Contribution of *Caridina nilotica* (Roux) in the Dagaa Fishery in Lake Victoria, Tanzania

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The contribution of Caridina nilotica *in the* Rastrineobola argentea *(dagaa) fishery was assessed at nine beaches in the Tanzanian part of Lake Victoria from May, 2001 to April, 2002. Additional data on dagaa and* Caridina *catches from Sweya beach between October, 2000 and April, 2001 were also included. Two main methods are used to catch* R. argentea *and* Caridina *in the Tanzanian waters of Lake Victoria: mosquito seine nets (5 mm and 10 mm mesh sizes) and catamaran lift nets (8 mm mesh sizes). The majority of the beaches used mosquito seine nets as the main gear; lift net fishing was dominant at Igombe and Busekera beaches.*

Between May, 2001 and April, 2002, 157,390 t of dagaa were harvested in the Tanzanian waters of Lake Victoria; mosquito seine nets harvested 139,674 t (89%) compared with 17,716 t by lift nets (11%). CPUE was 244 and 337 kg boat^{-1} day^{-1} respectively for lift nets and mosquito seine nets. A total of 17,326 t of Caridina *was harvested in the Tanzanian waters of Lake Victoria during the same period. More* Caridina *was harvested by mosquito seine nets (95%) than by lift nets (5%). Catch-per-unit-effort (CPUE; kg boat^{-1} day^{-1}) for* Caridina *ranged between 1.87 and 45 kg boat^{-1} day^{-1}, and varied with respect to location, time and fishing method. Sweya beach exhibited the highest CPUE and the lowest was at Nyangómbe beach. High CPUEs for* Caridina *were found during the rainy season at Sweya, Igombe, Kome and Busekera beaches. The rest of the beaches exhibited high CPUE during the dry season. CPUE of* Caridina *in lift nets was greater than in mosquito seines at Igombe and Busekera beaches. However, CPUE for dagaa at Igombe was higher for mosquito seines than lift nets. Reasons for these differences are unknown but probably relate to the location of fishing, particularly between inshore and offshore locations. Haplochromine cichlids were also abundant in the* R. argentea *catches at Igombe beach. The highest CPUE for haplochromines was at Igombe in January, 2002 and the lowest in June, 2001 (average CPUE for haplochromine cichlids at Igombe was 736 ± 746 kg boat^{-1} day^{-1} for lift nets). The total haplochromine catch for the region was estimated at 53,446 t. The carapace length (mm CL) distribution of* Caridina *in* R. argentea *commercial catches ranged between 1.5 mm CL and 8 mm CL depending on the gear used.*

Keywords: Catch rates, effort, exploitation, *Rastrineobla argentea*

Introduction

Since 1986, the abundance of *Caridina nilotica* (Roux) in the Tanzanian waters of Lake Victoria has increased tremendously, although few quantitative records are available (Cowx et al., 2003; Matsuishi et al., 2006). *Caridina nilotica* is observed in trawl catches, in the stomachs of Nile perch and is an important by-catch in the *Rastrineobola argentea* (dagaa) fishery by light attraction in Lake Victoria

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(Balirwa et al., 2003; Matsuishi et al., 2006). In Tanzania, the Fisheries Department records daily fish landings at the landing beaches (Budeba and Mous, 1995), although weaknesses in the data are acknowledged (Cowx et al., 2003). No record of *Caridina* in the dagaa fishery catches is made. A similar situation exists in Kenya and Uganda; consequently, there is no definitive record of the contribution of *Caridina* to catches. The only information on the scale of the catches was in 1995 when 3,180 t of *Caridina* was landed from the Kenyan waters of Lake Victoria (Othina and Osewe-Odera, Kenya Marine Fisheries Research Institute, Kismu, Kenya, unpublished data). In recent years, the markets for *R. argentea* have expanded from local to exporting to neighbouring countries like the Democratic Republic of Congo, Burundi, Rwanda and Zambia (Van der Hoeven and Budeba, 1992) where it is used for human consumption and in poultry feeds. With increasing demand for *R. argentea*, both in the local and foreign markets, fishing effort for *R. argentea*, and thus *Caridina* has progressively increased (Matsuishi et al., 2006), and this is a cause for concern. However, the situation with regard to the exploitation of *R. argentea* and *Caridina* is more fundamental than species targeted management. These two species are major prey items of *Lates niloticus* and *Oreochromis niloticus* in Lake Victoria (Ogari and Dadzie, 1988; Ogutu-Ohwayo, 1990; Hughes, 1992; Mkumbo and Ligtvoet, 1992; Budeba, 2003).

Management of fisheries relies on an underlying knowledge of stock abundance and population parameters (Cowx, 1996) for which a well-organized catch data collection system is required. As indicated, no such studies exist for *Caridina* on Lake Victoria, and assessment of dagaa catches is also weak (see Cowx et al., 2003). In view of the intensive exploitation of the *R. argentea* and the potential impact of the fisheries on the *Caridina* stocks, an assessment of the exploitation patterns of *Caridina* is needed. This paper assesses the exploitation levels of *Caridina* in the Tanzanian waters of Lake Victoria to gain an understanding of the dynamics of the dagaa fishery and the contribution of *Caridina* to the catches. Knowledge of the exploitation patterns of *Caridina* together with stock abundance of *Caridina* over time and space is fundamental for evaluating the future of the Lake Victoria fisheries. The CPUE for *Caridina* and dagaa per location and per fishing gear was estimated, and changes in CPUE over time and space are discussed. Using fishing efforts from a regional frame survey in 2000 (LVFO, Uganda, undated), an estimate of *Caridina* and dagaa catches for Tanzanian waters was derived to evaluate the potential threat posed by harvesting *Caridina*. The importance of monitoring the role of the dagaa fisheries in exploiting *Caridina* in Uganda and Kenya is stressed.

Materials and methods

Study area

The contribution of *Caridina* in the *R. argentea* fishery was assessed at nine beaches (Igombe, Sweya, Bwai, Kome, Busekera, Kibuyi, Nyangómbe, Minigo, Sota and Kijiweni beaches; Figure 1) in the Tanzanian part of Lake Victoria from May, 2001 to April, 2002. Additional data on dagaa and *Caridina* catches from Sweya beach between October, 2000 and April, 2002 was also included. Beaches were selected based on accessibility and importance as landing sites for the *R. argentea* fishery. The beaches were geographically separate to have a good representation of the catch characteristics in Tanzanian waters of Lake Victoria.

