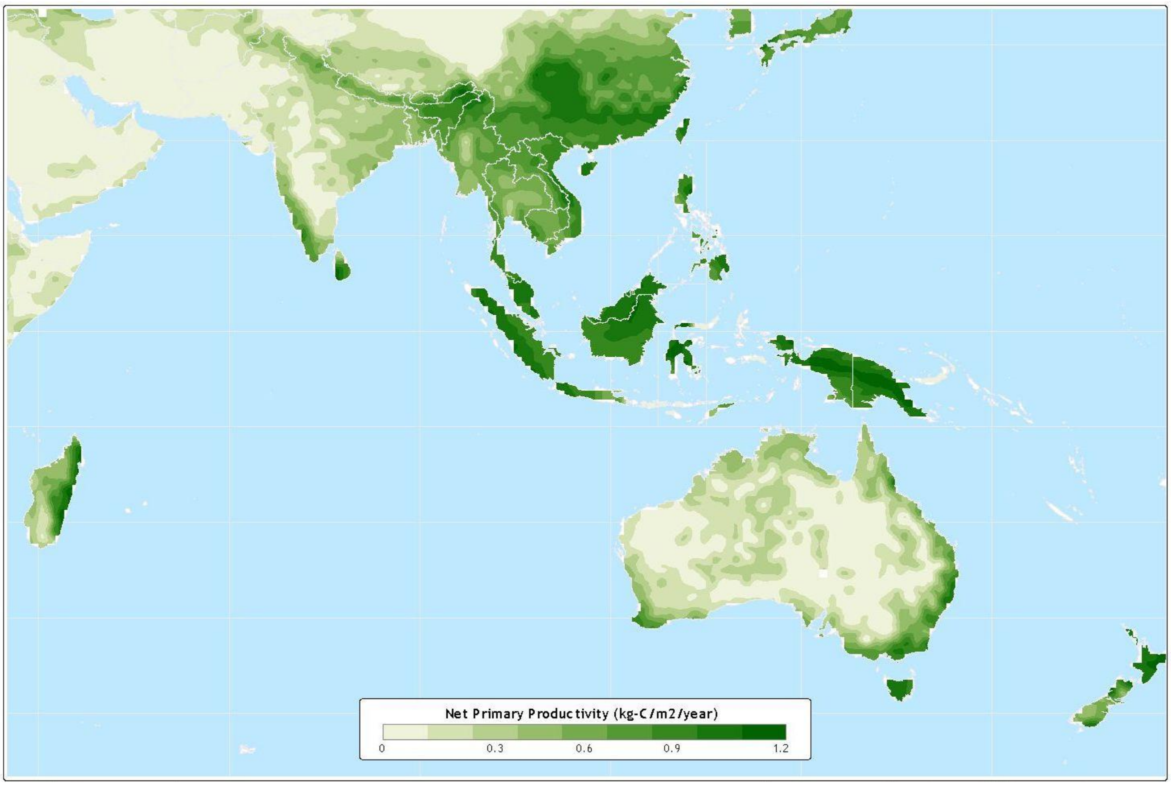
中国科协海智计划海南(海南大学)工作基地
海南大学环南海陆域生物多样性研究中心

2022 年报

Annual Report 2022



海南大学
HAINAN UNIVERSITY

2022 年海南省生态环境系统领导干部政治能力提升暨党务干部培训示范班圆满结束

为深入学习领会党的十九届六中全会、习近平总书记考察海南重要讲话和海南省第八次党代会精神，在 2022 年中国共产党第二十次全国代表大会来临之际，由海南省生态环境厅主办，海南大学生态与环境学院、海南无字教育服务管理有限公司联合承办的 2022 年海南省生态环境系统领导干部政治能力提升暨党务干部培训示范班于 2022 年 6 月 28 日至 30 日顺利召开。

海南省生态环境厅及各市县生态环境局主要领导共 54 人参加培训。海南大学生态与环境学院任明迅副院长组织和协调了培训班主要活动，并参加了开班仪式。海南省生态环境厅人事处苏俊处长在开班仪式上做了热情洋溢的开班讲话，鼓励大家认真学习、加强交流，实现能力有效提升，以更好地履行自己在实际工作中的职责。

此次培训班先后邀请了海南大学马克思主义学院吴朝阳副院长、海南大学马克思主义学院段捷频书记、海南大学副校长傅国华、海南省生态环境厅伍晓红副厅长和全占军总工程师为学员们授课。培训主题围绕习近平总书记十八大以来视察海南的系列重要指示批示精神、省第八次党代会精神、习近平生态文明思想、十九届六中全会精神以及海南禁塑与世界塑料污染治理、生态产品价值实现与实践路径等，通过图文并茂、深入浅出的讲解，引导参训干部解放思想、开拓创新、团结奋斗、攻坚克难，加快建设具有世界影响力的中国特色自由贸易港，让海南成为新时代中国改革开放的示范。

此次培训班的培训形式多样，既有紧张的授课，也有轻松愉快的国家公园精美风景与生物多样性的科普视频播放，以及无字教育公司带来的“海之蓝”凉粉美食和“六水共治”等主题的竞技棋盘游戏，受到学员们的广泛好评。

目 录

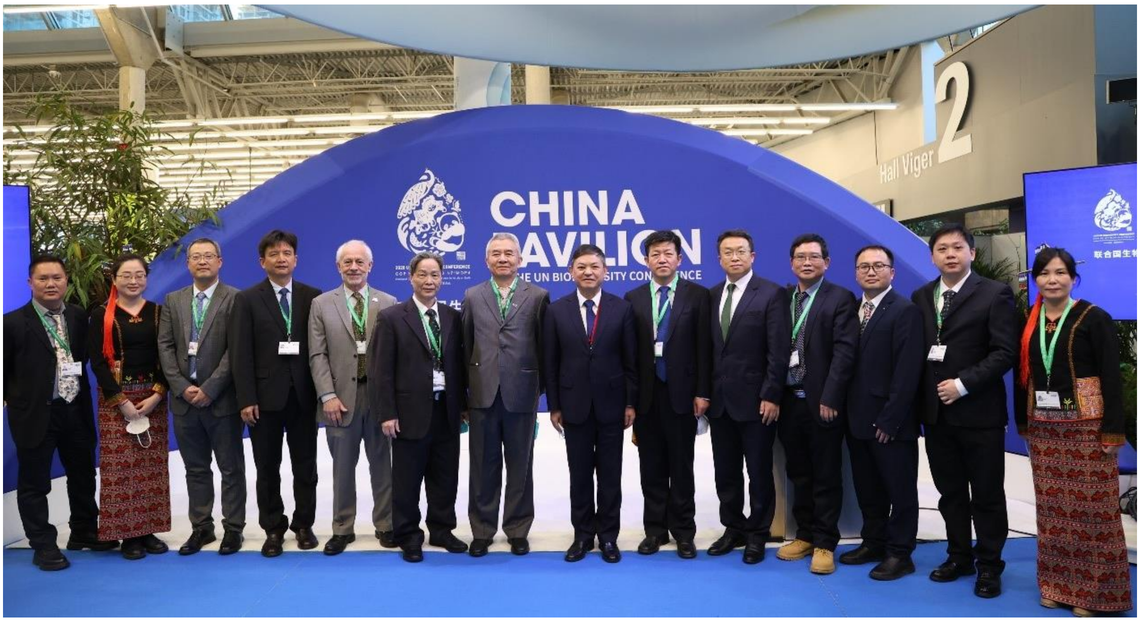
封面图片：环南海区域及周边地区的净初级生产力（制图：美国威斯康辛大学麦迪逊分校可持续与全球环境研究中心）。

中国角“海南日”展览宣介活动在 COP15 会议顺利举办

2022 年 12 月 7 日至 19 日，《生物多样性公约》第十五次缔约方大会（COP15）第二阶段会议在加拿大蒙特利尔顺利举办。会议期间，中国角通过 26 场不同主题的边会分享中国在生物多样性保护上的经验。当地时间 13 日下午，题为“中国海南热带雨林国家公园建设与生物多样性保护”边会在中国角举行。边会由海南省生态环境厅周学双总工程师主持，生态环境部赵英民副部长、IUCN 前主席章新胜先生、海南省林业局王楠副局长等分别作开幕致辞。COP15 组委会主席、国家生态环境部黄润秋部长在边会结束后专程看望了海南日活动的工作人员。

本次中国角“海南日”展览宣介活动由海南省生态环境厅和林业局共同举办，通过宣传展板、宣传片以及专题报告、讲解互动等多种形式，全方位推介海南热带岛屿型生态系统的特征、热带雨林的服务价值、海南特有明星物种以及海南响应国家战略开展生态系统保护修复和实施乡村振兴的生动实践，向世界展示了国家生态文明试验区建设、海南热带雨林国家公园建设、社区可持续发展、“两山”理论实践以及生物多样性保护的丰硕成果，讲述了海南生物多样性保护与可持续发展故事。

工作基地负责人任明迅教授做了现场专题报告，以“Traditional biodiversity knowledge in local agricultures of Hainan Island, China”为题，展示了海南当地少数民族黎族的传统文化，包括传统纺纱、染色、织造和黎族的刺绣技巧；介绍了生物多样性传统知识的利用，包括使用植物纤维、棉花和提取物，传统陶器制作、晒盐，旱地水稻种植、野生稻和当地品种等；阐述了传统知识在海南生物多样性保护和文化传承教育中的作用；指出了利用现代分子生物学技术揭示传统农业文化中的科学原理和资源循环利用理念，可为当代生物多样性保护和现代高效农业发展提高宝贵经验与珍稀品质资源。



一、中心概况

海南大学环南海陆域生物多样性研究中心于 2017 年 7 月正式成立，同年 11 月受海南省科学技术协会资助，成为海南大学首家“海外智力为国服务行动计划”工作站。2020 年 6 月，在整合海南大学相关学科引进的海智专家与骨干教师的基础上，成为中国科学技术协会海智计划海南（海南大学）工作基地。现任学术委员会主任李百炼教授（美国加利福尼亚大学河滨分校）、工作基地/研究中心负责人任明迅教授（海南大学生态与环境学院）。

中国科学技术协会海智计划海南（海南大学）工作基地和海南大学环南海陆域生物多样性研究中心实行“两位一体”的建设模式，聚焦海南岛、粤港澳大湾区、台湾地区以及环南海区域，集中开展海外智力引进、科技合作与交流、人才培养等，积极担当起海南大学在践行“一带一路”国家战略和国家生态文明试验区（海南）建设中的作用，力争成为环南海生物多样性与生态文化研究中心、区域合作与交流中心。

目前设置三个研究方向：（1）生物多样性与生态保育；（2）环南海区域生态安全；（3）传统生态文化与当代生态文明建设。

已与美国加州大学河滨分校、美国佛罗里达国际大学、日本东京大学、荷兰瓦赫宁根大学、美国夏威夷大学、德国莱布尼兹热带海洋研究中心、德国亚琛工业大学以及环南海地区的新加坡南洋理工大学、新加坡国立大学、新加坡植物园、柬埔寨皇家农业大学、菲律宾大学内湖省分校、越南 Ton Duc Thang 大学、中国台湾与香港地区多家机构签订了合作协议或开展过实质合作。

5 年以来，积累了大量的野外调查、科学实验和理论研究数据，从环南海区域收集了战略植物资源（热带作物野生近缘种、药用植物、油料植物、观赏植物

等）近 3000 份（含植物活体、腊叶标本、DNA、种子等）。

在中国科协、海南省科协和海南大学的指导与支持下，工作基地/研究中心大力开展海外智力为国服务行动计划，积极引进美国、日本、新加坡等地知名华裔学者与当地专家，开展聚焦海南省和环南海区域生态环境、生物多样性领域的合作研究与人才培养。目前，已引进海外智力专家有：

专家	国籍（是否华裔）	工作单位	研究领域
李百炼 Larry Bai-Lian Li	美国（华裔）	加利福尼亚大学河滨分校	人类生态学、生态规划
刘虹 Hong Liu	美国（华裔）	佛罗里达国际大学	生物多样性保护
任添荣 Yam Wing Tim	新加坡（华裔）	新加坡植物园	兰花保育与新品种选育
练春兰 Chunlan Lian	日本（华裔）	日本东京大学	森林资源与生态学
邹乐明 Chou Loke Ming	新加坡（华裔）	新加坡国立大学	珊瑚礁生态
张金龙 Jinlong Zhang	中国（华裔）	中国香港嘉道理农场暨植物园	植物分类与资源收集
谢宗宇	中国台湾（华裔）	中国台湾民享生态调查公司	生物多样性、 自然教育
张浩	中国香港（华裔）	中国香港高等教育研究院	生态规划
Pastor L. Malabrigo	菲律宾（非华裔）	菲律宾大学内湖省分校	植物多样性与生态文化
Sandra Yap	菲律宾（非华裔）	菲律宾远东大学	热带植物多样性
Van The Pham	越南（非华裔）	越南 Ton Duc Thang 大学	植物多样性
Vu Van Lien	越南（非华裔）	越南国家自然博物馆	生态环境
Wattana Tanming	泰国（非华裔）	泰国清迈诗丽皇后植物园	热带植物多样性护
Erizal Sodikin	印尼（非华裔）	印尼 Sriwijaya 大学	热带农业资源
Fabio Pinheiro	巴西(非华裔)	巴西 Campinas 大学	植物保育遗传学
Jordi Lopez-Puyol	西班牙(非华裔)	西班牙巴塞罗那植物所	岛屿植物 生态与保育

二、定位与研究方向

中国科学技术协会海智计划海南(海南大学)工作基地和海南大学环南海陆域生物多样性研究中心，以海南大学近五年引进的生态学与生物学专业青年人才为骨干，联合和引进海内外高端智力，聚焦海南省与环南海区域的生物多样性与生物资源、区域生态安全与生态服务功能优化与提升、传统生态文化与当代生态文明建设研究，主要服务国家“一带一路”战略、国家生态文明试验区(海南)、海南热带雨林国家公园以及中国特色自由贸易港建设。

（一）生物多样性与生态保育

主要针对海南省和环南海区域(海南岛、台湾岛、菲律宾群岛、婆罗洲、马来半岛、中南半岛等)，开展重要战略植物资源如重要作物野生近缘种、特色林木花卉等的发掘、引种与基础生物学研究。针对海南岛热带雨林、淡水湿地、珊瑚礁、红树林与城市关键海岸带等，揭示生物多样性形成与维持机制、解析关键生态过程、开展退化生态系统恢复研究，优化与提升重要生态系统的生态服务功能等，保障和提升海南省生态安全。

（二）环南海区域生态安全

针对海南省地处中国大陆与东南亚的中间地带、位于中国南方生态屏障前沿及“一带一路”关键节点等特点，利用集中引进环南海区域海智专家的基础，从海南岛、南海岛礁、粤港澳大湾区、环南海区域等不同尺度开展海南岛生态安全及关键生态系统生态服务功能优化与提升、区域环境安全与生态文明建设等合作研究与交流，为海南热带雨林国家公园、国家生态文明试验区等“三区一中心”建设保驾护航。

（三）传统生态文化与当代生态文明建设

发掘海南省及环南海区域的优秀生态文化，特别是入选国家级文化遗产与非物质文化遗产如洋浦千年古盐田晒盐技艺、琼中山兰稻作文化系统，以及有望申报农业文化遗产的木棉-稻田农林复合系统、五指山牙胡梯田等，从现代科学理论与技术角度，揭示其生物学基础与生态学原理，实现“把论文写在海南大地上”。同时，探索传统生态文化的现存价值及其在当代社会中的传承与利用途径，助力乡村振兴，提升海南地方民族及中华民族的文化自信、民族自信，通过生态文化和环境美化两个维度丰富生态文明建设内涵，打造国家生态文明试验区的“海南样板”。

三、大事记

➢ 中国工程科技发展战略海南研究院咨询研究项目结题

2022 年 3 月 20 日，工作基地/研究中心首席海智专家李百炼和负责人任明迅联合主持的中国工程科技发展战略海南研究院咨询研究项目《国家生态文明试验区(海南)背景下热带雨林国家公园体制机制创新研究》结题评审会在线上召开。来自新疆额尔齐斯河流域开发工程建设管理局的邓铭江院士、北京师范大学国家公园研究院张希武研究员（国家公园与自然保护地主任委员）、国务院发展研究中心苏杨研究员、浙江工商大学张海霞教授（自然资源学会国家公园专委会委员）、海南国家公园研究院汤炎非教授（执行院长）、海南大学龙文兴教授（海南国家公园研究院理事）、中国工程科技发展战略海南研究院李丽主任，以及项目组其他成员等 10 余人参加了会议。

