

SELF-ORGANIZATION OF BEHAVIOURAL PROFILES AND TASK ASSIGNMENT BASED ON LOCAL INDIVIDUAL RULES IN THE EUSOCIAL WASP *POLISTES DOMINULUS* CHRIST

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In eusocial insect societies, individuals have to work together to carry out some tasks, the nature of which depends both on the colony's own needs and on environmental features. Each individual constantly decides, acts and interacts with other individuals and the environment, thus continuously changing the state of the group. The latter is however a place where stable, self-regulated individual behaviours are organized. Studies on the processes which lead to the emergence of a stable collective order in insect societies have focused in recent years on the dynamics of individual interactions (DENEUBOURG et coll. 1987, 1989, 1990). These researches showed that by adopting some elementary rules of individual behaviour, a society can generate complex patterns and take decisions when encountering some external constraints.

Our own biological studies deal with the processes underlying task assignment in *Polistes dominulus* wasp colonies (THERAULAZ et coll. 1990 a, b, c). In these primitively eusocial species no morphological differences exist between castes at the adult stage, and the social roles are largely determined by social interactions. We have detected two types of interaction which regulate the organization of individual behaviour :

1. Direct interactions of the *hierarchical type*, which determine which individual will have precedence over another individual and organize the society into a linear structure;
2. Indirect interactions of the *trophic type*, which determine individuals' relationships with local environment, consisting of the brood, and which give rise in turn to actions performed by the individual on the brood such as brood-tending and/or foraging outside the nest.

Each of these two types of interaction, when it occurs, has reciprocal effects on the individual which depend on the possible outcome of the interaction (cf. fig.1).

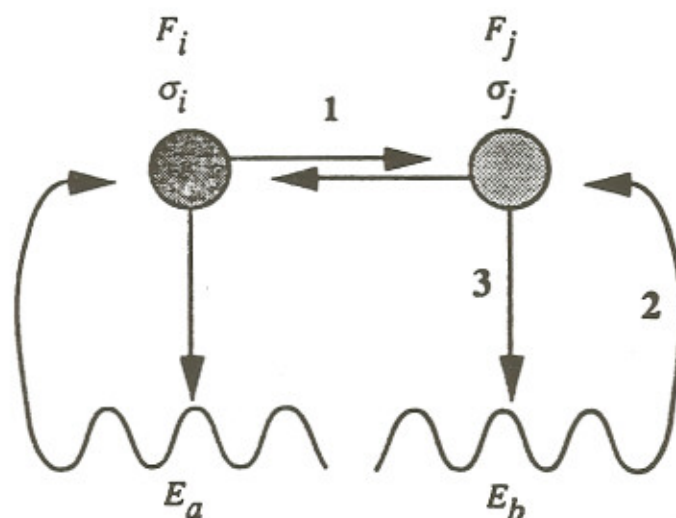



Fig. 1 Individual local action rules in *Polistes*

When a hierarchical interaction (1) occurs, for instance, the intrinsic probability (F) that the dominant animal will dominate increases by ϵ at each subsequent meeting, whereas this probability decreases at the same time by ϵ in the case of the subordinate animal. Likewise, when foraging activity (3) is triggered in an animal which comes into contact with specific brood-related stimuli (2 & E_b), the response threshold of the

animal to these stimuli will decrease by η , which increases its probability of responding to them on the next occasion. The model we put forward here, takes the above two local action rules into account. Each component in the system is characterized by 2 variables:

1. a force F , which occurs when random encounters take place in the nest space. Force F determines both the probability of encounter (by increasing the speed of movement on the nest), and the probability of domination at each encounter;

2. a response threshold σ to the stimulation arising from a specific point within the nest space : that containing the larval brood {  }.

In addition, the individual random moving component is modulated by a centripetal component which corresponds to a constant individual tendency to invest in egg-laying. The joint action of these two processes generates on one hand a stable hierarchy among the the individuals; one of them, the α individual (here individual No 3, cf. fig. 2), will never leave the nest, where it exerts considerable dominance; at the same time, the α individual's response threshold to brood stimulation increases constantly. And on the other hand, some individuals (here No 1,5 and 6) become specialized in foraging and larva-feeding tasks.

