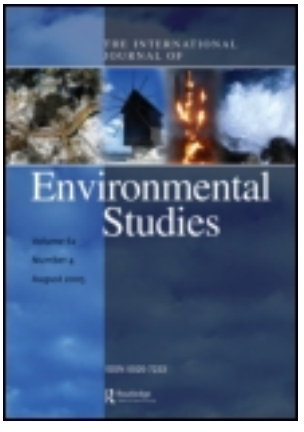

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Establishment of the moth: Niphograpta albiguttalis (Warner) (Lepidoptera: Pyralidae), a biological control agent of water hyacinth (Eichhornia crassipes) in waterways of Lagos and Ogun states, southwestern Nigeria

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Establishment of the moth: *Niphograpta albiguttalis* (Warner) (Lepidoptera: Pyralidae), a biological control agent of water hyacinth (*Eichhornia crassipes*) in waterways of Lagos and Ogun states, southwestern Nigeria

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The moth *Niphograpta albiguttalis* was found infesting water hyacinth on waterways in Nigeria in 2009 in the areas of Badagry, Ejirin and Epe in Lagos State and Iwopin in Ogun State. This moth has not been released in Nigeria but it was released as a biological control agent for water hyacinth in Ghana in 1996 and in Benin in 1993. It is not reported to have established in those countries, but it would appear that as a result of those releases *N. albiguttalis* is now present in Nigeria. The larval instars found were damaging only water hyacinth with bulbous petioles. The larval developmental periods ranged between 10 and 15 days ($n = 3$).

Keywords: *Niphograpta albiguttalis*; Water hyacinth; Establishment; Control

Introduction

Water hyacinth *Eichhorniae crassipes* is one of the fastest growing plants on earth. Originating in the upper Amazon, it has now spread to at least 50 countries around the world in the tropical and sub-tropical regions including Nigeria [1].

Water hyacinth first appeared on the waters of the southwestern part of Nigeria in 1984 through the Republic of Benin [2]. Since then, the weed has invaded nearly all inland waters in the southern part of the country, from low salinity lagoons in Lagos State to fresh water rivers, rivulets and creeks along the coastal areas of Ogun, Ondo, Edo, Delta, Bayelsa, Rivers, Cross River, and Akwa Ibom States. The weed has infested over 60% of Nigeria's fresh and brackish coastal waters including the Benin and Escravos River networks that are major operational areas for petroleum companies [3].

In May 1992, water hyacinth was confirmed on the River Niger in Kebbi State, a border area between the Federal Republic of Nigeria and the Republic of Niger [4]. By 1995, the weed had spread downstream to the Kainji Lake in Niger State, Jebba Reservoir in Kwara State and River Kaduna threatening the Shiroro Dam. These three dams are Nigeria's main

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sources of hydroelectric power generation. The weed threatens fishing and causes 50% loss of fish catch in Nigeria [3]. By spreading on the water bodies, it creates impenetrable barriers and obstructs navigation. It hinders irrigation by impeding water flow and clogging irrigation pumps. Since water is a necessity of life and water hyacinth threatens to make it scarce, unavailable or unsuitable even for normal requirements, there is a definite need to keep this weed in check.

The Federal government of Nigeria through the National Agency for Science and Engineering Infrastructure (NASENI) attempted to control this weed through physical removal and herbicides application, but recognised that these methods were not sustainable due to high cost. In 1994, 3.5M naira (US$23,333) were spent on the physical clearing of the River Niger upstream of the Kainji lake, and on the average US$5000 was spent on the manual removal from just one hectare of infested area [3].

With the problem still unsolved, biological control was considered, as a long-term, cost-effective and environmentally friendly method. The following host specific natural enemies, which were introduced against water hyacinth with notable success in many part of the world [5–7], were considered: *Neochetina eichhorniae* Warner and *Neochetina bruchi* Hustache (Coleoptera: curculionidae) and *Niphograpta albiguttalis* Warren (Lepidoptera: Pyralidae).

In May 1992, a consignment of 2527 adult weevils of *N. eichhorniae* was imported from Australia to the National Horticultural Research Institute (NIHORT), Ibadan. The weevils were mass reared, released and established on water hyacinth in Nigerian waterways [8].

In 2007, the African Development Bank (AfDB) in collaboration with NIHORT began to assess the problem of aquatic invasive weeds in Nigeria. In November 2008, larvae were found feeding vigorously on the petioles of water hyacinth during a damage assessment survey of the established *N. eichhorniae* in waterways of southern Nigeria. These larvae were collected, reared and identified as *Niphograpta albiguttalis*.

Adult moths of both sexes are extremely variable in coloration. Colour varies from golden yellow to charcoal grey, with brown, black and white markings. Adult moths do not feed on water hyacinth. They are commonly found resting on the underside of water hyacinth leaves. Mating occurs soon after emergence and oviposition begins soon afterwards. Some 70% of eggs are laid during the second and third nights and moths live for 4–9 days. Females lay 370 eggs on average. The life cycle takes 21–28 days [7,9–11].

