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The Role of Pheromones in Reproductive Behaviour with Special Reference to Olfaction

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Abstract

Pheromones are endogenous semiochemical messengers of ectohormone function produced by one individual and act as behaviour altering agents in the receiving individual of the same species. The triggering behaviours include Alarming, Signalling Sexual arousal, warning delineating territory, parental care. There are releaser, primer signaller and modular pheromones.

Key words : *Human Pheromones, Behaviour, Semiochemicals, Vomeronasal Organ*

Introduction

Animals have evolved diverse and remarkable responses to chemical information (Wyatt, 2003). Pheromones are semiochemical molecules used for communication between animals (Law and Regnier, 1971). They have evolved from eavesdropping of hormones (Sorensen and Stacey, 1999).These chemicals play a role in territoriality and social behaviour of animals. These processes are closely related to their role in the co-ordination of reproduction, and are especially important in individual recognition. The neural processing of pheromone signal within distinctive brain structure leads to marked changes in animal behaviour and endocrine status (Dulae and Torello, 2003; Kaba *et al*. 1992). Pheromones are species specific, which is conferred by variations in the blend of chemical compounds that are contained in the pheromone (Sorensen *et al*. 1998). The different blends of compounds elicit different responses in the receptors (Regnier and Wilson, 1971). The pheromones elicit both long lasting effects that alter the endocrine state of the recipient animal and short term effects on its behaviour (Halpern, 1987).

Pheromones are detected by the sensory neurons in the vomero-nasal organ, which is a bilateral tubular structure in the anterior region of the nasal cavity. Vomeronasal organ (VNO) axons project to the accessory olfactory bulb, which in turn transmits sensory information to the vomeronasal amygdala, then to the specific hypothalamic nuclei which are involved in regulating the genetically pre-programmed physiological and behavioural responses (Fernandez and Meredith, 1995, Mackay-Sim and Rose, 1986, Dulae and Torello, 2003). The VNO in humans consists of just pits that probably do not do anything. Interestingly the VNO is clearly present in the foetus but atrophies before birth. If humans do respond to hormones, most likely they use their normal olfactory system.

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Pheromones and Olfactory Effects on Reproductive Physiology

The polygynous female rodents, among whom the risk of infanticide is highest, show a tendency to terminate their pregnancy following exposure to the scent of an unfamiliar male (Becker and Hurst, 2008; Pillay *et al.* 2009; Marashi and Rulicke, 2012). Bruce (1959) observed this phenomenon in *Mus musculus* and hence this pregnancy block is termed as Bruce effect. This phenomenon was also observed in deer-mice (Eleftheriou *et al*. 1962), meadow voles (Clulow and Langford, 1971) and geladas (Eila *et al*. 2012). The neuro-endocrine path ways activated by the novel dominant male's urinal pheromones cause Bruce effect which give a mate choice for the females for the high quality males (Brennan, 2009; Brennan and Zufall, 2006; Becker and Hurst, 2009). Demonstration of specific olfactory effects on the reproductive physiology of mice by Parkes and Bruce (1961) and the finding that mating in male rats has been greatly reduced by olfactobulbectomy (Heimer and Larsson, 1967) points to the crucial role of olfaction in reproduction of rodents

Whitten Effect is the synchronization of the oestrus cycle among unisexually grouped females as a result of pheromone-laden urine of male mouse (Whitten *et al*. 1968). McClintock Effect is the menstrual synchrony shown by women living together for a considerably long time (McClintock 1971, 1998). The exposure of immature female mouse to male mouse urine induces the release of gonadotropin releasing hormone, which provokes its first oestrous, and when the immature female mouse was exposed to mature female's urine then its oestrous is delayed which is known as Vandenbergh Effect (Vandenbergh *et al*. 1975; Lombardi and Vandenbergh, 1977). The oestrous synchronization is shown by the lion pride also (Stern and McClintock, 1998). Lee–Boot effect is the suppression or prolongation of oestrous cycles of mature mice (and other rodents), when females are housed in groups and isolated from males (Lee and Boot, 1956). It is caused by the effects of an oestrogen-dependent pheromone, released via the urine, which acts on the vomeronasal organ of recipients.