The catch assessment survey at Sweya dagaa beach started from October, 2000 to April, 2002 and was operated slightly different from the other nine beaches. Catches of *R. argentea* and *Caridina* (kg) at Sweya beach were sampled from four boats per day on two occasions per week (eight days per month). Data recording from the other nine beaches was carried out on one day per month per beach from May, 2001 to April, 2002. Catches from a minimum of eight boats were sampled on each occasion. At each beach, the number of boats on the beach on the day of sampling, the number not operating and the number that went out fishing were recorded to determine the proportion of fishing boats as a raising factor from the frame survey data to determine total catches in Tanzania. For each fishing boat sampled, the number of crew, number of lamps, gear type and size, start and end fishing (duration of fishing), number of hauls per lamp and total catch were recorded.

The catch of each boat was sorted into fish species and *Caridina* and weighed (kg). Carapace lengths of individual *Caridina* were measured from a sub sample of 10 g according to the principal gear used. For each sampling day, the total catch from the sampled boats was divided by the total number of sampled boats to obtain the mean Catch-per-Unit-Effort (kg boat^{-1} day^{-1}) per gear type. The total *Caridina* and *R. argentea* catches per beach for the day

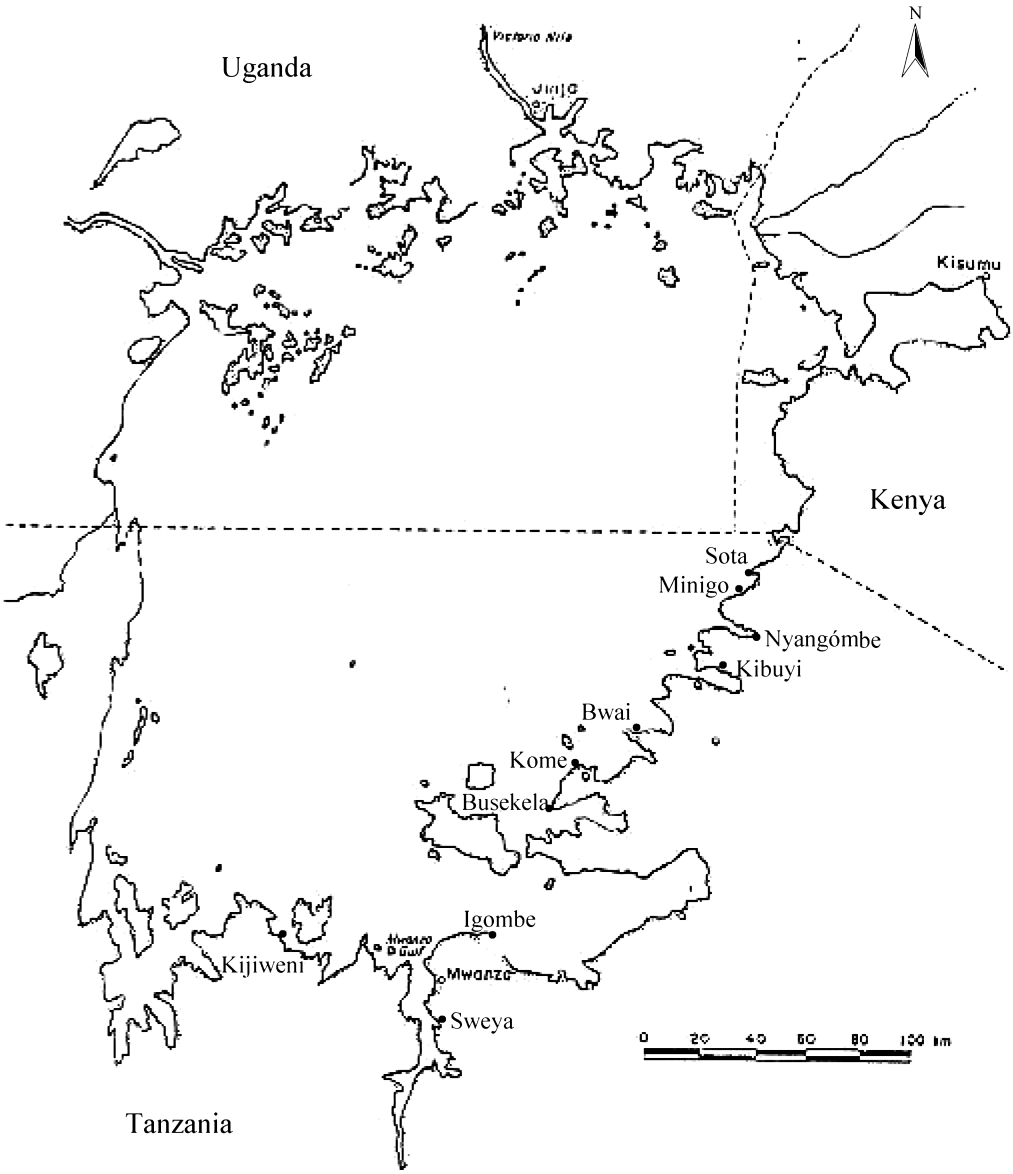

Figure 1. Dagaa and Caridina nilotica sampling stations in the Tanzanian waters of Lake Victoria.

were estimated by extrapolation of the CPUE from the sampled canoes to the total number of canoes operating from the beach on that day (CPUE gear x total number of boats fishing).

Data were sorted by month and estimations of mean CPUE of dagaa and *Caridina* were made (mean calculated by taking the average CPUE of all boats in that category). Data were analyzed for spatial variation in catches between fishing areas within each month and for temporal variation in catches between months, combining data for each fishing area.

Estimation of total catch

The annual catches for the years 2001/2002 were estimated by:

$$AC = (\text{CPBD} \times \text{FD} \times \text{Proportion of fishing boats} \times \text{Total number of boats recorded})/1000$$

where AC is the annual catch (t), CPBD is the mean catch-per-boat-per-day (CPUE, kg boat^{-1} day^{-1}) and FD is the number of fishing days in the year. For *R. argentea*, *FD* was 252 days (an average of

21 fishing days per month). Due to differences in catching efficiency, data from mosquito seines and lift nets operated from catamarans were calculated separately. Kruskall Wallis non-parametric analysis was used to test seasonal and spatial variations in CPUE in the ten sampled beaches.