This paper reports the presence and abundance of *Niphograpta albiguttalis* in Nigerian waterways and tries to determine the source of this agent.

Materials and methods

The study area

The study was carried out along the rivers, creeks and lagoons of the coastal states of southwestern Nigeria, which include Lagos, Ogun, Ondo Edo and Delta states. This intricate network of rivers, creeks and lagoons serves as conduits for channelling water from the hinterland to the coast. These waters serve as a means of transportation of goods and people around these coastal areas and are contiguous with similar waterways in neighbouring Benin. The sampled locations within the states are as follows:

Lagos State: Badagry Oto-Awori, Mile 12, Owode, Odo-Ogun, Itowolu, Majidun, Itoikin, Ejirin and Epe.
Ogun State: Oni, Makun and Iwopin.
Ondo State: Mahin, Ugbonla, Erona, Idogba, Oroto, Igbokoda and Igbekebo.
Edo State: Nikorowa, Ekenwa, Ofunama and Ajakurama.
Delta State: Koko, Ologbo, Ethiope West and Sapele.

Collection of samples

At each location ten sites were sampled. Each site was 0.5 km away from another. At each site a quadrant of 0.5 m^2 was thrown and all the plants within the quadrant were collected, placed into plastic bags and processed the same day as follows. Plants from each site were counted (to estimate the no. of plants/m^2) and weighed (to estimate biomass, kg/m^2). All plants from each site were examined for larvae, pupae and adults of insects other than *N. eichhoniae and N. bruchi* and each life stage was counted.

Larvae and pupae were taken to the laboratory and reared at room temperature (24–28°C), relative humidity of 79–92% and a 12 h photoperiod under natural light. The larva and pupa were placed into insect-free water hyacinth plants that were kept in plastic bowls (20 litres), covered with muslin cloth to prevent predation and the escape of adults after emergence, until adult emergence. Developmental periods of the larvae till adults were recorded. Emerged adults were separated to species per site.

Results

Niphograpta albiguttalis was found damaging water hyacinth at four locations in south-western Nigeria (table 1). Only low densities were found, 0.1 to 0.2 larvae per square m and only in plants with bulbous petioles. Where *N. albiguttalis* was found the density of plants ranged from 1.10 to 3.35/m sq. and plant wet weight ranged from 0.13 kg to 0.56 kg (table 1).

The larvae tunnelled in petioles and moved down to the central rosette of the plant to the rhizome causing petioles and plant to wilt, turn brown and rot. The larvae collected developed in 10–15 days (n = 3). Fully grown larvae bored a hole and entered an undamaged petiole and formed a cocoon. Pupation occurred within the cocoon. The mean pupal stage was 8 days (n = 3). Adult emerged from the petiole.

In this study most larvae (83%) were found in Lagos state, on the border state with the Republic of Benin (figure 1).

In all the 28 locations visited, 25 locations had slender petiole water hyacinth infestation while only 10 locations had bulbous petiole water hyacinth, which were areas with regrowth (table 1).

Discussion

Biological control method is cheap, environmentally friendly and sustainable. It has been widely considered and given priority over every other control method. Beginning in the early 1970s, the USDA and CIBC (now CABI-Bioscience) released the weevils *Neochetina eichhorniae*, and *N. bruchi* and later the Pyralid moth *Niphograph albiguttalis* as

Table 1. The estimated mean number and wet weight (kg) of water hyacinth plants with bulbous and slender petioles per square metre at each site and the mean number of larvae of *Niphograpta albiguttalis* found per square metre

Location	State	Bulbous petioles			Slender petioles		
		Number	Weight	No. of larvae	Number	Weight	No. of larvae
Badagry	Lagos	3.35	0.56	0.2	23.7	4.61	0
Ejirin	Lagos	2.9	0.52	0.1	19.2	3.93	0
Epe	Lagos	2.6	0.49	0.2	22.09	4.54	0
Iwopin	Ogun	1.9	0.18	0.1	21.3	3.57	0

biological control agents of water hyacinth in infested countries including Ghana, Benin and Nigeria. Releases were made in 1994, 1991 and 1993 for *N. eichhorniae* and 1994, 1992 and 1995 for *N. bruchi* respectively. They both established in these countries [8,12].

In many situations the control achieved has not been sufficient [13] and so there is need to release new agents to complement the damage caused by the weevils. This need has led to the release of a moth *N. albigutallis* in Ghana in 1996 and in Benin in 1993, but this moth did not establish in these countries [12]. The unsuccessful establishment of the moth may be due to lack of attention to some of the following issues discussed by Wright [14,15] and Julien *et al*. [16] that can limit or prevent progress. They include: site selection, obtaining and maintaining healthy colonies of agents for mass rearing, rearing and releasing healthy and fecund individuals; and, depending on the dispersal capacity of each agent, repeated and multiple releases.

