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Cover: The breathtakingly beautiful Silver Jubilee cover of JoTT is done in color pencils and ink by the 13-year old darling, Elakshi Mahika Molur.



First report of moth species of the family Tineidae (Lepidoptera) in regurgitated pellets of harriers in India

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Abstract: Caterpillars of Tineidae moths mainly feed on keratin sources and require moisture and warm temperature for emergence. The presence of Tineidae moth caterpillars, pupae, and adults in regurgitated pellets of harriers, diurnal migratory raptors wintering in India, suggests a potential dietary association and highlights the importance of considering associated organisms in raptor diet estimation studies. The caterpillars preferred rodent hairs present in the pellets over feather and arthropod remains. This is the first record of Tineidae moths on the pellets of harriers.

Keywords: Arthropods, caterpillar, diet, grassland, Harrier, Maharashtra, Monopis, pellets, pupae, raptor, regurgitate, Tineidae, Tirunelveli, undigested.

Regurgitating pellets to eject indigestible matter from the gizzard is observed in about 330 species of birds belonging to more than 60 families (Glue 1973). Among these families, pellets ejected by raptors usually contain undigested prey materials such as fur, feathers, bones, scales, and chitin (Philips & Dindal 1979). Pellets generally decompose within a few weeks to months (Wilson 1938; Marti 1974), but it can also remain intact for several years (Brooks 1929; Prestt & Wagstaffe 1973).

Most times, pellets either disintegrate on their own due to local weather conditions or are eaten by a variety of arthropods, including ants and beetles. Caterpillars are rarely found in pellets since they mainly feed on plant parts such as leaves, floral tissue, or fruits (Young 1997).

However, a particular group of moth caterpillars belonging to the family Tineidae feed on resources other than plant parts such as fur, feathers, arthropod remains, guano, wool, and hair (Robinson & Nielsen 1993) that are rich in keratin and chitin. Tineidae caterpillars are commonly found in bird nests, and undigested prey contents in raptor pellets form a significant part of their diet (Robinson & Nielsen 1993; Robinson 1998; Terry 2004; Sato et al. 2019). They aid in pellet decomposition by feeding on the fur and feather remains in pellets (Philips & Dindal 1979). Tineidae caterpillars also construct a tube-like larval case made out of the fur and feather remains in pellets (Nasu et al. 2007). Raptor pellets are known to support many invertebrates such as ants, trogid beetles and Tineidae moths for their breeding, feeding, and shelter requirements (Philips &

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Dindal 1979). Previous studies have recorded several moth species of the Tineidae family, i.e., *Monopis congestella*, *M. pavlovskii*, *M. crocicapitella*, and *M. longella* in the nests and pellets of the Great Horned Owl (Philips & Dindal 1979), Ural Owl and Goshawk (Nasu et al. 2008), eagles (Sharkov et al. 2003), and in bat droppings (Byun et al. 2014; Heckford & Beavan 2018). In New York, a single pellet of the Great Horned Owl had 60 caterpillars of Tineidae moths in it (Philips & Dindal 1979). However, Tineidae moths have not been recorded from harrier pellets previously.

Here, the occurrence of Tineidae moth caterpillars in harrier pellets and their potential role in influencing raptor diet estimation studies is described.

MATERIALS AND METHODS

The study focused on investigating the diet of harriers in their Indian wintering range, specifically in Rengarajapuram, Tamil Nadu state (8.5474, 77.7039) and Dahiwadi, Maharashtra (17.8243, 76.0504), from 2016 to 2022. Harrier pellets, regurgitated remnants of prey, were collected from roosting sites predominantly utilized by Montagu's Harrier *Circus pygargus*, Pallid Harrier *Circus macrourus*, and Western Marsh Harrier *Circus aeruginosus*. To prevent fungal attacks and ensure the preservation, the collected pellets were sun-dried and subsequently packed in zip-lock covers. Morphological

measurements including length and breadth were taken for each pellet in the laboratory. Prior to dissection, the pellets were soaked in water, facilitating the identification of prey items. Observations were made within the zip-lock packets to monitor caterpillar emergence, followed by a week-long observation period to determine the number of pupae present in the disintegrated pellets, thus providing an estimate of the emerged larvae or adults. These methods enabled a comprehensive analysis of the harriers' diet in the specified region and time frame.

