighted some of the benefits of car pooling but was limited to static routes with two riders per vehicle (optimally) or three (with heuristics). We present a more general mathematical model for real-time high-capacity ride-sharing that (i) scales to large numbers of passengers and trips and (ii) dynamically generates optimal routes with respect to online demand and vehicle locations. The algorithm starts from a greedy assignment and improves it through a constrained optimization, quickly returning solutions of good quality and converging to the optimal assignment over time. We quantify experimentally the tradeoff between fleet size, capacity, waiting time, travel delay, and operational costs for low- to medium-capacity vehicles, such as taxis and van shuttles. The algorithm is validated with .3 million rides extracted from the New York City taxicab public dataset. Our experimental study considers ride-sharing with rider capacity of up to 10 simultaneous passengers per vehicle. The algorithm applies to fleets of autonomous vehicles and also incorporates rebalancing of idling vehicles to areas of high demand. This framework is general and can be used for many real-time multivehicle, multitask assignment problems.

Keywords: ride-sharing | human mobility | vehicle routing | smart cities | intelligent transportation systems

Significance: Ride-sharing services can provide not only a very personalized mobility experience but also ensure efficiency and sustainability via large-scale ride pooling. Large-scale ride-sharing requires mathematical models and algorithms that can match large groups of riders to a fleet of shared vehicles in real time, a task not fully addressed by current solutions. We present a highly scalable anytime optimal algorithm and experimentally validate its performance using New York City taxi data and a shared vehicle fleet with passenger capacities of up to ten. Our results show that 2,000 vehicles (15 % of the taxi fleet) of capacity 10 or 3,000 of capacity 4 can serve 98 % of the demand within a mean waiting time of 2.8 min and mean trip delay of 3.5 min.

Tarnita 2017

Corina E. Tarnita et al., *A theoretical foundation for multi-scale regular vegetation patterns*. nature **541** (2017), 398–401.

n541-0398-Supplement1.mov, n541-0398-Supplement2.mov, n541-0398-Supplement3.mov, n541-0398-Supplement4.mov, n541-0398-Supplement5.pdf

Corina E. Tarnita, Juan A. Bonachela, Efrat Sheffer, Jennifer A. Guyton, Tyler C. Coverdale, Ryan A. Long & Robert M. Pringle

Self-organized regular vegetation patterns are widespread1 and thought to mediate ecosystem functions such as productivity and robustness2–4, but the mechanisms underlying their origin and maintenance remain disputed. Particularly controversial are landscapes of overdispersed (evenly spaced) elements, such as North American Mima mounds, Brazilian murundus, South African heuweltjies, and, famously, Namibian fairy circles5–13. Two competing hypotheses are currently debated. On the one hand, models of scale-dependent feedbacks, whereby plants facilitate neighbours while competing with distant individuals, can reproduce various regular patterns identified in satellite imagery1,14,15. Owing to deep theoretical roots and apparent generality, scaledependent feedbacks are widely viewed as a unifying and near-universal principle of regular-pattern formation1,16,17 despite scant empirical evidence18. On the other hand, many overdispersed vegetation patterns worldwide have been attributed to subterranean ecosystem engineers such as termites, ants, and rodents3,4,7,19–22. Although potentially consistent with territorial competition19–21,23,24, this interpretation has been challenged theoretically and empirically11,17,24–26 and (unlike scale-dependent feedbacks) lacks a unifying dynamical theory, fuelling scepticism about its plausibility and generality5,9–11,16–18,24–26. Here we provide a general theoretical foundation for self-organization of socialinsect colonies, validated using data from four continents, which demonstrates that intraspecific competition between territorial animals can generate the large-scale hexagonal regularity of these patterns. However, this mechanism is not mutually exclusive with scale-dependent feedbacks. Using Namib Desert fairy circles as a case study, we present field data showing that these landscapes exhibit multi-scale patterning—previously undocumented in this system—that cannot be explained by either mechanism in isolation. These multi-scale patterns and other emergent properties, such as enhanced resistance to and recovery from drought, instead arise from dynamic interactions in our theoretical framework, which couples both mechanisms. The potentially global extent of animal-induced regularity in vegetation—which can modulate other patterning processes in functionally important ways—emphasizes the need to integrate multiple mechanisms of ecological self-organization.

