Of ants and men: self-organized teams in human and insect organizations

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Abstract: To cope with today's complex, fast-paced, and ever-changing business environment, companies need to shift their overall structure to produce adaptive, highly responsive organizations. The use of teams, particularly self-organized teams with their reactive, emergent properties, may be one way of achieving this goal. Humans, however, are not the only creatures to use such teams: insect societies (ants, bees, wasps, and termites) are enormously successful in their domain, also live in complex, rapidly changing environments, yet achieve this without any centralized control or management. In this study, we examine fundamental issues of teamwork, and question whether such teams really are analogous. After detailing some of the striking similarities, we conclude that they are indeed equivalent and comparable. Thus, our work is a preliminary study into whether nature—specifically, insect societies—may provide not just a valid metaphor but, moreover, a model for organizational shift and effective function in human enterprise.

Introduction

Insect societies—colonies of ants, bees, wasps, and termites—have long been a source of amazement, inspiration, and metaphor to human society, and even to some writers on management (Morgan 1986; Kelly 1995; Bonabeau et al. 1999). When viewing a group of busy human workers on a factory floor or in an office, it is all too easy to analogize with a group of industrious ants or bees. This might be an amusing exercise, but could the similarities actually run deeper and be more fundamental? It has been highly advantageous for both humans and insects to be social: ants and other social insects dominate their world precisely because their social organization has given them competitive advantage over solitary insects (Wilson 1998). Humans too have benefited from their ability to work together and to live in complex societies and civilizations. Could it be that generic principles of work organization exist that are equally applicable whether considering human organizations or insect societies?

In this study, we focus on teams and team working, and particularly on self-organized teams, and argue that the principles and issues concerned with self-organizing teams are indeed similar between human and insect "organizations." If one is unsure of the validity of calling an insect society an organization, consider that they contain and coordinate a large number of members, all essentially working to the same goal—colony growth, productivity, and survival—and that they often exhibit a sophisticated and adaptive division of labor. For the same reasons, humans are motivated by the growth, productivity, and survival of their enterprises (Clippinger 1999). Humans, like insects, have the ability to self-organize (e.g., Stacey 1996; Camazine et al. 2001) and we would suggest that it would benefit organizations if they made intelligent investigations into self-organization and possible lessons from other self-organized systems found in nature. After considering the fundamental (definitional) notions and attributes of teams, we distinguish between self-organized and self-managed teams, and suggest that both humans and insect societies may involve self-organized teams. We then consider some aspects of effective team working, including team size, individual roles, and mechanisms of self-selection, and touch upon the idea of adhocracy, that is, the spontaneous, unplanned nature of self-organized teams. Finally, we discuss some broader issues and possible lessons.

What is a team?

How do biologists and management theorists perceive the notion of a team? In management, a group of people can be described as a work group or a team if they show most, if not all, of the following characteristics listed by Adair (1983):

- There is a definable membership of three or more people.
- There is a group consciousness or identity and the members think of themselves as a group.
- There is a sense of shared purpose and the members share some common task or goals.
- The members of the group are interdependent.
- The members interact, communicate, and influence one another, and react to one another.
- From time to time, the members of the team review the team's overall effectiveness.
- The team has an ability to act together as one.

Katzenbach and Smith (1993, pp. 45, 89), however, suggest that

> 'A team is a small number of people with complementary skills who are committed to a common purpose, performance goals, and approach for which they hold themselves mutually accountable,'

and that there is

> ‘the need for any team to produce something of incremental performance value that is more than the sum of each member’s efforts.’

Katzenbach and Smith concur with Adair's notion of a small group with common or shared objectives, but they introduce other notions of team working: those of complementary skills, performance goals, mutual accountability, and “incremental performance value.” They also hint at the phenomenon of emergence.

Finally, Larson and LaFasto (1989, p. 19) propose the following definition:

> ‘A team has two or more people; it has a specific or recognizable goal to be attained; and coordination of activity among the members of the team is required for the attainment of the team goal or objective.’

