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Research Paper

Range expansion of *Cydia pomonella* in India

Wasim Yousuf Mir[1], S.S Pathania[1], Muneeb ur Rehman[2], M.D. Shah[3], G.M Lone[1], Z.A. Rather[4] and Barkat Hussain[1]

*Division of Entomology *[1], Division of Fruit Science[2], RCRQA Lab[3], Division of Floriculture and Landscape Architect, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar, Srinagar Jammu and Kashmir (India)*
*e-mail: *bhatbari@rediffmail.com*

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ABSTRACT

***Cydia pomonella* is a quarantine pest and the larvae bore into apple fruits and render the fruits unfit for human consumption. In India, its introduction was observed in cold arid regions of Ladakh, and now also in some pockets of Baramulla. The emergence of the *Cydia pomonella* in the isolated region of Baramulla is a source of concern, prompting the need for containment efforts in other fruit-growing areas of Kashmir. Both, extensive and intensive surveys were carried out to determine the status of this pest in 56 villages of Baramulla during 2021 and 2022. Pheromone baited bi-sexual traps of Pherobank technologies for codling moth were installed in and around the incursion areas to detect their presence as a detection tool. In incursion areas, fruit damage was highest at Checkgojree (51.00 %), followed by Ruhama (40.83%).**

Key words: Apple, *Cydia pomonella*, fruit damage, India.

Apples, *Malus x domestica* Borkh got a prominent position among cultivated fruits in temperate regions of India, and some parts of Arunachal Prasesh, Himachal Pradesh, Utrakhand. Jammu and Kashmir contribute significantly, accounting for 60% of India's total apple production, producing 25-26 lakh metric tonnes annually from 1.729 lakh hectares, while Ladakh division yields 5644 metric tonnes from 1324 hectares (Rayees *et al* 2021). There are large number of insect pests attacking apple in India, and most damaging pests are san jose scal, aphids and mites. However, these pests are easily managed by the application of insecticides (Hussain *et al*., 2018). *Cydia pomonella* is a globally destructive pest of apples (Zhang, 1957), prevalent in Europe, USA, Canada, South Africa, Australia, New Zealand, Afghanistan, Iran, Pakistan, Germany, France, China, and other apple-producing countries of the world (Hussain *et al*., 2015; Szthre & Edland 2001). In India, it is confined to UT of Ladakh (Hussain *et al.,* 2015). Pawar *et al*. (1981) extensively reported the incidence of codling moth in apple growing regions of Ladakh.While, Zaki (1999) reported that infestation of codling moth in apple was 42.5 and 49.7 % in Leh and Kargil district, respectively. The larvae tunnel the fruits by eating the pulp, and the tunnels are filled with frass which render the fruits unsuitable for human consumption (Hussain *et al*., 2018). The historical introduction of *Cydia pomonella* is due to the transportation of infested apple fruits, contributed to its global spread. The entry mechanism into Jammu and Kashmir remains unclear, posing a researchable issue. Presumably, it may be linked to the introduction of high-density planting material or fruits from foreign countries or the transport of fresh fruits from Ladakh to Jammu and Kashmir without proper quarantine regulations. Kashmir valley faces challenges with numerous insect pests affecting apple industry, as recently *Cydia pomonella* got introduced in Baramulla either through the introduction of high density plantations or from Ladakh. It is crucial to establish management practices to prevent its further spread through growers alone. *Cydia pomonella* undergoes three larval stages and during winter, the full-grown larva hibernates within a thick silken cocoon, typically under loose barks, or debris near the tree base. Pupation occurs inside the cocoon in early spring, leading to the emergence of adult in early April. *Cydia pomonella* female lay eggs on both fruits and leaf surfaces (Hussain *et al.,* 2015; Witzgall *et al.,*2008). The utilization of pheromone technology for pest management represents a crucial technology for pest detection, pest spread and intensity of pest attack (Hussain *et al*., 2018).

