Litter Processing of Exotic and Indigenous Leaves in Njoro River, Kenya

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Abstract

The decomposition rate of riparian leaves can measure the potential of litter quality as a food resource for aquatic organisms. This is valuable given the changing composition of riparian trees where exotic species are becoming more dominant. The core objective of this study was to estimate breakdown rates of riparian leaves and macroinvertebrates participation by examining four tree species common along the riparian areas of River Njoro, Kenya at Egerton University. The study assessed decay rates of the leaves of *Grevillea robusta, Eucalyptus saligna, Pittosporum viridiflorum* and *Syzygium cordatum* in water. The classical decay coefficienct method was used after the leaves were immersed in water for 46 days. *Syzygium cordatum* and *Eucalyptus saligna* recorded the lowest decay rates (0.03). Decay rates for *P. viridiflorum* and *G. robusta* were 0.19 and 0.05 respectively. There was a statistically significant difference in the decay rates for each sampling day (p>0.05) for all tree species except *S. cordatum*. There was also a positive relationship between decay rate and macroinvertebrates for *P. viridiflorum.* Macroinvertebrate taxa favored leaves of *P. viridiflorum* and *G. robusta.* Leaves of *P. viridiflorum* decayed faster, were softer and favored by aquatic macroinvertebrates. Thus *Pittosporum viridiflorum* leaves are of good quality and should not be replaced by exotic species such as *E. saligna* and *G. robusta* in riparian areas of streams. For aquatic and riparian management, planting of *P. viridiflorum* along river banks is encouraged to improve the quality of food sources available for aquatic insects and the subsequent aquatic food web.

Key words: allochthonous, aquatic, decomposition, exotic, indigenous, *k*-values

Introduction

Shaded stream channels heavily depend on organic matter from outside sources (allochthonous organic matter) as the primary sources of energy for other stream processes. In such streams, the allochthonous leaves form the bulk of the organic matter compared to twigs, branches and bark (Graca *et al.,* 2005). Leaf litter decomposition generally occurs through a system of sequential processes. These include passive leaching of soluble compounds (Ribblett *et al.,* 2005), microbial colonization or conditioning of the leaves (Gessner and Chauvet, 1994), fragmentation by invertebrate shredders (Allan, 1996; Graca, 2001) and physical abrasion. Large invertebrate shredders play significant role in leaf litter breakdown in streams. Other studies report of a paucity of shredders in the tropics with increasing importance of some crustaceans and caddis fly larvae (*Phylloicus* sp.) as shredding organisms (Crowl *et al.,* 2001; Encalada *et al.,* 2010). On the contrary, temperate forested streams show significant shredding activity on leaves by stream macroinvertebrates (Boulton *et al.,* 2008; Dobson *et al.,* 2002; Leigh and Sheldon, 2009). Due to the paucity of shredding activities in the tropics, most scholars agree that microbes might play an essential role in controlling decomposition in tropical streams (Franken *et al.,* 2005; Reid *et al.,* 2008).

Upon entering streams, allochthonous organic matter form mixed leaf packs on streambed. These leaf packs are important areas that enhance litter decomposition (Kominoski *et al.,* 2009). Litter breakdown rates can provide a good estimate of detritus quality and can be an indirect measure of biological activity. Therefore, litter breakdown can be used as a measure of the potential of litter quality as a food resource for aquatic organisms. The study was focussed on Kenya because replacement of indigenous tree by exotic species is becoming common. The primary aim of this study was to assess and estimate breakdown rates of riparian leaves and macroinvertebrates participation on these leaves by examining the selected tree species common along the riparian areas of River Njoro, Kenya at Egerton University.

