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*Full Length Research Paper*

# Dynamics of plant functional groups composition along environmental gradients in the typical area of Yi-Luo River watershed

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**Biomass of dominant and companion species in plant functional groups may reflect associations among plant functional groups and species replacement along environmental (elevation) gradients in the typical area of Yi-Luo River. Using community ecology techniques, these researchers examined the influences of elevation factors on plant functional group dynamics and population interactions along elevation gradients in the drainage area of Yi-Luo River. Leaf/stem/fruit/total biomass of dominant and companion species in plant functional groups were calculated and the correlation between elevation and species biomass was analyzed. We showed that elevation was the most important environmental factor affecting the distribution pattern of biomass of plant functional groups composition. Total leaf and stem and fruit biomasses of dominant and companion 19 perennial herbaceous species in plant functional groups were significantly correlated with elevation gradient ($P<0.05$, $P<0.01$). Understanding the changes and their causes in these PFG is essential for further research of local ecosystem functions and the goal of sustainable development in the context of biodiversity conservation.**

**Key words:** Plant functional groups, environmental gradients, biomass, elevation, correlation.

## INTRODUCTION

Biomass of dominant and companion species in plant functional groups may reflect associations among plant functional groups and species replacement along environmental gradients from both abiotic factors (soil moisture, nutrients, disturbance, etc) and anthropogenic factors (land-use history, etc) (Smith et al., 1996; Bai et al., 2004). However, there are diverse contributions to the landscape diversity and habitat/biological diversity changes along elevation gradient in the Yi-Luo River.

Unfortunately, the plant functional group (PFG) concept is used as a framework for investigating the linkages between ecosystem functions and plant biodiversity (Hooper and Dukes, 2004, Hooper and Vitousek, 1997; Raunkiaer, 1934; Smith et al., 1996; Chapin et al., 1996; Liao et al., 2010). Moreover, more and more experiments/ models have assessed the relationship between biodiversity and ecosystem processes from PFG perspective, which links plant functional traits (morphological, structural, functional and biomass) and ecosystem functioning (Symstad et al., 2000; Grime, 1974, 1979, 1988, 2002; Walker et al., 1999; Kelly, 1996; Reynolds et al., 2004; Ogle and Reynolds, 2004; Kraft et al., 2008; Liao et al., 2010). For example, von Humboldt (1849) found that there are 16 species-based structural classes having different physiognomies or plant growth forms. Nobel et al. (1996) proposed a functional classification based on life history parameters that can be used to predict the dynamics of landscapes and communities. PFG approach therefore plays critical roles in furthering large-scale ecological studies in general, and studies on ecological functioning in particular (Smith et al., 1996;

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**Abbreviation: PFG,** Plant functional group.

