WEED SPECIES COMPOSITION IN THE RIPARIAN ZONE OF MOLAWIN RIVER, LAGUNA, PHILIPPINES

Jay T. Torrefiel and Inocencio E. Buot Jr.

Received: 12.05.2017 / Accepted: 27.06.2017

Abstract: Riparian zones are considered as some of the most species rich and most productive ecosystems. However, because of frequent disturbances and dispersal of propagules by water flow, riparian zones are very vulnerable to weed invasion. A survey was conducted to identify the major weeds present in the riparian zone of Molawin River. Three sampling sites have randomly been selected. Field surveys were done in the month of April, 2017, as close to plant peak-flowering as possible. Line intercept method was utilized with a 30 m transect, subdivided into 1 meter interval. The data were summarized using the following quantitative measures: mean height (H), relative height (RH), cover (C), relative cover (RC), frequency (F), relative frequency (RF) and Summed Dominance Ratio (SDR). A total of 52 weed species, belonging to 41 genera in 23 families were identified, of which 24 were annuals and 28 were perennials; 38 were broadleaf species, 9 were grasses, and 5 were sedges. Among the weed species, based on summed dominance ratio (SDR), *Alternanthera sessilis* with a value of SDR= 14.8% was the most dominant weed in the riparian zone of Molawin river.

Keywords: riparian zone, Summed Dominance Ratio, survey, weed

Introduction:

Riparian zones are defined as the interfaces between aquatic and terrestrial ecosystems, connecting the systems through the exchange of materials and energy (Gregory et al. 1991). Owing to their ecological uniqueness, riparian zones are important for the maintenance of local biodiversity. These ecosystems are under the influences of unique environmental conditions such as flooding disturbance regimes that causes the establishment of riparian vegetation (Stohlgren et al. 1998). The established vegetation in turn affects the dynamics of water flow and the movement of sediments and nutrients into the rivers (Peterjohn and Correll 1984; Décamps 1993). Moreover, riparian zones serve as landscape corridors making propagule dispersal via water flow possible, which is crucial to enable riparian plants to expand their range and maintain metapopulation dynamics (Staniforth and Cavers 1976; Schneider and Sharitz 1988; Campbell et al. 2002). These zones are considered as one of the most species rich and most productive ecosystems (Malanson 1993; Naiman et al. 1993; Gould and Walker 1997; Ward et al. 1999). They are also considered as one of the most potentially threatened ecosystems because of their

Jay T. Torrefiel:
Institute of Biological Sciences
College of Arts and Sciences
University of the Philippines Los Baños
Los Baños, Laguna, Philippines 4031
e-mail: jayttorrefiel@gmail.com

Inocencio E. Buot Jr.:
Institute of Biological Sciences
College of Arts and Sciences
University of the Philippines Los Baños
Los Baños, Laguna, Philippines 4031
e-mail: inocencio.buot@upou.edu.ph

sensitivity to human influences (Malanson 1993).

The high species diversity in riparian ecosystems can partly be explained by the periodical floods that destroy vegetation cover, creating bare ground allowing recolonization, and producing a shifting mosaic of vegetation patterns and landforms that creates diverse habitats (Malanson 1993; Hood and Naiman 2000). However, vulnerability to invasion by alien plants in riparian zones can be increased equally by the same factors that maintain the diversity of plant species (Malanson 1993). In riparian zones, aside from promoting native species diversity, disturbances that create unoccupied sites and dispersal of propagules by the flow of water may also promote invasions by alien vascular plants such as weed species (Stohlgren et al. 1998; Hood and Naiman 2000).

Hence, because of frequent disturbances and dispersal of propagules by water flow, riparian zones are very vulnerable to weed invasion. Competitive ruderal adaptations are present in certain weeds of agricultural systems allowing them to thrive in a wide range of habitats (Grime 1977). Accordingly, the preferred environments of these species include agricultural fields, roadsides and sparse meadows which are exposed to seasonal disturbances such as flooding (Miyawaki and Washitani 2004). These characteristics make agricultural weed species one of potential invaders of riparian zones. Pasture grass species are also a major source of plant invaders in riparian zones (Heywood 1989; Lonsdale 1994). Alien pasture grasses are introduced in many riparian zones around the world to prevent soil erosion or to serve as revegetation species after construction work (Imamoto et al. 2003). Consequently, it is not surprising, that these species which were particularly selected because of their rapid growth, adaptation to sunlit environments, and tenacity are now becoming invasive in many parts of the world (Myers and Bazely 2003). In addition certain species of submerged and floating plants that were primarily introduced as ornamentals such as *Eichhornia crassipes* (Mart.) Solms (water hyacinth) and *Pistia stratiotes* L. (water lettuce) can also be one of potential invaders of riparian zones (Miyawaki and Washitani 2004).

