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Nesting biology and Social behaviour of Paper wasp (*Polistes flavus*) and Honey bee (*Apis mellifera)* in District Mansehra, Pakistan

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Abstract

In the present study, nesting and social behaviour were carried out of *Polistes flavus* (Cresson) and *Apis mellifera* (Smith) from district Mansehra. Nest of paper wasps were found among bunches of leaves in the tree with 1-5 flat steps layers containing hundreds of hexagonal cells in one sided hanging to downward. Hive of the honey bee were pouched like containing double sided hexagonal cells one for eggs while in other stored food materials. X-ray diffraction was used for elemental analysis of *P. flavus* nests showed Ca with the highest amount of element while K with the lowest amount in descending order a: *P. flavus*: Ca>Al>Si; *A. mellifera*: Ca>Si>Mg. Social behaviour of *A. mellifera* showed strong defensive behaviours, pseudoattack, subsequent erratic flight, wing buzzing, mandibular pecking, abdominal pumping and abdominal twisting while *P. flavus* showed week defensive behaviour as compared to *A. mellifera*. Parental care was highly developed in *A. mellifera*. By disturbing, they try to protect their larvae in their nest by high defensive behaviour.

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Introduction

The name wasp applied to many winged insects of the order Hymenoptera, which also includes ants and bees (Bertram *et al.,* 2003). Most of the wasps are carnivorous, feeding on insects, grubs, or spiders. They have biting mouthparts, and have stings through which they paralyze their prey for eating. The sting can be used repeatedly. The thorax of a wasp is attached to the abdomen by a narrow stalk. Some wasps are solid black or dark blue, but most have red, orange, or yellow wings or markings while Stripes are common. The great majority of the waps are solitary, but one family (Vespidae) includes both social forms (paper wasps, hornets and yellow jackets) and solitary forms, e.g., the potter wasps (Bertram *et al.,* 2003).

In social wasp colonies there are usually three castes, the egg-laying queens (one or more per colony), the workers, or sexually undeveloped females and the drones or males. Social wasps build nests of a coarse, papery material, prepared by masticating wood fiber. The eggs are deposited in the compartments or cells of the nest where they develop into larvae and then pupae, emerging as adults. Adult social wasps feed chiefly on nectar and plant sap but feed the larvae with masticated animal food. In temperate regions a colony lasts a single season, the drones and workers dying in the fall. The mated queens take shelter during the winter and in spring lay eggs and start new colonies. In the tropics colonies continue indefinitely, dividing when they grow very large (Oldroyd, 2004).

Nests are typically built in hollow trees, but they are often found in barns, sheds, attics, and hollow areas of house walls. They rarely build the nests that are free hanging or in unprotected areas, such as tree and houses. They use decaying wood fiber to build a shell around their nest as protection. As winter approaches, the worker bees die off and the queen will leave the existing nest and find an empty log or other sheltered spot to spend the winter. They also use the bark fiber of trees to build their nests. They have smooth stingers, so they can sting over and over again. Their stings also carry venom that makes the stings hurt, itch or swell for about 24 hours. A European hornet sting has the same risk of allergic reactions from as with other wasp stings (Jones *et al.,* 2004).

The paper wasp, *Polistes flavus* is the most common type of wasp which is cosmopolitan throughout the world and mostly built their nest in human houses and trees. It is also the single largest genus within the family Vespidae, with over 300 recognized species and subspecies. Their innate preferences for nest-building sites leads them to commonly build nests on human habitation, where they can be very unwelcome; although generally non-aggressive, they can be provoked into defending their nests (Espelie *et al.,* 1996). All species are predatory and they may consume large numbers of caterpillars, in which respect they are generally considered beneficial. Polistes wasps can be identified by their characteristic flight, their long legs and dangle below their body (Turillazzi *et al.,* 1992). Polistes wasp complete their life cycle in four stages, pre-emergence phase, worker phase, reproductive phase and intermediate phase (Figure 2b; Karsai *et al.,* 1995).

