DECOMPOSITION OF LEAF LITTER IN TROPICAL AND SUBTROPICAL FORESTS OF SOUTHERN CHINA

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LIU, Q., PENG, S. L., BI, H., ZHANG, H. Y., LI, Z. A., MA, W. H. & LI, N. Y. 2005. Decomposition of leaf litter in tropical and subtropical forests of southern China. In order to examine the effects of global warming on the decomposition of forest leaf litter in Southern China, a reciprocal experiment was designed to decompose forest leaf litter in two sites across climatic zones. One site was located on Mt Jianfengling in the tropical zone and the other, on Mt Dinghushan in the subtropical zone. Both sites were located in NSTEC (North-South Transect in Eastern China), in which the temperature gradient along the transect was the major driver. The two sites had similar altitudes, soil types, annual mean rainfall and dry and wet seasons. The difference of annual mean temperature between sites was 3.7 °C. Leaf litters of 10 native dominant tree species were collected from the two sites and divided into single-species litter and mixed litter, and they were incubated on the forest floor of the two sites reciprocally. The results indicated that litter decomposed in the tropical site 1.36–3.06 times more rapidly than in the subtropical site. Apparent Q_{10}, calculated on the basis of the difference of temperature between sites, ranged from 3.7 to 7.5. The conclusion was that global warming would increase the rate of matter circulation in the subtropical forest ecosystem in China. Mixed litter decomposed more rapidly than single-species litter in subtropical site. Not all dominant species litter could represent mixed litter in

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decomposition. The variability of decomposition rates among the litter types was less in the tropical site than in the subtropical site. Therefore, the effect of litter quality on litter decomposition was less significant in the warmer conditions of the tropics.

Key words: Global warming – litter decomposition – multi-species leaf litter – subtropical monsoon evergreen broad-leaved forest – tropical evergreen forest

LIU, Q., PENG, S. L., BI, H., ZHANG, H. Y., LI, Z. A., MA, W. H. & LI, N. Y. 2005. Penguraian sarap daun di hutan tropika dan subtropika di selatan China. Satu eksperimen dijalankan untuk mengkaji kesan pemanasan global terhadap penguraian sarap daun hutan. Eskperimen ini direka bentuk untuk menguraikan sarap daun hutan di dua tapak merentasi zon iklim. Satu tapak terletak di Gunung Jianfengling di zon tropika sementara yang satu lagi di Gunung Dinghushan di zon subtropika. Kedua-dua tapak terletak di Transek Barat Laut di Timur China (NSTEC). Kecerunan suhu sepanjang transek merupakan pengaruh utama di kawasan ini. Kedua-dua tapak mempunyai altitud, jenis tanih, min taburan hujan tahunan serta iklim kering dan lembap yang serupa. Perbezaan min suhu tahunan antara kedua-dua tapak adalah 3.7 °C. Sarap daun 10 spesies pokok asal yang dominan dikumpul daripada kedua-dua tapak dan dibahagikan kepada sarap spesies tunggal dan sarap campuran. Sarap ini kemudiannya dieram di atas lantai hutan di kedua-dua tapak secara salingan. Keputusan menunjukkan bahawa penguraian sarap di tapak tropika adalah 1.36–3.06 kali lebih cepat berbanding tapak subtropika. Nilai Q_{10} ketara yang dikira berasaskan perbezaan suhu antara tapak berjulat antara 3.7 hingga 7.5. Kesimpulannya ialah pemanasan akan meningkatkan kadar kitaran jirim di ekosistem hutan subtropika China. Sarap campuran terurai lebih cepat berbanding sarap spesies tunggal di tapak subtropika. Bukan semua sarap spesies dominan dapat mewakili sarap campuran dari segi penguraian. Perbezaan kadar penguraian di kalangan jenis sarap adalah kurang di tapak tropika berbanding tapak subtropika. Oleh itu, kesan kualiti sarap terhadap penguraian sarap kurang signifikan di kawasan tropika yang lebih panas.

