Pests of Oyster Mushroom (*Pleurotus Ostreatus*) in Western Kenya

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Abstract:  
Productivity of oyster mushrooms has been hampered by pests but little is known about them. Pest spectrum of oyster mushroom on farms in western Kenya was investigated. Oyster mushroom *Pleurotus ostreatus* was established at three sites namely; old mushroom farm, new mushroom farm and on-station during short rains, dry season and long rains in Butere constituency Kakamega County between September 2012 and August 2013. Pests were sampled weekly and identified using taxonomic keys at the National Museums of Kenya. The mite *Pygmephorus* spp. (Acaridae) and dipterans *Megaselia scalaris* (Phoridae), *Bradysia* spp. (Sciaridae), *Culicoides* spp. (Ceratopogonidae) and *Anatrichus* spp. (Chloropidae) were identified. All the other pests except *Bradysia* spp. were reported at the three sites across the three seasons. The incidences of all these pests were reported only during the incubation phase of oyster mushroom. Incidences of *M. scalaris* were 42% of the total four pests that were sampled followed by *Culicoides* spp. at 33% with that of *Pygmephorus* spp. being 17% while that of *Anatrichus* spp. being 8%. *Pygmephorus* spp. was vectored by *M. scalaris* hence the incidence of *Pygmephorus* spp. depended on *M. scalaris*. These two pests were found to be pests of economic importance in oyster mushroom production causing both direct and indirect damage on oyster mushroom. The old mushroom farm reported high incidences of these two pests, with the new mushroom farm recording the lowest incidences. Equally the short rains recorded high incidences these two pests with long rains recording low incidences. Although *Bradysia* spp. has been considered a major mushroom pest, it was found to be a minor in the area of study.

Keywords: *Pleurotus ostreatus*, *Megaselia scalaris*, *Pygmephorus* spp., *Culicoides* spp., *Anatrichus* spp

1. Introduction  
Western Kenya contributes to the 65% of oyster mushrooms produced in Kenya as well as constituting a majority of the small-scale producers of oyster mushrooms in Kenya (Odendo et al., 2009). This is due to low investment costs, adaptability of oyster mushrooms to a wide range of weather conditions, easy availability of substrate materials, simple and easy cultivation procedures, no land requirements as production is indoor and high yields compared to button (Gateri et al., 2009). These are the factors that these small-scale farmers have found to be affordable for the improvement of their livelihood through oyster mushroom production (Kamau, 2007). The realization of the benefits associated with oyster mushroom cultivation by these farmers has been hampered majorly by pest infestation which account for serious yield losses in terms of quality and quantity of oyster mushroom estimated at 70% worldwide (Chandra et al., 2007). These pests not only cause yield losses but they can as well lead to a total crop failure in a single outbreak. Despite these losses, there is little knowledge on the spectrum of these pests and the damage they cause on oyster mushroom. The aim of the present study was to investigate the pest spectrum associated with oyster mushroom in Western Kenya.

2. Materials and Methods

2.1. Study Area  
The study was conducted in Lunza division Butere Constituency in Kakamega County under the Marama West Mushroom Growers Group farmers. Lunza division lies between latitudes 0°25’S and longitude 34°53’E and is located at an altitude of between 1240m-1641m above sea level. The area has an average annual temperature of 22.5°C having the minimum temperature of between 11°C-13°C and maximum temperatures of between 28°C-32°C. The area receives an...
average annual rainfall range of 1250–1750mm with two rain patterns made up of the short rains between September and December and the long rains between April and July with a dry period between January and February.

2.2. Mushroom Establishment

Oyster mushroom *Pleurotus ostreatus* was established across three rainfall seasons of the area consisting of short rain, long rains and dry season between September 2012 and August 2013. In each season oyster mushroom was established at three sites; - old oyster mushroom farm, New oyster mushroom farm and an on-station site (Marama West Mushroom Growers Group offices). Dried sugarcane leaves sourced locally were used as substrate. They were chopped to 2-4 cm size using substrate motorized chopper, soaked and drained overnight. Wheat bran 100 g and 10 g of calcium carbonate were added to 1kg wet weight of the substrate after which the substrate was packed into clear polythene bags of dimensions 20 x 30 cm (gauge 150) and the necks tied using polythene strands. The substrate was pasteurized in an improved substrate pasteurization chamber and left to cool for 24 hours. The substrate was then spawned by spawn sourced from Marama West Mushroom Growers Group. Each site per season had 90 1kg substrate bags. The bags were incubated in the dark at 25±2°C to allow for mycelial colonization of the substrate. The end of the incubation period was marked by dense white mycelium covering the entire substrate in the bag. The growing rooms were kept humid at 85-90% Relative Humidity with a 12h light/12h dark photoperiod at 23±2°C. The growing rooms were watered twice-thrice daily to enhance the humidity and induce fruiting body formation. The mushrooms were harvested in two flushes and the substrate blocks were destroyed.