This definition again accords with the notion of a team as a small group of people, save Adair considers the group to consist of three or more, with objectives to attain, but additionally introduces coordinated activity as a key attribute. Larson and LaFasto (1989) add that some so-called teams are excluded under their definition; for instance, they reject any situation in which the team’s accomplishment is merely additive, the sum of individual matches and performance—as in a Davis Cup tennis team. Thus, like Katzenbach and Smith (1993), a situation in which the whole is simply the sum of the individual parts is not considered sufficient for teamwork. Teams necessarily require coordinated cooperative action. (A doubles tennis match, therefore, in which a pair of players on one half of the court must work together to cover the court and return the ball would count as teamwork.) Intriguingly, these definitions and notions are strikingly similar to that held by biologists.

Anderson and Franks (2001) recently reviewed what it means to work as a team in animal societies (social insects, lions, baboons, bats and so on). They too recognized that a division of labor, therefore implying two or more individuals, and coordinated concurrent action is necessary in a team. Focussing on the structure of the task itself—that is, what is fundamentally required to complete the task (see Anderson, Franks and McShea 2001 for a more detailed treatment)—they viewed that

> ‘A “team” (*sensu* Anderson and Franks, 2001) carries out a “team task” meaning that it *necessarily* requires *different individuals* to perform *different subtasks*, i.e. components of the task, *concurrently*’ (Anderson and McShea, 2001*b*, p. 291; our italics).

In their view then, a distinction is made between a team and teamwork—Katzenbach and Smith (1993) stress the same point with respect to humans—and that a team is simply the set of individuals tackling a team task without any other provisos, conditions, or constraints.

One illustrative example of a team is decapitation in the ant *Pheidole pallidula* (Detrain and Pasteels 1992; Anderson and Franks 2001; Anderson, Franks and McShea 2001). This is an ant species that is polymorphic, that is, it contains both small ant workers (minors) and large workers (majors, often termed soldiers). If an intruder, for example an ant from another colony or species, attempts to enter the nest, a group of minors will pin down the victim and will recruit a major to decapitate it. Here, there are two distinct subtasks, pinning down and decapitation, and only with concurrent action can the goal be achieved. In this example, only the majors with larger and stronger mandibles can perform the decapitation (but they may occasionally be involved in pinning down too), and so this team task also involves some degree of specialized roles, the same as might be expected in a human team. Anderson and Franks (2001) and Anderson, Franks and McShea (2001) detail other animal teams, including those found in humpback whales, African wild dogs, lions, and hawks.

[Table 1 about here]

Drawing on Adair (1983), Katzenbach and Smith (1993), and Larson and LaFasto (1989), we take the salient features of human teams and compare them with those of insects (Table 1). Given the striking similarities, we propose that the basic notions and definitions of teamwork are similar in both human and non-human societies. Moreover, in both cases teams accomplish results that individual members when working alone could not (e.g., Katzenbach and Smith, 1993; Franks, Sendova-Franks and Anderson 2001); this is of course why individuals work together as a team and not as a set of independent individuals, a concept nicely captured by the following acronym: *TEAM* = *T*ogether *E*veryone *A*chieves *M*ore.

Self-managed versus self-organized teams

There are many types of team but we will focus exclusively on those that are self-organized, for several reasons. First, with the shift towards increasingly global, decentralized, internet-mediated organizations (e.g., Clippinger 1999), companies are likely to rely progressively on such teams (Katzenbach and Smith, 1993; Applebaum, Bethune and Tannenbaum 1999 and references therein). Second, it reflects our particular research interests, and third, and foremost, self-organized teams are the only types of teams insect societies possess.

Some writers on organizations tend to consider self-managed teams and self-organizing teams to be one and the same (Brodbeck 2002) but that is not our view, although features of self-organizing principles may occur in self-managed and other teams. In this study, we use definitions of self-managed teams derived from Stacey (1996), McMillan (2000) and McMillan-Parsons (1999). Table 2 lists the main attributes of self-managed teams and offers a comparison with those of self-organizing teams in order to clarify the distinctions derived from Stacey and McMillan's work. There are indeed significant differences between them, particularly relating to the dynamics and responsive of the team and also relating to leadership: self-managed teams have at least one individual whose primary role is organizational whereas self-organized teams have no designated leader. In such teams, decisions are usually collective (although this does not exclude some, or all, members leading for brief periods when necessary) and everyone's primary role is to carry out the task itself.