Introduction

Decomposition of forest litter is a key process in the nutrient cycle of the forest ecosystems. Changes in decomposition rate will influence the rate of matter circulation of forest ecosystem (Peng & Liu 2002). Study on the impacts of global warming on litter decomposition is an important pathway to understand the impacts on terrestrial ecosystem (Chapin 1991, Vitousek *et al.* 1994, Peng & Liu 2002).

Litter decomposition rate is controlled by intrinsic factors, such as chemical and physical properties of litter, and by extrinsic factors, i.e. environmental conditions including biotic factors such as species, abundance and activity of heterotrophic microorganisms and soil fauna, and abiotic factors such as climate, soil and atmospheric compositions (Peng & Liu 2002). With respect to the relationship of climatic condition and decomposition of litter, climatic factors including temperature and rainfall were the strongest determinant factors on the mass loss of litter (Dyer *et al.* 1990, Vitousek *et al.* 1994).

There have been a number of studies of the effects of temperature on litter decomposition. Litter decomposition rates increased with increasing temperature (Dyer *et al.* 1990). Decomposition rate exponentially decreased with higher altitude and lowering temperature (Vitousek *et al.* 1994). Only one single species, namely, *Metrosideros polymorpha*, was considered in their study. Question remained on whether decomposition rate of leaf litter of a single species could represent total leaf litter in tropical forest with mixed species of trees. However, it was difficult to directly compare litter decomposition rates in different sites due to non-uniform conditions and methods used in the experiments. In this study, we used transplant litter from different sites across climatic zones with relatively uniform conditions except temperature. Single-species litter and mixed litter were used as experimental materials.

NSTEC (The North-South Transect in Eastern China, the 15th international standard transect) is the typical series of latitude zonation driven by heat, in which all types of zonal vegetation ecosystem are controlled by the summer south-east monsoon (Peng 2001). Thus it provides a large-scale experimental field for the study of potential response of litter decomposition to higher temperature and, potentially, to global warming. We suggest an experiment of reciprocal forest litter decomposition, i.e. subtropical forest litter decomposed on tropical forest floor and vice versa. Experimental results by this method will provide valuable information to illustrate the responses of litter decomposition to global warming. Also the method may overcome the difficulties in scale transformation when results are extrapolated from small scale to large scale or from laboratory to natural conditions.

The problem approached in this study is how the decomposition rate of the same litter changes under natural conditions of different temperatures across tropical and subtropical zones. The experiment was designed to minimize the variation of rainfall, soil types, and elevation between sites and to examine temperature effects on decomposition rates. Through the experiment of reciprocal forest litter decomposition we want to test two null hypotheses: (1) decomposition rates of subtropical litters do not increase in tropical forest with higher temperature; and (2) decomposition rates of single-species litter and mixed litter are the same.

Materials and methods

Site description

Site J (tropical site) was selected in Mt Jianfengling, which is located in south-western Hainan Island, 18° 23'–8° 50' N, 108° 36'–109° 05' E. The mountain range goes in NE–SW direction with a peak altitude of 1412.5 m. Site J is located in tropical evergreen forest with altitude of 340–360 m, a mean annual temperature of 22.9 °C, mean annual rainfall of 1749–2000 mm, and soil type of Udult. There exist apparent dry and wet seasons with 80–90% of rainfall concentrating in the wet season from May to October and the rest in the dry season from November to next March.

Site D (subtropical site) was selected in Mt Dinghushan, which is located in Zhaoqing City, Guangdong Province (23° 09'–23° 11' N, 112° 30'–112° 34' E). Site D is located in subtropical monsoon evergreen broad-leaved forest, which is the local zonal vegetation, at the altitude of 290–300 m and with a mean annual temperature of 19.2 °C, mean annual rainfall of 1878 mm and soil type of Udult. The wet season is from April to September with more than 70% rainfall, and the dry season, from November to January.

Methods

The method of transplant litter decomposition was used in the reciprocal experiment. The temperature difference of 3–4 °C between sites J and D across climate zones represented equivalent potential temperature increase in Dinghushan under global warming scenario. The experiment was designed to minimize the variation of rainfall, soil types, and elevation between sites and to examine effects of temperature on decomposition rates.