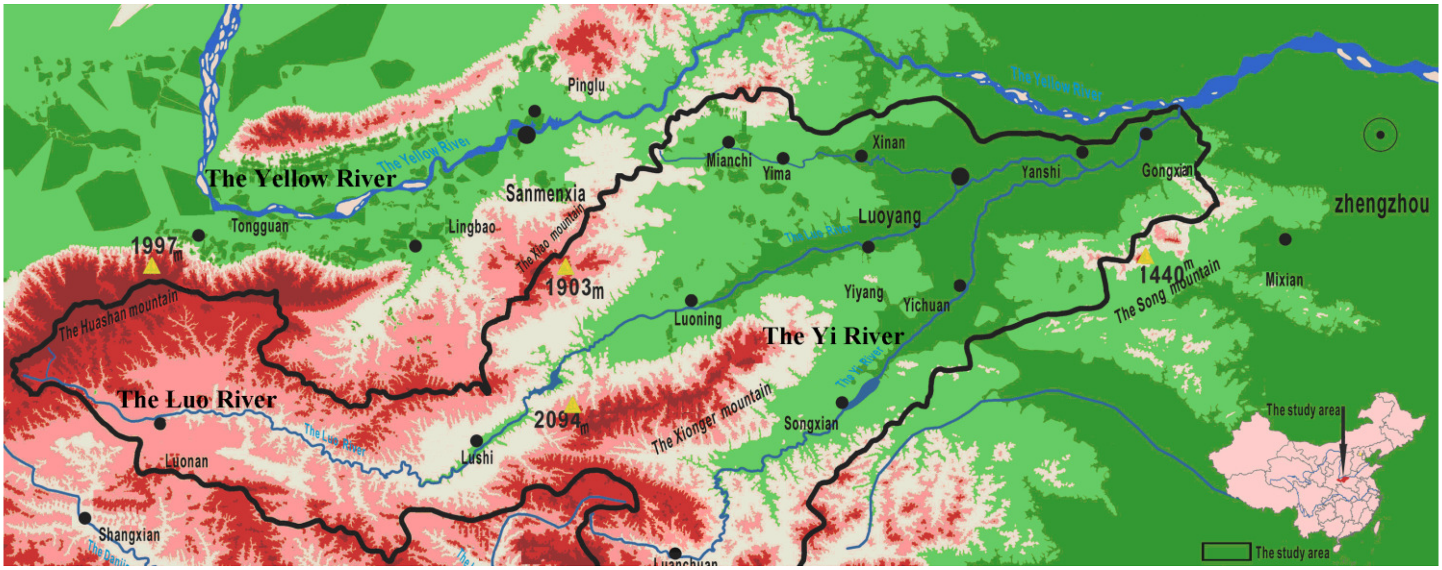



**Figure 1.** A digital cadastre map in the typical area of the Yi-Luo River watershed.

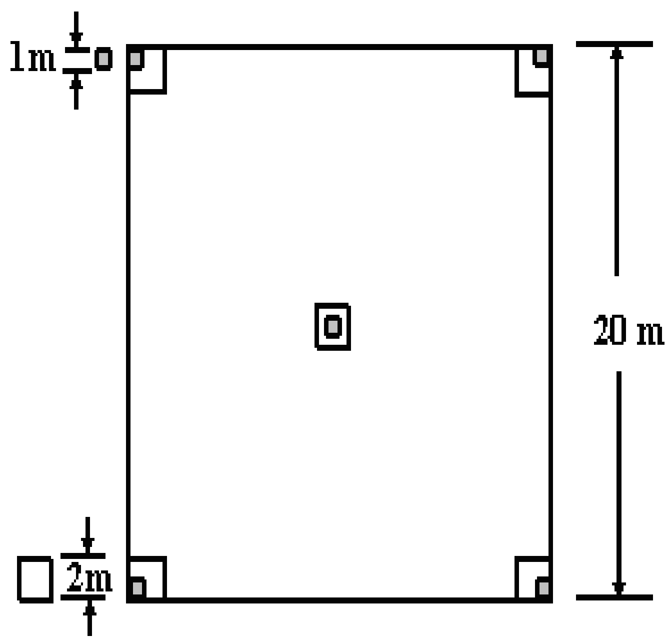



**Figure 2.** Investigation of each study plot.

Crowder et al., 2010; Kraft et al., 2008; Liao et al., 2010). Therefore, the objective of this study was to define the relationship between elevation gradient and biomass (total/leaf/stem/fruit) of dominant and companion perennial herbaceous species at PFG levels in the Yi-Luo River watershed.

## MATERIALS AND METHODS

A field investigation was conducted in July and November, 2008, to study the distribution patterns and the abundance features of the species in different habitats in the typical area of the Yi-Luo River watershed. The Yi-Luo River (111°53′ ~ 112°E and 33°25′ ~ 33°33′N) is dominated by an ecosystem of wetland together with dominant and companion herbaceous species. Possessing steep environmental gradients along the elevation gradient, this area is ideal for studying PFGs (Figures 1 to 3 and Table 1).

Using community ecology techniques, we investigated all plant species (dominant/companion herbaceous species), biomass (stem, leaf, fruit and total biomass) along elevation gradients (soil moisture, nutrients, etc) of Yi-Luo River in May and November, 2008, at elevations between 102.5 and 628 m. However, there were

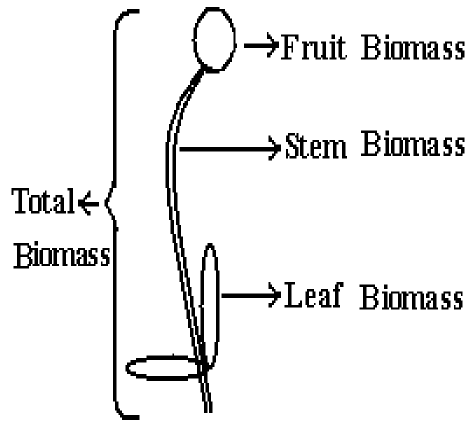



**Figure 3.** Research methods.

**Table 1.** The study plots of elevation/longitude/latitude along elevation gradients in the typical area of the Yi-Luo River watershed.

