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Neeta Devi Sharma
Department, of Entomology,
Dr. YS. Parmar, UHF, Nauni,
Solan, Himachal Pradesh, India

Anju S Khanna
Department, of Entomology,
Dr. YS. Parmar, UHF, Nauni,
Solan, Himachal Pradesh, India

Correspondence
Neeta Devi Sharma
Department, of Entomology,
Dr. YS. Parmar, UHF, Nauni,
Solan, Himachal Pradesh, India

Feeding losses due to damaging potential of grubs and adults of *Cyllodes indicus* in *Pleurotus sajor caju*

Neeta Devi Sharma and Anju S Khanna

Abstract
The research explorations were conducted to know the damaging potential of grubs as well as adults of *Cyllodes indicus* in *Pleurotus sajor caju* for the very first time in Himachal Pradesh. Insect free control bags yielded sporocarp production of 461.8 g, up to third week. Significantly reduced yields of 429.0 g, 279.6 g and 201.1 g were recorded in the bags with initial release of five, ten and twenty grubs, respectively. Similarly, 391.8 g sporocarp production were observed in insect free control bags as compared to bags inoculated with five, ten and twenty adults, respectively resulting in significant reduced yield of 289.0 g, 181.5 g, 133.1 g sporocrps utpo four weeks. Adults of the beetle caused more destructive losses as compared to the grub population in total yield of *Plerotus sajor caju*. In addition to quantitative losses, qualitative losses were also incurred in the form of tunneling in the stipe and hymenium, irregular holes and fringing of sporocarps which rendered them unfit for consumption and unmarketable. The highly destructive role of *C. indicus* grubs and adults on oyster mushroom can be visualized from these data.

Keywords: Feeding losses due, damaging potential, grubs, adults, *Cyllodes indicus*, *Pleurotus sajor caju*

Introduction
Oyster mushrooms (*Pleurotus* spp.), are lignocellulose loving fungus and can be easily recognized in nature due to their peculiar morphology with an eccentric short term or stipe. Due to simple low cost cultivation technology, it is the most popular cultivated edible mushroom, consumed for its delicacy, flavor, pleasant consistency besides having nutritive and medicinal value. The commercially cultivated mushrooms are highly susceptible to different mycetophagus arthropods and pathogens. Various insect pests feed on oyster mushrooms in India at different growth stages and cause extensive losses in yield and even sometimes caused total crop failure (Deepthi *et al.*, 2004) [4]. Bhattacharya *et al.*, (1993) [1] reported that the yield of mushrooms was reduced by 49% due to the pest attack. Among the various insect pests, coleopterans and dipterans are most prevalent and highly pathogenic (Kumar and Sharma, 2001; Cline and Leschen, 2005 and Kumar, 2006) [10, 3, 9]. Of the coleopteran insect pests which effect the cultivated oyster mushrooms various species of *Cyllodes* viz., *Cyllodes bipligiatus*, *C. ater* and *C. literatus*, *C. whiteii*, *C. bifacies* and *C. indicus* (Boving and Rozen, 1962; Hayashi, 1978; Johal *et al.*, 1992; Gnaneswaran and Wijayagunasekara, 1996, Wijayanti R and Sanjes, 2003 and Sharma, 2010) [2, 6, 7, 5, 11, 10] have been reported from oyster mushroom farms of different regions of the world including Himachal Pradesh. Besides this very little information is so far available on pests of oyster mushrooms in India as well as in Himachal Pradesh. We studied the damaging potential of beetle, *Cyllodes indicus* which was reported for the first time in Solan district of Himachal Pradesh (Sharma, 2010) [10] associated with *Pleurotus sajor caju*. Also, visual symptoms on sporocarps were observed which causes feeding losses to consumers.

