

REVIEW OF DIVISION OF LABOR

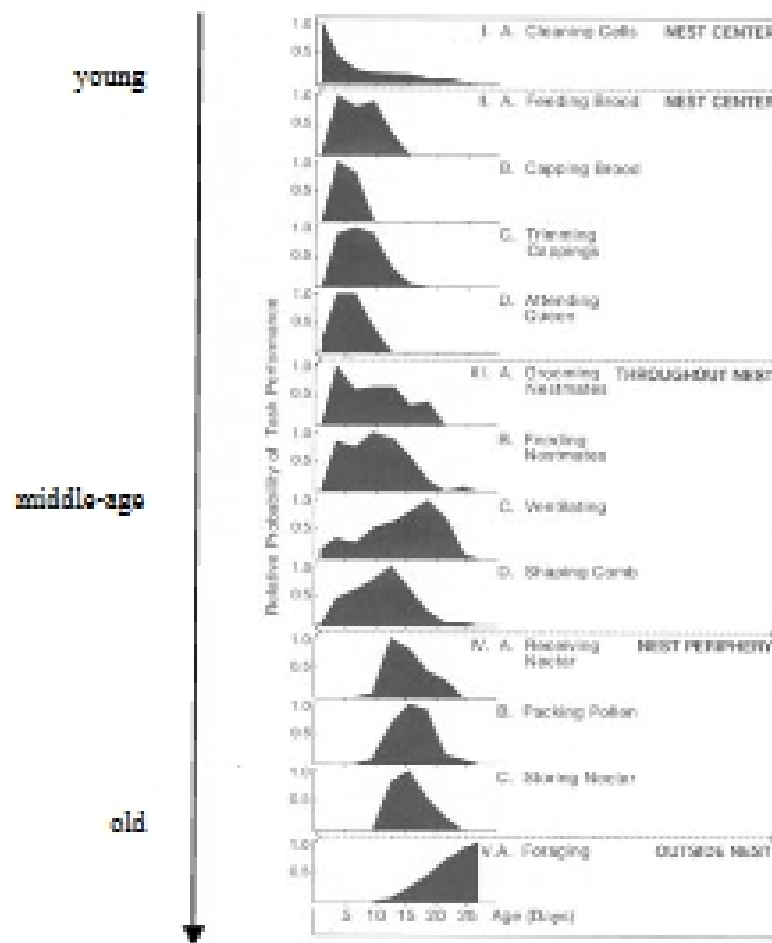


Figure 3.6. Changes in labor patterns across the life of a worker honeybee. From Seeley (2002a).

- Where bees repeatedly and non-randomly perform specific tasks.
- In general, bees show temporal polyethism, where task performance is dependent on age and coincident with the tasks found in the area of the nest the bee is in.
- Young bees perform tasks found in the center of the nest. Middle-aged bees tend to perform tasks in the periphery of the nest, such as food processing. Older bees perform tasks outside the nest such as foraging.

LEVELS OF ORGANIZATION

- Social insect colonies are groups of individuals that live together and reproduce as a unit. The colony represents a level of organization above the individual organism.
- The colony has its own characteristic morphology, behavior, internal organization, and life history pattern.
- Classical (meaning old) models of colony organization focused on the adaptive value of social structure.
- Recent models treat the social insect colony as a self-organized, decentralized system (meaning there is no central controller) in which behavior emerges from the independent actions and decisions of workers.
- Self-organizing models have been used to describe numerous colony processes, including homeostasis, mass action responses, and colony construction.
- By far the majority of empirical (experimental not theoretical) studies testing various hypotheses of models of division of labor use honey bees; specifically foraging behavior.

WHAT IS DIVISION OF LABOR

- Division of labor is where individuals repeatedly and non-randomly perform specific tasks.

- Among the social insects there are two general patterns of division of labor; 1) temporal polyethism (age-related division of labor), and 2) morphological polyethism, in which worker size and/or shape is related to task performance. Honey bees do not show morphological polyethism but many ant species do (e.g. soldier castes).
- Early studies focused on discovering correlations between behavior and worker age, defining and describing behavioral castes.