Results

Distribution of fishing effort

The 2000 frame survey identified 604 landing sites in Tanzania (Table 1), of which 369 were beaches associated with dagaa fishing. Of these beaches, 305 operate principally mosquito seines and 37 operate lift nets. The number of boats using mosquito nets in 2000 was 3,223 and 313 for lift nets. The number of lift net units operating in the Tanzanian waters increased rapidly after it was introduced from Lake Tanganyika, but there has been a sequential decline in numbers used from 507 in 1998 to 130 in 2002 (Cowx, 2005).

The intensity of fishing effort expended shows distinct regional variation in the operating gears. The mesh size of mosquito nets also varies by region. Uganda uses almost exclusively 5 mm mesh nets, whereas 5 mm nets are used inshore in Tanzania and 8-10 mm nets from catamarans offshore. In all three countries, effort, in terms of boats and number of fishers, has more than doubled in the past 10 years (Cowx, 2005). A high number of illegal beach seine nets of small mesh size ($<$10 mm) were also found operating in the fishery.

Catch assessment surveys

Two main methods are used to catch *R. argentea* and *Caridina* in Tanzanian waters of Lake Victoria: mosquito seine nets (5 mm and 10 mm mesh sizes) and catamaran lift nets (8 mm mesh sizes). The majority of the beaches use mosquito seine nets as the main gear; although lift net fishing was dominant at Igombe and Busekera beaches. The catch composition in the dagaa fisheries included *R. argentea*, *Caridina* and haplochromine cichlids, together with irregular and insignificant quantities of juvenile Nile perch and *Brycinus jacksonii*.

Caridina nilotica and *R. argentea* catches varied between the study beaches and seasonally (Figure 2; Tables 2 and 3). *Caridina* contributed between 1.9 and 45.0 kg boat^{-1}day^{-1} depending on location, time and fishing method. The highest CPUE was from Sweya beach during the rainy season, followed by Igombe, Kome and Busekera. The lowest CPUE was at Nyangómbe beach. The rest of the beaches exhibited high CPUE during the dry season. CPUE of *Caridina* was greater in lift nets than mosquito seine at Igombe and Busekera beaches. However CPUE for *R. argentea* at Igombe was significantly higher ($P < 0.05$) for mosquito seines than lift nets.

Table 1. Summary of Frame survey 2000 showing distribution of landing sites, crafts and gears between countries (values in brackets are density by country per km^2).

Item	Kenya	Tanzania	Uganda	Total
Area km^2	4080	34680	29240	68000
Landing sites	297 (0.07)	604 (0.02)	597 (0.02)	1498
Fishers	33037 (8.1)	56443 (1.62)	34889 (1.19)	124369
Fishing boats	10014 (2.45)	15533 (0.45)	15544 (0.53)	41091
Motorised boats	509 (0.12)	1526 (0.04)	2031 (0.07)	4066
Gillnets	126221 (33.69)	225800 (6.51)	294945 (10.18)	646966
Long lines	972087 (23.82)	2212571 (63.8)	254453 (8.7)	3439111
Beach seines	5245 (1.29)	1020 (0.03)	811 (0.03)	7076
Cast nets	4418 (1.08)	63 (0.001)	1276 (0.04)	5757
Hand lines	27789 (6.81)	14355 (0.38)	4585 (0.16)	46729
Traps	3192 (0.78)	2584 (0.07)	11349 (0.39)	17125
Scoop nets		807		807
Dagaa seines		22		22
Lift nets		315		315
Mosquito seines	11265 (2.76)	3278 (0.09)	2452 (0.08)	16995
Other gears	1706	1146	71	2923

