Biological Control Efforts of Water hyacinth (*Eichhornia crassipes* (Mart.) Solm) on Kainji Lake, Nigeria

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ABSTRACT

Biological control of water hyacinth (*Eichhornia crassipes* (Mart.) Solm) was monitored on Kainji Lake between 1995 and 1999. The two most important host specific natural enemies of water hyacinth (*Neochetina eichhorniae* and *N. bruchi*) were used and impacts of the weevils on water hyacinth were monitored on tri-monthly basis. The manual control initiated by the National Institute for Freshwater Fisheries Research (NIFFR) encouraged the fishermen to physically remove water hyacinth from their shores and open water. The lake hydrology, most especially during the drawdown period when the water volume is reduced tremendously, allows water hyacinth plants to be stranded by the bank of the lake thereby leading to massive destruction of the weed population and consequently the weevils population stability. The floristic composition of macrophyte intimately mixed with the water hyacinth was also monitored during the low and high water regimes. Among the prominent plant species found with water hyacinth included *Echinochloa stagnina, Mimosa pigra, Polygonium senegalensis Polygonium lanigarium. Sesbania dalzelli,* and *Vosia cuspidata* were found competing with the much favoured *Echinochloa spp* which serves as forage to livestock around the lake; However, no incidence of weevil attack was observed on any of the vegetation mixed with water hyacinth.

Keywords: Biocontol, Kainji Lake, Water hyacinth, Weevils

1. Introduction

The infestation of water hyacinth in the coaster areas of Nigeria was reported in 1983 (Akinyemiju 1987). Since then, the area covered by the weed has continued to increase while fresh ones are added annually at the end of the rains between October and December Akinyemiju (1994). However hyacinth on Kainji lake was first reported in 1989; Kusemiju (1994) and Akinyemiju (1995) both reported the extensive coverage of the lake by the noxious weed. Water hyacinth, a mat forming plant can multiply rapidly and double its population within 12-14 days under favourable environmental condition (Thyagarajan 1984).

Several studies have been carried out on by the vegetation of Kainji Lake (Imevbore, 1971, Hall 1975, Obot 1984). The invasion of Kainji Lake by water hyacinth in recent years attracted attention locally and internationally through the on-going Nigeria German KLFPP. The adverse economic and ecological implication of the presence of this noxious weed on Kainji Lake necessitated the initiation of different approaches to manage the weed. Among these various management options is biological control.

Biological control of aquatic weeds has been implemented in different parts of the world (Forno l981); Goyer and Stark, (1988); Harley (1984); Perkins,(1972); Baker et al (1974); Martryn (1985) and Manning 1979). It was generally reported that a natural enemy of water hyacinth from where it originated (Brazil) possesses the ability to suppress the population under favourable conditions. The National Institute for Freshwater Fisheries Research (NIFFR) adopted this method of using the much favoured bio-control agent (Nechetina spp) to control water hyacinth. Since the incursion of the weed into the Lake Kainji, the impact of these weevils was monitored and the results were presented. Also, a close observation has been made on the changes in the flouristic composition of aquatic vegetation of the Lake.

The objectives of this paper therefore are to evaluate the efficacy of bio-control agents *(Neochetina eichhorniae and N. bruchi)* introduced to the lake for the control of water hyacinth and evaluate any impact of the bio-control agents on other vegetation of the lake.

2. Materials and Methods

2.1 *Study Area*

Lake Kainji is located between latitude 9^{o} 45" and l0^{0} 08" and between longitude 4^{o} 05" and 4^{o} 09" with a total surface area of 1270 Sq Km. The lake stretches over 130 Km from south at the dam site to north at Yauri (Figure 1). The Lake is 24 Km at the widest part around Shagunu and over 60 m depth at its maximum; At full volume, the lake water may reach an altitude of 142 m above sea level. The lowest water level is reached in August at the peak of the raining season while the lake refills to variable high water levels between September and March before the early rains (Obot, l984). The Lake hydrology has been documented (Olokor, 1994). The Lake experiences two flood patterns; the white and black flood. White flood begins in August while black flood starts to come in as from October in the upper reaches of the lake every year. The highest water level is January while the lowest water level is between July and August.

2.2 Method of Study

Assessment of presence of other plants and weevil interaction

Aquatic plant species in association with water hyacinth were identified and recorded during low and high water regimes. The plants encountered were scored relatively to their presence and abundance. The abundance and dominance of observed macrophytes were represented by the following signs

-	=	Not Present
x	=	Present
xx	=	Dominant where present
xxx	=	Dominant and almost covering the water surface fully where present

2.3 Insect Release

Potential release locations were identified prior to the release of the weevils. The locations are as shown in Figure 1. The release locations were selected on the basis of relative high population of water hyacinth, release locations being relatively free of human interference and the fact that plants at the locations must be stable of for infestation by the weevils such that infestation can be monitored over time.

