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Pathological complexity and African elephant consciousness

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Abstract

Veit (2023) provides a framework for modelling and empirically investigating varieties of consciousness as a Darwinian phenomenon, based on abduction from life histories of animals. The alleged 'hard problem' is exposed as an artefact of ignoring mechanisms by which increasingly complex varieties of consciousness evolved under selection pressure over evolutionary time. I illustrate Veit's approach through a case study of a highly complex but non-human variety, consciousness in African elephants. This is useful for specifying more exactly the kind of anthropocentrism that Veit criticises.

Keywords

elephant consciousness, pathaological complexity, life history theory

Handling Editor: Walter Veit, University of Reading, UK

1. Introduction

Veit's (2023) programme for explaining the evolution and natural functions of consciousness encourages modelling consciousness in a specific species by reference to a *life history* account of the species in question. Here I will illustrate the potential value of Veit's programme by applying it to an iconic species with a number of special features (or, at least, features unique to its taxon of living and extinct pachyderms), the African savannah elephant (*Loxodonta africana*).

2. Veit's account of consciousness

Veit (2023) provides a high-level template for conceptualising, modelling, systematically observing, and experimentally probing consciousness according to Darwin's core insight for zoology. According to this template, to understand a specific animal's repertoire of capacities and characteristic responses, as well as its anatomy, one must build up a model of the selection history of these features – that is, one must model the animal *teleonomically*. Where consciousness is concerned, Veit extends and modifies the *environmental complexity thesis* of Godfrey-Smith (1996), according to which mind in general was naturally selected for its power to help animals successfully manage dynamically interacting environmental processes that genetic pre-programming could not anticipate in detail. Veit's adaptation of this idea emphasises attention to the contrast between more and less healthy functioning implicit in teleonomy; selection will favour metabolically expensive information-processing equipment necessary for consciousness only when it pays for itself by warding off *threats* to reproductive fitness that arise from complexity. This motivates the *pathological complexity thesis*: 'The function of consciousness is to enable the agent to respond to pathological complexity' (Veit, 2023, p. 2). Then the aspects of consciousness we should hypothesise and test in a particular species are to be constructed by abduction from the specific varieties of pathological complexity that historically regulated the selection and maintenance of the species in question.

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Three general features of Veit's proposed methodology merit emphasis in any application of it to a specific natural case.

First, Veit argues that models of an animal's mind and consciousness must attend to both external, exogenous, sources of complexity, and sources that arise endogenously from the animal's *agency*, the repertoires of actions it can take to modify the conditions on which distinctions between health and pathology depend.

Second, models of consciousness should not be anthropocentric, in the specific sense that they should not generally model manifestations of consciousness by comparative assessment against all of the dimensions of consciousness that humans characteristically attribute to themselves. Such anthropocentrism gives rise to the intractable but scientifically bogus 'hard problem' championed by some philosophers, because it leads us to look for unicorns, mechanisms that could functionally explain the full suite of human-style subjective experiences all at once. Veit's Darwinism partly consists in his insistence that consciousness arose gradually over evolutionary time, and that its historical development has a recursive structure. That is, more recently evolved features of consciousness arose largely as capacities selected to manage new pathological complexity generated by historically earlier features, interacting with the varying dynamic environmental niches colonised by different species. So, clams did not evolve crocodile consciousness because their minimal form of consciousness, in their marine environment of floating nutrients, did not present them with the panoply of complexity threats that greater anatomical articulation and life as an active liminal-zone predator presented to crocodiles. The same point arises in comparing crocodile consciousness with human consciousness. In general, this kind of comparison is much less informative than comparing crocodile consciousness with the consciousness of (a) their own near ancestors and (b) similarly equipped animals occupying relatively closely convergent niches. Continuing the example, it might be fruitful to compare crocodile consciousness with anaconda consciousness.

Third, the basic natural function that generated the evolution of all varieties of consciousness is *evaluation*: assessing which environmental contingencies should be responded to as opportunities and which as threats. We should thus implicitly – and often explicitly – model the selection of specific forms of consciousness from an economic point of view, but with Darwinian fitness maximisation as the specification of the more general idea of utility. Veit argues that the first historical manifestation of consciousness may have been simple aversive signals – in effect, pain (stripped of its special human complexification that often tangles it with disappointment and feelings of loss[1]). Later-evolved features of consciousness, including the suite found in humans – following Birch et al. (2020): perceptual or sensory richness, evaluative richness, selfhood and awareness of other selves, intertemporal integration of experience, and unity of cross-modal experience at a time – evolved to manage increased complexity resulting from the emergence of prior features. Thus, the evolution of consciousness is a kind of economic *ratchet effect* in evolution.

