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(*Torreya jackii*)

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(1. 317000 2. 20 0030)

Li-6400 XT (*Torreya ackii*)

(P_n)

P_n (P_{nmax}) (LSP)

(AQY) (V_{cmax}) (J_{max}) (TPU)

(LCP) (R_d) P_n P_n

P_n P_{nmax} LSP V_{cmax} J_{ma} TPU

LSP

LCP P_n

Photosynthetic traits of the endangered plant species *Torreya jackii*

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Abstract: A portable Li-6400 XT photosynthesis measuring system (LI-COR Biosciences, Lincoln, NE, USA) was used to explore how *Torreya jackii,* an endangered species endemic to China, adapts to the environment and to illustrate and determine various photosynthetic characteristics of *T. jackii* in three natural habitats with different light conditions, specifically gap, edge and understory habitats. Also, the physiological mechanisms that have resulted in the endangered status of this species were explored to provide baseline reference data in support of

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(Y505331)

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off-site conservation and population rejuvenation of *T. jackii*. The results for *T. jackii* growing in forest gap and edge habitats show that when the diurnal variation in the photosynthetic rates in the summer is graphed, typical

[6] [7]

(*Sinocalycanthus chinensis*)

[8] (*Heptacodium miconioides*)[9] (*Shaniodendron subaequale*)[10] (*Camellia nitidissima*)[11]

(*Tetraena mongolica*)

(*Zygophyllum xanthoxylon*)

[12] (*Litsea dilleniifolia*)

[13]

1

1.1

$2196.3 hm^2$ 54.2

[1,2]

29°45′N 119°50′E 410 m

ᾇ (*Cyclobalanopsis glauca*) ä ʌ (*Machilus leptophylla*) ä (*Rhus chinensis*) ä

(*Quercus fabri*) Â (Gap) 400m² è ˘ ɿ ὤ ʺI ˘ ʺI ä

˘ æ Â Ю(Understory) й 70%˘ ʺI ɲ æ˘ Â

(Edge) Æ ɏ ˘ ᛏ ˘ ʺI ä ä Ў ɏ ɲ Ю ǯ Â

1.2

1.2.1 ʺI ʛ

ɏ 2011 10 ˆ ˜ ä 2012 1 ˆ ʺΏ ˜ ä 4 ˆ ˜ ä 7 ˆ ˜ Э ˘

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è б ʌ ä ᵥ У ʊ ᾇ ä ʌ ä

ä ɹ 3 ˘ Li-6400 XT ɟ ʺI ɔ ɢ (LI-COR˘ USA) Ő ä

ʌ ʺI ʛ ˘ ʺI ˘ ÿ 6:00-18:00(ʺΏ ϴ 8:00—16:00) 2 h

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ɲ ᾇ a ɬ˘ ˘ Љ è CO_2 й ˘ ʛ ˆ ʿ O_2

(C_i, mol·mol^{-1}) ä (G_s, mmol·m^{-2}·s^{-1}) Â

1.2.2 ʺI ط

Li-6400 XT ɟ ʺI ɔ ɢ˘ ɢ ʺI ˘ 9:00-11:00 ʺI

ᛏ æ й 2000 ä1500 ä1200 ä1000 ä800 ä600 ä400 ä200 ä150 ä100 ä50 ä20 ɲ 0 mol·m^{-2}·s^{-1}

ʌ ɥ è ʊ ʺI Â ɱ 2000 mol·m^{-2}·s^{-1} ʺI ʌ 20 min

Â ʺI ط ᵥ ʌ й 25 Ņ˘ ⁸ 500 mol·m^{-2}·s^{-1} й 60% Â

1.2.3 CO_2 ط

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ط ˘ ˘ CO_2 й CO_2 ˘ ɢ ╟ ᵹ ˘ CO_2 ÿ 1500 ä

1200 ä 1000 ä 800 ä 600 ä 400 ä 200 ä 150 ä 120 ä 100 ä 80 ä 50 mol·mol^{-1} э CO_2

