

## Pheromones Play a Significant Role In The Behavior And Communication Of Tigers

Sirsendu Gayen<sup>1\*</sup>

Assistant Professor, Department of Chemistry, Vivekananda College, Thakurpukur, Kolkata – 700063, E-mail: [sgayensrci@gmail.com](mailto:sgayensrci@gmail.com) , Phone: 9836715703

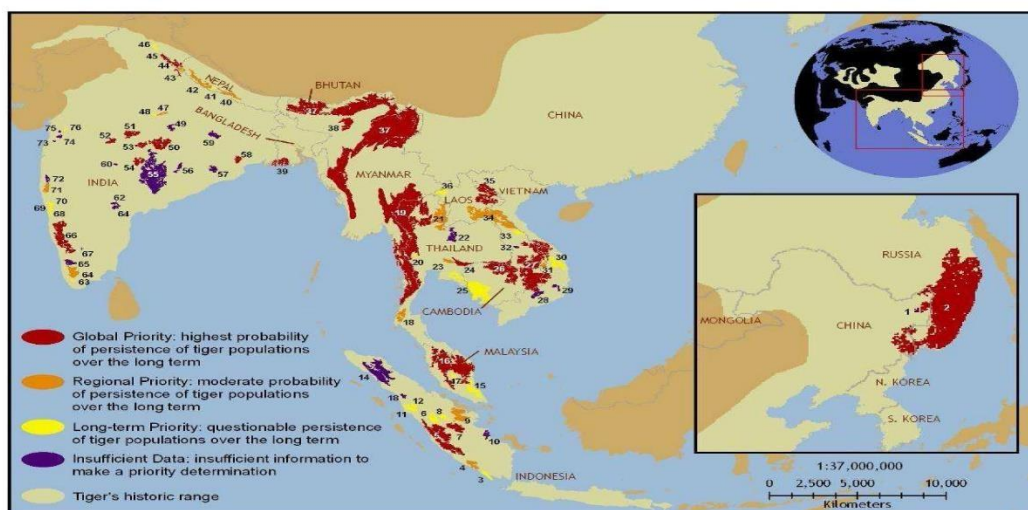
### ABSTRACT

Chemical communication through pheromones and semiochemicals is vital for the solitary social structure, territorial maintenance, and reproductive ecology of the tiger (*Panthera tigris*). This study examines how tigers utilize a sophisticated repertoire of olfactory signals—including urine spraying, scat deposition, rubbed secretions from facial and interdigital glands, and treescratching markers—to navigate their expansive home ranges. By employing the vomeronasal organ, tigers detect and analyze volatile and non-volatile chemical profiles that encode precise biological information regarding individual identity, sex, age, physiological stress, and reproductive availability. These persistent chemical boundaries function as a decentralized communication network, allowing tigers to maximize resource partitioning, minimize costly physical altercations, and locate mates across fragmented landscapes. Furthermore, this paper discusses how shifting paradigms in chemical ecology can inform modern tiger conservation, particularly in managing captive breeding programs and developing non-invasive monitoring tools. Understanding these olfactory dynamics provides critical insights into felid behavioral ecology and offers innovative frameworks for mitigating human-tiger conflict through targeted semiochemical management.

**Keywords:** *Panthera tigris*, Olfactory communication, Semiochemicals, Territorial marking, Vomeronasal organ, Behavioral ecology

### INTRODUCTION

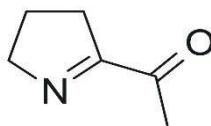
Tigers represent the largest feline species globally and constitute one of the most recognizable and emblematic animals on Earth [5]. The designation originates from the Latin term "tigris," which is itself derived from the Greek term "tigris," and may trace its etymology to an ancient Persian word signifying "arrow." This etymology underscores the tiger's well-established reputation for remarkable speed and ferocity. Tigers are distinguished by their characteristic orange pelage adorned with black stripes, and they represent the largest members of the Felidae family, characterized by a robust musculature and exceptional predatory capabilities.[6] The scientific designation for tigers is *Panthera tigris*. Five subspecies of tiger exist, each possessing a distinct scientific nomenclature. The Bengal tiger is designated as *Panthera tigris tigris*, the South China tiger as *Panthera tigris amoyensis*, the Indochinese tiger as *Panthera tigris corbetti*, the Sumatran tiger as *Panthera tigris sumatrae*, and the Amur tiger (alternatively referred to as the Siberian tiger) as *Panthera tigris altaica*. Three tiger subspecies have become extinct. These comprise the Caspian tiger (*Panthera tigris virgata*), the Bali tiger (*Panthera tigris balica*), and the Javan tiger (*Panthera tigris sondaica*). The IUCN Red List of Threatened Species classifies tigers as "endangered." This classification indicates that tigers encounter an exceptionally elevated risk of extinction within their natural habitats [5].



