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Soft-sided Tanks Improve Long-term Health of Cultured Cuttlefish

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The common European cuttlefish, *Sepia officinalis* Linnaeus, 1758, is being cultured in captivity to provide experimental animals for biological and biomedical research, and for testing methods applicable to larger-scale mariculture. This species adapts quite well to captivity, and several generations of cuttlefish have been grown in facilities in Europe and the United States (*e.g.*, 1–5). However, while jetting away from other animals during social interactions, or from human observers who have inadvertently startled them, cuttlefish occasionally collide into the walls of holding tanks (3). Moreover, recent work by Boal *et al.* (7) shows that social interactions (many of them deleterious) increase substantially when sub-adult and adult cuttlefish are maintained or cultured in higher densities, which they usually are. The accumulated damage to the skin caused by the collisions (see also 6) often contributes substantially to mortalities in the course of the one-year life cycle. Repetitive collision causes trauma, particularly to the posterior mantle tip, because the cuttlefish are most often jetting backwards when they hit the wall. The mantle tip is particularly vulnerable because the layer of muscle and skin overlying the posterior tip of the cuttlebone is quite thin. As a result, focally extensive, deep ulcerative dermatitis and cellulitis develop. We term this posterior mantle tip dermatitis (PMTD). Severe cases result in hemolymph loss, bacteremia, and death. Subacute, chronic cases result in fibrosing cellulitis and abnormal cuttlebone formation at the posterior apex; occasionally, the apex of the cuttlebone fractures. Because culturing a cuttlefish through its life cycle is expensive, methods that will increase survival to adulthood need to be developed.

We counted collisions for a total of 7 h over 3 days; the cuttlefish were males of about 1 kg, and females of about 0.5 kg. Collisions with tank walls can occur quite frequently: we counted rates of 0.75–1.25 events per animal per hour in a variety of tanks ($n = 4$ tanks), even when the animals were relatively calm (*e.g.*, when they were not sexually active, when the tanks contained only females or immature animals, and when human distraction was minimized). These rates increased to over 4.0 wall collisions per animal per hour when the animals were sexually active (*e.g.*, when two males were placed in a tank with mature females, or when human observers startled the cuttlefish).

Hulet *et al.* (8) suggested that a "bumper system" be installed along the walls of squid holding tanks to reduce skin damage from collisions with the hard surfaces. Modifying their concept, we have developed a simple system in which black plastic cushioning curtains were hung parallel to, and 10 cm away from, the inner surfaces of the tank walls (Fig. 1). The resulting holding arena was smaller—1.65 × 1.3 m (surface area = 2.145 m^2)—than the control tank. Water depth was held at 0.28 m, providing an overall volume of 0.6 m^3.

An identical control tank (1.85 × 1.5 × 0.28 m, surface area = 2.775 m^2, volume = 0.777 m^3) was set adjacent to the experimental tank. Animals in both tanks experienced the same water input, outside disturbances, light conditions, cleaning schedule, etc. Since no space was taken by cushioning curtains, the cuttlefish could roam through the entire volume of the control tank.

Hulet *et al.* (8) used cushioning walls that created a slope between the bottom of the tank and its hard walls. Although this design greatly reduced the impact when the side surfaces were hit, it restricted water movement behind this angled curtain, so the medium became increasingly anoxic, and hydrogen sulfide built up. The new tank design circumvents the water quality problem. First, we are using a flow-through seawater system and no substrate. We improved water circulation by placing the cushioning curtains parallel to the tank walls and by pumping fresh seawater into the area between the curtains and the walls. Two airlift pumps were used, each working at 9.45 l/min (2.5 gal/minute); the pumps were placed near the curtains at opposite sides of the tank and moved water from behind the curtains to the central area. The volume of water behind the curtains was 176.4 liters, and with both pumps operating that entire volume could be exchanged approximately every 9.3 minutes. No significant difference in pH or in oxygen concentration was found between the water in the control tank and that in the center arena of the experimental tank, or in the area between the cushioning curtains and the walls of the experimental tank.

Two sequential trials were conducted. In each trial, 4 sexually mature cuttlefish (2 males and 2 females, all free of any body

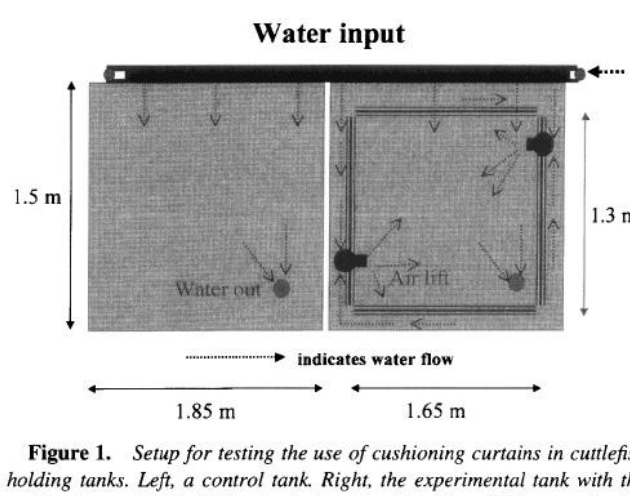

Figure 1. *Setup for testing the use of cushioning curtains in cuttlefish holding tanks. Left, a control tank. Right, the experimental tank with the cushioning curtain (bold lines) set along its sides. Two airlifts moved water from behind the curtain to the center of the tank, thus maintaining high-quality water on both sides of the curtain.*

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injury) were placed in each tank. Hence, the density in the experimental tank was slightly higher than in the control tank (0.54 *vs.* 0.69 m^2 per cuttlefish, respectively). The health of these adult animals was monitored throughout the trials.

Trial 1 lasted for 40 days. On day 11, one of the cuttlefish in the control tank developed PMTD. On day 17, a second cuttlefish in the control tank developed PMTD. None of the animals in the experimental tank showed any signs of PMTD, although two animals developed unrelated illnesses.

Trial 2 was conducted with four new healthy cuttlefish in each tank (2 males, 2 females). In the control tank, PMTD first occurred at day 7, and this animal died on day 11; thus animal density in this tank was lower during the remainder of the trial. By day 26, the three remaining animals in this tank showed PMTD; one died on day 42, one on day 49, and one is still alive at this writing (day 105). Once again, in contrast, none of the animals in the experimental tank developed PMTD. More importantly, the second trial is still in progress, and all four cuttlefish in the experimental tank are completely free of PMTD at day 105. Overall, for both trials, none of the 8 cuttlefish in the tank equipped with the cushioning sides exhibited PMTD, as compared with 6 out of 8 (75%) of the animals in the control tank (χ^2, $P < 0.014$).

The new tank design increases the maintenance effort in rearing the cuttlefish. Eight additional surfaces must be scrubbed as compared with traditional hard-sided holding tanks. Furthermore, the soft sides of the tank are more difficult to scrub than hard surfaces. Nevertheless, the efforts are worthwhile because cuttlefish nurtured through the life cycle in captivity have a relatively high value. Although our tank design did not reduce the number of social interactions among cuttlefish, which occur even at low densities (7), it reduced the resulting skin damage experienced by the animals, and thus increased their longevity.

Acknowledgments

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