й 300s Â

1.2.4 ʌ ʊ̈

ʛ б ʺI ˘ Æ ʌ ˘ ώ ᾇ ʺΏ ɖ ˘ ˘ ʌ

⅔ 2 mm ɫ˘ ʛ 1.00 g˘ ώ è˘ ╗ $CaCO_3$ ɲ 25 mL ˘ ! ˘

ʛ 2.5 mL ! ˘ ώ έ ˘ ╗ 10 mL м ˘ ʛ 30 min˘ ˘ ʛ 3 mL˘

ʌ ᛏ ʺI ʺI ˆ T6 й ˘ ˥ l ˘ OD_{663} ä OD_{645} Â Ю

$C_a=12.7\ OD_{663} - 2.69\ OD_{645}$ $C_b=22.9\ OD_{645} - 4.68\ OD_{663}$

1.3

Excel ṉ Origin7.5 ̇ ᛏ ṉ ˘ Photosyn Assistant 1.1.2 ̇ ᛚ ̓ ˝Ι ́ (P_{nmax}) ằ ˝Ι ṉ (LSP) ằ ˝Ι Š (LCP) ằ (AQY) ṉ O₅ (R_d) Â ́ й [14]:

$$P_n = \frac{\varphi.PAR + P_{nmax} - \sqrt{(\varphi.PAR + P_{nmax})^2 - 4.\varphi.PAR.K.P_{nmax}}}{2K} - R_d$$

è ̔ P_n й ̓ ˝Ι ́ ̔ P_{nmax} й ̓ ˝Ι ́ ̔ PAR й ˝Ι ́ ̔ φ й ̔ R_d й O₅ ̔ K й ˝Ι ́ ˘ Ȳ ɏ (0,1) ǯ Â Photosyn Assistant 1.1.2 ̇ ́ CO_2 ط ˘ ᛚ ◘ V_{cmax} ằ · J_{max} ằ м ‾ TPU ̆ ⊣ Long ṉ Bernacchi (2003)[15] Â

SPSS ̇ ᛏ ˘ ` ᛏ (one-way ANOVA) ṉ (LSD) a ̌ (=0.05) ̆ ḣ ¤ ῆ Â

2 б ᛏ

2.1 a ̌ ⊣ ◘

4 э ˘ ằ ằ Ю 3 è ˝Ι ́ (PAR) ⊣ ◘ У ˘ Э ˝Ι ́ æ ˘ ǯ ɨ ` ˘ PAR ḣ й 1860 mol·m-2·s-1 4 э è PAR Љ è ˘ ἐ ˘ Ю æ Â4 э è ⊣ ◘ б PAR ⊣ ◘ У ˘ è ´ 12:00 ᛚ ɕ ḣ ˘ 38 Ņ ˘ 4 э è Љ ˘ ǯ ˘ Ю æ Â ⊣ ◘ б PAR ⊣ ◘ ⊣ ˘ 12:00 ᛚ æ ˘ 4 э è Ю ɏ ṉ ˘ Ю ˘ ᛚ ɕ 73% Â

2.2 a ̌ ⊣ ˝Ι ́ ɔ

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3 è ˘ ằ ằ ˝Ω̧ ⊣ (G_s) ⊣ ◘ б P_n ⊣ ◘ У ˘ й ľ ` Ŀ ˘ ḣ 12:00 Â ˘ ằ ⊣ G_s ˝Ι ˘