Materials and Methods

Descriptions of the Study Site
The study was conducted in Njoro River in Nakuru County, Kenya, from May to July 2013. The Njoro River is a second order stream with a catchment area of approximately 200 km^2. The river is approximately 60 km in length originating from the Eastern Mau escarpments at an elevation of

2880 m and draining into Lake Nakuru at an attitude of 1750 m. The study site was in the Njoro river at Egerton University (S 00° 22.425', E 035° 55.892') at an elevation of 2262m. The study site was characterized by closed canopy cover and less frequently visited by humans and animals. The mean width of the river ($\pm$SE) at the time of the study was 4.77$\pm$0.32 m and mean depth 0.392$\pm$0.025 m. The bottom substrates was mainly comprised of fine silt and clay. Leaves and other organic matter from the riparian vegetation also formed a significant amount of the organic matter at the bottom of the stream. The site was heavily shaded by trees with a canopy cover of about 80%, but with cultivated land near the right bank. The cultivated fields present near the study site was mainly comprised of agricultural crops and a Eucalyptus plantation 15 m from the right bank. The slope of the right bank was 13° while the slope of the left bank was 9°. The Dominant riparian vegetation in the study site was *Syzygium cordatum* and *Grevillea robusta*. Some selected characteristics of Njoro River at the study site during the time of the study are presented in Table 1.

Table 1: Selected physico-chemical variables of the Njoro River at the study site measured from May to July 2013 (mean ±SE)

Date (2013)	DO (mg/L)	% Sat	Temperature(^{0}C)	pH	Conductivity (µs/cm)	Discharge (m3/s)
6th May	7.81±0.03	102.75±0.15	16.00±0.15	7.34 - 7.91	76.00±0.38	0.34
9th May	8.02±5.34	105.5±70.32	16.17±10.80	6.54 - 6.77	58.63±38.04	0.53
13th May	8.4±5.59	105.57±70.35	13.93±9.30	5.21 - 5.79	74.03±49.30	0.83
20th May	8.38±5.58	105.2±70.13	13.9±9.30	5.24 - 5.62	84.63±56.40	0.59
3rd June	8.08±5.45	105.4±70.30	16.43±11.40	4.97 - 5.65	108.57±72.23	1.54
1st July	8.68±5.80	105.6±70.33	14.37±9.53	6.11 - 6.25	109.2±72.87	0.15
5th July	8.06±5.43	105.73±70.4	14.87±9.88	4.4 - 5.63	107.5±71.58	0.12

Sampling, processing and analysis of Organic matter (leaves)

Four tree species were used for this study, two native riparian species (*Pittosporum viridiflorum* and *Syzygium cordatum*) and two exotic species (*Eucalyptus saligna* and *Grevillea robusta*) commonly grown along the riverbanks. The choice of the four tree species was dictated by the fact that these were the species dominating the study site. *Syzygium cordatum* was the most dominant native tree species while *Eucalyptus saligna* dominated the exotic species. Senescent leaves (mature leaves) were collected in the daytime from the trees and oven-dried at 60°C for 24 hours, after which they were weighed into 5 g packs each. The leaves were wetted to prevent breakages into smaller pieces, and then enclosed separately in 140 nylon litterbags of 5 x 5 mm mesh size and 11.0 x 11.0 cm to allow aquatic organisms to enter the litterbags. Each litterbag was coded depending on the particular tree species. In total, 140 litterbags were prepared after recording the initial dry mass (DM). The bags were then transported to the stream on 6 May 2013 and placed in a 50 m stretch randomly. Each string was secured in the stream channel by tying to tree roots and steel poles hammered into the streambed. Poles were randomly placed 0.5 m from each other to avoid bags from different strings meeting each other and were given codes corresponding to the respective bags for easier retrieval during sampling.

Five litterbags from each species were retrieved randomly during each sampling occasion, i.e. during 0, 3, 7, 14, 28, 56 and 60 days of exposure, therefore 20 litterbags in total were retrieved on each sampling day. The choice of the sampling intervals was in that order to allow comparisons with similar studies that have used the same sampling intervals in the past (Dobson et al., 2003, Masese and McClain, 2012). After retrieval, the litterbags were put in well-labelled polythene bags, fixed with 5% formalin and transported to the laboratory for further analysis. In the laboratory, the leaves were removed from the litterbags and rinsed with water through a 0.5 mm sieve to remove excess formalin, the accumulated sediments, attached debris and macroinvertebrates. Macroinvertebrates were sorted, identified, and stored in 70% ethanol. Identification was carried out under a light Dissecting microscope at 40 x10 magnification. The macro-invertebrates were identified to the family level using the Aquatic Invertebrates of South African Rivers identification key– A Field Guide by Gerber and Gabriel, (2002). Sub-samples of the leaf remnants after each exposure duration were oven-dried at $60^{o}C$ for 24 hours and weighed using weighing balance (Sartorius model: ED4202S, d=0.01g) to obtain dry mass remaining (DM_{rem}) and thereafter ashed at $500^{o}C$ for four hours to obtain ash-free dry mass remaining ($AFDM_{rem}$), calculated according to Benfield (1996) using formula (1):

$$\%OM = \frac{(DM_{sample} - AM_{sample})}{DM_{sample}} x100 \qquad (1)$$

Where: OM is organic matter, DM_{sample} is the sample dry mass and AM_{sample} is the sample ash mass. DM values are then converted to AFDM as follows:

AFDM = (DM) x (% organic matter)   (2)

AFDM values for each leaf bag are converted to percentage AFDM remaining, using formula (3):

$$\%loss\ AFDM = \frac{(InitialAFDM - FinalAFDM)}{(InitialAFDM)} X100 \qquad (3)$$

Assuming that on day = 0 the AFDM is 100%, then the percentage remaining can be calculated as:

% remaining AFDM = (100% - % loss AFDM).   (4)

The processing coefficient (- k) of the leaves were determined by fitting the data to the exponential model:

$DM_t = DM_0 e^{-kt}$

After *logarithmus naturalis (ln)*-transformations of the dry mass (DM) at the beginning and at the end of each exposure duration as follows:

$-k = (ln\ DM_0 - ln\ DM_t) / t$

derived from the exponential model, where DM_t = dry mass (g) remaining at time t, (days), DM_0 = initial dry mass (g) (Graca *et al.,* 2005).

In addition, the data was fitted to the linear model by regressing log_e percentages of the remaining dry mass (% RDM) on time. This enabled calculation of the time required for 50, 80, and 90% of the leaves to be processed in the stream (Boulton and Boon 1991; Petersen and Cummins 1974).

$y = b + ax$ (6)

Where *y* is the % RDM and *x* is the number of days, *b* is the slope and *a,* the intercept. The time required to have 50% of the material processed is referred to as the biological half - life (Petersen and Cummins, 1974).

Results

This study calculated leaf processing rates from exponential decay equations. The rates of mass loss (k-values) for the four tree species used in this study are presented in Table 2. The lowest decay rate was recorded on the leaves of *Syzygium cordatum* and *Eucalyptus saligna* at 0.03 each. Compared to these two tree species, the leaves of *Grevillea robusta* and *Pittosporum viridiflorum* recorded higher decay rates of 0.05 and 0.19 respectively. Among the four tree species, *Pittosporum viridiflorum* recorded the most rapid decay rate. For *Eucalyptus saligna,* statistical analysis of the *–k* values indicated significant differences in the decay rates (ANOVA, F= 6.441, df = 5, P = 0.001). SigmaPlot 20, was used for the analysis. The differences occurred between Days 3 vs Day 14 and Day 3 vs Day 56 of the experiment. Similarly, the decay rates for *Grevillea robusta* varied significantly among the six sampling dates (ANOVA, F= 10.533, df = 5, P <0.001). The difference specifically occurred between Day 3 vs Day 28. For *Pittosporum viridiflorum,* the decay rates were significantly higher for day 3 compared to day 14, 56 and 60 (ANOVA, F= 10.644, df= 5, P<0.001). However, there was no significant differences in the decay rates for *Syzygium cordatum* (ANOVA, F=1.09, df= 5, P=0.396)

Table 2: Decay rates in this study and other examples recorded in studies from tropical streams

Species	Location	k	DM	Reference
Trema micrantha	Costa Rica	0.559	Yes	Irons *et al.,* (1994)
Croton gossypifolius	Colombia	0.065	No	Mathuriau & Chauvet (2002)
Vanguera madagascariensis	Kenya	0.047	Yes	Dobson *et al.,* (2003)
Pittosporum viridiflorum	**Kenya**	**0.190**	**Yes**	**This study**
Pittosporum viridiflorum	Kenya	0.043	Yes	Dobson *et al.,* (2003)
Rhus natalensis	Kenya	0.026	Yes	Dobson *et al.,* (2003)
Clidemia sp.	Colombia	0.024	No	Mathuriau & Chauvet (2002)
Grevillea robusta	**Kenya**	**0.050**	**Yes**	**This study**
Euclayptus saligna	**Kenya**	**0.030**	**Yes**	**This study**
Syzygium cordatum	Kenya	0.022	Yes	Dobson *et al.,* (2003)
Syzygium cordatum	**Kenya**	**0.030**	**Yes**	**This study**
Syzygium cordatum	Kenya	0.001	No	Mathooko *et al.,* (2000)
Hibiscus tiliaceus	Hawaii	0.023	Yes	Larned (2000)
Dombeya goetzeni	Kenya	0.021	No	Mathooko *et al.,* (2000)
Dombeya goetzeni	Kenya	0.01	Yes	Dobson *et al.,* (2003)
Pithecellobium longifolium	Costa Rica	0.02	Yes	Irons *et al.,* (1994)
Psiduim guajava	Hawaii	0.008	Yes	Larned (2000)