**Figure 1.** Map showing historical and current geographical distribution of tigers, and priority areas for tiger conservation. (Source: Dinerstein et al. 2006, [www.savethetigerfund.org](http://www.savethetigerfund.org)) [4]

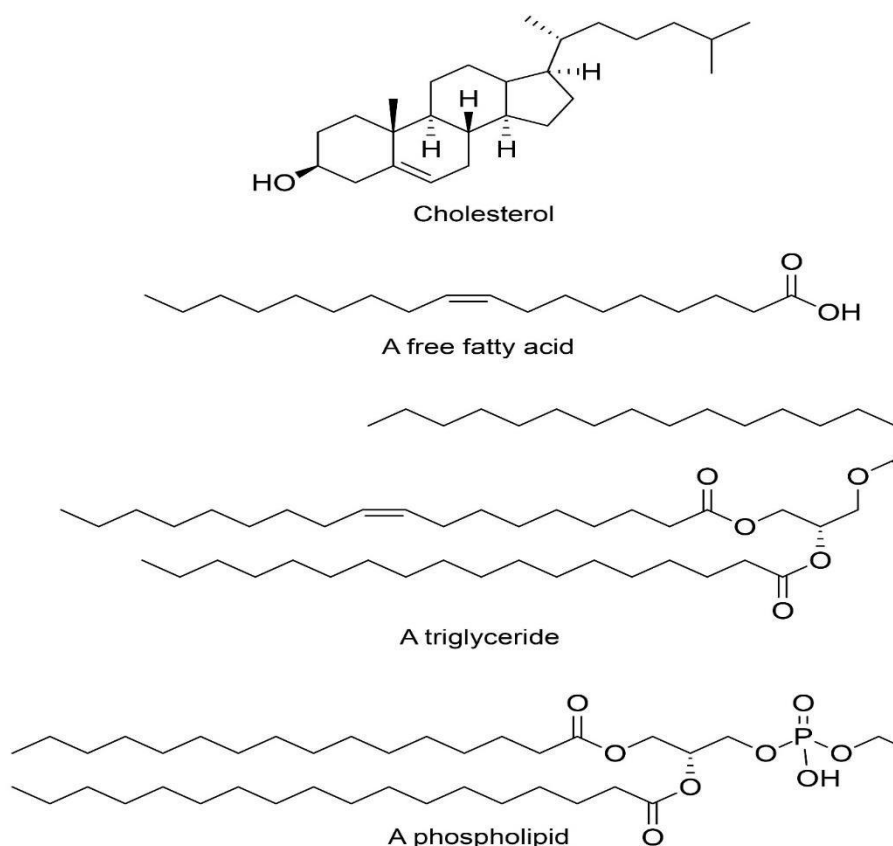
### Pheromone and it's role

Renowned wildlife biologist Ratan Lal Brahmachary has established himself as a leading figure in the study of tiger pheromones. The compound 2-acetyl-1-pyrroline (2AP), which is found in tiger urine used for territorial marking, is identical to the organic molecule responsible for the distinctive fragrance characteristic of aromatic rice varieties such as basmati [8].



**Fig2: Chemical diagram for 2-Acetyl-1-pyrroline**

Tigers engage in communication through the use of Marking Fluid (MF), a lipid-rich secretion that both males and females expel in an upward and backward direction via their urinary tract [2].



**Fig3: Structures of some common lipids (Source: Wikipedia)**

The volatile compounds present in the molecular fragrance are extended in duration through the application of lipid-based fixative agents, with a combined concentration ranging from 1–2 mg/ml [2]. Fixatives represent chemical or physical agents employed to preserve biological specimens, stabilize artistic works, secure aromatic compounds, or establish colorant permanence [9].

**Table 1** Classification of fixatives based on chemical composition

|    | Fixatives        | Examples                                   |
|----|------------------|--------------------------------------------|
| 1. | Physical agents  | Heat, microwaves                           |
| 2. | Aldehydes        | Formaldehyde, acrolein, glutaraldehyde     |
| 3. | Coagulants       | Methyl alcohol, ethyl alcohol, acetic acid |
| 4. | Oxidizing agents | Osmium tetroxide                           |
| 5. | Miscellaneous    | Picric acid, mercuric chloride             |

**Table 2** Classification of fixatives based on number of structures fixed

|    | Fixatives          | Examples                                           |
|----|--------------------|----------------------------------------------------|
| 1. | Simple fixatives   | e.g., Formaldehyde, picric acid, osmium tetroxide  |
| 2. | Compound fixatives | e.g., Bouin's fluid, formol saline, Zenker's fluid |

