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Ssanyu Grace Asiyo
Department of Biological Sciences, Kyambogo University, P.O Box 1 Kyambogo, Uganda.

Julius Kipkemboi
Department of Biological Sciences, Egerton University, P.O Box 536-20115, Egerton, Kenya.

Jude M Mathooko
Global Research Akademik and Mentoring Services (GRAMS), P.O Box 14824-20100, Nakuru, Kenya.

John Balirwa
Department of Fisheries Biology, National Fisheries Resource and Research Institute, P.O Box 343 Jinja, Uganda.

Correspondence
Ssanyu Grace Asiyo
Department of Biological Sciences, Kyambogo University, P.O Box 1 Kyambogo, Uganda.

Which movement pattern do *Clarias* species exhibit in the disturbed Mpologoma wetland, Uganda?

Ssanyu Grace Asiyo, Julius Kipkemboi, Jude M Mathooko, John Balirwa

Abstract
Small *Clarias* species (*Clarias liocephalus* (Boulenger) and *C. alluaudi* (Boulenger) movement patterns were analysed with Floy tags and through a structured questionnaire survey at the differently disturbed sites in the Mpologoma riverine wetland. Water physico-chemical characteristics, macroinvertebrate community and fish stomach content data were also collected. Water conductivity was higher at the highly disturbed sites while dissolved oxygen was lower at the highly disturbed sites than at the less disturbed sites (ANOVA, Tukey's test $p < 0.05$). Although floy tag recovery rate was low, a downstream movement during dry season and lateral movement in the rainy season were exhibited by the tagged fish. The fishermen (76.5%) concurred that these clariids move about and some fishermen (30.8 %) attributed the movement to reduction in water level. The results were attributed to the species' life history strategy, adaptation to change in environmental variables and avoidance of predators in deep waters.

Keywords: clariids, movement, Floy tags, wetland disturbance

Introduction
Catfishes are highly mobile fish. Their movements and habitat use within their natural range have been reported to be driven primarily by foraging behaviour and reproductive biology (Kadye and Booth, 2013) [17]. Other factors that determine movements and habitat use in most fish species include changes in temperature, water quality, food availability and suitable spawning areas (Zimmer *et al*., 2010) [41]. Movements of riverine fish species are further influenced by habitat conditions such as vegetation, substrate, water depth and water velocity (Kadye and Booth, 2013) [17]. These microhabitat variables are influenced by stream gradient, stream size and human activities which ultimately influence fish communities (Kadye and Moyo, 2007) [16]. Agricultural activities in wetlands alter hydrologic flows and dynamics of the flood pulse, undermining the ecological integrity of systems and changing the hydraulic connectivity between habitats (Kingsford *et al*., 2006 [18]; Conallin *et al*., 2010) [9]. Fish habitat use and movement patterns are disrupted and yet their movements have often been regarded as an adaptive behaviour for increasing growth, survival, reproductive success and consequently productivity of the fishery (Koed *et al*., 2006) [20].
The longitudinal movement and habitat use of several large catfish species have been studied in large lakes and rivers. Migration behavior of catfish (*Ictalurus punctatus*), flathead catfish (*Pylodictis olivaris*) and *Clarias gariepinus* have been studied within their natural range (Siegwarth and Johnson, 1994 [34]; Daugherty and Sutton, 2005 [10]; Kadye and Booth, 2013 [17]). However, little information is available for disturbed habitats and the lateral movements within wetlands (Mitamura *et al*., 2008; Conallin *et al*., 2010 [9]; Kadye and Booth, 2013 [17]). Microhabitats in papyrus wetlands maintain large populations of endemic wetland fish species including clariid catfishes (Chapman *et al*., 1999) [8]. Small scale Mpologoma riverine wetland fishery depend heavily on the endemic small *Clarias* species (*Clarias liocephalus* (Boulenger) and *C. alluaudi* (Boulenger)) for subsistence and bait for *Clarias gariepinus* and *Protopterus aethiopicus* fishing. This wetland, which is part of the Lake Kyoga basin, has been altered by land use changes associated with agricultural activities (Annon, 2004). Over 7000 hectares of wetlands have been converted into rice farms to cater for high population growth rate of 4.7 % in eastern districts of Uganda, (Musiime *et al*., 2005 [28]; MAAIF, 2009 [21]). Conversion of natural wetland to agricultural land use often results in habitat fragmentation and degradation which are widespread anthropogenic contributors to loss of fish species in many wetlands (Hugueny *et al*., 2011) [14].

Disturbance of fish habitats by the human activities can trigger changes in their life history strategies, dispersing them to remote areas to escape local habitat stressors and disrupt movements to specific habitats that are essential to a specific life stage (Diana *et al*., 2006) [11]. The objective of the study was to assess the variation movement patterns of small *Clarias* species at the differently disturbed sites in the Mpologoma riverine wetland. It was hypothesized that the movement patterns of small *Clarias* species would vary with differences in the habitat attributes including water quality, vegetation pattern and macro-invertebrates at the differently disturbed sites in the wetland.