Table legend: *k* means *k*-values, DM means Dry Matter

The data used for generating the *k*-values was fitted to a linear model that provided the time required for 25, 50, 75, and 90% of the leaves to be processed in the stream. Leaves of *S. cordatum* took the longest time to be processed in River Njoro while *P. viridiflorum* took the shortest time. It took 32 days to decompose 50 % of the leaves of *S. cordatum* while 50 percent of the leaves of *P. viridiflorum* decomposed in only 18 days.

Majority of the macronvertebrates were found on leaves of *Pittosporum viridiflorum* followed by *Syzygium cordatum*, *Grevillea robusta* and the least number of insects were present on leaves of *Eucalyptus saligna*. However, statistical analysis of the pooled data showed no significant differences in the number of macroinvertebrates collected between exotic and indigenous leaves (t=1.285; df= 22; P= 0.212). Neither were there significant differences among the individual tree species in terms of macroinvertebrates that colonized the litterbags (One-way ANOVA, F= 0.775, df=3, P=0.522). 22 groups of macroinvertebrate communities were collected in this study. Some of the groups included Ephemeroptera, Trichoptera, Diptera, Coleoptera, Plecoptera, Anisoptera, Zygoptera and Annelida among others. However,

insect groups dominated the study and contributed to about 79% of the total macroinvertebrates collected (Table 3). Baetidae abundance dominated in all the plant species followed closely by simuliidae. On the other hand, Chironomidae and Hydropsychidae preferred the leaves of *P. viridiflorum* compared to leaves of the other plant species. The number of Baetidae collected from the bags was significantly higher compared to all the other macroinvertebrate groups (ANOVA, F= 15.038, d.f = 4, P≤0.001). Apparently, Simuliidae and Hydropsychidae preferred the leaves of indigenous trees compared to those of exotic tree species as evidence by their higher abundance on these leaves.

Table 3: Major Macroinvertebrate groups colonizing the plant species

Macroinvertebrate groups	*E. saligna*	*S. Cordatum*	*P. viridiflorum*	*G. robusta*	ANOVA P-values
Baetidae	46.3±15.95	66.83±17.23	76.23±32.20	73.6±20.99	**0.741[n.s]**
Simuliidae	21.25±13.05	47.67±38.63	39.73±32.96	21.3±13.97	**0.619[n.s]**
Chironomidae	5.95±2.55	4.43±1.86	40.27±28.32	3.8±2.06	**0.456[n.s]**
Leptoceridae	14.45±6.47	15.07±5.85	8.03±4.67	12.05±4.30	**0.813[n.s]**
Hydropsychidae	6.8±2.96	19.1±10.06	30.9±10.59	10.95±3.98	**0.275[n.s]**

n.s – Not signficant

Macro-invertebrate functional feeding groups on the leaves varied among the four tree species. About 59% of the insects colonizing the leaves of *G. robusta* were Gatherers, 18 % were filtering feeders, 13% predators, 7% shredders and 3% scrappers (Table 4). A similar trend was recorded for *P. viridiflorum*, which had 60% Gatherers, 30% filtering feeders, 5% predators, 3% shredders and 2% scrappers. The trend in the remaining two tree species changed. *E. saligna* had 57% Gatherers, 25% filtering feeders, 13% shredders, 4% predators and 1% scrappers. For *S. cordatum*, 45% were Gatherers, 35% filtering feeders, 8% shredders, 7% predators and 5% scrappers. Cleary, gatherers and filter feeders dominated the leaves of the four tree species.