RESULTS AND DISCUSSION

The study provides the first record of Tineidae moth caterpillar, pupae, and adults occurring in harrier pellets. A total of 160 pupae were found in the pellets with a maximum of 38 pupae from one single pellet collected from Maharashtra in 2017; 15 pellets were collected from this harrier roost site and stored in a zip-lock cover. While examining these pellets to ascertain the diet of harriers, we initially observed a few dead caterpillars in the zip-lock packets. The caterpillars were white colored with brownish heads (Image 2). The adult moths were also present on the pellets with creamy white heads, and erect scales on vertex and frons. They had a filiform antenna; scape with black and brownish scales; basal of the wing black; forewings with black and white color in

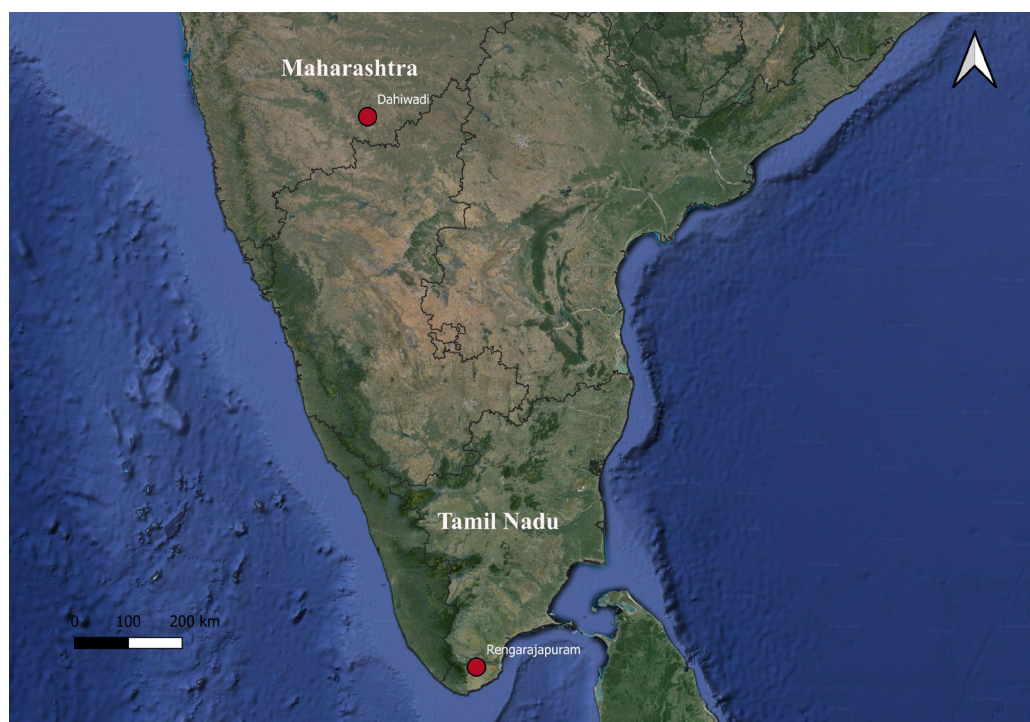


Image 1. Map showing harrier roost sites from where the collected pellets contained Tineidae moths.



Image 2. Water-soaked pellet with Tineidae moth caterpillars.

equal proportions and the apex was dull black and the termen white. There was a trace of a darker subterminal line originating from the apex and retracting in the middle before which there were two tiny black dots. Based on the above morphological characteristics, the moths were identified to be belonging to the genus *Monopis* (Kristensen 1999).

In 2021, during the collection of pellets from a roosting site in Tamil Nadu, a caterpillar belonging to the genus *Monopis* sp. was once again recorded. Despite the complete disintegration of the pellets, a total of 132 pupae were identified. Notably, within the same set of pellets, another *Monopis* species, specifically *Monopis* cf. *monachella* (Huang et al. 2011), was documented. This species exhibited distinctive characteristics, including a vertex and frons covered with erect white piliform scales (Image 3), filiform antennae, elongated wings with a moderately rounded apex, and a simple forewing pattern consisting of a round, purple-black color with a large rectangular oblique white marking on the costa, encompassing the subhyaline spot at the end of the discoidal cell (Robinson et al. 1994). Significantly, the collection of these pellets occurred shortly after a period of significant rainfall in the region. Despite the inability to determine the exact number of pellets, these findings provide valuable insights into the presence of *Monopis* species and their association with the harrier diet in the Tamil Nadu roosting site.