Litterbag technique was used to quantify litter decomposition rate. Leaf litter was collected from sites J and D in 2001 by picking the senescent leaves and newly deciduous leaves on the ground. The collected leaf litters were air-dried in the laboratory for seven days at room temperature. Next, for each litter type, seven replicate samples of air-dried material were oven dried at 70 °C to constant weight to determine the ratio between air-dried mass and oven-dried mass. The air-dried leaf litter was put into nylon mesh bags (bag size 15 × 15 cm and mesh size 1.0 mm). Each bag was filled with 15 g of air-dried single-species leaf litter or 20 g of air-dried mixed leaf litter (2 g for each species). With mixed species, the same amount of litter was used for each species. Seven plots were set randomly in each site. In the beginning of September 2001 the litterbags were incubated on the forest floor of each plot in both sites . The litterbags were retrieved from each plot every three months, i.e. in December in 2001, and in March, June and September 2002. Each type of litter had seven replicates for each retrieval time. The samples were oven dried at 70 °C to constant weight to determine remaining mass of litter for calculation of the decomposition constant (k) and per cent mass remaining over initial mass.

The tropical litter collected from site J was divided into the following three groups.

J1: *Vatica mangachapoi,* the most dominant species in tropical evergreen forest in Mt Jianfengling

J2: *Schima superba,* collected in tropical site, which is a common species in tropical and subtropical zones in south-east China

J3: Mixed leaf litter of 10 dominant species of tropical seasonal evergreen rain forest, including *V. mangachapoi, S. superba, Alseodaphne hainanensis, Sindora glabra, Litchi chinensis* var. *euspontanea, Lithocarpus fenzelianus, Canarium album, Madhuca hainanensis, Castanopsis carlesti* var. *hainanica* and *Gironniera subaequalis.*

The subtropical litter collected from site D was also divided into three groups.

D1: *Castanopsis chinensis,* the most dominant species in monsoon evergreen broad-leaved forest in Mt Dinghushan

D2: *Schima superba,* collected in subtropical site, which is a common dominant species in tropical and subtropical zones in south-east China

D3: Mixed leaf litter of 10 dominant species of subtropical monsoon evergreen broad-leaved forest, including *C. chinensis, S. superba, Cryptocarya chinensis, C. concinna, Aporosa yunanensis, Syzygium rehderianum, Acmena acuminatissima, Gironniera subaequalis, Ficus nervosa* and *Lindera chunii.*

Statistical methods

Decomposition constant was calculated using the first-order exponential equation (Olson 1963) to fit the decomposition process:

$\ln(M_t/M_0) = x - kt$ or the transformation form $y = Ae^{-kt}$

where

M_0 = initial mass

M_t = mass at time t

x = intercept = decomposition constant

$y = \ln(M_t/M_0)$

$\ln A = x$

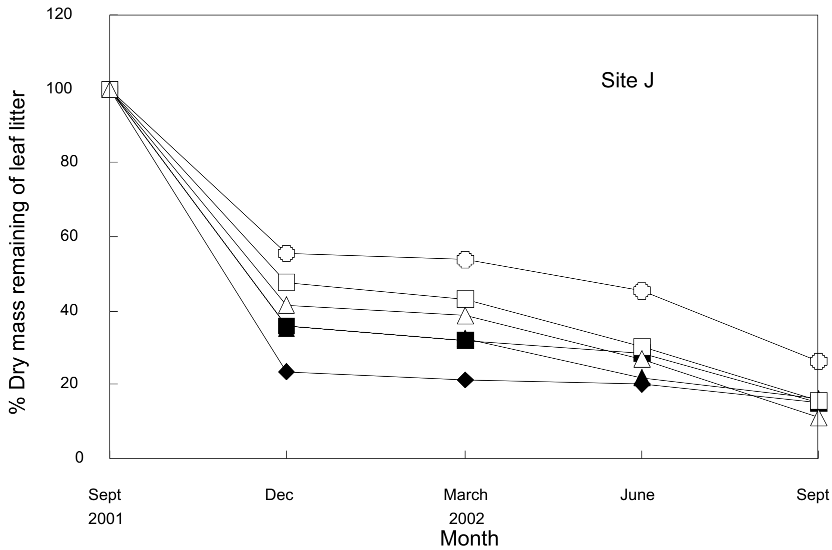
The fit of data to the equation was assessed using the coefficient of determination (R^2).