Urine of male mouse contains 2 sec-butyl-4, 5, dihydrothiazole; 2,3-dihydro-exobrivicomin and α and β farnesenes which depends on testosterone level of the animal. This induces oestrous in female mice, eliciting female attraction, inter male aggression and inter female aggression (Novotny *et al*. 1990, 1999; Kelly, 1996; Jemiolo *et al.* 1985). The adrenal gland of female mice produces compounds such as 2-hepatanone, *trans*-5-hepten-2-one, *trans*-4-hepten-2-one, n-pentyl acetate, *cis*-2-peten-1-yl-acetate and 2, 5 dimethyl pyrazine, that are present in its urine. These compounds delay puberty in female mice and attract and solicits male to initiate copulation (Novotny *et al*. 1986).

Why Olfactory Signals are Advantageous

Olfactory signals are advantageous over visual and acoustic signals because of their effectiveness over great distances and persistence in time. The chemical signals are effective even in the absence of the signalling animal. Olfactory communication is found to have a significant role in the reproduction of non-human primates which is frequently influenced by past experiences and determined by complexity of brain (Keverne, 1983, 1998). Loss of olfaction need not totally eliminate mating in animals even though it is often seriously impaired. Intact rams inseminate almost all ewes that are in oestrous at any one time, but olfactobulbectomized rams inseminate only half the ewes in oestrous. Reproductive behaviour of golden hamster, *Mesocricetus auratus* and bank vole, *Clethrionomys glareolus* have been found to be dependent on olfactory stimulation (Kruczek and Marchlewska-Koj, 1986; Kruczek *et al*. 1989).

Conclusions

Various studies demonstrate that the reproductive behaviour in many animals is influenced by pheromones and the olfactory signal is more advantageous to other signals in eliciting responses.

References

Becker, S.D. and J.L. Hurst. 2008. Pregnancy Block from a Female Perspective. *Chemical Signals in Vertebrates,* **11** : 141-150.

Becker, S.D and J.L Hurst. 2009. Female Behaviour Plays a Critical Role in Controlling Murine Pregnancy Block. *Proceedings of the Royal Society: Biological Sciences* **276**:1723-1729.

Brennan, P.A. 2009. Outstanding Issues Surrounding Vomeronasal Mechanisms of Pregnancy Block and Individual Recognition in Mice. *Behavioural Brain Research,* **200** (2) : 287-294.

Brennan, P.A. and F. Zufall. 2006. Pheromonal Communication in Vertebrates. *Nature,* **444** : 308-315.

Bruce, H.M. 1959. An Exteroceptive Block to Pregnancy in the Mouse. *Nature,* **84** : 105.

Clulow, F.V. and P.E. Langford. 1971. Pregnancy-Block in the Meadow Vole, *Microtus Pennsylvanicus*. *Reproduction,* **24** : 275-277.

Dulac, C. and A.T. Torello. 2003. Molecular Detection of Pheromone Signals in Mammals: From Genes to Behaviour. *Nature Reviews : Neuroscience,* **4** : 551-562.

Eila K.R., Amy, L., Thore J.B. and C.B. Jacinta. 2012. A Bruce Effect in Wild Geladas 1. , *Science,* **335** (6073) : 1222-1225.

Fernandez-Fewell, G.D. and M. Meredith. 1995. Facilitation of Mating Behaviour in Male Hamster by LHRH and AcLHRH5-10: Interaction with the Vomeronasal System. *Physiology and Behaviour,* **5** : 213-221.

Halpern, M. 1987. The Organization and Function of the Vomeronasal System. *Annual Review in Neuroscience*, **10** : 325-362.

Heimer, L. and K. Larsson. 1967. Mating Behaviour of Male Rats after Olfactory Buld Lesions. *Physiology and Behaviour,* **2** : 207-209.

Jemiolo, B., Alberts, J., S. Scohiniski-Wiggins., S. Harvey and M. Novoty. 1985. Behavioural and Endocrine Responses of Female Mice to Synthetic Analogues of Volatile Compounds in Male Urine. *Animal Behaviour,* **33** : 1114-1118.

Kaba, H., Li, C.S., Keverne, E.B., Saito, H. and K. Seto. 1992. Physiology and Pharmacology of the Accessory Olfactory Bulb. In: Doty, R.L. and D. Muller-Schwarze (Eds.), *Chemical Signals in Vertebrates*. Plenum Press, New York. pp : 49-54.

