The influence of pre-drying graminoid litter on the rate of mass loss from litter bags

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Pre-drying of material to attain a uniform moisture status is common practice in litter breakdown studies. Previous studies in aquatic environments have demonstrated that this influences the subsequent rate of breakdown. This study investigated whether the same were true in terrestrial environments using six different grasses in two different communities: a *Tristachya leucothrix – Loudetia simplex* short grassland and a *Cymbopogon validus – Digitaria natalensis* medium grassland. Results indicate that pre-drying may also alter the rate of breakdown of certain species in terrestrial environments. In one species, *Eulalia villosa*, pre-drying consistently retarded breakdown at both sites. Results from the remaining species were variable, but generally indicated little treatment effect. However, trends suggest that treatment effects may increase with progression of breakdown, and that these were opposite to those recorded for *Eulalia villosa*.

Dit is algemene praktyk in afbrekingstudies van plantafval om die materiaal vooraf te droog, sodat eenvormige voggehalte verseker kan word. Vorige studies van akwatiese omgewings het getoon dat dit die daaropvolgende afbreking beïnvloed. In hierdie ondersoek is daar, deur ses grassoorte van twee lokakiteite te bestudeer, probeer om vas te stel of dieselfde vir terrestriale omgewings geld. Die resultate toon dat vooraf-droging ook die afbrekingsnelheid van sekere spesies in 'n terrestriale omgewing mag beïnvloed. Een spesie, *Eulalia villosa*, het deurgaans getoon dat vooraf-droging, afbreking by beide lokaliteite vertraag. Variërende resultate is met die ander spesies verkry, maar hulle het in die algemeen weinig behandelingseffekte getoon. Nietemin dui die neigings daarop dat die behandelingseffek mag toeneem soos afbreking vorder.

Keywords: Breakdown, drying, grass, litter

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Introduction

Estimates of litter breakdown rates (as opposed to decomposition, *sensu* Witkamp 1971) are important parameters in modelling ecosystem mass flows and productivity. As such, several techniques have been employed to derive quantitative estimates (Singh & Gupta 1977). Of these, the litter bag method is the most commonly adopted (Heath & Arnold 1966; Gupta & Singh 1977; Singh & Gupta 1977; Swift *et al.* 1979; Shackleton *et al.* 1989) despite its drawbacks (Witkamp & Olson 1963; Swift *et al.* 1979).

This method involves the collection of plant material, either standing dead (necromass) or recently detached (litter) from the field. After collection, known masses of material are placed in litter bags in either the fresh (e.g. Attiwill 1968; Steinke & Ward 1987) or dry state. In general, it is customary to dry the material in an attempt to bring all samples to a uniform and constant moisture content prior to placement of subsamples in individual litter bags. This also facilitates storage of the collected material if it is not to be used immediately. Pre-drying may be achieved by one of several means: oven-drying (e.g. Curry 1969; Strojan *et al.* 1987; Shackleton *et al.* 1989), air-drying (e.g. Anderson 1973; Mitchell *et al.* 1986; Mitchell & Coley 1987), or air-drying with rehydration prior to placement of the litter bags in the field (e.g. Howard & Howard 1974; Anderson 1975).

However, there appears to be no knowledge of whether or not pre-drying influences subsequent breakdown rates in terrestrial environments. Significant effects have been shown in several studies of breakdown and decomposition in aquatic systems (Harrison & Mann 1975; Godshalk & Wetzel 1978; Rogers & Breen 1982). These demonstrated that pre-drying litter increased the rate of mass loss in the initial stages of breakdown but decreased it in the later stages, relative to undried litter.

The alteration of the initial moisture content could affect the subsequent breakdown rate in several ways (see Rogers & Breen 1982). (i) Dehydration causes shrinking and fracturing of cell walls and membranes which, upon rewetting, promotes rapid leaching of intracellular components, thereby accelerating the initial rate of mass loss. (ii) Lowering of the moisture content and leaching could alter the attractiveness of the litter as a substrate for microbial decomposers, thereby slowing initial mass loss whilst time elapses for recolonization and resumption of effective breakdown. (iii) Death of decomposer organisms already present on the material may result from changes in the moisture content. This would also reduce the rate of breakdown as described in (ii).

This study investigated the effects of pre-drying litter on the rate of litter breakdown in a subtropical, coastal grassland, assessing the null hypothesis that pre-drying had no effect on the subsequent rate of mass loss.

Study area

The study was conducted at two sites in Mkambati Game Reserve, Transkei (31°13′–20′S and 29°55′–30°4′E). Details of these two sites, the *Tristachya leucothrix* – *Loudetia simplex* and *Cymbopogon validus* – *Digitaria natalensis* sites, are given by Shackleton *et al.* (1988). The two sites differ in soil type, aspect, species composition and incidence of macrofaunal decomposers (Shackleton *et al.* 1989).