The National Institute for Freshwater Fisheries Research in collaboration with National Committee on water hyacinth based at Ibadan and IITA Benin Republic established both the field and laboratory insectary for where weevils multiplied over a period of six months before any release was carried out. The field insectaries were located in Yauri at the point of River Niger entrance into Lake Kainji in three floating cages with dimension 4m x 4m or 16m^{2}. Each insectary consists of nylon mosquito net size cage suspended on water by iron pole attached to the soil under water. Inside each insectary were assembled about 100 adult water hyacinth plants. In each insectary, approximately 50 adult weevils were introduced. These weevils have been previously reared at NIHORT, Idi-ishin, Ibadan.

Laboratories were located at both NIFFR headquarter at New Bussa and Kebbi State department of Fishery at Yauri where adult water hyacinth were placed in a plastic bowl of about 20 litre size. Three dozens of these bowls were used in each of the laboratory insectaries. Five adult plants were placed in each plastic bowl with almost 3-5 adult weevils were place in each bowl for insect multiplication.

In this study, insect release constitute the introduction of a whole water hyacinth plant previously checked for the presence of adult weevils approximately 6 weevils/plant comprising of adult pupa and larva stages of weevil's development. The infested plant was introduced into the upper reaches of River Niger beyond the lake towards Dolekana (the boundary of Nigeria) and all the six locations selected for monitoring as described above and monitored from October 1996 to April 1999. The weevils were introduced at four different times (August and November 1996; January 1996 and January 1997. The weevils allowed establishing till October 1996 when monitoring commenced.

2.4 Monitoring

The six permanent sites were selected for the monitoring the activities of the weevils are as shown in Figure 1. The general effects of the weevils on water hyacinth were assessed on a scale of 1-10. The criteria for damage score are as shown in Table 1. In addition, the number of feeding scars, dead and green leaves, leaf length and number of daughter plants were recorded on randomly selected 25 plants at each location. Observations were also made of associated aquatic plants with respect to species identification, frequency, impact of the weevils on them and their health in general.

Data collected were analyzed using descriptive statistics, correlation among the various parameters were also calculated, bar and line graph were used to show trends observed. Microsoft Exel 97 and SPSS 6.0 computer packages was used for all the analysis.

