International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 6, No. 4, p. 251-255, 2015

RESEARCH PAPER OPEN ACCESS

Pests of mushrooms in Cote d'ivore: the case of *Volvariella volvacea*

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Article published on April 29, 2015

Key words: Mushroom, *Volvariella volracea,* Dead palm trees, Pests, Côte d'Ivoire**.**

Abstract

The mushroom *Volvariella volvacea,* growing on dead palm trees, is attacked by pests that cause more or less important damages making them unmarketable. This study was performed in order to explore and identify these pests and to determine the extent of damages caused by them. Mushrooms harvested from dead palm trees and those sampled in the markets have permitted the determination of these pests and the assessment of the damages caused by them. Three kinds of pests were identified for the mushrooms harvested from the dead palm trees as well as for the mushrooms sampled in the markets. Those are: larvae of lepidoptera, maggots of flies and millipedes. The larvae of lepidoptera mainly attack the caps of the mushrooms. The damages consisted of bite marks (15% of cases), perforations (50% of cases) or destruction of more than half of the mushrooms (35% of cases). Myriapods are found mainly in the mushroom feet. They perforate and lodge there. Maggots of flies mainly attack mushrooms' buttons or eggs at early stages. Their action usually stops development of the mushroom's cap, foot and volva. Signs of pest attacks were observed on mushrooms harvested from the dead palm trees (39.29%) and sampled in the markets (40.88%). Maggots of flies, larvae of lepidoptera and millipedes cause respectively 10.27%, 4.6% and 0.91% losses of mushrooms harvested from the dead palm trees. For mushrooms sampled in markets, attacks of maggots, larvae and millipedes cause respectively 7.56%, 23.53% and 11.20% losses.

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Introduction

The mushrooms of the genus *Volvariella* are important sources of protein (Bano *et al.*, 1971; Chang, 1979; Ndong *et al.*, 2011). They are used worldwide, in countries of sub-Saharan Africa and especially by the people of Côte d'Ivoire (Boa, 2006). Several substrates including mainly rice straw (Chua and Ho, 1973; Chang, 1977; Dev *et al.*, 2004), cotton wool (Chang, 1979), and wheat straw (Philippoussis *et al.*, 2001) are used to produce *Volvariella volvacea*. Apart from these conventional substrates, it is shown that the dead palm tree, abandoned after the production of palm wine, is also a real production support of this mushroom (Delmas, 1989; Tiécoura *et al.*, 2013). Mushrooms are important sources of income for most rural populations in developing countries (Boa, 2006). For the Ivorians, *Volvariella volvacea* is a source of undeniable income (Tiécoura *et al.*, 2014).

However among the mushrooms harvested from the dead palm trees, some show signs of pest attacks, which often make them unmarketable depending on the extent of damages. The mushrooms are most often used in biological control of insects and their larvae; but the larvae of insects and other pests of mushrooms, including *Volvariella volvacea*, have so far not been extensively studied in Côte d'Ivoire. No publication is available today on this mushroom.

The objective of this study was to identify the pests that attack the mushroom, *Volvariella volvacea,* growing on the dead palm trees and to assess the impact of the damages on marketing.

Material and methods

The development of the mushroom *Volvariella volvacea* was observed on twenty-one (21) dead palm trees of the species *Elaeis guineensis* (Fig. 1). The mushrooms were collected on a 24-months period after the production of palm wine, on a one-hectare site at the University Felix Houphouët-Boigny. The different pests that attack the mushrooms and the types of damages they cause were identified. The data were collected regularly every two days as soon as the first mushroom appeared on the dead palm trees.

Some mushrooms sampled (collected) once a week in the main markets of the city of Abidjan were also observed in the same period of 24 months.

The mushrooms collected during each visit of dead palm trees or markets constitute a harvest.

Data mining

A harvest with no signs of pests' attacks on the mushrooms is said "not attacked harvest". In contrast, if the mushrooms bear traces of pests, the harvest is said "attacked harvest". The rates of mushrooms attacked by all the pests and by each type of pest were estimated.

Chi square test (χ^2) was used to compare: 1) the rates of attacked and not attacked mushrooms that were collected on dead palm trees and in the markets; 2) the rates of mushrooms attacked and not attacked by the different types of pests.

