

ISSN 1000-0933
CN 11-2031/Q

生态学报

Acta Ecologica Sinica



第 32 卷 第 11 期 Vol.32 No.11 **2012**

中国生态学学会
中国科学院生态环境研究中心
科学出版社

主办
出版



中国科学院科学出版基金资助出版

生态学报

(SHENGTAI XUEBAO)

第 32 卷 第 11 期

2012 年 6 月 (半月刊)

目 次

黑龙江省大兴安岭林区火烧迹地森林更新及其影响因子·····	蔡文华, 杨健, 刘志华, 等 (3303)
基于 B-IBI 指数的温榆河生态健康评价·····	杨柳, 李泳慧, 王俊才, 等 (3313)
川西亚高山暗针叶林不同恢复阶段红桦、岷江冷杉土壤种子损耗特征·····	马姜明, 刘世荣, 史作民, 等 (3323)
老龄阔叶红松林下层木空间分布的生境关联分析·····	丁胜建, 张春雨, 夏富才, 等 (3334)
内蒙古高原荒漠区四种锦鸡儿属植物灌丛沙包形态和固沙能力比较·····	张媛媛, 马成仓, 韩磊, 等 (3343)
角果藜的生长动态及其生殖配置·····	全杜娟, 魏岩, 周晓青, 等 (3352)
基于 MODIS/NDVI 时间序列的森林灾害快速评估方法——以贵州省为例·····	侍昊, 王笑, 薛建辉, 等 (3359)
祁连山西水林区土壤阳离子交换量及盐基离子的剖面分布·····	姜林, 耿增超, 李珊珊, 等 (3368)
水分和温度对春玉米出苗速度和出苗率的影响·····	马树庆, 王琪, 吕厚荃, 等 (3378)
施氮对水稻土 N ₂ O 释放及反硝化功能基因 (<i>narG/nosZ</i>) 丰度的影响·····	郑燕, 侯海军, 秦红灵, 等 (3386)
中国西北潜在蒸散时空演变特征及其定量化成因·····	曹雯, 申双和, 段春峰 (3394)
基于植被降水利用效率和 NDVI 的黄河上游地区生态退化研究·····	杜加强, 舒俭民, 张林波 (3404)
异速生长法计算秋茄红树林生物量·····	金川, 王金旺, 郑坚, 等 (3414)
乌兰布和沙漠沙蒿与油蒿群落的物种组成与数量特征·····	马全林, 郑庆中, 贾举杰, 等 (3423)
不同光强下单叶蔓荆的光合蒸腾与离子累积的关系·····	张萍, 刘林德, 柏新富, 等 (3432)
浑善达克沙地沙地榆种子雨的扩散规律·····	谷伟, 岳永杰, 李钢铁, 等 (3440)
咸水灌溉对沙土土壤盐分和胡杨生理生长的影响·····	何新林, 陈书飞, 王振华, 等 (3449)
外源 NO 对 NaHCO ₃ 胁迫下黑麦草幼苗光合生理响应的调节·····	刘建新, 王金成, 王鑫, 等 (3460)
呼伦贝尔草地植物群落与土壤化学计量学特征沿经度梯度变化·····	丁小慧, 罗淑政, 刘金巍, 等 (3467)
海南稻田土壤硒与重金属的含量、分布及其安全性·····	耿建梅, 王文斌, 温翠萍, 等 (3477)
江苏省典型区农田土壤及小麦中重金属含量与评价·····	陈京都, 戴其根, 许学宏, 等 (3487)
应用稳定同位素研究广西东方洞食物网结构和营养级关系·····	黎道洪, 苏晓梅 (3497)
利用细胞计数手段和 DGGE 技术分析松花江干流部分地区的细菌种群多样性·····	屠腾, 李蕾, 毛冠男, 等 (3505)
中国主要入海河流河口集水区划分与分类·····	黄金良, 李青生, 黄玲, 等 (3516)
基于 VGPM 模型和 MODIS 数据估算梅梁湾浮游植物初级生产力·····	殷燕, 张运林, 时志强, 等 (3528)
低温胁迫下虎纹蛙的生存力及免疫和抗氧化能力·····	王娜, 邵晨, 颜志刚, 等 (3538)
转 Bt 水稻土壤跳虫群落组成及其数量变化·····	祝向钰, 李志毅, 常亮, 等 (3546)
尼日利亚非洲蜂和安徽意大利蜜蜂及其杂交二代形态特征与微卫星 DNA 遗传多样性·····	余林生, 解文飞, 巫厚长, 等 (3555)
北京城市公园湿地休憩功能的利用及其社会人口学因素·····	李芬, 孙然好, 陈利顶 (3565)
基于协整理论的经济增长与生态环境变化关系分析——以重庆市渝东南地区为例·····	肖强, 胡聃, 肖洋, 等 (3577)
感潮河网区环境合作博弈模型及实证·····	刘红刚, 陈新庚, 彭晓春 (3586)
专论与综述	
国内外生态效率核算方法及其应用研究述评·····	尹科, 王如松, 周传斌, 等 (3595)
全球变化背景下的现代生态学——第六届现代生态学讲座纪要·····	温腾, 徐德琳, 徐驰, 等 (3606)
问题讨论	
流域环境要素空间尺度特征及其与水生态分区尺度的关系——以辽河流域为例·····	刘星才, 徐宗学, 张淑荣, 等 (3613)
研究简报	
不同光照强度对兴安落叶松几种主要防御蛋白活力的影响·····	鲁艺芳, 石蕾, 严善春 (3621)
木荷种源间光合作用参数分析·····	熊彩云, 曾伟, 肖复明, 等 (3628)
基于能值分析的深圳市三个小型农业生态系统研究·····	杨卓翔, 高阳, 赵志强, 等 (3635)

期刊基本参数: CN 11-2031/Q * 1981 * m * 16 * 342 * zh * P * ¥70.00 * 1510 * 37 * 2012-06



封面图说: 爬升樟木沟的暖湿气流——樟木沟是中国境内横切喜马拉雅山脉南坡的几条著名大沟之一,它位于我国西藏聂拉木县境内的希夏邦马峰东南侧,延绵 5400km 的 318 国道在此沟中到达其最西头。从聂拉木县城到樟木口岸短短的 30km 中,海拔从 4000m 急降至 2000m。在大气环流作用下,来自印度洋的暖湿气流沿樟木沟不断费力地往上爬升,给该沟谷留下了大量的降水。尤其是在雨季到来时,山间到处是流水及悬垂崖头的瀑布,翠峰直插云霄,森林茂密苍郁,溪流碧澄清澈,奇花异葩繁多,风景美如画卷,气势壮丽非凡。

彩图提供: 陈建伟教授 北京林业大学 E-mail: cites.chenjw@163.com

DOI: 10.5846/stxb201105050588

张萍, 刘林德, 柏新富, 朱建军. 不同光强下单叶蔓荆的光合蒸腾与离子累积的关系. 生态学报, 2012, 32(11): 3432-3439.