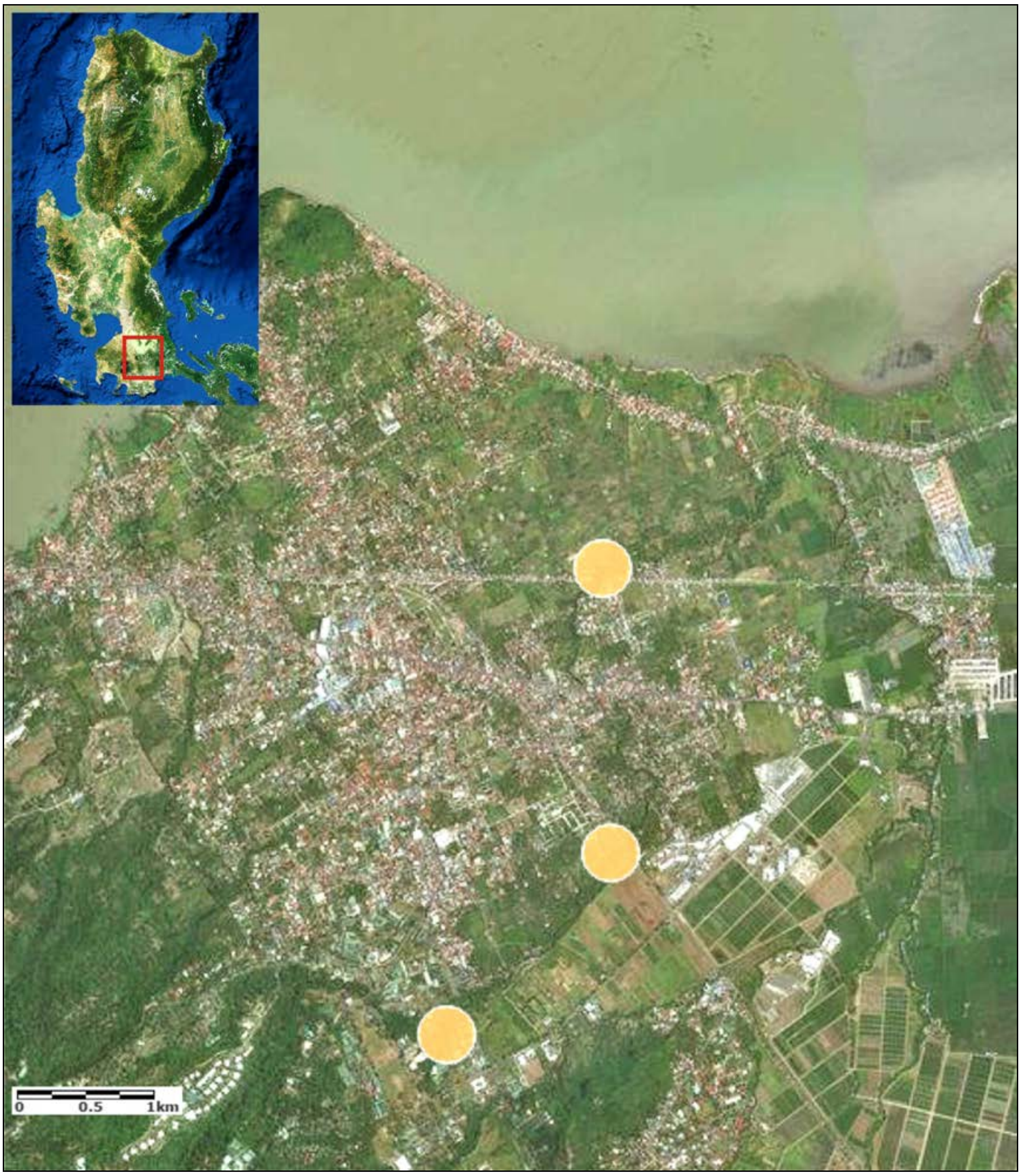
Due to the increasing negative impacts caused by alien invasive species, its control has become a priority for environmental management and a primary component of many habitat conservation efforts in many countries in recent years. Not all alien species, however, become invasive, that is why we must evaluate which alien species should be considered invasive so that they be given the top priority in management and control programs in order to appropriately conserve native species and ecosystems. However, in the riparian zones of the Philippines, little is known about the infestation and invasion of alien species such as weeds. Detailed information on the presence, composition, and dominance of weed species in the Philippine riparian zones are extremely rare. Thus, the objectives of this study were to identify the weed species present in the riparian zone of Molawin river and to determine the dominance of the weed species based on summed dominance ratio with height, cover, and frequency measurements.

Materials and methods:

A survey was conducted to identify the major weeds present in the riparian zone of Molawin River. The river, with a length of 8.970 km (Liongson et al. 2005) is one of the several low volume flowing rocky streams traversing the campus of the University of the Philippines Los Baños and certain areas of the town of Los Baños as well. Average rainfall of the season determines the volume of flow of the river and in times of typhoons or heavy rainfall it changes into a raging river (Liongson et al. 2005). Additionally, Molawin River is a minor tributary of the Laguna Lake, being one of the several small streams that empty into the Laguna Lake. The origin of the river has not yet been located but it is generally accepted that it springs from the upper elevations of Mount Makiling (Liongson et al. 2005).

Three sampling sites were randomly selected (Fig. 1).

Figure no. 1 Map of the study area. The map was generated using ArcGIS by the Environmental Systems Research Institute (ESRI 2016)



The first sampling site (Fig. 2a) is situated along 14°09'44.664" N latitude and 121°14'40.026" E longitude. While the second sampling site (Fig. 2b) is situated along 14°10'12.042" N latitude and 121°15'05.946" E longitude, the third sampling site (Fig. 2c) is situated along 14°10'55.188" N latitude and 121°15'04.428" E longitude.