| Number of site location | Elevation (m)† | Longitude (º) | Latitude (º) | Number of site location | Elevation (m)† | Longitude (º) | Latitude (º) |
|---|---|---|---|---|---|---|---|
| 1 | 102.5 | 112.6306 | 34.76944 | 12 | 268 | 111.7964 | 34.55556 |
| 2 | 103.5 | 112.7658 | 34.80556 | 13 | 311 | 111.6381 | 34.41944 |
| 3 | 105.5 | 112.7214 | 34.82500 | 14 | 342 | 111.3811 | 34.62778 |
| 4 | 105.7 | 112.8922 | 34.80833 | 15 | 519 | 111.1819 | 34.13611 |
| 5 | 123.6 | 112.9456 | 34.81389 | 16 | 538 | 111.1053 | 34.21111 |
| 6 | 177.6 | 112.2208 | 34.58056 | 17 | 577 | 110.9367 | 34.10278 |
| 7 | 179.1 | 112.2208 | 34.58611 | 18 | 594 | 110.9344 | 34.10278 |
| 8 | 200.7 | 112.1244 | 34.58056 | 19 | 612 | 110.8808 | 34.02222 |
| 9 | 212.4 | 112.0194 | 34.55278 | 20 | 642 | 110.8039 | 34.12500 |
| 10 | 230 | 111.9553 | 34.48611 | 21 | 660 | 110.7581 | 33.55278 |
| 11 | 257 | 111.8414 | 34.55278 | 22 | 682 | 110.6897 | 33.03333 |

†Above sea level.

no disturbance/land-use history at elevations between 102.5 and 628 m along environmental gradients of Yi-Luo River.

One (or three) study plots were established per 50 m elevation. A total of 22 plots were set. Each study plot (Figures 2 and 3), consisted of one 20 × 20 m tree layer quadrate, five (the center and four corners of the study plot) 2 × 2 m shrub layer quadrates and five 1 × 1 m herbaceous layer quadrates. There were thus, 22 tree layer, 110 shrub layer and 110 herbaceous layer quadrates. Plant species identified during this investigation were assigned into three functional groups according to plant life form: 1) trees; 2) shrubs; 3) herbaceous species (Diaz et al., 1999).

## RESULTS

This study showed 54 perennial herbaceous species (including dominant species and companion species of 19 perennial herbaceous) along wetland gradients of Yi-Luo River watershed. Moreover, this study show that dominant herbaceous species (*Cynodon dactylon* L., *Echinochloa crusgali*, *Digitaria sanguinalis*, *Polygonum lapathifolium* and *Bidens pilosa*) biomass (stem, leaf, fruit and total biomass) decreased, while the other dominant herbaceous species (*Conyza japonica*, *Cyperus globosus* All., *Juncus effusus* L., *Cyperus rotundus* and *Artemisia argyi*) biomass (stem, leaf, fruit and total biomass) increased along elevation gradients in the wetland area of Yi-Luo River. Among these landscape types, one species (*Cynodon dactylon L.*) biomass decreased obviously.

On the other hand, this study show that only two companion herbaceous species (*Acalypha australis* and *Ranunculus sceleratus*) biomass (stem, leaf, fruit and total biomass) decreased, while the other companion herbaceous species (*Setaria glauca*, *Descurainia sophia*, *Cyperus fuscus*, *Artemisia capillaris*, *Humulus scandens*, *Potentilla supine* and *Chenopodium serotinum*) biomass (stem, leaf, fruit and total biomass) decreased along elevation gradients in the wetland area of Yiluo River. Among these wetland types, one species (*Acalypha australis*) biomass decreased most, while one species (*Artemisia capillaris*) biomass increased most (Figures 6,