**Table 3** Classification of fixatives based on type of structures fixed

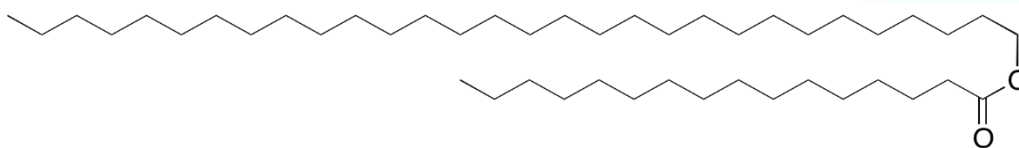
|    | Fixatives                 | Examples                                                                                                                        |
|----|---------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| 1. | Histochemical fixatives   | Formaldehyde, glutaraldehyde, vapor fixatives                                                                                   |
| 2. | Microanatomical fixatives | Bouin's fluid, 10% formalin, Zenker's fluid, formol calcium, Heidenhain's susa, Helly's fluid, Rossman's fluid,                 |
| 3. | Cytologic fixatives       | Champy's fluid, glacial acetic acid, alcohol, formol saline, Carnoy's fluid, Clarke's fluid, Newcomer's fluid, Flemming's fluid |

**Various types of Fixatives [9]**

This lipid composition encompasses cholesterol ester, wax ester, triglyceride, free fatty acids, diglyceride, monoglyceride, free sterol, and phospholipid, as identified through thin layer chromatography. Gas-liquid chromatographic analysis of the fatty acid methyl esters derived from the total lipid of the MF demonstrates notable distinctions when compared with the fatty acid profiles of groin and body fat tissues from tigers (as documented in previous studies). These differences are characterized by elevated concentrations of palmitoleic and myristic acids, along with highly unsaturated fatty acids. The palmitoleic acid concentration in both the total lipid and triglyceride fractions is substantially higher relative to the levels found in the wax esters and cholesterol esters of the MF-fat [2]

Wax esters (WE) are compounds formed when fatty acids bond with fatty alcohols, and they perform numerous biological roles. Many terrestrial arthropods accumulate substantial amounts of wax esters alongside other lipids on their cuticular surface to minimize water loss through evaporation [10,16,17]. A distinguishing characteristic of the alcohol component in wax esters involves a collection of saturated linear-chain primary alcohols ranging from C4 to C20, which are accompanied by their corresponding monoenoic unsaturated counterparts [2].





**Fig 4: Triacontanyl palmitate, a typical wax ester, is derived from triacontanyl alcohol and palmitic acid. (Source: Wikipedia)**

Marking Fluid (MF) serves as a primary constituent in Bengal tiger territorial communication, functioning as a controlled-release mechanism for chemical signals. The lipid component's effectiveness in this role stems from its inherent affinity for the volatile compounds present within the marking fluid [1].

### The ecological function and significance of tigers

Healthy forest ecosystems play a crucial role in mitigating severe weather phenomena, including cyclonic storms and sudden flooding [12]. The "green world hypothesis" introduced by Hairston et al. (1960), which posits that predator presence reduces prey populations and consequently enables plant communities to thrive, requires reassessment within human-influenced environments where livestock face predation from tigers, leopards, and dholes. Major apex predators, particularly tigers, are experiencing significant population declines across their native ranges [11]. International Tiger Day is observed annually on 29 July [14]. This observance was established during the Saint Petersburg Tiger Summit in 2010[15]. It is profoundly concerning that approximately 97% of wild tiger populations have already disappeared. Globally, tigers face extinction threats, with numerous populations classified as Endangered or Critically Endangered. The primary objective of this day is to enhance public understanding of tiger conservation challenges and develop strategies to reverse their accelerating decline [13].

Global Tiger Day, also known as International Tiger Day, offers a worldwide platform to honor, advocate for, and recognize the significance of wild tigers in our world. Functioning as an 'umbrella' species, safeguarding wild tigers and their ecosystems simultaneously protects thousands of other organisms, including humanity itself. As apex predators, tigers fundamentally influence the ecological systems they inhabit. They regulate herbivore populations to prevent overgrazing and preserve ecosystem balance. Tigers are solitary animals requiring expansive territories, which creates space for numerous other species to flourish. In India, over 350 rivers originate from tiger reserves. These reserves additionally absorb carbon, generate oxygen, and gradually discharge groundwater to mitigate flooding. Protecting tigers will simultaneously preserve these essential habitats. Tiger conservation will enable local communities and populations to sustainably benefit from habitat resources including timber, food, pasture, and ecotourism opportunities [12].

### CONCLUSION

The intricate reliance of big cats—and specifically tigers—on pheromones and semiochemicals underscores a sophisticated, invisible network that dictates their survival, territorial integrity, and reproductive success. As solitary apex predators navigating vast and increasingly fragmented landscapes, these felids depend on olfactory signals to transcend physical distances, replacing direct confrontations with persistent chemical boundaries. Ultimately, preserving the behavioral ecology of big cats requires protecting not just physical habitats, but also the invisible olfactory landscapes they rely upon to communicate, find mates, and coexist within their ecosystems.

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