## Anthropologie

### Gómez-Robles 2017

Aida Gómez-Robles, Jeroen B. Smaers, Ralph L. Holloway, P. David Polly & Bernard A. Wood, *Brain enlargement and dental reduction were not linked in hominin evolution*. PNAS **114** (2017), 468–473.

pnas114-00468-Supplement.zip The large brain and small postcanine teeth of modern humans are among our most distinctive features, and trends in their evolution are well studied within the hominin clade. Classic accounts hypothesize that larger brains and smaller teeth coevolved because behavioral changes associated with increased brain size allowed a subsequent dental reduction. However, recent studies have found mismatches between trends in brain enlargement and posterior tooth size reduction in some hominin species. We use a multiple-variance Brownian motion approach in association with evolutionary simulations to measure the tempo and mode of the evolution of endocranial and dental size and shape within the hominin clade. We show that hominin postcanine teeth have evolved at a relatively consistent neutral rate, whereas brain size evolved at comparatively more heterogeneous rates that cannot be explained by a neutral model, with rapid pulses in the branches leading to later Homo species. Brain reorganization shows evidence of elevated rates only much later in hominin evolution, suggesting that

fast-evolving traits such as the acquisition of a globular shape may be the result of direct or indirect selection for functional or structural traits typical of modern humans.

Keywords: endocast | postcanine teeth | evolutionary rates | selection | paleoanthropology

Significance: The evolution of the brain and of posterior teeth seem to follow parallel trends in hominins. Larger brain size is associated with reduced premolars and molars, but this association is not observed in all hominin species. We have evaluated this association in a quantitative way by measuring lineage-specific rates of dental and cerebral evolution in the different branches of the hominin evolutionary tree. Our results show that different species evolved at different rates and that brain evolution in early Homo was faster than dental evolution. This result points to different ecological and behavioral factors influencing the evolution of hominin teeth and brains.

## Bibel

Yardeni 1991

Ada Yardeni, *Remarks on the Priestly Blessing on Two Ancient Amulets from Jerusalem*. Vetus Testamentum **41** (1991), 176–185.

It is obvious that the silver plaques from Ketef Hinnom cannot solve the problem of the time of the composition of the Pentateuch. As was said above, it can prove only the existence of the priestly blessing in the pre-exilic period. It is possible that the rolled silver plaques were used as amulets to protect their owners from evil and to bring upon them the blessing of YHWH, not very different from the use of amulets in later times. Because of the priestly context which the blessing appears in the Bible and also in the Rule of the Community from Qumran, there still remains the question whether in early times such amulets were commonly used or only by priests.

## Biologie

Croft 2017

Darren P. Croft et al., *Reproductive Conflict and the Evolution of Menopause in Killer Whales*. Current Biology (2017), preprint, 1–7. DOI:10.1016/j.cub.2016.12.015.

Darren P. Croft, Rufus A. Johnstone, Samuel Ellis, Stuart Nattrass, Daniel W. Franks, Lauren J. N. Brent, Sonia Mazzi, Kenneth C. Balcomb, John K. B. Ford & Michael A. Cant

In Brief: Croft et al. show that in resident killer whales, older mothers suffer disproportionate costs when breeding at the same time as their daughters, an effect driven by the unusual demography of resident killer whales. These findings can explain for the first time why reproductive and somatic senescence have been decoupled in resident killer whales.

Highlights:

- Local group relatedness increases with age in female killer whales
- Young females are predicted to invest more in reproductive competition
- The costs of co-breeding with kin are greater for old compared to young females

Why females of some species cease ovulation prior to the end of their natural lifespan is a long-standing evolutionary puzzle [1–4]. The fitness benefits of post-reproductive helping could in principle select for menopause [1, 2, 5], but the

magnitude of these benefits appears insufficient to explain the timing of menopause [6–8]. Recent theory suggests that the cost of inter-generational reproductive conflict between younger and older females of the same social unit is a critical missing term in classical inclusive fitness calculations (the "reproductive conflict hypothesis" [6, 9]). Using a unique long-term dataset on wild resident killer whales, where females can live decades after their final parturition, we provide the first test of this hypothesis in a non-human animal. First, we confirm previous theoretical predictions that local relatedness increases with female age up to the end of reproduction. Second, we construct a new evolutionary model and show that given these kinship dynamics, selection will favor younger females that invest more in competition, and thus have greater reproductive success, than older females (their mothers) when breeding at the same time. Third, we test this prediction using 43 years of individualbased demographic data in resident killer whales and show that when mothers and daughters co-breed, the mortality hazard of calves from older-generation females is 1.7 times that of calves from younger-generation females. Intergenerational conflict combined with the known benefits conveyed to kin by post-reproductive females can explain why killer whales have evolved the longest post-reproductive lifespan of all non-human animals.

