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## Traditional knowledge of pest management and entomophagy: perspective on kiwi crop management by the Apatani tribe of Arunachal Pradesh, North East India

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**Conventional insect pest control methods and approaches are being used in agroecosystem management. However, some pest control methods affect human health and are unsustainable. Consumption of some insect pests as food by humans can be incorporated in a sustainable manner to manage the pest species, which locally provide some positive outputs. The traditional and sustainable ethno-entomophagy practice of the Apatani tribe, inhabiting primarily the Ziro valley of Arunachal Pradesh, North East India, can be considered a prime example of such practices. They consume three species of chafer beetles locally known as Jojer, Dikang-Diilang and Sanko-Tapu, i.e. *Anomala* sp., *Phyllophaga* sp. and *Lepidiota* sp. respectively. It is also known that the adults of these species are pests of the kiwi plant (*Actinidia deliciosa*) and chestnut tree species (*Castanopsis* spp.). In this study, we unravel the practice of entomophagy of these beetles by the Apatanese and understand its implications for the sustainable management of agroecosystems.**

**Keywords:** Chafer, entomophagy, kiwi, pest control, traditional knowledge.

MANY insects have been considered pests in the agroecosystems of settled agriculture. Several pest management approaches have been developed and used to increase productivity and sustain the world's ever-increasing human population<sup>1</sup>. A primary concern in agroecosystems is the current use of harmful pesticides, which can build up in plants and insects through bioaccumulation<sup>2</sup>.

Arunachal Pradesh, in north-east India, has a rich biodiversity and traditional ethno-entomological knowledge and practices<sup>3,4</sup>. The state consists of various ethnic tribes, and Apatani is one of the most distinctive tribes, well known for their unique tradition of highly efficient fish-cum-paddy cultivation<sup>5,6</sup>. The Apatanese have also frequently been considered one of the most advanced communities in the NE region with this productive cultivation system<sup>7</sup>. They primarily reside in the Ziro Valley, which has mixed sub-

tropical and temperate forests with a vast diversity of flora and fauna<sup>8</sup>.

Apatanese are different in practising primarily permanent wet paddy cultivation, unlike most other tribes of Arunachal Pradesh, which practice shifting/jhum cultivation. Therefore, most of their edible insect diets are aquatic<sup>9</sup>, and a few are terrestrial, including their famous chafer beetles (sub-family Rutelinae). Insect species of Rutelinae fall under the family Scarabaeidae and are commonly known as white grub pests<sup>10</sup>. They are considered economically important, with leaf-defoliating adults and their larvae feeding on various ground crops<sup>11</sup>. The present study highlights the indigenous cultural practice of eating these edible pest species by the Apatani tribe, which, in turn, is managed in an environmentally sustainable manner in the agroecosystems.

The study site is located within Ziro valley (27°34'19.9"N and 93°48'19.0"E; altitude 2212 m amsl; temperature  $T = 23^{\circ}\text{C}$ ; % relative humidity (RH) = 75%), and Yachuli (27°51'42.1"N and 93°78'09.6"E; altitude 1485 m amsl;  $T = 24^{\circ}\text{C}$ ; %RH = 85%) of the Lower Subansiri district (Figure 1), and Bomdila (27°22'24.3"N and 92°38'13.7"E; altitude 2587 m amsl;  $T = 24^{\circ}\text{C}$ ; %RH = 80%), West Kameng district in Arunachal Pradesh. This study is based on personal interviews and field surveys from April to September 2021 and 2022 with 10 randomly selected knowledgeable members and kiwi farmers of the study regions. The study included seven villages each in the Ziro Valley and Yachuli region and six villages in the Bomdila region, which are important kiwi-producing belts. Following the interviews, field visits were conducted and all the activities of the villagers, such as harvesting the insects, were photographed. Observation and monitoring of insects in the field were done during peak season.