Zhang P, Liu L D, Bai X F, Zhu J J. Photosynthesis and transpiration in relation to ion accumulation in *Vitex trifolia* under varied light intensity. Acta Ecologica Sinica, 2012, 32(11): 3432-3439.

不同光强下单叶蔓荆的光合蒸腾与离子累积的关系

张 萍, 刘林德, 柏新富, 朱建军*

(鲁东大学生命科学学院, 烟台 264025)

摘要:同步分析了生长在滨海滩涂沙地的灌木单叶蔓荆钠和钾离子的累积量与植物的水分累积消耗量与光合产物累积量的日变化特点和累积的关系,并比较了单叶蔓荆在晴天和阴天的木质部溶液离子浓度与植物水势的关系和水分利用效率的差别,结果表明:单叶蔓荆在光强度较高的晴天的水分利用效率高于阴天,在晴天的光合产物累积达到了阴天的约 4 倍,却只消耗了约为阴天 3 倍的水。随着植物体水势的降低,单叶蔓荆木质部溶液的钠离子的浓度和钾离子浓度呈降低趋势但不明显。木质部溶液的钾离子浓度和钾离子累积量无论在晴天和阴天都明显低于钠离子的浓度和累积量。单叶蔓荆的高浓度的钠离子吸收有可能在液泡累积并降低细胞的渗透势,增加细胞的吸水能力和植物的抗旱抗盐能力。

关键词:单叶蔓荆;水势;光合作用;钠累积;钾累积

Photosynthesis and transpiration in relation to ion accumulation in *Vitex trifolia* under varied light intensity

ZHANG Ping, LIU Linde, BAI Xinfu, ZHU Jianjun*

College of Life Sciences, Ludong University, Yantai 264025, China

Abstract: Land plants are constantly growing in environments not optimal for their growth and development, drought and saline stresses are often encountered by plants. These stresses will significantly affect the transpiration, ion absorption and photosynthesis of the plants. Because the photosynthesis of land plants is always accompanied by transpirational water loss, and because the xylem sap being transported to leaves during the transpiration process is not pure water, this in turn will result in the accumulation of ions in plant leaves. This is because the when the water in the xylem sap is transpired into the air, ions will be left in leaves. For this reason, the ratio between the amount of carbon assimilation and ion accumulation in plants may vary significantly under different environmental conditions even within the same plant. This is an important part of plant metabolism in terms of ionic nutrition and salt resistance. However, the relation between the simultaneous change and accumulation of ions and photosynthetic yield is rarely addressed and little is known about the relationship between the accumulation of ions and photosynthetic assimilant in *Vitex trifolia* L, a salt and drought resistant plant, the effect of environmental factors on that relationship is even more scarce. In this paper, the photosynthesis and transpiration in relation to ion accumulation in *V. trifolia* under varied light intensity (on cloudy/overcast and sunny days, respectively). The diurnal accumulation of photosynthetic assimilant was calculated through the integration according to the instantaneous photosynthetic rate of leaves against time, and the ion accumulation in leaves was yielded by integrating the instantaneous ion concentration of xylem sap against time. In this way, the ion concentrations, in relation to the transpiration rate and the water potential of *V. trifolia*, as well as the photosynthetic rate, were analysed on cloudy/overcast and sunny days,

基金项目:国家重点基础研究发展计划资助(2009CB421300)

收稿日期:2011-05-05; **修订日期:**2012-01-10

* 通讯作者 Corresponding author. E-mail: jzjzhu@gmail.com

respectively. Under natural conditions, the photosynthetic rate and the transpiration rate of *V. trifolia*, both on cloudy/overcast days was highly light dependent. On cloudy/overcast days, the pattern of photosynthetic rate and the transpiration rate of *V. trifolia* agreed very well with the changes in light intensity. However, on sunny days, the pattern of photosynthetic rate and the transpiration rate of *V. trifolia* did not follow the pattern of changes in light intensity exactly, especially in the afternoon when the water potential of the plant was low. This was an indication that the water status of the plant, may also have played a role in regulating the transpiration and photosynthesis of the plant. In terms of the overall water use efficiency (WUE) of a day, the performance of *V. trifolia* on sunny days was significantly higher than that on cloudy/overcast days. The photosynthetic assimilants accumulated on sunny days was four times of those accumulated on cloudy/overcast days, but with only just three times of the water consumed on cloudy/overcast days. In agreement with the report of some literatures, both the concentrations of sodium and potassium in xylem sap went down slightly with the decline of tissue water potential of the plant both on sunny and cloudy/overcast days, indicating that the ion concentration in xylem sap was regulated. The amount of sodium accumulated in *V. trifolia* was always higher than that of potassium either on sunny and cloudy/overcast days, suggesting that the sodium ions may have been positively absorbed in order for the plant cells to gain a lower osmotic potential to maintain a higher driving force for water absorption, which may be one of the reasons that *V. trifolia* had got a high resistance to salt and drought stresses.

Key Words: *Vitex trifolia* L; water potential; photosynthesis; sodium accumulation; potassium accumulation

在自然条件下,由于植物一般很难处于最佳的生长环境条件,环境条件经常会导致植物的水分胁迫和盐胁迫^[1-2]。植物在受到水分胁迫时,会产生一系列的生理反应,比较直接的是水分亏缺导致的整个植株水势降低,激素代谢发生变化^[3-4],保卫细胞膨压下降气孔关闭^[5-6],使植物难以获得光合作用需要的二氧化碳,导致光合作用下降或停止^[7-8],结果是根系向地上部分的水分运输和也受到影响^[9]。水分胁迫还能影响植物根系的水分和离子吸收,引起根的吸收特性的改变。在同时有盐胁迫的条件下,这种改变将使植物对水分、营养离子和有害盐离子的吸收关系变得更加复杂,反过来进一步影响地上部分的光合作用,蒸腾作用等代谢过程^[10-11]。