Figure no. 2 Sampling sites: a - the first sampling site; b - the second sampling site; c - the third sampling site (Photos by: Jay Torrefiel)

a

b

c

Field surveys were done in the month of April, 2017, as close to plant peak flowering as possible. Line intercept method was utilized. A 30 meter transect, subdivided into 1 meter interval was laid along the bank of the river. Each Interval was assessed and the following data were obtained from each weed species that was intercepted by the transect line: name of the weed species, height and cover (the length of the transect line intercepted by individual weeds). In this study, the concept of weeds follow that of Pimentel (1986), wherein weeds are defined as unwanted plants that invade highly disturbed habitats such as agricultural lands, causing decreased productive capacity of crop plants. The taxonomic literature used for identification of the weed species were the following: Major weeds of the Philippines by Moody et al. (1984); a practical field guide to weeds of rice in Asia by Caton et al. (2010); Vascular Flora of Mount Makiling and Vicinity (Luzon, Philippines), Part 3 and 4 by Pancho and Gruezo (2009; 2012). The currently accepted scientific name of the weed species was used, while, synonyms by which a certain weed species has been known were discarded. The International Plant Names Index (IPNI 2015), and the Species 2000 & ITIS Catalogue of Life, 2016 Annual Checklist by Roskov et al. (2016) were also consulted. The taxonomy of the weed species considered in this study is based on the currently accepted understanding and knowledge during the time of writing.

The data were summarized using the following quantitative measures: mean height (H), relative height (RH), cover (C), relative cover (RC), frequency (F), relative frequency (RF) and Summed Dominance Ratio (SDR). Moreover, the following formulas were used:

Relative height (RH):

$$RH = AH / TH$$

where:

AH = average height of species A

TH = total average height of all species

Cover (C):

$$C = TIL / TTL$$

where:
TIL = total intercept lengths of a species
TTL = total transect length

Relative Cover (RC):

RC = C / TC x 100

where:
C = cover values for a species
TC = total of cover values for all species

Frequency (F):

F = NI / TTI

where:
NI = number of intervals in which a species occurs
TTI = total number of transect intervals

Relative Frequency (RF):

RF = F / TF x 100

where:
F = frequency value for a species
TF = total of frequency values for all species

Summed Dominance Ratio (SDR):

SDR = RC + RH + RF / 3

Results and discussion:

A total of 52 weed species, belonging to 41 genera in 23 families have been identified, of which 24 were annuals and 28 were perennials; 38 represent broadleaf species, 9 were grasses, and 5 sedges (Tab. 1, Annexes). The perennial species that were recorded during the weed surveys were greater in number than those of the annual species. Most probably, this can be explained by the ability of perennial weed species to live longer in comparison with the shorter-lived annual weed species. Additionally, rather than relying completely on seeds for reproduction as exhibited by most annual species, vegetative reproduction is also evident in many perennial species enabling them to adapt from one year to the next through the help of structures such as bulbs, tubers, rhizomes, woody crowns etc. Modified stems are also present in some perennial species, allowing them to survive during times of dormancy over cold or dry seasons throughout the year. In a similar study conducted by Al-Gohary (2008) in eleven wadis (dry riverbed which contains water during rainy season only) of Gebel Elba in Egypt, perennial species particularly grasses were also found to be greater in number compared to annual species.

In this study, the Poaceae family had the highest number of species (9), followed by Cyperaceae and Asteraceae (5); Fabaceae and Amaranthaceae (4); Commelinaceae (3); Cleomaceae, Euphorbiaceae, Onagraceae, Piperaceae and Rubiaceae (2). While the remaining 12 families were represented by one species each. The family Poaceae, Cyperaceae, Asteraceae, Fabaceae and Amaranthaceae has high representation. In comparison with other studies, Miyawaki and Washitani (2004) based on their study on the invasion of alien plant species in Japanese riparian zones, recorded the highest number of species within Poaceae, Asteraceae and Fabaceae. Similarly, Daehler (1998) and Pyšek (1998) based on their studies on the taxonomic pattern of plant invasions concluded that the largest plant families (Poaceae, Asteraceae and Fabaceae) contribute most to the total number of alien species in local flora. However generally, the weed species composition in a particular area is influenced by environmental, edaphic and biological factors (Kim et al. 1983) as in the results of this study.

Most Poaceae species spread by growing densely spaced tillers, sometimes accompanied by thick litter production, promoting monocultures (Washitani 2002). Many species also spread horizontally by growing underground stems such as rhizomes, or aboveground prostrate stems such as stolons (Chapman and Peat 1992).

This was evident in the case of *Cynodon dactylon*, *Paspalum conjugatum* and *Pennisetum purpureum*, respectively, in this study (see Tab. 1, Annexes). From these rhizomes or stolons, new individuals can develop. In addition, Poaceae species also have vast root systems as in the case of *Eleusine indica* in this study, which are capable of storing enough food reserves, allowing them, once damaged, to regrow aboveground parts rapidly (Chapman and Peat 1992). Likewise, in many Cyperaceae species, rhizomes of varying lengths that can be tuberous are also present which serves as food storage organs. These rhizomes in many species also develop into an extensive underground system functioning as an organ for vegetative dispersal. This was evident in the case of *Cyperus rotundus* (see Tab. 1, Annexes) in this study. Many Cyperaceae species are associated with wetlands, or with poor soils even though they are capable of surviving in almost all types environment (Hipp 2007). The family Asteraceae, from an evolutionary point of view is considered as one of the most advanced families, and it contains many agricultural weed species that are widely distributed worldwide, many of which are very successful weeds (Heywood 1989) including the species recorded in this study (see Tab. 1, Annexes). The family Fabaceae also seem to have a high number of weed species including some species that are considered as serious weeds (Heywood 1989) such as *Aeschynomene indica* (Caton et al. 2010) which was recorded in this study. The nitrogen-fixing ability of Fabaceae species helps in invading nutrient-poor environments (Richardson et al. 2000). Most invasive Fabaceae species are rapidly growing shrubs, which are prolific seed producers and the seeds have the ability to survive during long periods of dormancy (Heywood 1989). The family Amaranthaceae, with a widespread and cosmopolitan distribution, includes several species considered as noxious weeds (Müller and Borsch 2005; Christenhusz and Byng 2016) such as *Amaranthus spinosus* (Caton et al. 2010) which was recorded in this study. Most of these species are able to survive in a wide range of environmental conditions including salty and even dry soils. Probably, the characteristics discussed above contributes to the success of these families as invaders of riparian zones.