Results and discussion

The identified pests and types of damages caused

Three types of pests have been identified in samples of *Volvariella volvacea* collected on dead palm trees and in the markets (Fig. 2). The most numerous were the larvae of lepidoptera. Five (5) kinds of larvae were distinguished (Fig. 2a to 2f) indicating that the mushrooms are attacked by five different Lepidoptera. The maggots of flies (Fig. 2g) and myriapods (Fig. 2h) are the other two types of pests observed.

Different damages are caused by these pests. For larvae of lepidoptera, bite marks (Fig. 2i), perforations (Fig. 2d) or a destruction of more than half of the mushrooms (Fig. 2k and 2l) were observed. Some larvae of lepidoptera (Fig. 2b, 2e and 2f) were the most devastating because they caused perforations and total destructions. Other larvae of lepidoptera (Fig. 2a and 2c) cause more frequently bite marks. This can be explained by their different weights. The first are bigger so they need more food for their development, while the second, smaller, they need less food.

The maggots of flies destroy buttons of mushrooms or stop their development (Fig. 2m and 2n). These maggots are different from those observed in decaying mushrooms. Indeed, the flies lay eggs in developing buttons of mushrooms and their larvae which feed on the buttons are therefore pests. In oyster mushrooms (genus- *Pleurotus*) and straw mushrooms (genus-*Volvariella*) growing centers, attacks of larvae of flies, sciarid flies and phorid plies, mites and millipedes (Oei, 1991; Njonga 2010) are mainly mentioned. The larvae and millipedes dig tunnels in the mushrooms.

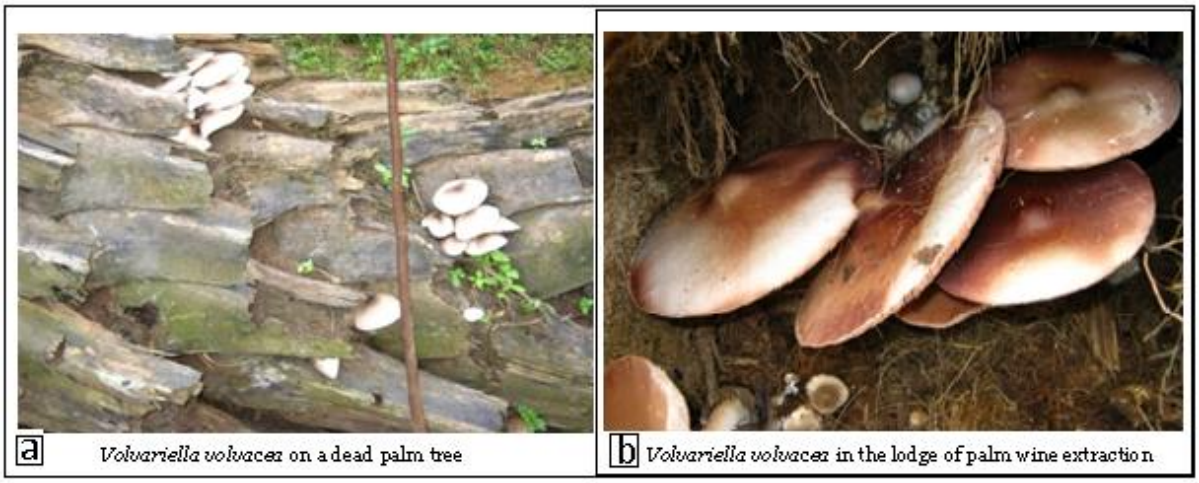

Fig. 1. Dead palm trees bearing the mushroom *Volvariella volvacea*.

