firmed that malic acid was labeled to a high degree.

The high degree of acidification and the carbon assimilation of this crop plant as evidenced from the present investigation provide the physiological basis for its known survival under a semiarid tropical environment. The fact that the CAM behavior has been observed for the first time in this field crop should lead to further survey of other tropical crops.

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Pheromones Are Involved in the Control of Sexual Behaviour in Birds

J. Balthazart and E. Schoffeniels

Laboratoire de Biochimie générale et comparée, Université de Liège,
B-4020 Liège, Belgium

As evidenced by the opinion expressed in textbooks [1], it seems generally accepted that birds lack a well-developed sense of smell. That this may not be true, however, is suggested by the complex structure of their olfactory apparatus [2] and by electrophysiological data [3]. Furthermore, it is possible to use olfactory signals as discriminating stimuli in operant conditioning experiments [4, 5], thus demonstrating that even the pigeon, microsmic among birds on the basis of its anatomy, has a threshold of differential sensitivity to odour very similar to that of the rat [5, 6], a macrosmic species in which a complex system of pheromonal communications has been demonstrated [7]. However, very few data are available concerning the role of olfaction in the bird's life though it is now established that some birds locate their food by smell (kiwi [8]; turkey vulture [9], petrels and shearwaters [10]). In two species, olfaction is also thought to play a role in the homing behaviour (Leach's petrel [11] and pigeon [12]).

It is thus surprising to notice the lack of research devoted to the study of intraspecific communication among birds while pheromonal interactions have been thoroughly investigated in other animal groups [7]. We have shown that in ducks the chemical composition of the preen gland secretion is different in males and females during the reproductive season but not in ducklings nor in adults at sexual rest [13]. These chemical compounds could thus play some role in the interaction between sexes and we have produced some experimental data strongly suggesting that it could be so.

During a complete reproductive cycle, we observed and recorded the behaviour of male domestic ducks (Rouen breed *Anas platyrhynchos*) which had been submitted to bilateral olfactory nerve section ($n_E = 10$) or to the sham operation ($n_C = 10$) when 8 days old. Figure 1 shows some of the data collected during this study and demonstrates that in the experimental birds the sexual behaviour was significantly inhibited. This did not seem to result from a general specific inhibition of the animals' activity as their maintenance (nibbling, dabbling, sleeping), and aggressive behaviour was similar to that of controls. They could have been systematically dominated by the latter: this would have induced their rarer presence in the water of the pond and their lower frequency of sexual behaviour but does not agree with the fact that they were not the subject of more aggressive actions. It is, however, well known that a stabilized hierarchy can be maintained without much overt aggression [14]. The plasma levels of pituitary-gonadal hormones in control and experimental birds were not different at the height of the reproductive season (testosterone: $E: 2.56 \pm 1.37$; $C: 3{,}23 \pm 1.33$ ng/ml; FSH: $E: 298 \pm 88$; $C: 360 \pm 170$ ng RP_1/ml; LH: $E: 3.19 \pm 1.09$; $C: 4.25 \pm 1.08$ ng CHLH-AE_1/ml; $x \pm n_E = 5$, $n_C = 8$, all differences not significant by two-tailed t-test). The observed behavioural inhibition could thus result from the lack of percep-

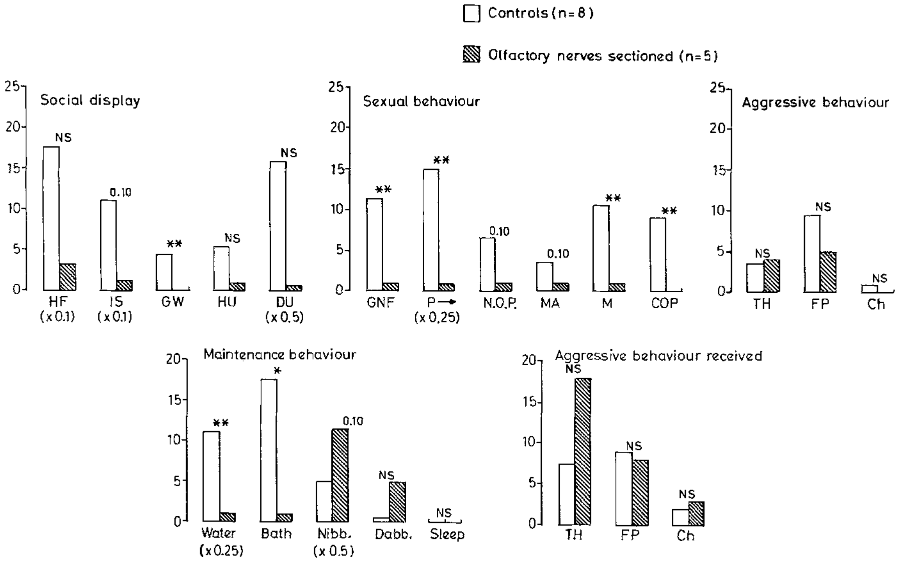

Fig. 1. Behavioural frequencies observed during 4 h (16 × 15 min during January) in olfactory nerve-sectioned and control male ducks. Statistical comparisons were performed by the Mann-Whitney U-test (** $p < 0.01$; *: $p < 0.05$; 0.10: $p < 0.10$; NS: $p > 0.10$). *HF* head flick; *IS* introductory shake; *GW* grunt whistle; *HU* head-up-tail-up; *DU* down up; *GNF* grasping the neck feathers; *P*→pumping toward a female; *NOP* non-oriented pumping; *MA* mounting attempt; *M* mount; *COP* copulation; *TH* threat; *FP* feather peck; *Ch* chase; *water* standing in the pond; *nibb* nibbling; *dabb* dabbling

tion of olfactory signals, originating from the females.