Material and Methods
1. Preparation of substrate, spawning and harvesting
The chopped wheat straw was soaked in clean tap water for 10-12 hours. After draining out excess water, the substrate was put in polypropylene bags of 125 gauges and sterilized at 1.5 kg/cm^2 (20lbs /inch^2) pressure for one to two hours in steam sterilizer. This sterilized substrate was spawned with freshly prepared (20-30 days old) grain spawn @ 2.0-3.0 per cent (i.e. 200g to 300g spawn/10 kg compost) on w/w basis and further filled in polypropylene bags as per requirement. Once the mycelial spread was complete (about 20 days after spawning), the bags were reversed and the poly propylene sheet was cut and removed. These bags were placed in cropping rooms. Water was frequently sprayed in the cropping rooms depending upon the atmospheric humidity.

The following environmental parameters were maintained in the cropping rooms:

Parameters	Spawning period	Cropping period
Temperature	10-30 ^{0}C (Optimum 22-26 ^{0}C)	16-30 ^{0}C
Relative humidity	85-95%	85-92%
Light	Nil	200 lux for 8-12 hours
Ventilation	Sufficient ventilation	Sufficient ventilation during fructification
CO_2	Up to 2000 ppm	Less than 600 ppm

Fruiting bodies were harvested on attaining maturity, by twisting slightly clock and anti-clockwise so that young developing sporocarps were not damaged.

2. Damaging potential of *Cyllodes indicus* in *Plerotus sajor caju*

The polypropylene bags (16" x 12") of 125 gauge, each containing 3 kg of pasteurized compost were used for this experiment. Five, ten and twenty grubs of *C. indicus* were released separately in these bags at pin head formation stage. Bags free of test insect were maintained as control. In another set of experiment, five, ten and twenty adults of *C. indicus* were released instead of grubs. All other parameters remained the same. Each treatment was replicated five times in both the set of experiments. The experiments were laid out under Completely Randomized Design (CRD).

Sporophore yield on day to day basis was taken for each replication of all the treatments as well as uninoculated control from day one of sporocarp appearance to the end of cropping. Since the sporocarps appear in distinct succession of flushes at weekly intervals in *P. sajor caju*, weekly yields per treatment were pooled to have information regarding the yield per flush. Data regarding yield per week were further pooled for each treatment to estimate total sporocarp yield.

Since the beetles prefer to feed upon sporocarps once they emerge, the population of test insect per 100 gm of sporocarps (grubs and adults) were counted at termination stage (3rd week). Symptoms produced by insect on sporocarps as well as substrate were observed carefully with naked eyes.

Results and Discussion

The data (Table 1) depict the efficiency of *Cyllodes indicus* grubs as pests of *P. Sajor caju* when released at pin head formation stage. The treatments receiving five grubs yielded sporocarps statistically equivalent to insect free control during first week. Compared to this, fruiting body production in other two treatments receiving ten and twenty grubs was significantly low during this period. Difference in yield between these two treatments was also significant during first week. Yields declined significantly during second week in all the treatments including control. However, during this period, mushroom production in the bags receiving five grubs (309.2g) was statistically similar to control (349.5g). Quantities of sporocarps produced in bags receiving ten and twenty grubs were significantly lower as compared to that obtained in the bags in which five grubs were released as well as insect free bags, but the difference between yields among themselves was not significant. Mushroom production further declined significantly during third flush in all the treatments barring insect free bags in which sporocarp yield of 345.9 g during third week was at par with the quantity of 349.5 obtained during second week. The bags receiving highest release of twenty grubs each, yielded only 30.90 g sporocarps during third week as compared to 127.2 g in bags with ten grubs and 298.5 in bags with five grubs. While mushroom production ceased in the treated bags after third week, 150 g of sporocarps were produced in insect free bags during fourth week also. This indicates that *C. indicus* grubs not only reduced the production of oyster mushroom but also reduced the cropping period. Overall, sporocarp production declined significantly in all the treatments as compared to control and this decline was significantly progressive with respect to the treatments. Insect free control bags yielded sporocarp production of 461.8 g, up to third week. Significantly reduced yields of 429.0 g were recorded in the bags with initial release of five grubs, 279.6 g in the bags with initial release of ten grubs and 201.1 g in bags receiving twenty grubs as initial releases. The highly destructive role of *C. indicus* grubs on oyster mushroom can be visualized from these data.