ꜛ 10:00 ꜛ ḣ˘ Љ ɫ Ю ˘ ꜛ 14:00 ꜛ æ ḣ ɫ Э ` ’ Ю $G_s$ й ľ ` Ŀ

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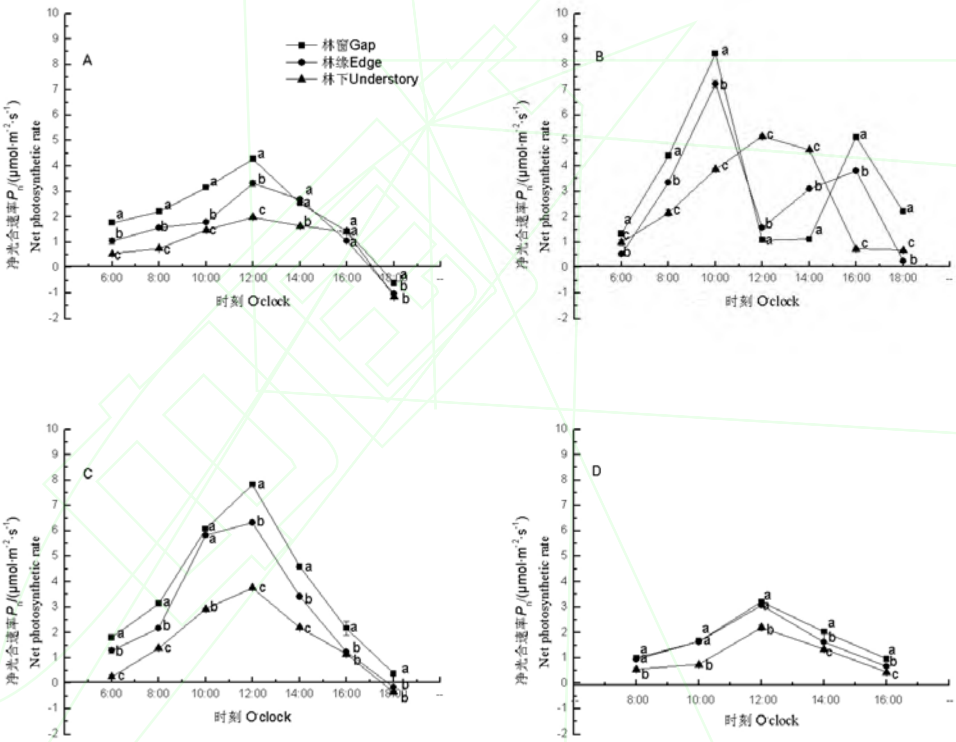