Veit argues (see Veit et al., 2025 for technical details) that pathological complexity is best conceptualised and measured using *life history theory* (Stearns, 1992), as operationalised using matrix population models (van Groenendael et al., 1988, 1994). Specifically, we can measure the complexity of an animal's adaptive traits, including its forms of consciousness, by identifying its *life history strategy*: the characteristic response patterns, both behavioural and cognitive, that it uses to maintain itself and produce offspring.

3. African elephants as model species

In focusing on the consciousness of the African elephant, we move far from the early stages of Veit's ratchet, and very close to the human case. Veit's ratchet effect explains why the most metabolically expensive brains in the history of life – those of humans, cetaceans, and elephants – are all relatively historically recent. The pathological complexity thesis predicts what we seem to empirically find, that multifunctional expressions of consciousness are strongly correlated with metabolic expense of brains, since only rising pathological complexity can economically justify bearing such costs.

I choose to feature elephants mainly for an opportunistic reason: they are the species I study. But for readers ultimately motivated by interest in human consciousness, yet mindful of Veit's injunction against viewing other consciousnesses by reference to our self-experience, elephants present a uniquely informative case. I have argued elsewhere (Harrison & Ross, 2025; Ross, 2024) that attention to convergent evolutionary circumstances makes elephants at least as rich a comparison species for humans as chimps and gorillas where life history is concerned. Like hominins, elephants have their evolutionary origins in East and central African semi-arid ecologies during extended period of volatile climate change that drastically and recurrently altered available vegetation and, particularly, distribution and concentrations of water. Both hominins and elephants evolved long lives, intense socialisation, remarkably metabolically expensive brains, lengthy gestation and childhood, alloparenting, complex communication systems, self-awareness, tool use and modification, and advanced problem-solving capacities. Both kinds of animals radiated widely from their African origin points, and spread across most continental land masses, ultimately thriving in prairies, scrubland, forests, semi-deserts, wetlands, and tundra.

4. The character of evidence

In setting out to describe elephant life history, crucial decisions must be made about relevant evidence bases. There is a small but growing literature reporting experiments aimed at eliciting aspects of elephant cognition. I am myself part of a group that has been running such experiments for the past five years (Harrison & Ross, 2025). Due to the extreme danger that wild elephants pose to nearby humans outside sturdy vehicles, however, all such experiments to date have involved tame elephants under human management.

Caution is always required in generalising from observations of animals in un-natural ecological circumstances, and Veit's account amplifies the importance of such caution. Where elephants are concerned, the problems with such inferences are particularly acute (Byrne & Bates, 2011). For reasons to be discussed below, a main feature of adult elephant life history is making highly risky decisions about foraging plans, and successful track records in such decisions are the basis for group acknowledgment of authority in leaders of matriarchal herds. Captive elephants provided with food and water by humans, even those who forage for themselves in substantial reserves such as those studied by my group, face no such risky choices. This should be expected to significantly distort their general cognitive profiles – imagine making inferences about human cognition entirely from samples of people born too wealthy to ever have to earn income or subject themselves to hierarchical control after childhood. A main objective of my group's work is to build experimental protocols with our tame elephants that do not require close presence of any people, in the hope that once fully tested for knowledge-generating power, these protocols can be extended to wild subjects. But achievement of this ambition lies in the future.

Most of what is known about African elephant life history therefore derives from passive field observation. Fortunately, this record is unusually rich. Due to their size, elephants are easily closely watched by researchers to whom they have become habituated, particularly from open vehicles. A compendious record of carefully staged observations has been compiled over decades by the Amboseli Elephant Research Project (AERP) (Moss et al., 2011). Over most of the study period, since 1972, the population of known individuals has gently but steadily increased under the protection of the park, and as of 2023 stood at 1,878. The ecology of the large park is varied and dynamic (Croze & Lindsay, 2011), so the researchers have been able to assemble full matrices of behaviours by specific elephants across ranges of ecological challenges, with a panel structure spanning half a century. With respect to the quantitative life history theory favoured by Veit et al., 2025, projection matrix methodology has been constructed and applied by AERP researchers (Lusseau & Lee, 2016).

