

Saving the injured: Evolution and mechanisms

Erik T. Frank and K. Eduard Linsenmair

Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg, Am Hubland, Würzburg, Germany

ABSTRACT

Rescue behavior focused on injured individuals has rarely been observed in animals. These observations though are from very different taxa's: birds, mammals and social insects. Here we discuss likely antecedents to rescue behaviors in ants, like social carrying and alarm pheromones. We then compare similarities and preconditions necessary for rescue behavior focused on injured individuals to evolve across taxa's: a high value of individuals, a high injury risk and social interaction. Ultimately we argue that a similar problem, how to rescue injured group members, has led to different mechanisms to save injured individuals across different taxa.

ARTICLE HISTORY

Received 13 June 2017
Revised 1 July 2017
Accepted 5 July 2017

KEYWORDS

chemical communication;
empathy; helping behavior;
pro social behavior; rescue
behavior; social insect

We described rescue behavior in *Megaponera analis* focused on ants that got injured while raiding termite prey.¹ These ants had termites clinging to them or had lost extremities during the fight (Fig. 1). After the hunt the injured “called for help” with a pheromone consisting of the compounds dimethyldisulfide (DMDS) and dimethyltrisulfide (DMTS), stored in their mandibular glands. They were then picked up by their nestmates and able to recover within the nest, thereby reducing their mortality risk. After some hours the injured became functioning members of the colony again. This behavior allowed a predatory species to reduce their foraging costs when hunting prey capable of inflicting injuries.

Antecedents of behavior



There are certain antecedents to this behavior in ants. In the closely related species *Paltothyreus tarsatus*, ants that were covered in soil (because of a cave in) send a distress call using the same substances (DMDS and DMTS) from their mandibular glands, thereby triggering attraction and digging behavior in their nestmates.² For this response to change toward attraction and picking up an injured ant should not require many evolutionary steps. Alarm pheromones and distress calls are very common in ants, generally leading to attraction to the source and attacking the cause of the distress.³ This was likely the origin for another type of rescue behavior observed in ants: saving ants that were trapped by antlions.^{4,5} These trapped ants likely elicit a distress/alarm pheromone, thereby attracting nestmates, which

over time started to attack not only the antlion but also tried to free the ant by pulling and digging.⁴

Carrying nestmates is also a common behavior in ants. It is used as a mechanism to recruit nestmates to food sources, to carry juvenile ants during emigrations to new nest sites or to carry dead ants out of the nest.³ While *M. analis* uses a different mechanism for recruitment, during emigrations and disposal of dead ants the carrying behavior is also present (pers. obs.).⁶ For this behavior to be used also in the context of carrying injured ants does not seem too difficult. It could also have derived from the termite carrying behavior after the hunt, i.e. the transition from “pick up and carry back termite” to “pick up and carry back nestmate.” Especially since injured ants remain at first at the hunting ground with the prey, unlike healthy individuals, which gather at the starting location of the raid.^{7,8}

Evolution of saving the injured

There are not many cases of rescue behavior focused on injured individuals in animals, for a detailed definition and examples of rescue behavior see Nowbahari & Hollis 2013.⁹ The behavior we observed in ants was the first to describe such conduct in insects that carry permanent injuries and are not in imminent danger of dying, but by rescuing them their mortality risk was reduced considerably. There are some examples of similar rescue behaviors in mammals and more recently also in birds.^{10,11} Rats for instance help free conspecifics trapped in cages.¹⁰

CONTACT Erik T. Frank  erik.frank@uni-wuerzburg.de  Department of Animal Ecology and Tropical Biology, Biocenter, University of Würzburg, Am Hubland, Würzburg, Germany.

Addendum to: Frank ET, Schmitt T, Hovestadt T, Mitesser O, Stiegler J, Linsenmair KE. Saving the injured: Rescue behavior in the termite-hunting ant *Megaponera analis*. *Sci Adv* 2017; 3:e1602187; DOI: 10.1126/sciadv.1602187

© 2017 Erik T. Frank and K. Eduard Linsenmair. Published with license by Taylor & Francis

This is an Open Access article distributed under the terms of the Creative Commons Attribution-NonCommercial License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.



Figure 1. *Megaponera analis* minor with 2 clinging termite soldiers. Notice the loss of the tarsus on the mid leg.