During another experiment designed to test the effect of olfactory signals, 2 groups of 4 visually isolated male ducks were exposed for 6 months to 2 females each which were impregnated either with amyl acetate (AA: $C_7H_{14}O_2$) or with ethyl acrylate (EA: $C_5H_8O_2$; females wore on their backs small plastic capsules filled twice a week with the chemical). Thereafter the sexual preferences of these two groups of males were tested by presenting them with pairs of unknown females impregnated with one or the other odour. A preference was recorded if the number of sexual actions toward one female was significantly higher than toward the other (binomial test). During 60 observations (2 groups of males × 5 pairs of females × 6 observations in each case) 20 significant preferences were observed: 8 in EA males (3 for EA females; 5 for AA females: $p>0.10$; binomial test) and 12 in AA males (2 for EA females; 10 for AA females: $p<0.038$). Though the two groups of males did not behave differently toward the females ($p<0.24$ by the Fisher test), AA males clearly preferred AA females, while no choice was observed in the other male group. Detailed analysis of these data (by separating different days of observation, different groups of males, difference pairs of females and different behaviour patterns) lead to the same conclusion which can be interpreted in two ways:

Either AA females were sexually more attractive irrespective of the chemical compound they were impregnated with. This would explain the preference of AA males but seems at first sight incompatible with the behaviour of EA males.

Or AA males associated, during the 6 months of training, the performance of sexual behaviour with the AA odour and oriented according to this conditioning of their behaviour during the choice tests. We should then explain why EA males did not develop a similar preference. The acrid odour of EA compared to the floral one of AA could be invoked here but this should be investigated in further experiments.

At the moment however, our knowledge of the olfactory possibilities of birds, joined to the present behavioural data and to the demonstration that the preen gland secretion of females is different from that of males, makes it very likely that pheromones are involved in the regulation of sexual behaviour in ducks. This opens a new and fascinating field of investigation.

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Inhibition of Embryonic Development in *Earias vittella* by Terpenoids

R.C. Mehta

Zoology Department, Ramjas College, University of Delhi, India

As several terpenoids have significant juvenile hormone activity [1, 2], and as the latter may block embryonic development in insects [3], certain terpenoids (camphene, carvacrol, carvone, cineole, citral, citronellal, eugenol, farnesol, geraniol, β-ionone, pseudo-ionone, dl-limonene, menthol, menthone, β-phellandrene, and α-pinene) were tested for their effect on embryonic development in *Earias vittella* (Lepidoptera: Noctuidae). The test compounds were dissolved in isopropyl alcohol and spread in different concentrations on the bottom of glass tubes (2-cm diam., 5-cm ht.). The eggs of *E. vittella*, obtained from its laboratory culture [4], were arranged into groups of 20 and placed at different age levels in contact with the test compounds in the glass tubes at 27±1 °C and 60–70% r.h., and examined daily for the number of eggs hatched. Appropriate controls were run and each experiment was

Table 1. Effect of certain terpenoids on embryonic development in *Earias vittella*

Terpenoids	Concentration [μg/cm²]	Inhibition of embryonic development in eggs [%]			
		24 h	48 h	72 h	96 h
Carvacrol	33.3	44.0±2.4	42.0±2.0	2.0±1.2	54.0±2.4
	66.6	96.0±2.4	44.0±2.4	42.0±2.0	56.0±2.4
	133.2	98.0±2.0	100.0±0.0	100.0±0.0	100.0±0.0
Eugenol	33.3	100.0±0.0	90.0±3.1	44.0±2.4	24.0±2.4
	66.6	100.0±0.0	100.0±0.0	94.0±2.4	26.0±2.4
	133.2	100.0±0.0	100.0±0.0	100.0±0.0	44.0±2.4
Farnesol	33.3	84.0±2.4	12.0±1.2	13.0±1.2	9.2±0.4
	66.6	92.0±2.0	36.0±2.4	48.0±2.0	45.0±2.2
	133.2	96.0±2.4	96.0±2.4	94.0±2.4	67.0±2.0
Geraniol	33.3	100.0±0.0	72.0±2.0	20.0±1.5	11.0±1.0
	66.6	100.0±0.0	100.0±0.0	46.0±2.4	48.0±2.0
	133.2	100.0±0.0	100.0±0.0	100.0±0.0	59.0±1.8