The larvae of this moth found in the waterways of two southwestern states in Nigerian in 2008 without release, could have been from adults dispersed from Benin the nearest site of release in 1993. This is most likely since more than 83% of the total larvae found in the four locations of the two states were found in Badagry, Ejirin and Epe, locations in Lagos state, the border state to Republic of Benin (figure 1). This is in agreement with the report of [12], which stated that adult *N. albigutallis* disperse rapidly up to 4 km per day. Similarly, *N. albiguttalis* was initially released only in southern Florida, but populations dispersed more than 500 km within 18 months [17]. This moth was released at two sites in Louisiana during May 1979 and collected 27 km from the nearest release site a year later [18].

The range of the larval developmental days of *N. albiguttalis* would have been a little more if the all the larvae found in the field and reared in the laboratory were first instar.

The preferential attack of plants with bulbous petioles alone by *N. albiguttalis* is in agreement with the observation of Julien [12]. This states that the moth targets new, tender plants, typically those on the edge of expanding mats, regrowth plants or those plants involved in early invasion.

Where biological control of water hyacinth is demonstrably successful it has been a result of the activities of either *N. eichhorniae* or *N. bruchi* or both. The impact of the moth on populations of the weed is insidious, hard to quantify and unlikely to control serious infestations of the weed [12]. But, the moth appears to complement the actions of other control methods, both biological and non-biological, by reducing spread and invasiveness [12].

N. albiguttalis was not released in Nigeria. As it is established in the western coastal waterways, it is likely that it moved into Nigeria from releases made in Benin. Future evaluation of the biological control of water hyacinth should also include evaluation of the population, spread and impact of this moth.

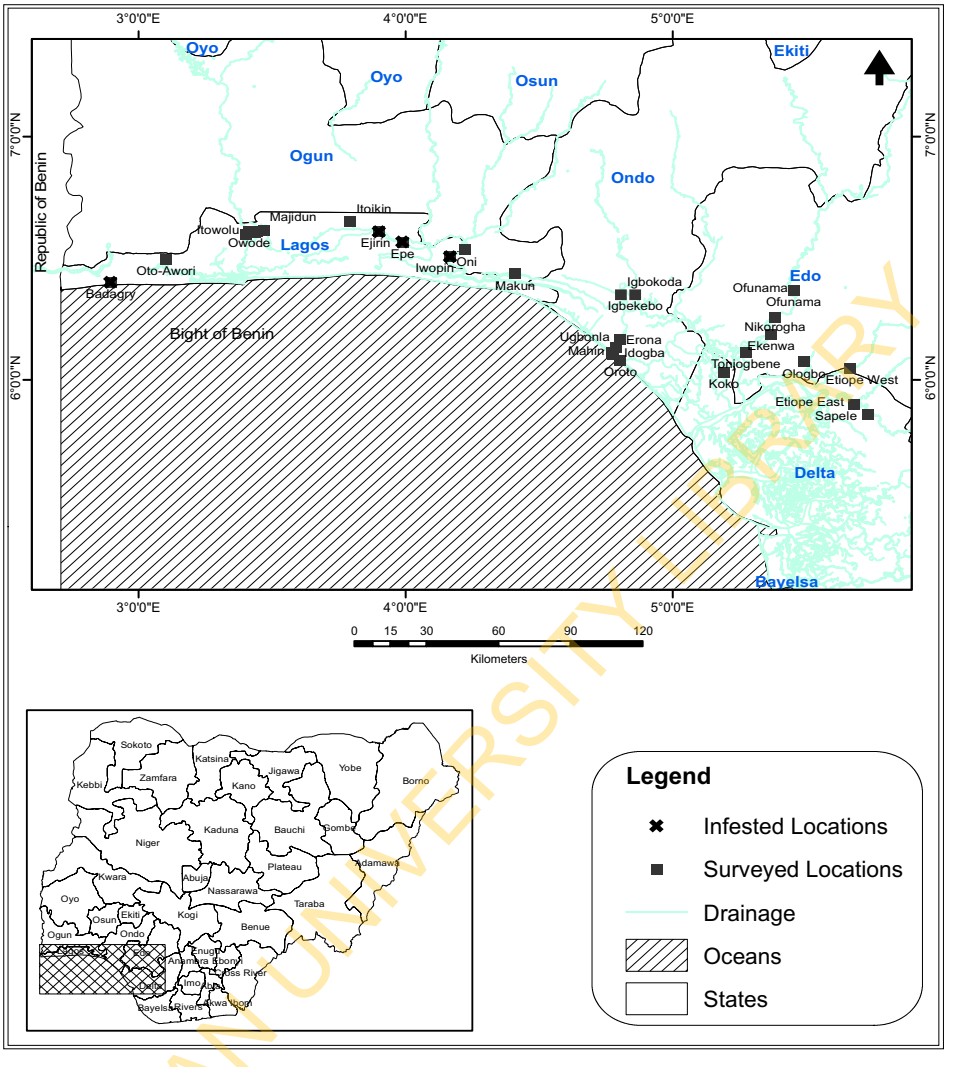

Figure 1. Locations in southern Nigeria where water hyacinth was surveyed for the moth *Niphograpta albiguttalis* and the sites where larvae of the moth were found.

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