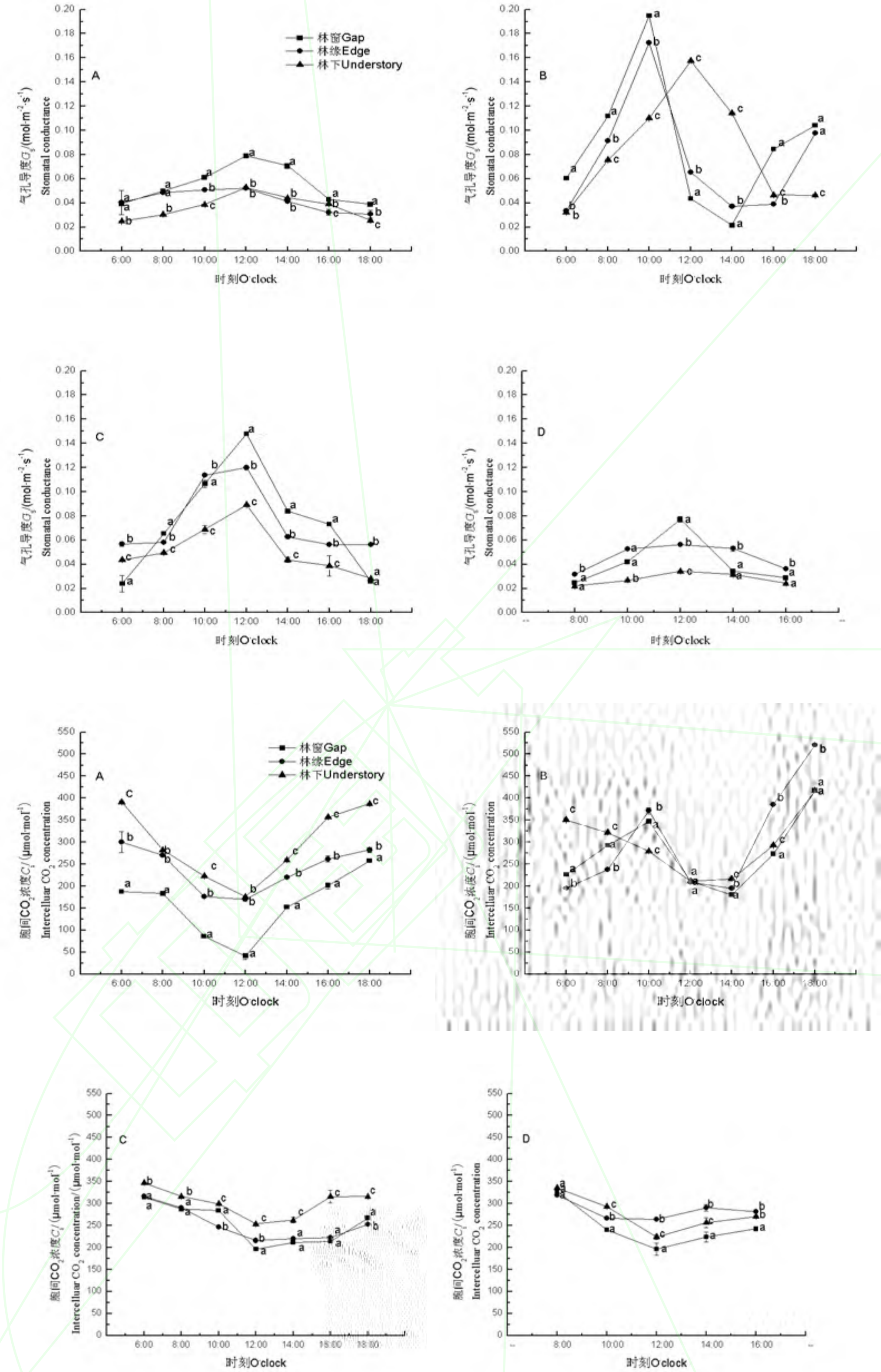

1 a˘ ʎ ʼ ˝Ī (*P*n) ȁ (*G*s) ȁ CO2 (*C*i) ʎ ◻

Fig. 1 Seasonal change in daily precess of net photosynthetic rate ȁ stomatal conductance ȁ intercellular CO_2 concentration of *Torreya jacki* under different habitats

ӥ ¤ ῆ ˘ a˘ (P<0.05)˘ A ȁ B ȁ C ȁ D ǂ ⁝ Ʒ ȁ ȁ ȁ ˝Ω 4 э

Table 1 Seasonal change in daily mean values of net photosynthetic rate à intercellular CO_2 concentration à stomatal conductance of *Torreya jackii* leaves under different habitats

Parameters	Habitats	Seasons			
		Spring	Summer	Autumn	Winter
(P_n) Daily mean values of net photosynthetic rate /(mol·m^{-2}·s^{-1})	Gap	2.72 ¤ 0.231Aa	4.03 ¤ 0.272Ba	4.76 ¤ 0.103Ca	1.77 ¤ 0.147Da
	Edge	2.08 ¤ 0.170Ab	3.81 ¤ 0.181Bb	3.79 ¤ 0.153Bb	1.58 ¤ 0.084Cb
	Ю Understory	1.45 ¤ 0.268Ac	3.31 ¤ 0.277Bc	2.28 ¤ 0.215Cc	1.05 ¤ 0.118Dc
(G_s) Daily mean values of stomatal conductance /(mol·m^{-2}·s^{-1})	Gap	0.06±0.001Aa	0.18±0.001Ba	0.08±0.001Ca	0.03±0.001Da
	Edge	0.04±0.003Ab	0.12±0.004Bb	0.07±0.002Ca	0.03±0.001Da
	Ю Understory	0.04±0.001Ab	0.08±0.002Bc	0.04±0.001Ab	0.02±0.001Cb
CO_2 (C_i) Daily mean values of intercellular CO_2 concentration /(mol·mol^{-1})	Gap	132.76±4.077Aa	260.82±1.842Ba	238.69±1.802Ca	245.91±6.852Da
	Edge	219.74±2.746Ab	279.90±2.735Bb	245.01±1.279Cb	263.07±3.163Db
	Ю Understory	259.45±1.323Ac	264.48±2.781Bc	289.46±4.493Cc	276.01±4.211Dc