Mann-Whitney U Test, a non-parametric test, was employed to analyse the differences of the per cent mass remaining between sites because the two sites were not randomly selected: thus, not all assumptions of univariate analysis of variance (ANOVA) were met. Within each site the ANOVA, which contained the main effects of litter types (six types) and retrieval dates (four dates) and a type × date interaction was analysed using univariate and then, by Tukey (Wieder & Lang 1982). The software used was SPSS 10.0.

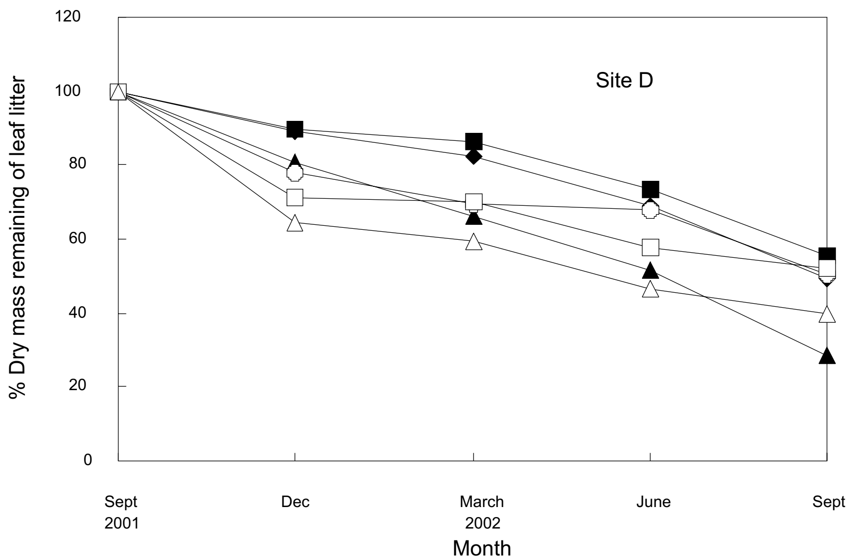
Results

Effects of site characteristics

The patterns of dry litter mass remaining are illustrated in Figure 1. The regression equations and decomposition constants (k) of the six types of leaf litter decomposed in sites J and D are shown in Table 1.



(a)



(b)

Figure 1 The per cent mass remaining of six types of litter over time in site J and site D

◆ : J1 (*Vatica mangachapoi*), ■ : J2 (*Schima superba*), ▲ : J3 (10 mixed litter collected from site J), ○ : D1 (*Castanopsis chinensis*), □ : D2 (*S. superba*), △ : D3 (10 mixed litter collected from site D)

Mean per cent mass remaining of each of the six litter types in site J was significantly different from that in site D (Table 2). Combining with the *k* values in Table 1, we inferred that decomposition rates of all six litter types in tropical site were higher than those in subtropical site. The apparent Q_{10} (the proportional increase in decomposition rate for 10 °C increase in temperature) calculated by subtropical litter types ranged from 3.7 to 7.5.

Effects of time

In our study the interactions of type × date were not significant in both site J and site D, so the main effects of litter type and retrieval date could be unambiguously interpreted (Wieder & Lang 1982). In site J the mass remaining of six types of leaf litter decreased quite rapidly in the first three months. The difference

Table 1 The regression equations and decomposition constants for six types of leaf litter collected from site J (tropical) and site D (subtropical) and decomposed reciprocally in both sites

Litter type	Decomposition rate, *k* [g/(g·a)]		Equation		R^2	
	Site D	Site J	Site D	Site J	Site D	Site J
J1	0.657	1.606	$y = 105.782e^{-0.657t}$	$y = 60.359e^{-1.606t}$	0.919	0.709
J2	0.548	1.679	$y = 105.069e^{-0.548t}$	$y = 76.249e^{-1.679t}$	0.902	0.897
J3	1.205	1.643	$y = 109.079e^{-1.205t}$	$y = 75.395e^{-1.643t}$	0.930	0.887
D1	0.548	1.168	$y = 96.437e^{-0.548t}$	$y = 91.743e^{-1.168t}$	0.929	0.908
D2	0.621	1.716	$y = 92.502e^{-0.621t}$	$y = 91.975e^{-1.716t}$	0.917	0.947
D3	0.876	1.935	$y = 91.231e^{-0.876t}$	$y = 89.637e^{-1.935t}$	0.948	0.921

