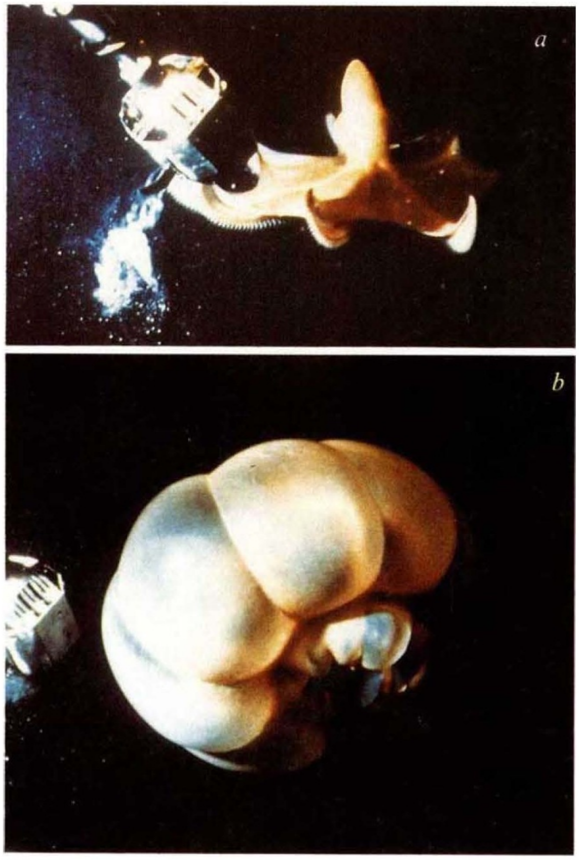
Octopod 'ballooning' response

SIR — Very little is known about the deep-sea octopuses of the order Cirroctopoda[1]. Observations of live animals were rare until recently because aquarium studies were possible only in the case of the flapjack devilfish *Opisthoteuthis*[2]. Deep-sea cameras subsequently allowed cirrate octopods to be photographed in their natural habitat[3,4]. We have now observed these animals from a submersible, providing the possibility for interacting with individual cirrates. This avenue for investigation could be fruitful in investigating the behaviour of other free-ranging, deep-sea animals.

During the French CALSUB programme[5] in February–March 1989 on board the research vessel *Le Suroît* in the southwestern Pacific, the crew (including M. Rio) of the diving saucer *Cyana* (SP 3000) saw a cirrate octopod (possibly of the genus *Cirrothauma*) off the northeast coast of Lifou Island (Loyalty Ridge) at a depth of 2,880 metres, just above the sea floor. The animal hovered in the horizontal 'inverted umbrella' position (see figure) previously observed[3]. The submersible was brought sufficiently close to touch the animal with the grab arm. This contact triggered a spectacular reaction, which we describe as the 'ballooning' response — from the inverted umbrella attitude (*a* in the figure) the animal changed in about 15 seconds to a pumpkin shape. The process is summarized below, based on our video recording of the animal.



a, A cirrate octopod hovering in midwater in the inverted umbrella position; the grab arm of the submersible has not yet made contact with the animal. *b*, The ballooning response at its peak, the outer web being fully extended, with arm tips reappearing at lower right. Note the proximal parts of the muscular arm trunks which are bent to form arcs (visible through the extended membranes).

During hovering, the outer-arm web was not fully expanded so that the so-called intermediate web was visible as a vertical connection between the main (outer) sheet of the web and the curved muscular arm trunk (*a*). On contact, the animal reacted by changing the curvature of the arms and fully expanding the web so that the arm crown took on a bell shape. The arm trunks continued to curve inwards while the web sectors lying between the arms bulged out strongly; the intermediate-web bands became high dividing membranes above each arm trunk. The arm tips then disappeared beneath the web (7 seconds after the beginning of the response). The ballooning increased for another 10 seconds, the curved arms being brought together more closely. The arm tips finally reappeared due to a peristaltic wave generated by a coordinated arm flexion moving backwards from the arm tips (*b*). While the animal remained stationary, some water must have escaped as the surface of the web smoothed; 30 seconds after the beginning of the response, the grooves between the web sectors disappeared and the body of the animal reappeared above the shrinking web sphere. After 43 seconds the fins, which had remained immobile during hovering and ballooning, were lifted, starting the backwards swimming movement: this completely 'emptied' the trailing arm crown.

We can only guess the function of the ballooning response. In an environment where downwelling light does not penetrate, tactile stimuli are likely to be important. The 'transformation' achieved by the ballooning response might have a stunning or disorientating effect on a potential predator in a first (possibly accidental) contact with the cirrate. The ballooning web, by providing 'imprecise' tactile cues, could thus be a defence mechanism.

S. V. BOLETZKY

URA 117 CNRS,
Observatoire Océanologique de Banyuls,
Laboratoire Arago,
66650 Banyuls-sur-Mer,
France

M. RIO

Centre Sciences de la Terre,
Université de Lyon I,
69622 Villeurbanne, France

M. ROUX

Laboratoire Sciences de la Terre,
Université de Reims,
BP 347 et URA
157 CNRS,
51062 Reims, France

1. Young, J. Z. *Phil. Trans. R. Soc.* **B325**, 189–237 (1989).
2. Pereyra, W. T. *Pacif. Sci.* **19**, 427–441 (1965).
3. Roper, C. F. E. & Brundage, W. L. *Smithson. Contr. Zool.* **121**, 1–46 (1972).
4. Pearcy, W. G. & Beal, A. *Deep-Sea Res.* **20**, 107–108 (1973).
5. Roux, M. *et al. Bull. Soc. géol. France* **162**, 675–685 (1991).

Vortex air rings

SIR — Commenting on Aref and Zawadzki's simulation-based studies on the linking of vortex rings[1], J. D. S. Jones in News and Views[2] asked whether the vortex-linking could be done experimentally. I recently observed and photographed underwater 'air rings', which I believe to be an example of this linking.

In November 1991 I rode in the submarine *Atlantis*, a commercial sightseeing submarine based at Kailua-Kona, Hawaii. A diver accompanied the submarine to a depth of about 50 feet, feeding fish, watching for sharks and blowing air rings. The diver was facing up when he produced each air ring, so each ring rose purely vertically. On one occasion (left-hand photo over page) the diver produced two air rings in quick succession, followed by a third. As he blew a fourth ring (right-hand photo) and destroyed it with his hand, the second ring caught up with the first and linked with it. The process was fascinating to watch: one portion of the second ring began to rise more quickly than the rest, as if the first ring were pulling it towards it. The corresponding portion of the first ring also began to rise more quickly than the rest of its ring, although not so markedly as in the second ring. Soon the second ring caught and linked to the first ring, forming a single large ring of irregular shape. After a few more seconds the situation became more complicated, with the large ring becoming unstable and the third ring catching up with the other two.

Although this technique seems to be