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Establishment of Neochetina spp. (Coleoptra: Curculionidae) for the control of water hyacinth (Eichhornia crassipes) infestation in Lake Tana, Ethiopia

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Abstract

Water hyacinth (Eichhornia crassipes) is a major problem in many parts of the globe causing various threats. In this study an attempt was made to assess the potential of Neochetina spp. introduced from Lake Victoria (Uganda), to control water hyacinth infestation. A lath-house of 10m by10m dimension was constructed near the shores of Lake Tana. Eight pairs of weevils were placed in tubs with several water hyacinth plants. The weevils allowed to feed and mate for 5-6 days and finally retrieved and inoculated into newly prepared tubs. Host specificity test was carried out among common plants in the Lake Tana areas. Within six months more than 2000 new adults were produced. The average feeding spot ranged from 0 - 6.53 with highest observed on Eichhornia crassipes. The result indicated that weevils are well acclimatized and established as reflected by egg deposition, egg hatching and extensive feeding scars on the leaf and petiole. The host specificity experiment shows that these weevils have strong affinity to water hyacinth compared to test plants. Apparently, there is a need for detailed and systematic study on the life cycle of both species prior to release into Lake Tana and its surrounding wetlands.

Introduction

Water hyacinth (Eichhornia crassipes) is one of the top ten worst weed in the world originating in South America (Patel, 2012). Its erect free-floating habit and showy flowers made it attractive for use in ornamental ponds and garden pools, which inevitably led to anthropogenic spread (Center et al., 1999). Its extremely fast growth habit coupled with short doubling time contributed for substantially high load of organic matter in aquatic ecosystems (Waithaka, 2013). The weed might have also germinated from seeds in the after bed when conditions are favourable . Rosette of water hyacinth plant can produce up to 3000 seeds a season which can stay viable for 15-20 years (Barrett, 1980). The weed can also poses human related health risks by creating conducive 35 environment that serve as an ideal breeding site for mosquitoes, schistomes (bilharzias) and other 36 human parasites (Amal et al., 2009, Gezie et al., 2018).

In Ethiopia, the weed was first reported in 1950 from Koka Lake and Awash River (Stroud, 1994). Lake Tana, largest lake in the country which is recently recognized as Biosphere Reserve by UNESCO, was infested by the weed in 2011(Wondie et al., 2012). The north-eastern part of the lake is the area most affected by weed causing various threats to the people and biodiversity in general. The level of water hyacinth coverage varied depending on season with highest biomass usually observed during rainy and post rainy seasons (Anteneh et al., 2015). This might be attributed to high concentration of nutrients that the lake is receiving from tributary rivers and catchment areas (Wondie et al., 2012). Local farmers and fishers are also complaining because of the drastic decline in crop, especially rice, and fish productions along with change of fish meat taste.

Based on the first survey in 2012, about 20,000 ha of the shore on the north-eastern part of the lake was covered with water hyacinth (BoEPLAU, 2012). The regional government understood the severity and the menace of the weed and promoted a massive campaign to manually remove the weed in collaboration with local farmers. Though painstaking and precarious because of health related problems 90 - 95% of the weed was claimed to be cleared from the lake (Edwards, 2013). Nevertheless, within two years the infestation was doubled and reached about 40,000 ha (Anteneh et al., 2015). This shows that the controlling method employed so far , i.e., mainly manual removal, was ineffective.

The methods implemented so far worldwide includes, physical, chemical and biological methods. The physical and chemical methods offer excellent short-term relief. However, they are costly, labor intensive and particularly chemical control poses adverse effect on the rich biodiversity (Yirefu et al., 2014). As a result there is a need for a true integrated approach that incorporate long-term management options as well (Grodowitz et al., 2000). One such approach is the use of bioagents such as the water hyacinth weevils, Neochetina spp. The weevils were very much successful as evident in East Africa, Uganda and Kenya (Ogwang and Molo, 2004), West Africa , Benin (Ajuonu et al., 2003) and Northern Africa , Egypt (Cillers et al., 2003). Moreover, the host specificity of these weevils have been tested in more than 274 plant species in 77 family's worldwide (Julien et al., 1999). To this day manual removal of water hyacinth remains the only method under practice in Lake Tana and has deemed ineffective so. Hence, it was found imperative to assess other long lasting solutions such as biological control agents for controlling water hyacinth. Therefore, the main objective of this study was to assess the effectiveness of Neochetina spp. for the control of water hyacinth infestation prior to releasing into Lake Tana and its associated wetlands.

Materials and methods

Culturing of water hyacinth and Neochetina spp.