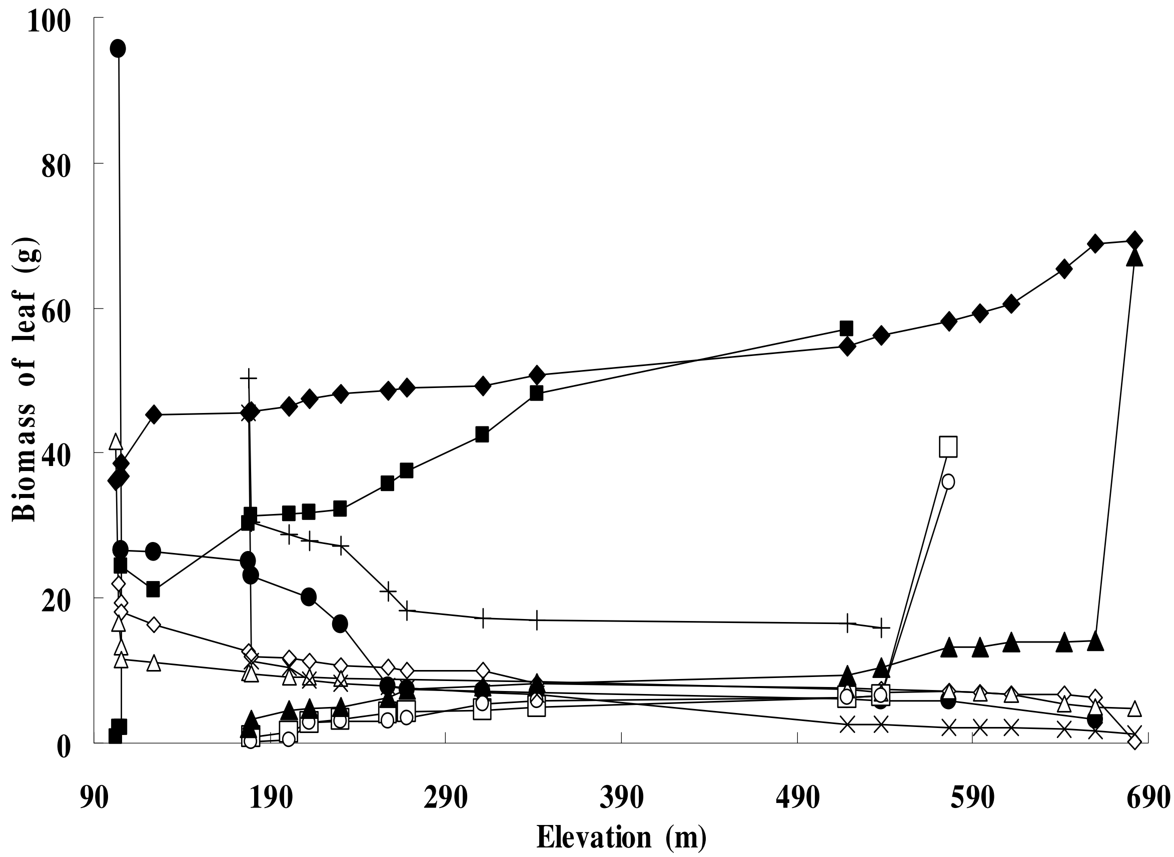



**Figure 4.** The biomass of the dominant herbaceous dry species. X axis stands for elevation; Y axis stands for biomass; -□- *Juncus effuses L.*; -△- *Digitaria sanguinalis*; -◆- *Conyza japonica*; -○- *Cyperus rotundus*; -◇- *Echinochloa crusgali*; -×- *Bidens pilosa*; -■- *Cyperus globosus* All; -▲-*Artemisia argyi*; -●- *Cynodon dactylon L;* -+- *Polygonum lapathifolium.*

7 and Table 2). However, the study analyzed the relationship between the biomass of the dominant and companion species in plant functional groups. To do this, the correlation between elevation and species biomass (stem, leaf, fruit and total biomass) was then analyzed. This study showed that dominant and companion herbaceous species biomass (stem, leaf, fruit and total biomass) was significantly correlated with elevation ($P<0.05$, $P<0.01$) (Figures 4, 7 and Table 2).

## DISCUSSION

This study showed that total leaf, stem and fruit biomasses of dominant and companion of 19 perennial herbaceous species in plant functional groups were significantly correlated with elevation gradient ($P<0.05$, $P<0.01$) (Table 2).

However, previous study showed that in shoreline vegetation, the role of plant interactions in determining zonation patterns depends on the environment gradient of both species and PFG levels (Lenssen et al., 1999). By using classification knowledge, Raunkiaer et al. (1934) reorganized life forms into plant growth forms. By analyzing a consistent aboveground community biomass of a 24-year data set of the Inner Mongolia grassland, Bai et al. (2004) found that community level stability arose from compensatory interactions among major components at both species and PFG levels, and ecosystem stability increased progressively from the species level to the whole community level. The watershed ecosystems in the Yi-Luo River are results of the historical natural activities.

