CHAPTER 3

Effect of selective clipping on regrowth and competitive ability of forage grass

Based on: Jane Bemigisha, Sip E. van Wieren, Andrew K. Skidmore, Alfred Stein, Jasper van Ruiven and Jan de Leeuw. (In preparation). Contrasting regrowth and competitive ability of *Lolium multiflorum* and *Dactylis glomerata* under selective clipping

Abstract

Regrowth capacity is one of the attributes that affect the competitive ability and persistence of forage plant species but this has not been established for most co-occurring livestock forage species under selective grazing. In a greenhouse experiment, we investigated the regrowth and competitive ability of a preferred and less preferred grass species, *Lolium multiflorum,* and *Dactylis glomerata*, respectively. We tested the effects of clipping intensity and species culture (monoculture and mixed) on the regrowth of the two species, and whether selective clipping (simulating selective grazing) affected *D. glomerata* more when clipped at less intensity than *L. multiflorum*. Regrowth in monoculture was significantly higher for *D. glomerata* than for *L. multiflorum* ($P < 0.05$). Mixed culture comparisons showed similar differences, but mean regrowth of *L. multiflorum* was significantly higher than that of *D. glomerata* ($P < 001$), suggesting that it was negatively affected by the presence of *L. multiflorum*. Selective clipping did not lead to higher competitive ability in *D. glomerata* as expected. Its neighbour *L. multiflorum* showed higher regrowth under selective clipping, possibly because of its head-start germination and larger stature. This may change over time because the mean regrowth of *D. glomerata* was greater under selective clipping than under uniform clipping (although the difference was not statistically significant). Selective grazing may therefore shift the regrowth and competitive ability in favour of *D. glomerata*.

3.1 Introduction

The vulnerability of plant species preferred for livestock grazing calls for prediction of their performance and survival in mixed vegetation communities (Noy-Meir, 1990). The performance of such species depends on management such as sowing time (e.g., Fetene, 2003) and traits, such as germination time and plant size (Humphrey and Schupp, 2004). The effect of selective herbivory may also depend on interactions of various environmental factors and this makes it difficult to predict. Although competition in forage species (e.g., Prins and Nell, 1990; Olff *et al*., 1999; Arsenault and Owen-Smith, 2002; Humphrey and Schupp, 2004) and plant responses to grazing in mixed plant species (e.g., Berendse *et al.,* 1992; Loo, 1993; Kuijper *et al*., 2004; Seggara *et al*., 2005; Tilman, 1988) have been widely studied, the simultaneous effects of selective grazing and competition for most co-occurring forage species is not known (Lenssen *et al*., 2004).

Competitive abilities have been studied in various ways, leading to different predictions and interpretations (Golderberg 1996). Golderberg (1990) defined competitive ability in terms of either the competitive effect (ability of an individual to suppress other individuals), or on the competitive response (referring to the ability of an individual to avoid being suppressed and ability to acquire and use resources). Competitive abilities may also be based on differences in growth rates, rate of increase in height and access to nutrients (Tilman, 1988). Competitive ability of forage plant species in response to defoliation may be determined by the regrowth capacity, i.e., renewed growth of leaves, the expansion of new shoots (Grime, 1979), and shoot density (e.g., Lenssen *et al*., 2004). Based on these definitions, this research has determined competitive ability through regrowth capacity based on dry matter (g) of re-sprouted plant tissue clipped or removed between clipping intervals.

The objective of this study was to investigate the effect of selective clipping (simulating selective grazing) on the regrowth and competitive ability of *L. multiflorum* when mixed with a species less preferred by livestock grazers, *D. glomerata*. We tested the effect of selective clipping (clipping *D. glomerata* at a higher clipping height than *L. multiflorum*). *D. glomerata* was expected to have higher regrowth under selective clipping than under uniform clipping as a consequence of *L. multiflorum* being clipped at a higher intensity while in the mixed cultures.