The honey bee, *Apis mellifera* queens are polyandrous. When they are about five days old they mate with a large number (625) of males (Estoup et al., 1994; Palmer *et al.,* 2000) of diverse genetic backgrounds (Baudry *et al.,* 1998). Honey bee colonies, therefore, comprise multiple patrilines of workers, each sired by a different male (Crozier *et al.,* 1996). Because the males are haploid, their daughters share 75 % of their alleles by descent. Conversely, workers that are daughters of different males share only 25 % of their alleles; those derived from their common queen mother. Task specialization has now been demonstrated for an extraordinary array of honey bee behaviour including nectar and pollen foraging (Calderone et al., 1988), caring for brood and removing dead larvae (Page *et al.,* 1989b), grooming nest mates (Frumhoff *et al.,* 1988), removing corpses and guarding the nest entrance (Robinson et al., 1988), collecting water (Kryger *et al.,* 2000), and thermoregulating the nest (Jones *et al.,* 2004; Oldroyd *et al.,* 1994). It has long been speculated that task specialization provides colony level benefits, and that genetically mediated diversity in task response

thresholds is important to the task allocation system in honey bees and by inference, other polyandrous haplodiploid social insects (Bertram *et al.,* 2003; Calderone *et al.,* 1989; Crozier *et al.,* 1985; Fuchs *et al.,* 1994; Myerscough *et al.,* 2004).

Honey bee colonies, are able to regulate the internal temperature of their nests with great precision (Jones *et al.,* 2004; Moritz *et al.,* 1992; Southwick, 1991; Heldmaier *et al.,* 1987). The workers regulate brood nest temperature depends on whether heating or cooling is required (Seeley, 1985). Waxes are used for building brood and storage cells and cuticular waxes minimize the loss of water across the integument and protect from attack by microorganisms, parasitic insects, and predators (Buckner, 1993). The queen substance is reportedly transmitted within the hive attached to the body surfaces of worker bees as a result of grooming behaviour (Seeley, 1979; Naumann, 1991). Drones deposit a long lasting inhibitory pheromone on the combs to decrease the drone brood production where it is perceived by the workers and the queen (Omholt, 1988). Tautz (1997) suggests that the dance sites of the bees on the wax comb may be chemically marked in some way because dancers keep to the same site during a foraging day. Objectives of the present paper include, to study the nesting and social behaviour between *P. flavus* and *A. mellifera* with parental care of their offspring.

Materials and methods

Observation for nesting behaviour of P. flavus and A. mellifera.

During the present study wasps and honey were collected from different sites: Baffa Mera Chotal and Collage Dhuraha located in Mansehra, Pakistan. Many visits were made for the observation for construction of their nest, hive and collected materials.

Elemental analysis

Different nests building material samples were grinded into fine powder, kept in sterilized vials and labelled accordingly: *P. flavus* and *A. mellifera*, respectively (Fig. 1). Samples were analysed by X-ray diffraction (XRD) (Wilson, 1990).

Observation for social behaviour and parental care

Many visits were made to collect nest of the wasp and hive of the honey bee where an active nest was found and attempt was made to provoke adults to defend by prodding them with the tip of a stick. Defensive behaviour was videotaped include departures, arrivals of the wasp and honey bee, collecting of food and nest building materials from the field to their nest and hive.

Results

Paper wasp and honey bee were identified from two types of nests collected from Baffa Mera Chotal and Collage Duraha located in Mansehra, Pakistan.

Comparison of architectural patterns of three wasp nests

Wasps built their nests in a systematic and architectural pattern observed during the present study:

The nest of *P. flavus* was found among bunches of leaves in the tree branches. Structurally, it was oval shaped and attached with a minute but strong stalk. It was formed with a single steps' layer of hexagonal cells which were directly opened outside. With increasing number of wasps, the workers started to build new layer beneath the old one. They reached to maximum 5 steps. The oldest layer was the largest and others were gradually decreased in size. Hive of the *A. Mellifera* were found on the tree attached elongated to the branch of the tree covered by thousand of the honey bees. Hives were doubled sided in which thousands of hexagonal cells were made. In one side they lay eggs while on the other side they stored the honey in these hexagonal cells (Fig. 3a and b)

Comparison of elemental analysis of three wasps nests samples

The elemental analysis by XRD shows the amount of elements of nest of *P. flavus*: Ca >Al >Si and *A. mellifera*: Ca>Si >Mg (Fig. 4a and b).