Materials and Methods

Study area

The Mpologoma River wetland (1°12' N, 34°40' E) is found in eastern Uganda and discharges over 610 million m^3 of water annually into Lake Kyoga (Ramsar 2008). It is a vast permanent swamp, extending up to 102 km from Lake Kyoga as a network of small vegetated valley bottoms in a slightly undulating landscape, fed by 38 sub-basins. The climate is tropical with rainfall ranging from 1470 mm to 2300 mm and maximum temperature 27 – 32 °C. Using the Digital Elevation Model of the ArcGIS (version 10.0, *ESRI*©), a map of the Mpologoma River wetland with the four differently disturbed study sites was delineated (Figure 1). Land use cover at each site was generated from Landsat ETM images of July 2011, verified by field survey data. Land use classes of 200 polygon ha. area surrounding each site were obtained to identify variation in land use pattern at the sites (Table 1). Each site was selected depending on the level of disturbance, ranging from intact wetland (least disturbed), moderately disturbed with small scale subsistence farming system and, highly disturbed with mechanised faming systems, along the wetland. Budumba (Site 1) and Mazuba (Site 2) were least disturbed with intact natural wetland and small gardens at the edge of the wetland respectively. Kapyani (Site 3) was moderately disturbed with small scale rice and maize farms of 2 – 6 acres inside the wetland, using low implement agriculture and rain-fed lowland systems (MAAIF 2009) [21]. Nsango (Site 4) was highly disturbed with a large scale rice scheme occupying over 3,000 hectares of the wetland. Artificial fertilisers and rain-fed lowland and irrigation systems were used at the scheme.