Methods

Necromass was collected in September 1986 from six grass species [*Cymbopogon validus* (Stapf) Stapf ex Burtt Davy, *Eulalia villosa* (Thunb.) Nees, *Loudetia simplex* (Nees) C.E. Hubb., *Themeda triandra* Forssk., *Tristachya leucothrix* Nees, and wire grasses]. The last is a combination of several species that could not be distinguished with certainty on the basis of vegetative characteristics alone. They were characterized by their filiform leaves, synchronous flowering period and unpalatability to herbivores [predominantly *Elionurus muticus* (Spreng.) Kunth, *Diheteropogon filifolius* (Nees) Clayton and *Rendlia altera* (Rendle) Chiov.]. The sward had been burnt one year prior to collection. It was presumed that the collection period coincided with the end of the non-growing season and most of the material was of a generally uniform age, having only recently entered the necromass component. After mixing, the bulk sample for each species was divided into material to be oven- dried and material that would remain undried.

Material to be dried was placed in a convection oven at 40°C for five days. Subsamples (n = 15) of the freshly collected material were weighed and oven-dried in the same manner to determine the moisture content of each species. The mass of undried material placed in the litter bags was then adjusted for the moisture content. This ensured that equal amounts (on a dry weight basis), to the nearest 0,01 g, were placed in the bags for each treatment.

Bags were constructed from nylon shade-cloth with a mesh size of 2 mm x 5 mm and closed with copper-coated staples. A large mesh size was selected to allow entry of all sizes of decomposer organisms. Each bag was colour-coded for the species and treatment using a small piece of coloured insulation wire attached to the corner.

Bags were placed in the field on 29 September 1986 on the soil surface between individual grass tufts of an unburnt sward. Five bags of each treatment for each species were retrieved from both sites at monthly intervals for the first three months and every two months thereafter. The total period was eleven months.

Upon retrieval any foreign material was removed from the surface of the bags. Each was placed in a plastic bag which was sealed and transported to the laboratory. There, the plastic bags were opened and placed in a convection oven at 40°C for five days.

When dry, the litter bags were opened and the contents emptied onto a sheet of white paper and hand-sorted to remove any soil or foreign matter. If necessary, organic material was viewed under 3× magnification to determine whether or not it was the same as the material originally placed in the bag. If the material had fragmented to a large degree and was compacted in soil the sample was placed in a solution of $MgSO_4$ with a specific gravity of 1.2 to separate the organic fraction from the soil in the manner described by Curry (1969). The $MgSO_4$ was then washed off with several rinses. The material was redried and weighed to the nearest 0,01 g. Pair-wise comparisons (t-tests) were made between the results for the dried and undried material for each species at each date. Comparisons were necessary for each date as it was possible that the effects of pre-drying may change with progression of breakdown as recorded from studies in aquatic systems.

Results and Discussion

Since the pattern of breakdown did not conform to an exponential model (see Swift *et al.* 1979) in most instances, alternative models were tested with appropriate curve-fitting procedures. It was found that a linear model could be applied to them all. However, this resulted in the levelling out of differences in mean daily loss for those species that conformed least to the linear model (although still significant). The derived constants (slope of the graph) and mean daily loss (%) are tabulated in Table 1.

The rate of mass loss from each species at both sites and for both treatments is illustrated in Figures 1(a) and 1(b). From these it is evident that, on the whole, breakdown was marginally faster at the *C. validus* – *D. natalensis* site than at the *T. leucothrix* – *L. simplex* site (also see Table 1). This corroborates the results obtained by Shackleton *et al.* (1989), which demonstrated that the *C. validus* – *D. natalensis* site was moister and had a greater faunal activity. The exception to this was *E. villosa* for which mass loss was markedly faster at the *T. leucothrix* – *L. simplex* site. Relative rates of mass loss between the different species (Table 1) were also similar to that reported by Shackleton *et al.* (1989). Thus, *E. villosa* and *T. triandra* experienced the most rapid loss of mass, and wire grasses and *T. leucothrix* demonstrated the least mass loss over the study period.