J1: *V. mangachapoi*, J2: *S. superba* collected from site J, J3: Mixed litter of 10 species collected from site J
D1: *C. chinensis*, D2: *S. superba* collected from site D, D3: Mixed litter of 10 species collected from site D

Table 2 Mann-Whitney U test of the significant differences of mean per cent mass remaining of litters between site J and site D

	J1	J2	J3	D1	D2	D3
Mann-Whitney U	7.000	58.000	133.000	139.000	86.500	77.000
Wilcoxon W	413.000	464.000	539.000	545.000	492.500	483.000
Z	-6.309	-5.473	-4.244	-4.146	-5.006	-5.162
Asymptote significance (2-tailed)	.000	.000	.000	.000	.000	.000

Grouping variable: Site
J1: *V. mangachapoi*, J2: *S. superba* collected from site J, J3: Mixed litter of 10 species collected from site J
D1: *C. chinensis*, D2: *S. superba* collected from site D, D3: Mixed litter of 10 species collected from site D

of per cent mass remaining between the first retrieval date and the second retrieval date was not significant but the differences among the other retrieval dates were significant (Figure 1a, Table 3). On the other hand in site D the mass loss of leaf litter were relatively even, the differences of per cent mass remaining among retrieval dates were significant (Figure 1b, Table 4).

Effects of leaf litter types

Within each site the mean per cent mass remaining of the six types of leaf litter were compared. In tropical site J the mass remaining of subtropical dominant species D1 (*C. chinensis*) was significantly different from the rest of the litter types, and J1 (*V. mangachapoi*) and D2 (*S. superba*) were significantly different. The rest of the comparative pairs were not significantly different (Table 5).

Table 3 Multiple comparisons of mean per cent mass remaining among retrieval dates in site J

Time (month)	6	9	12
3	0.679	0.000	0.000
6		0.024	0.000
9			0.000

The mean difference is significant at the 0.05 level

Table 4 Multiple comparisons of mean per cent mass remaining among retrieval dates in site D

Time (month)	6	9	12
3	0.028	0.000	0.000
6		0.000	0.000
9			0.000

The mean difference is significant at the 0.05 level

In subtropical site D mixed litter J3 and D3 were significantly different from single-species litter (except the pair of J3 and D2), but J3 and D3 were not significantly different. Common species J2 and D2 (*S. superba*) were significantly different (Table 6).

Combining with the results of *k* value from the regression equation (Table 1), we could make inference that the subtropical litter of the most dominant species *C. chinensis* (D1) decomposed significantly slower than all other types of leaf litter in tropical site J. The decomposition rates of mixed litter J3 and D3 and those of the common species *S. superba* J2 and D2 were not significantly different.

In subtropical site D the decomposition rates of mixed litter (J3 and D3) were significantly higher than those of single-species litter (except the pair of J3 and D2). The decomposition rate of subtropical litter D2 was significantly higher than tropical litter J2, although they were both *S. superba*.

Table 5 Multiple comparisons of mean per cent mass remaining among litter types in site J

	J2	J3	D1	D2	D3
J1	0.211	0.453	0.000	0.001	0.073
J2		0.998	0.000	0.442	0.998
J3			0.000	0.203	0.949
D2				0.017	0.000
D3					0.734

The mean difference is significant at the 0.05 level
J1: *V. mangachapoi*, J2: *S. superba* collected from site J, J3: Mixed litter of 10 species collected from site J, D1: *C. chinensis*, D2: *S. superba* collected from site D, D3: Mixed litter of 10 species collected from site D

Table 6 Multiple comparisons of mean per cent mass remaining among litter types in site D

	J2	J3	D1	D2	D3
J1	0.746	0.000	0.283	0.009	0.000
J2		0.000	0.008	0.000	0.000
J3			0.008	0.272	0.694
D2				0.793	0.000
D3					0.005

The mean difference is significant at the 0.05 level
J1: *V. mangachapoi*, J2: *S. superba* collected from site J, J3: Mixed litter of 10 species collected from site J, D1: *C. chinensis*, D2: *S. superba* collected from site D, D3: Mixed litter of 10 species collected from site D

There were more significantly different comparative pairs in site D (10 pairs) than in site J (six pairs). This meant that there was more variability of decomposition rates among litter types in subtropical site than in tropical site.