3.2 Methods

3.2.1 Study species

Two forage grass species, *L. multiflorum* and *D. glomerata,* with different growth characteristics and differing in terms of preference by livestock grazers, were selected. A detailed description of their characteristics is given in section 2.2.1. Although identified in Majella National Park, Italy, a Mediterranean field study site of the wider research connected to this study, the species also appear together elsewhere (temperate, tropical and subtropical areas) in natural or cultivated pastures (Hannaway *et al.,* 1999; Hubbard, 1968; Avery *et al.,* 2000; Lowe *et al*., 2005). In this study, *L. multiflorum* was identified as being preferred to *D. glomerata* by grazers*,* although the preference may differ depending on different field situations. Both species are widely grown for pasture and hay. Their regrowth and competitive ability under selective grazing, like those of most co-occurring livestock forage species, are not adequately studied.

3.2.2 Experimental set-up, clipping treatments and measurements

The same experiment set-up and clipping design as in section 2.2.2 was used, but the clipping treatments for this study differed by including selective clipping. In this study clipping intensity was classified into (a) uniform clipping, that is, clipping at the same height above the ground) and (b) selective clipping, that is, clipping *L. multiflorum* at high intensity (5 cm) to emulate its being preferred by grazers while D*. glomerata* was clipped at a lower intensity (10 cm). To minimize experimental time and space, the replicates of *D. glomerata* designed for clipping at high intensity were clipped instead at medium intensity (10 cm) to cater for selective clipping. This means that for *D. glomerata* the clipping intensity class code of High (5 cm) was replaced by another Medium class code (10 cm). Consequently, the analysis and sections on selective clipping show two medium clipping treatments of *D. glomerata* at Medium (S) and Medium (U), representing selective and uniform clipping, respectively. Note that the medium clipping intensity in both uniform and selective clipping was the same (10 cm); the codes (S and U) are used only for identification purposes. The clipped plant material was dried as in section 2.3.3. Regrowth was calculated as the difference between the dry matter of the clipped material at clipping T2 and the dry matter at clipping T3. Prior to analysis, regrowth of monocultures (sown with 40 seeds) was divided by two to enable comparison with the mixed

cultures (20 seeds for each of the two species). Data on dry matter yield is contained in Table 3.3.

3.2.3 Analysis

The analysis was conducted in two parts: (a) to test the effects of uniform clipping intensity, culture (monocultures and mixed) and species on regrowth, and (b) to test the effect of selective clipping (clipping *D. glomerata* at lower intensity than *L. multiflorum*).

3.2.3.1 Testing the effect of uniform clipping on regrowth

For this part of the analysis, Low (15 cm) and Medium (10 cm) clipping intensity replicates were used. Table 3.1 shows the species, cultures and clipping combinations.

Table 3.1 Data structure for uniform clipping analysis. Clipping intensity: Low = 15 cm height; Medium = 10 cm height. Note that the *high clipping* intensity for *D. glomerata* are not included because the replicates were clipped instead at medium height to test the effect of selective clipping.

Species	*Culture*	*Clipping height*	*No. of samples*
L. multiflorum	Monoculture	Low	18
		Medium	18
	Mix	Low	18
		Medium	18
D. glomerata	Monoculture	Low	18
		Medium	18
	Mix	Low	18
		Medium	18
		Total	**144**

A nested ANOVA was used to test the effect of clipping intensity nested within the species and species culture interaction, as illustrated in Figure 3.1.

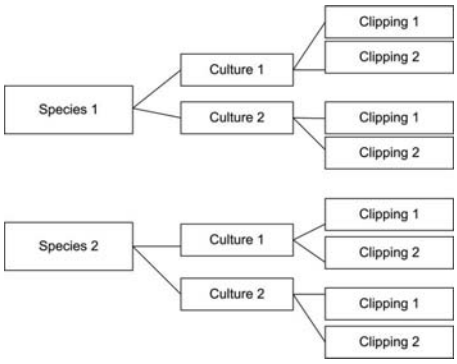

Figure 3.1 Illustration of the nested ANOVA model: clipping intensity nested in culture and species. Species 1 = *D. glomerata,* Species 2 = *L. multiflorum*; Culture 1 = monoculture, Culture 2 = mixed culture; Clipping 1 = low clipping intensity, Clipping 2 = high clipping intensity.