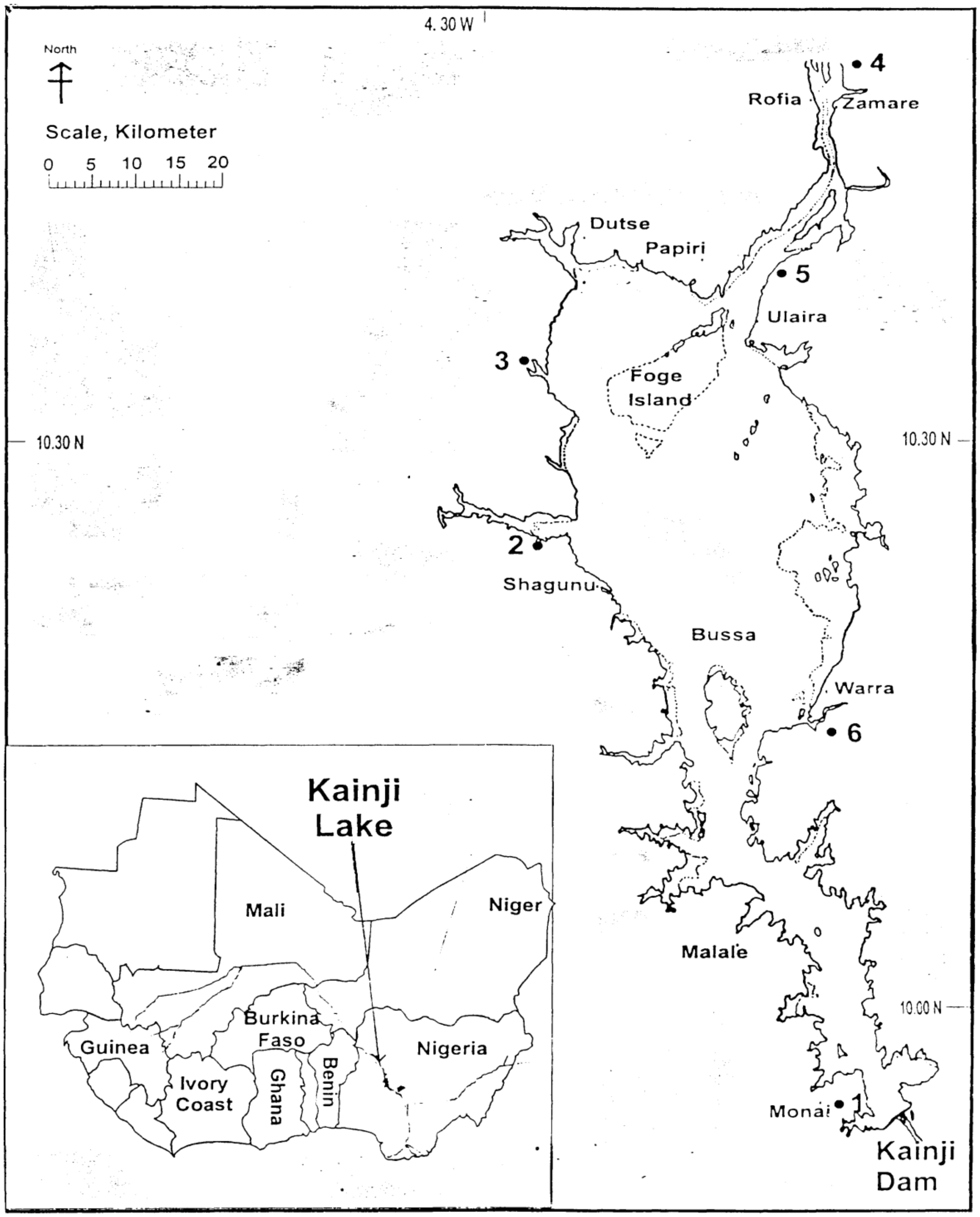

Figure 1: Map of Kainji Lake showing sampling stations (1 – 6)

Table 1: Criteria for scoring the general level of attack of weevils on water hyacinth plant.

Scale	Description
1	10% level of damage
2	20% level of damage
3	30% level of damage
4	40% level of damage
5	50% level of damage
6	100% level of damage
7	100% plus rolled leaves
8	100%
9	100% Plus less dense plants
10	100% Plus reduced plant population

3. Result and Discussion

3.1 Macrophyte Composition

Since the time of impoundment, earlier studies predicted that aquatic macrophyte most especially, the floating species will find it difficult to thrive on the lake (Imevbore, 1971). Recent invasion of the lake by water hyacinth changed this line of prediction and the major macrophyte found on the after water hyacinth invasion are listed in Table 2. It is obvious from Table 2 that the prominent species, which are found mostly at the upper region of the lake include *Vossia cuspidata, Sesbannia dalzeli, Saccioleptis africana* and *Polygonium* spp They are the dominant macrophytes found in almost every part of the lake. The bio-control agent did not attack any of these plants; this confirmed earlier reports of the host specificity of the weevils.

Vossia cuspidata and *Sesbania dalzeli* are competing very fast with the most favored Niger grass (*Echinochloa stagnina*) which is being utilized as forage for livestock by all the riparian communities. With the presence of *Vossia cuspidata, Sesbannia dalzeli and Saccioleptis africana* on the lake, the flouristic composition are changing gradually and the population of *Echinochloa stagnina* is reducing very fast. *Vossia cuspidata* and *Sesbannia dalzeli* are found to be useful in the same way as *Echinochloa* spp. *Sesbannia dalzeli* is a grain legume forb which could produce nodules thereby having potential to re-fertilize the soil of the drawdown area by fixing atmospheric nitrogen into the soil. Moreover, many fishermen utilize the stem as a floater during fishing. This factor gives the plant (*Sesbannia dalzeli*) a double advantage over *Echinochloa* spp. The biology and physiology of *Sesbannia dalzeli* require further in depth study to fully evaluate its full potential within the lake ecosystem.

3.2 Bio-control of Water hyacinth

It is difficult to estimate the population of the weevils because of the nocturnal nature of the adult insects *(Neochetina eichhorniae and N. bruchi)* which remains hidden near the base of the water hyacinth. Due to this factor, an indirect method of estimating weevils population as developed by Wright & Centre (1984) was used. A close relationship was found between number of adult weevils and the number of feeding scars on the water hyacinth leaves. The derived empirical formula:

$I = 0.0366S^{0{,}775}$ where I - weevils per plant and S = feeding scars per lamina.

This formula was employed to predict the population of the weevils. At the beginning of monitoring period in October 1996, the average population of adult weevils was estimated approximately one adult weevil per plant for either *N. eichhorniae or N. bruchi* at each of the monitoring locations. The adult weevils were buried in the crown of the plant. From the known biology of the weevil, the population of each of the weevil was expected to be more than 20,000 weevils both adult pupa and larva stages at each released location a year after the initial released. Figure 2 gives the maximum egg production and feeding impact under favourable environmental condition. The highest oviposition and feeding was attainable at 30 ℃. (Source: Deloach and Cordo, 1976).