Table 1: Effect of *C. indicus* grubs on weekly sporocarp production of *P. sajor caju*

Treatments	*Mean sporocarp yield (g) in the indicated weeks			Mean
	first week	second week	third week	
3 kg substrate + 5 grubs	679.2 (2.83)	309.2 (2.49)	298.5 (2.48)	429.0 (2.60)
3 kg substrate + 10 grubs	549.6 (2.74)	162.0 (2.21)	127.2 (2.10)	279.6 (2.45)
3 kg substrate + 20 grubs	429.7 (2.63)	142.7 (2.15)	30.90 (1.43)	201.1 (2.30)
Control	690.0 (2.84)	349.5 (2.54)	345.9 (2.53)	461.8 (2.65)
Mean	587.1 (2.76)	240.9 (2.35)	200.6 (2.30)	

*Average of five replications Figure in parentheses are log transformed values

CD0.05

Treatments (T) 0.06

Weeks (W) 0.05

T x W 0.11

The data referring to the effect of various population levels of *C. indicus* adults on sporocarp production of *P. sajor caju* have been placed in Table 2. As evident, the lowest count of five adults released at pin head formation did not have a significant effect on yield and 289.0 g of mean sporocarps produced in this treatment were found to be statistically at par with 391.8 g obtained in insect free control bags. However, infestation at higher levels of ten and twenty adults caused significantly higher damage, thus, reducing the sporocarp yield to 181.5 and 133.1 g respectively. These yields were significantly at par with each other. Oyster production declined significantly from first week to second week, as 546.2 g of mean production in first week declined to 224.4 g during second week. Mean sporocarp production during second and third week was significantly similar. However, significant decline was observed during fourth week when

just 44.60 g sporocarps were produced. While sporocarp production remained consistent up to third week in control bags, it declined significantly at weekly intervals in all the insect released treatments. However, decline was more significant during second week in the bags inoculated with twenty adults as compared to the bags receiving five and ten adults. Sporocarp yield of 119.4 g during second week in the bags with twenty adults was significantly lower than 279.6 and 134.0 g sporocarps produced in the bags having initial release of five and ten adults respectively; both quantities being significantly similar. Progressive decline in sporocarp production during third week was recorded in all the insect released treatments. However, production of 242.4 g fruiting bodies in the bags with five adults was significantly more than 105.0 g produced in the bags with ten adults which in turn was significantly higher than minimum of 17.0 g produced in the bags with twenty adults. Sporocarp production in all the treatments having insect inoculum was significantly lower than 357.0 g produced in the bags free of insect during third week. Production declined significantly in all the bags including control during fourth week. Near negligible produce was obtained during this period in the bags infested with insects as compared to significantly higher production of 162.0 g produced in insect free bags.

Table 2: Effect of adults of *C. indicus* on weekly sporocarp production of *P. sajor caju*

Treatments	*Mean sporocarp yield (g) in the indicated weeks				Mean
	first week	second week	third week	fourth week	
3 kg substrate + 5 adults	623.0 (2.79)	279.6 (2.45)	242.4 (2.38)	11.0 (1.04)	289.0 (2.46)
3 kg substrate + 10 adults	483.0 (2.67)	134.0 (2.12)	105.0 (2.02)	4.0 (0.60)	181.5 (2.26)
3 kg substrate + 20 adults	395.0 (2.60)	119.4 (2.07)	17.0 (1.23)	1.0 (0)	133.1 (2.12)
Control	684.0 (2.83)	364.0 (2.56)	357.0 (2.55)	162.0 (2.20)	391.8 (2.60)
Mean	546.2 (2.73)	224.2 (2.35)	180.3 (2.25)	44.60 (1.65)	

*Average of five replications Figure in parentheses are log transformed values

CD0.05

Treatments (T) 0.17

Weeks (W) 0.17

T x W 0.33

Significantly higher populations (Table 3) of 46.8, 150.8 and 210.8 grubs were recovered from the fruiting bodies produced in bags receiving respective initial release of five, ten and twenty grubs. Adult population also remained significantly different at every level of release with recovery of 5.8, 25.2 and 40.4 adults from the sporocarps produced in the bags initially receiving five, ten and twenty grubs respectively.