Pheromone application emerge as the primary means for monitoring, mass trapping, timing of treatments, implementing lure and kill strategies in insect pest management (Hussain *et al.,* 2020). The aim of our study is to determine *Cydia pomonella* range expansion and its incidence through non-destructive surveys in the incursion belts.

MATERIALS AND METHODS

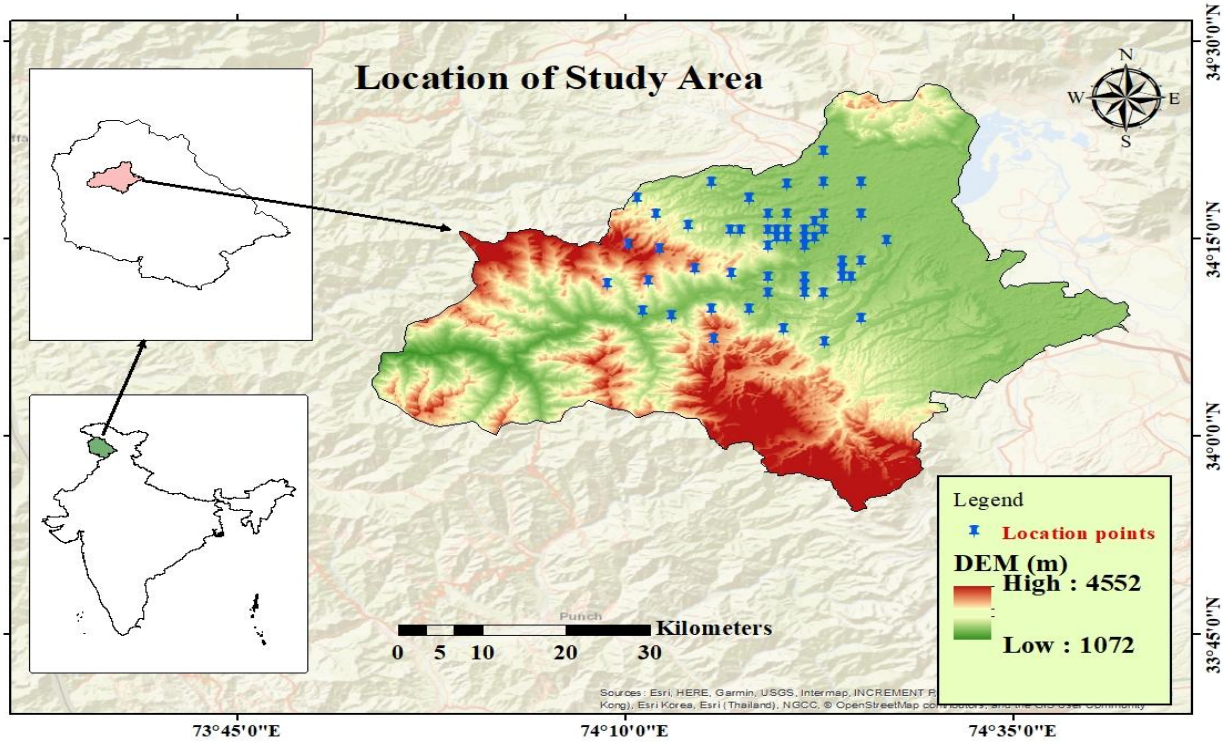
Extensive survey was conducted in Baramulla during 2021 & 2022 to study the nature of damage and range expansion of *Cydia pomonella* in the incursion areas on apple. From each village, three orchards were monitored and surveyed randomly to determine the infestation of *C. pomonella*. From one orchard, 1000 fruits were observed randomly by visual detection method during the peak infestation period.