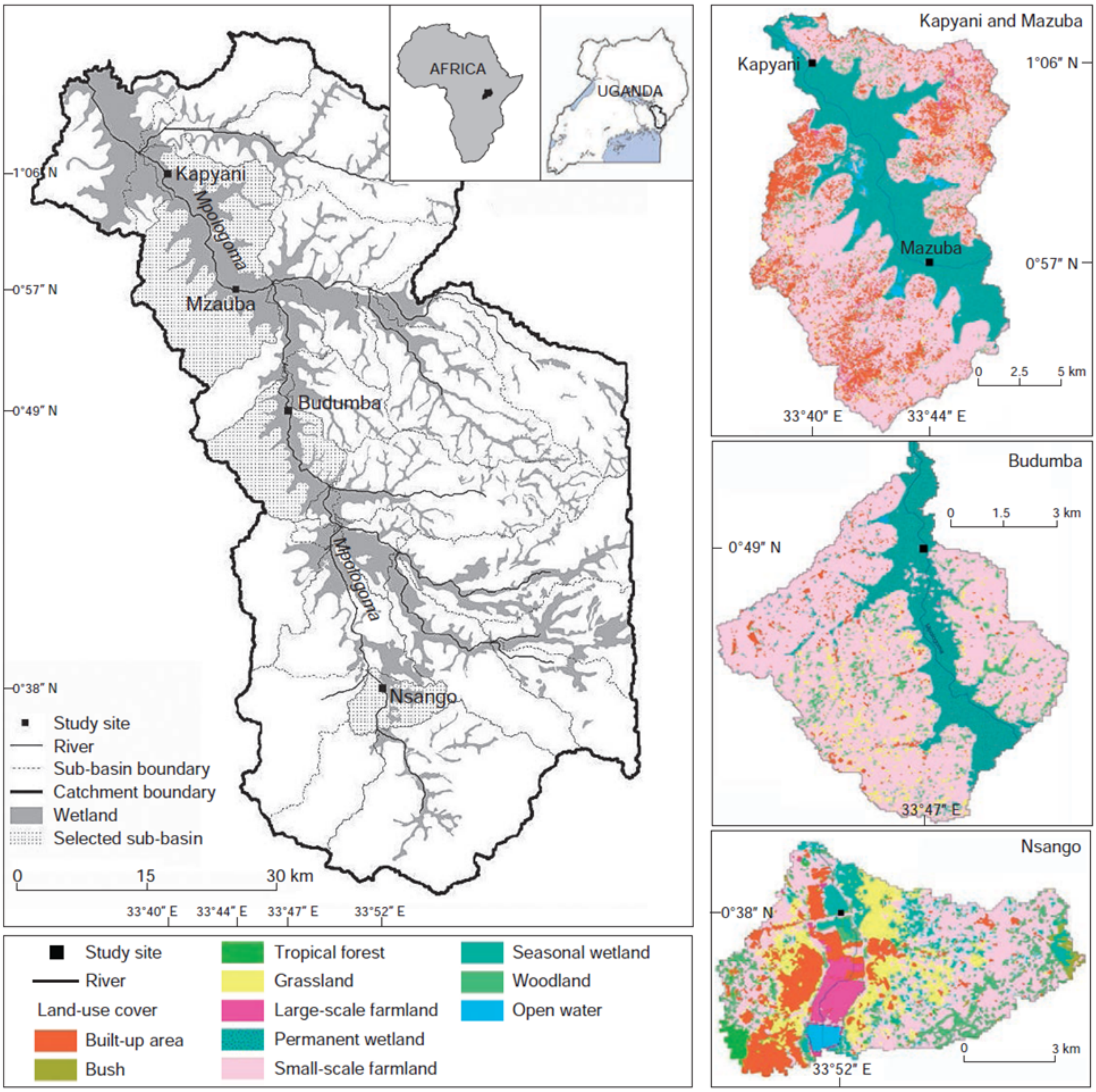

Fig 1: Land-use cover of three sub-basins surrounding study sites in the Mpologoma River catchment, Uganda, in July 2011

Habitat characteristics
Physico-chemical parameters
Water depth was measured at three different points using a deep stick within wetland nearby the fish trapping points once every month at each site. Water samples were also collected at the three different points nearby fish trapping areas for water quality assessment. Conductivity and pH were determined *in-situ* with a Hanna pH/Ec/TDS/°C HI 9813-6 meter and probe. Dissolved oxygen and temperature were determined on site by Oakton DO 110 meter and probe. Chemical analysis of alkalinity, NO_3-N, SRP and TP was done according to standard procedures (APHA, 1995) [4] in the laboratory. Macrophyte cover and substrate characteristics survey nearby the small *Clarias* species trapping sites were done using proportional additive assessment where the proportions of area was estimated and summed up to 100 percent. In this case, a habitat area of 100 m^2 was assigned the following attributes: depth – 50% 0 – 1 m, 50% 1-2 m; substrate - 25% gravel, 50% sand, and 25% silt; and cover – 30% submergent and 70% no cover basing on Habitat Suitability Matrix (HSM) method (Minns *et al*., 2001) [24].

Macroinvertebrate community
Macroinvertebrates were sampled during a single visit to each study site in the dry and wet season months (January and May respectively) of 2012. Macroinvertebrates were collected from macrophyte beds in each wetland using funnel traps designed for use in littoral habitats (Whiteside, 1974) [39]. Each sampler consisted of a plastic funnel (30-cm diameter) attached to a plastic plate, with mesh net of 0.5 mm. After removing the fish traps, a stick was used to dislodge the macroinvertebrates from the substrate and water column and collected with the funnel nearby the trapping area. The whole sample was washed into a bucket, stirred and sieved again with 0.5 mm mesh sieve. Macroinvertebrates retained were handpicked with forceps and preserved with 70% alcohol in vials for identification. Macroinvertebrates were considered as those organisms recognisable with the naked eye, excluding copepods, cladocerans and ostracods. All invertebrates were identified to the lowest taxon (genus) as much as possible. Notable exceptions were chironomids (family). The number of macroinvertebrate individuals per sample was expressed as their relative abundance as shown in equation 1 according to Batzer et al., (2001) [5]. R.A = (n x 100)/N (p_i x 100) where n is the number of individuals of one taxon; N is the total number of individuals in the sampling site; p_i is the proportion of the ith species.

Fish gut content analysis
Fish samples of small clariids were collected monthly using nine local basket traps baited with dead earthworms. Three traps were set randomly at three different points within the papyrus of each study site between 06:00 am and 12:00 pm. Each fish specimen was immediately sacrificed and its stomach contents were placed into separate vials and preserved with 40% alcohol. The degree of stomach fullness rates were recorded ranging from 0 (empty), 1 (quarter-full), 2 (hall-full), 3 (three quarter-full) and 4 (full stomach) as described by NaFIRRI (2007) [29]. Stomachs were then taken to the laboratory for stomach content identification. In the laboratory, the stomach contents were emptied into separate petri dishes and the prey items identified into different groups. The stomach food items were quantified using the volumetric method where the percentage volume contribution of each food item was visually assessed relative to all of the food items present in the gut. This was multiplied by the percentage fullness of the stomach. The importance of each food type between samples was then determined using the total number of points for each food type expressed as a percentage of the maximum number of points for a particular sample. The importance of each food item relative to other food items in any one sample was determined using the number of points of a food item expressed as a percentage.