## Luijckx 2017

Pepijn Luijckx et al., *Higher rates of sex evolve during adaptation to more complex environments*. PNAS **114** (2017), 534–539.

Pepijn Luijckx, Eddie Ka Ho Ho, Majid Gasim, Suyang Chen, Andrijana Stanic, Connor Yanchus, Yun Seong Kim & Aneil F. Agrawal

A leading hypothesis for the evolutionary maintenance of sexual reproduction proposes that sex is advantageous because it facilitates adaptation. Changes in the environment stimulate adaptation but not all changes are equivalent; a change may occur along one or multiple environmental dimensions. In two evolution experiments with the facultatively sexual rotifer Brachionus calyciflorus, we test how environmental complexity affects the evolution of sex by adapting replicate populations to various environments that differ from the original along one, two, or three environmental dimensions. Three different estimates of fitness (growth, lifetime reproduction, and population density) confirmed that populations adapted to their new environment. Growth measures revealed an intriguing cost of complex adaptations: populations that adapted to more complex environments lost greater amounts of fitness in the original environment. Furthermore, both experiments showed that B. calyciflorus became more sexual when adapting to a greater number of environmental dimensions. Common garden experiments confirmed that observed changes in sex were heritable. As environments in nature are inherently complex these findings help explain why sex is maintained in natural populations.

Keywords: evolution of sex | adaptation | Fisher–Muller hypothesis | Hill–Robertson interference

Significance: The existence of sexual reproduction despite its well-known costs is a decades-old puzzle. Although recent studies show that sex can be advantageous because it may facilitate adaptation, it remains unclear whether all types of adaptation result in the same sexual response. Using experimental evolution we show that adaptation to different environments results in varying amounts of sex and, more importantly, that higher levels of sex evolve when adapting to more complex environments. As environments in nature are inherently complex, our findings help explain why so many natural populations maintain such high levels of sex.

## Klima

### McMichael 2017

Crystal N. H. McMichael, Frazer Matthews-Bird, William Farfan-Rios & Kenneth J. Feeley, *Ancient human disturbances may be skewing our understanding of Amazonian forests*. PNAS **114** (2017), 522–527.

Although the Amazon rainforest houses much of Earth's biodiversity and plays a major role in the global carbon budget, estimates of tree biodiversity originate from fewer than 1,000 forest inventory plots, and estimates of carbon dynamics are derived from fewer than 200 recensus plots. It is well documented that the pre-European inhabitants of Amazonia actively transformed and modified the forest in many regions before their population collapse around 1491 AD; however, the impacts of these ancient disturbances remain entirely unaccounted for in the many highly influential studies using Amazonian forest plots. Here we examine whether Amazonian forest inventory plot locations are spatially biased toward areas with high probability of ancient human impacts. Our analyses reveal that forest inventory plots, and especially forest recensus plots, in all regions of Amazonia are located disproportionately near archaeological evidence and in areas likely to have ancient human impacts. Furthermore, regions of the Amazon that are relatively oversampled with inventory plots also contain the highest values of predicted ancient human impacts. Given the long lifespan of Amazonian trees, many forest inventory and recensus sites may still be recovering from past disturbances, potentially skewing our interpretations of forest dynamics and our understanding of how these forests are responding to global change. Empirical data on the human history of forest inventory sites are crucial for determining how past disturbances affect modern patterns of forest composition and carbon flux in Amazonian forests.

Keywords: Amazon | succession | carbon dynamics | hyperdominants | biomass

Significance: The Amazon harbors thousands of species and plays a vital role in the Earth's climate and carbon cycles. Much of what we know about the Amazon is based on censuses of only a small number of forest inventory plots, an even smaller number of which are censused repeatedly and used to study forest dynamics and carbon fluxes. The effects of ancient human impacts have never been properly assessed or accounted for in studies of Amazonian plots. New spatial analyses show that plots significantly oversample areas with high abundances of archaeological evidence of past human activities. This suggests that our interpretations of the Amazon's structure, composition, and function are based disproportionately on forests still reflecting the legacies of past human disturbances.

### Mukherjee 2017

Pami Mukherjee, Nitesh Sinha & Supriyo Chakraborty, *Investigating the dynamical behavior of the Intertropical Convergence Zone since the last glacial maximum based on terrestrial and marine sedimentary records*. Quaternary International (2017), preprint, 1–9. DOI:10.1016/j.quaint.2016.08.030.