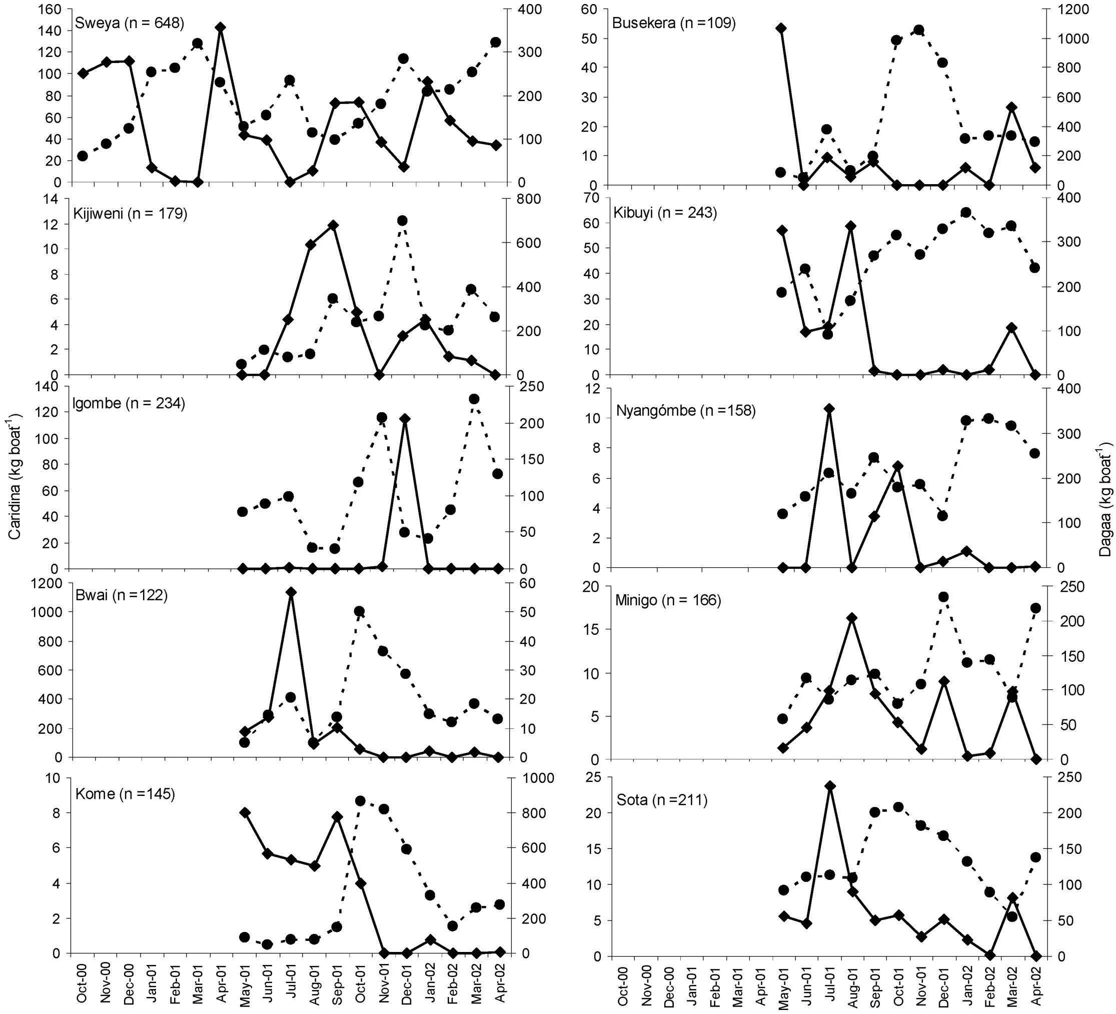

Figure 2. Monthly variations in the relative abundance of Caridina nilotica (●) in dagaa catches (⧫) from the studied beaches.

Catches of dagaa and *Caridina* at Sweya beach varied considerably between October, 2000 and April, 2002 (Table 2, Figure 2). During the rainy season, between October, 2000 and December, 2000, the contribution of *Caridina* was high and similar to the catch rate of dagaa, 111 ± 69 and 103 ± 58 kg boat^{-1} day^{-1} for *Caridina* and dagaa respectively. *Caridina* was not present in the catches in February and March, 2001 or July, 2001. Average CPUE for *Caridina* was 28 kg boat^{-1} day^{-1} and for dagaa was 220.4 ± 86.3 kg boat^{-1}day^{-1}between January, 2001 and December, 2001. In the 2002 (January to April)

Table 2. Estimated catch for dagaa and C. nilotica from Sweya beach between October 2000 and April 2002.

Year	*R. argentea* CPUE (kg boat^{-1})	*C. nilotica* CPUE (kg boat^{-1})	*R. argentea* estimated catch (kg)	*C. nilotica* estimated catch (kg)	Effort (no of boats)
Oct-Dec 2000	102.7 ± 58.3	110.9 ± 69.5	90179	96321	225
Jan–Dec 2001	220.4 ± 86.3	27.7 ± 39.7	495838	57832	504
Jan–Apr 2002	251.8 ± 95.7	54.3 ± 48.1	532085	104216	336
Total			1118102	258369	

Table 3. Catches of R. argentea and C. nilotica recorded from the studied beaches between May 2001 and April 2002.

Year	*R. argentea* CPUE (kg boat^{-1} day^{-1})	*C. nilotica* CPUE (kg boat^{-1} day^{-1})	*R. argentea* estimated catch (kg)	*C. nilotica* estimated catch(kg)	Effort (no of boats)
Sweya	226.1 ± 92.8	45.8 ± 43.2	8091967	153502	648
Kijiweni	245.6 ± 177.9	3.5 ± 4.0	336815	2999	179
Igombe (lift net)	109.0 ± 86.7	15.7 ± 57.1	118075	16032	234
Igombe (mosquito)	294.7 ± 147.2	0	4879	0	5
Bwai	412.8 ± 270.2	7.8 ± 15.8	188929	1295	122
Kome	309.2 ± 291.3	3.1 ± 3.2	119282	524	124
Busekera (lift net)	413.0 ± 347.6	9.4 ± 15.8	277388	5781	109
Busekera (mosquito)	399.3 ± 291.9	1.2 ± 2.7	174458	457	62
Kibuyi	279.7 ± 100.7	7.7 ± 16.6	397568	8598	296
Nyangómbe	216.8 ± 77.6	1.9 ± 3.5	51327	495	158
Minigo	137.5 ± 75.2	5.7 ± 5.9	42063	1632	166
Sota	158.6 ± 84.9	5.8 ± 8.0	57876	2381	200
Overall mosquito seine	237.2 ± 142.4	27.8 ± 38.7	2179900	171867	1960
Overall lift net	244.1 ± 281.3	12.9 ± 44.7	395464	21813	343

wet season, average CPUE for *Caridina* was 54.3 ± 48.1 kg boat^{-1} day^{-1}and for dagaa 251.8 ± 95.7 kg boat^{-1} day^{-1}. Generally, the abundance of *Caridina* in the dagaa catches showed an inverse relationship with the abundance of dagaa (Figure 2).

The abundance of *Caridina* at Kijiweni beach fluctuated between months without any obvious trend (Figure 2). The highest CPUE for *Caridina* was in September, 2001 and thereafter showed a decline. Based on CPUE, *Caridina* was not an important component in the dagaa fishery at this beach, with an average of 3.5 ± 4.0 kg boat^{-1} day^{-1} while for dagaa the CPUE was 245.6 ± 177.9 kg boat^{-1} day^{-1}. No *Caridina* was present in the dagaa catches at this beach in the months of May, 2001; June, 2001; November, 2001 and April, 2002.

Lift nets were the dominant gear used at Igombe beach, which may account for the marginal contribution of dagaa compared with that of haplochromine cichlids (Figure 3). The average CPUE for dagaa at Igombe was 109.0 ± 86.7 kg boat^{-1} day^{-1} for lift nets and 294.7 ± 147.2 kg boat^{-1}day^{-1} for mosquito seine nets. The average CPUE for haplochromine cichlids, mostly the zooplanktivorous *Haplochromis laparogramma*, was 736.5 ± 745.5 kg boat^{-1} day^{-1}for lift nets and zero for mosquito seine net (Table 4). The relative contribution of dagaa to the catches was generally highest