项目汇报人任明迅教授系统介绍了项目背景、主要内容、调研活动、成果与应用等，详细汇报了项目关于海南热带雨林国家公园生态功能的空间分异、中线高速公路对国家公园生态风险影响、木棉-稻田农林复合系统以及参与国家公园管理体制机制创新等方面的研究内容。邓铭江院士等评审专家对项目进展与成果进行综合评审，提出了宝贵建议。与会专家一致同意该项目结题。

➢ 积极参与海南大学“一院一校”国际化办学计划

依托工作基地/研究中心的国际合作研究基础，海南大学生态与环境学院成功获批 2 项海南大学“一院一校”国际化办学计划，分别是：战略合作伙伴项目(新加坡国立大学)、高端外专引智项目(新加坡南洋理工大学)。这使得我院和生态学

科成为我校唯一同时获批两项“一院一校”项目的学院和学科。

2021 年 12 月邀请了新加坡科学院邹乐明院士向海南大学生态与环境学院研究生讲授了《海洋生态学》课程。签订了合作协议。

此外，工作基地/研究中心和菲律宾大学筹建的环南海陆域生物多样性研究中心也进入了学校的国际联合科研平台培养项目库，将经过 2 年的合作研究与联合培养学生，积极申报中国科协“一带一路”国际科技组织合作平台建设项目。

➢ 获一项国家自然科学基金、五项海南省自然科学资金项目资助

工作基地/中心获批 1 项国家自然科学基金青年科学基金项目（负责人：张哲，资助经费：30 万元）；5 项海南省自然科学基金，其中包括面上项目 1 项：氮沉降驱动下海南霸王岭不同海拔森林土壤挥发性有机物排放动态及其影响因素研究(负责人：何禾，资助经费：8.00 万元)；青年基金 2 项：木棉-稻田体系中木棉花分解的养分动态及微生物机制(负责人：王文娟，资助经费：6.00 万元)；海南岛山地雨林优势树种陆均松和鸡毛松对不同水热条件的分子适应机制(负责人：凌少军，资助经费：6.00 万元)；高层次人才项目 2 项：五唇兰（兰科）的适宜生存区预测与谱系地理格局(负责人：张哲，资助经费：10.00 万元)；第四纪气候变化对海南岛及周边地区风筝果种群遗传结构和动态的影响(负责人：谭珂，资助经费：10.00 万元)。

➢ 组织出版了《热带生物学报》“中国国家公园”专辑

2022 年 2 月，工作基地/研究中心负责人任明迅教授联合海南大学林学院宋希强院长担任专辑召集人，在海南大学主办的《热带生物学报》上组织 “中国国家公园”专辑顺利出版。该专辑包括了 11 篇研究论文，涉及武夷山国家公园、大

熊猫国家公园、三江源国家公园、海南热带雨林国家公园等 4 个国家公园，内容覆盖国家公园空间规划、生物多样性调查与保护、生态系统服务功能、生态修复、社区生计、游憩与科普等多个方面，起到了促进国家公园研究进展与争鸣的积极作用，提升了海南大学的知名度与影响力，对促进海南省建设海南热带雨林国家公园、国家生态文明试验区等具有积极意义。

➢ 《海南热带雨林国家公园高速公路穿越段的环境监测与生态恢复技术》项目取得新进展

李百炼院士和任明迅教授联合主持的海南省院士创新平台科研专项《海南热带雨林国家公园高速公路穿越段的环境监测与生态恢复技术》，执行期为 2020-2023 年，经费 50 万元。项目组经过连续 3 年的实地调查、物种基因流分析及模型估算，研究了海南热带雨林国家公园的道路变化历史、景观动态及生态风险现状。最新研究发现，高速公路穿越段对海南热带雨林国家公园局域生态系统的影响目前较小。但是，道路伴随的生境隔离作用、噪音、污染等具有长期效应，存在一定的潜在风险，导致高速公路两侧的植物物种遗传分化。提出了应加强生境连通性、生态过程连续性和生态系统完整性以及防范道路径流对水体和农田的污染等建议，为海南热带雨林国家公园的生态修复、保护生态系统原真性和完整性、优化与提升生态服务功能提供了依据。

部分研究成果已在《生态学报》和《热带生物学报》发表。

➢ 参与荣获海南省自然科学奖一等奖、二等奖各 1 次

2022 年，工作基地/研究中心杨小波教授、任明迅教授作为主要完成人（分别排名第一、第六）的“《海南植物图志》编研及珍稀保护植物分布特征研究”

获得 2021 年度海南省科学技术奖自然科学奖一等奖。该成果全面系统地挖掘研究了海南植物资源，文图并茂地出版了《海南植物图志》1-14 卷，达 1000 多万字，不仅摸清了海南的植物种类的家底，直接为“海南热带雨林国家公园”的建设和植物种质资源可持续利用等国家发展战略服务。《海南植物图志》和《海南珍稀保护植物图鉴与分布特征研究》已经成为海南省和国内外科技工作者研究和保护海南植物的必备工具书。

博士后张哲博士作为第二主要完成人参与的“海南野生兰科植物生物多样性及其保护”获海南省自然科学二等奖。该成果首次系统地开展了海南全省范围的野生兰科植物调查；预测了海南特有兰科植物华石斛的潜在适宜生境和分布范围；阐明了内生真菌和内生细菌对兰科植物的促生潜力，揭示了兰科植物内生微生物的互作机理；突破了组织培养增殖技术、多倍体育种技术、种子共生萌发技术、内生微生物筛选与鉴定技术、原生境重引入技术和菌根育苗技术等关键技术瓶颈，建立了一套资源可持续保护与利用的关键技术体系，助力农民精准脱贫。

此外，张哲博士担任总导演、制片人和出镜解说制作的海南热带雨林国家公园科普视频系列获得中国科学技术学会举行的“典赞•2022 科普中国”提名。

➢ 与海南无字教育服务管理有限公司合作签订合作协议

2022 年 5 月 4 日，工作基地与海南无字教育服务管理有限公司合作签订战略合作协议。双方本着“优势互补、合作共赢、共同发展”的原则，基于双方文化与发展理念的高度认同及各自优势，建立合作伙伴关系，加强双方在生物多样性、国家公园、传统文化传承与宣传等青少年研学、科普及新技术推广等领域合作。

在此基础上，先后在海南昌江、海口美舍河凤翔湿地公园、琼中县无字教育虎岭科普研学基地合作开展了木棉生态及木棉文化科普；合作参与了海南省第十八届科技活动月暨万名大学生乡村科普行；在保亭县响水镇毛岸小学、白沙县青松乡中心学校、元门乡中心学校、琼中县什运中心小学、东方市江边乡中心小学、乐东县尖峰镇中心学校、五指山市水满乡中心学校、昌江黎族自治县王下乡中心学校等中小学，开展了以“建设生态文明，推进热带雨林科普”为主题的热带雨林自然教育系列科学普及活动。

四、代表性成果

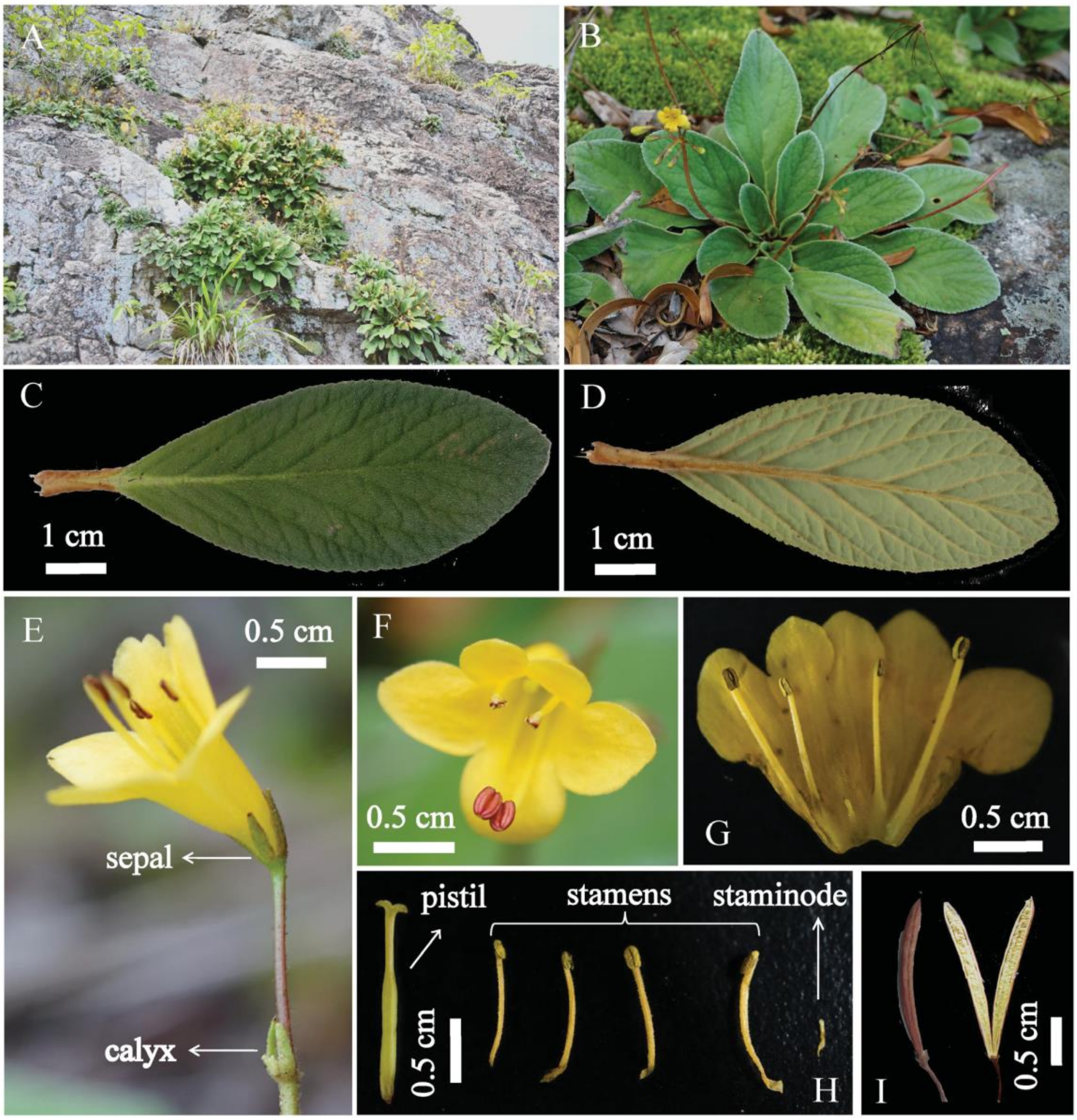
➢ 研究方向一：生物多样性与生态保育

工作基地/研究中心骨干成员任明迅教授、王文娟博士、向文倩博士等参与了海南省重大科技计划《木棉新优品种选育及产业化关键技术研究与示范》项目（执行期：2021-2023 年，总经费：722 万元），目前已开展昌江县木棉种植资源调查、种子繁育测定、嫁接繁殖等研究。任明迅教授还参与了海南省重大科技计划《红树林资源保育与生态恢复关键技术研究与应用示范》项目(2020-2023 年，总经费 1000 万；工作基地可支配经费 70 万元)，探究了半红树植物黄槿的遗传多样性及根系微生物，弄清了滨海盐场的濒危红树植物与耐盐微生物的来源，对进一步开展濒危红树植物评估和红树林退化机理研究等具有积极作用。

在对环南海区域苦苣苔科线柱苣苔属、马铃苣苔属的野外调查研究基础上，结合形态学与分子生物学证据，发现海南岛一个特有的马铃苣苔属(*Oreocharis*)新种：海南马铃苣苔(*Oreocharis hainanensis* S.J.Ling & M.X.Ren)。该种生长在海南岛低海拔裸露石灰岩、耐旱耐贫瘠，是苦苣苔科马铃苣苔属在此类生境生长的唯一物种；花冠亮黄色，花冠筒钟状，具有较高的园艺引种价值，是海南岛热带雨林原真性和完整性的一个有力证据(DOI：10.11646/phytotaxa.538.4.2)。

在我国特有的苦苣苔科圆唇苣苔属(*Gyrocheilos*)中发现了一种独特的花柱侧偏弯折现象。圆唇苣苔属所有物种的花柱侧偏且花柱顶端呈 90° 弯折，使得柱头位于花开口的中央位置。这种独特的花柱侧偏弯折现象可能来源于近缘的长蒴苣苔属(*Didymorcarpus*)的花柱下弯现象或镜像花(mirror-image flowers)。这种侧偏

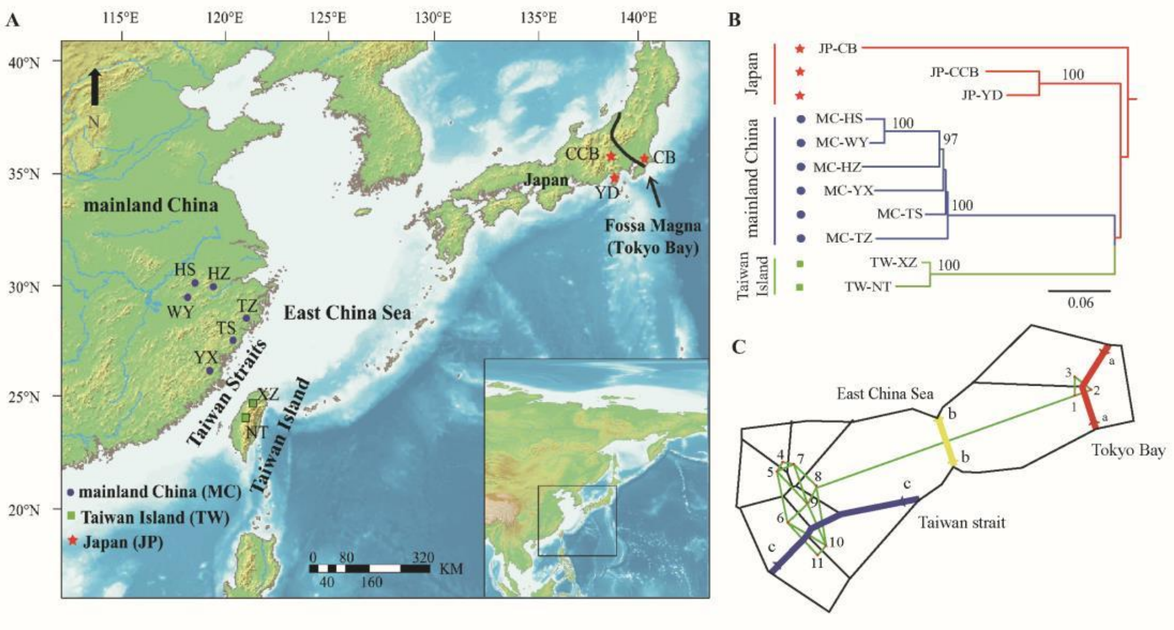
弯折的花柱，可能通过提供昆虫降落平台和使得柱头位于花开口中央和花瓣下唇的上方位置，提高了柱头接触访花昆虫的几率，是适应高海拔地区低频率访花者的一种机制（DOI:10.11931/guihaia.gxzw202112007）。



海南热带雨林国家公园特有的海南马铃苣苔(Phytotaxa, 2022, 538(4): 281-291)