(P<0.05) (P<0.05)

2.3

(P_{nmax}) (LSP) (AQY) P_{nmax} AQY LSP P_{nmax} LSP P_{nmax} LSP AQY AQY (LCP) LCP LCP LCP O_5 (R_d) R_d R_d

3 è (*V*cmax) ȁ · (*J*max) ȁ м ¯ (TPU)

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electron transport /(mol ·m^{-2}·s^{-1})					
м ¯ (TPU) Triose phosphate utilization rate /(mol·m^{-2}·s^{-1})	Gap	8.978±0.366Aa	22.931±0.936Ba	9.478±0.387Aa	4.116±0.168Ca
	Edge	5.285±0.215Ab	16.025±0.654Bb	8.826±0.360Cb	3.965±0.171Da
	Ю Understory	4.996±0.204Ab	12.394±0.506Bc	6.097±0.249Cc	2.273±0.093Db

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Table 3 Seasonal change in the chlorophyll content of *Torreya jackii* leaves under different habitats

⁄ Parameters	Habitats	Seasons			
		Spring	Summer	Autumn	˝Ω Winter
⁄ a Chlorophyll a /(mg·g^{-1})	Gap	2.82 ¤ 0.125Aa	3.17 ¤ 0.220Aa	3.01 ¤ 0.338Aa	2.53 ¤ 0.057Ba
	Edge	2.97 ¤ 0.233Aab	3.42 ¤ 0.117Aa	3.15 ¤ 0.278Aab	2.32 ¤ 0.150Bab
	Ю Understory	3.32 ¤ 0.172Ab	3.83 ¤ 0.136Bb	3.44 ¤ 0.486Ab	2.05 ¤ 0.228Cb
⁄ b Chlorophyll b /(mg·g^{-1})	Gap	0.89 ¤ 0.011Aa	1.18 ¤ 0.127Aa	1.04 ¤ 0.221Aa	0.87 ¤ 0.013Aa
	Edge	1.09 ¤ 0.146Ab	1.21 ¤ 0.075Ba	1.13 ¤ 0.050ABa	0.77 ¤ 0.072Cab
	Ю Understory	1.15 ¤ 0.013Ab	1.46 ¤ 0.181Aa	1.33 ¤ 0.101Aa	0.53 ¤ 0.031Bb
⁄ a+b Chlorophyll a+b /(mg·g^{-1})	Gap	3.71 ¤ 0.136Aa	4.35 ¤ 0.347Aa	4.05 ¤ 0.559Aa	3.40 ¤ 0.070Ba
	Edge	4.06 ¤ 0.379Aab	4.63 ¤ 0.192Ba	4.28 ¤ 0.328Bab	3.09 ¤ 0.222Ca
	Ю Understory	4.47 ¤ 0.185Ab	5.29 ¤ 0.317Bb	4.77 ¤ 0.587ABb	2.58 ¤ 0.259Cb

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(P<0.05)

