JUNE 2024

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TECHNICAL BROCHURE

WHITEFLY PACKHOUSE MANAGEMENT BROCHURE

FOR PACKHOUSE MANAGERS IN ACP COUNTRIES

Funded by the European Union

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CONTENTS

Figure 1: Leafy vegetable -sweet potato leaves for export – A preferred host for whiteflies- Photo by KO Fening.

Figure 2: Ornamental plants for export by Ghana Flowers and Green Ltd. Company – Ornamentals could be attacked by whiteflies -Photo by KO Fening

Background

This Whitefly packhouse management brochure for packhouse managers in ACP countries is a part of a series of 4 brochures for the whiteflies management:

1. Whitefly strategy management dossier for the control bodies
2. Whitefly inspection and identification brochure for inspectors and extension workers in ACP countries
3. Whitefly field management brochure for growers in Togo
4. Whitefly packhouse management brochure for packhouse managers in ACP countries

The ACP countries continue to receive increasing interceptions of whiteflies from commodities for export to the EU, especially leafy vegetables. For instance, in 2020, 90 interceptions of whiteflies (mainly B. *tabaci*) on leafy vegetables (41), vegetables (33), edible/infusion flowers (15), leafy fruits (1). The breakdown includes Togo (46), Nigeria (12), Cameroon (8), Suriname (8), Sierra Leone (5), RDC (4), Kenya (3), Congo (1) and The Gambia (1). Considering the new EU regulation already in force, much stringent guidelines are needed to be followed, to ensure interceptions of harmful organisms (specifically whitefly, *Bemisia tabaci*) do not rise to alarming levels that may warrant a ban in any of the affected countries. There is therefore the need to develop interventions to eliminate any potential whitefly or other quarantine pest in produce along the crop value chain (from fields of production, harvesting, sorting, and grading of produce in the packhouse and transporting the consignment to the point of exit).

This leaflet is designed to help people working in packhouses to check, identify and remove or treat any produce that are affected so that no whitefly or other quarantine pest is present in consignments meant for export. Commonly exported leafy vegetables that may be associated with the sweet potato whitefly, *Bemisia tabaci* are shown below (Photos by KO Fening):

a. Cassava (*Manihot esculenta*)

b. 'Alefu'(*Amaranthus* sp.)

c. 'Gboma' (*Solanum macrocarpon*)

d. Sweet potato (*Ipomoea batatas*)

Figure 3. Examples of commonly exported leafy vegetables with high potential for sweet potato whitefly, *Bemisia tabaci* infestation (Photos a-d is by KO Fening and e. by V. Eziah, University of Ghana)

e. Jute, Cochorus oritorius.

Figure 3. *(bis)* Examples of commonly exported leafy vegetables with high potential for sweet potato whitefly, *Bemisia tabaci* infestation (Photos a-d is by KO Fening and e. by V. Eziah, University of Ghana)

Dealing with whitefly – the important steps

Along the supply chain a series of protective measures and checks should be put in place to ensure whiteflies are not present in exported produce.

- At the on-farm level (more details are available in the "Whitefly Field management brochure for growers"):
  - Early scouting
  - Detection
  - Integrated Pest Management (IPM) Control:
    - Cultural: farm sanitation through regular weeding of weeds that serve as alternative hosts for whiteflies.
    - Physical: the use of yellow sticky traps (Fig. 13) for monitoring, mass trapping.
    - Biological: the use of natural enemies of pest, e.g. *Encarsia Formosa, Eretmocerus eremicus,* ladybird beetles, predaceous bugs, lacewings, phytoseiid mites, and spiders.
    - Chemical: biopesticides, botanicals and microbials.

It is prudent to harvest your produce early morning or late afternoon/evening to avoid them being scorched by the sun, which may hasten their deterioration (reduced quality) and shorten the shelf life.

When produce is harvested, it can be kept shortly in a withholding area where further scouting for detection of the developmental stages may be done. Yellow sticky trap can be set up in the vicinity of the produce to also monitor their presence. If whiteflies are detected at the holding area, a conscious effort should be made by removing the infested produce or by undertaking an effective postharvest or phytosanitary treatment such as cold storage, controlled atmosphere, washing, brushing, waxing, dipping, and heating.