The Intertropical Convergence Zone (ITCZ) is an integral component of the earth's climate system. It plays important roles in monsoon precipitation, transport of chemical tracers between the hemispheres, ENSO variability etc. The ITCZ is characterized by seasonal movement that stays several degrees north of the equator during the boreal summer and a few degrees south of the equator during the boreal winter. The seasonal movement across the hemisphere is driven by seasonal changes in insolation. Apart from seasonal migration ITCZ also moves in longer timescales that is governed by the orbital motion of the earth as well as by

the internal dynamics of the earth's ocean-atmospheric variability. Proxy records indicate the mean position of the ITCZ of the Indian Ocean sector was somewhat different relative to its estimated position considering solar insolation variability in orbital time scale. In this paper we investigate the movement of the ITCZ that occurred in millennium time scales and discuss its implications mainly on South Asian monsoon variabilities. The study relies on proxy data; the isotopic analysis of foraminifera and speleothem. One of the important implications of this study is that the Indian summer monsoon rainfall which is undergoing a slow decreasing trend for the last several decades is expected to experience a reverse trend in a few decades.

Keywords: Intertropical Convergence Zone (ITCZ) | Sea Surface Temperature (SST) | Asian monsoon variability | Proxy records

Schneider 2014

Tapio Schneider, Tobias Bischoff & Gerald H. Haug, *Migrations and dynamics of the intertropical convergence zone*. nature **513** (2014), 45–53.

Rainfall on Earth is most intense in the intertropical convergence zone (ITCZ), a narrow belt of clouds centred on average around six degrees north of the Equator. The mean position of the ITCZ north of the Equator arises primarily because the Atlantic Ocean transports energy northward across the Equator, rendering the Northern Hemisphere warmer than the Southern Hemisphere. On seasonal and longer timescales, the ITCZ migrates, typically towards a warming hemisphere but with exceptions, such as during El Niñ̈o events. An emerging framework links the ITCZ to the atmospheric energy balance and may account for ITCZ variations on timescales from years to geological epochs.

## Neolithikum

Jones 2017

Huw Jones, Diane L. Lister, Dawei Cai, Catherine J. Kneale, James Cockram, Leonor Peña-Chocarro & Martin K. Jones, *The trans-Eurasian crop exchange in prehistory: Discerning pathways from barley phylogeography*. Quaternary International **426** (2017), 26–32.

QuatInt426-026-Supplement1.xlsx, QuatInt426-026-Supplement2.xlsx

A number of crops that are of global importance today, including wheat (Triticum spp) and barley (Hordeum vulgare), were domesticated in Southwest Asia between 10,000 and 11,000 years ago and subsequently spread through the Old World, into Europe, North Africa and eastwards across Eurasia. Their routes of expansion have been a focus of debate and are increasingly being revealed by widespread dating of archaeobotanical remains from across Eurasia. Of particular interest is work by Zhao (2009) who proposed three routes for the spread of wheat into China: firstly, across the Eurasian Steppe, second by sea from India to the east coast of Eurasia and third, along the Hexi Corridor, which forms part of the Silk Road in western China. Molecular genetic analysis of cereal landraces have also elucidated routes of expansion of cereal cultivation and, in addition, have revealed how crops adapted to changing environments as they moved away from their centres of domestication. Genes involved in flowering time genes have been a particular focus of these studies, including the photoperiod response gene Ppd-H1 in barley, which controls flowering in response to increasing day-lengths in the spring. In this paper we present a phylogeographic analysis of Old World landrace and wild barley, through the analysis of a portion of the Ppd-H1 DNA sequence.

We discuss the geographic distribution of different haplotypes of this gene across Eurasia in the light of Zhao (2009)'s three routes and what it potentially reveals about trans-Eurasian pathways of contact between early farming communities.

Keywords: Barley | Flowering time | Photoperiod response | Domestication | Agricultural spread | Phylogeography

## Story or Book

KISER 2017

Barbara Kiser, *The Cradle of Humanity*. nature **541** (2017), 287.

The Cradle of Humanity. Mark Maslin. Oxford University Press (2017)

Examining early hominin finds in East Africa, he spotlights three stages (bipedalism in Australophithecus, a jump in brain size in Homo erectus and Homo sapiens' arrival some 195,000 years ago) and the roles of climate change, celestial mechanics and plate tectonics in their emergence. Ultimately, he theorizes that 'climate pulses' in the Rift Valley, in which hyper-arid conditions alternated with the formation of vast lakes, helped to drive the evolution of the big hominin brain.