The published compilation of AERP observations appeared in 2011. However, the record available for public scrutiny is much richer than the published summaries, and is maintained up to date, at the website Elephant Voices: https://www.elephantvoices.org/about-elephantvoices/team.html. Perusal of this site allows the user to survey a trove of 'anecdotes' reported by epistemically conscientious experts. At sufficient critical mass, given professional-quality reliability of observers, such anecdotes constitute scientific evidence.

The elephant life history reviewed below is based on this evidence about wild elephants, conditioned by personal judgment based on the many hours I have spent in the close company of tame but untethered and freely foraging ones.

5. African elephant life history and inferences concerning consciousness

A key determinant of all aspects of African elephant (henceforth, for brevity, 'elephant') life history is the challenge of maintaining very large bodies, with extremely metabolically expensive brains, in relatively arid savannah and scrubland. Elephant digestion is comparatively inefficient for a large herbivore, compounding the fact that the useful nutrient composition of many of their standard foods is low. Consequently, elephants in typical wild ecological settings spend 60%–80% of their waking time eating, and most of the rest travelling between food and water sources (Hart et al., 2008). Maintenance of their brains, the largest among terrestrial animals and near the top of the mammal distribution after controlling for encephalisation quotient (Byrne & Bates, 2011; Herculano-Houzel, 2013), is a major driver of this life history constraint.

In seeking to explain the selection of brains that make such extreme operating cost demands in normal habitats, it is important to review basic facts about elephants' unusual neuroanatomy. These directly suggest some special questions about elephant consciousness, which can guide research agendas. Following Veit's (2023) explanatory framework, the organ's high cost assures us that it produces life history effects that very strongly promote elephant expected fitness.

Elephant brains have unique architecture, not found to date in other mammals.[2] Almost all the special metabolic cost of the elephant brain (normalising for body size) is accounted for by densely folded cerebellar neurons, ten times the number occurring in any other terrestrial mammal (Herculano-Houzel, 2013). In species for which neuropsychological functions have been mapped, cerebellum is associated with regulating movement and spatial orientation of the body. This has led some scientists to speculate that the

massive cerebellar endowment was selected for management of the elephant's trunk (Maseko et al., 2013), which integrates the most complex range of functions of any organ (other than brains) observed in a living species. However, given the well-known general information-processing plasticity of neurons, elephants' advanced capacities for problem solving and rapid learning would be mysterious if the apparent cerebellar 'excess' was not recruited to support general cognition.

Putting these pieces together leads to abductive speculation about the basis for elephants' remarkably stable and decay-resistant memory, which allows them to apply single-exposure learning about environmental features after intervals of a decade or more (Byrne & Bates, 2011). Their expansive cerebellum may allow them to use somatic indexing as a cue-retrieval system – in effect, superior specific recollection in elephants may be a kind of muscle memory.[3] Harrison and Ross (2025), in the course of observing six African elephants engaged in risky choice tasks that require quantitative comparisons across novel domains of experience, find that elephants learn faster if the experimental protocol allows them to walk while making decisions; and they are clearly and consistently averse to standing still during such decisions even if offered immediate food rewards for doing so.

This hypothesis implies an interesting question about comparative elephant and human consciousness. People can attend to feelings of familiarity when executing well-trained physical movements, but generally do not describe, to themselves or others, articulated decompositions of such recalled feelings. When teaching athletic or artistic skills to others, they rely much more heavily on physical demonstration than on language-based scripts. Though elephants exhibit a wealth of indicators of social transmission of knowledge, wild elephants have not been observed to model physical actions while others attend to their modelling, in the way that apes and cetaceans have been observed to do. Investigations of elephant communications, when these progress as anticipated through applications of deep-learning-system technology to analysis of their sub-sonic rumbles, might shed light on whether elephants can consciously manipulate somatic memories to an extent that humans at least generally do not try to do. The idea here is that elephants might be able to *describe*, to themselves and others, techniques for such evident skills as testing air currents for learned indicators of distant rainfall. Of course, this possibility also depends on facts about the complexity and sophistication of elephant communication, about which more is said below.

