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Research Article

First record of Deaths Head Hawkmoth *Acherontia atropos* (Linnaeus, 1758) (Lepidoptera: Sphingidae), A Kleptoparasite of Honey Bees from Rahim Yar Khan, Punjab, Pakistan

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ABSTRACT

The Death's Head Hawkmoth (*Acherontia atropos*) is a remarkable species belonging to the family Sphingidae, known for its unique mimicry of a skull-like pattern on its thorax. This study presents the first documented record of *Acherontia atropos* in the role of a kleptoparasite preying upon honey bees in the Rahim Yar Khan, southern most district of Punjab, Pakistan. The findings shed light on the interactions between this enigmatic moth species and the honey bee colonies, highlighting potential implications for both the local ecosystem and apicultural practices.

Keywords: Deaths Head Hawkmoth (*Acherontia atropos*), *Apis mellifera*, New Record, Kleptoparasitic Behavior.

INTRODUCTION

In the years 1977-78, an Italian honeybee strain, *Apis mellifera* ligustica was introduced to Pakistan from Australia, successfully established after multiple endeavors (Muzaffar, 1982). Beekeeping has proven to be a lucrative trade in Pakistan, with reports indicating that over 4,000 beekeepers are currently involved in raising *A. mellifera*. The landscape boasts approximately 400,000 colonies of *A. mellifera*, yielding an annual production of 10,000 metric tons of honey. This thriving beekeeping industry directly benefits around 27,000 families (PARC, 2010-11).

The honey bees *A. mellifera,* both in their wild and managed states, assume a vital role in pollinating numerous crops and plants. This contribution extends beyond food security to impact the economy as well (Klein et al. 2007; van Engelsdorp and Meixner 2010). The diminishing numbers of honeybees raise alarms due to their pivotal involvement in ecosystem services (Vanbergen et al. 2013). The apprehension regarding the decline in colony numbers is justifiable in light of the mounting demand for crop pollination and the accompanying pressure to ensure an adequate supply of honeybee colonies (Goulson et al. 2015).

In recent times, intensified research initiatives have been undertaken to comprehend and address the substantial colony losses witnessed in numerous regions across the globe (Smith et al. 2013). A multitude of factors have emerged as potential drivers behind these colony losses (Potts et al. 2010; Pirk et al. 2014; McMenamin and Genersch 2015).

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One crucial factor is the international trade in honeybees and bee-related products, which serves as an active conduit for introducing non-native species and consequently propagating pathogens, parasites, and pests (as exemplified by the recent introduction of small hive beetles in Italy) (Mutinelli et al. 2014). In a parallel manner, honeybee colonies of *A. mellifera* in Pakistan encounter challenges from insects, mites, and several diseases (Mahmood et al., 2021).

The *Acherontia atropos* (Linnaeus, 1758), commonly known as the death's head hawkmoth, holds perhaps the most ominous reputation among all hawkmoths and even within the realm of Lepidoptera. This notorious standing arises from its distinctive and unsettling skull-like pattern adorning the thorax, along with the striking transverse black and yellow bands encircling the abdomen, resembling eerie 'ribs'. Further contributing to this image are the dusky forewings that, while at rest, elegantly drape on each side of the body akin to a cloak. To amplify this sense of unease, the moth emits a high-pitched squeak when disturbed. Altogether, these elements evoke a potent amalgamation of fear and apprehension, particularly in those lacking knowledge and susceptible to superstition (Kitching 2003; Zagorinsky et al. 2012).

These moths have gained recognition for infiltrating honeybee colonies with the intention of procuring honey and nectar (Swart et al. 2001; Pirk et al. 2016). What sets these moths apart are their distinctive attributes: not only can they replicate the queen's piping sounds, but they can also employ chemical camouflage. This defensive mechanism effectively shields them from worker bee attacks. This moth is widely distributed across Europe, Asia, and Africa, and has been reported as a visitor to beehives, where it acts as a kleptoparasite, feeding on honey cells within the hive (Moritz et al. 1991). Despite its intriguing behavior, there have been no confirmed records of *A. atropos* with its kleptoparasitic behavioral interaction with honey bees in the Rahim Yar Khan region of Punjab, Pakistan. This study aims to document the first occurrence of this moth and phenomenon in the area.

