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# Why summer harvesting of common reed is a viable management practice?

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**ABSTRACT:** A wetland stand of *Phragmites australis* (Cav.) Trin. ex Steud., located in Akigase Park, Saitama Prefecture, Japan was investigated to study the effects of summer harvesting. The effect from harvesting in June, when carbohydrate supplies in the rhizomes are at a minimum, was compared with harvesting in July, when rhizomes are recharged with carbohydrates. From April through October 2000, biomass of above and below-ground organs and bulk density ($\rho_{rhiz}$, an easily measured parameter proportional to the quantity of non-structural polysaccharide reserves) of rhizomes of different ages was measured. The present study quantitatively analysed the effects exerted on the regeneration dynamics of shoots and storage dynamics of rhizomes of a stand of *P. australis* subjected to summer harvesting. Summer harvesting did not exert significant effects (increase/decrease) on shoot biomass at the end of the same growing season. However, the seasonal pattern in rhizome storage showed a marked variation between the two harvested stands. The rate of increase in $\rho_{rhiz}$ of different age categories of rhizomes after shoot harvesting showed that the rate of $\rho_{rhiz}$ increase was negatively and linearly correlated with rhizome age in both June-cut and July-cut stands. Also cutting in June rather than July enabled to retard the recharging capacity of *P. australis* rhizomes. The study identified the seasonal changes of the quality of the rhizome reserves as essential for proper vegetation management.

**Key Words:** biomass, harvesting, rhizome storage

## Introduction

The common reed, *Phragmites australis* (Cav.) Trin. ex Steudel an emergent macrophyte species and frequently an important component in freshwater ecosystems, making it important to consider its impact on aquatic environments. In some parts of the world, *P. australis* is regarded as an unwanted, troublesome and invasive weed, and resolve to control its spreading while the Europeans are trying to preserve its existence in their water bodies. Both these attitudes may imply the need of managing this highly productive species, in aquatic habitats to meet different goals. Not only the ecological processes, components and relations of this species should be understood but also the properties and laws of the entire ecosystems related to *P. australis* should be well studied prior to setting either kind of managerial goals.

Summer cutting is a traditional management practice aimed at controlling the size and area of reed beds. Despite the relatively small efficiency of its application summer cutting is ecologically sounder than other contemporary control practices employed for achieving the same aims, such as herbicide application or mechanical removal of the entire community with scrapers (Husak 1978). Despite the ecological importance of this method, the studies conducted to investigate its effects exerted on both regeneration of shoots and dynamics of rhizomes are still scarce and more studies should be carried out to understand the governing laws of harvesting. The present study was carried out to study the viability of summer harvesting by answering and quantifying the question "how effectively shoot harvesting in two summer months can suppress/accelarate *P. australis* growth" in relation to above ground biomass and rhizome reserve storage level.

## Materials and Methods

### Study site and study design

The study was conducted in a wetland portion of Akigase Park, near the Arakawa River in Saitama City, Japan (35° 51" N, 139° 39" E). The park, located on the flood plain of the Arakawa River, is a nature reserve covering some 500 ha adjacent to the river and comprised of many such wetland areas. The study site covering about 0.1 ha, was dominated by a monospecific and more or less homogeneous (shoot height and stem distribution) stand of *P. australis*. The *P. australis* stand being more than 10 years old appeared to be in dynamic equilibrium.

To investigate the effects of summer harvesting on *P. australis,* the total area of approximately 0.1 ha was divided into three roughly equal plots. One third of the total area selected remained uncut throughout the observation period (control plot, referred as uncut stand in the further text), another third was cut on June 4 (June-cut stand) and the remainder was cut on July 4 (July-cut stand). All the shoots were cut 0.25 to 0.30 m above the substrate level so that no leaf blades were present on the remaining stubble.

Shoots were harvested over an area of 0.125 $m^2$ and rhizomes and roots were excavated, with a garden spade, up to a minimum depth of 0.6 m under the same area where the shoots were harvested. After finishing the sampling work in June and July, all the shoots in June- and July-cut stands were cut with hedge clippers, and the harvested shoots removed from the study area. In the laboratory each shoot sample was initially sorted into live and dead shoots. Root materials were cleaned of soil with a pressurized water spray, over a 4 mm sieve, which served to retain root material. All plant material including dead and live were cut into 2-3 cm long pieces and dried at 85°C to a constant weight (preferably 24 hours).

