

Short communication

Task partitioning in insect societies: novel situations

C. Anderson¹ and F.L.W. Ratnieks^{2,*}

¹ Department of Zoology, Duke University, Durham, NC 27708-0325, USA, e-mail: carl@duke.edu

Present address: LS Biologie I, Universität Regensburg, Universitätsstrasse 31, D-93040 Regensburg, Germany

² Department of Animal & Plant Sciences, University of Sheffield, Sheffield, S10 2TN, UK, e-mail: F.Ratnieks@shef.ac.uk

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Summary. Ratnieks and Anderson (1999) recently reviewed task partitioning in insect societies. They collated numerous examples of partitioned tasks involving the collection and transportation of colony resources to the nest. However, no non-foraging examples were known. Here we report task partitioning in excavation, emigration, and refuse disposal. We also report an example of task partitioning without strong division of labour.

Key words: Task partitioning, excavation, emigration, refuse disposal.

Recently, Ratnieks and Anderson (1999) reviewed the phenomenon of task partitioning (TP) in insect societies. A task is said to be partitioned when it is split into a number of sequential stages or subtasks – such as forage collection and transportation – and work is passed from one worker to another (Jeanne, 1986a; Ratnieks and Anderson, 1999). Ratnieks and Anderson (1999) cited many examples of TP in the collection and use of colony resources. However, no examples from other aspects of colony life were known. Here we fill this important gap by detailing examples of TP in nest excavation, colony emigration, and refuse disposal. TP is often mistakenly confused with division of labour, because both are aspects of work organisation and because the two often go together. However, it is logically possible to have TP without division of labour. We cite an example of excavation in the army ant *Neivamyrmex legionis* in which this appears to be the case.

Task partitioning without division of labour

Jeanne (1986a) hypothesised that TP without division of labour is a logical possibility. That is, material could be transferred between workers but workers regularly switch be-

tween the different subtasks. Subtask switching occurs in nest construction in small colonies of the social wasp *Polybia occidentalis* (Jeanne, 1986b) with builders and foragers often changing roles. Bates (1905:370) provides another example. He observed workers of *Eciton* (= *Neivamyrmex*) *legionis* raiding a *Formica* nest. Rather than enter through the nest entrance, the ants dug shafts through the soil to access the prey's brood chambers. Bates reports,

“In digging the numerous mines to get at their prey, the little [Neivamyrmex] seemed to be divided into parties, one set excavating, and another set carrying away grains of earth. When the shafts became rather deep, the mining parties had to climb up the sides each time they wished to cast out a pellet; but their work was lightened for them by comrades, who stationed themselves at the mouth of the shaft, and relieved them of their burdens, carrying the particles, with an appearance of foresight which quite staggered me, a sufficient distance from the edge of the hole to prevent them falling in again. All the work seemed to thus to be performed by intelligent co-operation amongst the host of eager little creatures; but still there was not a rigid division of labour, for some of them, whose proceedings I watched, acted at one time as carriers of pellets, and at another as miners, and all shortly afterwards assumed the office of conveyors of the spoil.”

This example has three unusual or novel features. The first is that it is an example of TP from excavation. Second, the report of no “rigid division of labour” is significant. With this limited description we can only speculate why this particular example of TP is not associated with division of labour and what, if any, the adaptive benefit is. It may simply be that workers have difficulty climbing out of the tunnel entrance with a load of soil and it was easier to pass material to another worker who is already on the surface. Alternatively, if workers have difficulty passing each other in the tunnels, then partitioning excavation and transportation at the shaft entrance will reduce the number of ants in a tunnel at any one time. This will not necessarily reduce the excavator's work

* Author for correspondence.

capacity because their trip duration is shortened (compared to the non-partitioned scenario). However, it will force any queueing for transfer partners to occur at the shaft entrance, where presumably interference between waiting ants is low, rather than inside the tunnel, where it may be high. This clearly deserves further investigation.