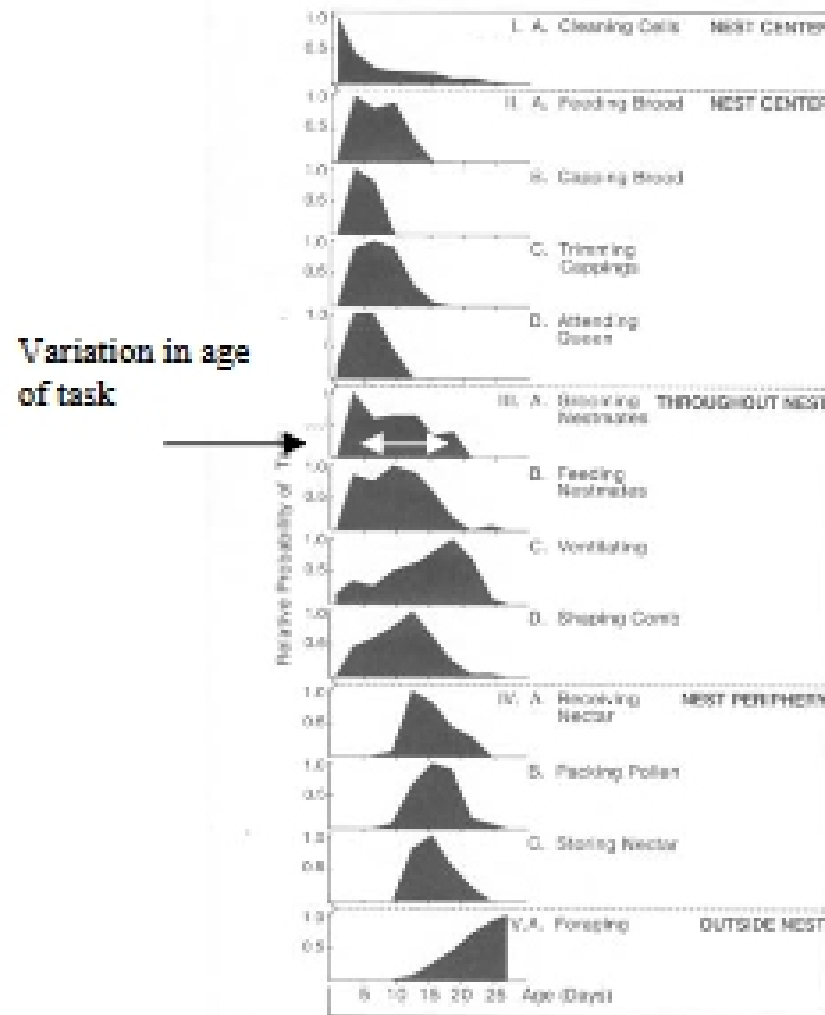


Figure 3.2 Changes in labor patterns across the life of a worker honeybee. (From Seeley 1993a)

- This approach is sufficient for studies of the ecology of division of labor, but not sufficient for studies of mechanisms of division of labor because

1) variation in task performance occurs independent of age

2) under “normal” conditions age may be a good predictor of task performance but is a poor predictor of task performance when colony conditions change

