

tively, and y_{CP} equals y in the limit of CP conservation. Thus the BELLE Collaboration result differs from zero by 3.2σ . Non-zero lifetime difference between different decay modes represents clear evidence for transformation of the D^0 particle into its anti-particle.

Therefore, both BABAR and BELLE Collaborations are able to show that there is oscillation in D -systems and they did not observe any CP violation. It is partly because of the limitation on the sensitivity of the experiments. The new experiments with higher accuracy could reveal the fate of CP violation in D -systems.

Turning now to the oscillation phenomena in the B_s -system, these have been observed by the CDF Collaboration by considering the B_s hadronic decays $\overline{B}_s^0 \rightarrow D_s^+ \pi^-$ and $D_s^+ \pi^- \pi^+ \pi^-$, and the semileptonic decays $\overline{B}_s^0 \rightarrow D_s^{(*)} l^- \bar{\nu}_l$, $l = e$ or μ . Using the probability density functions that describe the measured time development of B_s mesons that decay with the same or opposite flavour as their

flavour at production, they have measured the value of Δm_s (oscillation frequency). The measured $\Delta m_s = 17.77 \pm 0.10(\text{stat}) \pm 0.07(\text{syst}) \text{ ps}^{-1}$ with more than 5σ confidence level.

In summary, we have reviewed the recent experimental discoveries of oscillation phenomena in the two neutral systems where the effects are hardest to observe. In the coming years the oscillation parameters are likely to be well-measured and CP violation may be seen. A large signal for CP violation in these neutral meson systems would imply the presence of interactions beyond those described by the standard model.

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Orchids practice deception

Pooja Muralidharan

The plant–animal interaction is one of the most fascinating sub-disciplines of biology, which has drawn the attention of researchers. The animals often act as dispersal agents of pollination¹. The pollination system that exists in the insect (bee) pollinated orchid of the genus *Ophrys* is fascinating. The structural specialization seen in orchids belonging to the family Orchidaceae, instigates pollination by its specific pollinator species (bees)¹.

According to Ledford², the orchid discharges a scent which mimics the female sex pheromones offering a fallacious promise of sex to male bees (*Andrena*). The promise of quick profits allure the unwary visitor bee². The bee, responding to the inviting waves of overwhelming scent, approaches the flower with a desire of finding a mate. However, the bee is taken by surprise when it finds a flower instead. Hence, the bee in its attempt to copulate the flower, adheres large packs of sticky pollen to its head and abdomen. The bee then flies-off in an attempt to look for its

real mates. The process is repeated in another patch of the same orchid species, that is eventually pollinated. Hence the bee is a pollinator. The evolution of this type of deception in some species of orchids is speculated to be due to the high cost of production of the energy-rich nectar reward².

The orchid flower is bilaterally symmetrical. The basic orchid flower is composed of three sepals in the outer whorl and three petals in the inner whorl. The medial petal called labellum or lip is modified and enlarged. This serves to attract insects that pollinate the flower and acts as a landing platform for them.

Deception techniques in orchids that belong to the genus *Ophrys* can vary². As noted earlier, there are orchids that reward the pollinator with nectar. However, there are orchids that deceive pollinators (bees) with their appearance, smell and texture. The deception usually involves mimicking a female partner, for example, a female bee. Hence, by a combination of

visual, olfactory and tactile cues, the bees are deceived to act as pollinating agents for orchids (Figure 1).



Figure 1. An orchid flower that mimics a female bee using visual or olfactory signals. (Reference: http://www.blackwater-valley.org.uk/bee_orchid.htm; Source: Alan Eggleton for Blackwater Valley Countryside Partnership.)