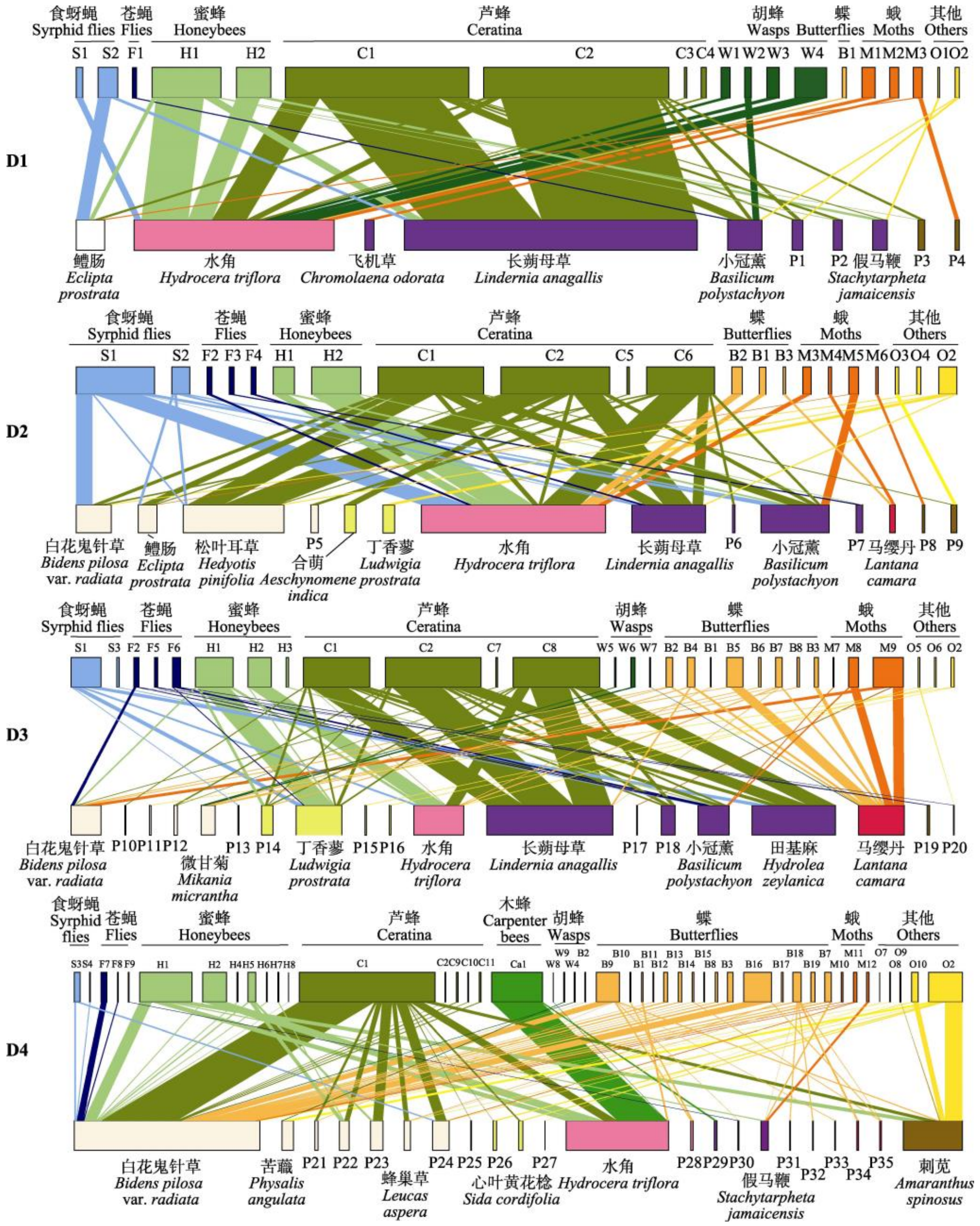
通过对间断分布于中国大陆、台湾岛和日本的孑遗植物苦苣苔(Conandron ramondioides)的 11 个种群进行简化基因组测序(ddRAD)研究发现，中国大陆、台湾岛和日本三个区域种群遗传分化极大，基因流受限；中国大陆和日本支系起源于一个共同祖先，分化于大约 11.85 Ma，台湾岛支系于大约 4.05 Ma 从中国大陆

支系分化而来。通过构建苦苣苔整个分布区域 SDM 模型发现，台湾岛支系和日本支系在末次盛冰期经历了明显的扩张，中国大陆和台湾岛支系在当前时期经历了明显的收缩，台湾岛支系适宜分布区域在未来时期会扩张，且中国大陆+台湾岛支系和日本支系存在明显的生态位分化（DOI：10.1111/jse.12937）。



中国大陆、台湾岛和日本三个区域的苦苣苔遗传关系（Journal of Systematics and Evolution, 2022）

通过对比分析海南岛海口市南郊的羊山湿地 4 个样地在旱季（5 月）与雨季（8 月）的传粉网络及其动态变化，揭示了揭示湿地生态系统的传粉网络结构特征以及在干湿季的变化规律。指出羊山湿地传粉网络共有 71 种开花的植物，131 种传粉者，传粉网络呈现低连接度、高嵌套度、中等网络特化程度的结构特征。4 个样地旱季的植物与传粉者种类高于雨季，而传粉网络的连接度、嵌套度与网络特化程度没有明显的季节差异。总体而言，羊山湿地物种多样性较高，边缘效应较明显，传粉网络结构较稳定（植物生态学报，DOI: 10.17521/cjpe.2021.0281）。



海南岛羊山湿地 4 个样地(D1-D4)旱季授粉网络（植物生态学报，DOI: 10.17521/cjpe.2021.0281）

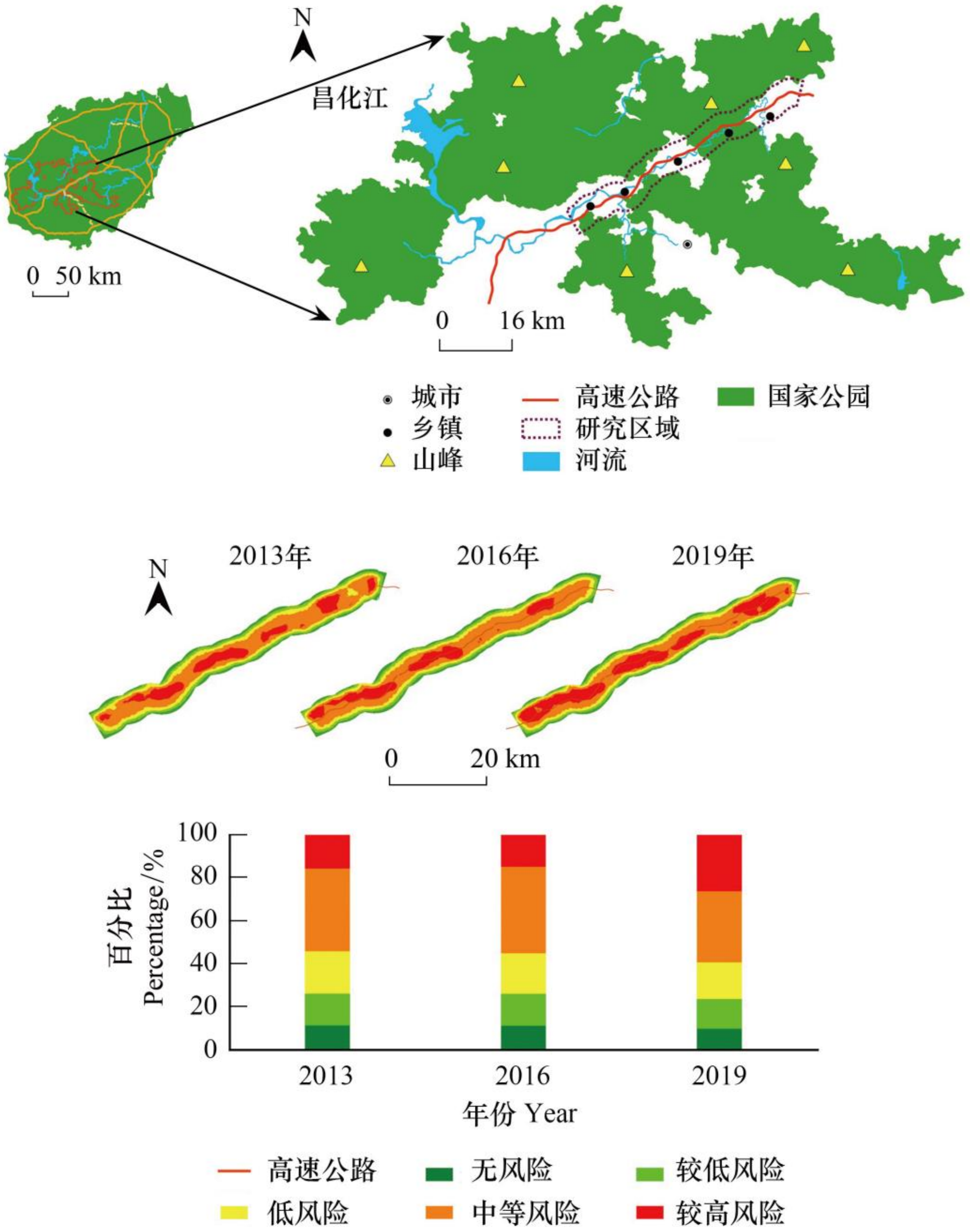
迄今为止，从环南海区域采集的战略植物资源（热带作物野生近缘种、药用植物、油料植物、观赏植物、亚洲热带植被建群种等）共有秋苦苣苔科、金虎尾科、木棉科、梅花草属、海棠科、兰科、唇形科、旋花科、风毛菊属以及苔藓植物腊叶标本约近 2000 份、DNA 种质资源近 3000 份。

➢ 研究方向二：环南海区域生态安全

参与承办了 2022 年 6 月 28 日至 30 日举行的海南省生态环境系统领导干部政治能力提升暨党务干部培训示范班；先后参加了三江源国家公园管理局、白沙县、儋州市等地方领导干部能力素质提升暨生态文明建设专题研讨班的授课等。

海南热带雨林国家公园被中线高速公路自东北-西南方向穿越，改变了局域景观分布格局，影响到生态系统完整性与原真性，可能存在潜在的生态风险。利用 2000、2010 和 2019 年海南热带雨林国家公园涉及的道路分布和土地利用数据，以及不同等级道路两侧的景观变化趋势表明，目前道路对国家公园景观的影响较小，但由于道路存在较明显的累加效应及传播作用，仍然需要注意道路对国家公园生态系统原真性和完整性的可能影响，建议加强大型道路如高速公路道路径流的汇流与净化、道路两侧生态廊道、长期环境监测等方面的研究。

2016 年高速公路建成后，林地面积略有减少，耕地最大斑块指数和景观优势度降低，林地和耕地斑块的内聚力指数下降，自然连通度略降低，破碎化程度加剧；高速公路穿越段中等生态风险区和较高生态风险区面积逐年增加。但隧道和高架桥路段在一定程度上维持了道路两侧的植被连通性，对局域生态系统没有明显影响。高速公路造成的生境隔离与破碎化可能累积产生远期的负面生态学效应。海南热带雨林国家公园高速公路穿越段位于生态敏感的水源涵养区，建议增设隧道式高架林地提升生境连通性和生态系统完整性、增加人工湿地汇聚和净化道路径流、设立长期生态监测样地对关键节点生态过程与生态系统功能特别是水源涵养与水质净化功能等开展监测与生态恢复。



海南热带雨林国家公园高速公路穿越段及不同等级生态风险的分布和比例

➢ 研究方向三：传统生态文化与当代生态文明建设

为贯彻落实习近平总书记“希望广大科技工作者以提高全民科学素质为己任，把普及科学知识、弘扬科学精神、传播科学思想、倡导科学方法作为义不容辞的责任”的指示，工作基地/研究中心任明迅教授主动带队，带领张哲博士、谭珂博

士、向文倩博士、魏雅丽博士研究生等积极参与海南岛各项科普活动及社区志愿者活动，深入浅出地向大众科普海南热带雨林国家公园中特殊的雨林奇观和独特的传统文化，以及海南传承千年的洋浦盐田晒盐技艺、木棉-稻田农林复合系统、滨海红树林生态与保护等，提高海南大众的科学知识和民族自信。将科研成果用通俗易懂的方式走进大众，积极推动形成讲科学、爱科学、学科学、用科学的良好氛围。

科普大讲堂
海南雨林生态与文化
【特邀讲师】任明迅
海南大学三级教授
博士生导师
海南省领军人才
主要从事生物多样性
与生态文化研究与教学工作
2022.11.15
10:00
扫码进入直播间

传统生态文化及其现代传承
系列讲座(第二讲)

报告题目：洋浦千年古盐田——国家级非物质文化遗产中的生态智慧

报 告 人：魏雅丽
(海南大学生态与环境学院)

报告时间：2022年4月21日
8: 30 - 9: 30

线下地点：海南观澜湖双优实验学校三楼会议室

扫描二维码直接观看
腾讯会议：108601434
主 持 人：任明迅

组织机构：中国科协海智计划海南(海南大学)工作基地
海南无字教育服务管理有限公司

工作基地/研究中心组织多项科普活动

1. 制作海南热带雨林国家公园科普系列视频及科普推文

工作基地/研究中心张哲博士后(合作导师：任明迅教授)在海南省林业厅智慧雨林中心的资助下，牵头组织了海南热带雨林国家公园的科普系列视频。任明迅教授、凌少军博士、谭珂博士、向文倩博士等参与录制，分别推出了《植物篇：

海南马铃苣苔》、《雨林生态篇：翅果》、《植物篇：木棉》，累计播放量达 11 万。此外，张哲博士后还牵头组织海南热带雨林国家公园系列科普推文，工作基地/研究中心参与撰写《当海岛遇上“天岛”：海南岛生物多样性的“巅峰之作”》、《“走出印度”龙脑香科的起源与扩散》、《翅果——风之旅者》、《除了雷公马，你还知道海南有哪些雷公？》、《当草本植物学会和台风“躲猫猫”》、《岛屿“兄弟”的反差发育》、《绝情谷之昌化江河谷》、《木棉：黎族稻田上的守望者》等，引领了海南省科学普及工作。

这些科普系列视频和科普推文是在海南省林业局（海南热带雨林国家公园管理局）、智慧雨林中心资助和指导下完成的宣传海南热带雨林国家公园的官方素材，具有较高的学术价值和人文价值。这些视频和推文雅俗共赏、寓教于乐、文理兼容，通过网络传播，快速高效地宣传了海南热带雨林国家公园的建设成效以及海南本土优秀生态文化，提升了海南国家公园和生态文明建设形象。

2. 揭示洋浦古盐田的生态学基础和耐盐微生物种质资源

工作基地/研究中心聚焦儋州洋浦千年古盐田（2008 年入选国家级非物质文

化遗产），开展微生物宏基因组学、特异微生物类群及生态过程等方面的研究。初步解析了洋浦盐田晒盐技艺的生物多样性基础与生态学原理，确定了关键微生物类群及其功能（Science of the Total Environment, 2022, 819, 152014. 中科院一区top，影响因子 10.75）。

在此基础上，深入挖掘古盐田特殊的反复晒泥及火山石晒盐阶段发现，“火山岩石槽晒盐”这一关键环节调节了耐盐微生物群落结构，促进了火山岩有益微量元素如硒、钵、锰等进入盐中，使得古盐田的成品盐独具风味且富含有益成分。

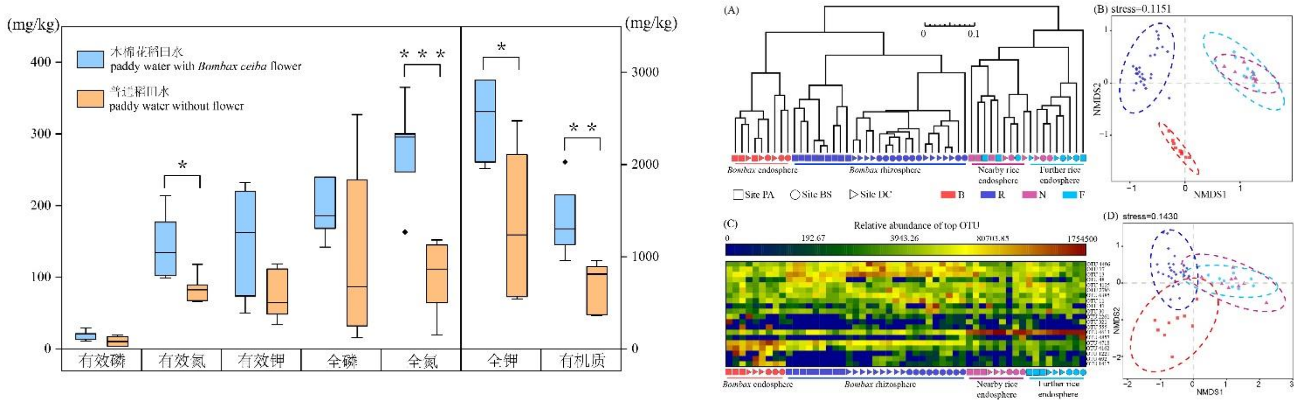
工作基地/研究中心还配合海南省科学技术协会梁海珠一级巡视员主持的民盟海南省委重点调研课题《以传统生态文化促进海南省全民科学素养提升的调查研究》，深入调研洋浦千年古盐田的传承现状与创新路径，提出要结合现代科技成果，打造“火山岩盐”品牌，提升制盐质量和经济附加值，助力乡村振兴和国家非物质文化遗产的传承与利用。