Tracking small Clarias fish movement
The movement patterns were monitored by using external Floy tags. Trapping and tagging for recapture was done at all the sites between August 2012 and August 2013 to determine spatial and seasonal aspects of small *Clarias* species movement behaviour. Fish to be marked by tagging were collected using five basket experimental fishing traps at the four differently disturbed sites. Live fish in good physical condition were selected immediately after capture. They were placed in a bucket containing cool water collected from the wetland. Individual fish specimen was picked for total length and weight determination and thereafter a floy tag inserted quickly through the fish's dorsal musculature passing between the anterior dorsal fin rays. Tagged fish were then placed in a bucket with freshly collected wetland water until they recovered their balance, breathing and swimming movements, after which they were released into the wetland from one selected point for the whole tagging exercise. Only those fish that showed a good reaction to the tagging were released. At each site, fish for tagging were randomly selected and tagged with differently coloured tags from those used at other sites. All tagging was performed on-site, at the margins of the wetland to avoid mortality caused by the stress of transportation. The tagging was based on procedures described by Mlewa *et al*. (2005) [26]. Tagged fish were released nearby the landing point of every site. The recovery of the released tagged fish was made through the fishery based on a cash reward and recording the location of the fishing activity (Hoggarth *et al*., 1999) [13]. Local fishermen were engaged in retrieval of recaptured tagged fish. Prior to the tagging exercise, an awareness creation was done through public meetings, posters, handouts and verbal announcements to fishermen indicating that for any caught tagged fish, the mean distance moved and direction from the release point (upstream or downstream) should be noted and reported to the researcher. Each tag returned by fishermen was recorded for its site and the indicators of fish movements including distance in metres at which the tagged fish was recaptured, direction from release point (downstream or up upstream of the river) and time in number of days after release were noted.
More information on the movement patterns and habitat use was generated from anonymous structured questionnaire distributed among the fishermen at every site to evaluate the small *Clarias* species movements and habitat attributes. During the fishing season, questionnaires were randomly distributed to fishermen, enquiring on the characteristics of the suitable fishing sites and breeding sites for small clariids, best and worst fishing season, small *Clarias* fish species' movement patterns and the possible reasons for the fish movement.

Data analysis
All data were analysed using the Statistical Package for Social Sciences (SPSS version 16, IBM ©). One-way ANOVA

followed by Tukey's Honestly Significant Difference (HSD) test was used when a significant F value was obtained to discriminate between the mean values of water quality parameters amongst the different study sites. Principal component analysis (PCA) was used to analyze association between physico-chemical parameters among sites with varied levels of disturbance. Loadings of the principal components (PCs) were derived from varimax orthogonal rotation and Kaiser normalization of the second and third PCs. Only those variables which loaded heavily on any of the principal components were considered. To check for relationships between variables and sites, regression correlation scores of the PCs were used. The number of macroinvertebrates per sample was expressed as their relative abundance for each site. The stomach fullness index of fish was determined to evaluate the feeding pattern of the small *Clarias* species at the differently disturbed sites. Occurrence percentage (F) was estimated using the formula indicated below as proposed by Stobberup *et al*., 2009. $F = (N_{ei} / N_t) \times 100$

Where N_{ei} is the number of stomachs containing a type of prey i and N_t is the total number of non-empty stomachs examined. The prey items were identified to family level and the relative proportion of each to stomach fullness was calculated (Hyslop, 1980). Stomach content data were combined into key prey groups for subsequent analysis: detritus, chironomids, molluscs, insects (larvae, pupal and adult stages of terrestrial insects), crustaceans (copepods and ostracods), oligochaetes (all worms) and higher plant material. The total number of tags recaptured was used to calculate the percentage tag return of the 202 released tagged fish in both the wet and dry season of 2012. The distances moved by the tagged fish were estimated in relation 100 m of a football pitch. Frequencies and percentages of responses of the socio-economic data on *Clarias* movement patterns were calculated. Cross tabulations along with the Chi square test were used to test the association dependency among variables and between variables and study sites.

Results

Wetland fish habitat characteristics

There were differences in the phosphorus concentration, electrical conductivity, substrate characteristics and plant cover at the differently disturbed sites in the wetland (Table 2). Water conductivity was as low as 115 µS/cm at least disturbed Budumba site and as high as 454 µS/cm at the highly disturbed Nsango site. Conductivity was significantly higher at highly disturbed Nsango site than at the other sites (ANOVA, Tukey's HSD test $p < 0.05$). It was also higher during the dry season than in the wet season. Dissolved oxygen was lower at highly disturbed sites than at the less disturbed sites ($p = 0.027$) in the wetland. The dissolved oxygen (DO) within the papyrus was lower at the highly disturbed Nsango site (0.76 ± 0.66 mgl^{-1}) compared to that of least disturbed Budumba site (1.76 ± 1.35 mgl^{-1}). Conductivity increased while dissolved oxygen and orthophosphate decreased in dry season at all site in the wetland. Nitrate concentration was very at all sites ranging from 0 to 0.043 mgl^{-1}. Total phosphorus was also lower at the highly disturbed sites than the less disturbed site. The principal component analysis (PCA) produced three principal components that explained 57.79% of the variance, loaded heavily for the variables; conductivity, pH, dissolved oxygen, orthophosphate and total phosphorus. With the exclusion of water depth and temperature, PCA II explained 69.84% of the variance. Although other variables significantly correlated with sites, dissolved oxygen, orthophosphate and conductance were the dominant contributors to variation among the sites in the wetland.