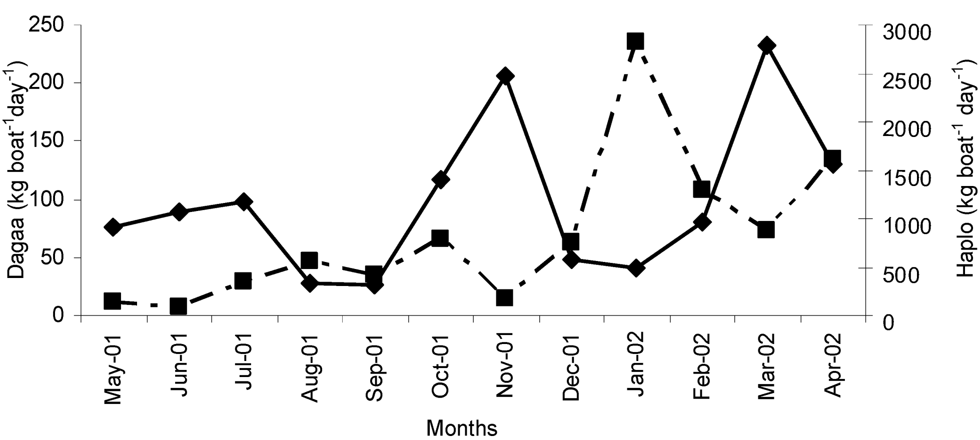

Figure 3. The relative abundance of haplochromine cichlids (–■–) and dagaa (♦) at Igombe beach (lift net data; n = 234 samples)).

Table 4. Estimated annual catch for dagaa and *Caridina nilotica* from different fisheries in relation to gear types operated in the Tanzanian waters from May 2001 to April 2002.

Type of fishery	Number of boats	Prop. Fishing	Dagaa CPUE (kg boat^{-1})	Dagaa estimated catch	*Caridina* CPUE (kg boat^{-1})	*Caridina* estimated catch	Haplo CPUE (kg boat^{-1})	Haplo estimated catch
Lift net	313	0.92	244	17716	12.9	935	737	53446
Mosquito seine	3245	0.72	237	139675	27.8	16391	0.0	0

when haplochromines were less abundant in the catches (Figure 3). *Caridina* was not encountered in the dagaa catches at Igombe beach for almost the whole study period, except in December, 2001, when 12.2 kg boat^{-1} day^{-1} was landed. Haplochromine cichlids were more abundant during the full moon period in the offshore deep-water stations, mostly in the rainy seasons (Y. Budeba, TAFIRI, Dar-es-Salaam, Tanzania, per. obs.). The appearance of haplochromine cichlids in the *R. argentea* catches at Igombe beach started in 1997 and fluctuated with an increasing trend up to the present level (Table 4). The same trend was found at Nyamikoma beach in the Speke Gulf (Y. Budeba, personal observation).

The occurrence of *Caridina* in the dagaa catches at Bwai, Kome, Busekera, Kibuyi, Nyangómbe Minigo and Sota beaches followed a similar general trend with minor seasonal fluctuations in relative abundance between beaches (Figure 2). The greatest contribution was during the dry season (June-September, 2001) but exhibited a decreasing trend associated with the dry season and contributed little after November, 2001, although some increase was found at Busekera, Kibuyi, Minigo and Sota in March, 2002. *Caridina* was more prevalent in the catches (>5 kg boat^{-1} day^{-1}) from the dagaa fisheries at Bwai, Busekera (lift net), Kibuyi, Minigo and Sota beaches (Table 3).

The catch rates of dagaa showed no consistent seasonal trends between the above mentioned beaches (Figure 2). There was no link to season although the catch rates for dagaa were generally higher when *Caridina* catches were depressed (Figure 2). Catch rates for dagaa were greatest (>300 kg boat^{-1} day^{-1}) at Bwai, Kome and Busekera beaches (Table 3).

Yield estimates

Considerable variation was found in the relative abundance of *Caridina* in dagaa catches at the landing beaches sampled (Figure 2). Similarly, catches for *Caridina* and dagaa based on the two gear types varied considerably between beaches (Table 3). However, using the mean catch rates from the sampled beaches it was possible to determine the annual catch rates (for the period of May, 2001 to April, 2002) for the two components of the catch using the data from the 2000 frame survey as the baseline for total effort (Table 1).

A total of 157,390 t of dagaa was harvested in the Tanzanian waters of Lake Victoria between May, 2001 and April, 2001 (Table 4) using lift nets and mosquito seine nets. The mosquito seine nets harvested 139,675 t (89%) of dagaa catch compared with 17,716 t by lift nets (11%). A total of 17,326 t of *Caridina* was harvested in the Tanzanian waters of Lake Victoria between May, 2001 and April, 2002 (Table 5). More *Caridina* was harvested by mosquito seine nets (16,391 t) (95%) than lift nets (5%). This difference was largely because there are more mosquito nets operating in the fishery and the catch rate for *Caridina* in lift nets was much lower (12.9 kg boat^{-1} day^{-1}) than mosquito seine nets (27.8 kg boat^{-1} day^{-1}). The total haplochromine catch for the region based on the mean catch rate for lift nets at Igombe beach (736.5 kg boat^{-1} day^{-1}) was 53,446 t.

Population size structure of Caridina nilotica in the dagaa catches

The carapace length (mm CL) distribution of *Caridina* in the bycatch of *R. argentea* artisanal catches ranged between 1.5 mm CL and 8 mm CL (Figure 4). Modal carapace length varied with month but not significantly. The differences were largely due to selectivity of the different mesh-sized nets and gears on the different beaches that made up the sample. Mature *Caridina* (>5 mm) were found in all catches.