Fruit damage (%): Fruit damage was recorded by randomly selecting 1000 fruits. The percent fruit damage was calculated by the formula:

$$\text{Fruit damage (\%)} = \frac{\text{No. of infested fruits infested}}{\text{Total No. of fruits observed}} \times 100$$

Fruit fall (%): The fruit fall (%) caused by *Cydia pomonella* was calculated by the following formula:

$$\text{Fruit fall (\%)} = \frac{\text{Number of infested fruits form the dropped fruits}}{\text{Total number of dropped fruits}} \times 100$$



Geographical map of District Baramulla depicting study areas

RESULTS AND DISCUSSION

Extensive surveys were carried out in different villages of district Baramulla during 2021 and 2022. Among

different villages (Table-1), highest cumulative per cent fruit damage of 7% was recorded in Binner village. Pooled data of the two years and the extensive survey revealed that Binner and Najibhat were the highly infested locations and fruit damage of 7% was recorded at both the locations. This may be attributed to growers of Binner were not following any management strategy, located adjacent to major hotspot, Nadihal. While, no significant infestation of *Cydia pomonella* recorded at Watergam, Juhama, Khushipora, Valanwar, Oplinia,Vushkara and Pazwalpora because pest not been spread into such areas during the survey years due to application of insecticides and pheromone trapping.

Table 1: Extensive survey of different villages of district Baramulla

S.No	Villages	Coordinates (Latitude & Longitude)	Fruit damage (%)		
			2021	2022	Pooled
1.	Binner	Lat-34.25 Long-74.34	5.00 (2.23)	9.00 (3.00)	7.00 (2.64)
2.	Chakla	Lat-34.26 Long-74.36	3.67 (1.91)	9.00 (3.15)	6.33 (2.51)
3.	Ladoora	Lat-34.26 Long-74.38	0.67 (1.24)	1.00 (1.00)	0.83 (0.91)
4.	Shitloo	Lat-34.26 Long-74.29	3.33 (2.03)	2.66 (1.79)	3.00 (1.73)
5.	Venkara	Lat-34.24 Long-74.32	0.67 (1.28)	1.33 (1.52)	1.00 (1.00)
6.	Tragpura	Lat-34.27 Long-74.37	0.00 (1.00)	2.33 (1.73)	1.16 (1.07)
7.	Brandob	Lat-34.25 Long-74.28	1.00 (1.00)	2.33 (1.52)	1.16 (1.07)
8.	Doniwari	Lat-34.36 Long-74.38	0.00 (1.00)	0.33 (1.14)	0.16 (0.77)
9.	Pazwalpora	Lat-34.20 Long-74.32	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
10.	Panzla	Lat-34.26 Long-74.33	1.33 (1.49)	1.33 (1.52)	1.33 (1.15)
11.	Sadahpora	Lat-34.25 Long-74.34	1.33 (1.52)	1.66 (1.58)	1.5 (1.22)
12.	Watergam	Lat-34.28 Long-74.36	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
13.	Juhama	Lat-34.25 Long-74.36	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
14.	Khushipora	Lat-34.21 Long-74.40	0.00 (1.00)	0.66 (1.00)	0.33 (0.57)
15.	Valanwar	Lat-34.28 Long-74.38	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
16.	Kalampora	Lat-34.22 Long-74.40	5.67 (2.50)	4.66 (1.00)	5.16 (2.27)
17.	Kansipora	Lat-34.20 Long-74.36	5.00 (2.44)	2.33 (2.34)	3.66 (1.91)
18.	Khaitang	Lat-34.18 Long-74.32	1.67 (1.29)	2.66 (1.63)	2.16 (1.49)
19.	Rangwar	Lat-34.28 Long-74.20	2.33 (1.52)	2.66 (1.63)	2.49 (1.57)
20.	Kanilbagh	Lat-34.26 Long-74.34	1.00 (1.00)	0.33 (0.57)	0.66 (0.81)
21.	Dardpora	Lat-34.18 Long-74.32	0.00 (1.00)	2.66 (1.63)	1.33 (1.15)
22	Poshbagh	Lat-34.28 Long-74.34	0.33 (1.00)	0.66 (1.14)	0.49 (0.7)

Table 1 continued……..