[Table 2 about here]

Self-organizing teams

Contrary to older, anthropomorphic writings (e.g., Step 1924; Ewers 1927) and current popular belief, the queen or any other member of an insect society, does not direct another individual where to go and what task to perform. These societies are not run through command-and-control but through a flat decentralized organizational structure in which individuals make their own simple decisions using information garnered from the local environment, or through signals and interactions among individuals (Wilson and Hölldobler 1988; Bonabeau et al. 1997; Anderson and Bartholdi 2000; Anderson and McShea 2001a). In other words, insect societies often harness the power of self-organization such that with the appropriate set of feedbacks, interindividual interactions, and proximate mechanisms, group-level adaptive behavior simply *emerges* (Kelly 1995; Bonabeau et al. 1997; Camazine et al. 2001; Johnson 2001; Anderson 2002). No one directs the foragers where to find food, the *network* of trails and interactions takes care of that; individuals are not allocated to tasks, the reverse is true: *the tasks allocate the workers* (Franks and Tofts 1994).

Human organizations may also involve self-organizing principles among their workforce. McMillan (2000 and as McMillan-Parsons 1999) examined whether self-organization played a role in two teams that formed during an organizational change program at the Open University in the UK between 1993 and 1996. The two teams were very successful project teams which were formed in response to issues that arose from the program. Both teams were composed of volunteers drawn from a wide range of staff categories and grades who had not worked together before. One team in just 9 weeks (including the Easter break) organized a one-day conference for 100 delegates that included 20 workshops in parallel streams with a mix of internal and external speakers, and an exhibition. The other team which started work in June had until October to carry out an employee survey of the University's some 3,500 staff. It agreed the survey contents, identified key areas for consideration such as confidentiality and feedback, participated in the selection of a professional survey organization, oversaw a pilot study, and agreed the final survey document. Further, it recommended to senior management a number of public feedback events, which later took place.

McMillan-Parsons (1999) found that the teams fitted Stacey's (1996) description of self-organizing groups or teams as ones that arise spontaneously around specific issues, communicate and cooperate about these issues, reach a consensus, and make a committed response to these issues. Further,

> 'research suggested that self organizing teams have a strong sense of shared purpose, strong personal commitment, display creative and spontaneous behaviors, have high levels of energy and enthusiasm, and that an inherent order emerges from their activities' (McMillan-Parsons 1999, p. 106).

Effective team working

Larson and LaFasto (1989) and Katzenbach and Smith (1993) found that for a team to be effective it needs a clear goal or goals and, moreover, that these need to be considered important and worthwhile by the team members. Self-organizing teams come into existence in response to an issue or an activity which motivates people to take action and to form an informal and temporary team (Stacey, 1996). The team would not exist without an impetus that was considered important and worthwhile. Similarly, Anderson and Franks (2001, p. 538) suggest that "teams in social insects only form in immediate response to the stimulus of a team task," for instance, an encounter with a large forage item that cannot be moved alone or the need for an urgent nest repair.