We found that the Apatani tribe popularly prefers three varieties of edible chafer beetles, also listed as economically important pest species. These are locally called Jojer, Dikang-Diilang and Sanko-Tapu, i.e. adult species of *Anomala*, *Phyllophaga* and *Lepidiota* respectively (Figure 2). These beetles emerge from the soil, swarm the kiwi plantations and wild chestnut trees, and extensively defoliate the leaves. Villagers collect these insects during their peak infestation season and consume them as a delicacy. They usually prepare these insects for consumption by removing their wings and then roasting, smoking, or boiling them; the raw/fresh form is the least preferred, even though some tribals consume it raw as well (Table 1). In the history of the Apatani tribe, it has also been reported that these beetles were once used in the barter system to exchange other goods and services, both intratribal and intertribal. Furthermore, organic kiwi cultivation has increased considerably in this region in the last few years<sup>12</sup>. No pesticides are being used in these horticultural fields. The yield of kiwi in the studied regions correlates with the practice of entomophagy, showing a significant increase where entomophagy is prominent ( $P < 0.001$ ) (Supplementary Table 1). Thus, perhaps the mere collection of these beetles for consumption by

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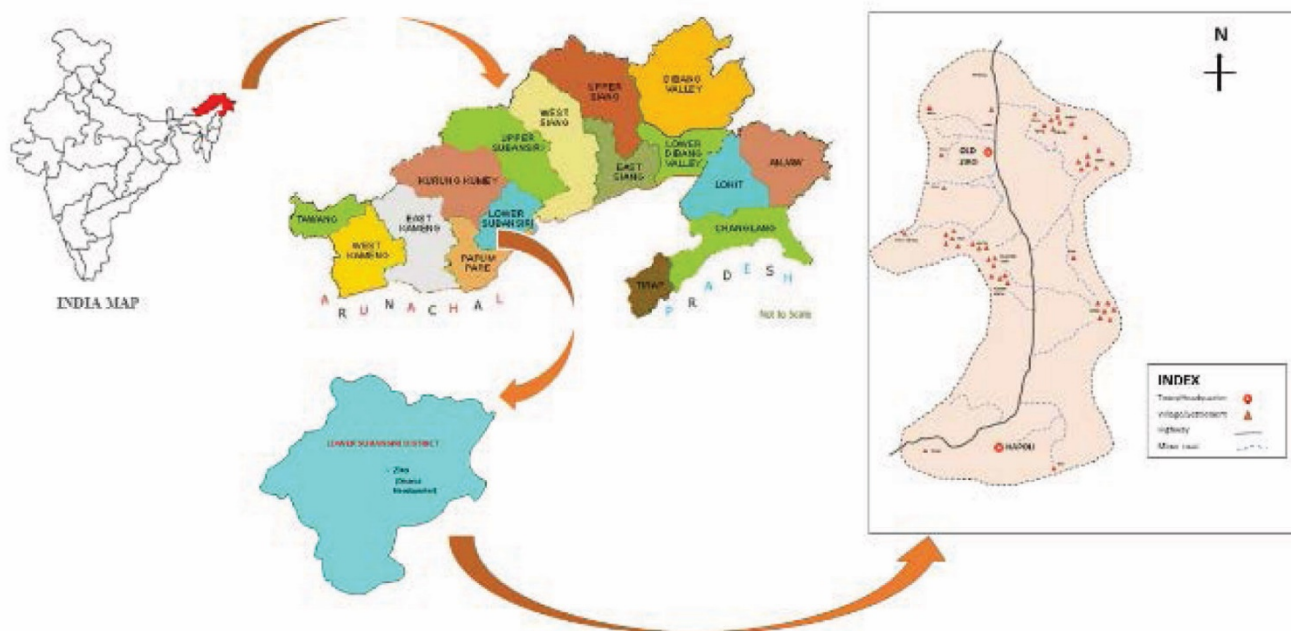


Figure 1. Location map of Ziro valley village settlement area in Arunachal Pradesh, North East India.