Seychelles warblers (*Acrocephalus sechellensis*) free group members from sticky seeds on their wings, which without help can be deadly for the entangled bird¹¹ and dolphins help injured individuals stay afloat so they can breathe.¹²

In all cases in which rescue was observed it was, to our knowledge, always in social species.⁹ This is an important prerequisite since rescue behavior always needs to have a fitness benefit for the helper. There are many different mechanisms through which rescue behavior can evolve:¹³ this can be through kinship relationship (benefiting of an increased indirect fitness) or through benefits for the helper by the helped individual, thus increasing their direct fitness in the long-term (e.g. reciprocal altruism).¹³ While one relies on interactions with closely related relatives (i.e., ants and Seychelles warblers), the other trusts on the reliability of an unrelated receiver (i.e., the behavior in rats). We would like to emphasize a further benefit: by rescuing an injured member of the group, the group as a whole remains larger and more robust, thereby potentially benefiting the fitness of the helper by living in a stronger/larger group (i.e., group augmentation, which increases both direct and indirect fitness).¹⁴ That is as long as the helped individual is able to remain a productive member of the group.

Two further factors, which we think are important for the evolution of rescue behavior focused on injury, are the frequency and fatality of injuries and the value of the individual (the last factor being important when considering indirect fitness and group augmentation). In mammals and birds, which generally live in relatively small groups, the value of an individual is usually large to very large for the group. Species in which individuals get

injured or handicapped relatively frequently should develop means of reducing the costs of these injuries, especially if these injuries are life-threatening without help. In the Seychelles warbler the risk of entanglement is low, but the costs of not being freed are large, causing death in many cases.¹¹ In contrast to *M. analis*, where the injury risk is high and the costs of rescuing are comparatively small (carrying back a nestmate compared with risking entanglement in the warbler). Ultimately though the main factors (and benefits) remain the same: *Megaponera analis* hunts in groups, have relatively small colonies with a low birth rate (i.e., high value of individuals) and suffers injuries which are often fatal without help (12–20 ants injured per day with a mortality of 32% without help).¹ Thus leading to a high value of a single forager for the survival of the family group.

There are some parallels that can be made between ancient human hunting processes and the foraging behavior of *M. analis*. Early humans also used to hunt highly defensive prey in groups.¹⁵ The value of the individual was certainly very high for the tribe and the costs of helping were often marginal compared with its benefit. If a person twisted his ankle in the wild, the risks this person faced returning alone were considerable, whereas by being helped by his fellow hunters his survival chance likely increased significantly.

All of these animals (including humans) faced the same problem: to increase the fitness of the helper (either directly or indirectly) an individual of the same group in distress (injured or handicapped) should be helped.¹³ Humans developed empathy for a multitude of reasons, for instance to better understand the social hierarchy of the group and general social interactions, and use this mechanism (empathy) also for helping individuals in need.¹⁶ Ants on the other hand use chemical communication for most of their social interactions,³ thus pheromones from the mandibular gland are used as the mechanism for a “call for help.” In both cases the method with which injured individuals are helped derived from an important mechanism for social interactions in the species. In other mammals it is still highly debated if empathy is the regulating mechanism^{10,17–20} and in birds it is yet unknown (it might be a vocal distress call).¹¹ While the drivers leading to the evolution of the behavior might be very different (kin-ship relationship, reciprocal altruism, group augmentation to name a few),^{9,13} the observed behavior remains the same (rescuing an individual in need) through differently evolved mechanisms.

Conclusions

We argue that the same problem has arisen in many different animal orders (how to rescue injured members of

the group to indirectly or directly increase the fitness of the helper). This led to the evolution of different mechanisms that deal with the same problem. While humans and potentially other mammals use empathy, ants use chemical communication.

Disclosure of potential conflicts of interest

No potential conflicts of interest were disclosed.