### Determination of bulk density of rhizomes

Rhizome clusters were blotted and the branches were tentatively dated using a method modified from Cizkova & Lukavska (1999) and Klimes et al. (1999). Identification of rhizome age categories was based on (i) branching hierarchy, (ii) condition of the shoots attached to vertical rhizomes: live green shoots are attached to one year-old rhizomes, dead shoots are attached to older rhizome material, (iii) condition of the nodal sheaths: intact and tightly covered in newly-formed rhizomes, loosely attached or partly disintegrated in one to two year-old rhizomes and absent in rhizomes over three years old, and (iv) color (which becomes darker with age). Rhizomes of up to six years of age were identified. A detailed description of the identification method is presented elsewhere (Karunaratne and Asaeda, submitted).

Bulk density ($\rho_{rhiz}$), an easily measurable parameter and a good indicator of the seasonal rhizome storage reserve content, such as TNCs, was selected to study the relationship between reserve accumulation/ remobilization and age of *P. australis* rhizomes. Using a sharp knife to prevent undue damage, rhizome segments bearing two undamaged nodes at either extremity of an inter-node were excised from undamaged rhizome branches. For each replicate sample on each sampling date, $\rho_{rhiz}$ of some 35 to 40 intact internodes from each age category was measured. Incomplete or damaged internodes were discarded.

### Statistics

The data were evaluated using factorial analysis of variance (ANOVA) with Tukey's multiple comparison as a posttest. Bartlett's test was used to test the homogeneity of variances. Unpaired *t*-test was used to evaluate the differences between two independent means. The differences between the single values were assessed using 95% confidence intervals for means.

## Results

Seasonal variation of rhizome shoot biomass, and its components and bulk densities ($\rho_{rhiz}$), a good indicator of the resource level of *P. australis* rhizomes, of different age categories measured at roughly one month intervals in June-cut and July-cut stands were compared with that of uncut stand (fig. 1). Only the mean values without the standard error (SE) are shown for $\rho_{rhiz}$ to increase the clarity. From April to the respective harvesting times, all the three stands (uncut, June-cut and July-cut) performed in an identical