另一方面,植物的光合作用总是伴随着蒸腾作用和叶片大量的水分散失。叶片的水分散失由植物从根部吸水并通过由蒸腾作用产生的蒸腾流带到叶片来补充。植物根系在吸水时也同时主动或被动地吸收土壤中的离子,这些离子将随蒸腾流进入植物的地上部分和叶片。因此,伴随着植物的光合产物的累积和水分消耗量的增加,各种盐离子也将在叶片积累。有研究表明叶片中离子积累的速度与植物木质部溶液的浓度和蒸腾耗水速度直接有关^[12-13],而植物的蒸腾耗水速度又与环境条件密切相关^[14-15],因此植物的叶片中离子积累的速度也与蒸腾条件有关。关于各种环境因子对植物的光合和蒸腾等的影响,关于植物的水分和盐分吸收,运输和分配,早就引起人们的关注并已经有了大量的研究报道和关于这些报道的综述^[16-21]。但是,关于植物在水分胁迫和盐的双重胁迫条件下植物的水分和盐离子的吸收累积特点及其与光合产物累积量的关系,一般都是分析干物质和盐分的总累积量^[22-25]。由于植物对于干物质和盐分的总累积量并不完全是由光合作用和根系吸收所决定的,例如呼吸作用的消耗,落叶和降水冲刷带走的离子和有机碳等,这些分析只是反映了植物的水分和盐离子的吸收累积特点及其与光合产物累积量的粗略的大致关系,要详细了解植物根系在不同的蒸腾条件下的水分和盐离子的吸收比例,植物的盐离子累积率及其与光合产物累积量之间的关系,就需要同步分析离子吸收和光合作用的日变化量的关系。然而由于离子吸收和光合作用的日变化量相对于植物体的总累积量太小,研究有一定的难度,因此相关的研究报道不多。根据单叶蔓荆木质部溶液中钠钾离子浓度,蒸腾速度和光合作用的同步变化和累积关系的分析,对此进行了初步探索。另一方面,当环境条件如光照,温度等改变时,植物的水分和盐离子的吸收和光合作用的累积特点和相互的比例关系都有可能发生改变,因此我们对晴天和阴天的相关变化进行了分析对比。分析研究这些条件下植物的水分和离子吸收及光合作用,了解植物

的水分和盐分吸收与光合同化量的关系,不仅能够作为分析比较不同植物之间的抗盐性的参考指标,而且能进一步了解植物的抗性生理机制,为农林业生产上培育抗旱抗盐作物或树木提供理论上的参考^[26-27]。

滨海滩涂沙地由于海水的侵蚀加上保水力低,生长在这种环境的植物往往受到水分胁迫和盐的双重胁迫,对它们的生存和生长构成了严重的挑战。因此生长在这种环境的植物对于胁迫具有较高的抵抗能力。生长在烟台附近滨海滩涂沙地的灌木单叶蔓荆(*Vitex trifolia* L. var. *simplicifolia* Cham),属于马鞭草科多年生落叶藤本植物,茎蔓生地面,着地处生有大量不定根,根系发达,深度可达土层 3 m 左右,有固沙改土、蓄水保墒的功能^[28-29],在山东沿海沙质海岸的常常大量野生生长,成为固沙植物,也是药用植物。本文分析比较了单叶蔓荆在晴天和阴天水分和盐离子的吸收累积特点及其与光合产物累积量的关系。

1 材料与方法

1.1 试验材料

供试验的材料为烟台海滨自然生长的单叶蔓荆(*Vitex trifolia* L. var. *simplicifolia* Cham),选择生长健壮长势一致的植株为材料,实验在 8 月下旬和 9 月初之间在野外自然状态下进行。

1.2 测定方法

1.2.1 光合速率(P_n)和蒸腾速率的测定

单叶蔓荆叶片的光合速率利用英国 PPsystems 国际有限公司的 TPS-1 型便携式光合作用测定系统测定。选定 3 个生长健康的待测株,以顶部向下第 2 片完全展开的成熟叶片为测定对象,从 6:30 至 17:30 每隔 1h 测定 1 次,结果以平均值计。植物的日光合作用累积值和水分日消耗量值以每两个测量值的中值连续积分计算并用 Origin 作图。

1.2.2 植株水势测定

植株水势用压力室法^[18]测定。在每次测定光合速率的同时,选取临近的枝条,剪取后立即用压力室测定其水势,每次测定 3 个枝条。

1.2.3 单叶蔓荆木质部溶液的钠钾离子含量测定

选取单叶蔓荆枝条,剪取后立即用压力室将木质部溶液压出,定量稀释后用 AA320N 型原子吸收分光光度计(上海分析仪器厂)测定并根据稀释倍数算出木质部溶液的原初钠钾浓度。从 6:30 至 17:30 每隔 1h 测定 1 次,结果以平均值计。植物的钠钾离子日累积值根据各个时间段的木质部溶液浓度和蒸腾失水量连续积分计算并用 Origin 作图。

2 结果与分析

2.1 晴天和阴天单叶蔓荆光合速率和蒸腾速率,光合产物累积量和水分消耗量与光强度的关系

图 1 为单叶蔓荆在多云和晴天的蒸腾速率和光合速率变化及相应的光照强度变化。由图 1 可见,在多云天气条件下,由于光照条件的限制,单叶蔓荆的蒸腾速率和光合速率都相对较低,并且随着光强度的变化而上升或下降。在短时间光照出现高峰时,单叶蔓荆的蒸腾作用和光合作用都同步出现了相应的高峰,光成为蒸腾和光合作用的限制因子。晴天单叶蔓荆蒸腾速率和光合速率表现为双峰曲线,也明显随着光强度的变化而上升或下降。光合速率在 8:30 左右达到第 1 个峰值,随后不断下降,11:30 左右下降至最低点,出现午休现象,11:30 以后光合速率又开始上升,不过此时上升较缓慢,在 15:30 时达到第 2 个峰值,之后光合速率急剧下降。从光照强度变化曲线可以看出,8:00—15:30 之间光照强度一直维持较高值,此时光合速率的升降幅度较小,15:30 以后光照强度急剧下降,光合速率随之快速下降。而多云天气下,光合速率日变化基本上呈单峰曲线,但不管是晴天还是多云天气光合速率的日变化均与光照强度的日变化密切相关。光照强度是蒸腾主要的限制因素,对单叶蔓荆的蒸腾和光合的连续积分的累积结果也显示出同样的趋势(图 1)。由于环境条件的波动,同一时间的单个测定结果不易比较,但积分后的结果使两者的差异变得非常清晰。在所测实验条件下,阴天植物光合作用日累积量为 $50.3 \mu\text{mol CO}_2/\text{m}^2$ 。晴天的光合作用累积量为 $198.8 \mu\text{mol CO}_2/\text{m}^2$,约为阴天的 4 倍。在蒸腾耗水方面,晴天植物白天的水分消耗量为 $84.5 \text{ mol}/\text{m}^2$,阴天植物白天的耗水量为