Table 4: Percentage composition of Macroinvertebrate Functional Feeding Groups (FFG) on the tree species

FFG	*G. robusta*	*P. viridiflorum*	*E. saligna*	*S. cordatum*
Gatherers	59%	60%	57%	45%
Filter Feeders	18%	30%	25%	35%
Shredders	7%	3%	13%	8%
Predators	13%	5%	4%	7%
Scrapers	3%	2%	1%	5%

Discussion

Pittosporum viridiflorum leaves, which had the highest decomposition rate decayed at a faster rate almost five times the rate recorded by Dobson *et al.,* (2003). This could be explained by the differences in mean temperatures and dissolved oxygen, which were higher in this study compared to the study by Dobson *et al.,* (2003). The *Syzygium cordatum* leaves on the other hand decayed at a rate close to the rate recorded in the previous studies in Njoro River (Mathooko *et al.,* 2000). The high decay rate for *P. viridiflorum* could be due to favorable conditions at the study site that could contribute to decomposition as well as the leaf structure. The soft structure of *P. viridiflorum* leaves and the preference by macroinvertebrates could explain the high rate of decomposition. *S. cordatum* and *Eucalyptus saligna* decomposed at a slower rate than the other two species in the study. Similar studies in tropical streams found that leaves of *Eucalyptus spp.* decomposed slowly than most tropical native species due to leaf toughness and presence of inhibitory compounds that deterred macroinvertebrate colonization (Masese and McClain, 2012). The slow rate of decomposition for *E. saligna* and *S. cordatum* could be due to the tough structure of these leaves. The tough structure make these leaves less palatable to macroinvertebrates thus, the low decomposition rates.

The Dominance of exotic species in tropical streams may have profound effects on overall stream functioning and metabolism. Magana (2001) hypothesized that the leaves from exotic species are poorer in quality than indigenous species they replace. This is evident in the high decay rate for *P. viridiflorum* making it have good quality compared to *E. saligna*. The concentration of nutrients leaching particularly from leaves of *S. cordatum* may also support the hypothesis that indigenous leaves are of better quality compared to exotic leaves. The higher leaching of nutrients relates to decomposition thus make these leaves available for utilization as food sources by aquatic organisms. This study is among the few that determined

decomposition rates of a range of tree species other than concentrating on single selected species. This study opted to use exponential decay coefficients to present decomposition information to enable comparison with decay rates from other studies that use the same method. Despite the inadequacy of standards for categorizing slow and fast decomposing leaves in the tropics, decay rates for this study fall within decay rates from similar studies in tropical streams despite the many reports of a paucity of shredders in the tropics (Dobson *et al.,* 2002; Mathuriau and Chauvet, 2002) and especially in Njoro River (Dobson *et al.,* 2002) to mediate breakdown. This means that most breakdown rates may be mediated by microbial activity and physical factors as reported elsewhere in the tropics (Dudgeon and Wu, 1999) although the importance of microbes to decomposition process is poorly understood in the tropics (Wright and Covich, 2005).

The decay rates for the four tree species differed significantly for the different days of exposure in water except for *S. cordatum*. Different leaves decompose at different rates in streams. The rate at which the leaves decompose is dependent upon various factors. As Wantzen *et al.,* (2008) explain, physical abrasion, fragmentation and influence of macroinvertebrates are some of the main factors that determine decay rates in rivers and streams. *Pittosporum viridiflorum* decayed at a faster rate suggesting it may be a high quality food resource for aquatic organisms. Several other authors such as Gessner and Chauvet (1994) reported the classical negative exponential decay trend displayed by four plant species in this study (Figure 1). The loss of mass of the leaves in water decrease from the first day of exposure in water towards the last day suggesting that the process of decomposition was taking place. Mathooko *et al.,* (2000) found that leaves immersed in the humid zone of rivers lost mass over time due to decomposition. Typical leaf mass loss exhibit an increase in mass after leaching due to microorganisms that colonize the leaves and build bio-film*s* thus increasing the mass (Moss, 2007). However, the leaves of the four tree species did not exhibit any increase in mass during the first days of exposure in water. The loss of leaf mass was exponetial from the first day to the last day of exposure in water. Leaves of *P. Viridiflorum* decomposed faster than leaves of the other four species as shown in Table 2. However, the biological half-life of *Eucalyptus saligna* was highest in this study compared to the other three species. This shows that it would take a longer time to decompose 50% of *Eucalyptus saligna* leaves than it would for the other tree species. The higher biological half-life of *Eucalytus saligna* leaves could be attributed to the toughness of the leaves. As Masese and McClain (2012) found in similar studies in tropical streams, the leaves of *Eucalyptus spp.*