E. villosa was the only species that demonstrated a consistent treatment effect throughout the study, in that mass

Table 1 Slope of linear decay model and mean daily loss (%)

Site	Species	Slope		$\bar{x}$ daily loss	
		Dried	Fresh	Dried	Fresh
T. leucothrix – *T. simplex*	*C. validus*	7.06	5.79	0.07	0.07
	E. villosa	5.94	9.53	0.15	0.20
	L. simplex	9.46	9.81	0.10	0.08
	T. triandra	5.23	4.64	0.16	0.18
	T. leucothrix	10.91	10.90	0.09	0.06
	Wire grasses	9.90	7.28	0.07	0.08
			Mean	0.107	0.112
C. validus – *D. natalensis*	*C. validus*	7.83	7.57	0.12	0.13
	E. villosa	7.06	9.92	0.13	0.18
	L. simplex	6.81	9.06	0.14	0.11
	T. triandra	5.62	6.33	0.20	0.17
	T. leucothrix	9.85	8.31	0.10	0.10
	Wire grasses	6.15	8.74	0.12	0.11
			Mean	0.135	0.133

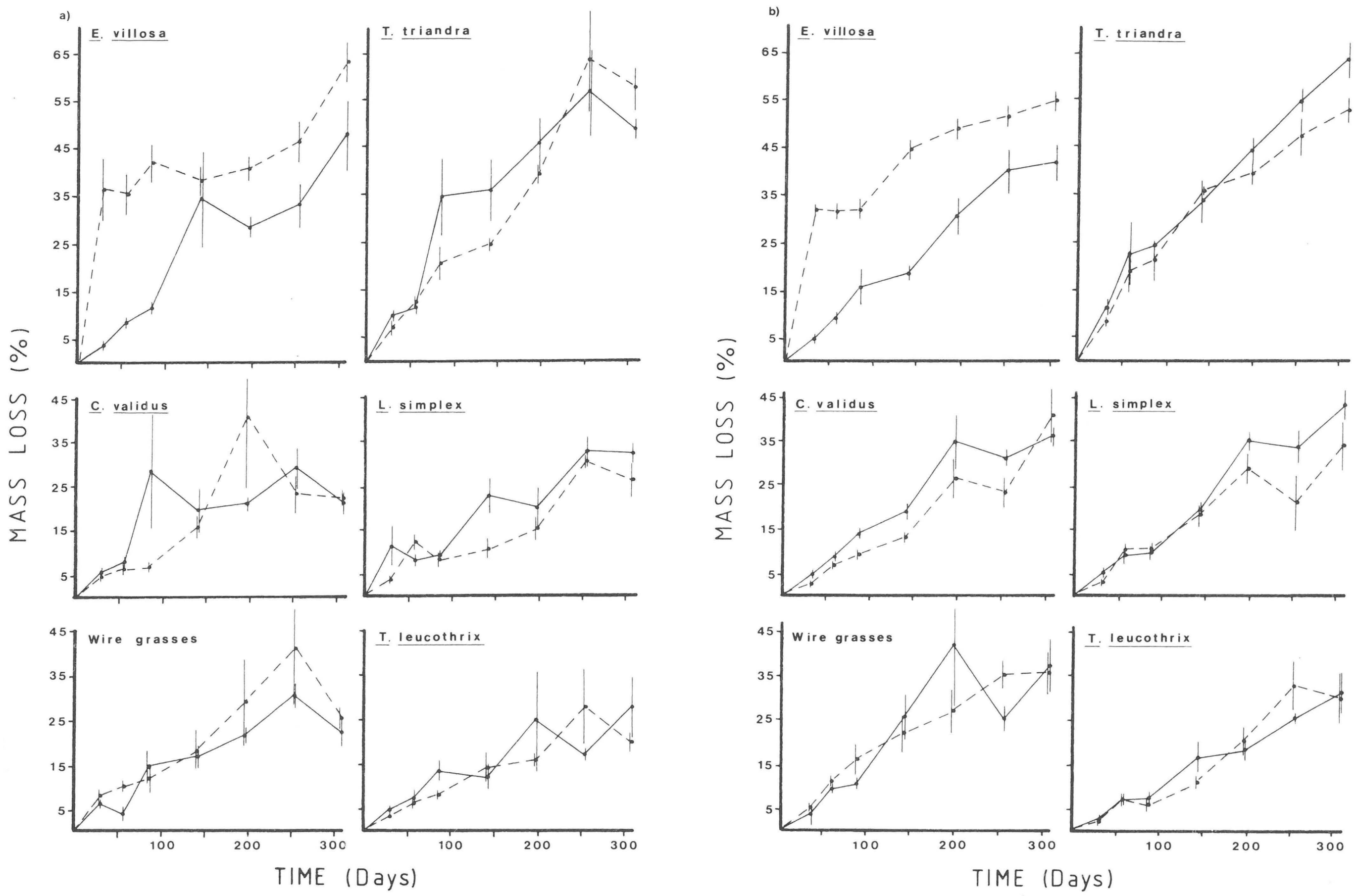

Figure 1 Mass loss from six graminoid species: (a) at the *T. leucothrix – L. simplex* site; (b) at the *C. validus – D. natalensis* site (•—• pre-dried litter, •– – –• undried litter). Bars represent standard errors.