2.3. Pest Sampling and Identification

Each of these sites per season was monitored for pest infestation weekly from the date when the mushroom was established to the harvesting of the second flush. Sampling of the pests was done by extraction of the pests from substrate bags under sterile conditions using an aspirator where only the adult stages of the insect pests were sampled. The aspirator was used since flies have been reported to be pests of economic importance in oyster mushroom production. The insect pests that were also seen flying on the bags were also sampled and formed part of the pests that were sampled from that particular substrate bag.

The sampled pests were sorted based on their morphological characteristics of colour and size using a hand lens, counted, labeled and preserved in 70% alcohol for further sorting and identification at the National Museums of Kenya (NMK) Department of Invertebrate Zoology. During further sorting at National museums of Kenya the legs of the flies were observed under a microscope in case of mushroom mites stuck in their legs. This is because flies associated with mushrooms have been reported to be major vectors of mushroom mites (Woodhall et al., 2009; Chidziya et al., 2013). In case of mushroom mites, the flies carrying the mites were noted and the mites were extracted from the legs, prepared and mounted before identification. Identification keys and pests at the collection of National Museums of Kenya (NMK) Department of Invertebrate Zoology were used during identification in consultation with the technicians of the Department.

2.4. Data Collection

The number of sampled pests was recorded per site across the three seasons.

3. Results

The pests attacking oyster mushrooms in western Kenya were composed of insects and mites. *Megaselia scalaris* (Diptera: Phoridae), *Culicoides* spp. (Diptera: Ceratopogonidae), *Anatrichus* spp. (Diptera: Chloropidae), *Bradysia* spp. (Diptera: Sciaridae) and *Pygmephorus* spp. (Acari: Pygmephoridae) were the pests that were observed on oyster mushroom farms in these regions. All these pests were reported at the three study sites but with exception of *Bradysia* spp. that was reported only at On-station. Among the dipterans, high incidences of *Megaselia scalaris* were recorded with low incidences of *Anatrichus* spp. while *Pygmephorus* spp. (Acarina) was third in terms of percentage incidences (Figure 1). All these pests were sampled only during the incubation phase of oyster mushroom with none being reported during fruiting phase.

![Figure 1: % Incidences of Pests Infesting Oyster Mushroom in Western Kenya](image)
M. scalaris and Pygmephorus spp. were the pests of economic importance in oyster mushroom production in this region as they were associated with both direct and indirect damage on oyster mushroom (Table 1). M. scalaris was the major vector of Pygmephorus spp. and the hairs that characterized their legs M. scalaris might have favoured their vectoring ability.

| Species          | Distinguishing Features                                                                 | Damage on Oyster Mushroom                                                                 |
|------------------|----------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------|
| *Megaselia scalaris* | Yellowish-brown in colour with a humped back. Wings apically rounded, two broad outer veins interiorly and weak oblique veins posteriorly. Legs covered with hair. Short antennae | Direct damage Larva feeds on oyster mushroom mycelium. Indirect damage Fecal excreta contaminate the substrate Flies vector *Pygmephorus* spp. |
| *Culicoides* spp.     | Brown coloured body with a slender elongated abdomen and humped back. Wings emerging from hind part of the back with beaded outer wing vein. Short stout piercing mouth part. Long segmented antennae. Male; antennae plumose and female; antennae non plumose. | Direct damage None Indirect damage Itchy bites on workers and personnel |
| *Anatrichus* spp.     | Dark coloured. Compound eyes with short thickened antennae. Two species based on presence and absence of the anal vein. | Direct damage None Indirect damage Nuisance flies in mushroom production units |
| *Bradysia* spp.       | Dark coloured body with elongated tampering abdomen. Distinct thickened segmented antennae. Long segmented legs. V-shaped venation at the center of the wing | Direct and indirect damage None due to their very low incidences. |
| *Pygmephorus* spp.    | Yellowish-brown in colour with a flattened appearance. Four pairs of segmented with pincher mouth parts. | Direct damage Patches of substrate uncolonised by mushroom mycelium but colonized by weed mold (*Trichoderma* spp.) in which they feed on. Indirect damage Fecal excreta contaminates the substrate |

Table 1: Pests Encountered on Oyster Mushroom Order, Family, Species, Distinguishing Features and Damage on Oyster Mushroom

Generally, the old mushroom farm had high incidences of the four pests with high incidences of *M. scalaris* and *Pygmephorus* spp. during short rains and high incidences *Anatrichus* spp. and *Culicoides* spp. during dry season and long rains respectively (Figure 2). New mushroom farm recorded low incidences of these pests during the same seasons. It is also evident that short rains across the three sites recorded high of *M. scalaris* and *Pygmephorus* spp.