火山石上晒盐过程形成了硒锶含量较高、风味独特的“火山石盐”

3. 木棉-稻田农林复合系统的资源循环过程与生态学基础

工作基地/研究中心深入研究了亚洲热带地区特有的“木棉-稻田农林复合系统”的生物学基础与生态学原理，发现（1）木棉树的存在显著提高了稻田土壤营养元素水平尤其是速效钾和土壤有机质的含量，同时改变了土壤细菌和真菌群落组成和多样性（Plant and Soil, 2022, 479(1): 543-558）；（2）木棉花掉落区的稻田水营养元素水平显著高于无木棉的稻田水，尤其是有效氮、全氮、全钾、有机质等的含量；（3）木棉具有生物防治的作用：木棉花吸引大量杂食性鸟类和害虫天敌，使得有木棉稻田的水稻害虫(稻飞虱、稻蓟马、大叶蝉等)的类型和数量均显著低于无木棉的稻田；（4）木棉提高了稻田物种多样性和生态系统稳定性，保存着当地的一些珍稀物种和残留的本底植被，增强了局域生境异质性和生物多样性（生物多样性, 2022）。

该系列研究成果都证实了海南昌江等地传统的木棉-稻田农林复合系统具有资源循环利用的朴素理念与传统耕作方式，蕴含着丰富的传统生物多样性知识与农耕文化，有望打造“木棉稻米”品牌、申报“中国重要农业文化遗产”。

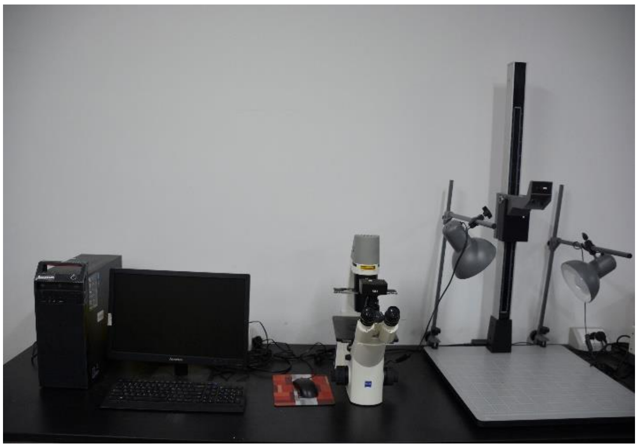


木棉树的存在显著提高了稻田土壤、稻田水的营养元素水平

五、平台建设

1. 分子生态学实验室

2. 植物形态分析实验室



3. 植物化学分析室

4. 陆基珊瑚养殖基地

万宁市山根镇的繁育区与养殖区（30 亩）

珊瑚幼体生长情况

珊瑚排卵与受精生长

5. 资源收集与保存

➢ 植物昆虫标本库

➢ 真菌标本库

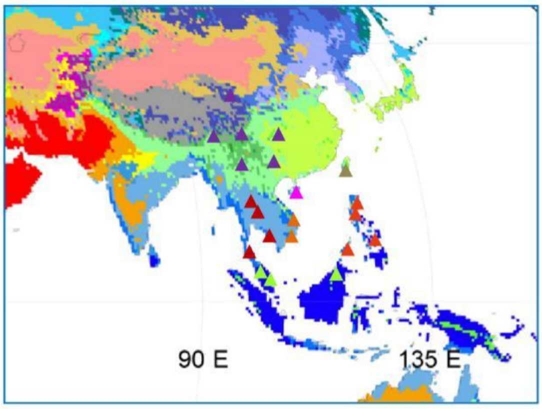
➢ 引种资源圃

➢ 野外重点采集与研究区域

▲ 广西和云南(横断山区)

▲ 台湾(恒春半岛、兰屿)

▲ 海南(霸王岭、尖峰岭)



▲ 菲律宾(吕宋岛、巴拉旺岛)

▲ 泰国(清迈、清莱)

▲ 越南(芽庄、巴拿山)

▲ 泰国(巴蜀、芭提雅)

▲ 马来西亚(沙巴、森美兰)

马来西亚（Kaki Bukit Tabur）

肯尼亚（Kilifi）

菲律宾（Arayat）

六、合作与交流

- 2022 年 1 月 4 日，参加了海南省重大科技计划项目《木棉新优品种选育及产业化关键技术研究与示范》工作启动会，将主要承担木棉栽培生态与木棉文化旅游资源研究。

- 1 月 12 日，在昌江王下乡参加了海南省重大科技计划项目“木棉新优品种选育及产业化关键技术研究与示范” 实地调研。

- 1 月 26 日，海南省科协林强副主席一行来访，慰问了工作基地。

- 2 月 11-12 日，任明迅教授、张哲博士、向文倩博士受邀参与“霸王岭热带雨林生态多样性及木棉全身是宝”研学活动。

- 2 月 12 日，工作基地/研究中心联合中国热科院环植所、海南无字教育公司以及多家相关企业，在昌江县举行了《昌江县文化和旅游产业融合发展研讨会》。

- 2 月 13 日，向文倩博士受邀参与海南热带雨林国家公园的科普系列视频《植物篇：木棉》录制。

Japan Society for the Promotion of Science 日本学術振興会

CERTIFICATE OF APPRECIATION

This is to certify that

Xiaolan Yao

has contributed as

Presenter

(Oral Paper for Research Group Session)

in the virtual symposium of **The 2nd International Symposium of Long-term Forest Monitoring Research in Asia**: "a research hub of long-term forest monitoring field centers on environmental changes and ecosystem responses: Collaborating for data, knowledge, and young researchers"
March 12-13, 2022

鎌田

Naoto KAMATA
Project Leader of the Japan Society for the Promotion of Science (JSPS)
Core-to-core Program Director, The University of Tokyo Chiba Forest

Sri RAHAYU
Local Coordinator,
Universitas Gadjah Mada

- 3 月 12-13 日，姚小兰博士生受邀参加第二届亚洲森林长期监测国际研讨会，并作学术报告《Ecosystem services and conservation priority regions of the Hainan Tropical Rainforest National Park in China》。

- 3 月 13 日，向文倩博士受邀参与在海口市美舍河凤翔湿地公园举办的“赏海口三月木棉红•观湿地鸟类和谐园” 春季湿地科普研学活动。

- 3 月 19 日，任明迅教授、张哲博士为三江源国家公园管理局骨干人员做了关于深化国家公园改革发展的研讨班授课。

《国家生态文明试验区（海南）背景下
热带雨林国家公园体制机制创新研究》
咨询研究项目结题汇报

项目负责人：李百炼
项目汇报人：任明迅

2022年3月20日

- ➢ 3 月 20 日，由美国加州大学河滨分校李百炼院士和海南大学任明迅教授联合主持的中国工程科技发展战略海南研究院咨询研究项目通过评审。

- ➢ 4 月 21 日，魏雅丽博士生受邀参加传统生态文化及其现代传承系列讲座，在海口市的观澜湖双优实验学校作了科普报告。

- ➢ 5 月 4 日，工作基地/研究中心与海南无字教育服务管理有限公司签订了合作开展科学普及和科技活动的合作协议。

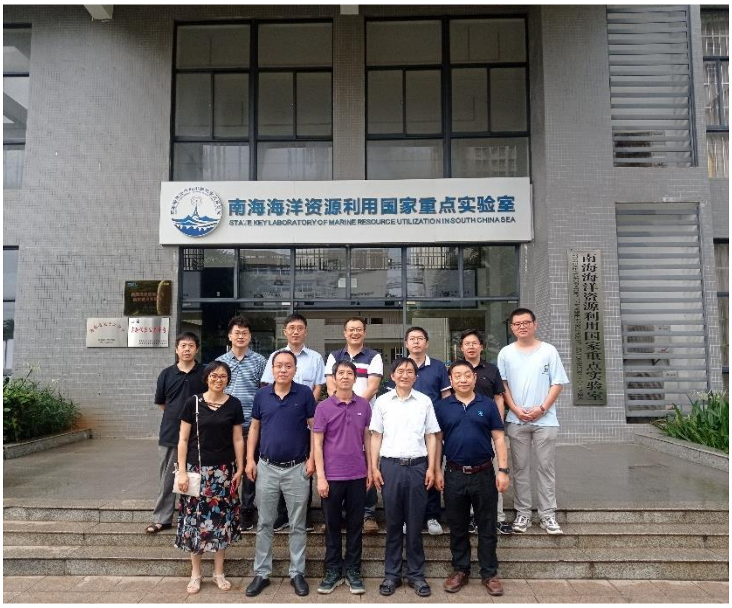
➢ 5月9日，魏雅丽博士研究生受邀在琼中县斧头岭宣传木棉的生态价值、药用价值、食用价值、木棉文化等。

➢ 5月18日，任明迅教授、向文倩博士、魏雅丽博士研究生等参加海南省第十八届科技活动月暨万名大学生乡村科普行启动仪式。

➢ 5月19日，任明迅教授带队参加海南省乡村振兴电视夜校广播版《乡村振兴越做越有》的录制，并接受了媒体采访。

- ➢ 5 月 20 日，任明迅教授、张哲博士、谭珂博士等人受邀参加在五指山市气象局举办的国际生物多样性日社区教育嘉年华活动。

- ➢ 5 月 30 日，任明迅教授参加了海南省科协举办的 2022 年海南省“全国科技工作者日”海南省科技工作者代表座谈会。



- ➢ 6 月 10 日-11 日，参与邀请了西北大学王文教授、中国科学院水生生物研究所何舜平研究员、浙江大学方盛国教授、西北工业大学王瑞武教授来访交流。

- 6 月 23 日，谭珂博士受邀在保亭县响水镇毛岸小学作了《热带雨林科普——石灰岩植物的生存策略》的科普课程。

- 6 月 30 日，谭珂博士受邀在白沙黎族自治县青松乡中心学校介绍了海南热带雨林独特的雨林奇观和海南长臂猿的保护。

- 6 月 28 日至 30 日，海南省生态环境系统领导干部政治能力提升暨党务干部培训示范班圆满结束。

- 7 月 1 日，谭珂博士受邀在白沙黎族自治县元门乡中心学校为 70 多名小学生授课。

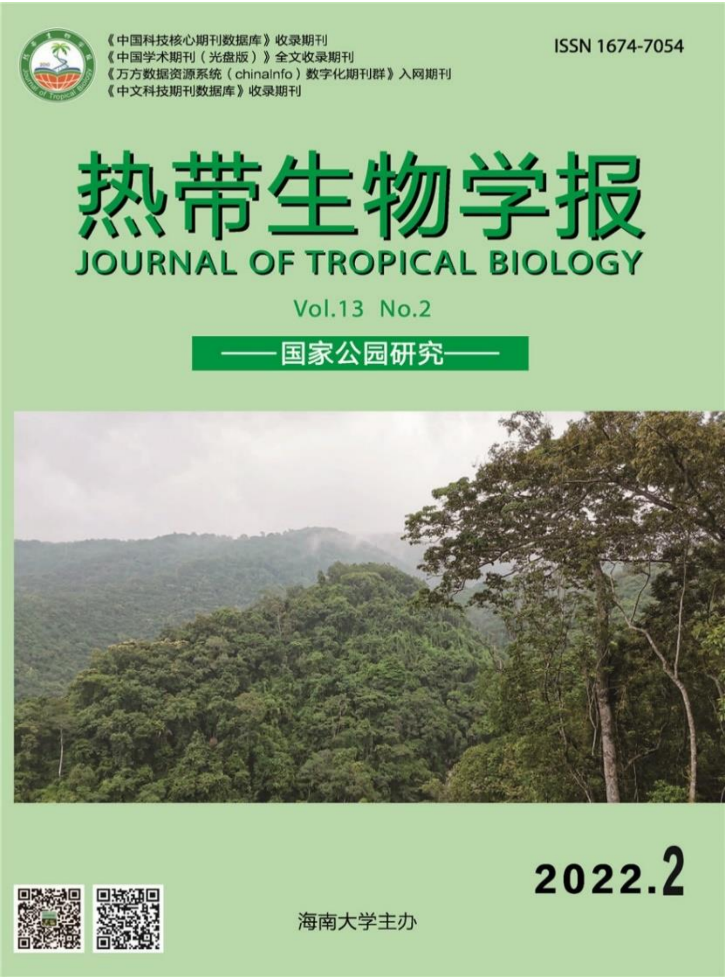
- 7 月 4 日下午，COP15 青年生物多样性科学探索海南活动启动仪式在海南大学思源学堂成功举办。

- 7 月 16 日-18 日，向文倩博士、魏雅丽博士研究生、马光辉博士研究等参加第四届全国民族生态学大会，并作了《基于生物多样性知识的黎族传统生态文化传承与创新利用》报告。

➢ 9月15日，由商务部资助、海南大学主办、生态与环境学院与国际教育学院联合承办的援外培训班《海洋地质调查与海岸带环境保护研修班》举行了开班仪式。

➢ 9月17日、24日，向文倩博士（博士后）在《海洋地质调查与海岸带环境保护研修班》为来自10多个国家24名学员授课。

➢ 9月25日-27日，赴儋州、昌江等地参与民盟海南省委重点调研课题《以传统生态文化促进海南省全民科学素养提升的调查研究》，并与当地村委会座谈。



《中国科技核心期刊数据库》收录期刊
《中国学术期刊（光盘版）》全文收录期刊
《万方数据资源系统（chinaInfo）数字化期刊群》入网期刊
《中文科技期刊数据库》收录期刊
ISSN 1674-7054

热带生物学报
JOURNAL OF TROPICAL BIOLOGY
Vol.13 No.2
——国家公园研究——

2022.2
海南大学主办

- ➢任明迅教授和宋希强教授联合在海南大学主办的《热带生物学报》组织出版了《国家公园研究》专辑。该专辑包括了 11 篇研究论文，涉及武夷山、大熊猫、三江源、海南热带雨林等 4 个国家公园，内容覆盖国家公园空间规划、生物多样性调查与保护、生态服务功能与生态修复、社区生计等多个方面，起到了促进国家公园研究进展与争鸣的积极作用。

- ➢ 10 月 10-30 日，在海南省林业局资助下，张哲博士联合无字教育公司在五指山市水满乡中心学校、东方市江边乡中心小学、乐东县尖峰镇中心学校、王下乡中心学校等开展了热带雨林自然教育系列活动。

《加拿大的氢能发展与海南建设绿色能源大省的机遇》

•主讲人：汤友志博士

主办单位：加中科技联盟（海南省海外创新中心）
中国科协海智计划海南（海南大学）工程基地
承办单位：海南大学化学工程与技术学院
海南大学生态与环境学院

2022年10月31日
北京时间 上午9:30-11:30

➢ 10 月 31 日上午，工作基地联合加中科技联盟（海南省海外创新中心）主办了面向海南碳达峰碳中和的专题讲座，特邀加中科技联盟共同主席汤志友博士在线参会。

➢ 10 月 13 日至 11 月 2 日，参与组织了商务部资助的援外培训班《老挝环境保护与评价研修班》，并参与授课。

➢ 11 月 4 日，向文倩博士为三亚市天涯区 2022 年社区教育管理人员业务提升培训会授课。

- 11 月 15，任明迅教授受海南省科学技术协会邀请，参与科普大讲堂，作了题为“海南雨林生态与文化”的报告。

- 11 月 15 日，张哲博士受邀在昌江黎族自治县霸王岭学校参与海南省乡村振兴电视夜校广播版《乡村振兴越做越有》节目走基层系列活动。

- 11 月 18-19 日，任明迅教授、张乐博士、姚小兰和魏雅丽博士生等参加 NESS 国际科学大会暨“生态保障人类命运共同体”学术研讨会。

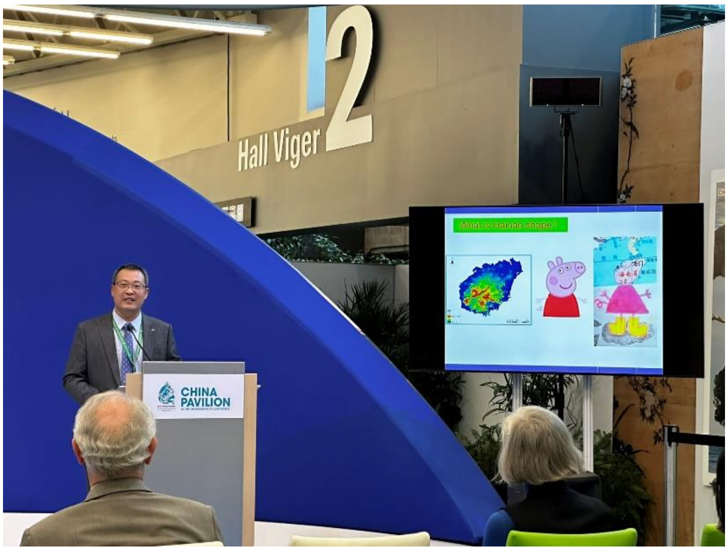
- 11 月 29 日，任明迅教授参加了第十一届海南省科技论坛，并组织了分论坛二《热带生态系统保育与可持续利用》、做了题为《海南生物多样性可持续利用与生态文化建设》的学术报告。张乐博士，向文倩博士以及多位研究生参加了论坛。