- In the packhouse:
  - The quality control manager must be in-charge, taking into consideration the farm history of the produce and whether whiteflies are a major problem there.
  - A representative sample of the produce (minimum 2%) must be taken and inspected for whiteflies at the pre-grading, grading and post-grading periods before the consignment leaves the pack house to the point of exit for final inspection and export.
  - Produce found to have whiteflies must be isolated from the rest or will warrant the implementation of a phytosanitary treatment such as washing with a mineral oil or detergent to ensure whiteflies are dislodged and killed.

Inspection tools such as hand lenses, head visors will aid the easy detection of whitefly developing stages and other quarantine pests.

Description of whitefly and its life cycle

Bemisia tabaci goes through six developmental stages, namely egg, first, second, third and fourth larval or nymphal stages and adult (Fig. 4). The duration of the egg to the adult stage depends on the climatic conditions and the host plant. For example, the duration of the egg-to-adult period of *B. tabaci* under laboratory conditions (25°C, 70 ± 10% RH, 14-hour photophase) was 19.8 days on collard, 21.2 days on soybean and 22.0 days on tomato (Takahashi *et al.* 2008).

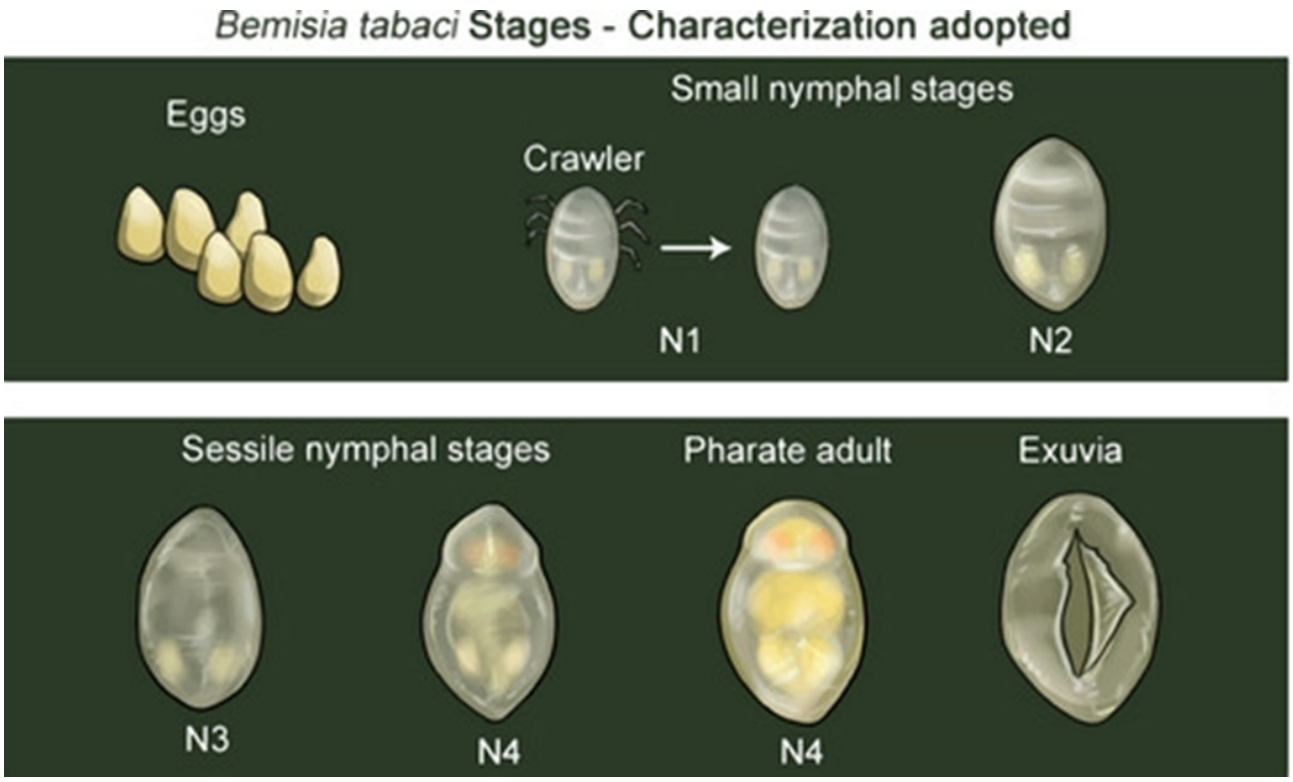


Figure 4: *Bemisia tabaci* developmental stages -
illustration by Gabriella Czepak Caston. Adapted from Czepak *et al.* 2018.