Table 3: Multiplication potential of *C. indicus* on *P. sajor caju* at termination

Treatments	Population in 100 g sporocarps		Mean
	Grubs	Adults	
3 kg substrate + 5 grubs	46.80	5.8	26.3
3 kg substrate + 10 grubs	150.8	25.2	88
3 kg substrate + 20 grubs	210.8	40.4	125.6
Mean	136.1	23.8	

CD0.05

Treatments (T) 1.5

Population (P) 1.3

T x P 2.2

Data assembled in Fig 1 indicated that both grubs and adults of *C. indicus* were destructive for oyster mushrooms; adults being more damaging than grubs. The total sporocarp production declined to 1287.0 and 1156.0 g in the treatments receiving five grubs and five adults respectively. Compared to this, yields were as high as 1535.4 and 1567.0 g in insect free bags. Whereas, the release of twenty grubs brought down the sporocarps yield to just 603.4 g, it was further reduced to 532.2 g when twenty adults were released initially.

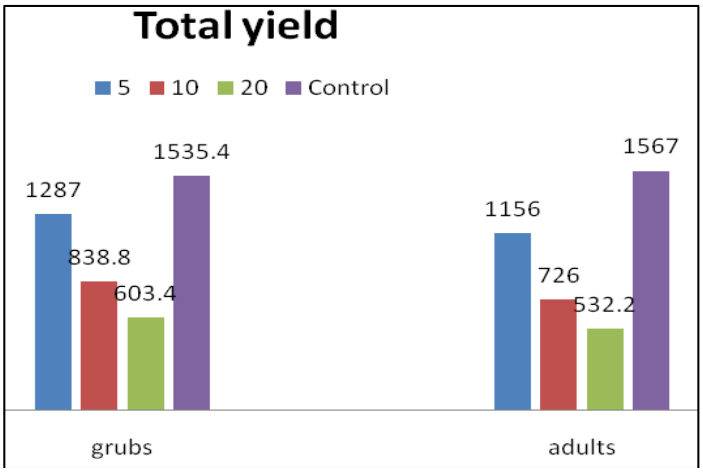

Fig 1: Effect of different populations of grubs and adults of *C. indicus* on total yield of *P. sajor caju*

Yield losses to the extent of 16.2, 45.4 and 60.7 per cent were recorded at the respective initial release levels of five, ten and twenty grubs. Adults caused more destruction with 26.2, 53.6 and 66.0 per cent losses in mushroom yield at respective initial release levels of five, ten and twenty adults (Fig. 2).

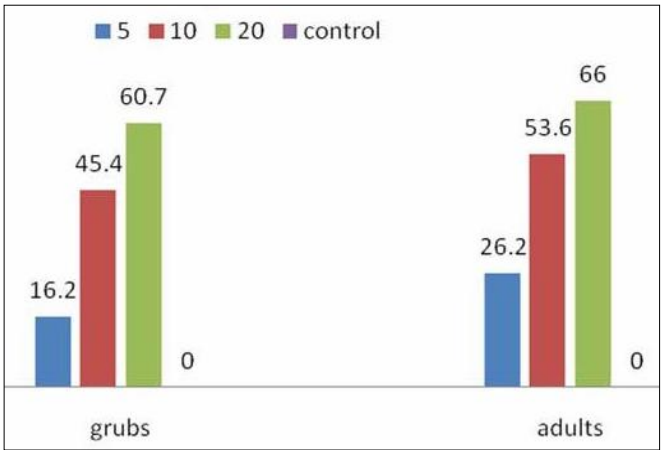

Fig 2: Per cent yield loss caused by different populations of grubs and adults of *C. indicus* on *P. sajor caju*