The plant taxa were dominated by Cyperaceae, followed by Poaceae, Convolvulaceae and Compositae at all the sites, while a few plant taxa were unique to particular sites. The moderately disturbed Kapyani and highly disturbed Nsango sites had a higher cover of *Polygonum* sp., *Leersia hexandra* and *Vossia cuspidata*. Rice and maize crops were common at these two sites. *Eichhornia crassipes* was only recorded at highly disturbed Nsango site. While the least disturbed sites Budumba and Mazuba had *Nymphaea* sp and *Ceratophyllum demersum*, they were dominated by *Cyperus papyrus.*

Wetland macroinvertebrate community composition

Fourteen invertebrate taxa were identified at the study sites in the wetland (Table 3). Oligochaetes, insects' larvae and gastropods were the dominant groups which also showed differences among the different sites. Oligochaetes had a higher percentage occurrence at the least disturbed site (Mazuba) than at the moderate and highly disturbed (Kapyani and Nsango) sites. Insects' larvae and gastropods were higher at the highly disturbed sites than the least disturbed sites. Particularly, chironomid larvae had a higher percentage at the Kapyani and Nsango than at the least disturbed Mazuba site. Other taxa were rare but present at all sites.

Fish gut content

Of the 738 stomachs examined, 15.3% (113) were full, 26.0% (191) were partially full and 58.3% (434) were empty. Eight food items comprising of aquatic flora and fauna were the dominant with varying occurrence percentage among the fish stomach at the different sites (Table 4). Oligochaetes were the most dominant prey at all sites with a range of occurrence percentage of 47.7 to 96.8 %. Molluscs and fish prey were rare (low occurrence percentage). Based on the percentage of relative importance, chironomids scored higher percentage compared to other food items at the highly disturbed sites (Figure 2). While small fish and insects scored higher percentages at the less disturbed than those consumed at the highly disturbed sites.

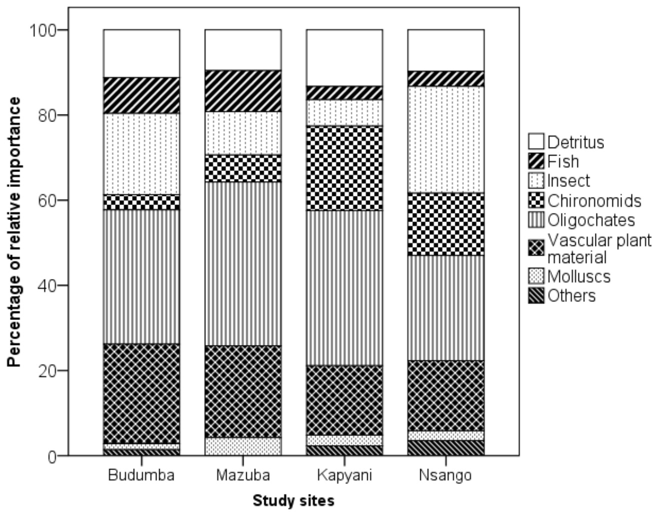

Fig 2: Percentage abundance of food items in small *Clarias* species at the different sites in the wetland

Small clariids movement pattern

A total of 253 fish with a total length range of 12.0 to 24.32 cm were tagged and released between January and December 2012 along the wetland (Table 5). Of these 15 tagged fish

(6.32%) were recaptured within about one month after release (Table 6). During the dry season months, all recaptured fish at the sites were found downstream as far as 120 m. Although, few recoveries of marked fish were made during the wet season months, fish were recaptured both upstream and downstream to the release point. The distances moved by the tagged fish ranged between 20 m to 120 m downstream and there were no significant differences between distances moved by the targeted fish at the differently disturbed sites. The water depth within the wetland varied with seasons. At all site the water depth was high inside the wetland particularly at Budumba and Kapyani with mean depth of 1.54 m and 0.84 m respectively. During the dry season water depth was low at all sites within the wetland, particularly at highly disturbed Nsango site with as low as 0.21 m.

More information on the movement and habitat use of the *Clarias* was derived from indigenous knowledge of the community members based the structured questionnaire survey (Table 7). Of the 124 respondents interviewed, 76% agreed that small *Clarias* species move and 30% believed these fish moved with changes in water level. The majority of fishermen (76.5%) could identify best fishing sites for small *Clarias* species and 58.5% of fishermen mentioned ideal areas are those with water depth range of 0.5 to 1.0 m, slowly flowing water, dense and mixed vegetation cover of different emergent macrophytes. They also revealed that such areas should have underneath rotting vegetation particularly grasses and other herbs. In addition, 46% of all respondents indicated that the ideal habitat substrate should be predominantly clay.