In terms of relative height (RH) (Tab. 2, Annexes), among the weed species, *Pennisetum purpureum* had the highest value (RH = 5.83%), whereas the other weed species with RH value of ≥ 5% included *Imperata cylindrica*, *Panicum maximum*, *Rottboellia cochinchinensis* and *Saccharum spontaneum*. While the RH values for the remaining species were 0.2 to 4.5% with *Euphorbia mucalata*, having the lowest (RH = 0.2%). As observed in this study, *Pennisetum purpureum* was relatively taller than the other species and growing in robust bamboo-like clumps, which most likely explains why it had the highest value for relative height. Regarding relative cover (RC) (see Tab. 2, Annexes), among the weed species *Alternanthera sessilis* displayed the highest value (RC =23%). The other weed species having RC value of ≥ 5%, includes *Pennisetum purpureum*, *Paspalum conjugatum*, *Synedrella nodiflora*, *Piper sarmentosum*, *Ludwigia octovalvis* and *Panicum maximum*. Whereas the RC value for the remaining species were 0.1 to 3% with *Euphorbia mucalata*, having the lowest value (RC = 0.1%). As observed in this study, *Alternanthera sessilis* featured a creeping habit, was growing in clumps and was extensively branched. Most likely these explain why it had the highest value for relative cover. In terms of relative frequency (RF) (see Tab. 2, Annexes), *Alternanthera sessilis* also had the highest value (RF = 20%). The other weed species having RC value of ≥ 3% includes *Synedrella nodiflora*, *Paspalum conjugatum*, *Commelina diffusa*, *Pennisetum purpureum*, *Calopogonium mucunoides*, *Eleusine indica*, *Asystasia gangetica*, *Alternanthera brasiliana*, *Ludwigia octovalvis* and *Piper sarmentosum.* The RF value for the remaining species were 0.4 to 2% with the following species having the lowest: *Amaranthus viridis*, *Mikania* *micrantha*, *Vernonia cinerea*, *Heliotropium indicum*, *Cleome viscosa*, *Commelina benghalensis*, *Murdannia nudiflora*, *Ipomoea trilobata*, *Cyperus kyllingia*, *Euphorbia maculata*, *Aeschynomene indica*, *Ludwigia adscendens*, *Leptochloa chinensis*, *Monochoria vaginalis*, *Hedyotis corymbosa*, *Sphenoclea zeylanica* and *Stachytarpheta jamaicensis* (RF = 0.4%). Flowering and fruiting in *Alternanthera sessilis* occurs throughout the year and the fruits can be dispersed extensively by both wind and water. As observed in the study, large quantities of the corky fruits of *Alternanthera sessilis* were floating in the water, thus, increasing the rate of dispersal. Most likely, this explains why *Alternanthera sessilis* had the highest value for relative frequency.

Moreover, in showing the dominance of a species in the community, the summed dominance ratio (SDR) is more useful than any single measure (e.g. height, cover and frequency). Using summed dominance ratio (SDR) is very appropriate because more or less it would balance out the biases caused by the individual measures. Thus, rather than utilizing single measures, summed dominance ratio (SDR) was used in the calculation of species dominance. *Alternanthera sessilis* proved the most dominant weed with a value SDR = 14.8% (see Tab. 2, Annexes). The other weed species having SDR value of ≥ 4 included *Pennisetum purpureum*, *Synedrella nodiflora*, *Panicum maximum*, *Paspalum conjugatum* and *Piper sarmentosum*. In contrast the SDR value for the remaining species were 0.23 to 3.56% with *Euphorbia muculata* having the lowest (SDR = 0.23%). The results indicated that *Alternanthera sessilis* together with *Pennisetum purpureum*, *Synedrella nodiflora*, *Panicum maximum*, *Paspalum conjugatum* and *Piper sarmentosum* were the most important weeds. The availability of suitable habitats and the supply of propagules of these alien weeds species recorded in the riparian zones of Molawin River may provide explanation on their success as riparian weeds. As discussed earlier, riparian zones are prone to frequent disturbances such as floods and construction works as well. These disturbances will lead to an increased occurrence of bare areas allowing the colonization of weed species (Gregory et al. 1991). Moreover, in the riparian zone of Molawin River, supply of propagule from the adjacent invaded and infested habitats such as low, to medium density residential, commercial, public/institutionalized areas, lake, pastures, agricultural fields and roadsides is most likely to cause significant impact to the further invasion of weeds.