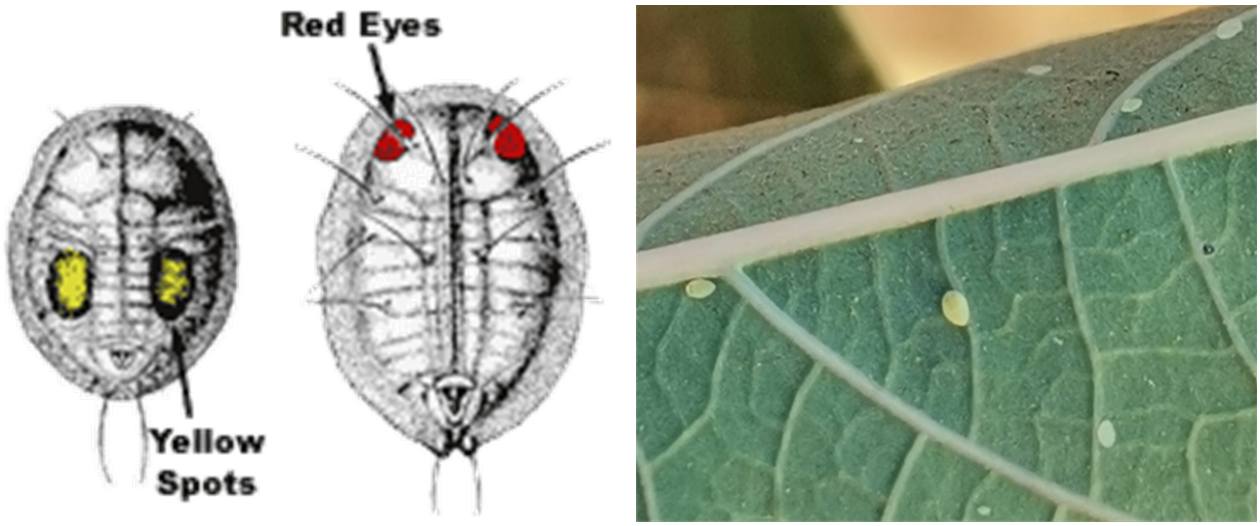
Eggs:

Female whiteflies deposit pear-shaped eggs (Figs.4-5) into the mesophyll or inner tissue of the leaf from the lower surface. Eggs are attached to the leaf by a stalk-like process. Eggs are white when first laid and become brown prior to hatching (Fig. 5). They are generally laid on the underside surface into the inner tissue of the younger upper leaves of the plant (Fig. 5). Females lay from 28-300 eggs depending on host and temperature.

Figure 5: SweetSweet potato whitefly, *Bemisia tabaci* eggs laid in a circle with a 1st instar crawler in the middle and older nymphs nearby. Photo by Erfan Vafaie, Texas A&M AgriLife Extension.

Nymphs:

The first nymphal stage is called crawler (Fig. 6) and the last stage is often referred to as the pupa. After hatching the crawlers move a short distance and settle to feed. Once settled, the subsequent three nymphal stages are scale-like and sedentary. Nymphs are creamy white to light green and oval in outline (Fig. 6b).



a. b.

Figure 6: a. 3rd (left) & 4th (right) instar nymphs called crawlers. (Photo by Tong-Xian Liu).
b. *Bemisia tabaci* nymphs on cassava leaf – Photo by KO Fening.