Belbin (1981, 1993), who is generally regarded as the father of team role theory (Holton 2001), concluded that an effective team included 9 roles and that every member of the team has a preferred role or set of roles. Too many or too few of one type of person would lead to an imbalance in the team that would reduce its effectiveness. Importantly, in self-organizing teams the members *self select* and there is no-one checking to see if they have the necessary range of attributes. In her study, McMillan (1999) discovered that members of the self-organizing teams studied learnt new skills and developed new attributes to meet the needs of the team. Insect teams also self select (but are limited in the amount of learning that takes place). For instance, in army ants—whose workers vary greatly in size within a colony—several individuals may work as a team when carrying prey items (Anderson and Franks 2001; Anderson, Franks and McShea 2001; Franks, Sendova-Franks and Anderson 2001). Transport occurs at a "standard retrieval speed," that is, the same rate as the rest of the flow of ants along the trail, thus minimizing congestion. To achieve this, it requires a particular matching of the weight of the ant team to the weight of the prey. Too few or too small ants (relative to the prey) means a slowly-moving item, thus clogging traffic; too large or too many, means an "over-skilled" fast moving team whose energies and efforts could be better employed in other ways. Self-selection appears to occur such that new individuals join the team and carry the item, so long as their input is valuable, that is, it increases the item's retrieval speed. An individual, especially a large ant, who joins the team and finds that the speed is increased too much will likely drop out. Thus, a simple individual-level rule generates an adaptive group-level functional unit—the team—without any hint of explicit coordination, direction, or command-and-control. Thus, in insect societies it is the structure of the task itself that determines the roles that individuals must play and therefore roles cannot be predetermined in the way that Belbin's work might suggest. Applebaum, Bethune and Tannenbaum (1999, p. 125) state that

> 'Team size can affect the team's productivity. Inappropriate group size (i.e. too large or small) can result in the lack of expertise, variety of ideas, development of cliques, and ineffectiveness in accomplishing the team's tasks' (Yeatts, Hyten and Barnes 1996).

Might ants have neatly overcome this particular problem?

Returning to Table 2 and considering the attributes of self-organized human teams we find that they are very applicable and relevant to social insect teams. Thus, they are not part of the formal organizational structure, they are indeed informal and transient, and, as previously stated, they spontaneously form around some appropriate task stimulus. Like self-organized human teams, there are no leaders, and everyone's primary role is to carry out the task rather than organize it for others. As such, each member is therefore empowered in some sense. Finally, taking advantage of the properties of self-organization, it generates teams that are adaptive and flexible and able to cope with a range of challenges. As with all self-organizing systems, an inherent order emerges without the need for managerial control.

Adhocracy

In their classic study of excellence in American companies, Peters and Waterman (1982) suggest that one characteristic of such organizations is adhocracy (*sensu* W.G. Bennis [see Morgan 1986, p. 57] and Mintzberg [1979]). These large, mature yet high-performing companies manage to generate the flexible and adaptive properties of smaller entrepreneurial organizations—in short, to "be big and yet to act small at the same time" (Peters and Waterman 1982, p. 201). Using teams is one key means of achieving that, for, as Flory (2002, p. 9) remarks, self-managed teams,

> 'are fast moving, fast learning groups, flexible, highly autonomous and have a well-developed pro-active attitude and sense of responsibility. These characteristics are the very reason they are brought into life as answers for organizations to respond to a fast moving world.'

(Though these teams are described as self-managed we would suggest that their attributes resonate well with self-organizing teams.) Such an idea is extremely relevant to insect societies too: they undoubtedly operate in a completely adhocratic manner, meaning that it is unplanned, and impromptu. With the exception of storing food for hard times, insect societies make no long term plans or forecasts (which also seems to be true of excellent companies [Peters and Waterman 1982, p. 312]). They simply react to challenges, circumstances, and opportunities as and when they arise. If an individual happens to find that the nest needs repairing, the larvae need feeding and so on, they may recruit individuals to help, even if it means recruits are taken from other (less important) work (e.g., Gordon 1995; Franks, Sendova-Franks and Anderson 2001). (They are not resting on their laurels though; they are continually monitoring the current situation, searching for problems, and seeking new opportunities, just like successful highly innovative companies, such as *3M* [Peters and Waterman 1982; Anderson and Bartholdi 2000].) Thus, in a short space of time a set of individuals may form at the site where they are needed. Of course, this doesn't necessarily mean that they are always involved in teamwork, as defined above, as they may tackle tasks in other ways (i.e., as group or partitioned tasks *sensu stricto* Anderson and Franks 2001). The key point is that individuals come together when needed to tackle a specific task, usually just making use of the individuals that happened to be in the vicinity, and they disperse when the task is completed, that is, in an adhocratic fashion.

Lessons from the (ant)hill?