Therefore, the results indicate that elevation was the most important environmental factor affecting the distribution pattern of biomass of PFGs. This study supported the hypothesis that environmental (elevation) gradient is a major ecological factor affecting PFG diversity and composition in the natural ecosystems (Smith et al., 1996; Grime, 1979; Kueppers et al., 2004; Lenssen et al.,1999; Walker et al.,1999). Moreover, the relationship between plant biomass (leaf/stream/fruit/total biomass) and elevation gradient seems important along watershed gradient in the Yi-Luo River from PFG perspective.

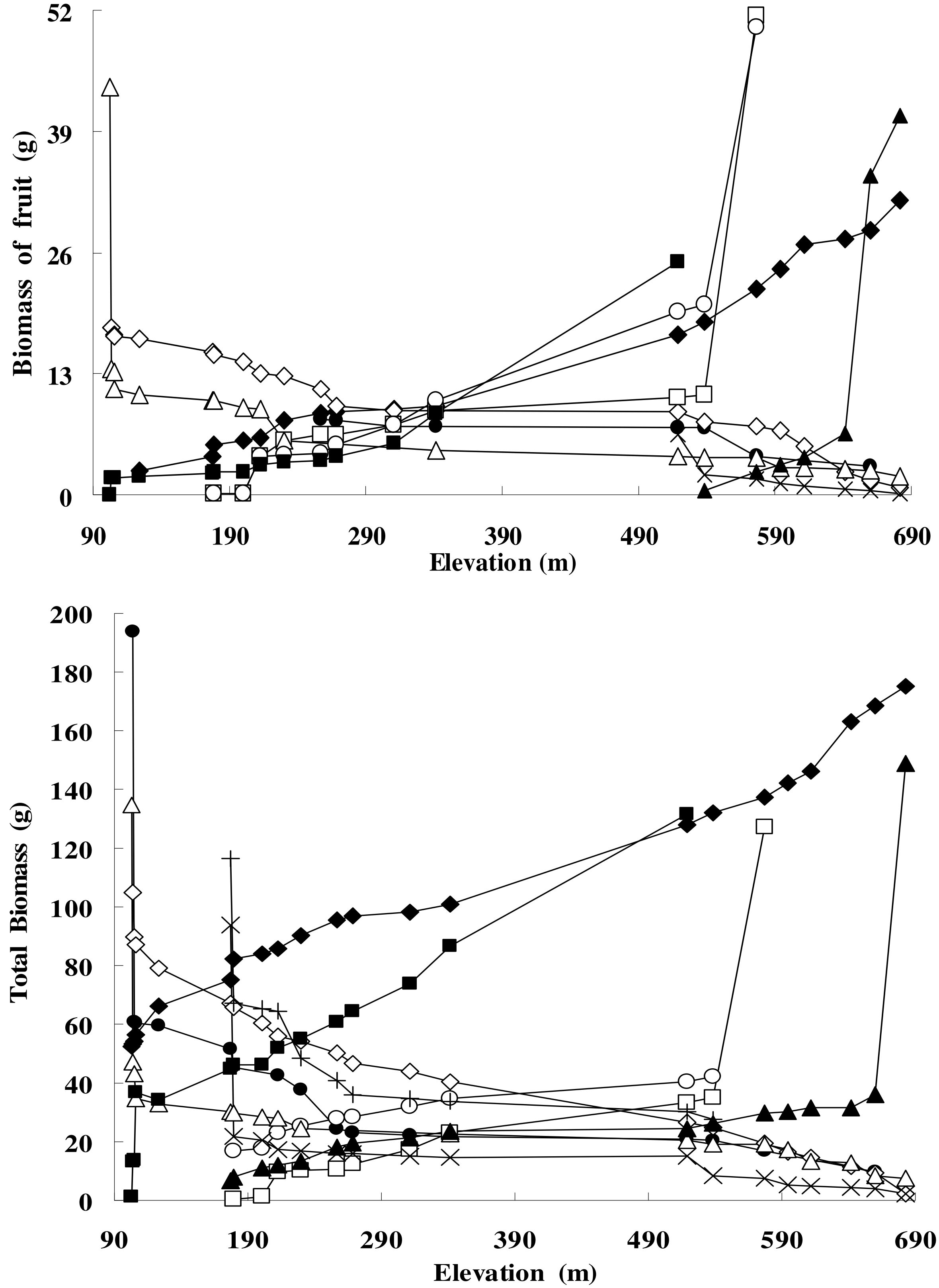
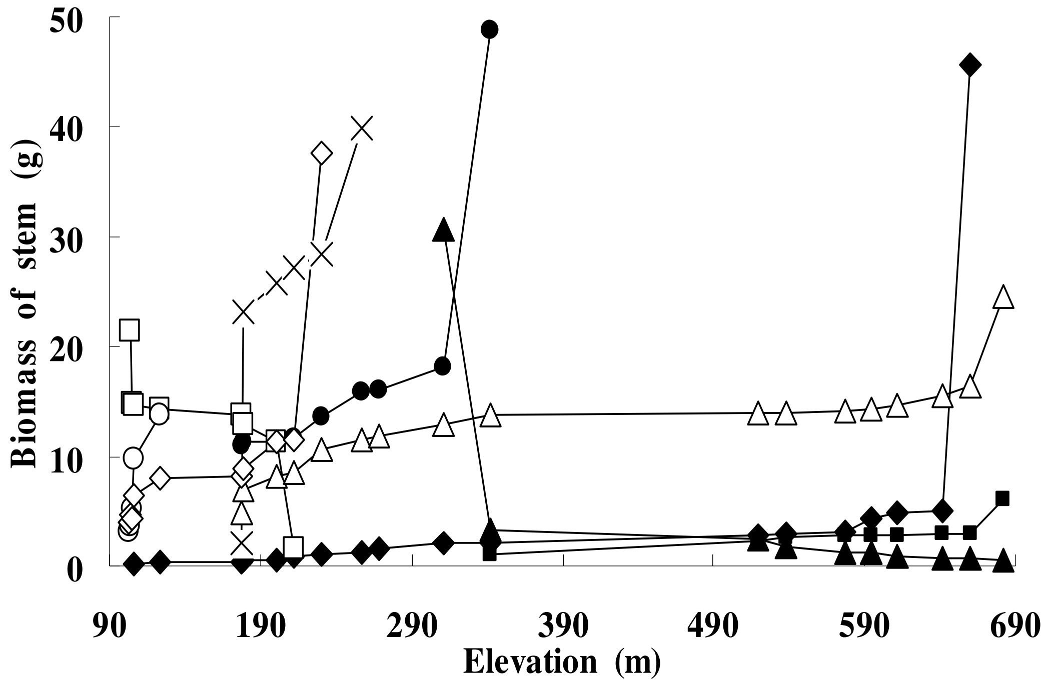