27.7 mol/m^2 , 阴天植物的耗水量却达到晴天的 $1/3$, 显示出在弱光条件下植物的水分利用效率更低。

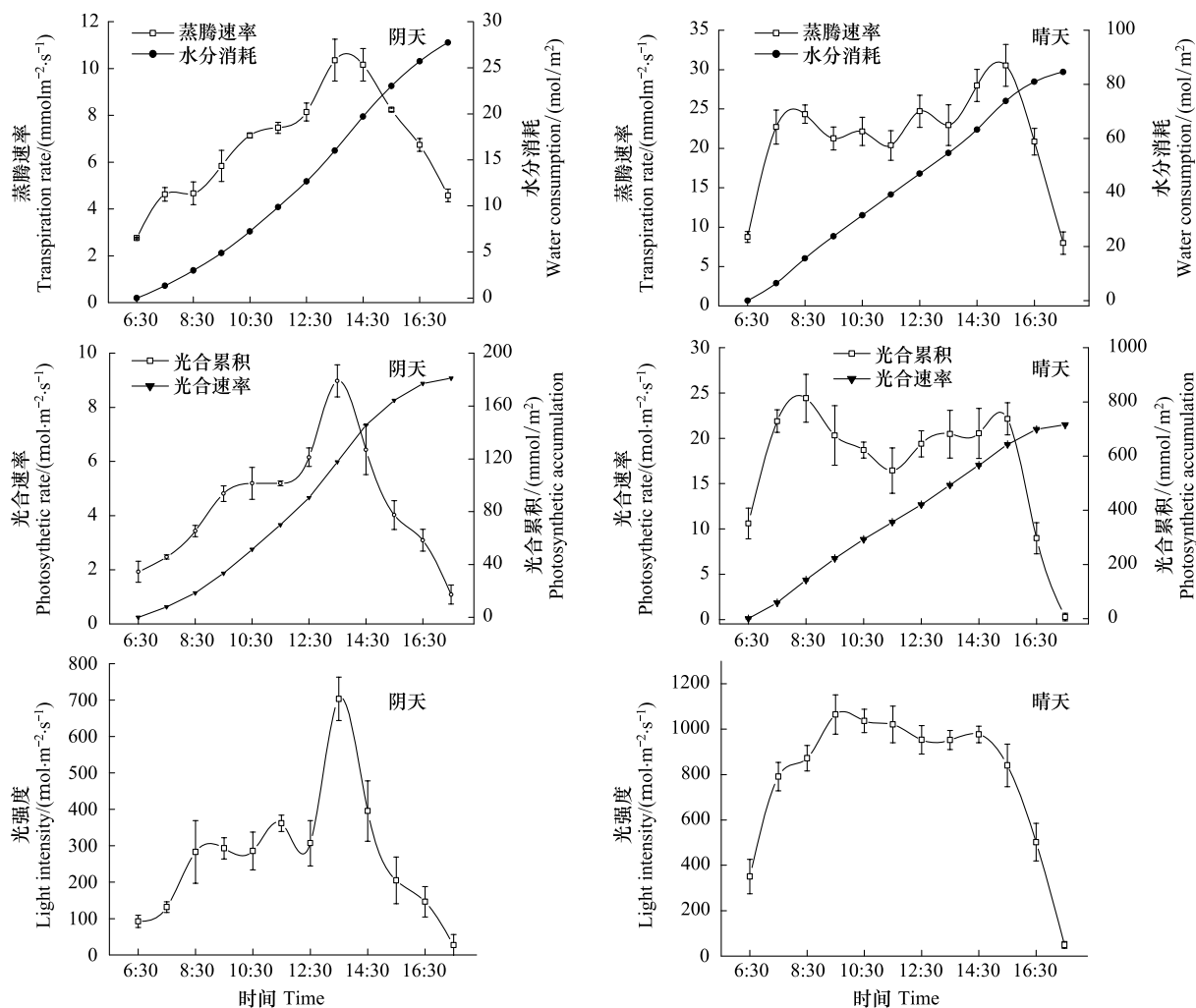


图1 单叶蔓荆在阴天和晴天的蒸腾耗水和碳同化速度和累积量与光照强度的日变化关系

Fig. 1 The relationship between light intensity and the rate/accumulation of water consumption and carbon assimilation in *V. trifolia* on cloudy and sunny days

由于进入植物根系吸收进入植物根木质部的不是纯水,所以植物的蒸腾流总是伴随着溶质的运输并在叶片积累。这些溶质中有的对植物是营养物质,有些可能是能造成胁迫或毒害的离子。随着植物蒸腾强度的增加,植物的吸水速度增加,这也就要求植物的吸水动力加大,造成根系的表面的土壤的微环境的溶液的水势下降和根表面局部土壤离子浓度增大。如果土壤溶液的离子浓度增大,有可能导致根木质部溶液和与土壤溶液的离子浓度梯度加大,引起植物水势下降和木质部张力的增大,进一步引起根的离子吸收量与木质部溶液离子浓度的改变。为了了解滨海环境中单叶蔓荆对水分和钠钾离子的选择性吸收,同时分析了伴随着植物的光合产物累积和水分消耗离子在单叶蔓荆叶片中的积累情况与气象条件的关系。单叶蔓荆木质部溶液在阴天和晴天随时间的变化如图2所示。实验表明,随着白天时间的推移和植物耗水的增加,植物木质部溶液的钠钾离子浓度没有非常明显的变化,但植物的水势在午后大幅度下降(图3),在12:30到14:30左右到达最低点。对于植物木质部溶液和植物水势变化的回归分析表明,植物木质部溶液的钠钾离子浓度有轻微的随着水势降低而增加的趋势,但由于数据标准差很大这种差别仍然在统计误差范围内(图4)。同时,根据一天不同时间蒸腾作用耗水量和对应的木质部溶液浓度积分得到的叶片中钠钾离子的累积量也表明,单叶蔓荆无论是在阴天还是晴天,白天一天吸收的以摩尔数为基础的钠的吸收量都明显高于钾的吸收量(图5)。

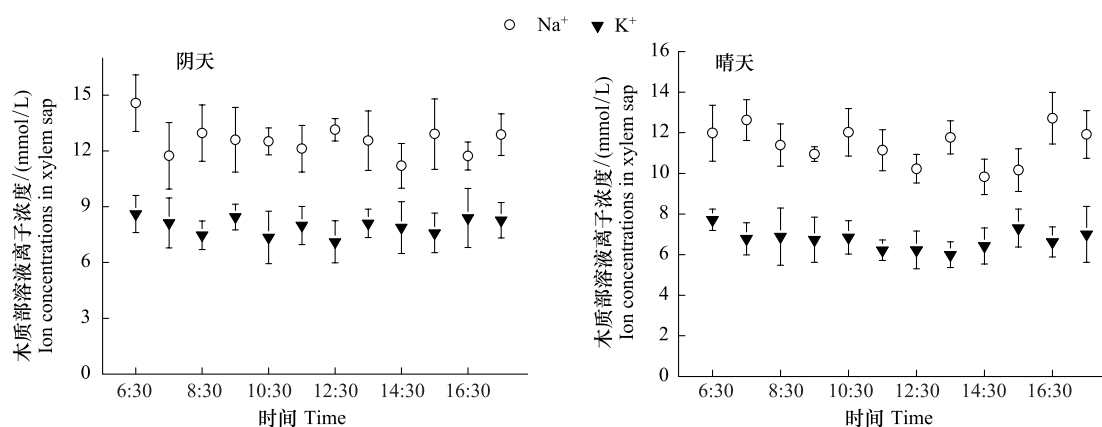


图2 阴天和晴天单叶蔓荆木质部溶液钠钾离子浓度随时间的变化

Fig. 2 Changes in sodium and potassium concentrations in xylem sap of *V. trifolia* on cloudy and sunny days