Conclusions:

A survey has been conducted to identify the major weeds present in the riparian zone of Molawin River. The family Poaceae, Cyperaceae, Asteraceae, Fabaceae and Amaranthaceae has the highest number of species respectively. Summed dominance ratio (SDR) was used in the calculation of species dominance rather than utilizing single measures and *Alternanthera sessilis* was found to be the most dominant weed, followed by *Pennisetum purpureum*, *Synedrella nodiflora*, *Panicum maximum*, *Paspalum conjugatum* and *Piper sarmentosum* respectively. These species were the ones controlling the ecosystem processes such as nutrient and energy flow in the river bank. Additional information on the composition of weed species in the different riparian zones of the Philippines is needed. Extensive surveys on a regular basis to document shifts in weed population are needed to identify potential problematic weeds so that they be given the top priority in management programs in order to appropriately conserve native species and ecosystems. Identification of the characteristics of weed species is the first step in the formulation of management strategies for riparian habitats and will provide relevant information for future studies such as on invasion biology and conservation ecology.

Rezumat:

COMPOZIȚIA SPECIILOR RUDERALE ÎN ZONA DE MAL A RÂULUI MOLAWIN, LAGUNA, FILIPINE

Zonele de mal sunt considerate ca fiind unele dintre ecosistemele cele mai bogate în specii și în același timp productive. Totuși, datorită perturbărilor frecvente cauzate prin curgerea apei și a dispersiei propagulelor, zonele de mal sunt foarte vulnerabile la invazia unei vegetații ruderale. A fost inițiat un studiu pentru identificarea pricipalelor plante ruderale prezente în zona de mal a râului Molawin. În mod aleatoriu au fost selectate trei puncte. Monitorizarea în teren a fost realizată în luna Aprilie 2017, în perioada de înflorire a plantelor. A fost utilizată metoda transectelor, transectele având o lungime de 30 m cu subdiviziuni de 1 m. Datele obținute au fost cuantificate utilizându-se următorii indici cantitativi: înălțimea medie (H), înălțimea relativă (RH), acoperirea (C), acoperirea relativă (RC), frecvența (F), frecvența relativă (RF) și Raportul de Dominanță (SDR). Un număr total de 52 de specii ruderale au fost identificate, aparținând la 41 de genuri și 23 de familii, dintre care 24 sunt anuale, iar 28 perene; 38 au frunze late, 9 graminee și 5 din grupa rogozurilor. Pe baza Raportului de Dominanță (SDR), dintre speciile studiate *Alternanthera sessilis* este specia dominantă în zona de mal a râului Molawin, având o valoare a SDR de 14.8%.

Acknowledgments:

The authors would like to thank Mr. Lief Erikson D. Gamalo for his help during the field surveys and the DOST-ASTHRDP for supporting the study.

References:

AL-GOHARY I.H. (2008), Floristic composition of eleven wadis in Gebel Elba, Egypt, *International Journal of Agriculture and Biology* 10: 151–160.

CAMPBELL G.S., BLACKWELL P.G., WOODWARD F.I. (2002), Can landscape-scale characteristics be used to predict plant invasions along rivers? *Journal of Biogeography* 29: 535-543.

CATON B.P., MORTIMER M., HILL J.E., Johnson D.E. (2010), *A practical field guide to weeds of rice in Asia*, 2nd Edition, International Rice Research Institute, Los Baños, Philippines, 118 p.

CHAPMAN G.P., PEAT W.E. (1992), *An introduction to the grasses: including bamboos and cereals*, Wallingford, Oxon, UK: CAB International, 111 p.

CHRISTENHUSZ M.J.M., BYNG J.W. (2016), The number of known plants species in the world and its annual increase, *Phytotaxa* 261 (3): 201–217.

DAEHLER C.C. (1998), The taxonomic distribution of invasive angiosperm plants: Ecological insights and comparison to agricultural weeds, *Biological Conservation* 84: 167-180.

DÉCAMPS H. (1993), River margins and environmental change, *Ecological Applications* 3: 441-445.

ESRI (2016), ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE (online), *ArcGIS, Redlands*, California, https://www.arcgis.com.

GOULD W., WALKER M. (1997), Landscape-scale patterns in plant species richness along an arctic river, *Canadian Journal of Botany* 75: 1748-1765.

GREGORY S.V., SWANSON F.J., McKEE W.A., CUMMINS K.W. (1991), An ecosystem perspective of riparian zones, *BioScience* 41 (8): 540-550.

GRIME J.P. (1977), Evidence for the existence of three primary strategies in plants and its relevance to ecological and evolutionary theory, *American Naturalist* 111: 1169-1194.

HEYWOOD V.H. (1989), Patterns, extents and modes of invasions by terrestrial plants, In: *Biological Invasions: A Global Perspective*, (Drake J.A., Mooney H.A., di Castri F., Groves R.H., Kruger F.J., Rejmánek M., Williamson M. eds), pp. 31-60, John Wiley and Sons, Chichester.

HIPP A.L. (2007), Nonuniform processes of chromosome evolution in sedges (*Carex*: Cyperaceae), *Evolution* 61 (9): 2175-2194.