The following model was used:

Regrowth = (Species*Culture)/Clipping

Indicating that the clipping effect is nested within the full factorial species × culture interaction model. This model is equivalent to the following formula:

$$Regrowth_{ijkl} = (Species_i * Culture_j)/Clipping_k + e_{ijkl} \quad \text{(Eq.3.1)}$$

where:

$Species_i$ = *D. glomerata* (i = 1) and *L. multiflorum* (i = 2)
$Culture_j$ = type of stand, i.e., mono (j = 1) and mixed (j = 2)
$Clipping_k$ clipping intensity, i.e., low (k = 1) and medium (k = 2)
$Regrowth_{ijkl}$ = the mean response for treatment combination i, j and k
e_{ijkl} = a normally distributed error term with mean zero.

3.2.3.2 Testing the effect of selective clipping on regrowth

Selective clipping was done by clipping *L. multiflorum* at high intensity (5 cm) and *D. glomerata* at lower intensity (10 cm) to emulate the higher preference by grazers for the former. Table 3.2 shows the species, cultures and clipping combinations. We expected that the mean regrowth of *D. glomerata* under uniform clipping would be less than under selective clipping, because under selective clipping the competitive effects of its neighbour *L. multiflorum* would be suppressed by the higher clipping intensity.
To test whether regrowth of *D. glomerata* was significantly affected by selective clipping (i.e., when clipped at a lower intensity than *L.*

multiflorum), the mean regrowth under selective clipping (coded S) was compared with mean regrowth under uniform clipping (coded U). An independent samples *t*-test was used for the comparison. The hypothesis tested was:

Ho: $\mu_{Dt\_U} = \mu_{Dt\_S}$
Ha: $\mu_{Dt\_U} \# \mu_{Dt\_S}$

where μ_{Dt_U} and μ_{Dt_S} are the regrowth means of *D. glomerata* under uniform clipping and selective clipping, respectively.

For both the ANOVA and the *t*-test, the effect was considered significant at $P \leq 0.05$.

Table 3.2 Data structure for testing the effect of selective clipping. Clipping intensity treatments*:* High = 5 cm clipping height, Medium = 10 cm clipping height, (S) = selective clipping, (U) = uniform clipping.

Species	Culture	Clipping intensity	No. of samples
L. multiflorum	Mix	High	18
		Medium	18
D. glomerata	Mix	Medium (S)	18
		Medium (U)	18
		Total	**72**

3.3 Results

3.3.1 Effect of clipping intensity, culture and species on regrowth (uniform clipping)

A contrasting response to culture treatments was found within and between the regrowth of the two species, and we found that *D. glomerata* was negatively affected by the presence of its neighbour *L. multiflorum*. Table 3.3 shows that the total mean regrowth in the monocultures of *D. glomerata* was 2.28 g greater than in the mixed cultures. On the other hand, regrowth in the monocultures of *L. multiflorum* was half that in the mixed cultures. Statistical comparison of the two species (Table 3.3 and 3.4) shows that the total mean regrowth in the monocultures of *D. glomerata* (2.44 g) was significantly higher than in the monoculture of *L. multiflorum* (1.55 g), and the difference was highly significant ($P < 0.001$). In the mixed cultures, the mean regrowth of *L. multiflorum* was significantly higher than that of *D. glomerata* ($P < 0.001$). Therefore, if the culture was a monoculture, we had higher regrowth of *D. glomerata*; if the culture

was mixed, we had higher regrowth of *L. multiflorum* (Table 3.5). This shows that the regrowth of *D. glomerata* was negatively affected by the presence of its neighbour *L. multiflorum*.

