The aspidistra and the amphipod

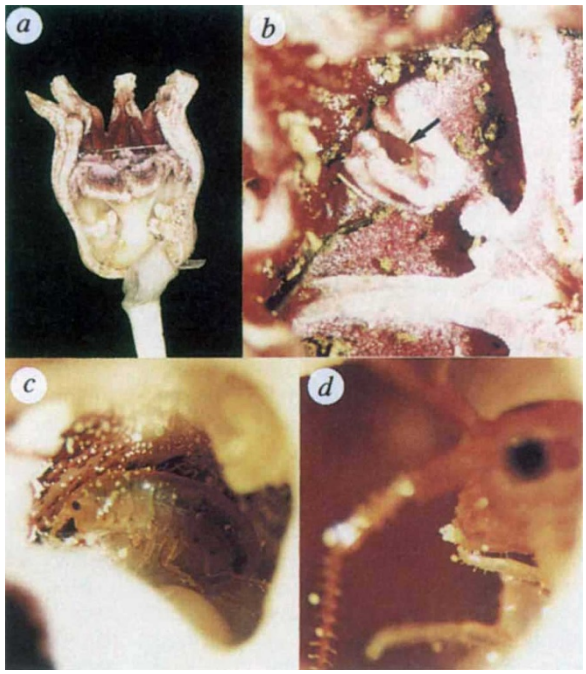
SIR — The aspidistra is an aberrant member of Convallariaceae (Monocotyledon: Asparagales)[1], which bears bell-shaped flowers close to the ground and was thought to be unique in being pollinated by slugs[2]. The pollination system of the aspidistra, however, has not yet been directly reported in its original area of distribution of East Asia. Recent observations made in its native habitat in Japan suggested that *Aspidistra elatior* is pollinated by pollen-eating, terrestrial amphipods.

The most unique characteristic of the aspidistra is a large, fleshy, disk-like stigma, which entirely blocks the lower inside corolla containing the stamens (*a*, *b* in the figure). The stigma of *Aspidistra lurida* is believed to act as an attractant and reward for slugs, which partly eat the stigma, gaining access to the stamens below, and thus taking part in pollination[2].

Aspidistra elatior Bl. is widely cultivated in China and Japan, but is thought to be indigenous to only a few small islands in the southern part of Japan[3]. The higher altitudes (300–622 m) of the island of Kuroshima in Kagoshima Prefecture are covered with evergreen oak forests whose understory is covered with aspidistras. We made observations of pollinator visits to the flowers here in March 1995.

No flowers were found with stigma damage. Among 89 flowers sampled and dissected, 37% were visited by various arthropods; isopods (8%), amphipods (8%) (*c* in the figure), collembolans (14%), thysanurans (1%), dipterans (3%, predaceous larvae of Mycetophilidae) and chiropods (2%). In 28% of the flowers, yellowish-white faeces composed of digested pollen were present, but no visitors were found. In these flowers, almost all pollen grains had disappeared. Pollen would accumulate in the bottom of the flower if not consumed by an organism.

To detect which organisms had left these faeces, five arthropod species (*Sphaerillo* sp. (Crustacea: Isopoda: Armadillidae), *Burmoniscus* sp. (Isopoda: Philosciidae), *Platorchestia japonica* (Amphipoda: Talitridae), *Hypogastrura* sp. (Insecta: Collembola: Hypogastruridae) and *Scolopocryptops* sp. (Chilopoda: Cryptopidae)) most frequently found in aspidistra flowers were observed in the laboratory. These arthropods, collected in or around the flowers, were introduced in plastic cases with aspidistra flowers which had been cut transversely. Among arthropods studied, amphipods and collembolans ate pollen (*d* in the figure), and amphipods excreted faeces which were identical with those left in the flowers in their natural habitat. The only slug species found on the islands, *Granulilimax fuscicornis* (Mollusca: Pulmonata), preyed on snails and never visited the flower.



A flower of *Aspidistra elatior* and its amphipod pollinator, *Platorchestia japonica*. *a*, Vertical section; *b*, top view of a stigma. An arrow shows a pore through which amphipods enter below. *c*, Vertical section of a flower being visited by an amphipod; *d*, an amphipod feeding on pollen.

Because anthers of *Aspidistra* are isolated from the upper disk-like stigma, self-pollination is unlikely if the flower is not visited by an organism. Seed-set confirmed in the natural habitats and the evidence of frequent amphipod visits to flowers suggest that the amphipod is the most likely candidate for the pollinator.

The pollinator status of the amphipod is further reinforced by the following evidence. (1) Between the disk-like stigma and the corolla, there are four small, narrow pores, through which the amphipods gained access to the stamen (*b* in the figure). The stigma acted as a block to rain and other flower-damaging arthropods, and as a gate for the selected pollinators. (2) The amphipods visited the flower to eat pollen, and left the flower with pollen attached to the body. (3) The amphipods cannot fly but are very able hoppers, and could thus transport pollen long distances.

Although the terrestrial talitrid amphipods are thought to have originated in Gondwanaland and reached South-East Asia on drifting land fragments[4,5], the Japanese species are thought to have adapted to terrestrial habitats rather recently from supralittoral habitats[6,7]. To detect whether the unique pollination system is ubiquitous amongst *Aspidistra*, observations are needed in the area of its greatest diversity, the southern parts of China.

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1. Dahlgren, R., Clifford, H. & Yeo, P. *The Families of the Monocotyledons* (Springer, New York, 1985).
2. Richards, A. J. *Plant Breeding Systems* (Allen & Unwin, London, 1986).
3. Sako, S. & Maruno, K. *Rep. Kagoshima Univ. For.* **16**, 33–62 (1985).
4. Hurley, D. E. *Am. Zool.* **8**, 327–53 (1968).
5. Friend, J. A. *A. Rev. Ent.* **31**, 25–48 (1986).
6. Morino, H. *Publ. Seto mar. Biol. Lab.* **22**, 171–193 (1975).
7. Bousfield, E. L. *Bishop Mus. Spec. Publ.* **72**, 171–210 (1984).

Cortical areas in visual awareness

SIR — I commend Crick and Koch[1] for their serious and innovative neurobiological approach to the problem of visual awareness and agree with several of their ideas, such as those for differential explicit representations from cortex to cortex. Space, however, constrains me to confine subsequent comments largely to areas of disagreement.

Crick and Koch hypothesize that "activity in V1 does not directly enter awareness". I feel that they should clarify an ambiguity in their text and their Fig. 1: do they believe that frontal cortical areas are involved in visual awareness, and if so, why? I also challenge their premise that only those visual areas that project directly to brain regions that "contemplate, plan and execute voluntary motor outputs" can participate directly in awareness. I disagree with claims that existing physiological and psychophysical evidence supports their hypothesis, and offer here evidence against excluding V1 and V2 from the process of visual awareness.

Neural correlates of working spatial and object memory are found in premotor cortex[2]. Ablations of frontal cortex do not affect visual acuity but may produce 'neglect', a stimulus–response failure in the absence of a sensory defect, attributed to "attentional components of motor responses, and not elementary, space-related visual perception"[3]. If Crick and Koch believe that these cortices and/or premotor and motor cortex are involved in visual awareness, I ask them to provide such evidence.