Table 1: Percentage land use cover of 200 ha areas around study sites in the Mpologoma River wetland, Uganda, in 2011

Land use type	Mazuba	Budumba	Kapyani	Nsango
	Undisturbed wetland	Least disturbed	Moderately disturbed (small-scale farms)	Highly disturbed (Large-scale rice scheme)
Man-made				
Built-up area	0	0.48	1.52	18.13
Subsistence farmland	0	8.67	50.25	18.18
Large-scale farmland	0	0	0.00	19.16
Subtotal	**0**	**9.15**	**51.77**	**55.47**
Natural				
Permanent wetland	100	90.63	36.21	13.30
Temporary wetland	0	0	10.15	5.58
Woodland	0	0.23	1.38	20.09
Grassland	0	0	0.48	4.31
Subtotal	**100**	**90.86**	**48.22**	**43.28**
Totals	**100**	**100**	**100**	**100**

Table 2: Small *Clarias* fish habitat metric characteristics and substrate description at the different study sites in the Mpologoma wetland during the wet season in 2012 (values are mean ± S.D., n= 256)

Habitat characteristics	Budumba	Mazuba	Kapyani	Nsango
Water depth (m)	0.52 ± 0.27	0.35 ± 0.14	0.30 ± 0.15	0.35 ± 0.14
Dissolved oxygen (mgl^{-1})	1.29 ± 1.32	1.76 ± 1.35^{a}	1.36 ± 0.37	0.76 ± 0.66^{a}
Temperature (^{o}C)	24.85 ± 1.11	25.03 ± 1.13	25.73 ± 1.47	24.76 ± 1.40
Conductivity (µS/m)	160 ± 27^{a}	180 ± 54^{b}	186 ± 67^{c}	357 ± 97^{a,b,c}
OPO_4^{3-} (mgl^{-1})	0.49 ± 0.39^{a,b}	0.26 ± 0.32	0.16 ± 0.15^{a}	0.16 ± 0.15^{b}
TP (mgl^{-1})	0.69 ± 0.54^{a,b}	0.66 ± 0.59	0.30 ± 0.29^{a}	0.23 ± 0.19^{b}
Description of sediments/substrate	Very dark, no sand or gritty feeling, a lot of decomposing plant materials (particularly of papyrus remains)	Dark brown, little soil (silt and clay), little gritty feeling, decomposing plant material (particularly of papyrus and grass remains)	Very dark, with sand and some gravel, more gritty feeling, a lot of decomposing soft plant material (particularly of grass, herbaceous plants and papyrus)	Very dark, little sand or gritty feeling, a lot of decomposing plant materials (particularly of grass, herbaceous plants and papyrus remains)

Values in the same column with the same superscript were not significantly different (Tukey's test; $P < 0.05$)

Table 3: Percentage occurrence of macroinvertebrates in the substrate at the different sites of the wetland in November 2012 (values represent percentage contribution of each taxa to total number)

Sub class		Budumba	Mazuba	Kapyani	Nsango
Oligochaeta	*Limnodrilus* sp	49.93	58.24	23.01	37.76
Hirudinea	*Haempis* sp	6.13	4.40	4.87	2.49
	Glossiphonia sp	1.65	-	-	-
Chironomiae	*Chironomus* sp. larvae	24.10	15.38	32.30	28.22
Diptera	*Culicodes* sp larvae	-	-	2.65	-
Ephemeroptera	*Afronurus* sp. larvae	3.31	4.40	0.88	-
Orthoptera	*Glyllotalpa* sp.	0.83	-	1.33	-
	Gyrinus sp. larvae	1.65	-	0.88	-
	Chaoborus sp. larvae	2.48	-	-	-

Odonata	*Idomacromia* sp. larvae	1.65	6.59	1.33	0.83
Hemiptera	*Lethocerus* sp	0.83	-	0.88	0.41
Gastropoda	*Physa* sp	5.79	6.59	29.65	20.33
	Helisoma sp	1.65	-	1.33	1.24
Bivalvia	*Lucinoma* sp	4.40	0.88	8.71	4.40
	Total	100	100	100	100

Table 4: Occurrence percentage (Op) of different food items in the stomachs of small *Clarias* species in Mpologoma River wetland, January to December 2012

Food items	Budumba	Mazuba	Kapyani	Nsango
Detritus	32.3	20.5	45.5	22.7
Fish	3.2	20.5	6.1	6.8
Insect	27.5	6.8	12.1	52.3
Chironomids	8.1	13.6	21.2	20.5
Oligochates	96.8	88.6	71.2	47.7
Vascular plant material	53.2	54.5	31.8	31.8
Molluscs	3.2	9.1	3.0	4.5
Crustaceans	3.2	0.0	4.5	6.8

Table 5: Number of small *Clarias* fish species, mean length and weight of the released tagged fish at the different sites in the wetland

Site	No.	Mean Total length (cm)	Mean Weight (g)
Budumba	64	15.78 ± 3.76	28.14 ± 17.39
Mazuba	47	18.02 ± 4.15	34.69 ± 18.12
Kapyani	56	18.16 ± 3.22	33.84 ± 20.21
Nsango	35	19.17 ± 5.15	44.78 ± 22.35