decomposed slowly than most tropical native species recording a decay rate of 0.018 k/day.
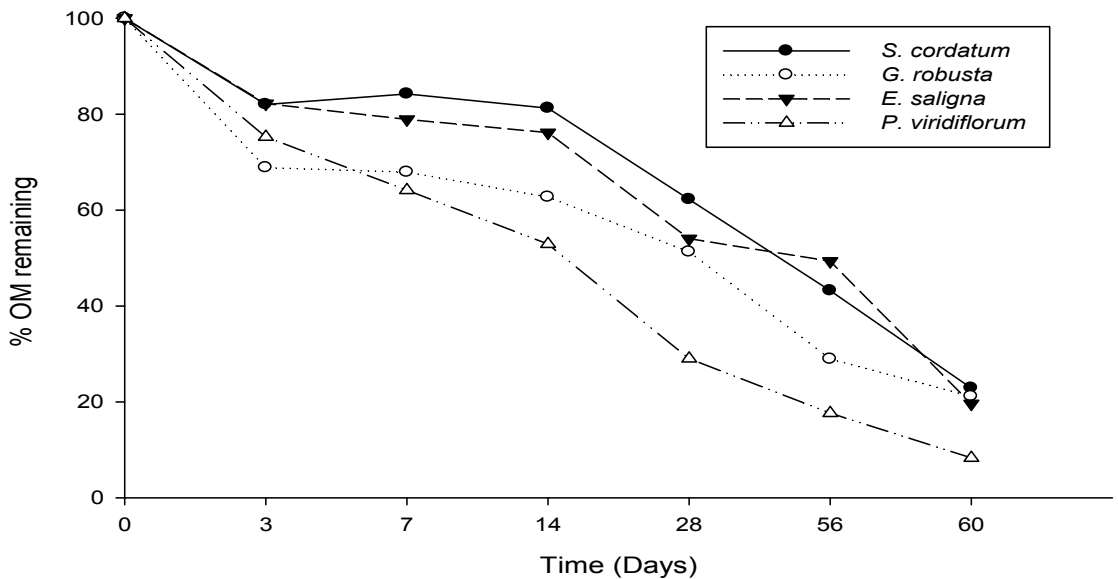

Figure 1: Changes of Percentage OM with time of the leaves exposed in Njoro River

There was a significant difference in abundance between Baetidae and the other four major groups of macro-invertebrates feeding on the leaves. Simuliidae only differed significantly with coenogrionidae. The dominance of Baetidae could be because they dominate the macro-invertebrate composition in River Njoro. According to M'Erimba (2004), Ephemeroptera (including Baetidae) and simuliidae were among the dominant groups contributing to more than 90 % of the total macroinvertebrates in Njoro River. The presence of Baetidae in high densities in Njoro River could be the probable reason explaining their dominance in this study too. The dominance of Baetidae in all the plant species could be related to their feeding mechanisms. Baetidae are mainly benthic gatherers adapted to feeding on FPOM deposited on benthic substrates in streams (Graca, 2001). Benthic food resources that Baetidae feed on include FPOM such as fungi and bacteria present on the leaf surfaces on the streambed in the form of biofilms. Through leaf conditioning, bacteria and fungi that form biofilms on the leaf surfaces may attract gatherers such as Baetidae. The same bacterial and fungal biofilms created on the leaves may also attract other filter feeders that may utilize FPOM present in the water column adjacent to the leaves (Graca, 2001).

Leaves of *Pittosporum viridiflorum* decomposed faster compared to the other plant species. The faster decaying could be probably because the leaves of *P. viridiflorum* are soft and represent high quality leaves. The fast decomposition rate would also mean that these leaves would attract fungi and bacteria thus forming a biofilm at a rate faster than the other plant species. Most Chironomidae are filter feeders while Hydropsychidae are Gatherers (Allan, 1996). These two groups of insects both feed on FPOM. The faster rate of FPOM and biofilm formation on the leaves of *P. viridiflorum* may explain the abundance of these two groups of insects on these leaves.