MATERIALS AND METHODS

Collection and preservation of specimens

Specimens of *A. atropos* were collected as living and dead individuals from the apiaries affiliated with Khwaja Fareed University of Engineering & Information Technology (KFUEIT) located in Rahim Yar Khan, Punjab, Pakistan. A comprehensive series of apiary surveys were conducted spanning the years 2022 to 2023, encompassing diverse tehsils within the Rahim Yar Khan district: Liaquatpur, Khanpur, Sadiqabad, and Rahim Yar Khan itself. Notably, it is a familiar sight to come across deceased *A. atropos* specimens in the vicinity of beehives, as honey bees eliminate intruders such as *A. atropos* attempting to infiltrate the hive, a phenomenon documented by BRUGER in 1946.

The living specimens were collected by using aerial nets and killed by using a killing Jar containing potassium cyanide. Following collection, meticulous care was taken to tag them after pinning by using common pins, a step aimed at facilitating subsequent analyses.

Identification process

The process of identifying the species was conducted using a Kruss microscope. The *A. atropos* specimens were meticulously identified up to the species level by referring to the identification key developed by Hampson. 1892, 1894, 1895, 1896, and also consulted the literature provided by Kristensen, 1999, Matyot, 2005 and Moulds et al.2020. Micrometry and a measuring scale were employed to accurately measure different aspects (such as body length, forewing length, and width) of *A. atropos*. The Labomed CZM6 microscope (10X / 22 W.F) was utilized to create illustrations of the identified species, which were then carefully stored in wooden boxes containing naphthalene balls and Coopex® powder to safeguard against ant and other arthropods damage, ensuring their preservation for future research.

Subsequently, 58 (28♀, 30♂) specimens were systematically organized within entomological drawers, thoroughly studied, and formally deposited at the Fareed Biodiversity Conservation Center located at KFUEIT in Rahim Yar Khan, Punjab, Pakistan. This step solidified their role in contributing to future scientific studies.

Kleptoparasitic-behavioral observations

Field surveys were conducted in various locations within the Rahim Yar Khan district to observe and document instances of *A. atropos* interacting with honey bee colonies. Observations were made during daylight hours (09:00 to 12:00 Am) when the moths were less active, allowing for detailed visual documentation

RESULTS

Identification Characters

Specimens were identified through available literature, with specific characteristics detailed here. Adult individuals

display a substantial and robust physique, notably marked by a distinctive 'death's head' or skull-like pattern on the thorax. The proboscis is characterized by its short and stout nature, adorned with delicate hair-like structures. Conversely, the antennae are robust and linear, ending with a hook-like projection. The legs exhibit a sturdy and compact build, particularly noticeable in the compressed mid and hind tarsi, lacking a ventral bristle brush at their base. Notably, the pulvillus is absent, and the paronychium reduced to a brief lobe. In male specimens, the genitalia feature an elongated and slender uncus, accompanied by a notably small gnathos. The saccus terminates with a bulbous tubular extension at its distal end, while the juxta appears broad and gently tilts upward on both sides of the midline. The valvae bear a cluster of elongated, toothed friction scales, and the harpes are distinctive, often resembling claw-like structures at their apex. The phallus is notably elongated, characterized by extreme slenderness and a lack of ornamental features (Figure 1).