The incidences of these two pests reduced in dry season with long rains recording the lowest incidences of these two pests.
on weed moulds such as Trichoderma spp. that compete with mushroom mycelium for nitrates as conditions during the long rains in this area.

Production units during this oyster mushrooms, the larvae initially attack the mycelium and progress to feeding on the sporophores. M. scalaris, a myceliophagous mite causing serious yield losses on mushrooms. However, Pygmephorus (Brennandania lambi) was a myceliophagus mite causing serious yield losses on mushrooms. Clift and Terras, 1995 and Smiley, 2009. Weed moulds grow in poorly prepared substrates. In present study substrate as they feed on weed moulds such as Trichoderma spp. that compete with mushroom mycelium for nitrates as observed by Woodhall et al., (2009) and Wicht, (1970). Pygmephorus spp. infestation is always an indicator of poorly prepared substrate. This created pockets of uncolonised substrate with lengthened duration to full spawn. Apart from the direct damage associated with M. scalaris on oyster mushroom, the excreta from M. scalaris larva contaminated the substrate making it un-fit for colonization by mushroom mycelium. A phenomenon also observed by Babar et al., (2012). Equally adult flies of M. scalaris were the key vectors of Pygmephorus spp. that were reported in this study. Gautam et al., (2009) reported that dipterans of the family Sciaridae and Phoridae were the key pests of oyster mushroom farms once the leaves are plucked for use as substrate.

4. Discussion

Insect pests of the order Diptera and Acari were pests that were reported on oyster mushroom farms in Western Kenya an observation similar to that of Gnaneswaran and Wijayagunasekara (1999) and Witch (1970). Although Chidziya et al., (2013) and Navarro et al., (2002) reported that dipterans of the family Scleridae and Phoridae were the key pests of oyster mushroom, dipterans of the family Ceratopogonidae and Chloropidae were also reported in these studies which are not pests of oyster mushroom.

The occurrence of Culicoides spp. (Diptera; Ceratopogonidae) in oyster mushroom production units is associated with the production of octenol (1-octen-3-ol) also know mushroom alcohol by the mushroom. Cotton, (2009) observed that octenol is produced by respiring mushroom during spawn run where in presence of CO2 attracts Culicoides spp. Thus, the respiring oyster mushroom during spawn run attracted Culicoides spp. into the production units. Cilek and Kline, (2002) also reported that a combination of octenol and CO2 is used in traps against Culicoides spp. Octenol is also found in sweat and breath of human and mammals as reported by Cotton, (2009) enables Culicoides spp. to identify their host thus cause the itchy bites on workers and farmers of oyster mushroom. The damp conditions during the long rains in this area favoured the prevalence of Culicoides spp. in this season compared to the other seasons. This was similar to the findings of Hill and Macdonald, (2008) where damp conditions favour breeding of Culicoides spp.

Anatrichus spp. (Diptera; Chloropidae) occurring in oyster mushrooms farms might have been majorly due to the proximity of the study sites to sugarcane plantation or the use of sugarcane leaves as substrate in this study. Gautam et al., (2009) reported that Anatrichus spp. were parasitic insects on borers that attack sugarcane hence would form part of flies that sneak into the mushroom farms due to proximity. Similarly, pupating larvae of Anatrichus spp. on sugarcane leaves would be transferred to the mushroom farms once the leaves are plucked for use as substrate.

M. scalaris recorded high incidences in this study and a pest of economic importance in oyster mushroom production in this area. These observation match previous findings as M. scalaris have been reported to be pest of economic importance in cultivated mushrooms. Zamani et al., (2005) reported M. scalaris infesting button mushrooms (Agaricus bisporus) and Johal and Disney, (1994) reported M. scalaris infesting oyster mushroom (Pleurotus sajorcaju). They both reported that the larvae of M. scalaris fed on mushroom mycelia and sporophores as well acting as vectors of mushroom pathogenic bacterium. Disney (2008) made similar observations and also reported that when M. scalaris infest cultured oyster mushrooms, the larvae initially attack the mycelium and progress to feeding on the sporophores. M. scalaris larva fed on oyster mushroom mycelium during the incubation reducing the amount of mycelium colonizing the substrate. This created pockets of uncolonised substrate with lengthened duration to full spawn. Apart from the direct damage associated with M. scalaris on oyster mushroom, the excreta from M. scalaris larva contaminated the substrate making it un-fit for mushroom mycelium colonization. A phenomenon also observed by Babar et al., (2012). Equally adult flies of M. scalaris were the key vectors of Pygmephorus spp. that were reported in this study. This is observation match findings of Navarro et al., (2002) with M. halterata vectoring Pygmephorus (Brennandania lambi). The temperature of about 25+2oC and Relative Humidity >75% that characterize the short rains in this region favoured the prevalence of M. scalaris. In terms of flight activity, mating and entry of M. scalaris into the production units during this season. This observation was also made by Koch et al., (2013). Annon, (2013) also reported that the seasonal peak activity of Megaselia spp. infesting mushrooms occurred between September and October a duration that match the duration of short rains in this area.