The activities of the weevils were prominent on every water hyacinth found on the lake. This is obvious from the data collected on the performance and stability of bio-control agents as shown in Figure 3 - 5. During the time of observation, April data gave a vivid assessment of the weevil's performance in terms of the number of feeding scars recorded (Figure 3a); this period corresponds with the drawdown period when the volume of the water in the lake is going down.

Table 2: Distribution and dominance of major macrophytes in Kainji Lake between August 1996 and January 1999

Species	Period of Observation (Low and High Water Level)					
	1996	**1997**		**1998**		**1999**
	August	**January**	**August**	**January**	**August**	**January**
Floating	xx	xxx	x	xx	x	x
Eichhornia crassipes	x	-	-	-	-	-
Pistia stratiotes	x	-	-	-	-	-
Lemna pauscotata	x	x	x	x	x	x
Ipomoea aquatic						
Submerged						
Ceratophyllum dermersum	x	x	-	x	-	x
Emergent						
Echinochloa stagnina	xxx	xxx	xx	xx	xx	xx
Echinochloa pyramidalis	x	x	x	x	x	x
Sacciolepis Africana	x	x	x	-	x	xx
Vossia cuspidate	x	x	x	xx	xx	xx
Leersia hexandra	x	x	x	x	x	x
Mimosa pigra	xx	xx	xx	x	x	x
Polygonium senegalensis	xx	xx	x	x	x	x
Polygonium lanigarium	xx	x	-	-	-	-
Sesbannia dalzieli	xx	x	x	x	-	xx
Sphenochlea zeylanica	-	x	x	x	x	x
Ludwigia decurrens	-	x	x	x	x	x
Sorghum arundinaceaum	x	x	x	x	x	x
Cyperus spp	x	-	xx	-	xx	x
Phygramite karka	-	x	x	x	x	x
Ipomoea asarifolia	x	x	x	x	x	x