Table 3.3 Mean dry matter (DM g) at T2: after 13 weeks and T3: after 18 weeks and mean regrowth (DM g) of *D. glomerata* (Dt) and *L. multiflorum* (L) in monocultures and mixed cultures at clipping intensities: Low (15 cm above the ground) and Medium (10 cm above the ground). Regrowth figures for monocultures are divided by two. Standard errors of the means and the 95% confidence intervals are presented in Table 2.1

Species	Culture	Clipping	Mean dry matter (DM g) T2	Mean dry matter (DM g) T3	Mean regrowth (DM g)
Dt	Mix	Low	9.09	9.16	0.07
Dt	Mix	Medium	8.67	8.76	0.09
Dt	Mono	Low	6.66	7.91	1.25
Dt	Mono	Medium	7.11	8.51	1.19
L	Mix	Low	12.2	13.45	1.28
L	Mix	Medium	11.5	13.62	2.12
L	Mono	Low	6.21	6.98	0.78
L	Mono	Medium	7.37	9.16	0.77

Table 3.4 Results of nested ANOVA for clipping nested within species and culture. Species: *L. multiflorum, D. glomerata*; clipping: Low and Medium clipping intensities.

Treatment	Estimate	*Std. Error*	t-value	P
Species	1.99	0.43	4.58	< 0.001
Culture	1.69	0.43	3.89	< 0.001
(Species * culture)/ clipping	-2.64	0.62	-4.26	< 0.001

Table 3.5 Regrowth as response to species, culture and clipping intensity in uniform clipping. *Dt = D. glomerata, L = L. multiflorum*.

Species	Culture	Clipping intensity	Response within species	Response between species
Dt	Monoculture	Low	-	Dt > L
Dt	Monoculture	Medium	Medium < Low	Dt > L
Dt	Mixed	Low	-	Dt < L
Dt	Mixed	Medium	Medium > Low	Dt < L
L	Monoculture	Low	-	L < Dt
L	Monoculture	Medium	Medium < Low	L < Dt
L	Mixed	Low	-	L > Dt
L	Mixed	Medium	Medium > Low	L > Dt

3.3.2 Effect of selective clipping

Selective clipping increased the regrowth of *D. glomerata*, but this was not significant. Figure 3.2b show the mean regrowth (DM g) of *D. glomerata* under selective clipping (M-selective) and uniform clipping (U-selective). Figure 3.2a shows regrowth (DM g) of *L. multiflorum* under (high) selective clipping (H-selective). The regrowth of *D. glomerata* was higher under selective clipping (0.75 g) than under uniform clipping (0.09 g). This difference is rather large, but the *t*-test results showed no statistical significance. We thus failed to reject the null hypothesis and concluded that selective clipping did not lead to significantly higher regrowth and therefore higher competitive ability of *D. glomerata*. Under selective clipping, *D. glomerata* was expected to have higher regrowth than *L. multiflorum,* as a consequence of *L. multiflorum* being clipped at a higher intensity. However, the mean regrowth was still less than that of *L. multiflorum* (Figure 3.2a).

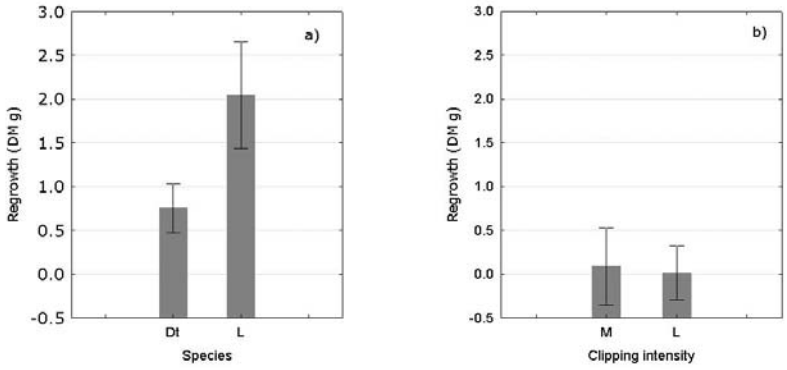

Figure 3.2 Mean regrowth of (a) *D. glomerata* (Dt) and *L. multiflorum* (L) under selective clipping, and (b) *D. glomerata* clipped at medium height in mixed cultures of selective treatment (M-selective) and uniform treatment (M-uniform). Vertical bars (whiskers) denote 0.95 confidence intervals.