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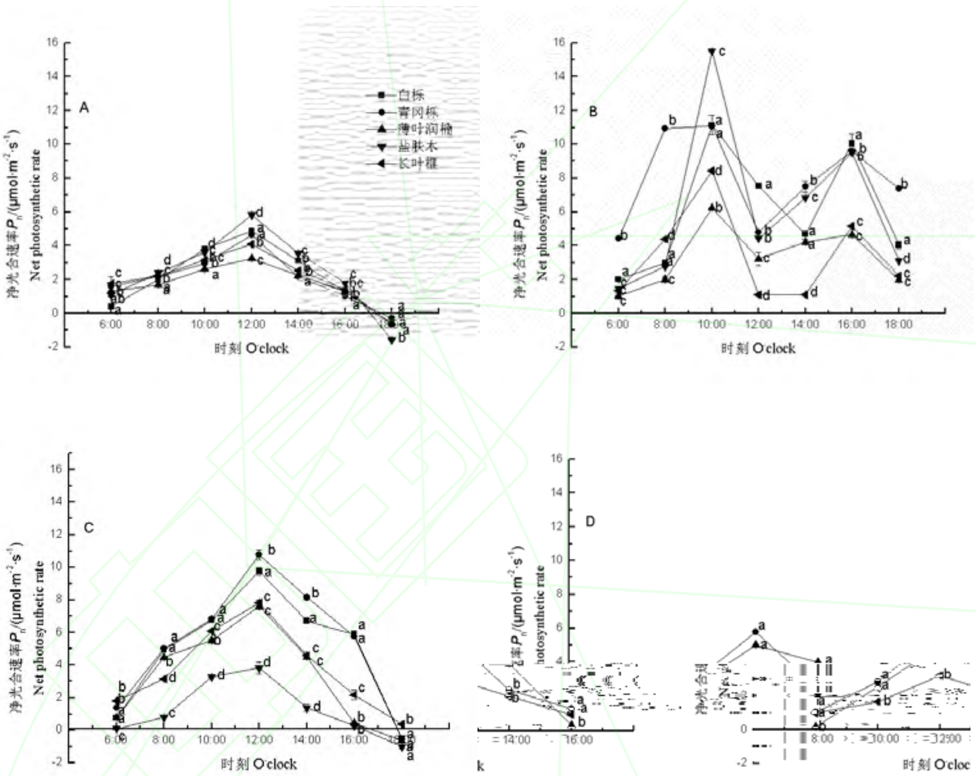

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Fig. 2 Seasonal change in daily precess of net photosynthetic rate of *Torreya jacki* and its accompanying species under different habitats

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Table 4 Seasonal change in daily mean values of net photosynthetic rate of *Torreya jackii* leaves and its accompanying species under different habitats

ᏻ Parameters	Species	Seasons			
		Spring	Summer	Autumn	˝Ώ Winter
P_n /(mol·m^{-2}·s^{-1})	Ꮧ (*Torreya jackii*)	2.72 ¤ 0.233Aa	4.03 ¤ 0.271Ba	4.76 ¤ 0.107Ca	1.77 ¤ 0.146Da
	ᾇ (*Cyclobal anopsisglauca*)	2.97 ¤ 0.187Ab	8.75 ¤ 0.231Bb	7.30 ¤ 0.294Cb	2.26 ¤ 0.057Db
	Ꮧ (*Machilus leptophylla*)	2.33 ¤ 0.132Ac	4.86 ¤ 0.115Bc	3.88 ¤ 0.259Cc	2.07 ¤ 0.510Db
	(*Quercus fabri*)	2.91 ¤ 0.042Ab	7.28 ¤ 0.307Bd	6.60 ¤ 0.255Cd	
	(*Rhus chinensis*)	3.25 ¤ 0.343Ad	7.82 ¤ 0.046Be	1.91 ¤ 0.041Ce	

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Table 5 Seasonal change in Light saturation point and Light compensation point of *Torreya jackii* leaves and its accompanying species under different habitats

ᏻ Parameters	Seasons	Species				
		Ꮧ *Torreya jackii*	Ꮧ *Machilus leptophylla*	ᾇ *Cyclobalanopsis glauca*	*Quercus fabri*	*Rhus chinensis*
˝Ι ɲ (LSP) Light saturation point	Spring	462±16.819Aa	628±25.637Ba	752±24.494Ca	564±23.025Da	530±22.861Da
	Summer	927±34.456Ab	940±38.375Bb	1288±49.499Cb	1206±48.826Cb	1108±45.233Db

