Dominant Functional Group Effects on the Invasion Resistance at Different Resource Levels

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Abstract

Background: Functional group composition may affect invasion in two ways the effect of abundance, i.e. dominance of functional group; and the effect of traits, i.e. identity of functional groups. However, few studies have focused on the role of

. C , [29 31]. C - I , [32]. I C , . P : , , . T [33]. M , C [34]. H ( ). W , ( ) W 20 : (, ,). W , W .

Materials and Methods

Ethics Statement

N 6 1.176 8.966 . T T U . T T U . C 6 1 . T I T U . C .

Experiment Design

W T U (28°3512N, 120°4791E) J 2008 M 2011.T 1800 , . T 19.5°C. P $^{-2}$ $^{-1}$. W 2200 μ , I C . T (AG): *Perilla frutescens* I ., B *Mazus pumilus* (B . .) V S ; (PG): *Inula japonica* T *Plantago asiatica* I ; (D): *Grewia biloba* G. D . *parviflora* (B) H.-M. *Koelreuteria integrifoliola* M ; (E): *Cinnamomum camphora* (L.) P *Urena procumbens* I . T M 2008, (, 80 ×80 ×60) J 2008, . F , (T 1). E 32 . T I P 32 . S . A 48 : 24 (×) 24 (. .). T (^{1}: 1.64±0.17, P 0.12±0.02 N 0.73±0.16) . T (: = 5:1; , ^{1}: 0.68±0.12, P 0.07±0.03 N 0.34±0.11). T N I T 6 ^{2} ^{1} N 2 ^{2} J 2009, O 2009, M 2010, J 2010, O 2010 M 2011. E *Cinnamomum camphora* (L.), . T , . T , . I , T (T 2) I ; , . T I 2008. H , . T J 2009. A 600 , 30 , 200 , . A , , H , , (T S1 F S1). H , (10.4 6.2% (PAR, 9:00 15:00) 601.8 8.9% 2011), . I M 2010 2011, . T , 100- (1 ^{2} 10×10) . A PAR (GLZ-C, Z T I C ., L) . T , ,

Table 1. The number of transplanted seedlings in different dominant functional group treatments.

	Dominant functional group treatment			
Resident species	**AG**	**PG**	**D**	**E**
AG				
Perilla frutescens (Linn.)	10	2	2	2
Britt and *Mazus pumilus* (Burm.f.) Van Steenis	10	2	2	2
PG				
Inula japonica Thunb	2	10	2	2
Plantago asiatica Linn	2	10	2	2
D				
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] S1). T PAR PAR
A 2009 M 2011 (F S1 . T

= 100× PAR / PAR . T Á 2009 M 2010 2010, J 2010 M 2011 2011.

Statistical Analyses

W [8,35,36] . I , *IV*) . E , :

$$x_{kj} = \frac{\sum_{i=1}^{n_k} a_{ijk}}{n_k}$$

a_{ijk} = j i k, n_k = k.

T RA_{kj} j k :

$$RA_{kj} = \frac{x_{kj}}{\sum_{k=1}^{g} x_{kj}}$$

g = .

T RF_{kj} j k :

$$RF_{kj} = \frac{\sum_{i=1}^{n_k} b_{ijk}}{n_k}$$

b_{ijk} = (1) (0) j i k.

T *IV* :