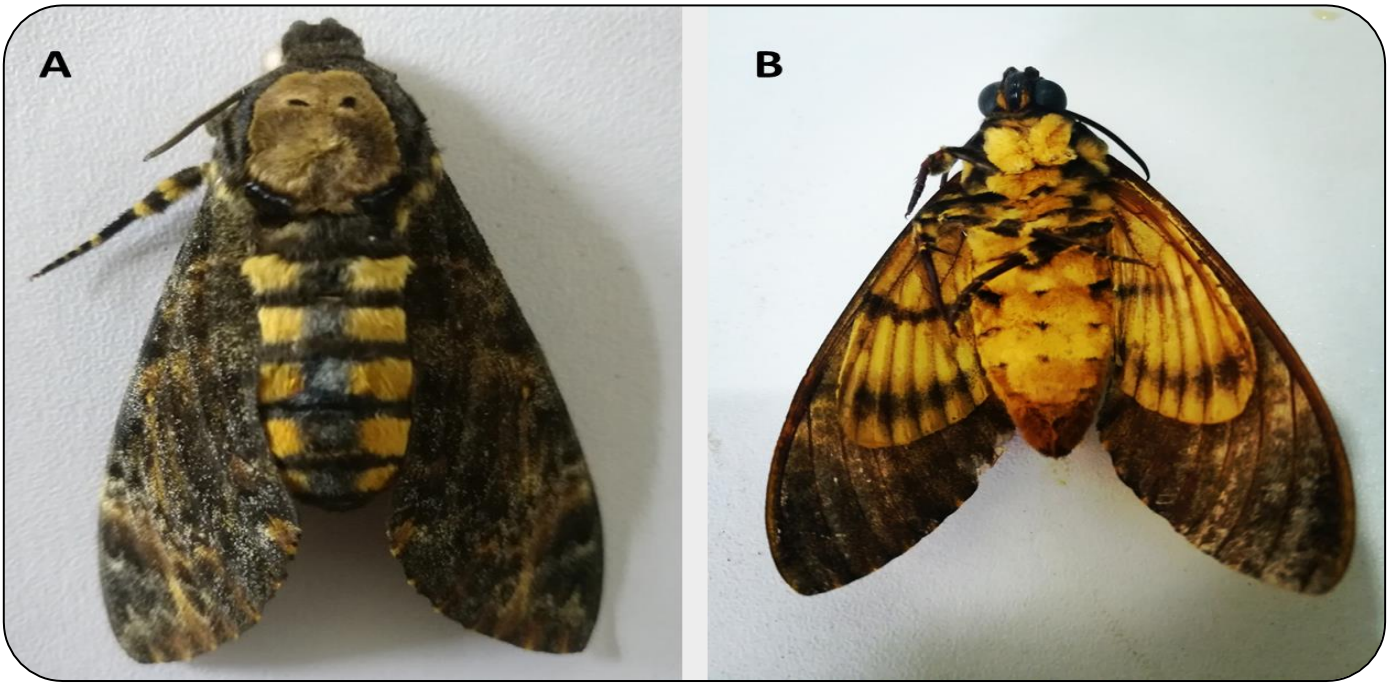

Figure 1. Dorsal (A) and ventral (B) view of *Acherontia atropos.*

Global geographic range and distribution

Reported once from Hainan China, Resident in Africa, the Mediterranean region and Middle East (to Iran, Turkmenistan and Kazakhstan). Records from elsewhere are the result of confusion with *Acherontia styx* or accidental imports.

Kleptoparasitic-behavioral observations

Through extensive surveys of honeybee colonies across multiple localities in District Rahim Yar Khan, we uncovered significant insights into the kleptoparasitic behaviors of *A. atropos* in relation to honey bee populations. Our observations revealed distinct patterns of interaction between A*. atropos* and honey bees, providing valuable results:

Opportunistic feeding behavior

We observed instances of *A. atropos* infiltrating honey bee colonies and consuming their stored resources of honey, indicating a kleptoparasitic feeding strategy.

Selective foraging

Through systematic surveys across multiple localities, we observed a disproportionate presence of *A. atropos* in colonies exhibiting signs of reduced vitality or smaller population sizes. Notably, *A. atropos* individuals displayed a tendency to linger around colonies with lower defensive capabilities or compromised hive structures, suggesting a strategic preference for vulnerable hosts. This selective foraging behavior may be driven by factors such as ease of infiltration and reduced competition within weaker colonies. Such observations underscore the nuanced foraging strategies employed by *A. atropos* to maximize resource acquisition within the apiary environment.