23	Oplinia	Lat-34.40 Long-74.32	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
24	Vushkara	Lat-34.32 Long-74.42	0.00 (1.00)	0.00 (1.00)	0.00 (1.00)
25	Katianwali	Lat-34.18 Long-74.36	0.00 (1.00)	1.00 (1.00)	0.5 (0.71)
26	Wagoora	Lat-34.38 Long-74.34	0.67 (1.14)	0.66 (1.28)	0.66 (0.66)
27	Chandoosa	Lat-34.42 Long-74.38	0.33 (1.00)	0.00 (1.00)	0.16 (1.00)
28	Bochu	Lat-34.20 Long-74.40	0.00 (1.00)	2.00 (1.41)	1.00 (1.00)
29	Hamray	Lat-34.16 Long-74.30	1.00 (1.38)	2.00 (1.73)	1.5 (1.22)
30	Nowpoora	Lat-34.28 Long-74.34	1.00 (1.00)	2.33 (1.69)	1.66 (1.28)
31	Sangrama	Lat-34.32 Long-74.38	0.33 (1.28)	0.66 (1.79)	0.49 (0.81)
32	Gundibakir	Lat-34.28 Long-74.42	0.67 (1.00)	0.00 (1.00)	0.33 (1.00)
33	Wussar	Lat-34.20 Long-74.36	0.00 (1.28)	0.66 (0.81)	0.33 (0.81)
34	Wandatpora	Lat-34.18 Long-74.38	0.67 (1.00)	0.00 (1.00)	0.33 (1.00)
35	Churoo	Lat-34.30 Long-74.30	2.49 (2.06)	1.67 (1.29)	2.08 (1.58)
36	Dawlatpora	Lat-34.32 Long-74.26	3.33 (1.52)	2.33 (1.24)	2.83 (1.35)
37	Balgam	Lat-34.16 Long-74.26	1.33 (1.38)	0.66 (1.28)	1.00 (0.91)
38	Dildarpora	Lat-34.21 Long-74.34	1.00 (1.00)	0.00 (1.00)	0.5 (1.00)
39	Poutkhah	Lat-34.28 Long-74.32	0.00 (1.00)	2.00 (1.69)	1.00 (1.00)
40	Soolusa	Lat-34.36 Long-74.28	0.00 (1.72)	1.33 (1.52)	0.66 (1.28)
41	Hayel	Lat-34.40 Long-74.30	2.00 (1.28)	0.66 (0.81)	1.33 (1.15)
42	Thinda	Lat-34.42 Long-74.30	0.67 (0.81)	2.33 (1.52)	2.33 (1.52)
43	Kreeri	Lat-34.30 Long-74.18	2.33 (1.52)	10.00 (3.63)	6.16 (2.50)
44	Najibhat	Lat-34.26 Long-74.32	4.00 (2.83)	10.00 (3.2)	**7.0** (2.64**)**
45	Durhama	Lat-34.38 Long-74.30	**7.00** (2.64)	3.66 (1.91)	5.33 (2.23)
46	Tappeer	Lat-34.34 Long-75.32	3.33 (1.84)	4.33 (2.28)	3.83 (2)
C.D.			**0.43**	**0.58**	**0.48**
SE(d)			**0.22**	**0.29**	**0.24**