It is a common theme in comparative evolutionary psychology to associate high intelligence, and neural information-processing capacity that supports it, to social complexity (Dunbar & Sutcliffe, 2012). In elephants, the social profile of their life history interacts strongly with the urgency of their foraging challenges. Thus the 'push' and 'pull' aspects of the selection of their expensive brains are likely closely entangled: foraging *complexity* favoured expensive brains, but expensive brains increased foraging demands. The social structure of their life history is likely best explained as the mechanism for achieving equilibrium in these evolutionary dynamics. Because an elephant's required portfolio of nutrients requires typically widely disbursed *ranges* of foods, elephants cannot forage opportunistically – that is, simply travelling semi-randomly within range of water sources and eating what they happen to find. The cumulative weight of AERP observations strongly suggests that matriarchal leadership – as well as leadership of 'bachelor herds' by experienced bulls[4] – is based on the contributions of leaders to foresight and planning of herd movements. Acoustic signature patterns of signals related to initiation and direction of travel have already been identified by field-based research (O'Connell-Rodwell et al., 2024; Payne, 1998), and under conditions of ecological stress these appear to both follow and trigger expressions of alternative inclinations by other individuals (Mutinda et al., 2011). It will not be surprising if, when elephant communications are better understood, this aspect of elephant pathological complexity is found to have generated selected for collective deliberation and joint reason-based decision making. This would have immediate implications for inferring characteristics of elephant consciousness.

As alluded to at several junctures above, the most direct research path to uncovering probable aspects of elephant consciousness is investigation of the syntax, semantics, and pragmatics of their communications.[5] When elephants are physically near others, as females and calves almost always are and bulls often are, they emit nearly continuous 'rumbling' at frequencies below human detection. These rumbles have been found to be dense with both recurrent acoustic patterns and variation, and are modulated by both laryngeal and trunk muscle contractions that appear to be under voluntary control (Maseko et al., 2013). The patterns are distinctively clustered within social communities, and captive elephants drawn from geographically distant populations and housed together rumble much less than elephants with common population origins. It is likely that they cannot understand one another's rumbles.

Efforts by people to decode rumble patterns, following the methods used with human symbol streams familiar from espionage, are likely to falter due to divergences in shared conceptual ontology between the species. But deep-learning AI systems need not be hampered by restrictive human assumptions about what is worth talking about,[6] and can search for statistical regularities and redundancies with greater power than any previous technology. Applications of these systems to recorded elephant rumbles are already yielding insights. Distinct self-identification signature signals used by adult elephants throughout their lives – that is, their names – have been identified. Very suggestively, these are emitted most frequently in communication by mothers

to young offspring (Pardo et al., 2024), replicating the pattern of human name use. As noted above, rumbles that indicate suggestions to travel after a period of exploiting a food or water source have also been isolated. Given the current exponential increase in power of deep-learning systems, it does not seem fanciful to suppose that researchers will soon be capable of engaging in conversation with elephants using sub-sonic microphones and acoustic synthesisers.[7] This offers the prospect of studying elephant consciousness using the method that is the overwhelmingly greatest source of knowledge of human consciousness.[8]

Close-quarter elephant communications through rumbling are accompanied by ear movements, head position adjustments, and trunk touching that also appear to have signalling properties. If such signals modulate rumble semantics – a possibility about which, as far as I am aware, nothing is yet known – then this may complicate efforts to decode rumbles using only acoustic recordings provided as data to deep-learning decoder systems. The AI decoders might also need access to video records.

At longer distances, elephants exchange information through seismic signals detected by sense organs in their footpads. There is suggestive evidence that such communication is used to relay information about locations of water and forage, but of course ranges of other possible uses are possible, which await systematic investigation.

Elephant females and calves generally travel in small herds that periodically aggregate into larger clan gatherings that can include hundreds of individuals who mutually recognise one another (McComb et al., 2000; Moss & Poole, 1983; Sukumar, 2003). The AERP data provide strong evidence of special friendships that cross herd boundaries within clans, and in one case such a friendship was observed to be the basis for the founding of a new matriarchal travelling herd (Moss & Lee, 2011). Following separations, friends display effusive greeting behaviour on re-contact. In general, elephants are highly demonstrative in expressing social emotions, most vividly of all in response to new births. Mothers make special trips to introduce calves to clan members who were not present when they were born (Moss et al., 2011), and orphan elephants rescued and fostered by people and then reintroduced into wild lives recurrently journey with their new offspring to present them to their former caregivers (Sheldrick, 2012). Famously, elephants show intense interest in the remains of dead conspecifics they knew, and their travel itineraries appear to take special account of opportunities to visit sites of such deaths.