- 11 月 30 日，任明迅教授、向文倩博士、魏雅丽博士生等参加和乐镇 2022 年乡村振兴论坛（第三期）暨 EOD 模式打造小海国家渔业公园方案及设想研讨会。

- 12 月 9 日，参加了联合国开发计划署（UNDP）-全球环境基金（GEF）海南农业生物多样性参与式原生境保护和可持续利用项目“生色宇宙——海南农业生物多样性论坛”。

- 12 月 12 日，向文倩博士应邀参加由海南国际传播中心、海口市外事办公室、英国驻广州总领事馆共同主办的第二季《洞见 •Insight》公益演讲活动。

- 任明迅教授接受《海南新闻联播》专访：海南热带雨林传统生态文化对乡村振兴与生态文明建设具有重要借鉴价值。



- 12 月 13 日至 18 日，任明迅教授参加《生物多样性公约》第十五次缔约方大会（COP15），作了"Traditional biodiversity knowledge in local agricultures of Hainan Island, China"报告。

- 12 月 15-18 日，“木棉-稻田农林复合系统”研究成果亮相 2022 年中国（海南）国际热带农产品冬季交易会（简称冬交会）。

- 12 月 17 日，向文倩博士受邀参与琼中山兰稻申遗项目推介会。从农业文化遗产保护的角度，指出琼中山兰稻作文化系统具有丰富的农业生物多样性、原生态的种植方式、绿色可持续的经济效益等诸多价值。

- 12 月 30 日，参加了俄罗斯莫斯科大学与海南大学联合举办的项目研讨会，任明迅教授作了题为“Soil microbes in two types of traditional agroecosystems of Hainan Island”的报告。

➢ 主办或参与主办的学术会议

会议名称	会议类别	会议时间	参加人数
昌江县文化和旅游产业融合发展研讨会	全国会议	2022 年 2 月	20
2022 年海南省生态环境系统领导干部政治能力提升暨党务干部培训示范班	全国会议	2022 年 6 月	54
COP15 青年生物多样性科学探索海南活动	全国会议	2022 年 7 月	50
海南碳达峰碳中和专题讲座	国际会议	2022 年 10 月	30
NESS 国际科学大会暨“生态保障人类命运共同体”学术研讨会	国际会议	2022 年 11 月	60
海南省第十一届科技论坛暨 海南生态文明大讲坛	全国会议	2022 年 11 月	200

➢ 学术报告情况

报告名称	报告人	会议名称	地点	时间
Traditional biodiversity knowledge in local agricultures of Hainan Island, China	任明迅	《生物多样性公约》第十五次缔约方大会	加拿大	2022.12
Soil microbes in two types of traditional agroecosystems of Hainan Island	任明迅	First joint workshop of Lomonosov Moscow State University and Hainan University	线上	2022.12
Ecosystem services and conservation priority regions of the Hainan Tropical Rainforest National Park in China	姚小兰	2nd International Symposium of Long-term Forest Monitoring Research in Asia	线上	2022.03

洋浦千年古盐田——国家级非物质文化遗产中的生态智慧	魏雅丽	传统生态文化及其现代传承系列讲座	海口	2022.04
基于生物多样性知识的黎族传统生态文化传承与创新利用	向文倩	第四届全国民族生态学大会	恩施	2022.07
海南雨林生态与文化	任明迅	科普大讲堂	海口	2022.11
海南生物多样性可持续利用与生态文化建设	任明迅	海南省第十一届科技论坛暨海南生态文明大讲坛	海口	2022.11
DOM 对耕地土壤铅、镉和砷污染修复与质量提升研究	黄青	第四届全国农业资源与生态论坛	海口	2022.11
垃圾分类及相关法律解读	黄青	山南市生活垃圾分类“雅砻行”讲坛	山南	2022.04
海南岛近 30 年面源污染氮磷环境排放特征研究	赵洪伟	中国环境科学学会污染源排放与管控专委会第一届学术年会	北京	2022.11
环境浓度 PSII 型除草剂会降低珊瑚的热适应性	赵洪伟	全国珊瑚礁论坛	三亚	2022.11

➢ 参加学术会议情况

会议名称	会议类别	会议时间	参会人员
海南省第十一届科技论坛暨海南生态文明大讲坛	全国会议（海口）	2022.11	任明迅
第一届广西珍稀濒危植物保护与利用学术研讨会	全国会议（广西）	2022.12	谭珂、马光辉、向文倩
第八届文化地理学术研讨会	全国会议（陕西）	2022.07	任明迅、马光辉
植物系统学家园微信群主题论坛	全国会议（线上）	2022.07	马光辉、向文倩

首届城市森林生物多样性研讨会	全国会议（线上）	2022.04	姚小兰
两院学坛	全国会议（儋州）	2022.04	任明迅、魏雅丽、杨淑云
首届植物科学前沿学术大会	国际会议（南京）	2022.04	马光辉
第六届生态文明与国家公园体制建设学术研讨会	全国会议（线上）	2022.05	任明迅、姚小兰
第四届全国农业资源与生态论坛	全国会议（海口）	2022.11	黄青
生色宇宙——海南农业生物多样性论坛	全国会议（海口）	2022.12	向文倩

七、社会兼职

姓名	学术组织或科研机构	职务	任职时间
杨小波	国际生物多样性计划中国委员会	委员	2012-
	海南省生态学学会	理事长	2010-
	中国生态学会	常务理事	2012-
	海南省植物学会	副理事长	2011-
	海南省环境学会	副理事长	2008-
	海南省环境教育协会	常务副会长	2008-
任明迅	《Collectanea Botanica》	编委	2014-
	《热带生物学报》	编委	2020-
	中国科协海智计划海南（海南大学）工作基地	负责人	2020-
	热带特色林木花卉遗传与种质创新教育部重点实验室	副主任	2019-
	海南省热带生态环境修复工程研究中心	主任	2019-
	海南省李百炼院士工作站	负责人	2018-
	海南省林学会	副秘书长	2018-
	海南省植物学会	理事	2016-
	海南省旅游协会研学行业分会专家委员会	委员	2022-
赵洪伟	中国太平洋学会珊瑚礁分会	会员	2018-
	海南省蓝丝带海洋环境保护协会	共同发起人	2018-
	中国未来海洋联盟	成员	2014-
	美国化学学会	会员	2012-

	海南省邹乐明院士工作站	平台负责人	2020-
	海南省热带生态环境修复工程研究中心	副主任	2019-
黄青	《亚热带植物科学》	编委	2020-
	海南省贺泓院士创新团队	负责人	2020-
	Frontiers in Microbiology	编委	2020

八、在研项目

国家自然科学基金：面上项目

- 环南海区域线柱苣苔属物种分化历史与长距离扩散格局(负责人：任明迅，执行期：2019.01－2022.12，总经费：60 万)

国家自然科学基金：地区科学基金

- 龙脑香科青梅属不同果实类型传播与适应的生态遗传学研究(负责人：唐亮，执行期：2021.1－2024.12，35 万)。
- 海南热带山地雨林苔藓植物群落多样性及其维持机制(负责人：张莉娜，执行期：2022.01－2025.12，35 万)
- 尖峰岭热带山地雨林叶内生与附生真菌-细菌的多层互作网络及其驱动因子研究(负责人：丁琼，执行期：2020.01－2023.12，40 万)
- 造礁珊瑚-虫黄藻共生体响应扑草净胁迫的分子机制(负责人：赵洪伟，执行期：2019.01－2022.12，40 万)

国家自然科学基金：青年科学基金

- 海南传统村落中遗存乔木木棉对附生兰科植物海南钻喙兰的生态廊道作用(负责人：张哲，执行期：2022.03－2024.12，总经费：30 万)

省部级项目

- 海南省院士创新平台绩效奖励科研经费：海南省传统农耕文化的生态学基础及其对现代高效农业与生态文明建设的作用(负责人：任明迅，执行期：2022-2024，经费：100 万)
- 海南省院士创新平台运营与建设经费 (负责人：任明迅，执行期：2022-2024，经费：50 万)
- 海南省院士创新平台 2020 年科研专项项目：海南热带雨林国家公园告诉公路穿越段的环境监测与生态恢复技术(负责人：李百炼、任明迅，执行期：2020-2023，经费：50 万)
- 海南省院士工作站(外籍)专项：(负责人：赵洪伟，执行期：2020.1-2023.12，50 万)
- 海南省贺泓院士创新团队专项：(负责人：黄青，执行期：2020.1-2023.12，30 万)
- 海南省“海智计划”海南大学工作站建设与运行专项经费(负责人：任明迅，执行期：2021-2022，经费：5 万)
- 海南省重大科技专项课题：农业农村面源氮磷对近海生态系统的影响及防控技术研究与示范 (负责人：赵洪伟，执行期：2021-2024，经费：180 万（含自筹 60 万）)

- 海南省重点研发项目：琼东陆源氮素排放与近海珊瑚礁退化关系历史反演及其调控策略(负责人：赵洪伟，执行期：2021-2023，经费：50 万)
- 海南省院士创新平台专项：城市化建设对海南岛珊瑚礁的影响及其可恢复性评价(负责人：赵洪伟，执行期：2021-2024，经费：31 万)
- 海南省自然科学基金高层次人才项目：五唇兰（兰科）的适宜生存区预测与谱系地理格局(负责人：张哲，执行期：2022-2025，经费：10 万)
- 海南省自然科学基金高层次人才项目：第四纪气候变化对海南岛及周边地区风筝果种群遗传结构和动态的影响(负责人：谭珂，执行期：2022-2025，经费：10 万)
- 海南省自然科学基金面上项目：氮沉降驱动下海南霸王岭不同海拔森林土壤挥发性有机物排放动态及其影响因素研究(负责人：何禾，执行期：2022-2025，经费：8 万)
- 海南省自然科学基金青年基金：木棉-稻田体系中木棉花分解的养分动态及微生物机制(负责人：王文娟，执行期：2022-2025，经费：6 万)
- 海南省自然科学基金青年基金：海南岛山地雨林优势树种陆均松和鸡毛松对不同水热条件的分子适应机制(负责人：凌少军，执行期：2022-2025，经费：6 万)
- 海南省科学技术厅青年科学基金项目：海南三种同域分布蝴蝶兰属植物的生殖隔离与适应性进化(负责人：张哲，执行期：2021-2024，经费：5 万)
- 清华大学环境模拟与污染控制国家重点联合实验室开放基金：(负责人：赵洪伟，执行期：2020.06-2022.06，8 万)
- 海南热带雨林国家公园霸王岭分局横向课题：科普视频拍摄于制作(负责人：张哲，执行期：2022-2023，经费：30.10 万)
- 海南智慧雨林中心横向项目：海南热带雨林国家公园科普推文编撰(负责人：张哲，执行期：2022-2022，经费：29.8 万)
- 海南省重点研发项目：生活垃圾焚烧飞灰资源化利用技术研究与示范(负责人：黄青，执行期：2022-2025，经费：36.45 万)
- 农业农村部科技教育司项目：海南地膜污染监测与技术评价 (负责人：黄青，执行期：2022-2022，经费：20 万)

九、主要论著目录

➢ 论文

1. Genome-wide RAD sequencing data suggest predominant role of vicariance in Sino-Japanese disjunction of the monotypic genus *Conandron* (Gesneriaceae). **Journal of Systematics and Evolution**, 2022. DOI: 10.1111/jse.12937 (责任作者：任明迅)
2. Microbial community and functional prediction during the processing of salt production in a 1000-year-old marine solar saltern of South China. **Science of The Total Environment**, 2022, 819: 152014 (责任作者：任明迅)
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4. Plastic mulch debris in rhizosphere: Interactions with soil-microbe-plant systems. **Science of the Total Environment**, 2022. DOI:10.1016/j.scitotenv.2021.151435 (责任作者：黄青)
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7. Competitive relationship between *Cleistocalyx operculatus* and *Syzygium jambos* under well-watered conditions transforms into a mutualistic relationship under waterlogging stress. **Frontiers in Plant Science**, 2022. DOI: 10.3389/fpls.2022.869418 (责任作者：杨帆)
8. Sphingomonas sp. Hbc-6 alters physiological metabolism and recruits beneficial rhizosphere bacteria to improve plant growth and drought tolerance. **Frontiers in Plant Science**, 2022. DOI: 10.3389/fpls.2022.1002772 (责任作者：盛红梅、安黎哲)
9. Filament union provides landing site for birds and increase pollen removal and deposition in an ornithophilous species. **Flora**, 2022, 288, 152025 (责任作者：任明迅)
10. *Oreocharis hainanensis* (Gesneriaceae), a new species from karst regions in Hainan Island,

South China. **Phytotaxa**, 2022, 538 (4), 281–291 (责任作者：任明迅)

11. The genus Parnassia in Vietnam, and a checklist of Vietnamese Celastraceae. **Phytotaxa**, 2022, 536(3), 213–227 (责任作者：MAXIM S. NURALIEV)
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13. Melatonin Mitigates Cadmium Toxicity by Promoting Root Architecture and Mineral Homeostasis of Tomato Genotypes. **Journal of Soil Science and Plant Nutrition**, 2022, 22, 1112–1128. DOI: 10.1007/s42729-021-00720-9 (责任作者：任明迅)
14. A chromosome-scale genome and transcriptomic analysis of the endangered tropical tree *Vatica mangachapoi* (Dipterocarpaceae). **DNA Research**, 2022, 29(2), 1-10 (责任作者：唐亮)
15. Abundance, spatial distribution, and characteristics of microplastics in agricultural soils and their relationship with contributing factors. **Journal of Environmental Management**, 2022. DOI: 10.1016/j.jenvman.2022.117006 (责任作者：黄青)
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17. Development of a highly sensitive and specific monoclonal antibody-based immunoassay for detection of okadaic acid in oysters and green mussels. **Food and Agricultural Immunology**, 2022, 33:1, 346-359. DOI: 10.1080/09540105.2022.2076812 (责任作者：赵洪伟)
18. Development of a specific monoclonal antibody based icELISA for detection of arecoline in traditional Chinese medicines and fresh areca nuts. **Food and Agricultural Immunology, 2022,** 33:1, 113-126. DOI: 10.1080/09540105.2021.2025347 (责任作者：赵洪伟)
19. Ecological circular agriculture: A case study evaluating biogas slurry applied to rice in two soils. **Chemosphere**, 2022. DOI: 10.1016/j.chemosphere.2022.134628 (责任作者：黄青)
20. Exogenous ABA and IAA modulate physiological and hormonal adaptation strategies in *Cleistocalyx operculatus* and *Syzygium jambos* under long-term waterlogging conditions. **BMC Plant Biology**, 2022. DOI:10.1186/s12870-022-03888-z (责任作者：杨帆)
21. Exploration of the Interrelationship within Biomass Pyrolysis Liquid Composition Based on

Multivariate Analysis. **Molecules**, 2022, DOI:10.3390/molecules27175656 (责任作者：黄青)

22. Microplastics in the soil environment: A critical review. **Environmental Technology & Innovation**, 2022. DOI: 10.1016/j.eti.2022.102408 (责任作者：黄青)
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27. Comparable and adaptable strategies to waterlogging stress regulated by adventitious roots between two contrasting species. **Tree Physiology**, 2022. DOI: 10.1093/treephys/tpab165 (责任作者：杨帆)
28. Dissecting the below- and aboveground specific responses of two waterlogging tolerant arbor species to nutrient supply under waterlogging conditions. **Tree Physiology**, 2022. DOI: 10.1093/treephys/tpac127 (责任作者：杨帆)
29. 海南热带雨林国家公园高速公路穿越段的景观动态与生态风险评估. **生态学报**, 2022, 42(16), 6695-6703. DOI:10.5846/stxb202006191601 (责任作者：任明迅)
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31. 环南海区域红树物种多样性分布格局及其形成机制. **植物生态学报**, 2022. DOI: 10.17521/cjpe.2022.0366 (责任作者：任明迅)
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➢ 学术著作

1. 申益春, 任明迅. 2022. 羊山湿地植被与景观. 中国建材工业出版社.