Comparison of social behaviour of the paper wasp and honey bee

During the present study, there were three social casts found in each wasp nest. Social behaviour of wasps showed strong foraging, defensive behaviours, pseudo-attack, subsequent erratic flight, wing buzzing, mandibular pecking, abdominal pumping and abdominal twisting. Many workers were seen busy in their duties, i.e., collection of building materials, foraging, construction of nest and care to offspring. Single female, queen was present for laying eggs. Many drones were permanently present on duty around the nest. Since their main job is to mate with the queen, males typically die soon after mating but they showed strong defensive behaviour when anything disturbed the nest or near to their nest. In the opening of the *A. mellifera* hive, a number of strong and very active drone wasps were present for prohibiting entry of foreign wasp. If they found another species, they attacked and killed them. The workers have no interest in the drones' activities. The queen lays five eggs in a small comb protected by several layers of papery material. She forages for wood fibres that chewed and mixed with saliva, form new layers for her nest. *Polistes flavus* built their nest among bunches of leaves of trees. Most of the nests are single layered but when the number of wasps increased they started to build the next layer over the old one and continue to 4-5 steps building. They visited time to time to their nest to care their eggs (Fig. 1a and b).

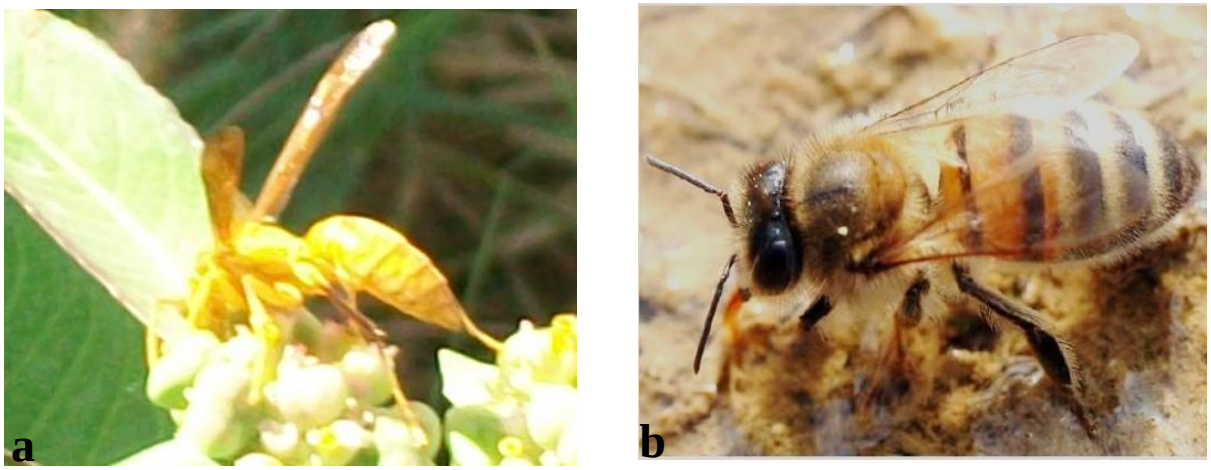

Fig. 1. Nest of the wasp and honey bee collected from Mansehra in which a: paper wasp, *Polistes flavus* (Cresson) from Chotal Baffa Mera; b: honey bee, *Apis mellifera* (Smith), from Collage Duraha.

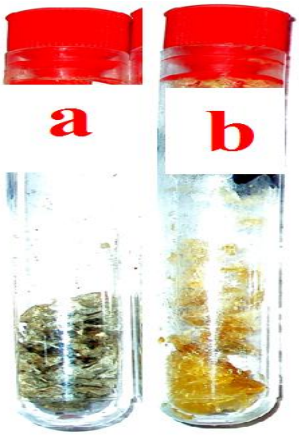

Fig. 2. Powder prepared for the XRD analysis of a: paper wasp, *Polistes flavus* (Cresson); b: honey bee, *Apis mellifera* (Smith).

Discussion

In the present study, the nest building activities, social behaviour and parental care were carried out in *P. flavus* and *A. mellifera*. Karsai *et al.* (1998) reported that *P. flavus* showed differences in the nests structure and architectural patterns from other wasp species with nest construction methods. In the present study, each worker wasps constructed nests in different shape, size, architectural patterns and their nest building activities were found quite different. The nest building behaviour in wasps is very advance as compare to the other arthropods. The worker wasps collected building materials from far

distance due to perception of availability of the construction materials in the surrounding.