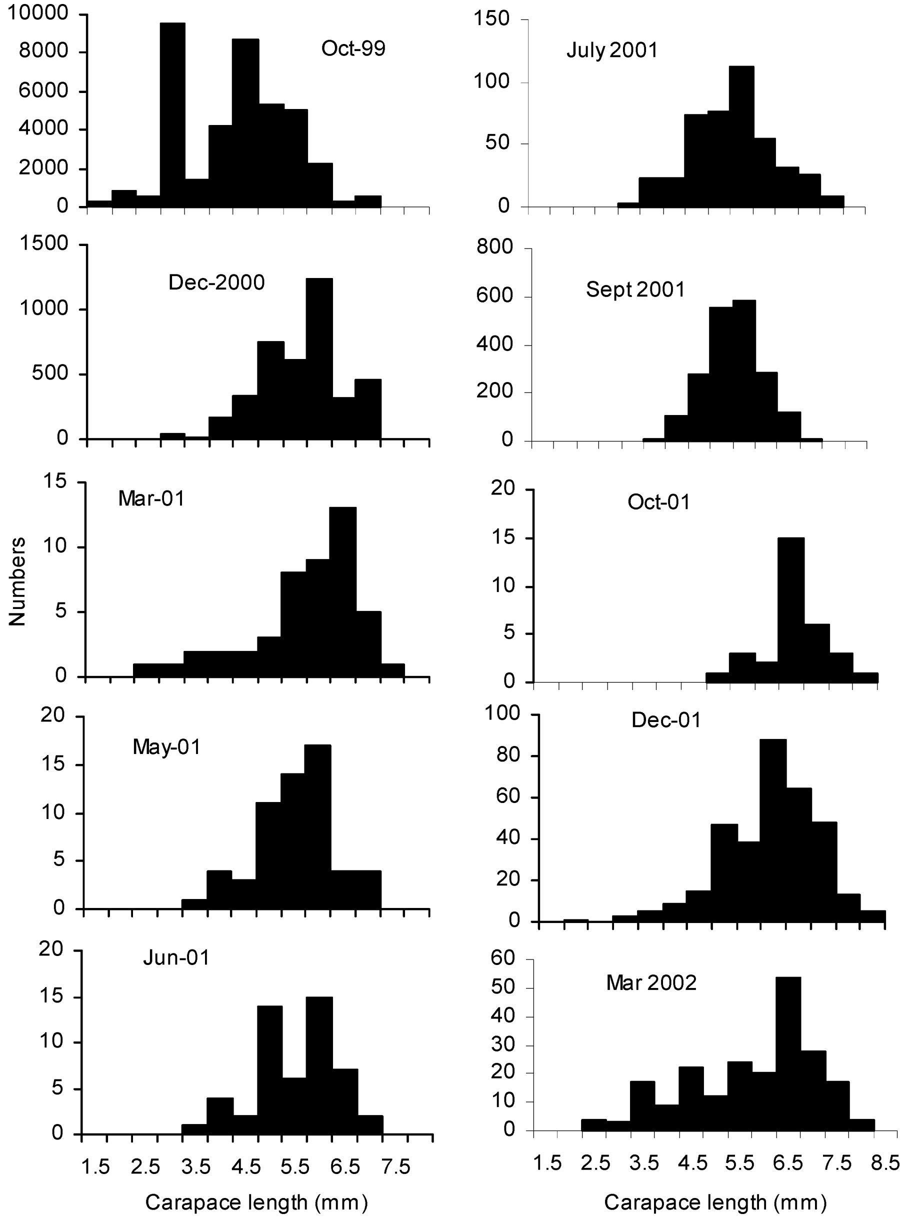

Figure 4. Size structure of Caridina nilotica in dagaa catches from the studied beaches between October 1999 and March 2002.

Discussion

Lack of catch assessment data for *R. argentea* and *Caridina* in the Tanzanian waters has prevented any evaluation of trends in recent years. However, considerable volumes of the two stocks are both present in the lake and harvested. *Rastrineobola argentea* catches increased in the Tanzania waters of Lake Victoria from 136,317 t in 1999 to 167,789 t in 2000 (Mkumbo, 2002). The present study estimated the annual catch for dagaa for the year 2001/2002 as 157,390 t and for haplochromine cichlids as 57 568 t (Table 4). Lake wide hydro acoustic surveys showed an increase in standing stock of *R. argentea* from 350,000 t to 1,200,000 t between August, 1999 and August, 2001 (Getabu et al., 2003). The average *Caridina* biomass for the whole lake was estimated at 22,694 t by hydroacoustic surveys (Getabu et al., 2003). The present study estimated the annual catch for *Caridina* for the year 2001/2002 was 17,326 t

(Table 4). Its contribution to catches has increased dramatically since the explosion of Nile perch, *L. niloticus* in the 1980s, probably as the species is exploiting the pelagic niche left by the demise of many haplochromines (Matsuishi et al., 2006; Wanink and Witte, 2000). *Caridina* is thus an important component in the dagaa catches, accounting for 11% of the catches from the fishery. This is an enormous contribution to the dagaa fishery in the Tanzania waters of Lake Victoria. This figure was obtained using 10 of the 369 dagaa beaches and is probably an underestimate because it does not cover the Bukoba area, where scoop net fishing is very important. With the increasing fishing effort in the dagaa fishery, more *Caridina* is likely to be harvested, but remain unreported. It is important, therefore, to strengthen the catch assessment of dagaa and haplochromines to include *Caridina*.

There were marked differences in the catch rates for *Caridina* and dagaa between the beaches surveyed and with season on each beach, although no consistent patterns emerged between beaches. This spatial variability in catch rates probably reflects differences in depth and bottom substratum of the fishing grounds; presence of bays and availability of food items for *R. argentea* and *Caridina* (Budeba, 2003). The fishing grounds associated with the landing sites ranged from shallow inshore waters (Sweya beach) to offshore waters up to 40 m deep (Igombe, Bwai). *Caridina* is known to live both in shallow and deep waters (Fryer, 1960; Budeba, 2003), but prefers deep, offshore waters during the dry months of the year. At Kibuyi, for example, from where the fishery exploits offshore waters, *Caridina* was abundant from May to August, but in the Mwanza Gulf (Sweya beach) *Caridina* was most abundant from October to May. It appears that *Caridina* migrates into deep-water stations during the dry season, where the dagaa fishers do not tend to operate (Budeba, 2003). These major migrations partly explain the absence of *Caridina* at Kibuyi beach during September to April and at Sweya beach from June to September (dry season).

Temporal shifts in the occurrence of *Caridina* in the dagaa catches could also be related to seasonal food availability and favorable temperatures. *Caridina* feed on algae, higher plant vegetation and detritus in the shallow waters but on zooplankton and detritus in deeper offshore waters (Fryer, 1960; Lehman et al., 1996; Budeba, 2003). The occurrence of these food resources, especially plankton, in Lake Victoria shows strong seasonality in the water column (Akiyama, et al., 1977; Talling, 1987; Ochumba and Kibaara, 1989; Mugidde, 1993; Gophen et al., 1993), partly related to thermal stratification and hypoxic/anoxic conditions in deep water during the rainy season. This seasonality, in part, explains the temporal shifts in *Caridina* in the dagaa catches. However, the absence of *Caridina* in the dagaa catches does not always correspond with its absence in the water column. This is because the distribution of *Caridina* is patchy (Mbahinzireki et al., 1998; Getabu et al., 2003) and its schooling behaviour complicates its catch characteristics.