$$IV_{kj} = RA_{kj} \times RF_{kj} \times 100$$

IV 0 ( ) 100 ( ). A (100) , . D . T *IV* *IV* M C , , / 1000 . T *IV* ( ). T PC-ORD 4.25 [37]. T *IV*

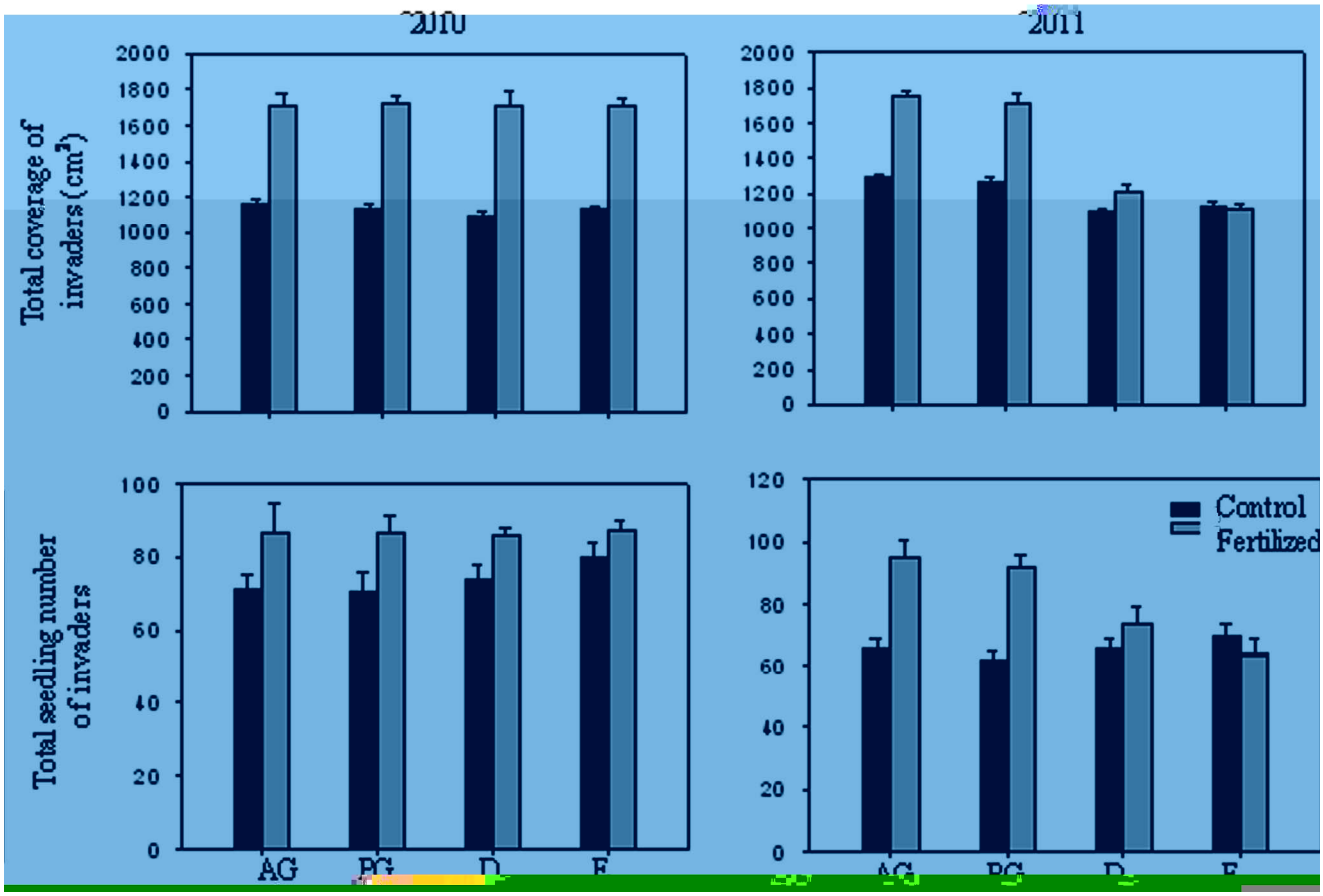

Figure 1. Effects of dominant functional group and fertilization on the coverage and seedling number of total invaders in 2010 and 2011. Dominant functional group treatments: AG – annual grass dominated pots. PG – perennial grass dominated pots, D – deciduous shrub or arbor dominated pots and E – evergreen shrub or arbor dominated pots.
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= 78, P = 0.001; $_{2011}$ = 4.234, = 78, P<0.001; : $_{2010}$ = 4.918, = 78, P<0.001; $_{2011}$ = 4.259, = 78, P<0.001). S , AG PG 2011, T - ANOVA , (T S2 S3 E S1). H , REI (E 4, : $_{2010}$ = 4.729, = 478, P<0.001; $_{2011}$ = 3.190, = 478, P = 0.002; : $_{2010}$ = 6.601, = 478, P<0.001; $_{2011}$ = 5.288, = 478, P<0.001). ANCOVA REI (T S4 E S1), REI (T S5 E S1).

Table 3. Results from two-way ANOVA of effects of dominant functional group (D) and fertilization (F) treatments on the coverage and seedling number of invaders in pots in 2010 and 2011.