* Values in parenthesis are square root transformed values

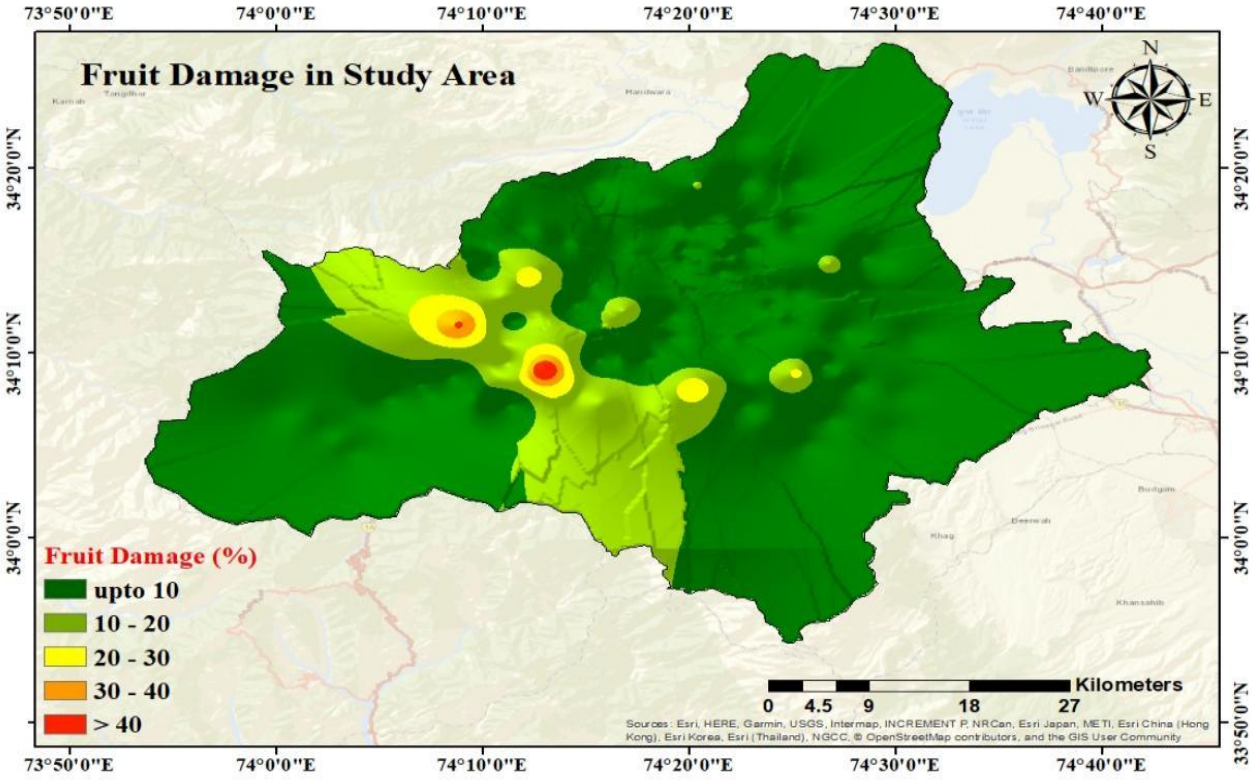
Weissling & Knight (1994) used the non-conventional traps in apple orchards for monitoring *Cydia pomonella* because these traps were pan type and impregnated with molasses rather than with pheromone blends.These

results are not in close agreement with Hussain *et al.,* 2021 who reported that the highest *Cydia pomonella* trap catch due to the species specific pheromone baited traps. While Martin *et al.,* 2014 clearly observed that the modeling of the adult population provides insights for the present and future damage of *Cydia pomonella* in commercial apple and pear orchards. They reported adult trapping provides useful information for expected fruit damage but the untimely number of insecticide applications will not depict the exact fruit damage for fruit damage modelling. The data revealed that among the ten hotspots, the highest fruit fall of (51.00 %) recorded at Checkgojree, followed by Ruhama (40.83%). Minimum cumulative mean fruit fall (10.49 %) recorded at Ushkara. The main reason behind the fruit fall at Checkgojree and Ruhama is lack of awareness among the farmers against this pest. The data of ten hotspots revealed, maximum fruit damage at Checkgojree, 56.5 % followed by Ruhama 40.83 %. A minimum fruit damage at Fresthar 15.49 % during the intensive survey. Most of the studies conducted across the globe revelead that fruit damge caused by colding moth is significantly reduced by the application of insecticides *(*Shahnawaz *et al.,* 2014; Kaplan*, 2023;* Hatteland *et al.,* 2023*).* Aziz *et. al*., 2023, observed high infestation in upper belts and less infestation in plains of Baramulla. Kadoić Balaško *et al*., 2022 observed that the highest trap catch also leads to the highest fruit damage, as the population of *Cydia pomonella* is more, besides, *Cydia pomonella* adults are highly fecund. Witzgall *et al.,* 2008 provided the brief management strategy for *Cydia pomonella* and reviewed that IPM plots are less damaged as compared to non-managed orchards. Our survey results and orchardists of Checkgojree and Ruhama villages observed more fruit damage because orchardists were not following any management practices and were unaware about *Cydia pomonella.*