Discussion

Effects of site

In this study the decomposition rates of the six litter types were significantly higher in site J than in site D, so the first null hypothesis, i.e. decomposition rates of subtropical litters do not increase in tropical forest with higher temperature, was rejected. Instead, we suggest that increase in temperature was a major controlling factor on decomposition rates. The higher the temperature, the quicker the litter decomposed. Even though there had been such reports previously (Trofymow *et al.* 2002, Liski *et al.* 2003), our study was the first in Asia tropics to achieve directly the conclusion of same litter and through reciprocal litter transplant experiment across climate zones. This provides more convincing evidence for better prediction of the response of forest litter decomposition to global warming. The rational inference is that global warming will promote litter decomposition rates in subtropical forest in China.

Comparing the decomposition rates (*k* value) we obtained with those at similar altitude in global tropics and subtropics (Anderson & Swift 1983), we showed that the *k* values in site J (1.169–1.935) were in middle level and close to those in the dipterocarp forest in Sarawak and Mulu (1.7), but much higher than those in Hawaii. This is probably because the forest in site J was similar to these dipterocarp forests in that it had the species *V. mangachapoi* of Dipterocarpaceae family, a characteristic family of tropical rain forest in east Asia. While in site D the *k* values (0.548–1.205) were close to that in the montane rain forest in Puerto Rico (0.9) and Jamaica (0.5–0.7).

Previous studies have shown that decomposition rates in NSTEC decreased with increasing latitude. For instance, the *k* values were 0.209–0.351 in the warm temperate zone of North China (Wang & Huang 2001), 1.16–3.54 in Xiqing, Fujian Province in middle subtropical zone (Lin *et al.* 2001), 0.288–1.398 in Dinghushan (Zhang *et al.* 2000), 0.422–1.108 in Heshan (Zhou *et al.* 1995) and 0.422–1.578 in Jianfengling (Jiang & Lu 1991). In this study the *k* values in site J were higher than those in site D, which were close to those in Heshan and the previous study in Dinghushan.

Schima superba was distributed in tropical, southern subtropical and middle subtropical zones in China and the *k* values of its local litter decomposition are listed in Table 7. Correlation between *k* values and temperature showed that the log-linear relationship was not significant ($R^2 = 0.661$, $p = > 0.05$). The inability to construct a log-linear correlation model between *k* values and temperature might be caused by the data being derived from different experimental methods. However, the trend that *k* values increased with higher temperature was obvious. In this study the decomposition rate (*k* values) of subtropical litter of *S. superba* (D2) increased from 0.621 in subtropical site to 1.716 in tropical site, while that of tropical litter J2 decreased from 1.679 in tropical site to 0.548 in subtropical. The decomposition rates in the tropical site were not significantly different, but in the subtropical site D subtropical litter D2 was higher than tropical litter J2.

The *k* value (0.621) of leaf litter of *S. superba* of this study (D2) was lower than the 0.883 reported by Zhang *et al.* (2000). This might be due to the difference in altitude of study sites, which brought about the differences in temperature.

Temperature effects on decomposition rate could be reflected by apparent Q_{10}. In this study the Q_{10} was in the range of 3.7–7.5. This range is close to 4.0–6.2 for leaf litter in Hawaii (Vitousek *et al.* 1994).

Effects of time and climatic seasonality

Rainfall can influence the physical process of chemical component leaching from litter; the more the rainfall the faster the litter decomposition (Austin & Vitousek 2000). Moisture affects mass loss and nutrient release (Orchard & Cook 1983). In tropical ecosystems rainfall has positive effects on litter decomposition (Latter *et al.* 1998). Thus, seasonality of rainfall can also affect the decomposition process.