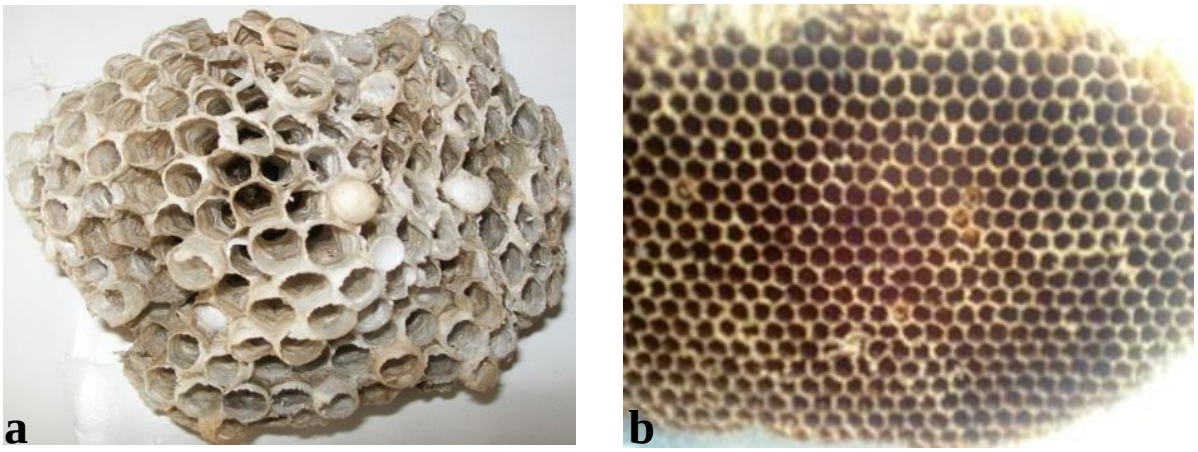

Fig. 3. Comparison of architectural patterns of the nest of the paper wasp, *Polistes flavus* (Cresson) from Baffa Mera Chotal: b; honey bee, *Apis mellifera* (Smith), from Collage Duraha.

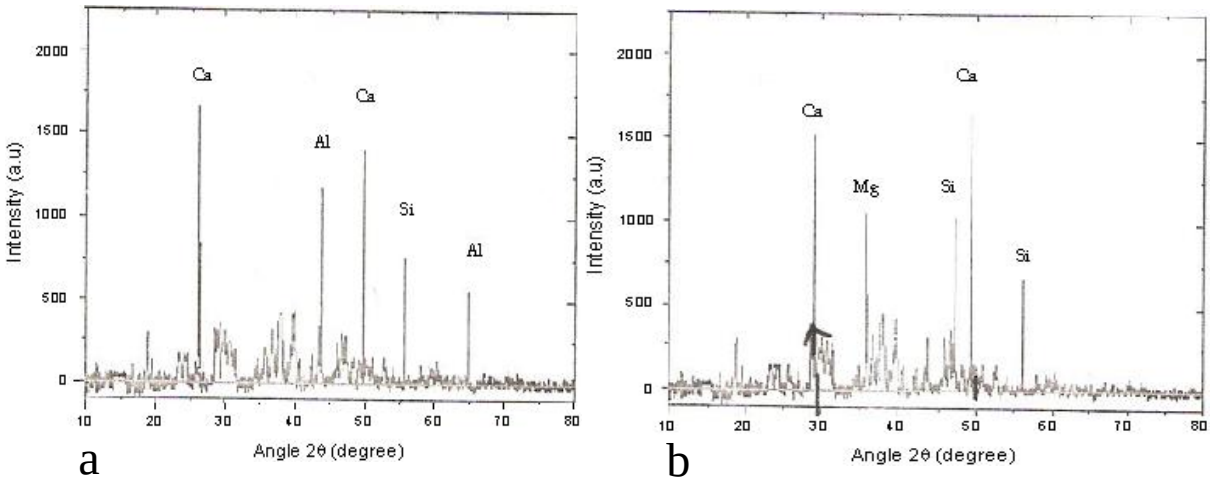

Fig. 4. Comparison of elemental analysis by XRD of the paper wasp, *Polistes flavus* (Cresson) from Baffa Mera Chotal: a, *Apis mellifera* (Smith) Collage Duraha: b, located in Mansehra, Pakistan, respectively.