2. 张哲，宋希强. 2022. 海南热带雨林国家公园风景名胜图册. 中国林业出版社.

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十、代表性论著首页

JSE Journal of Systematics and Evolution

doi: 10.1111/jse.12937

Research Article

Genome-wide RAD sequencing data suggest predominant role of vicariance in Sino-Japanese disjunction of the monotypic genus *Conandron* (Gesneriaceae)

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Abstract Disjunct distribution is a key issue in biogeography and ecology, but it is often difficult to determine the relative roles of dispersal vs. vicariance in disjunctions. We studied the phylogeographic pattern of the monotypic *Conandron ramondioides* (Gesneriaceae), which shows Sino-Japanese disjunctions, with ddRAD sequencing based on a comprehensive sampling of 11 populations from mainland China, Taiwan Island, and Japan. We found a very high degree of genetic differentiation among these three regions, with very limited gene flow and a clear Isolation by Distance pattern. Mainland China and Japan clades diverged first from a widespread ancestral population in the middle Miocene, followed by a later divergence between mainland China and Taiwan Island clades in the early Pliocene. Three current groups have survived in various glacial refugia during the Last Glacial Maximum, and experienced contraction and/or bottlenecks since their divergence during Quaternary glacial cycles, with strong niche divergence between mainland China + Japan and Taiwan Island ranges. Thus, we verified a predominant role of vicariance in the current disjunction of the monotypic genus *Conandron*. The sharp phylogenetic separation, ecological niche divergences among these three groups, and the great number of private alleles in all populations sampled indicated a considerable time of independent evolution, and suggests the need for a taxonomic survey to detect potentially overlooked taxa.

Key words: demography, ecological niche differences, isolation by distance, phylogeography, relict plant, species distribution model.

1 Introduction

Due to its vast extension, stretching from boreal to tropical ecosystems, East Asia is a key region for relict species/lineages that survived the Cenozoic climatic deterioration, and thus often presents complicated species distribution patterns, for example, disjunctions (Qiu et al., 2009, 2011; Qi et al., 2014; Tang et al., 2018). Traditionally, two alternative explanations have been proposed to explain species disjunct distributions (Tallis, 1991), that is long-distance dispersal across pre-existing geographical barriers, or the fragmentation of a widespread ancestral range (vicariance) by the formation of geographical barriers such as mountain uplifts and marine transgressions. The role of dispersal vs. vicariance has for decades fascinated scientists in the fields of biogeography and evolutionary ecology, but the relative contribution of these diversification forces to current species geographic patterns is still debated, partly due to the elusiveness of extinction and the high numbers of biotic, abiotic and stochastic factors that overlap throughout the geological ontogeny of each region (Caujapé-Castells et al., 2017).

Conandron ramondioides Siebold & Zucc. is the only species of the genus *Conandron* Siebold & Zucc. (Gesneriaceae), with a disjunct distribution in mainland China (in four provinces: Anhui, Fujian, Jiangxi, and Zhejiang), Taiwan Island, and the Japanese islands (Honshu, Kyushu, Shikoku, and the Ryukyus) (Wang, 2004; Wang et al., 2010; Xiao et al., 2012). This monotypic genus is distinctive for its radially symmetrical corolla with four fertile stamens and cohesive anthers (Wang et al., 2010). The molecular data available indicate that *C. ramondioides* is a relict taxon that probably

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Microbial community and functional prediction during the processing of salt production in a 1000-year-old marine solar saltern of South China

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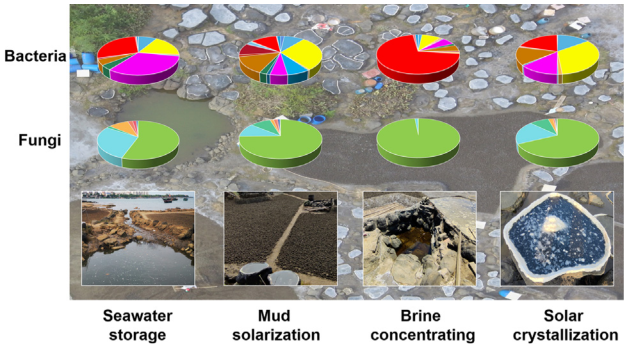
HIGHLIGHTS

- Mud solarization and brine crystallization on basalt platforms are two key steps of traditional techniques.
- The richness and diversity of bacterial and fungal communities changed dramatically during salt-making processes.
- The traditional salt-making techniques selected and maintained highly specialized microorganisms.

GRAPHICAL ABSTRACT



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ABSTRACT

In Hainan Island, South China, a 1000-year-old marine saltern has been identified as an intangible cultural heritage due to its historical complicated salt-making techniques, whereas the knowledge about this saltern is extremely limited. Herein, DNA sequencing and biochemical technologies were applied to determine bacterial and fungal communities of this saltern and their possible functions during four stages of salt-making, i.e. seawater storage, mud solarization, brine concentrating, and solar crystallization. The results showed that both of bacterial and fungal communities were suffered from significant changes during processing of salt-making in Danzhou Ancient Saltern, whereas the richness and diversity of bacterial community dominated by Proteobacteria, Bacteroidota and Cyanobacteria was considerably greater than that of fungal community dominated by Ascomycota, Basidiomycota and Mortierellomycota. Additionally, the succession of bacterial community was closely associated with both of salt physicochemical properties (Na^+, Cl^-, total phosphorus, total nitrogen, Ca^{2+} and Mg^{2+}) and bacteria themselves, whereas fungal community was more closely associated with physicochemical properties than fungi themselves. Importantly, *Cyanobium*_PCC-6307, *Synechococcus*_CC9902, *Marinobacter*, *Prevotella* and *Halomonas* as dominant bacterial genera respectively related to the metabolisms of amino acid, carbohydrate, terpenoids/polyketides, lipid and nucleotide were correlated with salt flavors. Saprophytic and saprotroph-symbiotroph fungi dominated by *Aspergillus*, *Mortierella*, *Amanita*, *Neocucurbitaria* and *Tausonia* also played core roles in the formation of salt flavors including umami and sweet smells. These findings revealed the highly specified microbiome community in this 1000-year-old saltern that mainly selected by brine solarization on basalt platforms, which is helpful to explore the underlying mechanisms of traditional salt-making techniques and to explore the useful microbes for nowadays food, medicine and chemical industries.

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Dissolved organic matter (DOM) was detected in MSWI plant: An investigation of DOM and potential toxic elements variation in the bottom ash and fly ash

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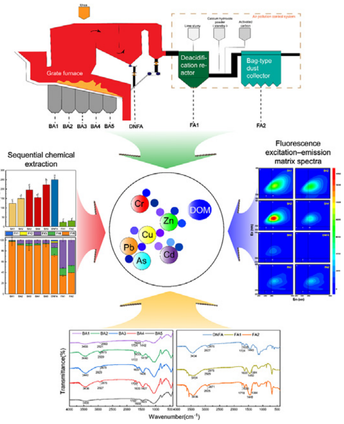
HIGHLIGHTS

- DOM and PTEs (potential toxic elements) in different sections of MSWI plant were analyzed.
- DOM was detected in fly ash and significantly increased in deacidification tower.
- PTEs were gradually released and enriched in the burn section, except for As.
- Fe-Mn hydroxide-bound fractions of PTEs increased in deacidification tower markedly.
- Humic-like substances increased the effective fraction of PTEs in bottom ash and fly ash.

GRAPHICAL ABSTRACT



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ABSTRACT

The content of dissolved organic matter (DOM) and potentially toxic elements (PTEs) were investigated in the bottom ash (BA) and fly ash (FA) of different sections of the municipal solid waste incineration (MSWI) plant. BA and FA were collected from the dry (BA1-BA2), burn (BA3-BA4), and burn-out (BA5) sections of the grate incinerator; FA was collected after denitration (DNFA), and from the deacidification tower (FA1) and bag-type dust remover (FA2), respectively. The DOM concentration in BA was higher than that in FA, the highest concentration was in BA3 (556.18 mg/kg), while the lowest concentration was in DNFA (17.53 mg/kg). DOM in BA was mainly composed of protein-like, fulvic-like, tryptophan-like, and humic-like substances, of which humic-like substances accounted for more than 40%. DOM in FA consisted of tryptophan-like and humic-like substances, of which humic-like substances accounted for more than 80%. DOM still existed in BA which may be related to the incomplete combustion, and the

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Plastic mulch debris in rhizosphere: Interactions with soil-microbe-plant systems

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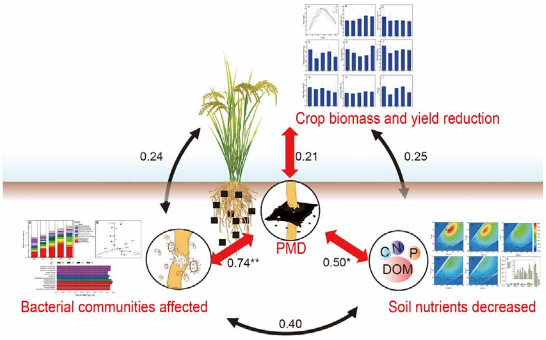
HIGHLIGHTS

- The proportion of P was increased by plastic mulch debris (PMD) up to 110.34%.
- PMD increased the total OTUs of bacteria by 0.03–17.05%.
- PMD reduced the diversity and evenness of bacterial (Shannon) by 0.69–7.55%.
- The rank of impact degree of PMD on factors were, "soil > microbe > plant".
- Specific influence mechanism of PMD on agroecosystem is indicated to be complex.

GRAPHICAL ABSTRACT



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ABSTRACT

Large amounts of plastic mulch debris (PMD) accumulated in the soil can endanger agroecosystems. However, little is known about the interactions between PMD and soil-microbe-plant systems. In this study, a pot experiment (four replicates) in tropical greenhouse was conducted to investigate the effects of PMD (polyethylene) at different concentrations (0, 0.4, 0.8, 4.0, 6.0 g kg^{-1}) on soil nutrients, rhizosphere bacterial communities and rice growth. This study further explored the interactive mechanisms between PMD and environmental factors based on correlation analysis and previous studies. The results showed that PMD continuously reduced the soil capabilities to store nutrients (C, N, P, humic-like substances) and increased the proportion of P and biodegradable dissolved organic matter (DOM). At the full ripening stage of rice growth, total organic carbon (TOC), total nitrogen (TN) and total phosphorus (TP) in all PMD treatments significantly decreased by 60.86, 52.51 and 34.83% respectively as compared to CK ($p < 0.05$). Furthermore, PMD increased the total abundance of bacteria but reduced the diversity and evenness of bacterial communities, which further affected microbial metabolic functions. Total OTUs and Shannon decreased 0.02–17.05% and 0.69–7.55% in treatments. At harvest-time, PMD reduced the biomass and yield of rice with 11.34 and 19.24% (all treatments on average) lower than CK. Under the influence of PMD, the order of correlation size between PMD and one environmental factor was PMD-soil > PMD-microbe > PMD-plant, and the order of correlation between two environmental factors was soil-microbe > microbe-plant > soil-

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RESEARCH ARTICLE

Soil bacterial and fungal communities respond differently to *Bombax ceiba* (Malvaceae) during reproductive stages of rice in a traditional agroforestry system

Wen-Juan Wang · Jing Wen · Wen-Qian Xiang · Pastor L. Malabrigo Jr · Ming-Xun Ren

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Abstract

Background Agroforestry is a promising approach for sustainable agriculture due efficient resource cycling and improved soil fertility. *Bombax ceiba* (Malvaceae), a tall tree with red flowers blooming in spring, is traditionally planted in rice fields in tropical Asia. However, the role of *B. ceiba* in the agroforestry systems remains unexplored.

Methods We collected 81 soil samples at different distances to *B. ceiba* (0 m (D0), 1 m (D1), and 5 m (D5)) at a typical *B. ceiba*-rice agroforestry system in Hainan Island (south China) during three reproductive stages of rice- booting, heading and maturity. We assessed spatiotemporal variations of soil nutrient properties (by a soil nutrient analyzer (YT-TRX03)), and soil bacterial and fungal communities (by sequencing 16S rRNA gene and internal transcribed spacer (ITS) region, respectively).

Results *B. ceiba* improved the soil nutrient conditions in a rice field, particularly the availability of potassium and soil organic matter. Soil microbial communities were significantly affected by the distances to *B. ceiba* and the reproductive stages of rice. Available potassium was the principal driver of soil bacterial diversity and structure. In contrast, fungal diversity was negatively correlated with total nitrogen, while soil organic matter was the main factor shaping fungal community structure.

Conclusions. Our results show that *B. ceiba* has positive impacts on abiotic traits of rice-growing soils. *B. ceiba* can change soil microbial community structure, however, the principal soil driver varied according to microbial taxa. These findings support the ecological basis of traditional agroforestry systems prevalent in tropical Asia.

Keywords Rice field · Agroforestry · Microbial diversity · Traditional farming practice

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Wen-Juan Wang, Jing Wen and Wen-Qian Xiang contributed equally to this work.

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ORIGINAL RESEARCH
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Limited-Distance Pollen Dispersal and Low Paternal Diversity in a Bird-Pollinated Self-Incompatible Tree

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Bird pollination in Asia is regarded as an uncommon phenomenon and, therefore, only a few investigations on mating pattern and paternity in fruits of Asian bird-pollinated plants have been conducted. Here, we examined spatial genetic structure, pollen dispersal, and multiple paternity in a natural population of *Bombax ceiba* (*B. ceiba*) (Malvaceae) in Hainan Island, South China, using simple sequence repeat (SSR) markers. A low genetic diversity ($H_e = 0.351 \pm 0.0341$ and 0.389 ± 0.043, respectively, for adults and offspring) and bottleneck effects were observed. Genetic kinship was significant within 400 m or in 1,800–3,800 m. Both the mating pattern and paternity analysis confirmed obligate xenogamy and a low multiple paternity in *B. ceiba*. There was a strongly negative relationship between the frequency of matings and the distance between mating pairs. The average pollen dispersal distance was 202.89 ± 41.01 m (mean ± SE) and the farthest distance of $>$ 1 km was recorded. Realized mating events showed an extremely leptokurtic distribution within 1,200 m, suggesting that the pollen dispersal distance was consistent with the optimal foraging theory of generalist birds such as *Zosterops* spp. and *Pycnonotus* spp. Paternity per tree ranged from two to six and the average effective number of pollen donors per maternal plant was 3.773, suggesting a low level of paternity diversity as compared to other bird-pollinated plants. We concluded that optimal foraging behavior by generalist birds could explain the leptokurtic pollen dispersal distribution and predominantly near-neighbor matings in *B. ceiba*. The limited pollen dispersal distance and low multiple paternity were consistent with low fruit setting rate (3.27 ± 0.93%) in this self-incompatible tree, which was caused mainly by the restricted flight distance of birds and human disturbances. Low genetic diversity and significant spatial genetic structure might have largely resulted from logging and human collection of fruits.