Behavioral responses of honey bees

Honey bees exhibited defensive behaviors in response to the presence of *A. atropos*, including heightened aggression and increased hive guarding, indicating a recognition of the threat posed by the kleptoparasite.

Additionally, during our surveys, we encountered both dead and living specimens of *A. atropos* inside and outside the Honeybee colonies (Figure 2).

Figure 2. *A. mellifera* colony visited (A) and was attacked by *A. atropos* (B,C).

DISCUSSION

The present study marks the first documentation of *A. atropos* in Punjab, Pakistan, exhibiting its unique kleptoparasitic behavior on *A. mellifera* colonies. Through our observations, we noted the opportunistic feeding behavior and selective foraging activity of *A. atropos*, accompanied by the aggressive defensive responses of honey bees, aligning with previous studies on honey bee behavior (Bodlah et al., 2024). Adult *A. atropos* are well-known for their inclination towards procuring honey from bee hives, a behavior extensively documented by researchers (Koeniger et al., 2010).

Evidence also suggests a species-specific adaptation within the Acherontia genus for acquiring honey from various Apis species (Kitching, 2003; Kitching, 2006). Specifically, *A. atropos* predominantly targets the European honey bee *A. mellifera*, as evidenced by documented instances. Conversely, there is a dearth of records for *Acherontia* styx and *Acherontia lachesis* raiding *A. mellifera* hives, despite the cohabitation of these species. Instead, *A. lachesis* has been observed extracting honey from the giant honey bee *Apis dorsata*, and *A. styx* from *Apis cerana*, with a single instance noted for *Apis koschevnikovi* (Koeniger et al., 2010). Interestingly, despite their proximity, *A. styx* has never been reported to exploit *Apis dorsata* hive resources.

Nevertheless, this honey-gathering behavior poses risks, as bees vigorously defend their colonies. It has been identified a notable adaptation in *A. atropos*, which chemically mimics the cuticular fatty acids of *Apis mellifera*, rendering itself "invisible" to bees upon hive entry (Moritz et al.,1991). This sophisticated mimicry implies a longstanding interaction between Acherontia and Apis species. The successful raiding of honey bee hives necessitates distinct cuticular hydrocarbon profiles among *A. mellifera, A. cerana*, and *A. dorsata*, implying that *A. styx* and *A. lachesis* would need to mimic *A. cerana* and *A. dorsata*, respectively (Frances et al., 1985).

CONCLUSION AND RECOMMENDATIONS

The identification of Deaths Head Hawkmoth *A. atropos* as a kleptoparasite of honey bees in Rahim Yar Khan, Punjab, Pakistan, highlights a significant ecological discovery with potential implications for agricultural sustainability. This finding emphasizes the necessity of understanding the complex interplay between honeybee pests and their

hosts, particularly in agriculturally significant regions like Southern Punjab. As apiculture plays a crucial role in both crop pollination and economic support for rural communities, the emergence of *A. atropos* introduces new challenges that demand immediate attention. The economic viability of honey production, essential for the livelihoods of beekeepers and the local economy, faces a potential threat from this newfound parasite. Furthermore, given the traditional medicinal uses of honey in the region, the impact of *A. atropos* on honeybee populations could extend beyond economic concerns to affect cultural practices and societal well-being. Effective hive management and the development of control measures for existing pests are essential, but the unique threat posed by *A. atropos* requires a tailored approach, including comprehensive impact assessments and the formulation of field-appropriate control strategies. By proactively addressing the infestation of parasitic mites and the outbreak of honeybee diseases exacerbated by *A. atropos*, stakeholders can work towards safeguarding both the ecological balance and the economic prosperity of Southern Punjab's agricultural sector. In conclusion, the discovery of *A. atropos* as a kleptoparasite of honey bees in Rahim Yar Khan, Punjab, Pakistan, underscores the importance of continued research and proactive measures to mitigate its impact on honeybee populations and agricultural sustainability.

AUTHOR CONTRIBUTIONS

All authors contributed equally to this research.

COMPETING OF INTEREST

The authors declare no competing interests.

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