HOOD W.G., NAIMAN R.J. (2000), Vulnerability of riparian zones to invasion by

exotic vascular plants, *Plant Ecology* 148: 105-114.
IMAMOTO H., GOTO K., SHIRAI A., WASHITANI I. (2003), Effect of the introduction of exotic grasses to solid rock slopes on the vegetation succession of the site, *Ecology and Civil Engineering* 6: 1-14.
IPNI (2015), THE INTERNATIONAL PLANT NAMES INDEX (online) *Plant Names*, http://www.ipni. org.
KIM S.C., PARK R.K., MOODY K., (1983), Changes in the weed flora in transplanted rice as affected by introduction of improve rice cultivars and the relationship between weed communities and soil chemical properties, *Res. Rept. ORD.* 25: 90–97.
LIONGSON L.Q., TABIOS III G.Q., DAŇO A.M. (2005), Laguna Lake's Tributary River Watersheds, In *Ecosystems and People: the Philippine Millennium Ecosystem Assessment (MA) Sub-global Assessment* (Lasco R.D., Espaldon M.V.O.), Environmental Forestry Programme, College of Forestry and Natural Resources, University of the Philippines Los Baños.
LONSDALE W.M. (1994), Inviting trouble: introduced pasture species in northern Australia, *Australian Journal of Ecology* 19: 345-354.
MALANSON G.P. (1993), *Riparian Landscapes*, Cambridge University Press, Cambridge, 296 p.
MIYAWAKI S., WASHITANI I. (2004), Invasive alien plant species in riparian areas of Japan: the contribution of agricultural weeds, revegetation species and aquacultural species, *Global Environmental Research* - English Edition 8 (1): 89-101.
MOODY K., MUNROE C.E., LUBIGAN R.T., PALLER E.C. (1984), *Major weeds of the Philippines*, Weed Science Society of the Philippines, Los Baňos, Philippines, 269 p.
MÜLLER K., BORSCH T. (2005), Phylogenetics of Amaranthaceae based on matK/trnK sequence data: evidence from parsimony, likelihood and Bayesian analyses, *Annals of the Missouri Botanical Garden* 66-102.
MYERS J.H., BAZELY D.R. (2003), *Ecology and Control of Introduced Plants*, Cambridge University Press, Cambridge.
NAIMAN R.J., DECAMPS H., POLLOCK M. (1993), The role of riparian corridors in maintaining regional biodiversity, *Ecol. Appl.* 3: 209-212.
PANCHO J.V., GRUEZO W.S. (2009), Vascular Flora of Mount Makiling and Vicinity (Luzon, Philippines), Part 3, *Philipp. Agric. Sci.* 92 (Suppl. 1): S1-S496.
PANCHO J.V., GRUEZO W.S. (2012), *Vascular Flora of Mount Makiling and Vicinity (Luzon, Philippines)*, Part 4, National Academy of Science and Technology (NAST) Philippines, Department of Science and Technology, Bicutan, Taguig City and Institute of Biological Sciences, University of the Philippines Los Baños, College, Laguna, Philippines (Publishers), 405 p.
PETERJOHN W.T., CORELL D.L. (1984), Nutrient dynamics in an agricultural watershed: observations on the role of a riparian forest, *Ecology* 65: 1466-1475.
PIMENTEL D. (1986), *Biological invasions of plants and animals in agriculture and forestry*. In: Ecology of Biological Invasions of North America and Hawaii, Mooney H.A. and Drake J.A. eds., Springer-Verlag, New York, pp. 149-162.
PYŠEK P. (1998), Is there a taxonomic pattern to plant invasions? *Oikos* 82: 282-294.
RICHARDSON D.M., ALLSOPP N.C., D'ANTONIO M.S., MILTON J., REJMANEK M. (2000), Plant invasions – the role of mutualisms, *Biological Review* 75: 65-93.
ROSKOV Y., ABUCAY L., ORRELL T., NICOLSON D., FLANN C., BAILLY N., KIRK P., BOURGOIN T., De WALT R.E., DECOCK W., De WEVER A. eds. (online) (2016), *Species 2000 & ITIS Catalogue of Life*, *2016 Annual Checklist*, www.catalogueoflife.org/annual-checklist / 2016, Species 2000: Naturalis, Leiden, the Netherlands. ISSN 2405-884X.
SCHNEIDER R.L., SHARITZ R.R. (1988), Hydrochory and regeneration in a bald cypress? Water tupelo swamp forest, *Ecology* 69: 1055-1063.
STANIFORTH R.J., CAVERS P.B. (1976), An experimental study of water dispersal in *Polygonum* spp., *Canadian Journal of Botany* 54: 2587-2596.
STOHLGREN T.J., BULL K.A., OTSUKI Y.C., VILLA A., LEE M. (1998), Riparian zones as havens for exotic plant species in the central grasslands, *Plant Ecology* 138: 113-125.
WARD J.V., TOCKNER K., SCHIEMER F. (1999), Biodiversity of floodplain river ecosystems: ecotones and connectivity,

Regulated Rivers: Research & Management 15: 125-139.
WASHITANI I. (2002), *Introduced grasses for revegetation*, In: Ecological Society of Japan, eds., Handbook of Alien Species in Japan, Chijinshokan, Tokyo, 207 p.