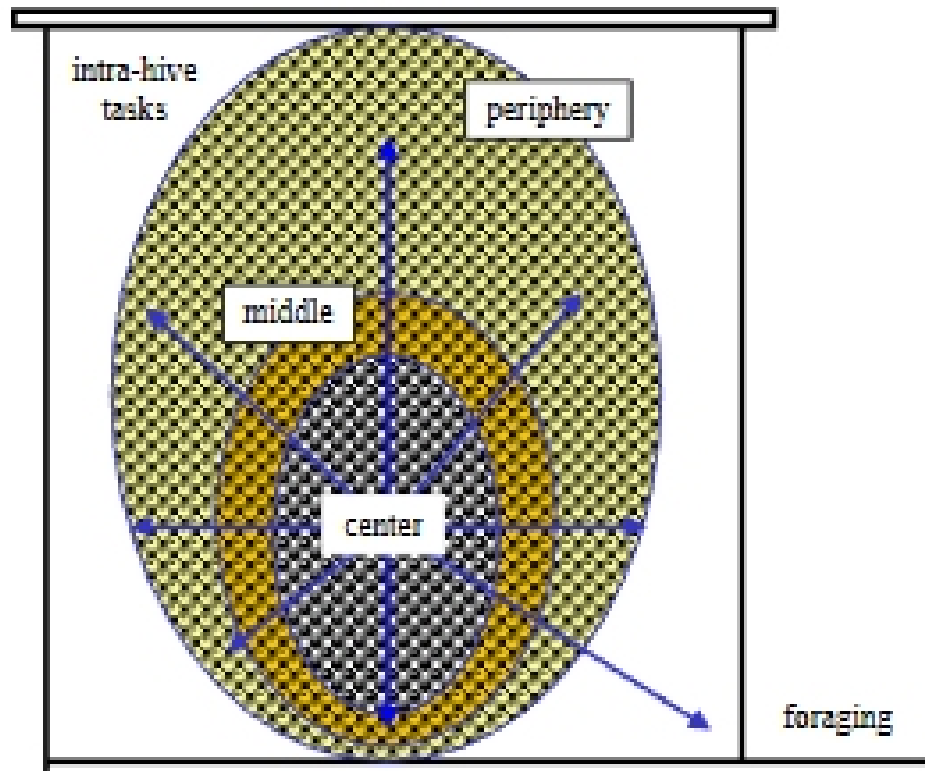
3) as colony labor demand changes workers show behavioral flexibility, either performing tasks not previously seen in their repertoires, or switching from one task to another.

FORAGING FOR WORK

- The foraging for work (FFW) model of division of labor shows how a flexible division of labor with temporal polyethism could emerge from a simple set of rules for individual task performance that is not necessarily related to worker age or size.
- FFW has two main components; 1) a behavioral algorithm (set of processes or rules), and 2) a spatial arrangement of tasks.
- The behavioral algorithm is; 1) perform any task for which there is a need, 2) once a task is performed, continue to perform the same task, 3) if this task no longer needed, move to another area of the nest and attempt to perform tasks there.

Tofts C (1993) Bulletin of Mathematical Biology 55: 891-918.

Tofts C, Franks NR (1992) Trends in Ecology and Evolution 7: 346-349.



- Tasks are arranged spatially in a series of zones.
- A given task can be performed in only one zone.
- Tasks are arranged functionally, like a production line.
- The opportunity to perform a task depends on the activity of other workers upstream in the sequence.
- The zone in which a bee seeks work depends on how many times she fails to find the task for her current zone, the relative number of bees performing the upstream task, and the availability of downstream tasks.

- FFW assumes no intrinsic variation in task performance among workers. (Intrinsic here means there is no physiological or genetic variation.) This essentially means that all workers are viewed as equal. Variation in task performance is generated by variation in the spatial encounter probabilities for tasks.
- In this model, changes in task performance are driven entirely by the opportunity to perform a task. FFW generates flexible task allocation that varies directly in response to changes in task needs. This means if there is a large demand for one task, more bees will perform that task.
- FFW can theoretically generate temporal polyethism. New workers emerge in the brood area of the colony and initially seek work in that area. The influx of young workers tends to force older workers to move away from the center to find tasks. Older workers die at a higher rate than younger workers, generating a work sink in the areas in which they are located.
- FFW has been controversial. Critiques have stated that its assumption of no intrinsic (within bee) effects on task performance is falsified by physiological and genetic correlations of temporal polyethism. Simply put, FFW views all bees as equal. Genes or physiology are not considered as factors affecting the work a bee does.
- The level of temporal polyethism the FFW model can generate has also been disputed.
- Finally, the argument has been made that a single behavioral algorithm is unlikely to explain division of labor that has evolved in many different ecological contexts.