Table 6: Floy tags recovery, direction of movement of tagged fish and mean water depth within the wetland at the different study sites along the wetland (August 2012 to July 2013)

Site	Release Date Dry season	Tag No.	Downstream	Upstream	Days at recapture	Water depth (m)
Budumba	Jan-12	495	20 m		3 day	0.57
Budumba	Feb-12	473	70 m		10 days	0.45
Budumba	Mar-12	482	50 m		4 days	0.51
Budumba	Jul-12	551	120 m		8 days	0.48
Budumba	Jul-12	567	80 m		15 days	0.48
Mazuba	Jan-12	76	20 m		3 days	0.34
Mazuba	Feb-12	91	18 m		5 days	0.25
Kapyani	Feb-12	450	110 m		5 days	0.34
Kapyani	Feb-12	446	50 m		10 days	0.34
Kapyani	Feb-12	442	90 m		21 days	0.34
	Wet season					
Kapyani	Apr-12	423	120 m		25 days	0.51
Kapyani	May-12	417		80 m	11 days	1.53
Kapyani	Aug-12	403	80 m		14 days	0.84
Nsango	May-12	295		10 m	5 days	0.53
Nsango	May 12	283		20 m	6 days	0.76

Table 7: Summary of responses based on community members interviewed at the different study sites indicating the level of indigenous knowledge on small *Clarias* species movement and habitat preference in the Mpologoma riverine wetland

	Budumba (n = 46)	**Mazuba** (n = 27)	**Kapyani** (n = 49)	**Nsango** (n= 29)	**Overall** (n = 151)
Knowledge of Catfish movement					
Yes	80.4	89.7	51.0	100	76.5
No	10.9	0	16.3	0	8.5
Not applicable	8.7	10.3	32.7	0	15.0
Knowledge of the fish moving season upstream/downstream					
Wet season	39.1	27.6	24.5	58.6	35.9
Dry season	47.8	37.9	22.4	24.1	34.7
Not applicable	13.0	34.5	49.0	17.2	29.4
Main reasons for moving					
Low water	37.3	20.0	52.8	3.4	30.8
High water	11.6	24.0	8.3	17.2	14.3
Following water	20.9	20.0	30.6	20.7	23.3
Limited food items	7.0	8.0	8.3	44.8	15.8
Spawning time	23.3	28.0	0	13.8	1.5

Knowledge of small Clarias fish habitats					
Yes	84.8	75.9	55.1	100	76.5
No	0	0	4.1	0	1.3
Don't know	15.2	24.1	40.8	0	22.2
Best fishing areas for small Clarias fish species					
Water level					
Less than 0. 5m	0	0	8.5	20.7	6.8
0.5 to 1 m	60.5	50	48.9	79.3	58.5
Above 1 m	11.6	17.9	0	0	6.8
Don't know	27.9	32.1	42.6	0	27.9
Substrate characteristics					
Stony	2.7	0	0	19.0	4.3
Sandy	0	3.8	12.9	0	4.3
Clay soft	64.9	53.8	38.7	33.3	49.6
Don't know	32.4	42.3	48.4	47.6	41.7
Small Clarias species Catch (Individuals per trap per day)					
Low	9 ± 4	9 ± 3	10 ± 4	14 ± 3	10 ± 4
Peak time	30 ± 2	44 ± 3	36 ± 2	51 ± 3	39 ± 3

Discussion

Wetland fish habitats vary with the ecological heterogeneity of the limnological characteristics and biota of any aquatic ecosystem (Onyango and Jentoft, 2010) [31]. In Mpologoma wetland, fish habitat attributes; water level, vegetation cover, substrate composition and invertebrate community varied among sites with different land uses. Land uses such as agricultural activities affect water and sediment inputs, destabilize the existing habitat attributes and set off a complex cascade of changes (Allan, 2004) [1]. High conductivity and low dissolved oxygen at the highly disturbed sites were attributed to effects wetland perturbation by agricultural activities (Kuhar *et al*., 2007 [23]; Ssanyu *et al*., 2014 [36]). The use of agricultural fertilizers for intensive rice production accounted for the higher conductivity and lower dissolved oxygen observed in Nsango than the other sites. The low dissolved oxygen due to the redox reactions resulted in lower orthophosphate at the highly disturbed sites than at the less disturbed sites. Water depth within the wetland did not vary significantly among the three upstream sites as it did at downstream, Kapyani site. This was attributed to differences in rainfall and temperature regimes and the cumulative increase in water depth downstream of the river. The occurrence of the long rains (March to May), the short rains (September to November) and the high rainfall variability explains the progressively drier climate from east to west in the Lake Kyoga basin (WREM, 2008). In addition to the increasing farming activities within the wetland, Kapyani site was potentially vulnerable to both droughts and floods. There were variations in vegetation cover at the different sites and this was attributed to the land use changes associated with wetland conversion for agriculture. Such disturbances encourage growth of a mixture of plants including opportunistic herbaceous species (Raghubanshi and Tripathi, 2009).