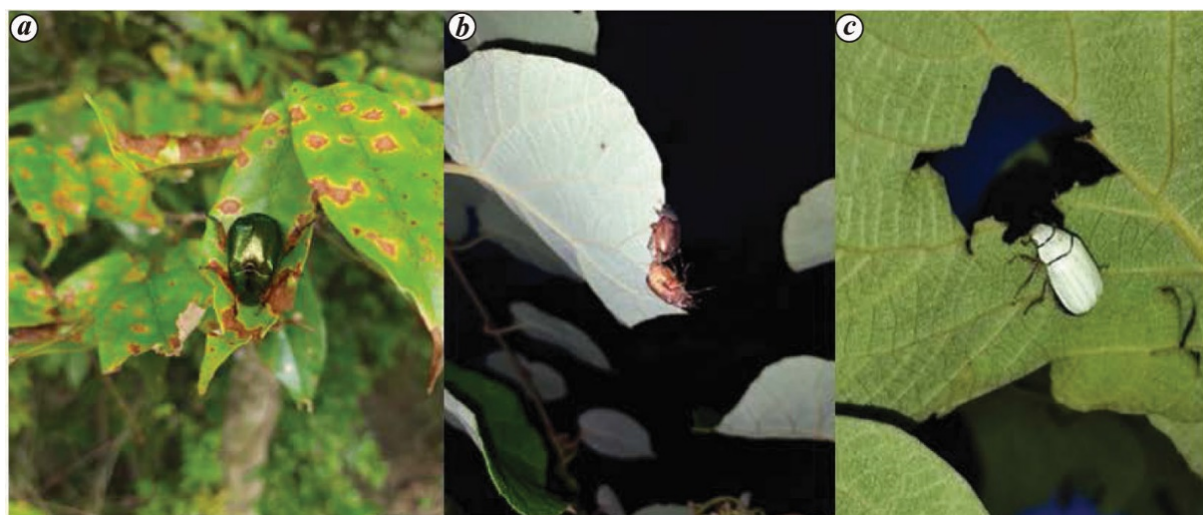


Figure 2. Edible chafer beetle species recorded in kiwi and chestnut agroecosystems in the Ziro valley, Arunachal Pradesh (July 2021 to September 2021): (a) Jojer (*Anomala* sp.), (b) Dikang-Diilang (*Phyllophaga* sp.) and (c) Sanko-Tapu (*Lepidiota* sp.).

Table 1. List of edible chafer beetles consumed by the Apatani tribe of the Ziro valley, Arunachal Pradesh, North East India

Edible insects	Vernacular name	Host plants	Season	Consumption mode
<i>Anomala</i> sp.	Jojer	Chestnut trees ( <i>Castanopsis</i> spp.), kiwi leaves ( <i>Actinidia deliciosa</i> ), maize leaves ( <i>Zea mays</i> Linn.)	May–September (peak season is July–August)	Wings removed and roasted, boiled, fried, steamed, cooked in bamboo, mixed with pike-pila (local Apatani dish) and even consumed in raw/fresh form
<i>Phyllophaga</i> sp.	Dikang-Diilang	Kiwi plant	May–September (peak season is July–August)	Wings removed and roasted, boiled or fried
<i>Lepidiota</i> sp.	Sanko-Tapu	Chestnut tree leaves kiwi leaves, plum tree leaves ( <i>Prunus</i> spp.)	May–September (peak season is July–August)	Wings removed and roasted, boiled or fried

entomophagy enthusiasts is the only activity observed that controls these pests during the cropping season.

The modern agricultural explosion influenced the Ziro Valley region to cultivate cash crops such as kiwi (*Actinidia deliciosa* Chev.)<sup>13</sup> and cardamom (*Amomum subulatum* Roxb.)<sup>14</sup>. Organic kiwi fruit is a boon for Arunachal Pradesh, especially the Ziro Valley region<sup>15</sup>, with the establishment of many micro, small and medium enterprises for kiwi-based products. An Apatani entrepreneur has made India's first organic kiwi wine, which was launched in October 2017 (ref. 16). With the increase in kiwi cultivation in the past few years, the host plant expansion of these edible polyphagous beetles has also been observed. The adult beetles have shifted to kiwi plants from chestnut trees in the Ziro Valley agroecosystem. The practice of entomophagy is found to be realistic for sustainable control of these pests ([Supplementary Table 1](#)). Many gregarious orthopteran pest species are also reported to be collected and consumed by ethnic people in many African and Asian countries<sup>17,18</sup>. The vibrant collection and practice of entomophagy of edible insect pests in an area show decreased emergence of the pests in the next generation compared to non-practice regions<sup>19</sup>. Contrasting patterns were observed in kiwi plantations in the Ziro Valley. Unpaired *t*-tests for each beetle population showed no significant ( $P > 0.05$ ) variation in the two generations of observation ([Supplementary Figure 1](#)). The chafer beetle population remained stable in the next generation, possibly due to less intense insect collection in the kiwi plantations far away from the settlement areas.

The approach of entomophagy in agroecosystems can be widely beneficial since edible insect pests possess higher nutritive value<sup>20</sup>. The utilization of these beetles as human food or animal feed should be encouraged since these leaf chafers have good nutritional value<sup>9</sup>, and showed no toxicity effect or increased immune-modulatory effect on a mouse model (unpublished observations). However, one cannot expect absolute control over huge swarming pests by merely collecting and consuming them. Yet, in the Ziro valley, the entomophagy practice of these beetle pests by the Apatanese can be viewed as an exemplary example of sustainable management with local traditional, socio-cultural practice in non-native cash crops while avoiding harmful insecticides or pesticides.

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