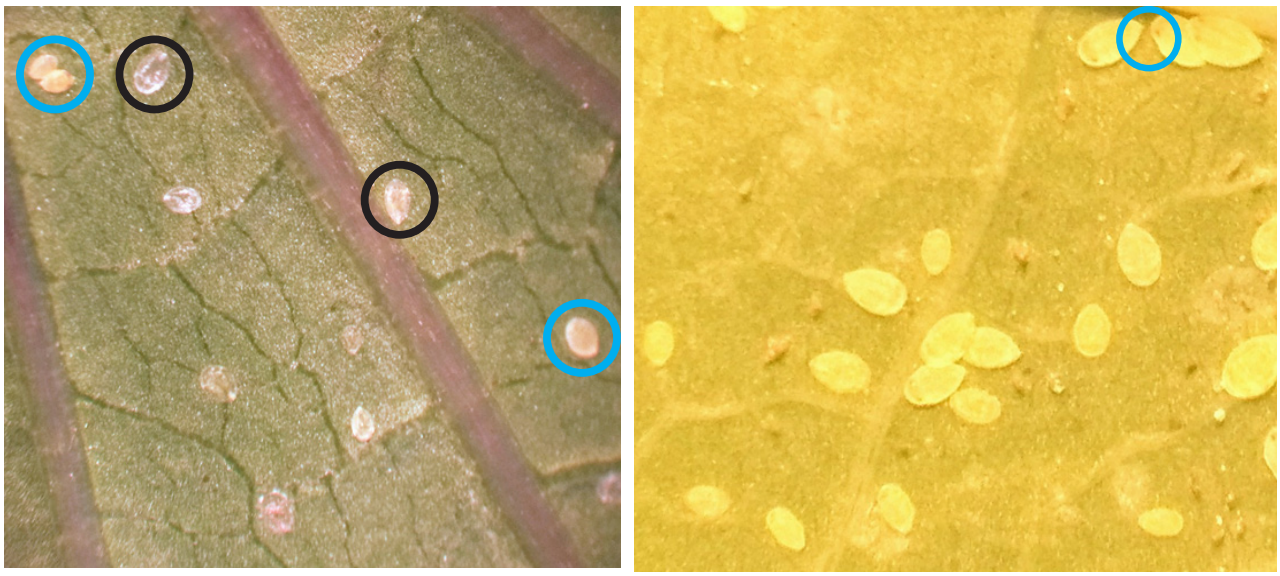


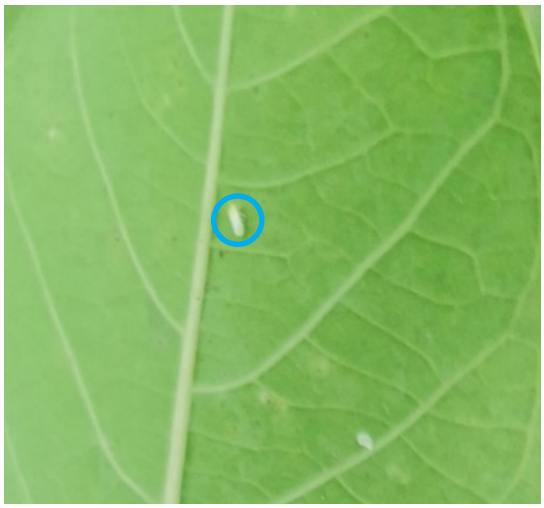
Figure 7: *Bemisia tabaci* nymphs (blue circle) and shed skin (exuvia) (black circle) on cassava and sweet potato, respectively as observed under the light microscope. Photos by KO Fening.

The eggs and early nymphal stages (1st and 2nd instars) might be difficult to observe with the naked eye, unless aided by a magnifying lens. Count large nymphs (3rd and 4th instars), those that are visible to the naked eye (Figs. 6-7). The 3rd & 4th instar nymphs appear as flattened, egg-shaped disks or 'scales (Figs. 6-7). Although the 3rd & 4th instar nymphs should be visible to the naked eye, some of them may blend in with the leaf surface (Fig. 6). So, look for the two yellow spots on the 3rd and young 4th instars and the developing red «eye» spots on the matured or largest 4th instar (sometimes referred to as the pupae) (Fig. 6).

Adults:

Adult sweet potato whiteflies are small, approximately 1mm in length, with a pale yellow body and two pairs of white wings and covered with a white waxy powder (Fig. 8). At rest, wings are held in an inverted V position. Their compound eyes are red.

a.



b.

Figure 8: a. Adult *B. tabaci*- Photo from Public Domain - Released by the USDA-RS/original image by Stephen Ausmus. b. Adult *B. tabaci* on cassava leaf- Photo by KO Fening

Avoid confusion of Bemisia tabaci with other whiteflies

The adult of the sweet potato whitefly (*Bemisia tabaci*) closely resembles the greenhouse whitefly (*Trialeurodes vaporariorum*) but is slightly smaller and yellower. More distinctively, the wings of B. tabaci are held vertical and parallel along the body (Fig. 8a) compared to *Trialeurodes vaporariorum* where the wings are held horizontal along body (Fig. 9).