References

- [1] Frank ET, Schmitt T, Hovestadt T, Mitesser O, Stiegler J, Linsenmair KE. Saving the injured: rescue behaviour in the termite-hunting ant *Megaponera analis*. *Sci Adv*. 2017;3:e1602187. doi:10.1126/sciadv.1602187. PMID:28439543
- [2] Crewe RM, Fletcher DJC. Ponerine ant secretions: the mandibular gland secretion of *Paltothyreus tarsatus* Fabr. *J Entomol Soc South Afr*. 1974;37:291-8
- [3] Hölldobler B, Wilson EO. *The Ants*. Cambridge, Mass: Belknap Press of Harvard Univ. Press; 1990
- [4] Nowbahari E, Scohier A, Durand JL, Hollis KL. *Ants, Cataglyphis cursor*, use precisely directed rescue behavior to free entrapped relatives. *PloS One*. 2009;4:e6573. doi:10.1371/journal.pone.0006573. PMID:19672292
- [5] Hollis KL, Nowbahari E. A comparative analysis of precision rescue behaviour in sand-dwelling ants. *Anim Behav*. 2013;85:537-44. doi:10.1016/j.anbehav.2012.12.005
- [6] Villet MH. Division of labour in the Matabele ant *Megaponera foetens* (Fabr.) (Hymenoptera Formicidae). *Ethol Ecol Evol*. 1990;2:397-417. doi:10.1080/08927014.1990.9525400
- [7] Frank ET, Linsenmair KE. Flexible task allocation and raid organization in the termite-hunting ant *Megaponera analis*. *Insectes Soc*. 2017. doi:10.1007/s00040-017-0579-2
- [8] Frank ET, Linsenmair KE. Individual versus collective decision making: Optimal foraging in the group-hunting termite specialist *Megaponera analis*. *Anim Behav*. 2017;130:27-35. doi:10.1016/j.anbehav.2017.06.010
- [9] Hollis KL, Nowbahari E. Toward a behavioral ecology of rescue behavior. *Evol Psychol*. 2013;11:647-64. doi:10.1177/147470491301100311. PMID:23864298
- [10] Bartal IBA, Decety J, Mason P. Empathy and pro-social behavior in rats. *Science*. 2011;334:1427-30. doi:10.1126/science.1210789
- [11] Hammers M, Brouwer L. Rescue behaviour in a social bird: removal of sticky „bird-catcher tree“ seeds by group members. *Behaviour*. 2017;154:403-11. doi:10.1163/1568539X-00003428
- [12] Siebenaler JB, Caldwell DK. Cooperation among adult dolphins. *J Mammal*. 1956;37:126-8. doi:10.2307/1375558
- [13] West S, Griffin A, Gardner A. Evolutionary explanations for cooperation. *Curr Biol*. 2007;17:R661-72. doi:10.1016/j.cub.2007.06.004. PMID:17714660
- [14] Kokko H, Johnstone RA, Clutton-Brock TH. The evolution of cooperative breeding through group augmentation. *Proc R Soc Lond B*. 2001;268:187-96. doi:10.1098/rspb.2000.1349. PMID:11209890
- [15] Ferraro JV, Plummer TW, Pobiner BL, Oliver JS, Bishop LC, Braun DR, Ditchfield PW, Seaman JW, III, Binetti KM, Seaman JW, et al. Earliest archaeological evidence of persistent Hominin Carnivory. *PloS One*. 2013;8:e62174. doi:10.1371/journal.pone.0062174. PMID:23637995
- [16] Batson CD. How social an animal? *Hum Capacity Caring Am Psychol*. 1990;45:336-46. doi:10.1037/0003-066X.45.3.336
- [17] Vasconcelos M, Hollis K, Nowbahari E, Kacelnik A. Pro-sociality without empathy. *Biol Lett*. 2012;8:910-12. doi:10.1098/rsbl.2012.0554. PMID:22859561
- [18] Decety J, Bartal IBA, Uzefovsky F, Knafo-Noam A. Empathy as a driver of prosocial behaviour: highly conserved neurobehavioural mechanisms across species. *Philos Trans R Soc Lond B*. 2016;371:20150077. doi:10.1098/rstb.2015.0077. PMID:26644596
- [19] Sato N, Tan L, Tate K, Okada M. Rats demonstrate helping behaviour toward a soaked conspecific. *Anim Cogn*. 2015;18:1039-47. doi:10.1007/s10071-015-0872-2
- [20] Schwartz LP, Silberberg A, Casey AH, Kearns DN, Slotnick B. Does a rat release a soaked conspecific due to empathy? *Anim Cogn*. 2017;20:299-308. doi:10.1007/s10071-016-1052-8. PMID:27822786