Foster and Ratnieks (2001) observed the colonies of *A. mellifera* and reported that male production was undertaken by queens or unmated workers. Karsai *et al.*, (1998) examined the complexity and specialization in task partitioning at both individual and colony levels. Consistent with models of Oster *et al.,* (1978) predicted that in small wasps colonies, risk tolerant and behavioural flexibility of individual workers would be preferred, whereas wasps species characterized by large colonies, should relied upon a high rate of exploration and exploitation of the environment by numerous small specialized worker wasps. In the present study, each nest was found in different locations which showed that they build their nest in individual places. The reason was due to they have advance social behaviour.

Matsuura *et al.,* (1991) described that the *A. mellifera* has the largest colony size (1,500-4,500 cells) among the six subspecies. In each cells 1-4 eggs laid by the wasp. In the present study, it was found that nest of *A. mellifera* has a number of hexagonal cells and step wise portion prepared in which thousands of eggs laid by the queen wasps and number of larvae hatched and steps wise come out from the cells. One can argue that it is inherited characters which were developed different from race to race.

Hermann *et al.,* (1975) showed that in *P. flavus*, the heavily sclerotized sting shaft ensured the mechanical penetration into the victim, while the highly specialized venom gland delivers the powerful venomous secretion. For this purpose, an impressive

muscular supply surrounded the glands reservoir. Billen (2006) showed that the secretion was forced into the venom gland duct by muscle contraction; it was carried straight through the sting and injected it into the victim. In the south-east Asian, Stenogastrinae, the secretion of the Dufour gland was used in larval nutrition and nest defence. During the present study, the aggressive behaviour of the wasp was clearly found. The reason for such behaviour was to protect themselves from external environmental factors, such as interference of humans, removal of their nests from the houses and during cutting the tree branches where they built their nests.

Rossi and Hunt (1988) presented that the wasps collected their food from fields of different crops like rice, cotton, wheat etc. The raw materials from cotton field were used for construction of their nests. In the present study, it was observed that the wasps collected their food from different fruits markets. The fruits were also found as a source of food. Such materials and foods were easily available from the surroundings of the wasp nests.

Wilson (1990) reported that elemental analysis by XRD was used to determine chemical composition of wasps nests constituents. During the present research, the same technique was used. The major constituents in the nest were calcium, silicon, magnesium, aluminium and potassium, the peeks in the diffractivegrams showed different level of these constituents. In both studies, the calcium was present in the highest frequency in the constructed materials which gave strengthen to the nest and hive.

Defensive behaviour was studied by Eberhard (1969) in *P. flavus* appeared to be non-existent during early stages of colony establishment. However, a pseudo attack was elicited from drone wasps upon strong provocation. During the present study, it was carried out by tapping on the leaf on which the nest was built or by actually touching the nest. However, many worker wasps were found doing security duty around the nests for protection. Therefore, wasps have well developed management system for protection of their nests. One can argue that due to such behaviour wasps were used their old nests for the next season.

Owen (1962) observed pseudo attack in *P. flavus*. Warning behaviours of the wasps have been described by Jeanne *et al.,* (1972). In the present study, it was observed that the drone wasps flew nearby around their nests, but not toward the object where nest was found. Therefore, these wasps built their nests in the homes and trees because they are familiar with people.

Eisner (1994) studied the wasp hunting behaviour. In both studies, wasps hunted their prey in two steps: in the first step, wasps explored the environment until they located and visited a potential prey, and in the second one, they attacked and tried to capture the prey. One can argue that wasp used hunting prey according to their food requirements. Hunt (1984) investigated the wasps' foraging behaviour. In the present study, it was observed that hymenoptera modified their flight when they perceived a black spot on a light object. They attracted on small elements that has a high contrast with its surroundings. In these conditions, the spiders' retreated, which were made of white silk can be an efficient visual and mechanical protection.

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