A temperature-controlled weevil rearing lath-house of dimensions 10m by 10m was constructed at Bahir Dar University immediately behind the Maritime Academy (Figs. 1-2). 150 adult weevils were brought from Ethiopian Sugar Corporation Research and Developmental Center located at Wonji on April 2017. The water hyacinth was cultured in tubs (70 cm x 20 cm) and fertilized with freshly obtained cow dung (10 gm per tube) and left for a week to acclimatize the new environment.

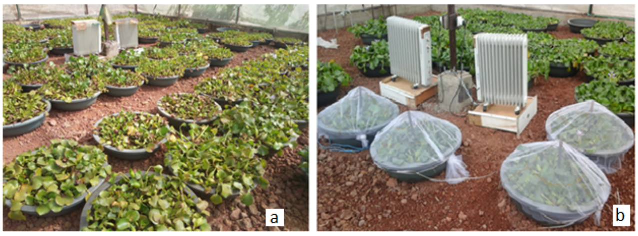

Figure 1: Experimental set up of water hyacinth weevil feeding damage and host-specificity test in lath house in Peda Campus, Bahar Dar University (a) water hyacinth in tubs aclimatizing (b) sort of mass rearing

Family	Genus/species	Common name	Feeding spots/ insect/day
Cyperaceae Fabaceae Poaceae Pontederiaceae Solanaceae Nymphaeaceae Musaceae Gramineae Celastraceae Blank Control	Cyperus papyrus Cicer arietinum Zea mays Saccharum officinarum Eichhornia crassipes Lycopersicon esculentum Nymphaea Musa Oryza sativa Catha edulis Only water	Papyrus Chickpea Maize Sugarcane Water hyacinth Tomato Water lily Banana Rice Khat	0 0 0 0 6.53 0 0 0.07 0 0 0

Table 1: Average feeding scars of the weevil Neochetina spp. among selected test plants for two consecutive months

Weevil stocking and mass rearing

Tub-rearing technique was used to rear the weevils (Ogwang and Molo, 1997). Fifty adults were introduced at first release out of 150 and allowed to feed, mate and lay eggs for about 5-6 days. To reduce adult death weevils were transferred every two days into new jar and supplied with healthy water hyacinth leaves until the weevis were well acclimatized to the new environment . For rearing eight paired adults were placed into the tub and were covered with the net.

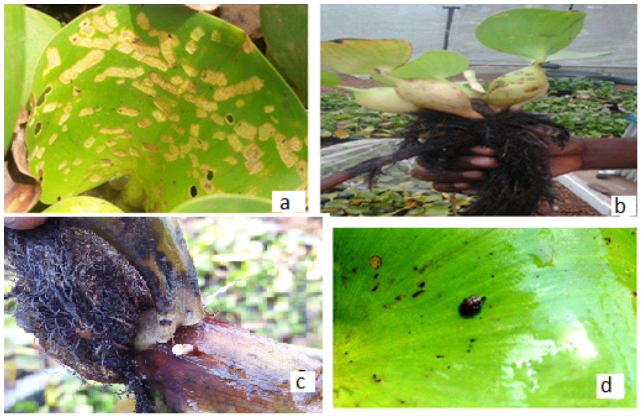

Figure 2: feeding scars and adult water hyacinth weevil (a) leaves, (b) petioles, (c) roots and (d) adult weevi

Host specificity tests

A no choice test was conducted on a selected test plants chosen according to the phylogenetic screening techniques indicated by Wapshere (1974) to test the host specificity of the weevils for two consecutive months. Test plants were selected primarily on the basis of the level of relatedness to the target weed; their economic or ecological importance, and on the basis of the degree to which they share the same habitat with the weed of interest. Accordingly, ten test plants belonging to nine families and one blank without any plant material were used for this particular study. Four adult individuals starved for 24 hrs were randomly placed in each jars with respective food items. The jars were checked every two days for weevil death and damage by the weevil. Subsequently dead ones were removed and replaced with new individuals. The same thing was done for test plants if degradation or color change was observed. Finally, plants were examined and number of feeding spots were recorded every week.

Data analysis

The efficiency of the weevils was examined based on the extent of damage to the different parts of the weed especially by counting number of scars. Moreover, simple descriptive statistics was used for comparison purpose among the tubs.

Results

Acclimatization of Neochetina spp.

The number of individual adults ranged from 50-67 per tub with a mean value of 65 adults per tub. Taking 65 as a mean value, the total number of adults produced so far reached to about 2275 individuals.. The larvae and adults exclusively fed on different parts of water hyacinth plant, adults mainly feeding on the leaf while the larvae usually spent more time feeding on the crown and the petiole on the way (Figs. 3-4). Moreover, two different types of scar markings were observed with circular scars being the most predominant followed by rectangular scars.