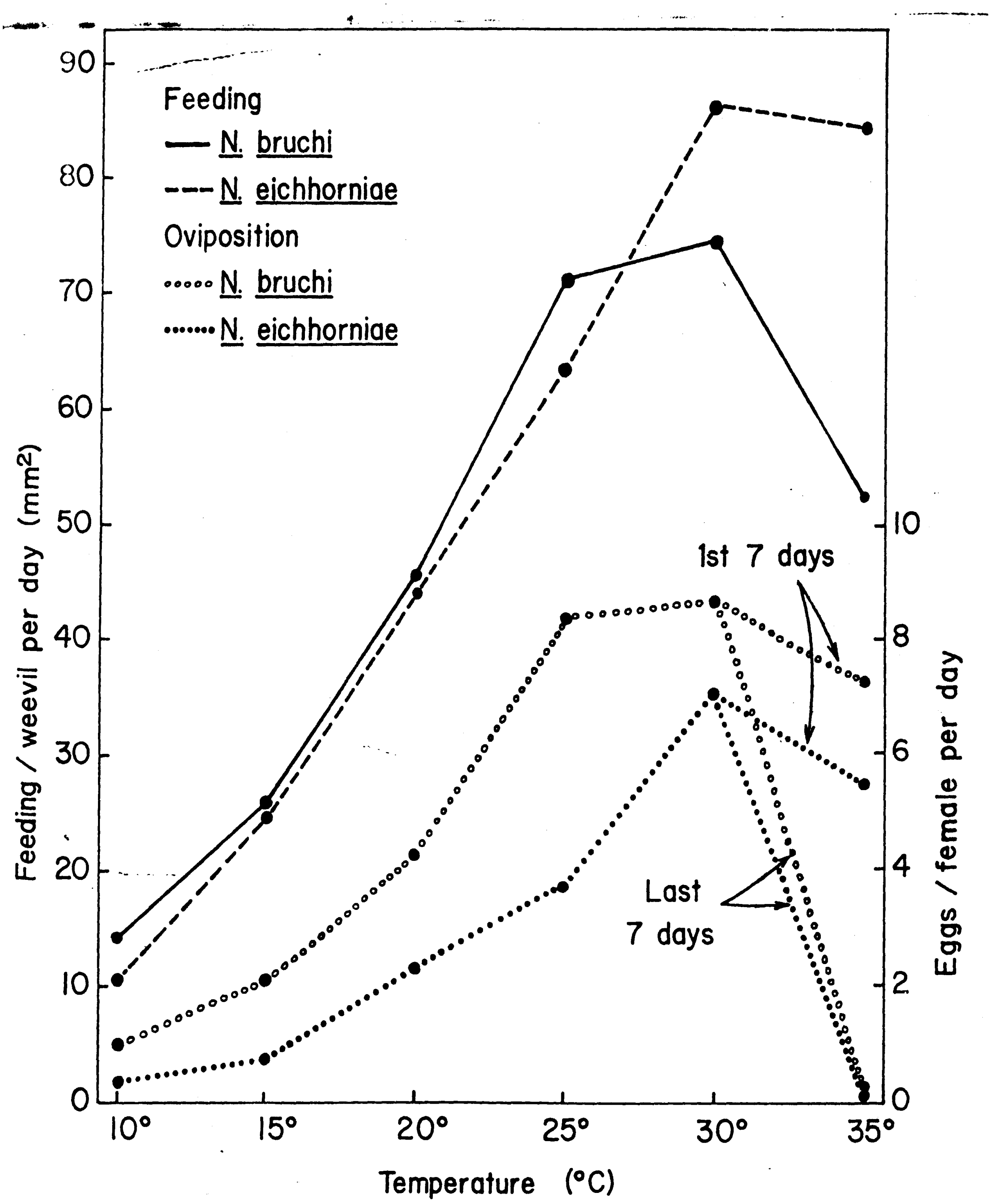

Figure 2: Egg production and feeding impact under favourable environmental condition.

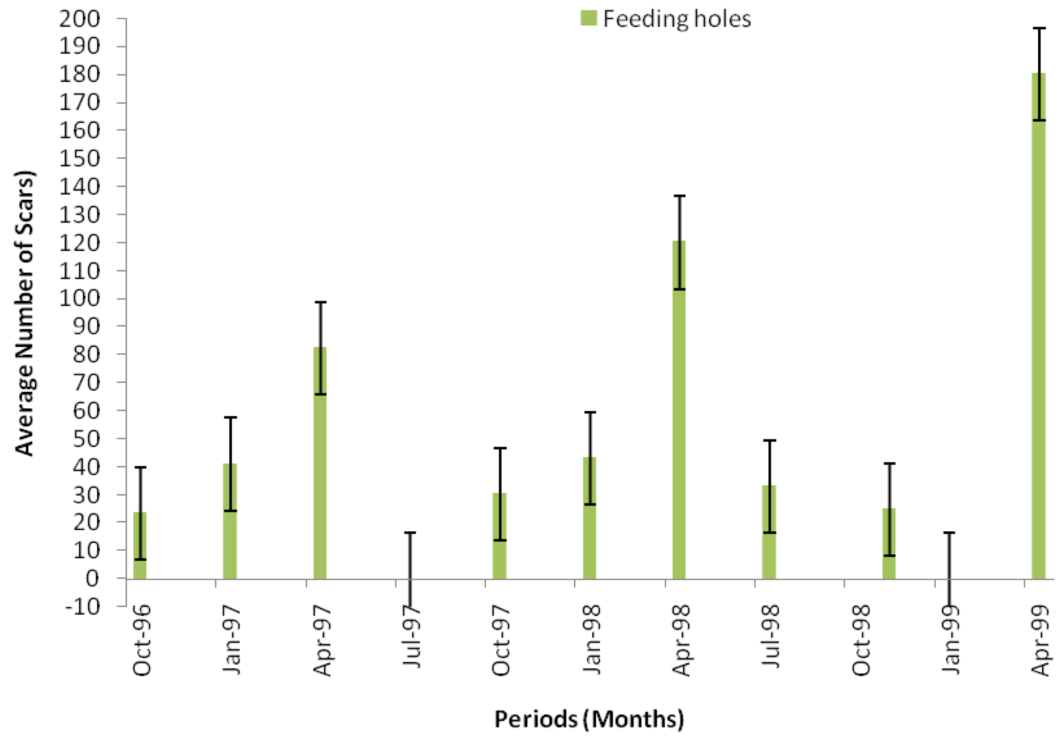

Figure 3a: Number of feeding scars per plant of the assessed water hyacinth population