Table 2: Assessment of fruit fall and fruit damage by *Cydia pomonella* in major hot spots of Baramulla

Parameters		**Fruit fall (%)**			**Fruit Damage (%)**		
Hotspots	Coordinates	2021	2022	Pooled	2021	2022	Pooled
Nadihal	Lat-34.25 Long-74.37	24.33 (4.98)	13.66 (4.08)	19.00 (4.35)	24.67 (5.00)	15.66 (4.08)	20.16 (4.48)
Checkgojree	Lat-34.26 Long-74.34	56.00 (7.53)	46.00 (6.78)	51.00 (7.14)	61.33 (7.83)	51.66 (7.24)	56.5 (7.51)
Rohama	Lat-34.25 Long-74.33	48.33 (7.02)	33.33 (6.28)	40.83 (6.38)	50.67 (7.17)	38.66 (6.28)	44.66 (6.68)
Delina	Lat-34.22 Long-74.42	16.67 (4.19)	18.00 (4.06)	17.33 (4.16)	15.33 (4.00)	15.66 (4.06)	15.5 (3.93)
Singpora	Lat-34.20 Long-74.41	26.67 (5.22)	17.33 (4.63)	22.00 (4.69)	29.00 (5.46)	21.00 (4.63)	25.00 (5.00)
Chandkout	Lat-34.24 Long-74.36	41.33 (6.48)	13.33 (5.61)	27.33 (5.22)	27.33 (5.24)	30.66 (5.61)	29.00 (5.38)
Authoora	Lat-34.25 Long-74.34	17.33 (4.16)	9.33 (5.15)	13.33 (3.65)	24.67 (5.00)	25.66 (5.15)	25.16 (5.01)
Freshthar	Lat-34.26 Long-74.34	10.00 (3.30)	11.00 (4.31)	10.50 (3.24)	13.33 (3.76)	17.66 (4.31)	15.49 (3.93)
Guitiyar	Lat-34.25 Long-74.36	18.00 (4.27)	31.00 (5.44)	24.5 (4.94)	17.66 (4.29)	28.66 (5.44)	23.16 (4.81)
Ushkara	Lat-34.19 Long-74.36	11.33 (3.48)	9.66 (4.84)	10.49 (3.23)	12.00 (3.58)	22.66 (4.84)	17.33 (4.16)
C.D (p≤0.05)		**1.29**	**0.86**	**1.21**	**1.18**	**0.86**	**1.16**
SE(d)		**0.61**	**0.40**	**0.50**	**0.55**	**0.40**	**0.45**

* Values under parenthesis are square roots transformed values



Map showing fruit damage (%) in Baramulla

CONCLUSION

The invasion of Cydia pomonella in few pockets of Baramullaha is the cause of concern and the uni-sexual as well as bi-sexual lures produced by Pherobank technologies contained the pest in the incursion belt and there is a need to use other management options to contain the pest in the incursion area to restrict its geographical boundary as well to eradicate this pest. There is a need to focus on this dreadful pest, otherwise it will engulf the whole fruit industry of Kashmir and increase the cost of cultivation by applying more insecticides on the apple crop.

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