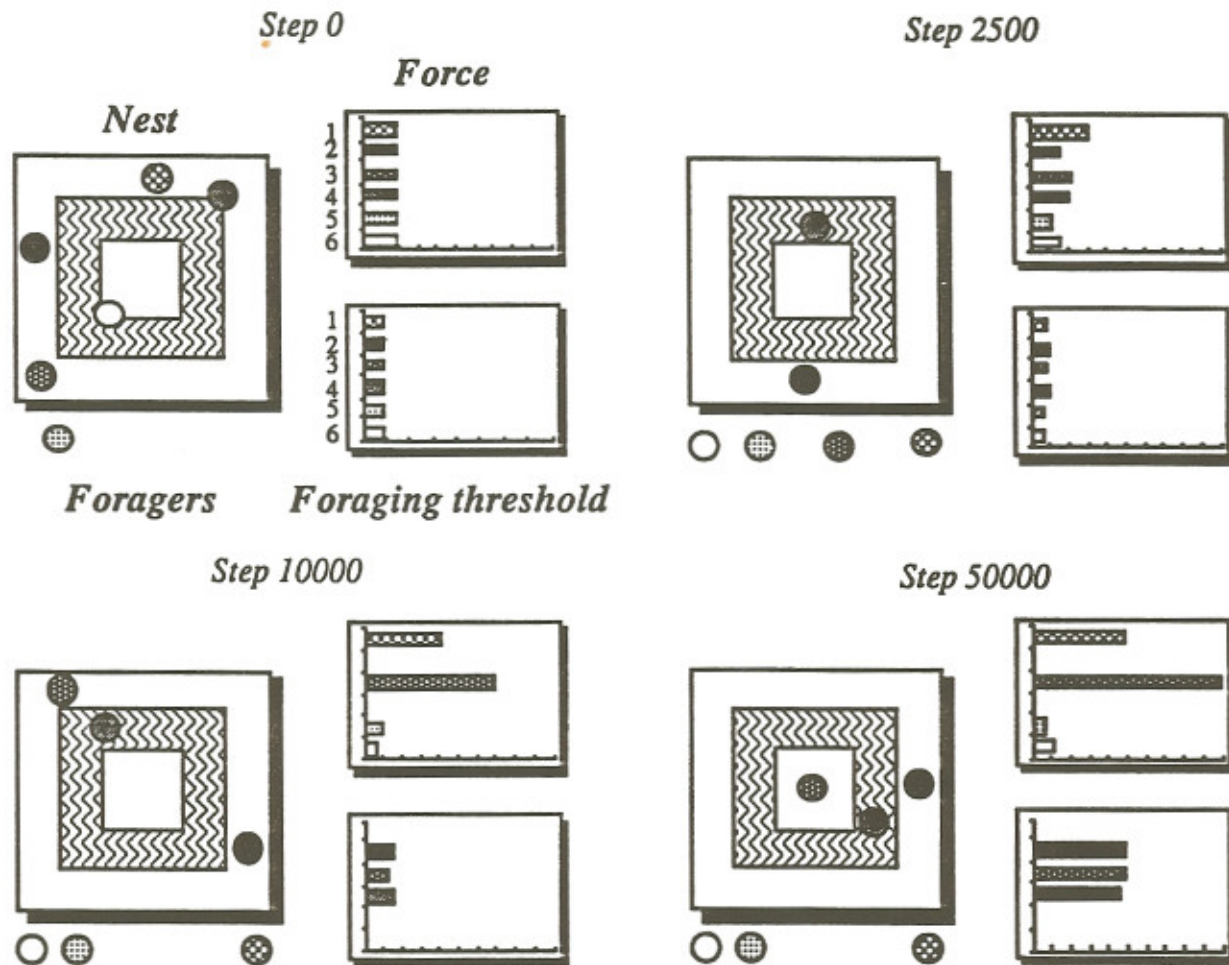


Fig.2 Self-organization of collective tasks and genesis of the hierarchy in a 6-individual group

Each individual enjoy behavioural autonomy, and it is the history of its interactions with other individuals in the colony which determines its own intrinsic features. The processes we have described here act like positive feed-back, so that even quite small internal or external fluctuations are rapidly amplified. A group of individuals whose elementary behavioural rules are very simple is thus able to coordinate individual activities within collective structures in order to carry out a particular general task. The type of task performed will depend on the individual local action rules. Moreover, the interplay between these structures and the environment can generate diverse patterns of collective behaviour starting with the same elementary behavioural algorithms. This type of model, which combines simplicity, reliability and adaptability, can be applied to organizing groups of robots with simple reconfigurable elementary features, so that they perform complex tasks.

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