The gear type (fishing method) and the means of propulsion also have an impact on the relative abundance of *C. nilotica* in the *R. argentea* fishery. Lift nets have a higher CPUE for *Caridina* than mosquito seine nets, both at Igombe and Busekera beaches. This is probably because lift net fishing takes place in the offshore waters and is able to exploit the true pelagic stocks in this zone. The majority of lift net fishers use outboard engines and are able to travel long distances and exploit a wider range of fishing grounds. Cowx (2005) observed similar catch rates for *R. argentea* from 5 mm and 10 mm mosquito seine nets, although the 5 mm net caught a greater component of *C. nilotica*, which was virtually absent in the catches of the 10 mm net. He further reported a higher proportion of haplochromines in the 10 mm net and suggested that haplochromines were either able to avoid the 5 mm net or were not caught where 5 mm nets operate in shallow inshore waters.

The dominance of 5 mm and 10 mm mesh sizes mosquito seine nets at most beaches indicated that this gear has replaced the beach seine fishery dominant in the 1990s (Ligtvoet et al., 1990; Mous et al., 1991). Fishers consider the mosquito seine nets to be more efficient and are able to exploit the pelagic and offshore areas, thus they have greater economic viability. However, the proliferation of 5 mm mesh nets is a cause for concern because they are particularly selective of *Caridina.*

The haplochromine cichlids, which made up more than 83% of the lake ichthyomass in the pre Nile perch era (Kudhongania and Cordone, 1974) and was believed to have undergone extinction in the late 1980s (Witte et al., 1992), showed a huge recovery in the 1990s (Witte et al., 2000) and was an important by-catch in the dagaa catches at Igombe beach. The changes in catch composition of the *R. argentea* fishery found during the present study are the reflection of the ongoing ecological changes in Lake Victoria. The catch composition in the dagaa fishery by light attraction was almost 100% *R. argentea* in the past. Mous et al. (1991) reported *R. argentea* to be the target catch in the night fishery by light attraction at Igombe beach. From 1999, the catch composition at Igombe beach has changed completely and is now dominated by haplochromine cichlids (Y. Budeba, TAFIRI, Dar-es-Salaam, personal observation). One possible explanation for the high contribution of haplochromine cichlids at Igombe and Nyamikoma beaches is that the fishers tend to use lift nets further offshore where the resurgence of haplochromines is most prominent. This was corroborated by the relative absence of haplochromines in the lift net catches at Busekera beach, which tend to operate inshore.

Conclusions

In Lake Victoria, the dagaa fishery is expanding as the Nile perch fishery exhibits declining catch rates and appears to have reached its potential (Matsuishi et al., 2006). Lower initial capital investment for dagaa compared with heavy capital investment for Nile perch fishing and high local demand for dagaa and *Caridina* has contributed to the expansion of dagaa and *Caridina* fisheries in Tanzania. The high demand for *Caridina* arises because it is used as bait in haplochromine hand-line fisheries, as poultry feed or as fertilizer. The increasing levels of exploitation of *Caridina* by man and high predation pressure by fishes (Budeba, 2003) also pose a threat to the *Caridina* stocks in the lake. This arises because *Caridina* is an important food for all the major commercial fish species and is a link in the transfer of energy from the lower to the higher trophic level (Matsuishi et al., 2006). Excessive exploitation of *Caridina* may potentially lead to deterioration in the Nile perch fishery and the catch may not recover because of fishing down the food web which is taking the food base (Budeba, 2003). However, Kolding et al. (2006) suggested that the fisheries of Lake Victoria are driven by elevated nutrient loading and do not consider such a scenario probable. Fortunately, *Caridina* has a higher production turnover, high fecundity, high growth rate and high natural mortality and can probably sustain high exploitation pressure (Budeba, 2003). However, the resurgence of haplochromine cichlids in Lake Victoria, especially in areas where the Nile perch have declined, may pose a further threat to the *Caridina* stocks, and possible competition with the extant dagaa stocks. The threats are based on food resource utilization since both haplochromines and dagaa depend on zooplankton, *Chaoborus* larvae and *Caridina* for food (Budeba, 2003; Katunzi et al., 2003) and the increased predation pressure on Caridina stocks may lead to an imbalance or disruption in the food web. Therefore, managing and sustaining Lake Victoria fisheries, particularly Nile Perch, requires monitoring and perhaps regulation of the quantities of *Caridina* being extracted.

References

Akiyama, T., Kajumulo, A. A., Olsen, S., 1977. Seasonal variations of plankton and physico-chemical condition in Mwanza Gulf, Lake Victoria. Bulletin of Freshwater Fisheries Research Laboratory 27, 49–61.

Balirwa J. S, Chapman, C. A., Chapman, L. J., Cowx, I. G., Geheb, K., Kaufman, L. Lowe-McConnell, R. H., Seehausen, O., Wanink, J. H., Welcomme, R. L., Witte, F., 2003. Biodiversity and fisheries sustainability in the Lake Victoria basin: an unexpected marriage? Bioscience 53, 703–716.

Budeba, Y. L., 2003. The role of *Caridina nilotica* (Roux 1833) in the Lake Victoria fisheries, Tanzanian waters. PhD Thesis, the University of Hull, Yorkshire.

Budeba, Y. L, Mous, P. J., 1995. Fisheries statistical service system and Government framework. In: F. Witte and W. L. T. Van Densen (Eds.), *Fish stocks and fisheries of Lake Victoria*. A *handbook for field observation*s, pp. 173–186. Samara Publishing Limited, Cardigan, Wales.

Cowx, I. G., 1996. The integration of fish stock assessment into fisheries management. In: I. G. Cowx (Ed.), *Stock Assessment in Inland Fisheries*, pp. 495–507. Fishing News Books, Blackwell Science Ltd., UK.

Cowx, I. (Ed.), 2005. Review of the exploitation pressures on the fisheries resources of Lake Victoria. LVEMP National Secretariat, Entebbe, Uganda.

Cowx I. G., Van der Knaap M., Muhoozi L. I, Othina, A., 2003. Improving fishery catch statistics for Lake Victoria. Journal of Ecosystem Health and Management 6, 299–310.