	Coverage			Number of seedlings		
	MS	F	P	MS	F	P
2010						
D	2222.19	0.90	0.45	59.47	2.74	0.06
F	4104535.79	1653.61	<0.001	1875.00	86.34	<0.001
D×F	2121.62	0.85	0.47	47.06	2.17	0.11
Error	2482.17			21.72		
2011						
D	545145.42	492.48	<0.001	481.19	25.96	<0.001
F	745751.04	673.71	<0.001	2806.02	151.37	<0.001
D×F	174719.39	157.84	<0.001	944.80	50.97	<0.001
Error	1106.94			18.54		

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Discussion

T . H ,

Figure 2. The coverage and seedling number of different functional groups of invaders in the pots dominated by different dominant functional groups in 2010 and 2011. Dominant functional group treatments: AG – annual grass dominated pots, PG – perennial grass dominated pots, D – deciduous shrub or arbor dominated pots and E – evergreen shrub or arbor dominated pots. $AG_{invasive\ species}$ – the invader belong to annual grass. $PG_{invasive\ species}$ – the invader belong to perennial grass. $D_{invasive\ species}$ – the invader belong to deciduous shrub or arbor. $E_{invasive\ species}$ – the invader belong to evergreen shrub or arbor. The legends are as given in Figure 1. Arrows (↓) indicate that the coverage and seedling number of invaders had lower values in the pots dominated by same functional group than those dominated by other functional group.
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Figure 3. The indicator value (IV) of invaders for coverage (A) and seedling number (B) in the pots dominated by same functional group and the pots dominated by other functional group in 2010 and 2011. Higher indicator values represent higher colonization success. *indicate significant difference between the pots dominated by same functional group and the pots dominated by other functional group.
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Table 4. Results from the indicator species analysis for the control and fertilized pots of 2010 and 2011.

	Coverage				Number of seedling			
	2010		2011		2010		2011	
	Control	Fertilized	Control	Fertilized	Control	Fertilized	Control	Fertilized
CA	D(34.5**) ↓	ns	D(30.3*) ↓	PG(29.9**)	ns ↓	ns	E(36.1*) ↓	PG(29.3*)
CT	E(31.8*) ↓	ns	ns ↓	AG(27.6*)	ns ↓	ns	ns ↓	ns
CG	PG(27.2*)	ns	PG(26.9*)	AG(27.1*)	PG(31.4*)	ns	ns	ns
BB	E(90.3**) ↓	ns	D(34.4**)	PG(28.1**)	D(37.9**) ↓	ns	ns	ns
TA	AG(28.4**)	ns	AG(28.7**)	AG(30.8**)	ns	ns	ns	ns
TAM	PG(50.5**)	ns	PG(47.6**)	ns	PG(54.1**)	ns	PG(54.8**)	ns
OC	AG(27.7*) ↓	ns	PG(27.6*)	ns	ns ↓	ns	ns	ns
RJ	AG(31.5*) ↓	ns	ns ↓	ns	ns ↓	ns	ns ↓	ns
PP	E(31**) ↓	ns	AG(30.6*) ↓	ns	ns ↓	ns	ns ↓	ns
GT	D(34.2*)	E(26.4**)	D(33.7**) ↓	AG(32**)	D(35.9*)	ns	D(36.8*) ↓	AG(31.5**)
RC	E(32.6*) ↓	ns	AG(33.8**) ↓	AG(32.2**)	AG(34.6*) ↓	ns	ns ↓	ns
VN	D(26.8*)	ns	PG(27*)	PG(33.8*)	ns	ns	ns	AG(32.8*)
LC	E(29.6*) ↓	AG(26.4**)	PG(31.4**) ↓	AG(38.1**)	ns ↓	ns	ns ↓	ns
HM	D(27.6**)	ns	ns	AG(47.9**)	ns	ns	ns	AG(42.9**)
EJ	AG(37.7**) ↓	ns	AG(36.3**) ↓	AG(40.3**)	ns ↓	ns	ns ↓	AG(39.6*)
PT	ns ↓	ns	D(29.1*) ↓	AG(28.2**) ↓	ns ↓	ns	D(31.6*) ↓	ns
SB	D(28.8*) ↓	ns	AG(30.3**) ↓	ns	ns ↓	ns	ns ↓	ns
PS	ns ↓	ns	ns ↓	AG(28.1*) ↓	D(31.3*) ↓	ns	ns ↓	ns
EO	ns	ns	ns	ns	ns	ns	ns	ns
ND	ns	AG(32.9**)	ns	AG(50.2**)	ns	ns	ns	ns