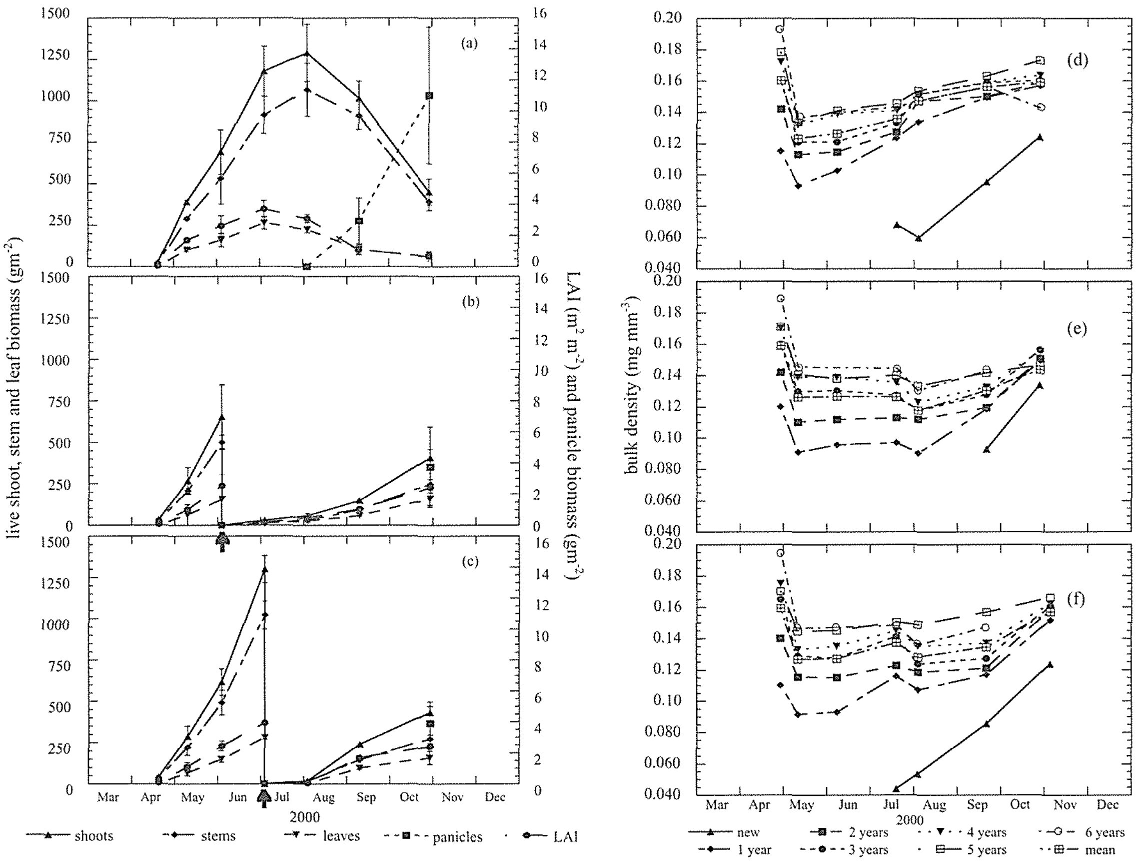


**Fig. 1.** Seasonal variation of shoot biomass and rhizome bulk density (of different ages and mean excluding new rhizomes) of *P. australis* in (a) & (d) uncut, (b) & (e) June-cut, (c) & (f) July-cut. Standard error for $\rho_{rhiz}$ means varied between 0.0006-0.0012.

manner having similar growth characteristics such as time of spring formation of shoots, variation of shoot density, biomass and height and LAI etc (at $p < 0.05$). Total above ground biomass, LAI and shoot height attained by the three stands in June were 0.69, 0.65, 0.62 kg $m^{-2}$; 2.61, 2.53, 2.44 $m^2$ $m^{-2}$ and 1.99, 1.81, 1.96 m uncut, June-cut and July-cut stands, respectively.

ANOVA performed to investigate the significance of above parameters on the stand performance revealed similar stand performance in June, at the harvesting of June-cut stand (the values being not significantly different $p$<0.05). In July too, July-cut stand showed similar growth performance to that of uncut stand parts.

After the harvesting treatments, the maximum shoot biomass attained by the June-cut and July-cut stands in late October were 0.41(0.04 and 0.43(0.04 kg $m^{-2}$, respectively (not significantly different at $p$<0.05). The maximum leaf area indexes (LAI) in late October were 2.30(0.12 and 2.330.04( $m^2$ $m^{-2}$ in June-cut and July-cut stands, respectively indicating no significance difference between the two harvesting treatments. The shoot biomass and LAI in uncut stand at this time was 0.45(0.04 kg $m^{-2}$ and 0.66(0.06 $m^2$ $m^{-2}$, respectively. This showed even though the harvesting increased the LAI it did not increase the total shoot biomass. In late October, the mean shoot height reached by the two harvested stands did not show any significance difference (at $p$<0.05); July-cut stand reaching a mean stand height of 1.14(0.02 m while, that of June-cut stand was 1.0(0.07m. No further significant increase in shoot height and also shoot biomass was anticipated due to the fact that both the stands started forming panicles by October, which coincides with cessation of the active growth phase of shoots. It was observed that both the treated stands displayed similar performances with respect to biomass and stand height of above ground stand parts by late October, irrespective of time of harvesting.