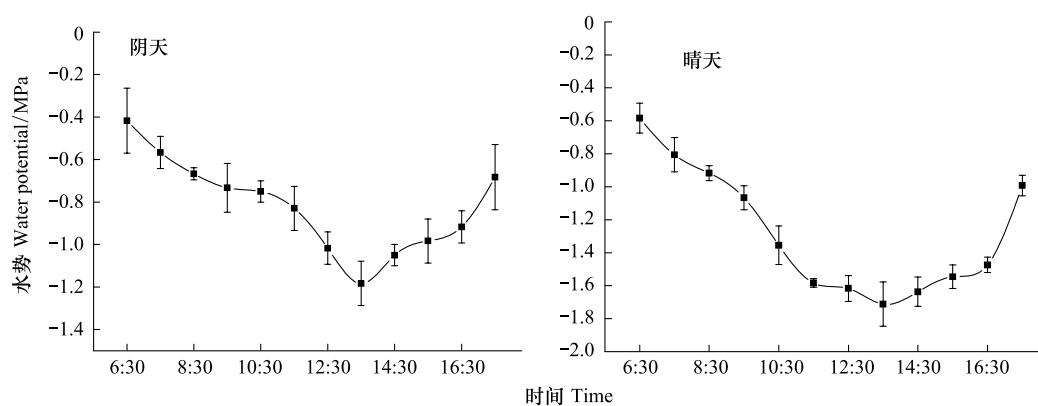


图3 阴天和晴天单叶蔓荆组织水势随时间的变化

Fig. 3 Changes in water potentials in tissues of *V. trifolia* on cloudy and sunny days

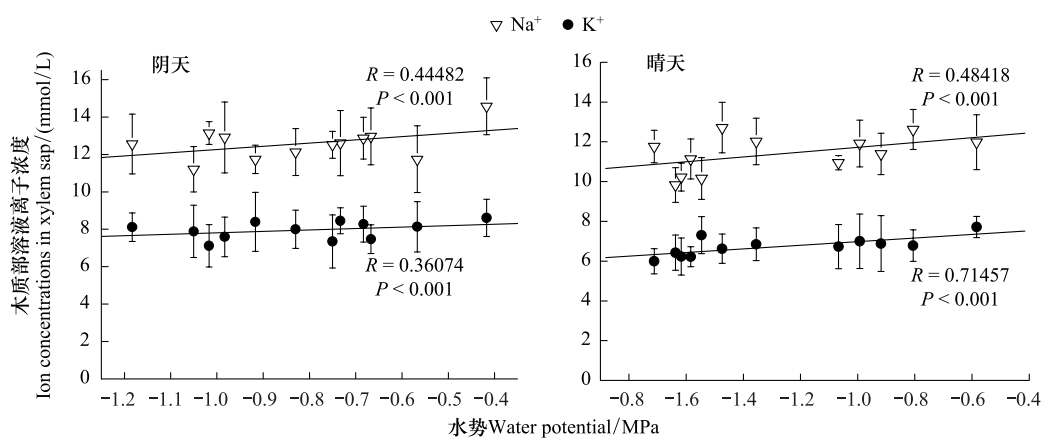


图4 阴天和晴天单叶蔓荆木质部溶液钠钾离子浓度与组织水势的关系

Fig. 4 Changes in sodium and potassium concentrations in xylem sap of *V. trifolia* in relation to tissue water potentials on cloudy and sunny days

2.2 阴天和晴天单叶蔓荆木质部溶液钠钾离子浓度随时间的变化

进一步的分析表明(表1),单叶蔓荆叶片的日蒸腾耗水量,晴天为 84.51 mol/m^2 , 阴天为 27.74 mol/m^2 ,

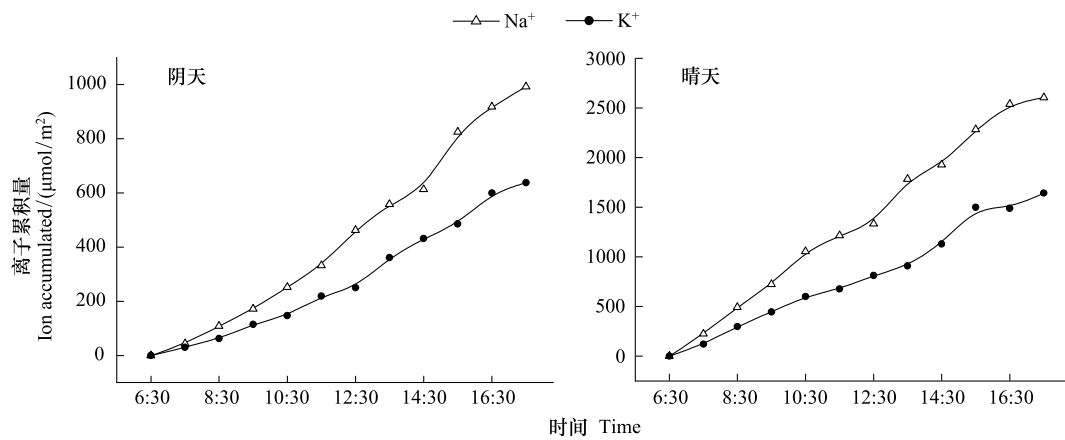


图5 阴天和晴天单叶蔓荆叶片的钠钾离子蓄积量随时间的日变化趋势

Fig. 5 Diurnal changes in sodium and potassium accumulation leaves of *V. trifolia* on cloudy and sunny days

晴天约为阴天的3倍,但光合作用的累积碳固定量却分别为715.53和181.04 mmol/m²,晴天为阴天的4倍。由此计算出的光合作用水分利用效率,晴天为8.47,阴天为6.52。钠离子的日蓄积量,晴天为2604.8 μmol/m²,阴天为991.9 μmol/m²,晴天为阴天的2.63倍;钾离子的日蓄积量,晴天为1642.9 μmol/m²,阴天为637.7 μmol/m²,晴天为阴天的2.58倍,两者晴天和阴天的比例几乎完全相同;晴天和阴天钠钾离子的吸收累积比分别为0.630和0.643,也几乎完全一致。与蒸腾耗水量相比,晴天植物对离子的相对吸收量明显低于阴天,但被认为是有害的钠离子和钾离子的吸收比例与蒸腾耗水量和植物的水势,在本实验所测定的环境条件范围内没有差别。

表1 单叶蔓荆叶片的水分利用效率,光合碳固定量,蒸腾耗水量,钠钾离子蓄积量和累积比的关系

Table 1 The relationship between water use efficiency, cumulative photosynthetic carbon fixation and water consumption, amount and ratio of sodium and potassium accumulation

天气 Weather	累积光合碳固定 Cumulative photosynthetic carbon fixation /(mmol/m ²)	蒸腾耗水量 Cumulative water consumption /(mol/m ²)	Na 累积 Sodium accumulation /(μmol/m ²)	K 累积 Potassium accumulation /(μmol/m ²)	K/Na 累积比 Ratio of sodium and potassium accumulation	水分利用效率 Water use efficiency /(mmol CO ₂ /mol H ₂ O)
阴天 Cloudy	181.04	27.74	991.9	637.7	0.643	6.52
晴天 Sunny	715.53	84.51	2604.8	1642.9	0.630	8.47