/(mol·m^{-2}·s^{-1})	Autumn	752±30.700Ac	604±20.575Ba	808±28.903Cc	700±28.577Dc	160±6.531Ec
	ˇΩ Winter	428±17.473Aa	467±6.153Bc	544±9.961Cd		
ˇI Š (LCP) Light compensation point /(mol·m^{-2}·s^{-1})	Spring	10±0.408Aa	18±1.306Ba	13±1.469Ca	18±1.143Ba	18±2.776Ba
	Summer	20±0.816Ab	10±0.463Bb	4±0.372Cb	4±0.165Cb	4±0.489Cb
	Autumn	14±0.571Ac	8±0.489Bb	8±0.177Bc	25±0.255Cc	30±0.326Dc
	ˇΩ Winter	10±0.408Aa	8±0.326Ab	8±0.189Ac		

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ˇI ¯ ╒ æ ˇI ᐱ ˘ LSP ṇ LCP ᐱ ɞ ˇI ˘ ˇ ⁝ ᴇ ɞ ˇI ṇ ˇI ¯ ╒ Â ˘ 3 è ᐱ LSP ṇ LCP ˘ ᐱ ᐱ ˇI ¯ ╒ ˘ ˇI ¯ ╒ Â AQY ˇI ɔ ˇI ¯ [18] 3 è ᐱ AQY Љ ˘ ἐ ˇI ¯ Â 3 è ᐱ R_d ˘ O₅ Â ˘ V_{cmax} ӳ ᐱ Rubisco ầ Ŀ˘ Rubisco ᐱ ˇI ɔ è ẓ ◘ RuBP CO_2 ˇΩ [19] J_{max} Ʒ RuBP Ą ╒˘ æ ⁸ ˇI ◘ ɔ ṇ NADPH Ą ˘ ӱ ᴳ ᐱ V_{cmax} ᐱ У ⁸ [20] м (TP) ˇI ɔ ˥ ӊ ˘ TPU ¯ æ TP ˘ ˇI ɔ ӊ ᐱ ˇI æ Â ᐱ ᐱ V_{cmax} ầ J_{max} ầ TPU Љ ˘ ᐱ ˇI

ɔ è ẓ ◻ RuBP CO_2 Rubisco ɲ ╗˘ · ȣ ɷ
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J_{max} ằ TPU ˘ ˝Ï ɔ ╒˘ P_{nmax} ≁ Â ⊓
ằ ʎ ˝Ï ľ ´ ˛ Ŀ ˘ ᴳ ʎ P_n æ Ұ ằ
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ط Â ɿ ὤ ˝I ˘ PAR ’ ˝I ’ Ю ˝I ʎ ◻
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P_n Ұ ằ Ұ Ю̆ б (*Cathaya argyrophylla*) PAR
æ P_n æ[21] У Â 4 э P_{nmax} ≁ ˘ б Ю ˘ ʎ
ʎ ˝I Â Ю ˝I ˘ æ LCP ¯ ˝I
˝Ï ɔ ’ AQY ˝I ¯ ’ æ R_d ≁ ╠ Ұ ˀ O5 ˘ ˝Ï

˜ ў Ⅎ ǯ У Â P_n ᾱ ᴇ ╒ æ˘ ᵥ ┺

Â ÿ ⁄ б ἐ ʊ ˝Ɪ́ ╒ ⁄ Љ ˘ 4 э è ⁄

P_n ɏ è Ю ˘ з ɏ ˝Ɪ ɲ [8] ɕ ⁄ ˝Ɪ́ ╒˘ P_n ´ Ю

˘ ˝Ɪ́ ˘ ╒ æ˘ ˘ Ʈ ╒ ˘ ᵥ .

˘ Ʈ ╒ . ˘ a a ↑ ˘ ˘ ѝ

Ю ɲ ˘ ˝Ɪ Ɪ ˀ ɲ ѝ [1] ⁄ ⁄ ↑ ˘

ѝ ˜ Ⅎ ǯ У Â ˘ ȁ ⁄ LCP ɏ ἐ 4 ʊ

˘ ⁄ a ˘ ἐ ↑ ɏ ⅃ è Ю ˘ ɏ [1] G

⁄ ɏ a ¯ Æ˘ ˝Ɪ a ƀ˘ ╒ [28] ≠ ⁄

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