



Research Article

Pheromone-based monitoring of codling moth in isolated belt of Baramulla, Jammu and Kashmir, India

DANISHTA AZIZ*, WASIM YOUSUF, BARKAT HUSSAIN, ISHTIYAQ AHAD, ZAKIR HUSSAIN KHAN, SIVA KUMAR and T. VENKATESAN

Division of Entomology, SKUAST-K, Shalimar, Srinagar - 190025, Jammu and Kashmir, India

*Corresponding author E-mail: daniaziz9974@gmail.com

ABSTRACT: Codling moth is being reported in other countries of the world. It is a destructive and direct pest on apples and other fruit crops. The pathway for the occurrence of codling moth in the isolated belt of Baramulla is a cause of concern, and there is a need to contain this insect pest in other fruit-growing areas of Kashmir Valley. Here, we report a codling moth attacking apple and pear plants in the incursion belt. The fruit damage on apple in the belt was recorded more than 10% on delicious varieties. The codling moth was monitored and identified by using species-specific sex pheromone. The morphological and molecular tools were used to identify the codling moth.

KEYWORDS: Baramulla, codling moth, isolated area, management, pheromone

(Article chronicle: Received: 29-01-2023; Revised: 27-03-2023; Accepted: 30-03-2023)

INTRODUCTION

The codling moth is a destructive pest of apples throughout the world (Zhang, 1957). Commercial production of apples across the globe led to the severe infestation of codling moth. It is now widely distributed in Europe, the USA, Canada, South Africa, Australia, New Zealand, Afghanistan, Iran, Pakistan, Germany, France, China, and other apple-producing countries of the world (Pruthi, 1938; Hussain *et al.*, 2015). In India, it is restricted to Ladakh (Hussain *et al.*, 2015; Hussain *et al.*, 2018). In Ladakh, it is widely distributed in all the hamlets of Kargil and Leh, respectively. Because of the extensive damage caused by the codling moth in Ladakh, it has been declared a regional pest. However, for the last few years, isolated orchards of the areas in the Nadihal belt of Baramulla district in Kashmir Valley witnessed a huge infestation of codling moths. During the 19th century, apple trees associated with different stages of codling moth were transported by colonists to many countries from Europe. Also, the transport of un-screened and infested apple fruits and planting materials from quarantine regions acts as the main source of distribution of codling moth worldwide. However, in Jammu and Kashmir, the entry of codling moth is not clear. It is a researchable issue, how the incursion of codling moth occurs in the isolated belt of Baramulla, but it is

presumed that the entry of codling moth in J&K is due to the introduction of high-density planting material/fruits from the foreign countries or the transport of fresh fruits from Ladakh to Jammu and Kashmir without any or poor regulations.

In India, apple cultivation is done in Jammu and Kashmir, Himachal Pradesh, Uttarakhand, and some parts of Arunachal Pradesh (Hussain *et al.*, 2018). Apple as a main source of economy is the major fruit crop of Jammu and Kashmir, contributing about 60 percent of total apple production among all the cultivated fruits before splitting it into two union territories, J&K and Ladakh (Ahmad *et al.*, 2021). In Jammu and Kashmir, Baramulla district is the main apple-producing hub and the world's second-largest apple market. So, a study has been taken up to monitor the codling moth in Baramulla district of Jammu and Kashmir.

MATERIALS AND METHODS

Lures

Sex pheromone lures were prepared in the Pheromone Technology Laboratory (PTL^{Lab}) and manufactured at the Division of Entomology, SKUAST-K, India which were used for the study. All the standard lures made from the PTL^{Lab} were provided to the Faculty of Agriculture, Wadura, Sopore.

Traps and liners

The standard fluorescent yellow color delta traps were also prepared from the Pheromone Technology Laboratory (PTL^{Lab}) in the Division of Entomology, SKUAST-K, for trapping codling moths.