The above suite of extensively documented behavioural patterns provide a strong abductive basis for hypothesising evaluative richness, and selfhood and awareness of other selves, as features of elephant consciousness.

A specific aspect of evaluative richness in humans is conscious acknowledgment of social expectations as a motivation for self-control. Elephants demonstrate a range of behaviours consistent with – though certainly not yet decisive evidence for – such awareness of social norms (Bradshaw, 2009; Ross, 2019; Wrage et al., 2023). A widely discussed instance of possible elephant norm enforcement occurred in South African reserves, where herds of young bulls orphaned by human culls of their birth herds committed recurrent lethal violence against rhinoceroses, but halted this uncharacteristic aggression almost immediately when older bulls from other parks were introduced into their environments (Slotow et al., 2000; Slotow & van Dyk, 2001). These episodes might be attributable to hormonal regulation involving no consciousness of normative expectations; however, the young elephants continued to experience musth (albeit with reduced frequency), so the completeness and immediacy of the behavioural response would be puzzling in the absence of a cognitive aspect.

6. Conclusion

The weight of observational evidence reviewed above suggests that elephants might, like humans, exhibit the full suite of aspects of consciousness canvassed by Birch et al. (2020). If this hypothesis is supported as further evidence accrues, then convergence of this specific kind between elephants and humans will offer much stronger inferential leverage concerning the particular pathological complexities that explain the nature of human consciousness than, as a matter of logic, evidence about only one species can offer. The logical problem in question is that, trivially, a single species is a cluster of unique properties, so any of these are equally good candidates for abductive hypothesising with respect to selectively relevant pathological complexities. Comparison with one or more closely genetically related species adds relatively low leverage against this problem. Where differences are observed, these can support inferences about the evolutionary *timing* of the emergence of a feature of consciousness. For example, the apparent disinterest of chimpanzees in sharing subjective perspectives suggests that this important aspect of awareness of other selves was also missing in their most recent common ancestor with humans. But this example illustrates the limitation in confidence where such reasoning is concerned, since we must allow for the possibility that chimps lost this disposition, or even capacity, if its value for their fitness declined after the point of separation from hominids. By contrast, shared ecological history of two distantly related species, such as humans and elephants, provides a stronger basis for inferences from features of pathological complexity.

But here it is important to attend to Veit's guidance against forms of anthropocentrism special to the study of consciousness. We should not, for example, hypothesise *deficits* in elephant consciousness because they do not store stable external records of their thoughts or communications, as humans do. As argued at length by Harrison and Ross

(2025), humans use such scaffolding to address two core limitations associated with their reliance on dense frontal cortex. First, external records compensate for decay of individual memory. Second, shared social access to external epistemic scaffolds helps ground human groups in common foundations for joint expectations and inferences. This is important in a species with strong imaginative tendencies that systematically contaminate relationships between cognitive models and perceived reality. Elephants, with highly stable individual memories rooted in their cerebellar layers, and less active imaginations, were under no similar selection pressure. Emphasis on this difference very exactly expresses Veit's pathological complexity thesis: humans, but not elephants, are under continuous threat of collective insanity, and this should be expected to result in differences in their respective forms of consciousness.

Avoidance of anthropocentrism in Veit's sense here consists in treating the importance of constructed semantic scaffolding in human consciousness as *irrelevant* to modelling elephant consciousness. The evolution of elephant consciousness is not a train on a trip to human consciousness that stopped a station or two short of the final destination. On the other hand, these two evolutionary trajectories might have run along more closely parallel tracks than those followed by any other kinds of animal, and this might be of profound importance to future practical efforts to build more cooperative interspecific relationships outside zones of captivity.