3 讨论

实验结果表明,环境条件不仅影响单叶蔓荆的光合作用,水势和蒸腾速率等生理参数,而且对这种植物的离子吸收和累积也有极大的影响。其中光强度的影响最为显著。阴天和晴天的光强度差别不仅影响着植物的光合作用速率和产物的累积以及水分消耗,而且还影响着植物的水分利用效率。对于单叶蔓荆来说,在光强度较高的晴天的水分利用效率反而高于阴天。一般来说,阴天的气象条件更有利于减少水分蒸发,提高植物的水分利用效率。为什么单叶蔓荆的水分利用效率反而高于阴天,推测可能与单叶蔓荆的叶片上的表皮毛结构有关。由于表皮毛对光的反射,吸收和衍射,在弱光条件下叶片细胞能吸收到的光就更少,更向下接近于光补偿点。这样由于光合作用相对比较微弱,减去植物暗呼吸的消耗后光合产物的净累积量就相对更少,结果造成单叶蔓荆在阴天的水分利用效率更低。但是,由于单叶蔓荆的生存环境是滨海沙地,含盐量高并且沙地持水能力低,要经常面对干旱和盐的双重胁迫,环境条件相对比较恶劣,因此虽然叶片上的表皮毛结构影响了植物在弱光条件下对光的吸收,造成光能的散失并降低了植物的水分利用效率,但在强光条件下,叶片上的表皮毛结构却使植物能够更多地反射和吸收光能,降低叶片的光能吸收,从而降低强光造成的高蒸腾和高温

伤害,以及气孔受到水分胁迫关闭时细胞内二氧化碳不足时强光对叶绿体的伤害,因此可能有助于提高单叶蔓荆对在受到干旱和盐胁迫的抗性。

一般说来,植物的离子吸收并不和水分吸收成正比例^[20],这是因为当植物的蒸腾速度大大降低,木质部溶液流速大大降低时,植物根系吸收的离子不能迅速向上运输而在自根而上的木质部溶液中积累,溶质浓度提高;反过来,当植物的蒸腾速度高时,木质部溶液流速也加大,使根系吸收的离子迅速被带走从而使植物的木质部溶液在高速蒸腾时离子浓度相对较低。在我们的实验中,单叶蔓荆离子的吸收和植物的水分消耗量呈正相关关系,可能是由于阴天和晴天的蒸腾速度差不够大,加上木质部导管的缓存,使得植物晴天和阴天的木质部溶液离子浓度差别不太大。单叶蔓荆木质部溶液的钾离子浓度和钾离子累积量都明显低于钠离子的浓度和累积量,有可能是单叶蔓荆主动吸收并在液泡累积钠离子降低细胞的渗透势,增加细胞的吸水能力,这也可能是单叶蔓荆同时具有较高的抗旱和抗盐能力的原因之一。另一方面,单叶蔓荆在晴天的光合产物累积达到了阴天的约4倍,却只消耗了约为阴天3倍的水这一结果可能意味着单叶蔓荆是喜光植物,对弱光的适应能力较差,这也有可能是单叶蔓荆往往是滨海滩涂的先锋植物,一旦高大植物成林,单叶蔓荆群落就衰退甚至消失的原因,对烟台附近海岸带的考察表明,与实验区生境类似的地带单叶蔓荆群落消失,大都已经被乔木和其他林下植物取代。金门岛海岸带的植被演替也有类似的现象^[30]。这需要结合生态演替过程深入研究。

References:

- [1] Chaves M M, Flexas J, Pinheiro C. Photosynthesis under drought and salt stress: regulation mechanisms from whole plant to cell. *Annals of Botany*, 2009, 103: 551-560.
- [2] Pinheiro C, Chaves M M. Photosynthesis and drought: can we make metabolic connections from available data? *Journal of Experimental Botany*, 2011, 62: 869-882.
- [3] Dodd I C, Davies W J. Hormones and the regulation of water balance // Davies P, ed. *Plant Hormones*. New York: Springer-Verlag, 2010: 519-548.
- [4] Dodd I C, Egea G, Watts C R, Whalley W R. Root water potential integrates discrete soil physical properties to influence ABA signalling during partial rootzone drying. *Journal of Experimental Botany*, 2010, 61(13): 3543-3551.
- [5] Wong S C, Cowan I R, Farquhar G D. Stomatal conductance correlates with photosynthetic capacity. *Nature*, 1979, 282(5737): 424-426.
- [6] Parida K A, Jha B. Salt tolerance mechanisms in mangroves: a review. *Trees-Structure and Function*, 2010, 24(2): 199-217.
- [7] Gama P B S, Inanaga S, Tanaka K, Nakazawa R. Physiological response of common bean (*Phaseolus vulgaris* L.) seedlings to salinity stress. *African Journal of Biotechnology*, 2007, 6(2): 79-88.
- [8] Muller B, Pantin F, Génard M, Turc O, Freixes S, Piques M, Gibon Y. Water deficits uncouple growth from photosynthesis, increase C content, and modify the relationships between C and growth in sink organs. *Journal of Experimental Botany*, 2011, 62(6): 1715-1729.
- [9] Tavakkoli E, Rengasamy P, McDonald G K. The response of barley to salinity stress differs between hydroponic and soil systems. *Functional Plant Biology*, 2010, 37(7): 621-633.
- [10] Bayoumi T Y, Eid M H, Metwali E M. Application of physiological and biochemical indices as a screening technique for drought tolerance in wheat genotypes. *African Journal of Biotechnology*, 2008, 7(14): 2341-2352.
- [11] Munns R, James R A, Sirault X R R, Furbank R T, Jones H G. New phenotyping methods for screening wheat and barley for beneficial responses to water deficit. *Journal of Experimental Botany*, 2010, 61(13): 3499-3507.
- [12] Ebrahimia R, Bhatla S C. Effect of sodium chloride levels on growth, water status, uptake, transport, and accumulation pattern of sodium and chloride ions in young sunflower plants. *Communications in Soil Science and Plant Analysis*, 2011, 42(7): 815-831.
- [13] Álvarez S, Navarro A, Nicolás E, Sánchez-Blanco M J. Transpiration, photosynthetic responses, tissue water relations and dry mass partitioning in *Callistemon* plants during drought conditions. *Scientia Horticulturae*, 2011, 129(2): 306-312.
- [14] Edelstein M, Plaut Z, Ben-Hur M. Sodium and chloride exclusion and retention by non-grafted and grafted melon and Cucurbita plants. *Journal of Experimental Botany*, 2011, 62(1): 177-184.
- [15] Skirycz A, Inzé D. More from less: plant growth under limited water. *Current Opinion in Biotechnology*, 2010, 21(2): 197-203.
- [16] Overstreet R, Jacobson L. Mechanisms of ion absorption by roots. *Annual Review of Plant Physiology*, 1952, 3(1): 189-206.
- [17] Lundegardh H. Mechanisms of absorption, transport, accumulation, and secretion of ions. *Annual Review of Plant Physiology*, 1955, 6(1): 1-24.