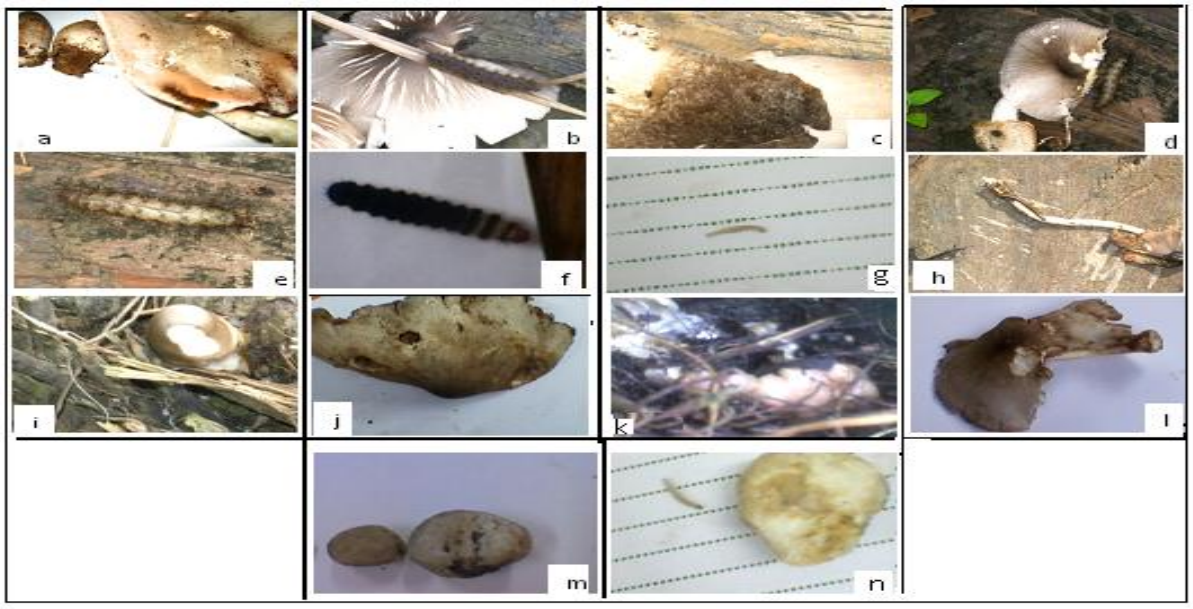

Fig. 2 . Pests of the Mushroom, *Volvariella volvacea*, and some types of damages caused.
Legend: a - f = larvae of different lepidoptera; g = maggot flies; h = millipede; i to n = damages (i = crunching, j = perforation, k-l = total destruction, m-n = arrested development of mushroom eggs).

Evaluation of the rates of harvests attacked by the pests

Marks of pest attacks were observed on 39.29% of the mushrooms harvested from dead palm trees and 40.88% of the mushrooms collected in the markets (Fig. 3). These rates of "attacked harvests" are not significantly different ($\chi^2_{theoretical}$ = 3.84; $\chi^2_{calculated}$ = 0.030; α = 5%). They are significant because they represent more than a third of the harvests. If the presence of attacked mushrooms in a harvest renders

it unmarketable, pest attacks could cause immeasurable losses. According to Oei (1991) and Njonga (2010), it is difficult to have healthy harvests without protection measures of the mushrooms. The attacked harvests will be sold by sorting attacked mushrooms that have a low market value.

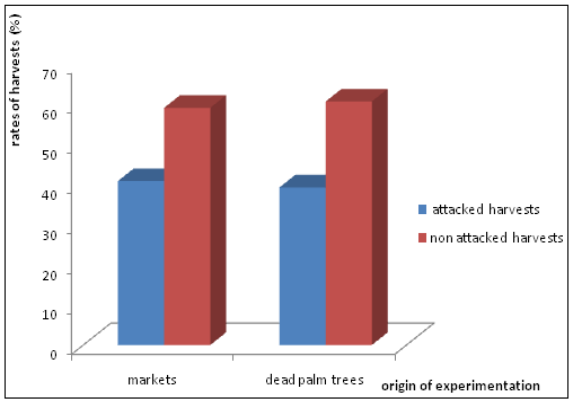

Fig. 3. Attack rates of harvests from markets and dead palm trees.

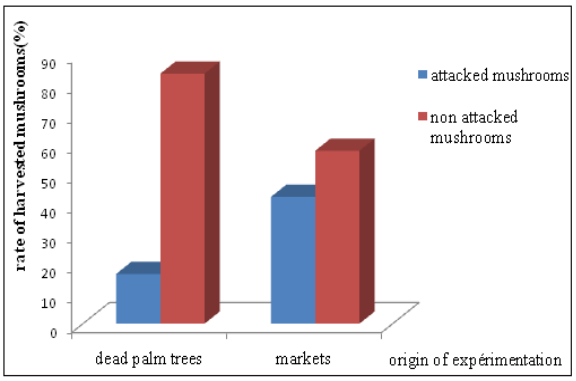

Fig. 4. Evaluation of the rate of attecked mushrooms observed on markets and on dead palm trees.