**Figure 5.** The biomass of the dominant herbaceous dry species. X axis stands for elevation; Y axis stands for biomass; -□- *Juncus effuses L.*; -△- *Digitaria sanguinalis*; -◆- *Conyza japonica*; -○- *Cyperus rotundus*; -◇- *Echinochloa crusgali*; -×- *Bidens pilosa*; -■- *Cyperus globosus* All; -▲- *Artemisia argyi*; -●- *Cynodon dactylon L;* -+- *Polygonum lapathifolium.*



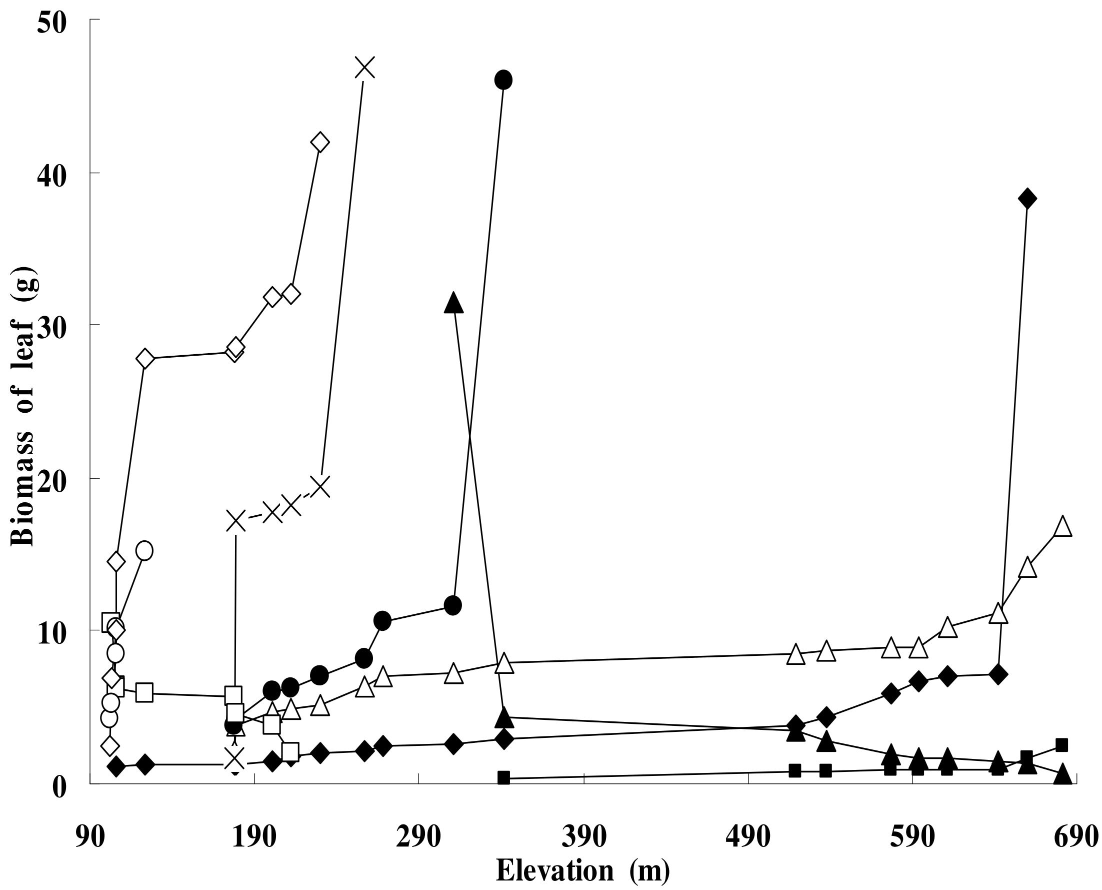




**Figure 6.** The biomass of the companion herbaceous dry species. X axis stands for elevation; Y axis stands for biomass; △ *Setaria glauca*; ○ *Descurainia Sophia*; ◆ *Cyperus fuscus;* ╳ *Artemisia capillaries;* ▲ *Acalypha australis*; □ *Ranunculus sceleratus*; ● *Humulus scandens;* ◇ *Potentilla supine*; ■ *Chenopodium serotinum.*