Pheromone based survey

Surveys were conducted at different locations in Kashmir Valley, India using pheromone detection techniques against codling moths. Yellow-coloured delta traps with sticky liners and the standard lures were prepared in Pheromone Technology Laboratory (PTL^{Lab}), in the Division of Entomology, SKUAST-K and bisexual lures for codling moth were provided by the Pherobank technologies Private Limited, Srinagar. These traps were installed at different locations in Kashmir valley during the last week of March till harvesting of apple fruits using the standard codling moth lures. The traps were hung in trees about 2.5 meters above the ground level. These traps were monitored for the presence and absence of codling moths in all the districts of Kashmir Valley. The presence of codling moth was found only in the isolated incursion belt of Nadihal, Baramulla.

The experiment was carried out in the areas of Nadihal village of Baramulla district. At the experimental site pheromone baited traps at 5 traps/ha were installed in the selected apple orchards for the detection of adult moths. Simultaneously, fruit boring larvae were reared under controlled conditions in confined chambers of the laboratory at the Division of Entomology, FoA, Wadura to rear the codling moth. Both larvae and adults were sent to NBAIR for DNA barcoding for identification purposes. Adults were also identified morphologically at a taxonomic laboratory of the Division of Entomology, FoH, Shalimar. Different morphological characters were observed in both male and female moths of codling moth and also major body parts including male as well as female genitalia which were observed under a stereo zoom microscope.

RESULTS AND DISCUSSION

The results revealed that the codling moth adults (Fig. 1d) are about 10.2 mm long and have a wing span of 15 mm, dusty greyish brown in colour having coppery wings with dark copper-colored posterior forewing margins, however, the hind wings are pale brownish grey. Similarly, Hussain *et al.* (2021) also reported that codling moth adults having grayish brown color, one inch in length, had coppery wings with a dark copper color at the tip region. The adult moths hold the wings back over their abdomen in a tent-like shape while in a resting position. The adult female moths lay eggs

of around 1 mm diameter either on fruits or leaf surfaces which hatch into larvae. Our findings are in line with Lacey and Unruh (2005). Eggs were clear white and circular when freshly laid (Fig. 1a). The newly emerged larval instars were white with a blackish head; however, the lateral instars are light pink in colour with a black head and the size of the full-grown last instar was about 11.98 mm (Fig. 1b). The first instar larvae enter the apple fruits through the calyx end, boring into the fruit. At the entry points, excreta was thrown out, which was produced by the boring larvae and form tunnels inside the pulp of fruit to reach the seed locules and feed on the whole seed. Codling moth larvae bore into the fruits, and feed on seeds and create exit holes by pushing waste material out (Hussain *et al.*, 2021). After feeding, the full-grown last instar comes out of the fruit for pupation. The pupation sites which are preferred by codling moth larvae are under the loose or dead bark of apple trees. The last instar makes white silken cocoons and overwinters during spring forming a brown compact pupae (Fig. 1c) with an average size of 9.64 mm and emerged as adult in early April. A similar report was produced by Pajac *et al.* (2011), which reported that the pest overwinters as a full-grown larva within a thick, silken cocoon, that were found under loose bark and in soil or debris around the tree base. Different stages of codling moth are shown in Figure 2.

Some diagnostic features of the codling moth include: (i) Wing venation of codling moth typically heterogeneous with the hind wing having only eight veins while twelve in the forewing (Fig. 2d and e) (Bradley *et al.*, 1973 & Horak, 2006). The Frenulum of males is single unbranched while that of females with more than one acanthi ranging between 2-6. However, in present study, it was maximum of three, and that too of variable sizes (Common, 1999). (ii) Antennae densely covered with one row of scales per segment (Fig. 2f) with small intercalary sclerite between basal two antennal segments. (iii) Male and female genitalia which are critically important for the identification of tortricids (Horak, 1991). Male genitalia (Fig. 2a): Valvae variable in shape, usually simple and symmetrical. Sclerotized costal margin (dorsal edge) relatively straight and sacculus (ventral edge) rounded apically with a prominent indentation at the neck and a ventral spine; densely hairy cucullus; tegument triangular-shaped; uncus absent. Juxta is a simple shield-shaped plate, in Olethreutinae juxta firmly folded and fused with anellus and aedeagus. Aedeagus (Fig. 2b) had seven spine-like structures, five arranged in a line at the tip and two at the middle. Female genitalia (Fig. 2c): corpus bursa rounded with two small spine- or thorn-like structures called signa; ductus bursae shorter and robust with a large rounded sterigma.