Kelly, D.R. 1996. When is a Butterfly Like an Elephant? *Chemistry and Biology,* **3** : 595-602.

Keverne, E.B., 1983. Chemical Communication in Primate Reproduction. In: J.G Vandenbergh (Ed), *Pheromones and Reproduction in Mammals*. Academic Press, New York. pp : 79-92.

Keverne, E.B., 1998. Vomeronasal/Accessory Olfactory System and Pheromonal Recognition. *Chemical Senses,* **23** : 491-494.

Kruczek, M. and A. Marchlewska-Koj. 1986. Puberty Delay of Bank Vole Females in a High-Density Population. *Biology of Reproduction,* **35** : 537-541.

Kruczek, M., Marchlewska-Koj, A. and L.C. Drickamer. 1989. Social Inhibition of Sexual Maturation in Female and Male Bank Voles (*Clethrionomys glareolus*). *Acta Theriologica,* **34** : 479-485.

Law, R.H. and F. E. Regnier. 1971. Pheromones. *The Annual Review of Biochemistry,* **44** : 533-548.

Lee, S. Van der, and L.M. Boot. 1956. Mouse Husbandry, Breeding and Development: Pheromone Effects, Transgenic Mouse Facility, University of California. *Acta Physiologica Pharmacologica Neerlandica,* **5** : 213.

Lombardi, J.R. and J.G. Vandenbergh. 1977. Pheromonally Induced Sexual Maturation in Females: Regulation by the Social Environment of the Male. *Science,* **196** : 545-546.

Mackay-Sim, A. and J.D. Rose. 1986. Removal of the Vomeronasal Organ Impairs Lordosis in Female Hamsters: Effect is Reversed by Luteinising-Releasing Hormone. *Neurobiology,* **42** : 489-493.

Marashi, V. and T. Rulicke. 2012. The Bruce Effect in Norway Rats. 1. *Biology of Reproduction,* **17** : 1 - 5.

McClintock, M.K. 1971. Menstrual Synchrony and Suppression. *Nature,* **229** : 244-245.

McClintock, M.K. 1998. Regulation of Ovulation by Human Pheromones. *Nature,* **392** : 177-179.

Novotny, M., Harvey, S. and B. Jemiolo. 1990. Chemistry of Male Dominance in the House Mouse, *Mus domesticus*. *Experientia,* **46** : 109-113.

Novotny, M.B., Wiesler, D. and L. Zidek. 1999. Positive Identification of the Puberty- Accelerating Pheromone of the House Mouse: the Volatile Ligands Associating with the Major Urinary Protein. *Proceedings of the Zoological Society of London: Biological sciences,* **266** : 2917-2022.

Parkes, A.S. and H.M. Bruce. 1961. Olfactory Stimuli in Mammalian Reproduction. *Science,* **134** : 1049.

Pillay, N., Kinahan, A. and A. Anouska. 2009. Mating Strategy Predicts the Occurrence of the Bruce Effect in the Vlei Rat *Otomys irroratus*. *Behaviour,* **146** : 139-151.

Regnier, F.E. and E.O. Wilson. 1971. Chemical Communication and Propaganda in Slave-Maker Ants. *Science,* **172** : 267-269.

Sorensen, P.W. and N.E. Stacey. 1999. Evolution and Specialization of Fish Hormonal Pheromones. In: Johnston, R.E., D. Muller-Schwarze., P.W. Sorensen (Eds.), *Advances in Chemical Signals in Vertebrates*. Kluwer Academic/Plenum Publishers, New York, pp : 15-47.

Sorenson, P.W., Christensen T. A. and N. E. Stacey. 1998. Discrimination of Pheromonal Cues in Fish: Emerging Parallels with Insects. *Current Opinion in Neurobiology,* **8** : 458-467.

Vandenbergh, J.G., Whitsett J.M. and J.R. Lombardi. 1975. Partial Isolation of a Pheromone Accelerating Puberty in Female Mice. *Journal of Reproductive Fertility,* **43** : 515-523.

Whitten, W.K., Bronson, F.H. and J.A. Greenstein. 1968. Estrus-Inducing Pheromone of Male Mice: Transport by Movement of Air. *Science,* **161** : 584-585.