Based on the analysis of pellet remains, it was evident that caterpillars exhibited a clear preference for consuming pellets that contained rodent hairs, followed by bird feathers (Figure 1). However, it is noteworthy that the caterpillars did not consume the available grass, seeds, bones, bird gizzard, or eggshells found within the pellets. The outer surface of the pellets remained intact, and the presence of caterpillar frass was observed inside

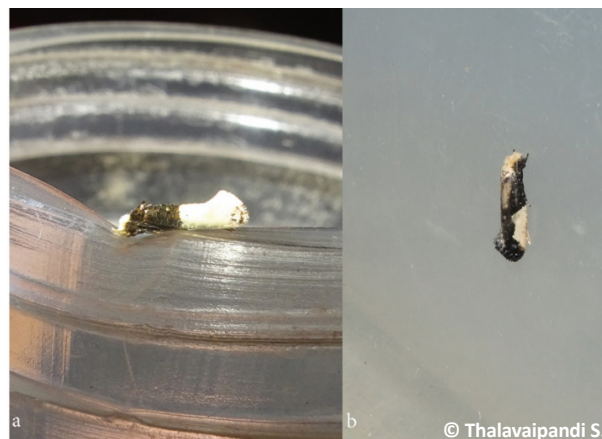


Image 3. The adult Tineidae moths found from the pellets: a—*Monopis* sp. | b—*Monopis* cf. *monachella*.

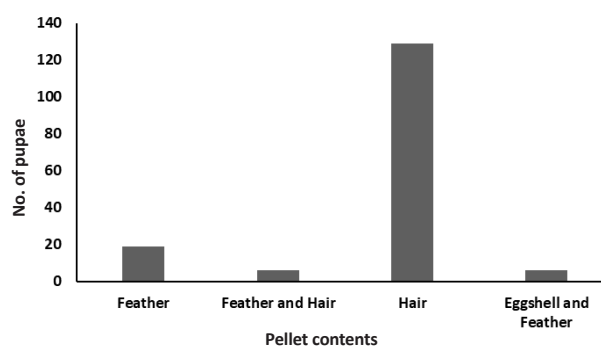


Figure 1. Graph showing the number of pupae in pellets with different prey contents.

the pellets, indicating that the caterpillars had actively fed on the pellet contents.

The life cycle stages of tineid moths, including their eggs, larvae, and pupae, are known to be sensitive to environmental variables, such as temperature and humidity (Griswold & Crowell 1936). Temperature fluctuations have been shown to significantly influence the egg-laying behavior of these moths (Brimblecombe & Lankester 2013). Although the pellets were thoroughly dried and carefully packed, the emergence of caterpillars and a few adults from the zip-lock packets indicated that the moths may have laid their eggs while the pellets were still in the field before collection. Subsequently, these eggs remained dormant until they were exposed to moisture upon opening the bags in the laboratory. An alternative explanation could be that the larvae were already feeding on the pellet contents from within, and the water soaking process stimulated to come out from the pellet. It is important to note that certain moth species can maintain prolonged dormancy as eggs,

caterpillars, or pupae (Young 1997). To further validate these assumptions, additional in-depth investigations on the ecology and behavior of Tineidae moths are warranted.

This observation marks the first-ever documented instance of Tineidae moth caterpillars within harrier pellets. The identification of Tineidae moths as the decomposers of these pellets highlights the need to explore the factors that facilitate their egg-laying and pupation processes, as not all collected pellets across the years showed signs of infestation. Understanding these conditions is crucial, as they can potentially affect the availability of pellets and introduce biases in dietary estimates, not only for harriers but also for other raptors. If Tineidae moths frequently disintegrate harrier pellets containing feathers and hairs, it can lead to a skewed representation of the dietary preferences of these birds, favoring alternative prey categories in the estimations. Therefore, further investigations into the interaction between Tineidae moths and harrier pellets are essential for accurate dietary assessments and to avoid potential biases in ecological studies involving raptors.

The distribution of tineid moth species in India is currently poorly documented. The presence of *M. monachella* in the pellets collected from Tamil Nadu is noteworthy, as previous records of this species were limited to Kerala and Karnataka, where it was identified using light traps (Pathania & Rose 2004). Therefore, our study provides the first distribution record of *M. monachella* in Tamil Nadu. On the other hand, the tineid moth in the pellets collected from Maharashtra could not be identified at the species level due to the unavailability of type specimens. This highlights the pressing need for comprehensive taxonomic studies on moths, particularly within grassland ecosystems, which have received limited attention thus far. Such preliminary information is crucial for studying host-specificity and can provide valuable insights into the conservation status of these moths, especially considering the declining status of harrier populations due to landscape changes and the loss of grasslands (Ganesh & Prashanth 2018; Saravanan et al. 2021).

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