Figure 9: Adults of the greenhouse whitefly, *Trialeurodes vaporariorum*. (Unlike, *B. tabaci,* the fourth-instar nymphs have very long waxy filaments and a marginal fringe). (see photo above). Photo ©University of California.

Symptoms of whitefly damage

Whiteflies use their stylets in sucking sap from the phloem of plant stems and leaves. High populations of whiteflies cause leaves to turn yellow, appear dry, distorted, discoloured, or fall off (Fig. 10). Whiteflies also excrete honeydew (sugary liquid). Leaves get sticky and covered with black sooty mould (Fig. 11) that grows on honeydew as a result. Honeydew attracts ants, which may interfere with the activities of natural enemies that control whiteflies and other pests.

Figure 10: Damage symptoms and adults of *B. tabaci* on cotton leaf. Photo by David Riley, University of Georgia (CC BY)

Figure 11. Sooty mould on leaf. (Morningchores, 2021).

Figure 12: Damage symptoms and adults of *B. tabaci* on French bean leaf (Photo from A.M. Varela, *icipe*).

Post-harvest measures to monitor and control whitefly

Post-harvest measures are essential to prevent post-harvest infestation and reduce the chance of infested produces reaching the packhouse. The following measures should be implemented:

- Ensure all operators involved in harvest and post-harvest activities can recognize whiteflies and whiteflies symptoms, and know what to do when they find it.
- Have procedures in place, in the field and packhouse, to inspect for whiteflies presence and damage at all produces handling, packing and storage sites. This involves visual checks. This procedure should be available to operators at any time.
- Initiate a whiteflies Alert system and put intervention and isolation procedures in place when whiteflies infested produce is identified.
- Maintain a system for keeping records of packhouse inspections. This detection log should include observations and control measures applied and should be available for audit/NPPO inspections.
- Ensure practices and facilities are in place for the management of all waste, including pest-damaged produces.
- Use refrigerated storage facilities where possible.
- Apply post-harvest treatments, when necessary, using plant protection products:
  - as in the case of field applications, the national authorities should be able to provide guidance on which products to use and how to use them (e.g. application method, dose rate, pre-harvest interval);
  - these must be in accordance with the registration status in the country of origin and the maximum residue level (MRL) of the active ingredient in the EU.

- Ensure harvested produce is never exposed to pest attack during packing, storage (including temporary storage), or transport (road, port or airport). This includes physical screening of transported consignments and packing areas to prevent pest entry. Use of pest-proof packaging is also an option.
- Train all people involved in post-harvest handling so they are aware of and always apply good practices at all times to reduce the risk of pest damages.

This will reduce the chance of infested produces reaching the packhouse. As mentioned above, it is essential to have a strict procedure in place in the packhouse to inspect all produce and identify infested produces. On receiving the produce, packhouse managers must have:

- Procedures in place to record the condition and phytosanitary status (pest presence) of the produce when it arrives at the packhouse;
- A system in place to record all whiteflies control treatments applied pre- and postharvest to each lot;
- A traceability system in place to ensure that each lot is identified and maintained separately through all post-harvest operations.

The packhouse should be designed to prevent the entry of insects (insect-tight). If whiteflies are detected in sticky traps, then inspection of the packhouse is needed to find any possible entry point. Inside the pack house, monitoring of whiteflies is done by placing yellow sticky cards in the pack house (Fig. 13). The sticky cards should be placed at strategic points particularly near the entrance, near the windows and at different points inside the pack house. These cards should be examined regularly or daily for presence of adult whiteflies and replaced periodically (preferably weekly).

- The observance of adult whiteflies (Fig. 8) in the yellow sticky trap (Fig. 13) may call for their possible presence in the commodity for export, thus careful examination must be done during inspection to detect them in commodities for export.

Other than monitoring, physical inspection of the harvested produce against whiteflies in the pack house should be done at three points:

1. Before grading (pre-grading): a representative sample (minimum 2%) should be taken and inspected for all the life stages of whiteflies by wearing a head visor fitted with a magnifying lens (Fig. 14) or using a table/ hand lens and could be observed under a light microscope for more details (Fig. 16).
2. During grading: when the produce is being graded, a quality controller should sample (minimum 2%) the produce being graded and inspect it for whitefly infestation (Fig. 15).
3. After grading (post-grading): after the produce has been graded and packed ready for dispatch from the packhouse, a sample (minimum 2%) should be taken, inspected for presence of whiteflies.