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Notes

1. That a male mantis goes on mating while being devoured by his partner is not necessarily evidence that he feels no pain, as similar behaviour would be in a person. People *do* persist in activities that are very painful, finishing marathons and staying put in dentist's chairs. But being cannibalised would arrest a person's mating activity because they would immediately focus almost all their attention on the immediate prospect of death.
2. I emphasise 'to date'. Sperm whales have remarkable life history similarities to elephants, though in a radically different ecological setting (Whitehead, 2003). This might be thought to predict some neurostructural convergence. Sperm whales have unusually large cerebellar *volume,* but so do cetaceans in general (Maseko et al., 2012). However, brain region volumes are unreliable indicators of neural area density. Proportions of types of neurons in the sperm whale brain have not yet been measured using the method applied by Herculano-Houzel (2013) to elephant brains.
3. See Buzáski et al., 2022 for a survey of evidence on such memory structures in various species.
4. The sexual segregation of adult elephant society was almost certainly selected for its advantage in reducing competition for food sources between large bulls and developing calves; bulls can emphasise wide dispersion and fast travel, while mothers and offspring can emphasise *careful* foraging.
5. Most readers will interpret this statement as implying that I think that elephants likely 'have language'. This interpretation is intended. Much entrenched opinion in linguistics and analytic philosophy notwithstanding, the continuous refinement of criteria for identifying 'true' language so that this can continue to be viewed as a unique attribute of humans, in the face of scientifically valid discoveries of ever greater sophistication of animal communications, has become an embarrassment. Natural selection almost never produces the kind of sharp boundary between morphological, behavioural, or cognitive phenomena as is encapsulated in any idea of 'true language'. In any event, humans can safely go on celebrating, if so inclined, the hugely ecologically important fact that they alone produce long-lasting externally stored records of their communications.
6. Here again, we can derive a useful suggestion from Veit's proposed methodology: the AI decoders should be fed information about elephant life histories.
7. We should not assume that wild elephants would be motivated to engage in conversation with humans, and tame elephants might do so in ways that are far from natural communication. But as long as there has been successful decoding of conversations among elephants, these limitations will be open to checking.
8. It is urgent that careful ethical protocols be developed before this capacity arises and is applied in research. Being addressed conversationally by another species might significantly *alter* elephant consciousness. And as soon as people become capable of talking to elephants, they will be capable of lying to them.

References

Birch, J., Schnell, A., & Clayton, N. (2020). Dimensions of animal consciousness. *Trends in Cognitive Sciences*, *24*(10), 789–801. https://doi.org/10.1016/j.tics.2020.07.007

Bradshaw, G. (2009). *Elephants on the edge*. Yale University Press.

Buzáski, G., McKenzie, S., & Davachi, L. (2022). Neurophysiology of remembering. *Annual Review of Psychology*, *73*, 187–215. https://doi.org/10.1146/annurev-psych-021721-110002

Byrne, R., & Bates, L. (2011). Elephant cognition: What we know about what elephants know. In C. Moss, H. Croze, & P. Lee (Eds.), *The Amboseli elephants* (pp. 174–182). University of Chicago Press.

Croze, H., & Lindsay, W. K. (2011). Amboseli ecosystem context: Past and present. In C. Moss, H. Croze, & P. Lee (Eds.), *The Amboseli elephants* (pp. 11–28). University of Chicago Press.

Dunbar, R., & Sutcliffe, A. (2012). Social complexity and intelligence. In T. Shackelford & J. Vonk (Eds.), *Oxford handbook of comparative evolutionary psychology* (pp. 102–117). Oxford University Press.

Godfrey-Smith, P. (1996). *Complexity and the function of mind in nature*. Cambridge University Press.

Harrison, G., & Ross, D. (2025). *The gambling animal*. Profile.

Hart, B., Hart, L., & Pinter-Wollman, N. (2008). Large brains and cognition: Where do elephants fit in? *Neuroscience & Biobehavioral Reviews*, *32*(1), 86–98. https://doi.org/10.1016/j.neubiorev.2007.05.012

Herculano-Houzel, S. (2013). *The Human Advantage*. MIT Press.