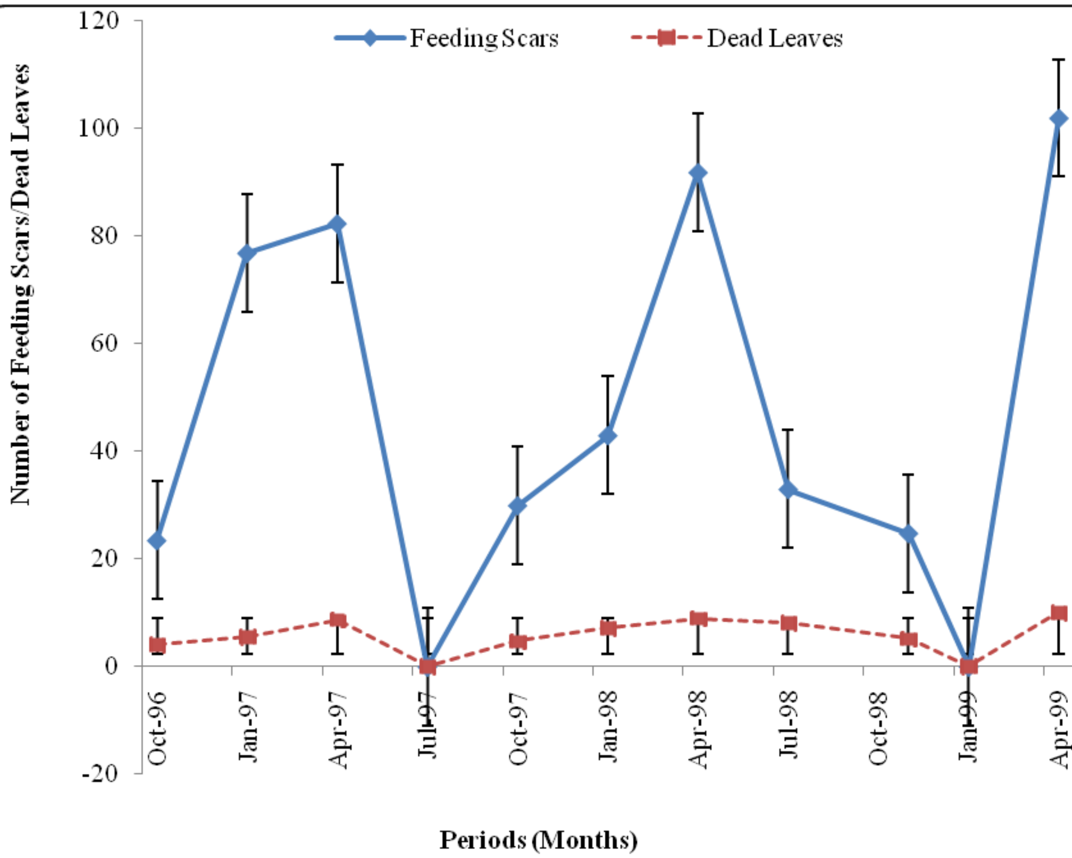

Figure 3b: Relationship between weevil's feeding scars and rate of water hyacinth leaf mortailty

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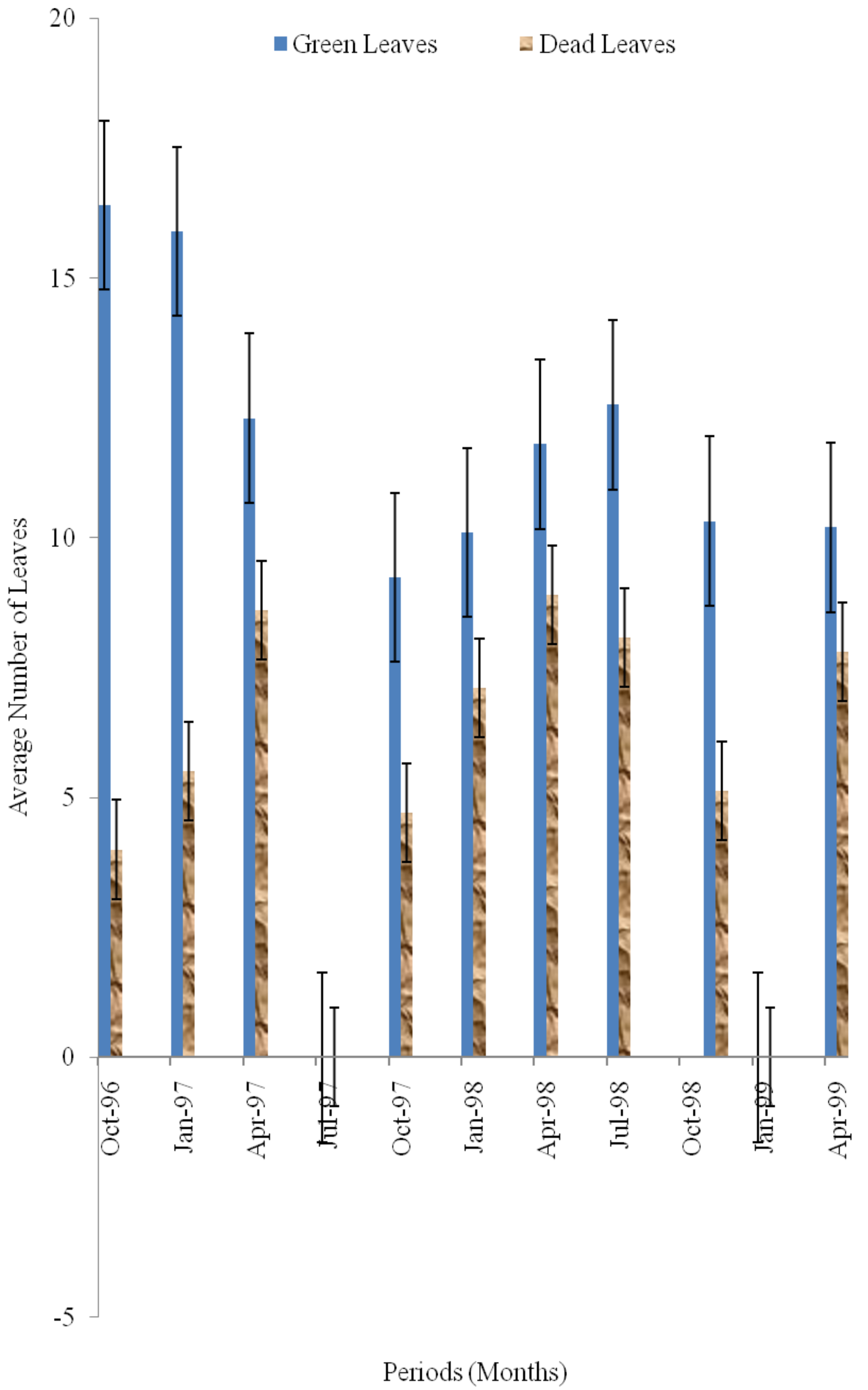