Figure 13. Monitoring and mass trapping of whiteflies and other insects (e.g., thrips) in a greenhouse using yellow sticky traps (Photo adopted from Russell IPM).

Note during the inspection that leafy vegetables and ornamental plants for export may harbour the developing stages of whiteflies (mostly eggs and nymphs) (Figs. 5-6-7) and occasionally the adults (Fig. 8). Adults and eggs (Fig. 5) may hide at the underside of the young leaves, whereas the nymphal stages (Figs. 6-7) may prefer the underside of older leaves. Care must be taken to detect them.

Produce infested with whiteflies should be isolated from the pest free produce and destroyed appropriately or alternatively use an appropriate postharvest or phytosanitary treatment to dislodge and kill them.

Some of the treatments that can be applied in an integrated manner to control whiteflies infestation in produce include cold storage, use of controlled atmosphere, washing, brushing, waxing, dipping, and heating.

- Cold room (also called cool room, chiller room) is a walk-in storage facility in controlled condition to keep a consistent temperature. It is widely used to preserve the quality of stored products like fruits, vegetables, etc. A typical cold room temperature ranges from -5°C to 10°C (www.coldroomplus.com).
- Cold storage may involve precooling of vegetables just after harvesting (on-farm precooling), transporting them in cold vans and storing them in cold rooms or packhouses with cooling facilities. This will maintain the quality of the produce and prolong the shelf life.

Following post-harvest treatments have been implemented with varying degree of efficacy:

- A controlled atmosphere is an agricultural storage method in which the concentrations of oxygen, carbon dioxide and nitrogen, as well as the temperature and humidity of a storage room are regulated. Both dry commodities and fresh fruits and vegetables can be stored in controlled atmospheres. In a controlled or modified atmosphere, air coming into the storeroom or packhouse or being re-circulated within the room must pass through a monitoring and control system to achieve the desired effect.

- Heat treatment involving two varying temperatures in a decreasing manner (i.e., hot water dip of produce for 52°C for 3 min, and followed by 25°C for 3 min) is another option used for some produce to dislodge and kill pests (Abad and Martinez, 2002; Ben-Yehoshua, 2001; Ansari and Feridoon, 2007)
- Washing the infested produce in water mixed with mineral oil to dislodge and kill the whiteflies (Fig. 16).
- The use of surface coating material such as wax can maintained the quality, taste and increase the shelf lifeshelf life (Porat *et al.*, 2005) of some commodities.

Untreated infested produce should not be dispatched from the pack house to the market.

A follow-up in the field where the whitefly infested produce was harvested should also be done and appropriate management measures taken to control the pest (more details in the "Whitefly field management brochure for growers").

Only produce inspected to be free from whiteflies and other quarantine pests should be sent from the pack house to the point of exit for final inspection before approval is granted by the Phytosanitary Inspectors for their export.

Figure 14. Recommended inspection tools (head visor fitted with a magnifying lens, inspection tools bag, forceps and knife or dagger and touch light above), recommended for the pack house to detect pests in commodity for export. Photo by KO Fening, ARPPIS, University of Ghana.

Figure 15. Training of pack house staff on postharvest handling (sorting, grading and inspection for pest). On the table in the photo are chilies and eggplant, which are also critical commodities for export and whiteflies hosts. Note the use of head visors by pack house staff. Photo by KO Fening, University of Ghana, ARPPIS.

Figure 16. Detail inspection by University of Ghana team for the developing stages of whiteflies and other pests on Jute under a light microscope. Where available light microscope will offer a detail observation of diagnostic features of the pest, after an initial observation with hand lens or head visors (Photo by V. Eziah, University of Ghana).

Fig. 17. Postharvest or phytosanitary treatment of leafy vegetable with mineral oil mixed with water to dislodge and kill developmental stages of whiteflies at a pack house. Photos taken by KO Fening, ARPPIS, University of Ghana. (Note these photos were taken before the COVID pandemic).

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Notes

JUNE 24

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