Figure 1. Stages of codling moth (a) Egg (b) Larva (c) Pupa (d) Adult.

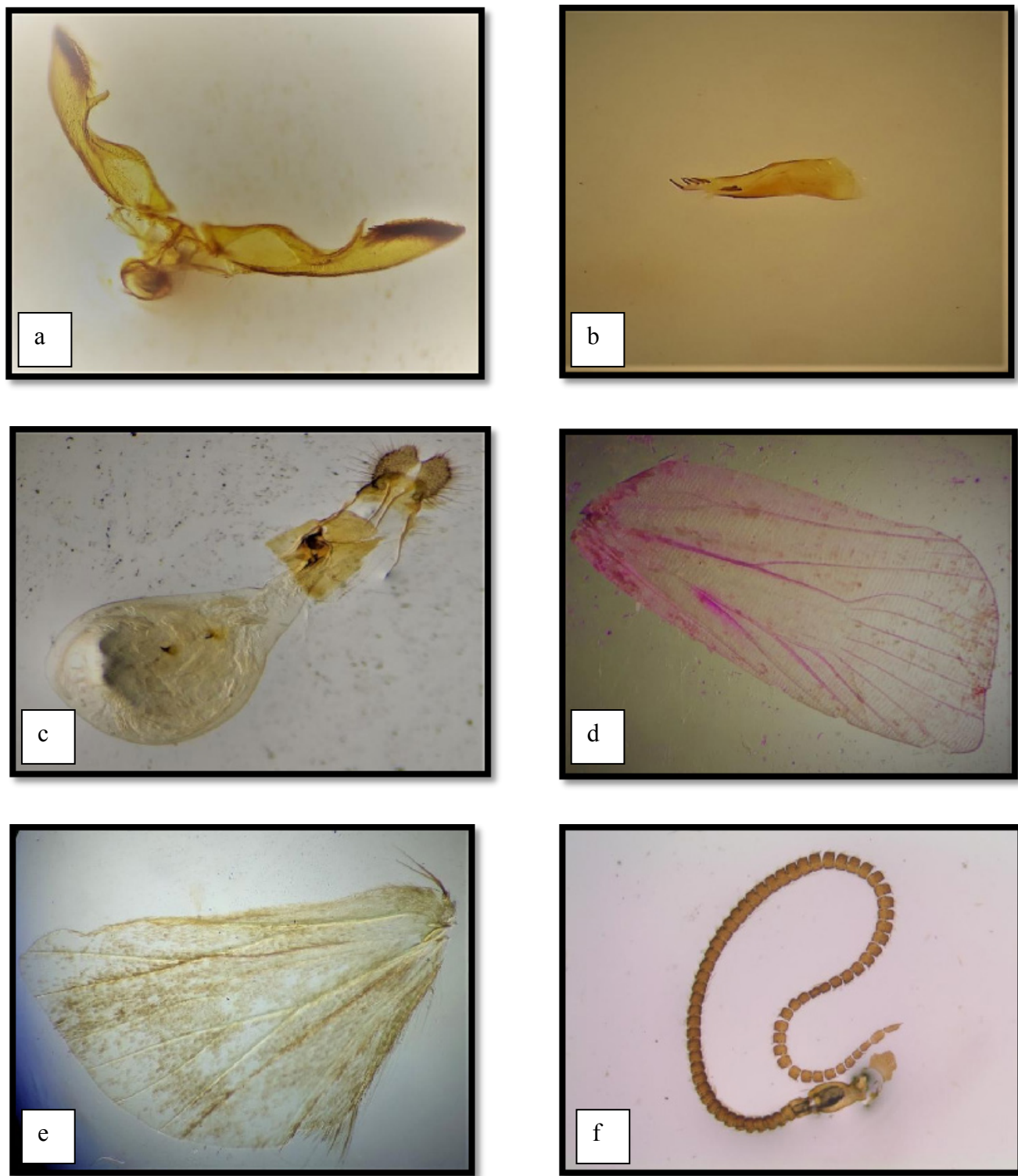


Figure 2. Diagnostic parts of codling moth. (a) Male genitalia (b) Aedeagus (c) Female genitalia (d) Forewing (e) Hindwing (f) Antenna.

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