Box 12.1 Trap-jaw ants

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The success of ants is often attributed to their remarkable social behaviour and cooperation. Group foraging species such as army ants can recruit hundreds or thousands of individuals to defend, divide, and retrieve resources such as a large insect or even a small vertebrate. However, not all ants are social hunters — some of the most successful predatory ants are solitary hunters. How do they compete with the social recruiters for resources? One way is by having some of the fastest jaws in the animal kingdom.

Of the many remarkable cases of extreme feeding ecology in the family Formicidae, few rival that of trap-jaw ants (Figure 12.1.1a). These ants use their oversized jaws and associated catapult-like muscle-firing ability to strike prey with extreme speeds and forces — exceeding 60 m/s and 500 times their own body weight, respectively (Gronenberg *et al*. 1993; Patek *et al*. 2006). These strikes are typically used for crushing, impaling, de-limbing, trapping, or ejecting prey or competitors. However, some trap-jaw ants in the genus *Odontomachus* can also use their high-powered strikes as an escape mechanism; by triggering their mandibles against the ground, they can launch *themselves* several centimetres into the air in response to threats (Patek *et al*. 2006) (Figure 12.1.1b).

Evolution and Ecology

The term 'trap-jaw ants' neither describes a single taxon nor a single clade. In a fascinating example of convergent evolution, trap-jaw morphology has evolved independently at least four times in ants, occurring in at least seven genera from three different subfamilies (Ponerinae, Myrmicinae, and Formicinae) (Figure 12.1.1c). The repeated evolution of this feeding syndrome makes it an ideal system for

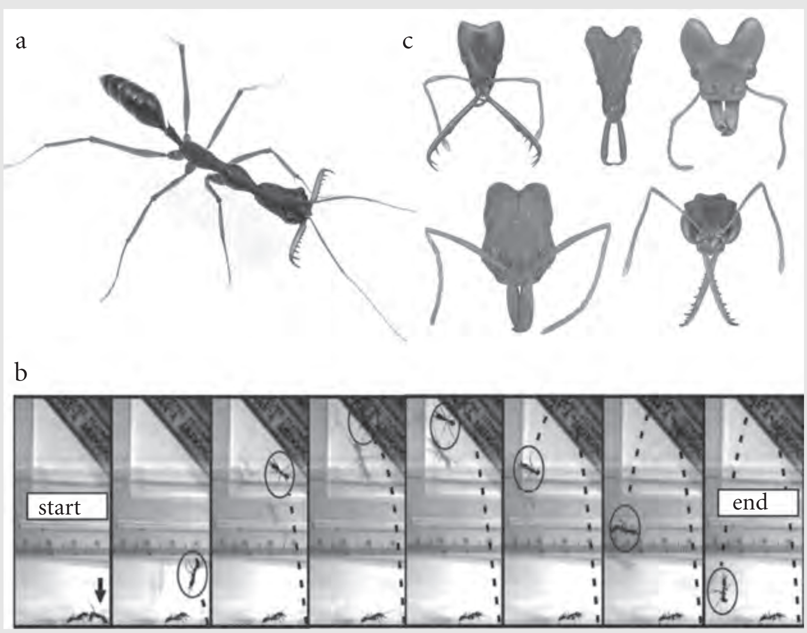

Figure 12.1.1 (a) The trap-jaw ant *Odontamachus coquereli* from Madagascar with its jaws "locked open" and ready to strike. (Photo: Alex Wild). (b) An image sequence of an *Odontomachus bauri* worker "jumping" with her jaws to escape an attacker. (Image: Patek et al. (2006) Copyright 2006 National Academy of Sciences, USA). (c) Examples of variation in trap-jaw ant morphology. Top row, left to right: *Acanthognathus*, *Strumigenys*, and *Daceton* (subfamily Myrmicinae); bottom row, left to right: *Odontomachus* (subfamily Ponerinae) and *Myrmoteras* (subfamily Formicinae). (Photos: www.AntWeb.org.)

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Box 12.1 continued

understanding the evolutionary prerequisites for, and ecological correlates of, feeding morphology and mechanics. Trap-jaw ants vary in size from a couple of millimetres (e.g. many *Strumigenys*) to over a centimetre (e.g. some *Odontomachus*). They are found in most biomes, but are particularly diverse in tropical and subtropical regions. Trap-jaw ants are commonly found in litter habitats (such as the genera *Anochetus* and *Strumigenys*), but will also nest arboreally (*Daceton* and some *Odontomachus*), and many are ground dwellers living in a variety of habitats including under stones, in rotten logs, and in termite mounds. Trap-jaw ants are highly predatory and most are dietary generalists, preying upon and scavenging a variety of arthropods. However, some species in the genus *Strumigenys* appear to specialize on springtails, while others in the genus *Odontomachus* prey predominately on termites, and a few have even been observed harvesting seeds (Brown and Wilson 1959a; Ehmer and Hölldobler 1995). However, for most trap-jaw ant species, little is known about their natural history.

Morphological and Mechanical Variation

Trap-jaw ants show considerable variation both within and among taxa in terms of mandible size, shape, and the mechanics of storing and generating force (Figure 12.1.1c). The mandibles are elongated and project from the head (anteriorly when relaxed, laterally when cocked), and store energy using a latch or 'click' mechanism. Across trap-jaw species, this mechanism is built using different anatomical structures, such as modifications of the jaw insertion points in *Odontomachus*, a modified labrum in *Strumigenys* and *Daceton,* which blocks the mandibles from closing, and by interlocking mandibular processes in *Acanthognathus* (Gronenberg 1995; 1996; Gronenberg and Ehmer 1996). In addition to the variation in locking mechanisms, the relative size, orientation, and attachments of mandible opener and closer muscles vary dramatically across trap-jaw ants. Across taxa, the mandible closer muscles can occupy over 60% of the head volume, and are often contained in visible oversized lobes extending the posterior margins of the head. Furthermore, variation in muscle volume is accompanied by variation in the relative composition of muscle fibre types. For example, in some trap-jaw ants, the small trigger muscles that release the strike are among the fastest muscles known in animals (Gronenberg *et al*. 1993). Finally, the shapes and surfaces of the jaws themselves vary considerably among species (Figure 12.1.1c). The jaws may be long or short, narrow or broad. Many trap-jaws are capped by large medially oriented terminal teeth, and the leading edges of the mandibles may also be lined with teeth, which may be sharp or blunt; the leading edges may also lack teeth and have a wedge- or scissor-like surface more suitable for cutting. Whether or not these variations are optimized for capture of certain prey-types, colony defence, or jumping ability is largely unknown and is a rich area for more research.

1990; Powell and Franks 2005, 2006). Aspects of body shape such as relative leg length are likely to be adaptations to the specific mode of foraging employed by the respective species; surface-running ants have longer legs, whereas ants that live in an interstitial environment such as leaf litter have short legs (Kaspari and Weiser 1999; Kronauer *et al*. 2007b; Schöning *et al*. 2005; Weiser and Kaspari 2006). Some species also display worker polymorphism, variation in worker sizes and body shape, producing a worker-caste particularly adapted to a foraging task (see Plate 10). For example, the leaf-cutting ants in the genus *Atta* produce a range of worker sizes: the largest workers with their strong mandibles cut leaves, other large workers walk fast to transport them, whereas smaller workers tend fungus inside the nest (Wilson 1980). Morphological differences may also occur interspecifically, predicting the diversity and toughness of leaves harvested (Wetterer 1995). Sometimes, very small workers ride on leaves carried by large workers, which may have two important defensive functions