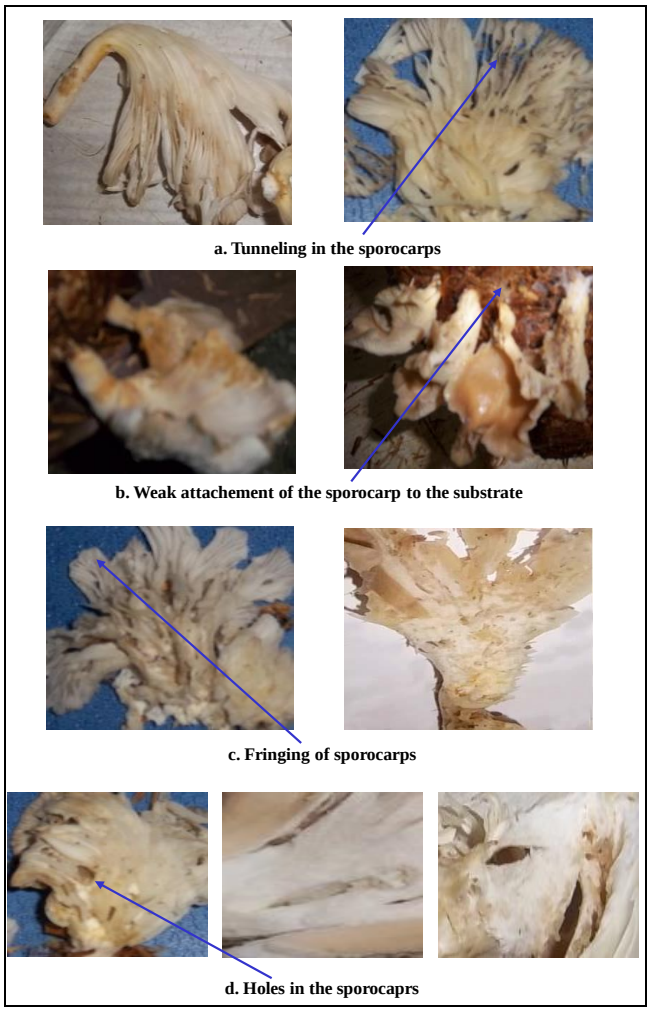

Fig 3: Visual symptoms caused by *C. indicus* on Sporophores of *P. sajor caju*

Cyllodes indicus not only incurred quantitative losses but also deteriorated the quality of sporocarps as visual symptoms of damage were evident on the fruiting bodies, rendering them unsuitable for consumption. Grubs found a most suitable hiding space within the gill lamellae where they fed voraciously, causing tunneling/perforations in the gills. This symptom is often referred as “Salt shaker pins” perforated by larval tunnels. As the pin formation initiated, they moved from substrate to sporocarps, forming tunnels, thus, weakening the attachment of sporocarp to the substrate. As a result, the fruiting bodies were loosely intact and often drooped down. Fringing of sporocarps edges was observed in case of severe infestation. As adults devoured the sporocarps, they produced irregular holes which rendered the produce unmarketable. It was almost impossible to clean the sporocarps infested with grubs as they hid in huge numbers within the lamellae.

Conclusion

Yield losses to the tune of 16.2, 45.4 and 60.7 per cent were assessed in the treatments receiving five, ten and twenty grubs respectively at pin initiation stage, as compared to insect free control. The losses caused by adults at these release levels were estimated at 26.2, 53.6 and 66.0 per cent respectively. As the result of feeding of grubs and adults qualitatively losses occurred, which made the fruiting bodies unfit for consumption.

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