In addition to partitioning excavation, these *Neivamyrmex* ants also partitioned the collection and transportation of the prey once the mines were completed. At the surface the ants crowded around the mine entrance “some assisting their comrades to lift out the bodies of the Formicae, and others tearing them in pieces, on account of their weight being too great for a single [*Neivamyrmex*]; a number of carriers seizing each a fragment, and carrying it off down the slope” (Bates, 1905: 369–370). Thus, the third special feature is that TP between collection and initial processing of the prey occurs away from the nest, unlike other examples reviewed in Ratnieks and Anderson (1999).

Nest excavation

Ratnieks and Anderson (1999: 96) mentioned nest excavation in *Pogonomyrmex* ants as a possible partitioned task (D.M. Gordon, pers. comm.) but no details were available. We have since found two examples of partitioned nest excavation:

- a) *Myrmecocystus setipes* ants partition nest excavation between excavators and transporters. “Some of the ants carry out earth: others are detailed to remain outside, their business to sweep away the dust and so prevent it falling back into the nest.” (Hingston, 1929: 80).
- b) In the harvester ant *Messor barbarus*, Hingston (1929: 151–152) observed a colony excavating its nest on a slope. Eight ants excavated material and placed it in a pile. A ninth ant remained on the top of the pile „picked up each load and pitched it over the precipice”.

Colony emigration

We have found two examples of TP during colony emigration in ants. Belt (1928: 60–61) poured carbolic acid into the entrance of a leaf cutter ant (*Atta* sp.) colony which caused it to emigrate to a new site. He wrote,

“Next day I found them busily employed bringing up the ant-food [fungus-garden] from the old burrows, and carrying it to a new one a few yards distant; and here I first noticed a wonderful instance. Between the old burrows and the new ones was a steep slope. Instead of descending this with their bundles, they cast them down on the top of the slope, whence they rolled them to the bottom, where another relay of labourers picked them up and carried them to the new burrow. It was amusing to watch the ants hurrying out with bundles of food, dropping them over the slope, and rushing back immediately for more.”

Presumably, by dropping the material to the lower group, time is saved in transportation, in the same manner as the “arboreal cutters” who cut and drop leaves from the

canopy to the “cache exploiters” on the ground in *Atta sexdens* (Fowler and Robinson, 1979; Ratnieks and Anderson, 1999).

The fire ant, *Solenopsis invicta*, is native to seasonally flooded areas of S. America. When the nest is flooded, workers form a living raft upon which the queen and brood travel. The raft floats downstream until it reaches dry land. Workers on top of the raft pass brood to workers on the shore who carry the brood up the muddy slope to dry land (H. L. Vasconcelos, pers. comm.).

Leaf cutter ants and refuse disposal

Colonies of the leaf cutter ant *Atta colombica* are known to dispose of their refuse (exhausted plant material and fungus garden) outside the nest (e.g. Weber, 1972). Anderson (in prep.) documented the multistage/indirect transfer TP of refuse disposal in a Costa Rican *A. colombica* colony. The colony was situated on top of a river bank and a trail led down-slope to a refuse pile several metres below. Material was sometimes taken directly from the nest to the main refuse pile (i.e. no TP), but more often was deposited on one of three caches on the trail. Other workers collected material from a cache and carried it farther down-slope, either to a lower cache, or to the main pile. In this manner, refuse loads were potentially transferred at each of the three caches before arriving at the main pile. The indirect transfer caused by caching introduced delays to both material and workers and appeared to reduce ergonomic efficiency. For instance, collection of material from a cache took an average of 43 s. The adaptive value of partitioning this task is unclear but is possibly related to reducing spread of disease and parasites into the colony by separating intra- and extra-nidal workers. A similar conclusion was reached by Hart and Ratnieks (in prep.) who documented partitioning of refuse disposal to internal dumps in *Atta cephalotes*: in this example there was also clear evidence of division of labour. Workers in the main nest did not enter the refuse chamber – material was cached at the chamber entrance – and workers that worked within the chamber did not leave.

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