Changes in riparian vegetation composition due human activities, together with modification of stream morphology, decreased habitat diversity, affected water quality and consequently alter the invertebrate composition of streams (Urska Kuhar *et al*., 2007) [23]. This explained the variation in the macroinvertebrates composition among the differently disturbed sites in the wetland. According to Bruton (1979b), catfishes are generally known to be benthic feeders. The dominant food items for the small *Clarias* species were insect larvae which were found abundant in the substrates at all the sites. The food items could have varied with changes in the prevailing ecological conditions in the wetland. The results from this study revealed that small *Clarias* species depend on a wide range of prey, hence the omnivorous feeding habit like other clariids such as *C. gariepinus* and *C. anguillaris* (Offem *et al*., 2009 [30]; Alhassan *et al*., 2011 [2]). Individual fish display different foraging strategies such as hunting in the substrate for earthworm and chironomids and surface feeding on floating debris and small fish (Kadye and Booth, 2013) [17]. This search for food partly explains the clariids need to move about the wetland.

Small *Clarias* fish species exhibited downstream and upstream movement in the wetland based on both the experimental tagging and indigenous knowledge from local fishermen. Fish movement is an adaptive strategy involving shifting of part or all of a population in time between discrete sites but not necessarily involving predictability or synchronicity in time, since inter individual variation is a fundamental component of populations (Vokoun and Rabeni, 2005) [38]. The seasonal upstream and downstream movement exhibited by small *Clarias* species, is common habit of riverine species in search for suitable habitats (Vokoun and Rabeni, 2005) [38]. While the water level in the river channel rose during the wet season, a few small *Clarias* species moved upstream towards inundated vegetation zones to avoid the large-fast swimming predators (*Protopterus* sp and *C. gariepinus*) in the deep waters downstream. Fish movements are some of the strategies by which individual fish may easily and quickly adjust to variations in local habitat changes (Saraniemi *et al*., 2008 [33]; Zimmer *et al*., 2010) [41]. Water depth decreases upstream during the dry season forcing these fish to move downstream looking for suitable foraging habitats. The modified wetland fish habitats by agricultural activities could have affected the proper upstream movement to rather lateral movement which was demonstrated by a few recoveries in the wet season. Many of the tagged fish could have moved laterally to the release point due to the increasing water level in the rainy season, particularly at the disturbed sites. Therefore the human induced wetland disturbance affected small *Clarias* species movements in the wetland. Increased wetland disturbance could affect the fish population by negatively impacting the fish synchronised movement necessary for breeding and feeding in the different seasons in the wetland.

Many studies of other catfish species migrations have associated movements to spawning and foraging behavior triggered by change water quality (Siegwarth and Johnson, 1994) [34]. From the gonado somatic index analysis, these small *Clarias* species spawn at the beginning of the rainy season (April to May and October to November) (Ssanyu *et al*., 2014)

[36]. Therefore, the clariids start moving upstream looking to suitable spawning site with clear flowing water in the rainy season. In the dry season, water level reduced upstream, water quality declined in the shallow areas which necessitated the small catfish to move downstream. The observation was similar to that of flathead catfish migration in three streams in the North America (Siegwarth and Johnson, 1994) [34]. During the dry season, reduction in water level led to restrictions in catfish movement and fragmentation of the fish population by habitat discontinuity created by alternation of dry areas and shallow pools within the wetland. This also explains the downward movements and the higher chances of the recovering tagged the fish that was observed in the dry season.

The recovery rate of tagged fish in the present study was low (about 6%). This was comparable to other similar studies which had only 1% tags recovery (Hay and McKinnell, 2002) [12]. Therefore, the mark and re-capture method used could have underestimated the movement patterns due to low number of tagged fish and recovery efficiency. According to Knouft and Spotila (2002) [19], mark and re-capture studies under-estimate movements of tagged individuals due to the low recapture rates and other inefficiencies of the method. Movement that occurs within a site cannot be accurately quantified unless recapturing at adjacent sites is avoided to prevent overlaps (Knouft and Spotila, 2002) [19]. In this study, the sites were more than 10 km far apart each other and therefore overlaps were negligible. The lateral distance between recapture and release locations was used to determine distance moved by fish. Under-estimations in fish movement studies can also be reduced when re-sampling is done in a large area of stream using contiguous re-capture method (Knouft and Spotila, 2002) [19]. Another short-coming of this telemetry study was that relatively few catfish could be monitored relative to the population size and duration of monitoring was constrained by seasonal abundance of small catfish along the wetland. Therefore, a combination and comparison of telemetry and radio telemetry techniques, would be useful for further assessment of the movements of small *Clarias* species.

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