- [18] Leggett J E. Salt absorption by plants. Annual Review of Plant Physiology, 1968, 19(1): 333-346.
- [19] Dulorme M, Musseau O, Muller F, Toribio A, Bâ A. Effects of NaCl on growth, water status, N₂ fixation, and ion distribution in *Pterocarpus officinalis* seedlings. Plant and Soil, 2010, 327(1/2): 23-34.
- [20] Patela A D, Jadeja H, Pandey A N. Effect of salinization of soil on growth, water status and nutrient accumulation in seedlings of *Acacia Auriculiformis* (Fabaceae). Journal of Plant Nutrition, 2010, 33(6): 914-932.
- [21] Summart J, Thanonkeo P, Panichajakul S, Prathepha P, McManus M T. Effect of salt stress on growth, inorganic ion and proline accumulation in Thai aromatic rice, Khao Dawk Mali 105, callus culture. African Journal of Biotechnology, 2010, 9(2): 145-152.
- [22] Cramer G R, Alberico G J, Schmidt C. Leaf expansion limits dry matter accumulation of salt-stressed maize. Australian Journal of Plant Physiology, 1994, 21(5): 663-674.
- [23] Eker S, Cömertpay G, Konuşkan O, Ülger AC, Öztürk L, Çakmak I. Effect of salinity stress on dry matter production and ion accumulation in hybrid maize varieties. Turkish Journal of Agriculture and Forestry, 2006, 30: 365-373.
- [24] Dadkhah A R, Griffiths H. The effect of salinity on growth, inorganic ions and dry matter partitioning in sugar beet cultivars. Journal of Agricultural Science and Technology, 2006, 8(3): 199-210.
- [25] Hamdia M A, Shaddad M A K. Salt tolerance of crop plants. Journal of Stress Physiology and Biochemistry, 2010, 6(3): 64-90.
- [26] Pardo J M. Biotechnology of water and salinity stress tolerance. Current Opinion in Biotechnology, 2010, 21(2): 185-196.
- [27] Passioura J B, Angus J F. Improving productivity of crops in water-limited environments. Advances in Agronomy, 2010, 106: 37-75.
- [28] Yang H X, Chu J M, Zhang J T. Wild plants inhabiting on the sand fore-coasts of Shandong Peninsula. Bulletin of Botany, 2011, 41(1): 50-58.
- [29] Zhao K F, Zhang B Z, Liu Y H. Growth status of drought and salt-tolerant plants introduced into the delta of Yellow River. Journal of Shandong Normal University: Natural Science, 1991, 6(2): 80-95.
- [30] Administration Office of Kinmen National Park. An Survey of the Plantation Succession in Kinmen Coastal Areas. 2010. website address: http://www.cpami.gov.tw/chinese/index.php?option=com_content&view=article&id=12131&Itemid=104.

参考文献:

- [28] 杨洪晓, 褚建民, 张金屯. 山东半岛滨海沙滩前缘的野生植物. 植物学报, 2011, 41(1): 50-58.
- [29] 赵可夫, 张宝泽, 刘寅虎. 在黄河三角洲引种的耐盐耐旱植物的生长情况. 山东师范大学学报(自然科学版), 1991, 6(2): 80-95.
- [30] 金门国家公园管理处. 金門海岸植被演替調查研究. 2010. website address: http://www.cpami.gov.tw/chinese/index.php?option=com_content&view=article&id=12131&Itemid=104

ACTA ECOLOGICA SINICA Vol. 32, No. 11 June, 2012 (Semimonthly)

CONTENTS

Controls of post-fire tree recruitment in Great Xing'an Mountains in Heilongjiang Province	CAI Wenhua, YANG Jian, LIU Zhihua, et al (3303)
The assessment of river health using Benthic-Index of biotic integrity for Wenyu River	YANG Liu, LI Yonghui, WANG Juncai, et al (3313)
Consume of soil seeds of <i>Betula albo-sinensis</i> and <i>Abies faxoniana</i> in different natural successional stages of subalpine dark coniferous forest in western Sichuan, China	MA Jiangming, LIU Shirong, SHI Zuomin, et al (3323)
Habitat associations of understorey species spatial distribution in old growth broad-leaved Korean pine (<i>Pinus koraiensis</i>) forest	DING Shengjian, ZHANG Chunyu, XIA Fucui, et al (3334)
Nabkha morphology and sand-fixing capability of four dominant <i>Caragana</i> species in the desert region of the Inner Mongolia Plateau	ZHANG Yuanyuan, MA Chengchang, HAN Lei, et al (3343)
Growth dynamics, biomass allocation and ecological adaptation in <i>Ceratocarpus arenarius</i> L.	QUAN Dujuan, WEI Yan, ZHOU Xiaoqing, et al (3352)
A rapid assessment method for forest disaster based on MODIS/NDVI time series; a case study from Guizhou Province	SHI Hao, WANG Xiao, XUE Jianhui, et al (3359)
Soil cation exchange capacity and exchangeable base cation content in the profiles of four typical soils in the Xi-Shui Forest Zone of the Qilian Mountains	JIANG Lin, GENG Zengchao, LI Shanshan, et al (3368)
Impact of water and temperature on spring maize emergence speed and emergence rate	MA Shuqing, WANG Qi, LÜ Houquan, et al (3378)
Effect of N application on the abundance of denitrifying genes (<i>narG/nosZ</i>) and N ₂ O emission in paddy soil	ZHENG Yan, HOU Haijun, QIN Hongling, et al (3386)
Temporal-spatial variations of potential evapotranspiration and quantification of the causes in Northwest China	CAO Wen, SHEN Shuanghe, DUAN Chunfeng (3394)
Analysis of ecosystem degradation and recovery using precipitation use efficiency and NDVI in the headwater catchment of the Yellow River basin	DU Jiaqiang, SHU Jianmin, ZHANG Linbo (3404)
An assessment method of <i>Kandelia obovata</i> population biomass	JIN Chuan, WANG Jinwang, ZHENG Jian, et al (3414)
Quantitative characteristics and species composition of <i>Artemisia sphaerocephala</i> and <i>A. ordosica</i> communities in the Ulanbuh Desert ...	MA Quanlin, ZHENG Qingzhong, JIA Jujie, et al (3423)
Photosynthesis and transpiration in relation to ion accumulation in <i>Vitex trifolia</i> under varied light intensity	ZHANG Ping, LIU Linde, BAI Xinfu, et al (3432)
Diffusion of elm seed rain in Otindag Sand Land	GU Wei, YUE Yongjie, LI Gangtie, et al (3440)
Effect of saline water irrigation on sand soil salt and the physiology and growth of <i>Populus euphratica</i> Oliv.	HE Xinlin, CHEN Shufei, WANG Zhenhua, et al (3449)
Regulation of exogenous nitric oxide on photosynthetic physiological response of <i>Lolium perenne</i> seedlings under NaHCO ₃ Stress	LIU Jianxin, WANG Jincheng, WANG Xin, et al (3460)
Longitude gradient changes on plant community and soil stoichiometry characteristics of grassland in Hulunbeir	DING Xiaohui, LUO Shuzheng, LIU Jinwei, et al (3467)
Concentrations and distributions of selenium and heavy metals in Hainan paddy soil and assessment of ecological security	GENG Jianmei, WANG Wenbin, WEN Cuiping, et al (3477)
Heavy metal contents and evaluation of farmland soil and wheat in typical area of Jiangsu Province	CHEN Jingdu, DAI Qigen, XU Xuehong, et al (3487)
The studies on the food web structures and trophic relationships in Guangxi Dongfang Cave by means of stable carbon and nitro- gen isotopes	LI Daohong, SU Xiaomei (3497)
Analysis of bacterial diversity in the Songhua River based on nested PCR and DGGE	TU Teng, LI Lei, MAO Guannan, et al (3505)