Significant relationships between the coverage and seedling number of each invader and certain dominant functional group treatment are shown for having the highest coverage and seedling number in the treatment. Numbers in parentheses are the indicator values (*IV*). Significance values are calculated based on 1000 randomizations in a Monte Carlo simulation, with *P<0.05, **P<0.01 and ns not significant (P>0.05). Species abbreviations are as given in Table 2. Arrows (↓) indicate that the coverage and seedling number of invaders had lower values in the pots dominated by the same than by another functional group, which indicates limiting similarity.

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2010. I 2011, D E ($F_{3,\ 20} = 137.64$, P<0.001,), AG PG. P [38

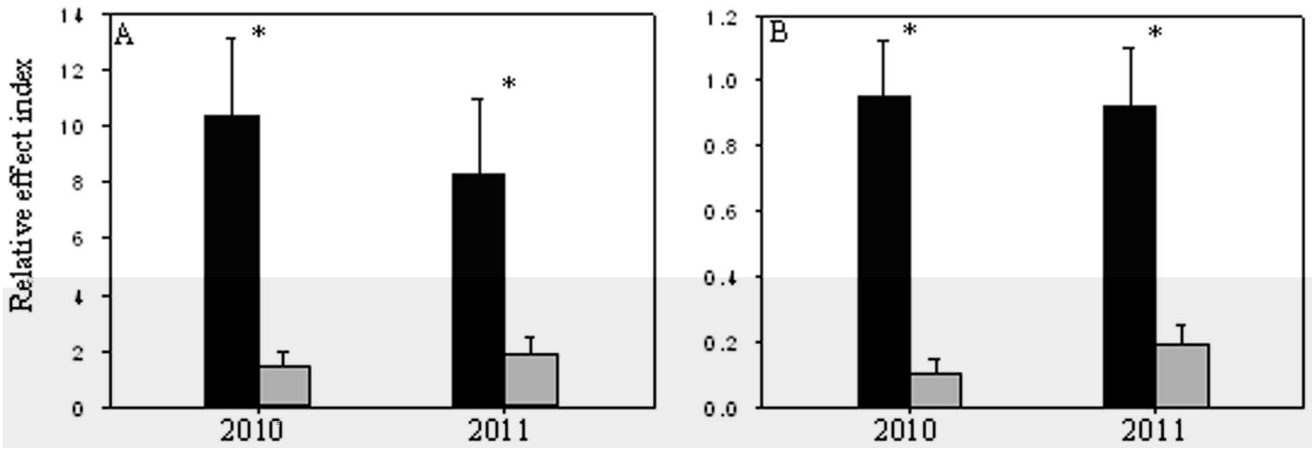

Figure 4. The relative effect index (REI) IV of invaders for coverage (A) and seedling number (B) in the pots dominated by same functional group and the pots dominated by other functional group in 2010 and 2011. Higher values of REI indicate more positive effect of fertilization on the colonization of invaders. *indicate significant difference between the pots dominated by same functional group and the pots dominated by other functional group. The legends are as given in Figure 3.

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40]. C . W 2010 . C , . H : ; , . T [8,41], [14] - , [42]. A , . I [8,27,38]. O . A , . T REI , . I . H , . W , [29] . B , . H , . T 2010 2011, . C . I . H , , . M . C ( ) [1,11,14], .

S - [27]; , D , (. .) [27]. T , - . A [43 45]. U - ‘ ’, .

Supporting Information

File S1 Contains: Table S1 T . **Table S2** R - ANOVA . S (*P*<0.05) . A (↑) (↓) . T 2010 2011 **Table S3** R - ANOVA . S (*P*<0.05) . A (↑) (↓) . T 2010 2011 **Table S4** R ANCOVA (REI) . S (*P*<0.05) . T 2010 2011 **Table S5** R ANCOVA (REI) . S (*P*<0.05) . T 2010 2011 **Figure S1** T . D : A) . B) , C) D) . T . I 20 (2009-A 2010-M 2010-A 2011-M). (DOC)

Acknowledgments

W M N , E ., E .

Author Contributions

C : JW YG. P : CBZ YB ZKD. A : JW. W : JW YG.

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