The three-factor ANOVA performed to investigate the effects of rhizome age (excluding new rhizomes), stand (or treatment) and sampling date (from June to September) on $\rho_{rhiz}$, showed significant effects. The effect of age and stand treatment on the seasonal storage pattern (by means of $\rho_{rhiz}$) is explained as shown in fig. 1. For each sampling date, rhizome bulk density increased with rhizome age irrespective of the time of harvesting in all the three stands ($P \leq 0.05$). However, $\rho_{rhiz}$ decreased from April to May to support the spring formation of shoots. There was a higher % decrease in $\rho_{rhiz}$ of younger rhizome age categories with respect to older counterparts, implying a significantly larger contribution for spring shoot growth from the younger rhizome age categories. After the both treatments the minimum storage level of rhizomes was observed in August. From August onwards, the $\rho_{rhiz}$ started to increase in all age categories in both stands. The rate of increase in $\rho_{rhiz}$ of different age categories of rhizomes after shoot harvesting showed that the rate of $\rho_{rhiz}$ increase was negatively and linearly correlated with rhizome age in both June-cut and July-cut stands. The two-factor ANOVA performed for late October sampling (including new rhizome category) confirmed the main effect of stand was very significant while that of age was extremely significant on $\rho_{rhiz}$. However, the treatment did not have the same effect at all values of age. Comparison of the mean(SE $\rho_{rhiz}$ of different age categories in October shows that both harvesting treatments reduced the storage accumulation capacity of older rhizome age categories when compared to their younger counterparts, June treated stand achieving the lowest among the treated stands. However, the $\rho_{rhiz}$ of the younger rhizomes less than two years old (inclusive) did not show significant difference between the two treatments.

## Discussion

Summer harvesting is an ecologically friendly management/control technique, practiced in many parts around the world. Despite the ecological importance of this method, the studies conducted to investigate its effects exerted on both regeneration of shoots and dynamics of rhizomes are still scarce. It was observed that mostly as a controlling technique, invasive reed stands are commonly harvested during July to August. The present study quantitatively analyzed the effects exerted on the regeneration dynamics of shoots and storage dynamics of rhizomes of a stand of *P. australis* subjected to summer harvesting.

Summer harvesting did not exert significant effects (increase/decrease) on shoot biomass at the end of the same growing season. Also in late October, no significant differences were observed between the times of harvesting with respect to shoot biomass and height even though harvesting reduced stand height. Rhizome storage was affected by shoot harvesting and also by the time of harvesting, during the same growing season. After spring exhaustion of rhizome reserves in May in uncut stand and after August in June-cut and July-cut stands showed an increased rate of reserve ($\rho_{rhiz}$) accumulation over time with increasing rhizome age (negative correlation). Based on that the older rhizome age categories support the spring formation of shoots more than the younger age categories do and the comparison of the mean $\rho_{rhiz}$ in late October, June-cut stand may perform poorly during the following growing season, while July-cut stand may perform more or less similar to the control stand. This proposal was further supported by a study carried out during 2001 in the same study site. It has shown that harvesting shoots during the previous growing season had reduced shoot biomass in June-cut stand by 27% where as July-cut stand was not significantly different to that of the uncut stand. Hence, it can be seen that study has major implications for the management of reed swamp communities; harvesting in June suppresses the growth of the reed, especially in the following year(s) while in July or August, maximizes the nutrient removal when applied to treatment of wastewater using *P. australis*. Further, June treatment may probably weaken the stand beyond repair after several years of repeated harvesting.

Best timing for shoot harvesting for nutrient removal is a major issue in wastewater treatment facilities using emergent plants such as *P. australis*. June harvesting removed 0.69 kg $m^{-2}$ of shoot biomass while July harvest removed 1.18 kg $m^{-2}$, which are 46 and 9% lower than the maximum shoot biomass attained by the control stand parts. However, July harvesting removed the seasonal maximum leaf biomass (0.26 kg $m^{-2}$) thereby removing higher % of leaf bound nutrients than harvested in August (leaf biomass in uncut stand 0.22 kg $m^{-2}$). Karunaratne and Asaeda (2002) showed that *P. australis* may contain an average of 2% shoot bound nitrogen and 0.2% shoot bound phosphorous in early July. Since leaf tissues contain a higher nutrient content than stem tissues, July harvesting may remove a higher amount of nutrients than August harvesting even though the total shoot biomass is slightly lower. Since, a major leaf abscission was observed from August leaves became harder towards the end of the growing season. Therefore, if the harvested shoots should be used as forage, July (a higher leaf biomass) or early (lower leaf biomass) harvesting may make them more palatable.

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