Preliminary delineation and classification of estuarine drainage areas for major coastal rivers in China	HUANG Jinliang, LI Qingsheng, HUANG Ling, et al (3516)
Estimation of spatial and seasonal changes in phytoplankton primary production in Meiliang Bay, Lake Taihu, based on the Vertically Generalized Production Model and MODIS data	YIN Yan, ZHANG Yunlin, SHI Zhiqiang, et al (3528)
Viability and changes of physiological functions in the tiger frog (<i>Hoplobatrachus rugulosus</i>) exposed to cold stress	WANG Na, SHAO Chen, XIE Zhigang, et al (3538)
Community structure and abundance dynamics of soil collembolans in transgenic Bt rice paddyfields	ZHU Xiangyu, LI Zhiyi, CHANG Liang, et al (3546)
Morphological characteristics and microsatellite DNA genetic diversity of Nigeria African honey bee, Anhui <i>Apis mellifera</i> and theirs hybrid generation II	YU Linsheng, XIE Wenfei, WU Houchang, et al (3555)
Effects of social-demographic factors on the recreational service of park wetlands in Beijing	LI Fen, SUN Ranhao, CHEN Liding (3565)
Co-integration theory-based analysis on relationships between economic growth and eco-environmental changes: taking the south-east district in Chongqing city as an example	XIAO Qiang, HU Dan, XIAO Yang, et al (3577)
The cooperative environmental game model in the Tidal River Network Regions and its empirical research	LIU Honggang, CHEN Xingeng, PENG Xiaochun (3586)

Review and Monograph

Review of eco-efficiency accounting method and its applications	YIN Ke, WANG Rusong, ZHOU Chuanbin, et al (3595)
Overview on the 6th international symposium on modern ecology series of 2011	WEN Teng, XU Delin, XU Chi, et al (3606)

Discussion

Scale analysis of environmental factors and their relationship with the size of hierarchical aquatic ecoregion: a case study in the Liao River basin	LIU Xingcai, XU Zongxue, ZHANG Shurong, et al (3613)
--	--

Scientific Note

Effects of different light intensities on activities of the primary defense proteins in needles of <i>Larix gmelinii</i>	LU Yifang, SHI Lei, YAN Shanchun (3621)
An analysis of photosynthetic parameters among <i>Schima superba</i> provenances	XIONG Caiyun, ZENG Wei, XIAO Fuming, et al (3628)
Research on three small-scale agricultural ecological-economic systems in Shenzhen City based on emergy analysis	YANG Zhuoxiang, GAO Yang, ZHAO Zhiqiang, et al (3635)

《生态学报》2012 年征订启事

《生态学报》是中国生态学学会主办的自然科学高级学术期刊,创刊于 1981 年。主要报道生态学研究原始创新性科研成果,特别欢迎能反映现代生态学发展方向的优秀综述性文章;研究简报;生态学新理论、新方法、新技术介绍;新书评介和学术、科研动态及开放实验室介绍等。

《生态学报》为半月刊,大 16 开本,280 页,国内定价 70 元/册,全年定价 1680 元。

国内邮发代号:82-7 国外邮发代号:M670 标准刊号:ISSN 1000-0933 CN 11-2031/Q

全国各地邮局均可订阅,也可直接与编辑部联系购买。欢迎广大科技工作者、科研单位、高等院校、图书馆等订阅。

通讯地址:100085 北京海淀区双清路 18 号 电 话:(010)62941099; 62843362

E-mail: shengtaixuebao@rcees.ac.cn 网 址: www.ecologica.cn

编辑部主任 孔红梅 执行编辑 刘天星 段 靖

生 态 学 报

(SHENGTAI XUEBAO)

(半月刊 1981 年 3 月创刊)

第 32 卷 第 11 期 (2012 年 6 月)

ACTA ECOLOGICA SINICA

(Semimonthly, Started in 1981)

Vol. 32 No. 11 (June, 2012)

编 辑	《生态学报》编辑部 地址:北京海淀区双清路 18 号 邮政编码:100085 电话:(010)62941099 www.ecologica.cn shengtaixuebao@rcees.ac.cn	Edited by	Editorial board of ACTA ECOLOGICA SINICA Add: 18, Shuangqing Street, Haidian, Beijing 100085, China Tel: (010)62941099 www.ecologica.cn Shengtaixuebao@rcees.ac.cn
主 编	冯宗炜	Editor-in-chief	FENG Zong-Wei
主 管	中国科学技术协会	Supervised by	China Association for Science and Technology
主 办	中国生态学学会 中国科学院生态环境研究中心 地址:北京海淀区双清路 18 号 邮政编码:100085	Sponsored by	Ecological Society of China Research Center for Eco-environmental Sciences, CAS Add: 18, Shuangqing Street, Haidian, Beijing 100085, China
出 版	科 学 出 版 社 地址:北京东黄城根北街 16 号 邮政编码:100071	Published by	Science Press Add: 16 Donghuangchenggen North Street, Beijing 100717, China
印 刷	北京北林印刷厂	Printed by	Beijing Bei Lin Printing House, Beijing 100083, China
发 行	科 学 出 版 社 地址:东黄城根北街 16 号 邮政编码:100717 电话:(010)64034563 E-mail: journal@csbg.net	Distributed by	Science Press Add: 16 Donghuangchenggen North Street, Beijing 100717, China Tel: (010)64034563 E-mail: journal@csbg.net
订 购	全国各地邮局	Domestic	All Local Post Offices in China
国外发行	中国国际图书贸易总公司 地址:北京 399 信箱 邮政编码:100044	Foreign	China International Book Trading Corporation Add: P. O. Box 399 Beijing 100044, China
广告经营 许 可 证	京海工商广字第 8013 号		



ISSN 1000-0933
CN 11-2031/Q

国内外公开发行

国内邮发代号 82-7

国外发行代号 M670

定价 70.00 元