Fryer, G., 1960. The feeding mechanism of some Atyid prawns of the genus *Caridina*. Transactions of the Royal Society Edinburgh 64, 217–244.

Getabu, A., Tumwebaze, R., MacLennan, D. N., 2003. Spatial distribution and temporal changes in the fish populations of Lake Victoria. Aquatic Living Resources 16, 159–165.

Gophen, M., Ochumba, P. B. O., Pollingher, U., Kaufman, L. S., 1993. Nile perch (*Lates niloticus*). Verh. Int. ver. Limnol. 25, 856–859.

Hughes, N. F., 1992. Nile perch, *Lates niloticus*, predation on the freshwater prawn, *Caridina nilotica,* in the Nyanza Gulf, Lake Victoria, East Africa. Environmental biology of Fishes 33, 307–309.

Katunzi, E. F. B., Zoutendijk, J., Goldschmidt, T., Wanink, J. H., Witte, F., 2003. Lost zooplanktivorous cichlid from Lake Victoria reappears with a new trade. Ecol. Freshw. Fish. 12, 237–240.

Kolding, J., Van Zwieten, P., 2006. How resilient is Lake Victoria? Accounting for states, trends and processes of its fisheries and environment in a data limited situation. ICES CM 2006/I:32 Poster.

Kudhongania, A. W., Cordone, A. J., 1974. Batho-spatial distribution pattern and biomass estimate of the major demersal fishes in Lake Victoria. African Journal of Tropical Hydrobiology and Fisheries 3, 15–31

Lehman, J. T., Mbahinzireki, G. B., Mwebaze-Ndawula, L., 1996. *Caridina nilotica* in Lake Victoria: Abundance, Biomass and diel vertical migration. Hydrobiologia 317, 177–182.

Ligtvoet, W., Mous, P. J., Budeba, Y. L., Mkumbo, O. C., Klinge, M., 1990. Features of the developing artisanal Nile perch (*Lates niloticus*) and dagaa (*Rastrineobola argentea*) fisheries in the southern Lake Victoria. Proceedings of the symposium on socio-economic aspects of Lake Victoria Vol 1. UNDP/FAO/IFIP, RAF/87/099-WP/05/90 (En).

LVFO. Regional status report on Lake Victoria frame surveys for 2000, 2002 and 2004. Kenya,Tanzania and Uganda http://www.lvfo.org/downloads/Regional%20 frame%20survey%202000-2004.pdf (accessed 7 February 2007).

Matsuishi T., Muhoozi L., Mkumbo O., Budeba Y., Njiru M., Asila A., Othina A., Cowx I. G., 2006. Are the exploitation pressures on the Nile perch fisheries resources of Lake Victoia a cause for concern? Fisheries Management and Ecology 13, 53–71.

Mbahinzireki, G. B., Lehman, J. T., Ochieng H., 1998. *Caridina nilotica*: Spatial distribution and egg production in Lake Victoria, Uganda. In: J. T. Lehman (Ed.), *Environmental change and response in East African Lakes*, pp. 117–124. Kluwer Publishing, Dordrecht, the Netherlands.

Mkumbo, O. C., 2002. Assessment and management of Nile perch (*Lates niloticus* L.) stocks in the Tanzanian waters of Lake Victoria. PhD Thesis, The University of Hull, Yorkshire, UK.

Mkumbo, O. C., Ligtvoet, W., 1992. Changes in the diet of Nile perch, Lates niloticus (L), in the Mwanza Gulf, Lake Victoria. Hydrobiologia 232, 79–84.

Mous, P. J., Budeba, Y. L., Temu, M. M., Van Densen, W. L. T., 1991. A catch effort data recording system for the fishery on the small pelagic *Rastrineobola argentea* in the southern part of Lake Victoria: In: I.G. Cowx (Ed.), *Catch effort sampling strategies, their application in fresh water fisheries management*, pp. 335–348. Fishing News book. Blackwell Scientific Publications Ltd., UK.

Mugidde, R., 1993. The increase in phytoplankton primary productivity and biomass in Lake Victoria (Uganda). Verhandlungen Internationale Vereiniging fur theoretische und angewandte Limnologie 25, 846–849

Ochumba, P. B. O. and Kibaara, D., 1989. Observations on blue-green algal blooms in the open waters of Lake Victoria, Kenya. Afr. J. Ecol. 27, 23–34.

Ogari, J., Dadzie, S., 1988. The food of Nile perch, *Lates niloticus* (L.) after the disappearance of the haplochromine cichlids in the Nyanza Gulf of Lake Victoria. Journal of Fish Biology 32, 571–577.

Ogutu-Ohwayo, R., 1990. Changes in the prey ingested and the variations in the Nile perch and other fish stocks of Lake Kyoga and the northern waters of Lake Victoria (Uganda). Journal of Fish Biology 37, 55–63.

Talling, J. F., 1987. The phytoplankton of Lake Victoria (East Africa). Arch. Hydrobiol. Beih. Ergebn. Limnol. 25, 229–256.

Van der Hoeven, J. J., Budeba, Y. L., 1992. A marketing study on the Tanzanian part of Lake Victoria: the Mwaloni Kirumba market, Mwanza, and the export market for fresh fish and fillet. UNDP/FAO Regional Project for Inland Fisheries Planning IFIP. RAF/87/099 – TD/44/92 (En).

Wanink, J. H., Witte, F., 2000. The use of perturbation as a natural experiment. Effects of predator introduction on the community structure of zooplanktivorous fish in Lake Victoria. Advances in Ecological Research 31, 553–570.

Witte, F., Goldschmidt, T., Wanink, J. H., Van Oijen, M. J. P., Goudswaard, P. C., Witte-Maas, E. L. M., Bouton, N., 1992. The destruction of an endemic species flock: Quantitative data on the decline of the haplochromine cichlids of Lake Victoria. Environmental Biology of Fishes 34, 1–28.

Witte, F., Msuku, B. S., Wanink, J. H., Seehausen, O., Katunzi, E. F. B., Goudswaard, P. C. Goldschmidt, T., 2000. Recovery of cichlid species in Lake Victoria: an examination of factors leading to differential extinction. Reviews in Fish Biology and Fisheries 10, 233–241.