In this study the difference of mass loss patterns in site J and site D reflected the effects of variation in actual evapotranspiration. The drastic descent of litter mass remaining in the first three months (September to November) in tropical site J (Figure 1a) seemed to be related to seasonality of climate. September and October were still in the wet season but the litter decomposed rapidly. The second period of three months from December to February was in dry and winter seasons, and the litter decomposed slowly.

However in subtropical site D the mass remaining decreased relatively evenly and the litter mass remaining were significantly different among the successive periods. Probably the reason was that lower temperature in the first three months

Table 7 The decomposition constants (*k*) of *S. superba* leaf litter decomposed *in situ* under different temperature (T) conditions

Location	T(°C)	*k*	Literature
Mt Jiangfengling	22.9	1.679	In this study
Mt Heshan	21.7	0.860	Zhou *et al.* 1995
Mt Dinghushan	21.6	0.8834	Zhang *et al.* 2000
Mt Dinghushan	19.2	0.6205	In this study
Fujian	19.4	0.91	Lin *et al.* 2001

in Dinghushan was unfavourable for rapid decomposition. Hence there was no drastic decrease in mass loss (Figure 1b). This implied that temperature was more important when moisture and temperature together exerted influence on litter decomposition in this study.

Effects of species on litter decomposition

In subtropical site D the decomposition rates of tropical mixed litter J3 and subtropical mixed litter D3 were significantly higher than those of single-species litter (except the pair of J3 and D2). In site J the decomposition species D1 (*C. chinensis*) were significantly lower than those of all other litter types. Also the tropical mixed litter J3 and subtropical mixed litter D3 did not decompose faster than other single-species litters. So the second null hypothesis was rejected in site D, but not in site J.

In site D the dominant single-species litter could not represent mixed litter, while in site J dominant single-species litter J1 (*V. mangachapoi*) and J2 (*S. superba*) could represent the tropical mixed litter J3. D2 (*S. superba*) could represent the subtropical mixed litter D2, but D1 (*C. chinensis*) could not. Therefore, whether or not the decomposition rate of a single species could represent total leaf litter in tropical forest cannot be ascertained.

Chapman *et al.* (1988) found that there were larger quantities of soil fauna in mixed forest of spruce and pine than in the single-species forests of each of these species. Blair *et al.* (1990) suggested that mixed litter increased the heterogeneity of resources and changed the abundance of decomposers. It might be the more abundant decomposers that caused mixed litters to have higher decomposition rates than single-species litter in the subtropical site of our study.

In site D, D2 decomposed faster than J2, though they were the same species, i.e. *S. superba.* According to our unpublished chemical analysis data the quality indices (C, N, P, lignin and holocellulose) of J2 and D5 were similar. So the difference could possibly be attributed to 'home field advantages' (Gholz *et al.* 2000), such as local soil microorganism community and soil fauna.

As shown in Tables 5 and 6, there were more comparative pairs with significant differences in site D (10 pairs) than in site J (six pairs). This might suggest that the higher the temperature the lesser the variability in decomposition rates of the various litter types, and in turn, the lesser the effect of litter quality on the difference of litter decomposition. Thus, the effect of litter quality on litter decomposition was less significant in higher temperature conditions than in lower temperature.

With respect to the variation ranges of decomposition rates, there were differences of 1.36–3.06 times in decomposition rates (k values) between sites (most were above 2.0 times), while the differences were 1.02–2.20 times between litter types. It is suggested that temperature affected decomposition rates more strongly than litter types and temperature played a predominant role in the variability of decomposition rates in this study.

Conclusions

Global warming will surely increase decomposition rates of forest leaf litter in the subtropics of China. Mixed-species litter decomposed more rapidly than single-species litter in subtropical site. Not all dominant single-species litters could represent multi-species mixed litter with regard to decomposition rate. The effect of species on decomposition rate decreased with increasing temperature. The effects of temperature on decomposition rates were greater than those of species. Temperature plays a predominant role in litter decomposition.

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