Urinary proteins and pheromonal communication in mammals

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Urinary proteins play a significant role as pheromones and pheromone-binders in mammalian reproduction and social behaviour. The present study was carried out to quantify the urinary proteins in five different mammalian species viz mouse, rat, rabbit, bovine and human. The results revealed that the male rodents excrete large amounts of urinary protein as compared to that of other mammals. In addition, the male mammals excrete a higher quantity of protein than do the females, suggesting the role of androgens in excretion of protein. The presence of higher concentration of urinary proteins in rodents suggests that the rodents depend more on urinary proteins for olfactory/social communication.

Mammals can send powerful messages through chemical signals, which bring about physiological and behavioural changes in the recipient of the same species. Urine is reported to be the major source for pheromonal communication. The pheromonal compounds(s) has been successfully characterized in the urine of mouse, rat, bovine, tiger, and elephant, and the bioactivity of the identified compounds is well demonstrated. Chemical characterization of urinary substances (volatiles) in different mammals shows that active compounds may be acids, alcohols, aldehydes, ketones etc. Rats and mice excrete a large amount of protein (non-volatile) in their urine but the function remained unknown for many years. The apparent waste of such a large quantity of protein in urine first suggested the idea that it may be involved in some physiological function; its presence in the male urine was an indication that it could be involved in pheromonal communication.

Recent investigation in mouse (major urinary protein), rat (α2M globulin) convincingly demonstrated that urinary proteins play a significant role in the delivery of chemical messages. It is believed that these urinary proteins bind to odourant molecules inside the bloodstream and release them in urine. Most interestingly the time of dissociation of the odourant–protein complex is very long and urinary protein can store and slowly release in air the odourants for hours and days. In addition, urinary proteins are usually stable to drying and heating and are not likely to be quickly denatured when released out of the body. For instance, the major urinary proteins (MUPs) of male mouse bind the signalling volatiles in the bloodstream and release them along with urine into the environment. Male mouse urinary protein itself acts as pheromone by accelerating the puberty in young female mice. It seems that this phenomenon of excreting large quantities of proteins in urine is typical of rodents. In this note evidence has been provided that male rodents excrete larger amounts of urinary protein than females rodents or other mammals.

Urine was collected from sexually mature reproducitively active males and females of five different mammals viz., mouse (Albinos: Swiss Strain), rat (House Rat), rabbit (New Zealand bred strain), bovine (Jersey type) and humans. The protein of different urinary samples was precipitated with ammonium sulphate at 60% of saturation (0°C) and total protein was estimated according to Lowry et al. using cow albumin as reference. The results (Table 1) revealed that male mammals particularly rodents excreted higher concentration of urinary protein than females. The amount of protein present in the mouse, rat and rabbit was significantly higher than that of bovine and human. Therefore, it is possible that the variation of urinary proteins in mammals may have an evolutionary significance. Available reports strongly indicate that the major behavioural and reproductive activities of rodents, especially those of the mouse and rat are dependent on chemical signals present in the urine. The production of urinary protein in mice is dependent on androgens that are higher in males than in females, and among males, are higher in dominants than subordinates. Accordingly, testosterone induces...
synthesis of urinary protein in females\(^1\). The present results show that males excreted higher concentration of proteins than females suggesting that male hormones are involved in secretion of urinary proteins. Thus the present finding is in agreement with the concept that males use urinary proteins for the maintenance of reproductive and dominance status. In females other proteins may be important. For instance, proteinaceous material (Aphrodisin) in hamster vaginal discharge appears to play a direct role in facilitating the copulatory behaviour of males of this species\(^1\).

The involvement of olfactory communication by urinary signals is not reported in primates. Further, the relationship of accumulation of proteins in urine and its role on biocommunication is not known. In addition, the present study indicates that mammals like ox and humans may depend on proteins of biological fluids other than urine for olfactory communication. In humans, the most abundant odour component in males is known to be E-3-methyl-2-hexenoic acid (E-3M2H), which is liberated from apocrine gland secretions. E-3M2H is carried to skin surface by two proteins, apocrine secretion odour binding protein 1 and 2 (ASOB1 and ASOB2); the ASOB2 was identified as apolipoprotein D (apoD) which acts as pheromone binding protein in humans\(^4\). The saliva is another recognized medium for chemical communication reported in pig. A protein purified from the saliva of boar shows binding activity to steroid pheromones\(^6\). Remarkably all these soluble proteins, i.e., urinary, vaginal, salivary and sweat belong to large family of lipocalins, which generally act as carriers for hydrophobic ligands in aqueous biological fluid\(^6\). Available reports and the present study strongly suggest that urinary proteins are specific to male rodents.

It is still not known whether volatile and non-volatile molecules show synergistic effect in biocommunication. The probable suggestion is that once the recipient is attracted by the volatile odour, it may proceed near the donor to sniff and lick the surface imbued with non-volatile odour, which alone or together modulates the particular behaviour, but this concept has not been experimentally proved. Hence it would be interesting to investigate the presence of urinary protein in other species and study their role in biocommunication.

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### References

2. Schouenib F J, Wiesler D, Jorgenson J W, Carmack M & Novotny M. Urinary volatile constituents of house mouse, Mus

### Table 1 — Quantification of urinary protein in five mammals

<table>
<thead>
<tr>
<th>Mammals</th>
<th>Protein concentration (mg/ml)</th>
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<tbody>
<tr>
<td></td>
<td>Male</td>
</tr>
<tr>
<td>Mouse</td>
<td>3.57 ± 0.31</td>
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<tr>
<td>Rat</td>
<td>3.77 ± 0.14</td>
</tr>
<tr>
<td>Rabbit</td>
<td>2.24 ± 0.12</td>
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<tr>
<td>Bull/Cow</td>
<td>1.64 ± 0.06</td>
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<tr>
<td>Human</td>
<td>1.52 ± 0.08</td>
</tr>
</tbody>
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\(P\) values: \(*<0.05; \dagger<0.01; \ddagger<0.001\)