Lusseau, D., & Lee, P. (2016). Can we sustainably harvest ivory? *Current Biology: CB*, *26*(21), 2951–2956. https://doi.org/10.1016/j.cub.2016.08.060

Maseko, B., Jacobs, B., Spocter, M., Sherwood, C., Hof, P., & Manger, P. (2013). Qualitative and quantitative aspects of the microanatomy of the African elephant cerebellar cortex. *Brain, Behavior and Evolution*, *81*(1), 40–55. https://doi.org/10.1159/000345565

Maseko, B., Spocter, M., Haagensen, M., & Manger, P. (2012). Elephants have relatively the largest cerebellum size of mammals. *The Anatomical Record*, *295*(4), 661–672. https://doi.org/10.1002/ar.22425

McComb, K., Moss, C., Sayialel, S., & Baker, L. (2000). Unusually extensive networks of vocal recognition in African elephants. *Animal Behaviour*, *59*(6), 1103–1109. https://doi.org/10.1006/anbe.2000.1406

Moss, C., Croze, H., & Lee, P. (Eds.), (2011). *The Amboseli elephants*. University of Chicago Press.

Moss, C., & Lee, P. (2011). Female social dynamics: Fidelity and flexibility. In C. Moss, H. Croze, & P. Lew (Eds.), *The Amboseli elephants* (pp. 205–223). University of Chicago Press.

Moss, C., & Poole, J. (1983). Relationships and social structure in African elephants. In R. Hinde (Ed.), *Primate social relationships: An integrated approach* (pp. 315–325). Blackwell.

Mutinda, H., Poole, J., & Moss, C. (2011). Decision making and leadership in using the ecosystem. In C. Moss, H. Croze, & P. Lew (Eds.), *The Amboseli elephants* (pp. 246–259). University of Chicago Press.

O'Connell-Rodwell, C., Berezin, J., Pignatelli, A., & Rodwell, T. (2024). The use of vocal coordination in male african elephant group departures: Evidence of active leadership and consensus. *PeerJ*, *12*, Article e17767. https://doi.org/10.7717/peerj.17767

Pardo, M., Fristup, D., Lolchuragi, D., Poole, J., Granli, P., Moss, C., Douglas-Hamilton, I., & Wittemyer, G. (2024). African elephants address one another with individually specific name-like calls. *Nature Ecology & Evolution*, *8*(7), 1353–1364. https://doi.org/10.1038/s41559-024-02420-w

Payne, K. (1998). *Silent thunder*. Simon & Schuster.

Ross, D. (2019). Consciousness, language, and the possibility of non-human personhood: Reflections on elephants. *Journal of Consciousness Studies*, *26*(3-4), 227–251.

Ross, D. (2024). Comparative cognitive science and convergent evolution: Humans and elephants. *Cultural Science*, *14*(1), 77–84. https://doi.org/10.2478/csj-2022-0011

Sheldrick, D. (2012). *Love, life, and elephants*. Farrar, Straus, & Giroux.

Slotow, R., & van Dyk, G. (2001). Role of delinquent young "orphan" male elephants in high mortality of white rhinoceros in Pilansberg National Park, South Africa. *Koedoe*, *44*, 85–94.

Slotow, R., van Dyk, G., Poole, J., Page, B., & Klocke, A. (2000). Older bull elephants control young males. *Nature*, *408*(6811), 425–426. https://doi.org/10.1038/35044191

Stearns, S. (1992). *The evolution of life histories*. Oxford University Press.

Sukumar, R. (2003). *The living elephants: Evolutionary ecology, behaviour, and conservation*. Oxford University Press.

van Groenendael, J., de Koon, H., & Caswell, H. (1988). Projection matrices in population biology. *Trends in Ecology & Evolution*, *3*, 264–269.

van Groenendael, J., de Koon, H., Kalisz, S., & Tuljapurkar, S. (1994). Loop analysis: Evaluating life history pathways in population projection matrices. *Ecology*, *7*, 2419–22415. https://doi.org/10.2307/1940894

Veit, W. (2023). *A philosophy for the science of animal consciousness*. Routledge.

Veit, W., Gascoigne, S., & Salguero-Gómez, R. (2025). Evolution, complexity, and life history theory. *Biological Theory*. https://doi.org/10.1007/s13752-024-00487-z

Whitehead, H. (2003). *Sperm whales: Social evolution in the ocean*. University of Chicago Press.

Wrage, B., Papadopoulos, D., & Benz-Schwarzburg, J. (2023). Ubuntu in elephant communities. *Journal of the American Philosophical Association*, *10*(4), 814–835. https://doi.org/10.1017/apa.2023.24

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