loss was significantly less from pre-dried material on all sampling dates at both sites. However, this was primarily a function of the more rapid mass loss recorded during the first sampling interval. Thereafter the rate of loss was similar. Generally, mass loss from dried material was also less than from undried in wire grasses, although not consistent at all sampping dates, nor was this difference ever statistically significant (Table 2). In contrast, loss appeared to be slower from undried material of all the other species, most noticeably for *C. validus* and *T. triandra* at the *C. validus – D. natalensis* site and *C. validus* and *L. simplex* at the *T. leucothrix – L. simplex* site. However, the differences were usually not significant (Table 2).

Moreover, the pattern of increased rate of loss initially, changing to a decreased rate of loss with time reported in similar comparisons from aquatic systems was not evident in this study. The closest to this pattern was exhibited by *T. triandra* at the *T. leucothrix – L. simplex* site. However, it is noteworthy that in several instances the magnitude of the difference in mass loss between the two treatments increased with time, i.e. the curves in Figure 1 are diverging. This is especially so for *T. tiandra*, *L. simplex* and *C. validus* at the *C. validus – D. natalensis* site. This implies that had the study continued over a longer period, consistent significant differences may have been detected as breakdown progressed. This certainly warrants repetition of the experiment over a longer period.

Despite these loose trends, summarization of significant differences (Table 2) indicates that pre-drying generally had little consistent effect on the rate of mass loss, except with *E. villosa*, where it greatly retarded the rate of mass loss in both communities. Results for *C. validus* at the *C. validus – D. natalensis* site were inconsistent and probably require a

Table 2 Differences in mass of pre-dried and undried litter at successive sampling dates

		Time (days)						
Site	Species	29	57	85	141	197	254	300
T. leucothrix – L. simplex	*C. validus*	**	–	***	**	–	*	–
	E. villosa	*****	*****	****	****	****	****	**
	L. simplex	–	–	–	–	–	–	–
	T. triandra	–	–	–	–	–	–	*
	T. leucothrix	–	–	–	–	–	–	–
	Wire grasses	–	–	–	–	–	*	–
C. validus – D. natalensis	*C. validus*	–	–	–	–	–	–	–
	E. villosa	****	*****	*****	–	****	**	*
	L. simplex	–	*	–	**	–	–	–
	T. triandra	–	–	–	***	–	*	*
	T. leucothrix	–	–	*	–	–	–	–
	Wire grasses	–	***	–	–	–	–	–

– : not significant; * : $p < 0.05$; ** : $p < 0.025$; *** : $p < 0.01$; **** : $p < 0.005$; ***** : $p < 0.0005$.

Note: All marked significant differences indicate that pre-drying accelerated the rate of breakdown except in the case of *Eulalia villosa* where pre-dried bags lost mass at a significantly slower rate.

larger sample size to elucidate any meaningful trend. However, the irregular significant differences displayed between the two treatments for most of the species at one sampling date or another suggest that the effects of pre-drying need further investigation. Alternatively, these differences may be due to changes in micro-environmental conditions, with concomitant changes in micro-organism populations. Hence, further investigations into the effects of pre-drying should be attempted under controlled conditions.

As *E. villosa* was the only species that demonstrated a consistently significant treatment effect, it is difficult to predict which of the three mechanisms proposed by Roger and Breen (1982) may be responsible. The most likely appears to be that pre-drying removed the decomposer organisms already present on the necromass at the time of collection. However, for this to have been the case, *E. villosa* had to have been characterized by decomposer organisms absent on the other species. Presently we have no proof of this. Had the other two possible effects of pre-drying suggested earlier [(i) fracturing and leaching of intracellular components, and (ii) alteration of attractiveness of the substrate for colonization] been manifest, it would be likely that they would have occurred in all the species. This is further supported by the very rapid loss of mass from undried material of *E. villosa* (>30% in the first month). Conclusive validation of this would require investigation of the phylloplane organisms of the different species.

Conclusion

Pre-drying of material to attain uniform starting conditions for breakdown studies in terrestrial environments may affect subsequent rate of mass loss from litter bags. In this study it was demonstrated that it markedly reduced the rate of mass loss of one of the six species studied, especially in the early stages. Trends suggest that the reverse may apply in other species as breakdown progressed. Consequently, pre-drying may affect mass loss in any one species and not another, and the effects may be opposite in two different species. To accommodate the possibility of such an effect it is recommended that pre-drying is not employed in future studies.

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