Annexes:

Table no. 1 The identified weed species based on family/species, common name, life cycle and weed type

Species	Family	Common name	Life cycle	Weed type
	Acanthaceae			
Asystasia gangetica (L.) T.Anderson		Creeping foxglove	Perennial	Broadleaf
	Amaranthaceae			
Alternanthera brasiliana (L.) Kuntze		Brazilian joyweed	Perennial	Broadleaf
Alternanthera sessilis (L.) R.Br. ex DC.		Sessile joyweed	Perennial	Broadleaf
Amaranthus spinosus L.		Spiny amaranth	Annual	Broadleaf
Amaranthus viridis L.		Slender amaranth	Annual	Broadleaf
	Asteraceae			
Aegaratum conyzoides L.		Goat weed	Annual	Broadleaf
Eclipta prostata L.		American false daisy	Annual	Broadleaf
Mikania micrantha Kunth		Bitter vine	Perennial	Broadleaf
Synedrella nodiflora (L.) Gaertn.		Node weed	Annual	Broadleaf
Vernonia cinerea (L.) Less.		Little iron weed	Perennial	Broadleaf
	Boraginaceae			
Heliotropium indicum L.		Indian heliotrope	Annual	Broadleaf
	Cleomaceae			
Cleome rutidosperma DC.		Purple Cleome	Annual	Broadleaf
Cleome viscosa L.		Asian spiderflower	Annual	Broadleaf
	Commelinaceae			
Commelina benghalensis L.		Benghal dayflower	Perennial	Broadleaf
Commelina diffusa Burm.f.		Spreading dayflower	Annual	Broadleaf
Murdannia nudiflora (L.) Brenan		Doveweed	Perennial	Broadleaf
	Convolvulaceae			
Ipomoea trilobata L.		Little bell	Annual	Broadleaf
	Curcubitaceae			
Melothria pendula L.		Creeping cucumber	Perennial	Broadleaf
	Cyperaceae			

Cyperus iria L.	Grasshoppers cyperus	Annual	Sedge
Cyperus kyllingia Endl.	White kyllingia	Perennial	Sedge
Cyperus rotundus L.	Purple nut sedge	Perennial	Sedge
Fimbristylis dichotoma (L.) Vahl	Two leaf fimbry	Perennial	Sedge
Fimbristylis miliacea (L.) Vahl	Lesser fimbristylis	Annual	Sedge
Dennstaedtiaceae			
Pteridium aquilinum (L.) Kuhn.	Common bracken	Perennial	Broadleaf
Euphorbiaceae			
Euphorbia hirta L.	Hairy spurge	Annual	Broadleaf
Euphorbia maculata L.	Spotted spurge	Annual	Broadleaf
Fabaceae			
Aeschynomene indica L.	Indian jointvetch	Perennial	Broadleaf
Calopogonium mucunoides Desv.	Caloponium	Perennial	Broadleaf
Desmodium sp.	Desmodium	Perennial	Broadleaf
Mimosa pudica L.	Sensitive plant	Perennial	Broadleaf
Onagraceae			
Ludwigia adscendens (L.) H.Hara	Water primrose	Perennial	Broadleaf
*Ludwigia octovalvis (*Jacq.) P.H.Raven	Mexican primrose-willow	Perennial	Broadleaf
Piperaceae			
Peperomia pellucida (L.) Kunth.	Shiny bush	Annual	Broadleaf
Piper sarmentosum Roxb.	Lolo pepper	Perennial	Broadleaf
Phyllantaceae			
Phyllanthus niruri L.	Gale of the wind	Annual	Broadleaf
Poaceae			
Cynodon dactylon (L.) Pers.	Bermuda grass	Perennial	Grass
Eleusine indica (L.) Gaertn	Goosegrass	Annual	Grass
Imperata cylindrica (L.) P.Beauv.	Swardgrass	Perennial	Grass
Leptochloa chinensis (L.) Nees	Red sprangletop	Annual	Grass
Panicum maximum Jacq.	Guinea grass	Perennial	Grass
Paspalum conjugatum Berg.	Carabao grass	Perennial	Grass

Pennisetum purpureum Schumach.	Napier grass	Perennial	Grass
Rottboellia cochinchinensis (Lour.) Clayton	Itch grass	Annual	Grass
Saccharum spontaneum L.	Wild sugarcane	Perennial	Grass
Polygonaceae			
Persicaria hydropiper (L.) Delabre	Water-pepper	Annual	Broadleaf
Pontederiaceae			
Monochoria vaginalis (Burm.f.) C.Presl ex Kunth	Heartshape false pickerelweed	Perennial	Broadleaf
Portulacaceae			
Talinum fruticosum (L.) Juss.	Waterleaf	Perennial	Broadleaf
Rubiaceae			
Hedyotis corymbosa (L.) Lam.	Two flowered oldenlandia	Annual	Broadleaf
Hedyotis biflora (L.) Lam.	Oldenlandia	Annual	Broadleaf
Sphenocleaceae			
Sphenoclea zeylanica Gaertn.	Wedgewort	Annual	Broadleaf
Urticaceae			
Pilea microphylla (L.) Liebm.	Rockweed	Annual	Broadleaf
Verbenaceae			
Stachytarpheta jamaicensis (L.) Vahl	Blue porterweed	Perennial	Broadleaf

Table no. 2 Mean height (H), Relative height (RF), Cover (C), Relative cover (RC), Frequency (F), Relative frequency (RF), and Summed dominance ratio of weeds (SDR) in the riparian zone of Molawin river