Figure 4: Effect of two weevils on water hyacinth leaf production

Figure 3a & b shows the level of feeding activities of the weevils between October 1996 and April 1999. Except for July 1997 and January 1999 when data were not collected, the result revealed a good performance of the weevils in suppressing the massive proliferation of water hyacinth over a given time. When monitoring commenced in October 1996, the number of feeding scars increased until April 1997. The highest feeding scar has been consistently recorded in April every year during the specified monitoring period (Figure 3a). When feeding scars increases, the photosynthetic ability of the plant is reduced and this eventually leads to growth retardation and finally plant death. Feeding scars also correlate positively with the dead leaves recorded (r = 0.67) and this is significant at 5% level of probability (Figure 3b). The leaf productions of water hyacinth during the monitoring period were shown in Figure 4. The numbers of dead and green leaves recorded were compared; the trend of the dead leaves is similar to what is observed for the feeding scars. The impact of the two weevils *(N. eichhorniae* and *N. bruchi)* shows a high positive

correlation between feeding scars and dead leaves r =0.72. As the number of feeding scars increases which shows that the weevils were feeding on water hyacinth, the number of dead leaves increases in these ways. During feeding the weevils remove the epidermal layers of water hyacinth leaf, which contain chlorophyll used for photosynthesis activities. Due to this factor, the plant becomes retarded in growth and finally death will result and this agreed with the report of Dehoach 1976; Perkin & Maddox 1976.

Over the years, plants were found to be more stable on the lake in April when compared with other period of the year. Fresh water hyacinth plant usually comes with the flood into the lake as from August with the peak in January (Olokor, 1994). Low feeding scars observed in January (Figure 3a & 3b) could be due to the dilution of the existing water hyacinth population on the lake with the fresh ones coming with the flood from the neighbouring countries which may carry no weevils. Immediately after the flood and the water in the lake recede, the plants get stabilized and the weevils start to destroy the existing water hyacinth population adequately.

Moreover, the Lake hydrology left the plants stranded during the low water regime and the efforts of the riparian communities involved in the manual control reduces the population of the plants on the lake during these periods. Once the plant population decreased the weevils population dynamic will be affected since the weevils could not multiply nor survive without the presence of water hyacinth (Perkin & Maddox 1976). At the highest peak of feed scars observed, the population dynamic of the weevils estimated with formula $1=0.0366S^{0,775}$ is approximately 4-5 weevils per plant.

Figure 4 shows leaf population of water hyacinth during the monitoring period. The figure shows the average number of green and dead leaves recorded on the individual plants observed between October 1996 and April 1999. There was negative trend between green leaf and dead leaves. Though the trend is not stable but persistently dead leaves continue increase as shown in Figure 4. As from October 1996, it is quite apparent that the number of green leaves followed a downward trend while the number of dead leaves is increasing. As at April 1999, green leaves has dropped in number when compared to the time that the monitoring began. The dead leaves as well increases over time marginally. There was a negative correlation between green and dead leaves (r = 0.36) but now significant at 5% level of probability. It should be noted that the feeding activities of the weevil contributes to the destruction of water hyacinth leaves.