3.4 Discussion

Under uniform clipping, we found contrasting responses in the regrowth of the two species to clipping intensity and culture, but in mixed cultures both species showed higher regrowth when clipped at the higher clipping intensity (10 cm) than at the lower intensity (15 cm). The higher regrowth in the mixed species under higher clipping intensity demonstrates high competitive traits in both grass species. Such grasses rapidly regrow in response to intense damage and thus

have the capacity to rapidly re-establish leaf canopy following defoliation (Grime, 1979). Other plants, such as *Lolium perenne,* increase photosynthetic efficiency as compensation following defoliation (Wolfson, 1999). In their experiment, Boyd and Svejcar (2004) also found that production values were higher for clipped plots than for unclipped plots, indicating compensatory production of the studied herbaceous plants in response to defoliation. Minimal changes in pasture species composition have also been found as a result of varying grazing management through seasonal rests, mob stocking and cutting for hay (Garden *et al*., 2000). Our results suggest higher productivity under intensive grazing. This response is, however, not uniform among species in monocultures. For example, the regrowth in monocultures of *D. glomerata* was higher under low clipping intensity than under medium, and higher than found in *L. multiflorum.* The response to culture treatments in the regrowth of the two species showed that *D. glomerata* was negatively affected by the presence of its neighbour *L. multiflorum*. If the culture was a monoculture, then we had higher regrowth of *D. glomerata;* if the culture was mixed, then we had higher regrowth of *L. multiflorum*. This phenomenon has also been found in *L. multiflorum* when mixed with other species (Lowe *et al*., 2005). Navas and Moreau-Richard (2005) have found that the abundance of target species depends on the competitive response of neighbour species. Comparable results have been found by Seggara *et al*. (2005), in which competitive *Elyonurus adustus*, *Leptocryphium lanatum* and *Andoropogon semiberbis* show highly significant levels of neighbourhood interference.

In this study, we found that the total regrowth of *D. glomerata* was higher in monocultures than in mixed cultures, but the total regrowth of *L. multiflorum* was less in monocultures than in mixed cultures. The results suggest that, in contrast to *L. multiflorum,* under uniform grazing *D. glomerata* regrows more when in monocultures than in mixtures. Therefore, in pasture management practices that include *L. multiflorum,* consideration may be given to a mixed culture rather than a monoculture in order to increase forage productivity. This requires further testing of the response, using different species mixes.

Contrary to expectation, selective clipping did not lead to higher competitive ability of *D. glomerata.* As in uniformly clipped mixed cultures, the regrowth of *L. multiflorum* was higher than that of *D. glomerata* under selective clipping. Comparable results were shown by Lenssen *et al*. (2004), in which the responses of *Archanara*-infested and non-infested *Phragmites* shoots revealed no increased competitive suppression by *Epilobium* due to selective herbivory. Their study suggests that, rather than selective grazing, different

environmental interactions may have determined the competitive abilities. In our study, *L. multiflorum* may owe its higher competitive ability to such traits as earlier germination and larger stature. Humphrey and Schupp (2004) have found that *B. techtorum* has a competitive advantage because of a head-start over native perennial grass seedlings. Espigares *et al*. (2004) have found that early emergence of *Retama sphaerocapus* seedlings increases their biomass in relation to herbaceous plants. Fetene (2003) has also found comparable results in *Acacia etbaica* and *Hyperrenia hirta*, where *Hyperrenia* competes more aggressively with *Acacia* when the latter is planted within an already grown grass community. In addition, the large stature (larger basal area) of *L. multiflorum* enhances its regrowth in relation to *D. glomerata*. The advantage of basal area in plant competition has been attested by Navas and Moreau-Richard (2005). In addition, defoliation prior to heading has been reported to foster regrowth in *L. multiflorum* (Hannaway *et al.*, 1999).