Species	Family	H (cm)	RH (%)	C (cm)	RC (%)	F	RF (%)	SDR (%)
	Acanthaceae							
Asystasia gangetica (L.) T.Anderson		41.3	2.82	0.02	2	0.08	3	2.61
	Amaranthaceae							
Alternanthera brasiliana (L.) Kuntze		22.1	1.51	0.01	1	0.07	3	1.84
Alternanthera sessilis (L.) R.Br. ex DC.		21.6	1.47	0.2	23	0.51	20	14.8*
Amaranthus spinosus L.		36	2.4	0.01	1	0.06	2	1.8
Amaranthus viridis L.		16	1.1	0.0016	0.18	0.01	0.4	0.56
	Asteraceae							
Aegaratum conyzoides L.		27.2	1.86	0.013	1.5	0.06	2	1.79
Eclipta prostata L.		21	1.4	0.01	1	0.02	0.9	1.1
Mikania micrantha Kunth		13	0.89	0.002	0.2	0.01	0.4	0.5
Synedrella nodiflora (L.) Gaertn.		29.4	2.01	0.04	5	0.16	6.2	4.4
Vernonia cinerea (L.) Less.		34	2.3	0.0028	0.32	0.01	0.4	1.01
	Boraginaceae							
Heliotropium indicum L.		30	2.1	0.002	0.2	0.01	0.4	0.9
	Cleomaceae							
Cleome rutidosperma DC.		9	0.6	0.0034	0.39	0.02	0.9	0.63
Cleome viscosa L.		7.5	0.51	0.003	0.3	0.01	0.4	0.4
	Commelinaceae							
Commelina benghalensis L.		7	0.5	0.002	0.2	0.01	0.4	0.37
Commelina diffusa Burm.f.		8.3	0.57	0.02	2	0.11	4.4	2.32
Murdannia nudiflora (L.) Brenan		25	1.7	0.0012	0.14	0.01	0.4	0.75
	Convolvulaceae							
Ipomoea trilobata L.		11	0.75	0.0027	0.31	0.01	0.4	0.49
	Curcubitaceae							
Melothria pendula L.		11	0.75	0.006	0.7	0.03	1	0.82
	Cyperaceae							

Cyperus iria L.	18	1.2	0.002	0.2	0.02	0.9	0.77
Cyperus kyllingia Endl.	6	0.4	0.0017	0.2	0.01	0.4	0.33
Cyperus rotundus L.	5	0.3	0.002	0.2	0.02	0.9	0.47
Fimbristylis dichotoma (L.) Vahl	19.5	1.33	0.002	0.2	0.02	0.9	0.81
Fimbristylis miliacea (L.) Vahl	20	1.4	0.002	0.2	0.02	0.9	0.83
Dennstaedtiaceae							
Pteridium aquilinum (L.) Kuhn.	37.8	2.58	0.024	2.6	0.04	2	2.39
Euphorbiaceae							
Euphorbia hirta L.	18	1.2	0.002	0.2	0.02	0.9	0.77
Euphorbia maculata L.	3	0.2	0.0009	0.1	0.01	0.4	0.23
Fabaceae							
Aeschynomene indica L.	42	2.9	0.0017	0.2	0.01	0.4	1.17
Calopogonium mucunoides Desv.	26.3	1.75	0.03	3	0.1	4	2.92
Desmodium sp.	24	1.6	0.002	0.2	0.02	0.9	0.9
Mimosa pudica L.	28	1.9	0.003	0.3	0.02	0.9	1.03
Onagraceae							
Ludwigia adscendens (L.) H.Hara	20	1.4	0.0013	0.15	0.01	0.4	0.65
*Ludwigia octovalvis (*Jacq.) P.H.Raven	39.2	2.68	0.04	5	0.07	3	3.56
Piperaceae							
Peperomia pellucida (L.) Kunth.	7.1	0.48	0.007	0.8	0.06	2	1.09
Piper sarmentosum Roxb.	65.9	4.5	0.057	6.6	0.09	3	4.7
Phyllantaceae							
Phyllanthus niruri L.	12	0.82	0.003	0.3	0.03	1	0.71
Poaceae							
Cynodon dactylon (L.) Pers.	27.8	1.9	0.0068	0.78	0.02	0.9	1.19
Eleusine indica (L.) Gaertn	12.1	0.826	0.03	3	0.1	4	2.61
Imperata cylindrica (L.) P.Beauv.	74	5.1	0.005	0.5	0.02	0.9	2.17
Leptochloa chinensis (L.) Nees	15	1	0.0017	0.2	0.01	0.4	0.53
Panicum maximum Jacq.	81.6	5.57	0.04	5	0.09	3	4.52
Paspalum conjugatum Berg.	11.6	0.792	0.07	8	0.11	4.4	4.4
Pennisetum purpureum Schumach.	85.5	5.83	0.08	9	0.1	4	6.28

Rottboellia cochinchinensis (Lour.) Clayton	81	5.5	0.01	1	0.02	0.9	2.47
Saccharum spontaneum L.	79.5	5.43	0.01	1	0.02	0.9	2.44
Polygonaceae							
Persicaria hydropiper (L.) Delabre	24.1	1.65	0.01	1	0.09	3	1.88
Pontederiaceae							
Monochoria vaginalis (Burm.f.) C.Presl ex Kunth	23	1.6	0.002	1	0.01	0.4	1
Portulacaceae							
Talinum fruticosum (L.) Juss.	37	2.5	0.026	3	0.01	0.4	1.97
Rubiaceae							
Hedyotis corymbosa (L.) Lam.	20	1.4	0.0027	0.31	0.01	0.4	0.7
Hedyotis biflora (L.) Lam.	11.3	0.771	0.009	1	0.03	1	0.92
Sphenocleaceae							
Sphenoclea zeylanica Gaertn.	64	4.4	0.0035	0.4	0.01	0.4	1.73
Urticaceae							
Pilea microphylla (L.) Liebm.	4.3	0.29	0.03	3	0.06	2	1.76
Verbenaceae							
Stachytarpheta jamaicensis (L.) Vahl	51	3.5	0.002	0.2	0.01	0.4	1.37

Notes: * - most dominant species based on SDR.