One of the fastest way of by which hyacinth multiply its number under favourable conditions is the production of daughter plants through stolons. Figure 5 shows the trend in the off shoot development of water hyacinth plants. It was obvious that the number of new off shoot plants follows a downward trend since the time the monitoring started except for July 1998 and April 1999 respectively. The reason for these could be due to the fluctuation in the water level of the lake particularly during the drawdown period in the lake hydrology which reduces the water hyacinth population of the lake naturally and which invariably reduces population of the weevils. This result agrees with the finding of of Goyer and Stark 1984; Forno 1981 and Thielien *et al* 1994 and it shows that the bio-control is effective in controlling the weed under favourable environment.

4. Conclusion

The effectiveness of weevils *(Neochetina eichhorniae and N. bruchi)* cannot be over emphasized as long as the weed population is available as the host specificity has been validated by earlier research. Biocontrol is a good complement on the integrated weed control employed on water hyacinth on Kainji Lake.

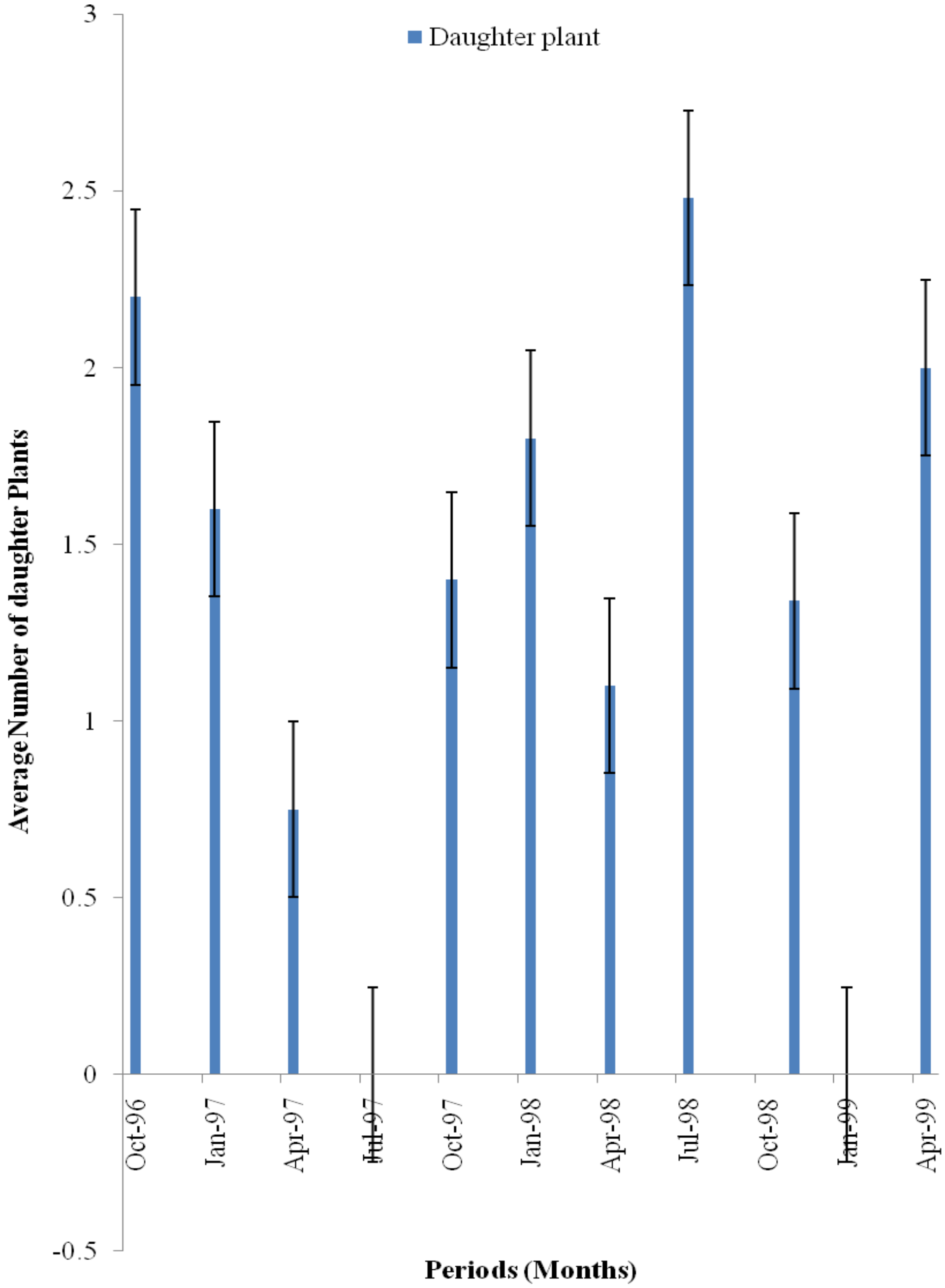

Figure 5: Rate of daughter plant proliferation assessed on water hyacinth plants

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