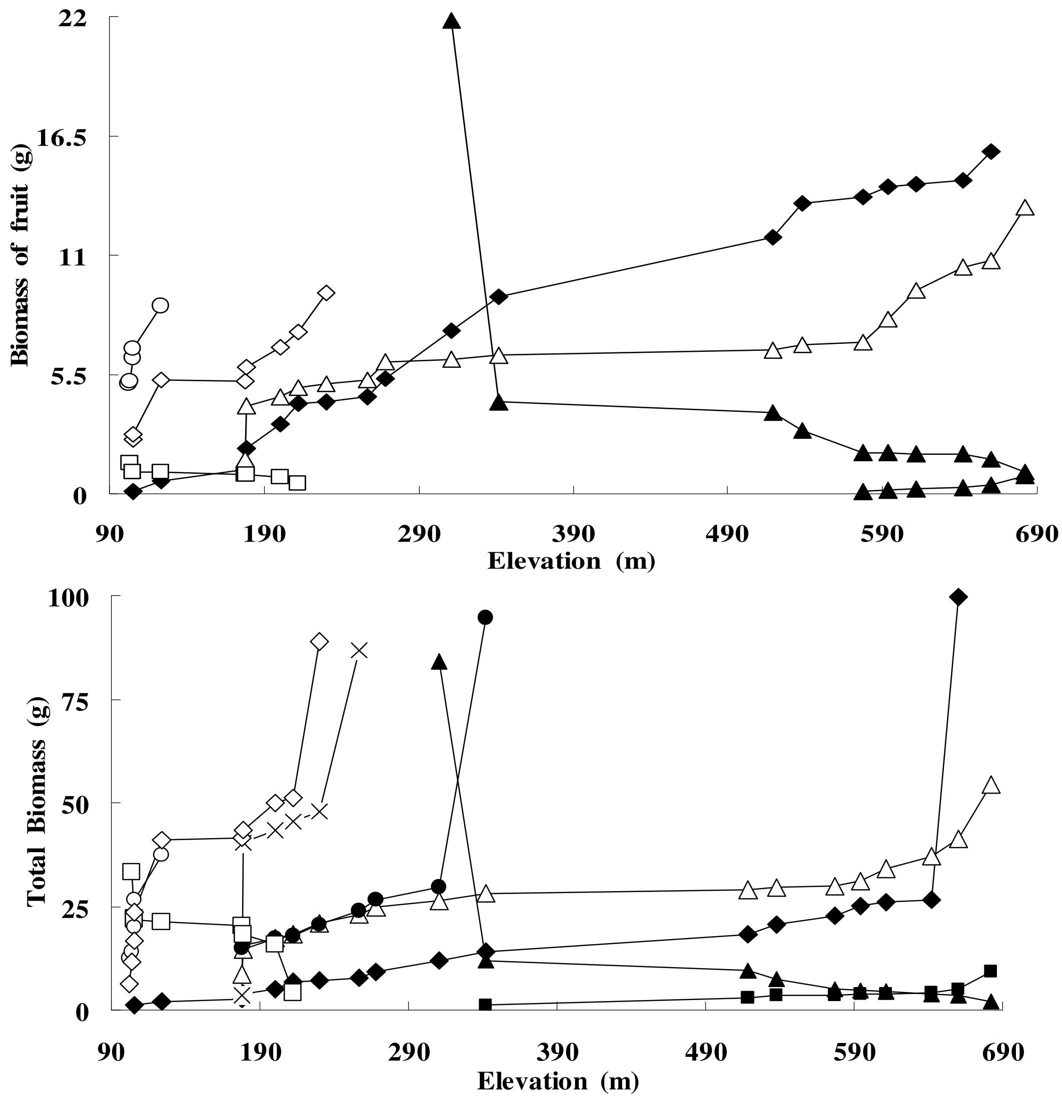



**Figure 7.** The biomass of the companion herbaceous dry species. X axis stands for elevation; Y axis stands for biomass; -△-*Setaria glauca*; -○-*Descurainia Sophia*; -◆-*Cyperus fuscus;* -×-*Artemisia capillaries;* -▲-*Acalypha australis*; -□-*Ranunculus sceleratus*; -●-*Humulus scandens*; -◇-*Potentilla supine*; -■-*Chenopodium serotinum.*

**Table 2.** The correlation between elevation and biomass of dry species in PFGs.

| Dominant species | Stem biomass | Leaf biomass | Fruit biomass | Total biomass | Companion species | Stem biomass | Leaf biomass | Fruit biomass | Total biomass |
|---|---|---|---|---|---|---|---|---|---|
| *C. dactylon L.* | -0.622* | -0.581* | -0.823* | -0.583* | *C. fuscus* | 0.508* | 0.584* | 0.990** | 0.706** |
| *C. japonica* | 0.984** | 0.958** | 0.984** | 0.986** | *S. glauca* | 0.837** | 0.891** | 0.887** | 0.880** |
| *E. crusgali* | -0.960** | -0.867** | -0.953** | -0.958** | *H. scandens* | 0.795* | 0.785* | / | 0.791* |
| *J. effuses L.* | 0.729* | 0.671* | 0.720* | 0.947** | *A. capillaris* | 0.823* | 0.868* | / | 0.868* |
| *D. ischaemum L* | -0.531* | -0.551* | -0.622** | -0.589** | *A. australis* | -0.720* | -0.734* | -0.758* | -0.735* |
| *C. rotundus L.* | 0.717* | 0.703* | 0.881** | 0.788** | *R. sceleratus* | -0.762* | -0.808* | -0.833* | -0.790* |
| *B. pilosa* | -0.577* | -0.598* | -0.823* | -0.567* | *C. serotinum* | 0.772* | 0.732* | 0.897* | 0.772* |
| *P. lapathifolium* | -0.680* | -0.669* | / | -0.680* | *D. sophia* | 0.883* | 0.905* | 0.940* | 0.907* |
| *A. argyi* | 0.591* | 0.592* | 0.837* | 0.592* | *P. supina* | 0.720* | 0.908** | 0.938** | 0.898** |
| *C. globosus* All | 0.973** | 0.880** | 0.896** | 0.971** | | | | | |

* $P<0.05$, ** $P<0.01$.

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