Under continued selective clipping, the higher regrowth of *L. multiflorum* may be reversible at a time beyond the experiment. The reason is that *D. glomerata* showed a higher regrowth under selective clipping (in which *L. multiflorum* was clipped at higher intensity) than under uniform clipping, although the statistical difference was not significant. The observed response of *D. glomerata* under selective clipping is not conclusive given the insignificant statistical difference, apart from other clues. To reiterate, *D. glomerata* is a perennial grass, with higher regrowth in the monoculture; it grows taller, has a deeper root system, and continues to grow later in the season than the annual *L. multiflorum*. *D. glomerata* has also shown exceptional adaptation to defoliation because of its high sheath: stem ratio, which, it is proposed, allows it to maintain photosynthesis and a level of carbon supply sufficient to support regrowth (Cullen *et al*., 2006). These traits suggest potential for higher competitive ability beyond the experiment time (i.e., at the time when *L. multiflorum*, an annual grass, gets to the senescence stage). Unlike *D. glomerata*, *L. multiflorum* already showed signs of senescence by the end of the experiment. Lack of comparable replicates for *L. multiflorum* under selective clipping, however, limited further understanding of its response.

To sum up, a statistically based greenhouse experiment provided important and unexpected information on regrowth for different species in relation to different clipping intensities. Clipping has been used to simulate selective livestock grazing. The method may be applied to different species mixes at field level, considering the role of

underlying competition mechanisms such as resource and tiller development dynamics, clipping frequency, the manner of forage removal, trampling, dunging and resting (Bakker, 1989; Loo, 1993; Tilman, 1988).

3.5 Conclusions

Under uniform clipping, we found contrasting response to clipping intensity and culture treatments in the regrowth of the species. In monocultures, both species showed a more positive response to higher clipping intensity, suggesting higher productivity under intensive uniform grazing. The statistical results, however, showed that under uniform clipping rather than clipping intensity the higher regrowth of *L. multiflorum* compared with that of *D. glomerata* was largely attributable to species and culture.

The response to culture treatments within and between the regrowth of the two species showed that *D. glomerata* was negatively affected by the presence of its neighbour *L. multiflorum*. Comparing the two species under uniform clipping, the total mean regrowth in monocultures of D*. glomerata* was significantly higher than that in monocultures of *L. multiflorum* ($P < 0.05$). Mixed culture comparisons showed similar differences, but mean regrowth of *L. multiflorum* was significantly higher than that of *D. glomerata* ($P < 0001$).

Selective clipping did not lead to higher competitive ability of *D. glomerata* as expected. The regrowth of *L. multiflorum* was higher than that of *D. glomerata,* possibly because former germinated two weeks earlier. Over time, however, selective clipping can shift regrowth and competitive ability in favour of *D. glomerata*. *D. glomerata* showed higher regrowth in response to selective rather than uniform clipping, although the statistical difference was not significant. Moreover, perennial nature may give it an advantage over the annual *L. multiflorum* late in the growing season. This needs to be further investigated. Underlying competition mechanisms such as resource and tiller development dynamics as well as clipping frequency which were controlled or not included in this study may also be important considerations for further research.

The application of this study to different species mixes, especially in field situations, will provide an opportunity to confirm the findings. At field level, the research effort needed to study the competitive dynamics in various co-occurring forage species and covering large areas may be costly. Remote sensing approaches that improve information detail, content and frequency of observation need to be

investigated. In the next chapter, we show that hyperspectral remote sensing can be used to study competitive ability of co-occurring forage grass based on associated biophysical vegetation variables such as dry matter yield and height.