Keywords: mating system, paternity analysis, pollen flow, microsatellite DNA, genetic diversity, Bombacoideae

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Competitive Relationship Between *Cleistocalyx operculatus* and *Syzygium jambos* Under Well-Watered Conditions Transforms Into a Mutualistic Relationship Under Waterlogging Stress

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Competition and abiotic stress such as waterlogging (WL) represent main factors limiting plant growth and determining plant resistance and distribution patterns in wetland ecosystems. One of the basic steps for wetland restoration is to plant trees to ensure a quicker recovery and prevent erosion. Plant survival and adaptation are considered criteria of principal priority for the screening of plant species for wetland ecosystem restoration. WL influences plant species in wetlands *via* the deterioration of the plant root environment which leads to oxygen deficiency that affects plant growth, photosynthesis, respiration, and other metabolic processes. A suitable plant species was determined according to tolerance to WL during wetland vegetation recovery activities. Thus, two tree species (*Cleistocalyx operculatus* and *Syzygium jambos*) that showed a certain waterlogging tolerance were chosen to study their behaviors in different planting model and environmental conditions. Given that interspecific relationship should be considered during plant community construction, the eco-physiological adaptable mechanisms between these woody plants under well-watered condition and waterlogging stress were explored. Results showed that both species were waterlogging-tolerant species due to their ability to adapt to submergence conditions for 120 days. Moreover, *C. operculatus* possessed stronger tolerance to waterlogging stress because of a significant adventitious roots biomass accumulation. A competitive relationship was found between *C. operculatus* and *S. jambos* under well-watered condition, and *C. operculatus* showed better growth performance benefited from morphological responses (plant height, number of blade and leaf area) and endogenous hormone variations. In comparison, *S. jambos* suffered some negative effects when the well-watered mixed planting was used. However, the competitive relationship under well-watered condition was transformed into mutualistic relationship

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Sphingomonas sp. Hbc-6 alters physiological metabolism and recruits beneficial rhizosphere bacteria to improve plant growth and drought tolerance

Fang Wang[1], Yali Wei[2], Taozhe Yan[1], Cuicui Wang[1],
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Drought poses a serious threat to plant growth. Plant growth-promoting bacteria (PGPB) have great potential to improve plant nutrition, yield, and drought tolerance. *Sphingomonas* is an important microbiota genus that is extensively distributed in the plant or rhizosphere. However, the knowledge of its plant growth-promoting function in dry regions is extremely limited. In this study, we investigated the effects of PGPB *Sphingomonas* sp. Hbc-6 on maize under normal conditions and drought stress. We found that Hbc-6 increased the biomass of maize under normal conditions and drought stress. For instance, the root fresh weight and shoot dry weight of inoculated maize increased by 39.1% and 34.8% respectively compared with non-inoculated plant, while they increased by 61.3% and 96.3% respectively under drought conditions. Hbc-6 also promoted seed germination, maintained stomatal morphology and increased chlorophyll content so as to enhance photosynthesis of plants. Hbc-6 increased antioxidant enzyme (catalase, superoxide, peroxidase) activities and osmoregulation substances (proline, soluble sugar) and up-regulated the level of beneficial metabolites (resveratrol, etc.). Moreover, Hbc-6 reshaped the maize rhizosphere bacterial community, increased its richness and diversity, and made the rhizosphere bacterial community more complex to resist stress; Hbc-6 could also recruit more potentially rhizosphere beneficial bacteria which might promote plant growth together with Hbc-6 both under normal and drought stress. In short, Hbc-6 increased maize biomass and drought tolerance through the above ways. Our findings lay a foundation for exploring the complex mechanisms of

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Filament union provides landing site for birds and increase pollen removal and deposition in an ornithophilous species

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ABSTRACT

Filament union is a widely distributed characteristic in angiosperms where the stamens in a flower are united by filaments in diverse modes. Yet, its adaptive significance has remained empirically unexplored. *Bombax ceiba* (Malvaceae) has large red flowers with two whorls of stamens differing in degrees of filament union, and therefore provides an opportunity to explore the adaptive significance of filament union. We observed floral visitors in a large wild population of *B. ceiba* in Hainan Island, south China. We manipulated the filament union and dyed pollen grains for two whorls of its stamens to explore effects of filament union on bird visitation and pollination consequences. We found that the main floral visitor to *B. ceiba* was *Zosterops palpebrosa*, which foraged for nectar via landing on stamens, petals, and branches. When filaments were separated, bird forage attempts and visit durations decreased due to weakened support for bird landing. Consequently, pollen removal was also decreased significantly. Filament union may help in generating the landing sites for the visiting birds to drink nectar, and thus, increases the frequency of their contact with the nearby five-branched stigmas, facilitating pollen deposition from other flowers. Therefore, filament union in *B. ceiba* may function as an efficient mechanism of cross-pollination by low-frequency but high-efficiency pollinators through stabilizing the anther position and by providing the united stamens as landing sites for birds, and increasing both pollen removal and deposition.

1. Introduction

In many flowers, anthers and/or filaments are united (Foerste, 1888; Ren, 2008), resulting into synantherous stamens (e.g. Asteraceae and Orobanchaceae), anthers united in two pairs (mostly in didynamous stamens of Lamiales), and monadelphous stamens (Malvaceae) or diadelphous stamens as in Papilionaceae (Foerste, 1888; Mani and Saravanan, 1999). Such united growth of stamens may alter spatial positionings of anthers and anther-stigma separation (herkogamy), which may affect the pollination process (Ren, 2008). For example, anther union could promote pollen removal because aggregated anthers increase contact precision of pollen with pollinators and decrease the pollen wastage (Henslow, 1888; Mani and Saravanan, 1999; Ren and Tang, 2010).

Filament union, in which the stamen's filaments are connate, but the anthers are separate from each other, is a widely distributed phenomenon in angiosperms, occurring in about 40 families (Ren, 2008), and shows considerable diversity in growth patterns and degrees of union. Despite the frequent occurrence of filament union, its effects on the pollination process are poorly understood, with only a few incidental descriptions associated with monadelphous stamens in Malvaceae (Ruan et al., 2004; Johri and Raghuvanshi, 2014; Rasoamanana et al., 2019) and diadelphous stamens in Papilionaceae (Galloni et al., 2008). Theoretically, filament union can enhance the strength of stamens, protect the pistil and stamen itself from being damaged by floral visitors, or help to keep the anthers at a relatively stable position (Harder and Barrett, 1993; Kudo, 2003; Zhang, 2004). In Theaceae, Euphorbiaceae, *Aegiceras* spp., and *Durio* spp., filament union might gather slender stamens together to support the moving pollinating birds, and keep anthers at the center of the flower, which may promote pollen removal by birds with low visiting frequency but high pollination efficiency (Ren, 2008; Ren et al., 2016; Song et al., 2019). In this scenario,

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Oreocharis hainanensis (Gesneriaceae), a new species from karst regions in Hainan Island, South China

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Abstract

Oreocharis hainanensis, a new species of Gesneriaceae is described and illustrated from low-altitudual karst areas in Hainan Island, South China. The new species is easily distinguished from its closely-related *O. jasminina* by campanulate floral tube, zygomorphic corolla and exserted stamens. It also shows different habitats from the four currently-recognized *Oreocharis* taxa on the island. Molecular phylogeny analysis based on plastid *trn*L-*trn*F and nuclear ITS1/2 sequences supported the delimitation of the new species, which forms a monophyletic clade with all the other *Oreocharis* taxa from Hainan Island. The roles of habitat and floral isolation in the evolution of the new species and its affinities are discussed. The species was assessed as Vulnerable (VU C1 and D2) according to IUCN Red List Categories and Criteria.

Keywords: Morphology, Molecular, New taxon, Karst

Introduction

Oreocharis Bentham (1876: 1021) was recently re-delimited to include ten small or monotypic genera and the species number reach to over 160 species, based on extensive molecular phylogenetic studies (Möller *et al.* 2011, Weber *et al.* 2013), while *Bournea* Oliver (in Hooker 1893: 2254) was re-instated as an independent genus (Chen *et al*. 2020). *Oreocharis* belongs to tribe Trichosporeae Nees (1825: 143), subfamily Didymocarpoideae Arnott (1832: 121) of Gesneriaceae, and it is phylogenetic closed to *Aeschynanthus* Jack (1823: 42), *Cyrtandra* Forster & Forster (1776: t. 3) and *Agalmyla* Blume (1826: 766). *Oreocharis* is predominantly distributed in China with approximately 147 species, and some species distributed in the Indochinese Peninsula and Japan (Chen *et al*. 2018, Jin *et al.* 2021, Kong *et al.* 2021). The *Oreocharis* underwent early and rapid explosive radiation in Miocene (Kong *et al.* 2021), it can be divided into two clades. One clade is mainly distributed in Southwest China and characterized by yellow corolla with four stamens, and another clade is mainly distributed in South and Southeast China and characterized by purple corolla, some species evolved with two stamens (Jin *et al.* 2021). All species are rosette plants with spirally arranged leaves, axillary inflorescences, and showed a strikingly-high diversity in floral syndromes with limited differences in habit and fruit structure (Li & Wang 2005, Wei 2010, Jin *et al.* 2021), and the evolution from zygomorphy to actinomorphy in corolla was detected (Jin *et al.* 2021).

As a distinctive part of the globally important Indo-Burma biodiversity hotspot (Myers *et al.* 2000), Hainan Island in South China harbors 14 genera and 25 species of Gesneriaceae, including two endemic genera and ten endemic species (Li & Wang 2005, Ling *et al.* 2017, 2020b). Currently, four taxa of *Oreocharis* were recognized in Hainan Island, i.e., *O. dasyantha* Chun (1946: 287) var. *dasyantha*, *O. dasyantha* var. *ferruginosa* Pan (1987: 283), *O. flavida*

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Article

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The genus *Parnassia* in Vietnam, and a checklist of Vietnamese Celastraceae

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Abstract

We summarize the knowledge on taxonomy and distribution of the genus *Parnassia* in Vietnam. Two species of the genus are found in Vietnam. We report additional records of *P. wightiana*, which appears to inhabit the provinces Ha Giang and Yen Bai. We provide detailed morphological description of the Vietnamese populations of this species, and discuss their deviation from the known variation range of *P. wightiana*. We report for the first time the second species of *Parnassia* from Vietnam, and provisionally identify it as *P. procul*. Our discovery of this species in Lam Dong Province in southern Vietnam is the first record of the genus outside the northern highlands within the country. We illustrate both Vietnamese species of *Parnassia* with analytical photographs, and show their distribution on a map. Additionally, we present an updated checklist of the family Celastraceae in Vietnam, which reflects the most recent views on taxonomic boundaries of the family and its genera, and includes discoveries of the last years as well as some earlier reports absent in the previous works. In total, 17 genera and 93 species are accepted in the checklist.

Keywords: Celastrales, flora, Indochina, *Parnassia procul*, *Parnassia wightiana*, Parnassiaceae, plant taxonomy

Introduction

The history of inventory of Celastraceae in Vietnam shows several significant steps. Pitard (1912a, 1912b) listed 12 genera and 45 species from the territory of modern Vietnam, assigned by him to Celastraceae and Hippocrateaceae. A significant amendment of Pitard's treatment was made by Tardieu-Blot (1948a, 1948b, 1948c). Pham (2003) accepted 17 genera and 72 species. The most recent checklist by Nguyen (2003a, 2003b) comprises 13 genera and 80 species currently considered in Celastraceae and assigned by the author to Celastraceae and Siphonodontaceae. The difference in the number of genera accepted in these treatments is largely related to different views on the intergeneric boundaries; the views on taxonomic identity (and, therefore, synonymization) of the species also varied significantly.

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Article

Melatonin Improves Drought Stress Tolerance of Tomato by Modulating Plant Growth, Root Architecture, Photosynthesis, and Antioxidant Defense System

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Abstract: Tomato is an important vegetable that is highly sensitive to drought (DR) stress which impairs the development of tomato seedlings. Recently, melatonin (ME) has emerged as a nontoxic, regulatory biomolecule that regulates plant growth and enhances the DR tolerance mechanism in plants. The present study was conducted to examine the defensive role of ME in photosynthesis, root architecture, and the antioxidant enzymes' activities of tomato seedlings subjected to DR stress. Our results indicated that DR stress strongly suppressed growth and biomass production, inhibited photosynthesis, negatively affected root morphology, and reduced photosynthetic pigments in tomato seedlings. Per contra, soluble sugars, proline, and ROS (reactive oxygen species) were suggested to be improved in seedlings under DR stress. Conversely, ME (100 μM) pretreatment improved the detrimental-effect of DR by restoring chlorophyll content, root architecture, gas exchange parameters and plant growth attributes compared with DR-group only. Moreover, ME supplementation also mitigated the antioxidant enzymes [APX (ascorbate peroxidase), CAT (catalase), DHAR (dehydroascorbate reductase), GST (glutathione S-transferase), GR (glutathione reductase), MDHAR (monodehydroascorbate reductase), POD (peroxidase), and SOD (superoxide dismutase)], non-enzymatic antioxidant [AsA (ascorbate), DHA (dehydroascorbic acid), GSH (glutathione), and GSSG, (oxidized glutathione)] activities, reduced oxidative damage [EL (electrolyte leakage), H_2O_2 (hydrogen peroxide), MDA (malondialdehyde), and $O_2^{\bullet-}$ (superoxide ion)] and osmoregulation (soluble sugars and proline) of tomato seedlings, by regulating gene expression for *SOD*, *CAT*, *APX*, *GR*, *POD*, *GST*, *DHAR*, and *MDHAR*. These findings determine that ME pretreatment could efficiently improve the seedlings growth, root characteristics, leaf photosynthesis and antioxidant machinery under DR stress and thereby increasing the seedlings' adaptability to DR stress.

Keywords: tomato; photosynthesis; root growth; oxidative damage; melatonin; drought; gene expression

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ORIGINAL PAPER

Melatonin Mitigates Cadmium Toxicity by Promoting Root Architecture and Mineral Homeostasis of Tomato Genotypes

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Abstract

Crop production has been extensively affected globally due to heavy metal pollution. Cadmium (Cd) toxicity is a major abiotic factor that reduces crop yield via reducing plant growth, nutrient losses, and root morphological changes. Melatonin (ME) is a well-studied strong antioxidant and nontoxic biomolecule, enhancing plants' tolerance to environmental stresses. In this study, we examined the response of tomato genotypes to Cd toxicity and the potential functions of ME in improving Cd stress tolerance. Roots of three tomato genotypes (Fenli, Badli2, and Shidun 197) were pretreated with ME (100 μM) for 3 days, followed by application of Cd (35 μM) for one week. The treatments were as follows: (1) CK (control); (2) Cd treatment; and (3) ME + Cd treatment. Cd was applied in the form of $CdCl_2$. The results revealed that seedlings with ME pretreatment (100 μM for 3 days) exposed to Cd (35 μM for 7 days) had better plant growth and root activity. ME supplementation significantly enhanced root architecture and boosted mineral nutrient uptake. Moreover, pretreatment of ME reduced leaf Cd levels by decreasing root-to-shoot transport of Cd. In conclusion, ME application modifies the root growth pattern as well as increases mineral nutrient homeostasis in tomato genotypes under Cd stress. Our results showed that ME reduced Cd-induced phytotoxicity in all tomato genotypes by enhancing biomass production, root system architecture, and macro and micro nutrient uptake by decreasing Cd uptake in all tomato genotypes.

Keywords Tomato genotypes · Root architecture · Mineral homeostasis · Cadmium · Melatonin

1 Introduction

Heavy metals are major pollutants of the environment that affect every living being on the earth (Altaf et al. 2021a). Moreover, heavy metals are well known to be necessary microelements for plants to develop and complete their life cycles. Increased levels of these metals, on the other hand, maybe harmful to plants and impede different metabolic processes (Hasan et al. 2009; Valivand et al. 2019; Shahid et al. 2021; Shakoor et al. 2021). Notably, Cd is a severe environmental contaminant that has a detrimental effect on crop growth and possible health risks linked with food chain pollution (Ajjimaporn et al. 2012). Moreover, Cd is not an essential nutrient, for the plants; however, it

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Resource Article: Genomes Explored

A chromosome-scale genome and transcriptomic analysis of the endangered tropical tree *Vatica mangachapoi* (Dipterocarpaceae)

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Abstract

Vatica mangachapoi is a tropical tree species native to Southeast Asia. It has long been valued as a timber species because the wood resists decay, but it is now considered vulnerable to extinction due to habitat loss and overexploitation. Here, we present the first chromosome-level genome assembly of *V. mangachapo*i that we created by combining data from PacBio long read sequencing with Hi-C proximity ligation and Illumina short-read sequencing. The assembled genome was 456.21 Mb, containing 11 chromosome and a BUSCO score of 93.4%. From the newly assembled genome, 46,811 protein-coding genes were predicted. Repetitive DNA accounted for 53% of the genome. Phylogenomic and gene family analyses showed that *V. mangachapoi* diverged from a common ancestor of *Gossypium raimondii* 70 million years ago. Transcriptome analyses found 227 genes that were differentially expressed in the leaves of plants grown in normal soil relative to plants grown in dry, coastal, sandy soil. For these genes, we identified three significantly enriched with GO terms: responses to organonitrogen compounds, chitin-triggered immunity, and wound response. This genome provides an important comparative benchmark not only for future conservation work on *V. mangachapoi* but also for phylogenomics work on Dipterocarpaceae.