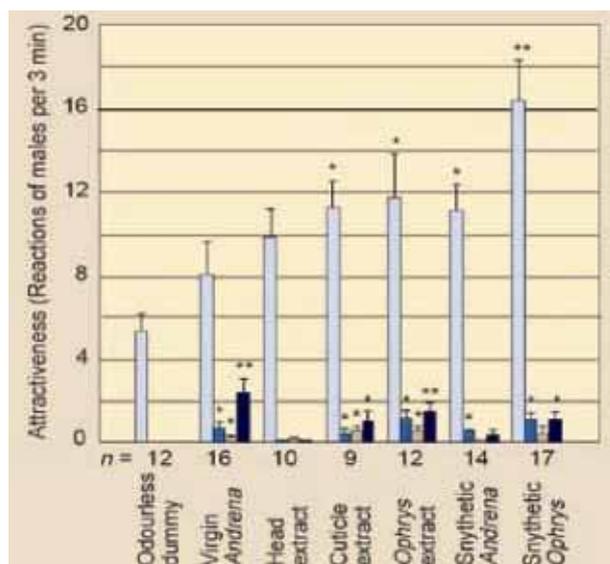


Figure 2. Reactions of *Andrena nigroaenea* males in behavioural tests in the field. Odourless dummies (Soxhlet-extracted, dried *A. nigroaenea* females) scented with different samples were offered to *A. nigroaenea* males in a patrolling area for 3 min. Means of approaches to the dummy to less than 5 cm (pale blue bars), pouncing on the dummy (royal blue bars), alighting on the dummy (beige bars) and copulation attempts with the dummy (dark blue bars) are plotted. Mann–Whitney *U*-test was used for statistical analysis. Asterisks indicate significant differences between the reaction types of the odourless dummy group and each of the other six test groups at significance levels of * $P < 0.05$ and ** $P < 0.001$. (Adapted from Schiestl *et al.*⁴.)

This work is an attempt to understand the dynamics of the primary mechanism used by orchids to attract bees. It can be concluded that orchids use chemical mimicry to attract bees, as it is known that bees respond to distant odour. The chemical mimicry is fascinating as the bees are attracted to the orchids sexually. This type of interaction observed between two different kingdoms, Plantae (orchids) and Insecta (pollinator) is unusual and noteworthy.

Gas chromatography (GC) and mass spectrometry (MS) can provide an effective combination (GC–MS) to separate volatile organic compounds³. The electroantennogram (EAG) is a technique to measure average output of antennae (paired appendages) to the brain for a given odour. This technique is commonly used in electrophysiology to study the function of olfactory pathways in insects. It is

also widely applied in screening insect pheromones by examining the responses to fractions of compound mixture separated using GC. Schiestl *et al.*⁴ used GC–MS and EAG to compare the response behaviour of male bees to orchid volatiles and female bee pheromones. They found that 15 different components from the attractive odour samples of female bees triggered the male antennae. The GC–MS analysis of the *Ophrys* flower extracts contained 14 out of 15 different components. This study supports the conclusion stated earlier that orchids use chemical mimicry to attract potential pollinators. The principal compounds identified belonged to the straight chain saturated and unsaturated hydrocarbons with 21–29 carbon atoms⁴.

Behavioural assays using male bees were followed by studies that involved preparing a mixture containing 14 syn-

thetic hydrocarbons that were mixed in proper proportions. These 14 hydrocarbons occurred both in bee-scent as well as in flower-scent. The results of the behavioural experiments clearly showed frequent copulation attempts by the male when this blend of 14 compounds was applied to a dummy. A mixture of the short- and long-chained alkanes and alkenes like heneicosane, dosocane, tricosane, tetracosane, pentacosane, hexacosane, heptacosane, pentacosene, heptacosene, nonacosene are considered to be key components that trigger copulation⁴.

Prasophyllum leek orchids also offer nectar reward to their pollinators. On the other hand, there are some orchids that deceive their pollinators using a different method. For example, *Cyanicula gemmata* attracts its pollinator, the flower beetles, by offering the false promise of food with its brightly coloured petals. Similarly, the orchid labellum of *Drakaea glyptoden* attracts male wasps, *Zapilothynnus trilobatus* by emitting volatiles mimicking the female sex pheromones.

The orchid deceives its pollinator with false promise of sex. The insect thereby loses sometime that would otherwise be used in seeking real mates or food. Hence it is important to point out that it is advantageous for male bees to distinguish a deception from a true female bee.

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