The general decomposition trend evidenced by the increase in the number of macro-invertebrates per litterbag as the study progresses from day 0 towards day 28 may be due to leaf conditioning. According to Strauss and Lamberti (2002), leaching of sugars and amino acids from leaves after a few days of emersion in the water attracts fungi and bacteria to the leaves. This leaf conditioning may explain the increase in insect communities on the leaves some of which may congregate on these leaves for feeding. The softening of leaves due to presence of fungi and bacteria increases the food value for other insects especially shredders (Wantzen *et al.,* 2008).

The high numbers of macro-invertebrates on day 28 for the three leaf species except for *Syzygium cordatum* may also be due to leaf conditioning. By day 28 more than 50 % of the leaves of *P. viridiflorum* and *G. robusta* had decomposed. This means that the leaves were well conditioned by day 28 hence could be prefered by the macroinvertenate communities which were found in high numbers in these respective litter bags. The highest Discharge recorded on day 28 could also influence the number of macroinvertbrates collected from the litter bags. Large amount of water could have forced these macoinvertebrates to seek refuge in the litterbags. Similar patterns were observed by Albeho (2008) who found that other factors such as environmental factors on the sampling day could influence colonisation by macroinvertebrate communities on litter bags. Despite the relative importance of invertebrate shredders to leaf breakdown in streams (Moss, 2007), the number of shredders colonizing the leaves in this study was low in relation to Gatherers and filter feeders. Several factors may explain the low number of shredders colonizing leaves in this study. Reports of a paucity of shredders in the tropics (Dobson *et al.,* 2002; Wantzen and Wagner, 2006) may be one of the reasons. Other studies have concluded that though macro-invertebrate assemblages are high in the tropics shredders are limited (Masese, 2009). The limited knowledge on the identification of these organisms also explain the low number of shredder taxa in tropical stream studies (Merritt and Cummins, 1996).

The dominance of gatherers and filter feeders in the leaves during this study may be due to the influence of the feeding mechanisms of these functional feeding groups. Gatherers primarily feed on FPOM and UFPOM present on stream substrate (Masese and McClain, 2012). They contribute to further leaf decomposition by feeding on organic matter that settles onto the streambed from the water column (Graca, 2001). Fungi and bacteria form important part of FPOM those gatherers depend on in order to derive their nutrition, and they would preferably feed on FPOM colonized by biofilm (Allan, 1996). The biofilm present on the leaves may attract many gatherers to feed on these leaves. Filter feeders dominating the leaves may also be participating in feeding on the FPOM present in the water column at that point. According to Merritt and Cummings (1996), benthic filter feeders such as caddis flies spin nets on the stream substrates to collect organic matter from the water column. The leaf packs may be important substrates upon which filter feeders may anchor when feeding on FPOM from the water column. The bacterial and fungal biofilms created on the leaves could explain the dominance of gatherers and filtering feeder populations in leaves of the four tree species.

Conclusions

The dominance of Baetidae in all the plant species could be related to their feeding mechanisms in which they primarily feed on FPOM deposited on benthic substrates in streams. The dominance of gatherers and filtering feeders in the leaves during this study may also be due to their feeding on FPOM and UFPOM present on stream substrate. These organisms contributed to further leaf decomposition by feeding on organic matter that settles onto the streambed from the water column. *P. viridiflorum* leaves are better in quality compared to the other leaves. The leaves are soft, decomposed faster that the leaves of the other tree species, therefore, may be easily available as food sources for aquatic organisms. The argument that *P. viridiflorum* leaves are of good quality is supported by the fact that the leaves had the lowest biological half-life and the highest number of macroinvertebrates compared to the other tree species. The fast decompositions means that leaves of *P. viridiflorum* serve as the best in terms of decomposition and offering food items to aquatic organisms. Therefore, exotic trees such as *E. saligna* and *G. robusta* should not be used to replace it as the preferred tree species to be planted along the riparian areas of streams. *E. saligna* had the lowest number of macroinvertebrates suggesting poor quality leaves.

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