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SHORT COMMUNICATION

URINE PRODUCTION IN *OCTOPUS VULGARIS*

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In a recent paper (Wells and Wells, 1989) evidence was presented indicating that *Octopus vulgaris* takes up water and salts through the digestive gland appendages, the so-called 'pancreas'. Animals with the digestive gland ducts ligated lost weight at around 11 % of the body mass per day and died after about 48 h. Animals with the ducts exteriorised, leaving a sufficient length to perform peristalsis, did not lose weight.

Figures for the rate of fluid loss through the ultrafiltration-based kidneys were available only from the very large (10–12 kg) *Octopus dofleini*, which produced an average of 62.4 ml kg^{-1} or 6.2 % of its body mass in 24 h (Harrison and Martin, 1965). If we assume that the rate of urine production will scale with metabolic rate, i.e. as body $mass^{0.74}$ (Wells *et al.* 1983*a*) the predicted rate for an *O. vulgaris* of 0.5 kg would be 69.7 ml or 13.9 % of the body mass in 24 h.

Two sorts of experiment were made to test this prediction. In the first, the renal papillae were cannulated, as Harrison and Martin had done with *O. dofleini*. A number of experiments was made with *O. vulgaris* in the 1–2 kg range; in most cases the animals succeeded in dislodging the cannulae. In five instances where the cannulae were still securely in place after 6–25 h, urine was produced at rates that varied from 6.1 to 11.1 % of the body mass in 24 h; scaled for smaller animals of 0.5 kg, these rates rise to 7.1–14.9 %. The inaccuracies of the direct collection method were plain when the animals were examined at the end of the experimental runs; the renal sacs were very expandable and the fluid remaining in the sacs varied enormously from one individual to the next.

Further experiments were therefore made as follows. Each animal was anaesthetised (2.5 % ethanol) and the renal sacs were pressed gently to expel any urine that was easily voided. The papillae were then ligated. Six hours later the octopus was again anaesthetised and weighed. The ligatures were removed and the urine expressed as before. The animal was weighed again. Urine volume was taken from the mass difference. Because the animals ranged in mass from 194 to 680 g (most were in the range 350–400 g) and it was intended to compare the figures with those reported in Wells and Wells (1989) the results were again scaled for 0.5 kg animals.

Key words: water balance, cephalopod, *Octopus*, fluid uptake, urine production.

Table 1. *Urine production as a percentage of body mass in 24 h*

	Urine production (%)
A Animals operated upon at approx. 09:00 h	9.50±1.99 (N=8)
B Animals operated upon at approx. 21:00 h	13.01±3.62 (N=7)
C Animals operated upon at approx. 09:00 h and fed 30 min later	14.02±3.95 (N=7)

Values are mean±S.D.

One-way ANOVA, F=4.075, 0.025<P≤0.05.

t-tests: A and B, t=2.293, 0.01<P<0.025; A and C, t=2.865, 0.005<P<0.01; B and C, t=0.520, 0.1<P<0.375.

Table 1 summarises the results of these experiments. Each animal was fasted for 4 days before use. Table 1A shows urine production by eight fasted animals, over approximately 6 h periods beginning at around 09:00 h. Table 1B shows urine production from seven animals in similar experiments beginning at 21:00 h. There is evidence that activity and metabolic rate increase at night (Wells *et al.* 1983*a*). Table 1C shows urine production from a third group, of seven animals, each fed a crab weighing about 10 g within half an hour of the start of a 6 h period starting at 09:00 h; all of these octopuses attacked, killed and began to eat their crabs during the first half-hour of the run. Feeding is also known to increase metabolic rate (Wells *et al.* 1983*b*).

The results followed expected trends. Fed animals produced more urine than unfed animals. The difference is significant (P<0.01) only for the group operated on in the morning, the higher rate for fasting animals tested at night closely approaching that of octopuses fed during the day (0.1<P<0.375).

The fluid uptake experiments reported in Wells and Wells (1989) were all made with animals fasted for 4 days. Mass losses following operations that would have prevented water from reaching the digestive gland appendages averaged 11.64±3.00 % over 24 h (N=26). In the present series of experiments, urine production by fasting animals averaged 11.13±3.30 % (N=15). In comparing the *O. vulgaris* results with those from *O. dofleini*, data from fed animals must be used. Here the scaled results from *O. dofleini* predict urine production at 13.9 % of the body mass per day; seven fed *Octopus vulgaris* actually produced 14.02±3.95 %.

The agreement between mass loss when water uptake is prevented and during normal urine production is plainly very close. On these figures urine production accurately balances water uptake through the digestive gland appendages. This is surprising in an animal that is both hyperosmotic with respect to the sea water that it lives in (Wells and Wells, 1989) and possessed of a large exposed body surface. One must suppose that if any cutaneous uptake occurs it is accurately balanced by loss through the gills, which have a small (0.5 kPa maximum) positive blood pressure in the afferent vessels. More importantly, it is clear that the surface of the animal, with the exception of the active transport system in the digestive gland appendages, is essentially impermeable.

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