Host specificity tests

Excluding two hours of starvation, Neochetina species survived a maximum of three days without any food items. It means the longevity of the insect without any food available was about 5-6 days. However, when weevils were placed on non-target plants their longevity drastically increased.. Greatest survival (average longevity) occurred on Eichhornia crassipes. The average feeding spots ranged from 0-6.53 with the highest observed on water hyacinth. Among the plants tested the weevils fed only on water hyacinth causing numerous feeding scars/spots (Table 1). Fewer scars were also noted on the leaves of Musa, though it was negligible compared to water hyacinth. However, in the paired choice test, the weevils specifically fed on water hyacinths. On the tested plants, the weevil never fed on members of the following families (Cyperaceae, Fabaceae, Poaceae, Solanaceae, Nymphaeaceae, Gramineae and Celastraceae).

Discussion

It is clear that various weeds of tropical and temperate origins are introduced into Ethiopian water bodies with or without consent from mandated organizations. Of these, water hyacinth, water lettuce and the fern Azolla are among the few that need serious attention and follow up by the government and concerned institutions. When it comes to water hyacinth, its occurrence is not a recent phenomenon as it was first reported in Ethiopia about 60 years ago from Koka Lake and the Awash River (Stroud, 1994). There is no clear and tangible evidence on how and who introduced this deadly weed. However, many scholars believe that the weed might have been introduced as ornamental plant and/ or as biofilter which is often the case in many other parts of the world (Julien et al., 1999).

Among various groups of insects, the weevil, Neochetina spp are the most important biological control agents against water hyacinth with apparent success in the tropics including East Africa (Harley, 1990; Julien and Griffiths, 1998; Julien et al., 1999; Cilliers et al., 2003). Their strong herbivory effect along with strict host specific habit contributes these weevils to be an ideal candidate as bio-agent for controlling water hyacinth infestation (Julien et al., 1999; Yirefu, 2017). Great care is required while weevils are transported from an already established areas to other localities as this might affect the final outcome in terms of proper establishment of the weevil population (Yirefu et al., 2014). There is a possibility of weevil death because of prolonged sunlight exposure and other fungal pathogens during the transportation process (Julien et al., 1999). Though few weevils died probably as a result of failure to acclimatize to the new environment and aging, the weevils' in the present study were well established with adult number reaching more than two thousands within short period of time.

Extensive feeding scars of various shapes were observed on the leaf and petioles. The dominant feeding scar was circular hole followed by rectangular holes. Similar findings were also reported from other studies with Eichhorina eichhorniae making circular hole while Eichhorina bruchi drags epidermal layer of the leaf and produce rectangular holes (Heard and Winterton, 2000). The perforation causes significant loss of functional leaf surface and also may allow entry of pathogens which ultimately slows down plant growth and eventually leads to its death (Yirefu, 2017). The larvae is observed tunneling inside the petioles and fed upon the inner tissues of the petioles. Then they moved to the roots to form cocoon, out of root hairs and pupated within the root systems. So the damage is both internal and external with the larvae being the most voracious as it took long time to pupate.

In the present study, the maximum days the weevil survived without any food item was about 5-6 days. This result is comparable with the work of Yirefu (2017), who concluded that the weevil cannot survive more than seven days without food. However, the longevity varied among test plants and water hyacinth plant, with maximum longevity recorded on water hyacinth plant.

Weevils voraciously scrap leaves and petioles. Number of scrapings per insect per day ranged between 0 and 6.53 with the highest observed on water hyacinth plant (Tab. 1). Previous studies

reported that an adult weevil produced an average of about 20 feeding spots per day, and damage by five adults could kill a medium size water hyacinth plant in the laboratory in about 10 days. The number of feeding scars in the present study seems lower compared with the above study, however, similar results are available and reported in various literatures (eg. Yirefu , 2017) . One possible factor for the discrepancy among various studies might be temperature as growth, reproduction and feeding efficiency of the weevil drastically lower when temperature drops (Julien et al., 1999 and Yirefu , 2017). Moreover, adult weevils preferred young leaves as from the fact that youngest leaf was often fed upon while only partially opened. So, better to test with plant parts taken from younger plants or start the testing with new seedlings for standardization.

In general among the tested plants the weevils have strong affinity to water hyacinth though few scars were observed on the leaf of the genus Musa. However, weevils when simultaneously provided with members of the family Pontederiaceae and Musacea, the weevil fed solely on the former one. Yirefu (2017) also indicated that weevils might also feed on families like (e.g. Araceae, Brassicaceae, Commelinaceae) other than Pontederiaceae; however, oviposition was impossible in any of these plants. Hence, what matter is whether an insect of interest can develop on a plant species, not just feed on it as the criterion for judging the safety of an insect before introduction (Zwolfer and Harris, 1971). This study supported the safety introduction of the weevil into water hyacinth infested water bodies of the country and can be a good solution to control water hyacinth infestation in Lake Tana and other aquatic ecosystems in the country.

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