In human enterprises, teams tend to be small, in the order of 3–15 members (Peters and Waterman 1982; Katzenbach and Smith 1993). Intriguingly, this may also be true of insect societies, despite the fact that colony size varies over several orders of magnitude. Single colonies of some species, such as *Dorylus* driver ants, may contain more than 20 million individuals, yet their teams also contain just a few individuals (Franks, Sendova-Franks and Anderson 2001). Across all known social insect teams, team member ship is usually two or three and probably a few tens at most (C. Anderson and N. R. Franks, unpubl. ms). Such similarity in team size may just be coincidence but, alternatively, it may hint at a more fundamental organizational principle. This will only be resolved by more detailed research in both fields.

Teams are discrete functional units, a view shared both by management theorists (Katzenbach and Smith 1993, p. 21) and social insect researchers (Anderson and McShea 2001a,b). With their introduction into a particular company or colony, a new hierarchical level is generated. This is not hierarchy in the usually thought of sense as in a level of chain-of-command within a company, but an organizational level, a new intermediate level above that of the individual worker, and below that of the company or colony as a whole (Anderson and McShea 2001a,b). In the same way that histologists viewing a human body at the tissue level will likely have radically new ideas and insights about how it works and functions compared to cytologists, viewing the same body at the cellular level, so management theorists and practitioners (and social insect researchers too) have much to gain from adopting a multiple-levels perspective, and considering their organization both at a worker and teams level. As Lewin (1993, p.174) notes:

> 'The lives of individual ants and individual humans are transformed by membership in a larger entity, an entity they also help create.'

Given that insect societies, and presumably their teams, have existed for approximately 100 million years, and that such well-coordinated teamwork has likely been favored and shaped by natural selection because it is adaptive, might they hold some useful lessons for human organizations? We suggest that under certain circumstances, particularly fast-moving competitive environments, insect societies may provide a model of how an adaptive organization can be run extremely successfully. Of course, we are not advocating that companies start running their whole operations like an ant colony, but the proximate rules and embarrassingly simple algorithms employed by insect societies have proved to be enormously successful as an alternative way of solving dynamic, complex, logistical problems in companies (a new field known as "swarm intelligence"; Bonabeau, Dorigo and Theraulaz 1999; Anderson and Bartholdi 2000; Bonabeau and Theraulaz 2000; see especially Bonabeau and Meyer 2001). Importantly, Coleman (1999), citing Baskin (1998), suggests that "models of organization that are based on living systems are naturally organic and adaptive."

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Team Attributes	**Human Teams**	**Insect Teams**
Definable membership of two or more	Yes	Yes
Team consciousness or identity	Yes	?
Common, overall purpose or goal	Yes	Yes
Members interact, communicate, and influence each other	Yes	Yes
Members have complementary skills and abilities	Yes	Yes
Activity is coordinated	Yes	Yes
Team has ability to act as one	Yes	Yes
The members consider themselves mutually accountable	Yes	No
There are performance goals	Yes	No
Team evaluates itself	Yes	No
There are emergent properties	Yes	Yes

Table 1

Comparison of likely attributes of human and insect teams

Self-managed Teams	Self-organized Teams
Part of formal organization structure	Not part of formal organization structure
Formal, temporary, or permanent	Informal and temporary
Not spontaneously formed	Formed spontaneously around issue(s)
Indirectly controlled by senior management	Boundaries influenced by senior management
Managers decide ‘who’ and ‘what’	Team members decide ‘who’ and ‘what’
Replace the hierarchy	Often in conflict with or constrained by the hierarchy
Empowered by senior management	Empowered by the team’s members
Strongly shared culture	Cultural differences provoke and constrain
Some sense of shared purpose	Strong sense of shared purpose
Order created via recognized processes	Inherent order emerges
Behaviors influenced by procedures and roles	Spontaneous, creative behaviors
Strong sense of team commitment	Strong sense of personal commitment
Some energy and enthusiasm	High levels of energy and enthusiasm
Decision making is mainly a planned process	Decision making is mainly a spontaneous process
At least one member’s primary role is organizational	All members’ primary role relate to the task

Table 2

Attributes of self-managed versus self-organized teams (adapted from McMillan 2000, p. 191)