Pygmephorus spp. did not cause direct damage on oyster mushroom. Although Navarro et al. (2002) reported that Pygmephorus (Brennandania lambi) was a myceliophagus mite causing serious yield losses on mushrooms. However, when in abundance, they contaminate the substrate making it un-fit for colonization by mushroom mycelium as observed by Woodhall et al., (2009) and Wicht, (1970). Pygmephorus spp. infestation is always an indicator of poorly prepared substrate as they feed on weed moulds such as Trichoderma spp. that compete with mushroom mycelium for nitrates as reported by Clift and Terras, 1995 and Smiley, 2009. Weed moulds grow in poorly prepared substrates. In present study Pygmephorus spp. were found adhering on the legs of M. scalaris flies an observation that was also made by Woodhall et
al. (2009) and Chidziya et al., (2013). Pygmephorus spp. are usually vectored upon attaining migratory stage a stage majorly attained due to overcrowding. Apart from being vectored by M. scalaris, Pygmephorus spp. infestation may have been facilitated by the storage of the raw substrates on mushroom production farms. The sicker that characterizes their body during hypopus state (Tsarev, 2003) may have allowed them to adhere on the personnel and equipment during substrate preparation. In addition to this, pasteurization temperature and duration might have not provided sufficient heat to destroy the Pygmephorus spp. and provide a sufficient condition for growth of mushroom mycelium. Smiley, (2009); Pecchia, (2009); Clift and Terras, (1995) reported that non-uniform pasteurization of the substrate at temperatures below 600°C in less than 3 hours created pockets of un-pasteurized substrate in which Pygmephorus spp. thrive in. The pasteurization of substrate already packed in polythene bags in this study at temperatures of about 500C-600C for 90 minutes on-station and 2 hours on-farm caused non-uniform pasteurization of the substrate creating pockets of un-pasteurized substrate. Consequently, the un-pasteurized substrate discouraged the growth of mushroom mycelium while favouring the growth of weed mould (Trichoderma spp.) as also observed by Smiley, (2009). The growth weed mould enhanced the infestation of Pygmephorus spp. which feeds on these moulds.

The incubation phase of oyster mushroom was the most susceptible stage to infestation by these two pests since no pests’ incidences were reported during the fruiting phase a finding that was also observed by Sanchez, (2010).

Incidences of Bradysia spp. was low despite being reported as a major pest in mushroom production. O’Connor and Keil (2005) reported that mushroom variety influenced developmental time, survivorship, weight and reproduction of scarid with the hybrid strain of button mushroom (Agaricus bisporus) being the most favourable. P. ostreatus could be having a negative effect on survivorship of Bradysia spp. resulting in insignificant incidences of Bradysia spp. Disney et al. (2013) reported parasitization of larvae of fungus feeding dipterans by M. scalaris. Bradysia spp. larvae could have been parasitized by the M. scalaris larvae resulting to low their incidence.

In reference to the incidences of the M. scalaris and Pygmephorus spp. across the sites, continued cultivation of oyster mushroom at the old mushroom farm provided sufficient breeding grounds for these pests. Jess and Bingham, (2004) reported that M. scalaris are insect pests of mushroom whose population increases rapidly in preceding generations when efficient control measures are not observed. Thus, these breeding sites provided the initial sources of pest infestation in the production unit leading to a rapid population increase of these pests once the oyster mushrooms were established on this farm.

5. Conclusion

M. scalaris is a pest of economic importance in oyster mushroom production in western Kenya and is also a major vector of Pygmephorus spp. The short rains were characterized by high incidences of these two pests with the incubation phase being the susceptible phase of mushroom to these pests.

Age of a mushroom production unit contributed to pest infestation

6. Acknowledgements

Special thanks to Kenya Agricultural Productivity and Agribusiness Project (KAPAP) for funding this study and to Kenya Industrial Research and Development Institute (KIRDI) and National Museums of Kenya (NMK) for formulating and supervising the study. Thanks to Marama West Mushroom Growers Group for allowing their facility to be used during the study and laboratory technicians Zoology Invertebrate Department at NMK for their taxonomic expertise advice.

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