Evaluation of the rates of attacked mushroom by origin of harvests

Almost 20% of the mushrooms harvested from dead palm trees and 40% of the mushrooms collected in the markets are attacked by pests (Fig. 4). Both rates are significantly different ($\chi^2_{theoretical}$ = 3.84; $\chi^2_{calculated}$ = 6.66; α = 5%). This statistical difference is due to the fact that the mushrooms sold in the markets of Abidjan come from several localities where the various climatic conditions favor different activities of the pests (Tiécoura *et al.*, 2014). Forty percent (40%) of attacked mushrooms represent a loss of income that can be estimated at nearly 2.500.000FCFA for the markets sellers of Abidjan (Tiécoura *et al.*, 2014).

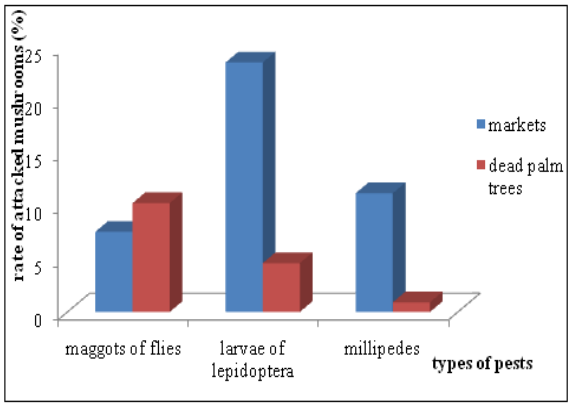

Fig. 5. Comparison of the effects of different pests on the mushrooms collected from the markets and dead palm trees

Evaluation of the damage rate due to different types of pests

Different types of pests contribute to varying levels to the damages observed on the mushrooms (Fig. 5). The maggots of flies, larvae of lepidoptera and millipedes cause respectively 10.27%, 4.6% and 0.91% of the damages observed on the mushrooms harvested from dead palm trees. For mushrooms collected in markets, attacks of maggots of flies, lepidoptera larvae and millipedes cause respectively 7.56%, 23.53% and 11.20% of the damages. The χ^2 test shows that the rates of damages due to the different types of pests are significantly different for both the harvests from the dead palm trees ($\chi^2_{theoretical}$ = 5.09; $\chi^2_{calculated}$ = 7.53; α = 5%) and the harvests from the markets ($\chi^2_{theoretical}$ = 5.09; $\chi^2_{calculated}$ = 12.03; α = 5%) Maggots of flies are responsible for the majority of the damages observed on the mushrooms harvested from dead palm trees. In contrast, the damages observed on the mushrooms collected in the markets are mainly caused by larvae of Lepidoptera. Concerning the markets, these results are explained by the fact that mushroom pickers do not harvest necrotic mushroom buttons or containing maggots. In contrast, they pick the mushrooms attacked by other pests. Indeed, the presence of maggots in some mushrooms can cause buyers to refuse any harvest. The fact that the mushrooms come from many regions also explains the high rate of mushrooms attacked by larvae of lepidoptera. Myriapods are less dangerous because they rarely attack the mushroom

cap. Larvae of lepidoptera are a real danger for mushrooms as they cause more than 25% damages and make these mushrooms non-marketable.

Conclusion

Like any other plants, the mushroom *Volvariella volvacea* growing on dead palm trees is more or less attacked by pests such as larvae of lepidoptera, maggots of flies and millipedes. These damages cause more or less significant losses for households that generate their revenues from the sale of this mushroom. To increase the income of peasants who make their living by collecting and selling this mushroom and encourage rural mushroom growing, it is necessary to clearly identify lepidoptera and flies which cause these damages. The natural predators and parasites of these pests must be studied to consider a biological control. A study of the different varieties of *Volvariella volvacea* can allow the selection of the ones that are less attacked by these pests and protect them against the risk of damage.

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