Key words: dipterocarp forests, genome assembly, whole-genome duplication, tree genomics, conservation biology

1. Introduction

Dipterocarpaceae is a pantropically distributed family of trees known for producing high-value timber and for being a species of ecological importance, including ∼500 species. Dipterocarpoideae is the largest and most diverse subfamily, comprising 13 genera and accounting for over 90% of the species in the family.[1] Species of the Dipterocarpoideae provides the foundation on the establishment of ecosystems in tropical forests.[2] In Southeast Asian tropical forests, Asian dipterocarp forests provide a variety of ecosystem services, including global carbon balance, regional climate regulation, and

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Research article

Abundance, spatial distribution, and characteristics of microplastics in agricultural soils and their relationship with contributing factors

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ABSTRACT

Agro-ecosystem contamination with microplastics (MPs) is of great concern. However, limited research has been conducted on the agricultural soil of tropical regions. This paper investigated MPs in the agro-ecosystem of Hainan Island, China, as well as their relationships with plastic mulching, farming practices, and social and environmental factors. The concentration of MPs in the study area ranged from 2800 to 82500 particles/kg with a mean concentration of 15461.52 particles/kg. MPs with sizes between 20 and 200 μm had the highest abundance of 57.57%, fragment (58.16%) was the most predominant shape, while black (77.76%) was the most abundant MP colour. Polyethylene (PE) (71.04%) and polypropylene (PP) (19.83%) were the main types of polymers. The mean abundance of MPs was significantly positively correlated ($p < 0.01$) with all sizes, temperature, and shapes except fibre, while weakly positively correlated with the population ($p = 0.21$), GDP ($p = 0.33$), and annual precipitation ($p = 0.66$). In conclusion, plastic mulching contributed to significant contamination of soil MPs in the study area, while environmental and social factors promoted soil MPs fragmentation. The current study results indicate serious contamination with MPs, which poses a concern regarding ecological and environmental safety.

1. Introduction

The use and production of plastics on a large scale, especially single-use plastics, has resulted in an abundance of plastic debris in the environment. It has been investigated and accepted widely that microplastics (MPs) in the aquatic environment are serious threat and have the potential to negatively affect marine ecosystems and even humans (Sharma and Chatterjee, 2017). However, less scientific attention has been paid to the terrestrial environment especially the agro-ecosystem (Wang et al., 2021a). Around 63,000–430,000 tons and 44,000–300 000 tons of MPs are annually introduced to agricultural land in Europe and North America respectively (Nizzetto et al., 2021), which is much greater than the global annual input (93,000–236,000 tons) of MPs in the ocean (Van Sebille et al., 2015). The application of plastic mulch, tunnels, sewage sludge, fertilizer bags and shade, flood and street runoff, and atmospheric fallout are the main sources of high MPs distribution in the terrestrial ecosystem (Bläsing and Amelung, 2018; van den Berg et al., 2020; Yang et al., 2021). Among these sources, plastic mulching is the major source due to its worldwide practice in agriculture (Ali et al., 2021; Huang et al., 2020). Plastic mulching is extensively used in agriculture to improve microclimatic variables suitable for enhancing crop growth and production and to use water efficiently (Guo et al., 2020).

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Ecological circular agriculture: A case study evaluating biogas slurry applied to rice in two soils

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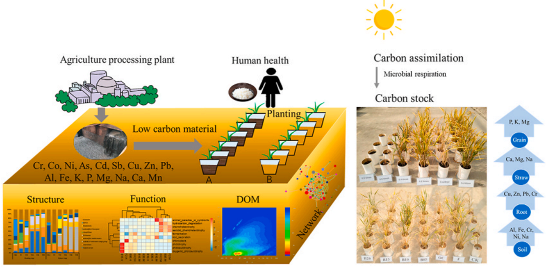
HIGHLIGHTS

- Carbon storage increase was similar in paddy and upland soils at 20% slurry rate.
- Dominant components of dissolved organic matter differed between the two soil types.
- Macronutrients accumulated in the grain produced by rice in upland soil.
- Rice quality was enhanced in slurry treatments of upland soil compared to control.
- Soil microbial community improved with slurry compared to chemical fertilisers.

GRAPHICAL ABSTRACT



ARTICLE INFO

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Biogas slurry
Ecological circular agriculture
Carbon stock
Mineral elements
Microbial diversity
Amylose and protein

ABSTRACT

In the context of carbon peak, neutrality, and circular agricultural economy, the use of renewable resources from agricultural processing for plant cultivation still needs to be explored to clarify material flow and its ecological effects. Paddy-upland rotation is an effective agricultural strategy to improve soil quality. This study evaluated the effects of biogas slurry application against those of chemical fertilisers in these two typical Chinese cropping soils. The application of biogas slurry increased total carbon content in paddy soil by 73.4%, and that in upland soil by 65.8%. Conversely, application of chemical fertiliser reduced total carbon in both soil types. There were significant positive correlations between total carbon and Zn, Cu, and Pb in rice husks grown in paddy soil ($R^2 = 0.95, 0.996, 0.95$; $p < 0.05$). The content of amylose in biogas slurry treatment of paddy soil increased by 35.9%, while that in upland soil decreased by 19.2%. After biogas slurry was applied, the contents of fulvic acid- and

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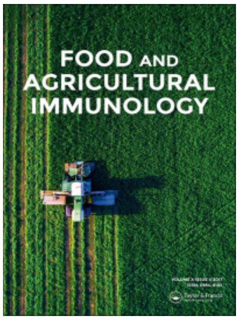

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Development of a highly sensitive and specific monoclonal antibody-based immunoassay for detection of okadaic acid in oysters and green mussels

Cheng Liang, Yuxiang Ji, Jiyong Ma, Chundong Zhang & Hongwei Zhao

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Development of a specific monoclonal antibody-based icELISA for detection of arecoline in traditional Chinese medicines and fresh areca nuts

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ABSTRACT
Arecoline, the dominant alkaloid existing in areca nuts, is an addictive substance and classified as a Group 2B potential human carcinogen. Currently, the detection of arecoline is mostly dependent on chromatography-based approaches, which are time-consuming and expensive. We used arecaidine as a hapten to produce a highly specific monoclonal antibody (mAb) against arecoline. An indirect competitive enzyme-linked immunosorbent assay (icELISA) was developed using the mAb-A5H12, to detect arecoline in traditional Chinese medicines and fresh areca nuts. The icELISA indicated that the half maximum inhibition concentration (IC50) for arecoline was 67.9 ng/mL, with a working range of 10.1–502.6 ng/mL and a limit of detection (LOD) of 3.6 ng/mL. High-performance liquid chromatographic (HPLC) confirmed the accuracy and the working range of icELISA, suggesting that the icELISA approach based on the arecoline specific antibody could be a widely applicable and easy operation method in detection of arecoline in foods and medicines.

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KEYWORDS
Arocoline; caidine; monoclonal antibody; icELISA; immunoassay

Introduction

Arecoline is the predominant alkaloid in the areca (betel) nut, which is considered as the world's fourth most common human psychoactive agent, after alcohol, nicotine, and caffeine (Papke et al., 2015). Arecoline has multiple effects on the central nervous system (including elation and anxiolysis) and is considered as an addictive substance (Heatubun et al., 2012; Volgin et al., 2019). However, arecoline has been proposed as a

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Ecological circular agriculture: A case study evaluating biogas slurry applied to rice in two soils

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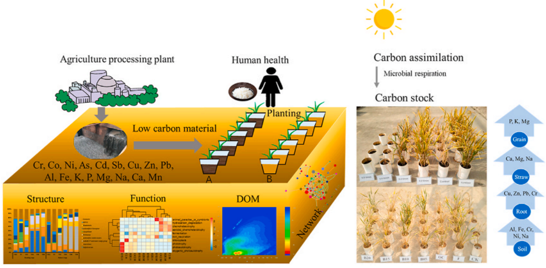
HIGHLIGHTS

- Carbon storage increase was similar in paddy and upland soils at 20% slurry rate.
- Dominant components of dissolved organic matter differed between the two soil types.
- Macronutrients accumulated in the grain produced by rice in upland soil.
- Rice quality was enhanced in slurry treatments of upland soil compared to control.
- Soil microbial community improved with slurry compared to chemical fertilisers.

GRAPHICAL ABSTRACT



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Amylose and protein

ABSTRACT

In the context of carbon peak, neutrality, and circular agricultural economy, the use of renewable resources from agricultural processing for plant cultivation still needs to be explored to clarify material flow and its ecological effects. Paddy-upland rotation is an effective agricultural strategy to improve soil quality. This study evaluated the effects of biogas slurry application against those of chemical fertilisers in these two typical Chinese cropping soils. The application of biogas slurry increased total carbon content in paddy soil by 73.4%, and that in upland soil by 65.8%. Conversely, application of chemical fertiliser reduced total carbon in both soil types. There were significant positive correlations between total carbon and Zn, Cu, and Pb in rice husks grown in paddy soil ($R^2 =$ 0.95, 0.996, 0.95; $p < 0.05$). The content of amylose in biogas slurry treatment of paddy soil increased by 35.9%, while that in upland soil decreased by 19.2%. After biogas slurry was applied, the contents of fulvic acid- and

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RESEARCH **Open Access**

Exogenous ABA and IAA modulate physiological and hormonal adaptation strategies in *Cleistocalyx operculatus and Syzygium jambos* under long-term waterlogging conditions

El-Hadji Malick Cisse[1,2†], Juan Zhang[1†], Da-Dong Li[1], Ling-Feng Miao[1,3], Li-Yan Yin[2] and Fan Yang[1,4*]

Abstract

Background: The mechanisms of abscisic acid (ABA) and auxin (IAA) in inducing adventitious root (AR) formation, biomass accumulation, and plant development under long-term waterlogging (LT-WL) conditions are largely unexplored. This study aimed to determine the roles of exogenous application of ABA and IAA in two woody plants (*Cleistocalyx operculatus* and *Syzygium jambos*) under LT-WL conditions. A pot experiment was conducted using a complete randomized design with two factors: (i) LT-WL and (ii) application of exogenous phytohormones (ABA and IAA) for 120 d.

Results: Results revealed that exogenous ABA and IAA promoted LT-WL tolerance in both species. In *C. operculatus* and *S. jambos*, plant height, the number of blades, leaf area, and fresh shoot weight were increased by exogenous IAA under LT-WL. However, exogenous ABA affected more the adventitious and primary root in *C. operculatus* compared to *S. jambos*. LT-WL decreased drastically the photosynthetic activities in both species, but adding moderate amounts of exogenous ABA or IAA protected the photosynthesis apparatus under LT-WL. Exogenous phytohormones at certain levels decreased the superoxide anion level and malondialdehyde accumulation in plants under LT-WL. Also, the increase of the peroxidases and superoxide dismutase activities by exogenous phytohormones was more marked in *C. operculatus* compared to *S. jambos*. Meanwhile, the catalase activity was down-regulated in both species by exogenous phytohormones. Exogenous ABA or IAA positively regulated the jasmonic acid content in ARs under LT-WL. Moderate application of exogenous ABA or IAA in plants under LT-WL decreased the ABA content in the leaves. Lower accumulation of IAA and ABA in the leaves of *C. operculatus* under LT-WL was positively correlated with a decrease in antioxidant activity.

Conclusions: Lastly, *C. operculatus* which has greater morphology indexes was more tolerant to waterlogging than *S. jambos*. Moreover, the adaptive strategies via exogenous ABA were more built around the below-ground biomass

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molecules

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Article

Exploration of the Interrelationship within Biomass Pyrolysis Liquid Composition Based on Multivariate Analysis

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Abstract: The diverse utilization of pyrolysis liquid is closely related to its chemical compositions. Several factors affect PA compositions during the preparation. In this study, multivariate statistical analysis was conducted to assess PA compositions data obtained from published paper and experimental data. Results showed the chemical constituents were not significantly different in different feedstock materials. Acids and phenolics contents were 31.96% (CI: 25.30–38.62) and 26.50% (CI: 21.43–31.57), respectively, accounting for 58.46% (CI: 46.72–70.19) of the total relative contents. When pyrolysis temperatures range increased to above 350 °C, acids and ketones contents decreased by more than 5.2-fold and 1.53-fold, respectively, whereas phenolics content increased by more than 2.1-fold, and acetic acid content was the highest, reaching 34.16% (CI: 25.55–42.78). Correlation analysis demonstrated a significantly negative correlation between acids and phenolics ($r^2 = -0.43$, $p < 0.001$) and significantly positive correlation between ketones and alcohols ($r^2 = 0.26$, $p < 0.05$). The pyrolysis temperatures had a negative linear relationship with acids (slope = -0.07, $r^2 = 0.16$, $p < 0.001$) and aldehydes (slope = -0.02, $r^2 = 0.09$, $p < 0.05$) and positive linear relationship with phenolics (slope = 0.04, $r^2 = 0.07$, $p < 0.05$). This study provides a theoretical reference of PA application.

Keywords: pyrolysis liquid; acetic acids; phenolics; pyrolysis temperature; multivariate statistical analysis

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1. Introduction

Thermal pyrolysis is one of the most promising ways for the conversion of abundant biomass residues into the biochar, pyrolysis liquid and various volatile gases [1,2].

Pyrolysis liquid (PA), also named pyroligneous acid, is a crude condensate generated from the distillation of smoke produced during biomass pyrolysis, and is highly oxygenated organic smoke liquid, comprising organic acids, phenolics, aldehydes, ketones and alcohols [3,4]. PA can be used as antimicrobial and antioxidant agents to improve plant growth and enhance soil nutrient health conditions because of its advantageous physical and chemical properties [5,6]. The application of PA is attributable to its chemical compositions directly [7–9].

The chemical compositions of PA depend on multiple factors influencing pyrolysis (e.g., feedstocks and pyrolysis conditions). When pyrolysis temperatures increased from 300 °C to 600 °C, acids and aldehydes content decreased, whereas phenolics and ketones obtained from giant reeds increased [10]. Wei et al. [11] reported that the PA components were prepared by pyrolyzing walnut shells within three temperatures ranges. The results from their study indicated that the acids content at 151–310 °C was 4-fold higher than that

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Microplastics in the soil environment: A critical review

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ABSTRACT

Environmental pollution of microplastics (MPs) is known to be anthropogenically mediated menace to biosphere and becoming a debatable concern globally. Large quantities of plastic fragments are left behind after crop cultivation. The leftover plastic debris, gradually degrade into minute fragments with a diameter of less than 5 mm, known as MPs. MPs are responsible for many changes in the soil physicochemical characteristics, including porosity, enzymatic activities, microbial activities, plant growth, and yield. Because of their ubiquitous nature, high specific surface area and strong hydrophobicity, MPs play an important role in the transportation of toxic chemicals such as plasticisers, polycyclic aromatic hydrocarbons (PAHs), antibiotics, and potentially toxic elements (PTEs). MPs may be transported deep into the soil and can pollute underground water. This review paper investigates the deleterious effects of MPs on the soil environment, enzymatic activities, soil microbes, flora, fauna and crop production, and highlights the general concept of MPs contamination as well as its possible environmental consequences. The review also converses some of the key areas for future research and for key stakeholders concerned with policymaking

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Monoclonal antibody-based enzyme-linked immunosorbent assay and lateral flow immunoassay for the rapid screening of paraquat in adulterated herbicides

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ABSTRACT

The use of the herbicide paraquat has been banned in many countries due to its high toxicity. However, there is an issue that illegal addition of paraquat in herbicide products. Therefore, a rapid, sensitive, and portable method will be useful to detect paraquat in adulterated herbicides for regulation purpose.

In the present study, an indirect competition enzyme-linked immunosorbent assay (icELISA) was developed with a new paraquat-specific monoclonal antibody (mAb) for paraquat detection. The icELISA results showed a 50% inhibitory concentration (IC_{50}) of 7.63 ng/mL with a working range (IC_{20}-IC_{80}) of 1.68–33.1 ng/mL. In addition, a lateral flow immunoassay (LFIA) with a cut-off value of 20.0 ng/mL was also developed. The LFIA showed no detection of the herbicides diquat, glyphosate and glufosinate up to 50 μg/mL. Nine herbicide samples were collected across Hainan province, China and analyzed by the LFIA dipsticks. One out of the nine samples was tested positive, which was confirmed with icELISA and HPLC. The accuracy of the LFIA was further verified through onsite tests in different places in China. Forty-seven commercial herbicide products were tested via the LFIA dipsticks, of which 9 samples were positive and confirmed with HPLC analysis.

The paraquat LFIA exhibited the most promising potential as the point of care (POC) device for the rapid screening of paraquat in adulterated herbicide products.

1. Introduction

Paraquat (PQ, N, N'-dimethyl-4,4′-bipyridinium dichloride) is a non-selective herbicide to control broad-leaf weeds since the 1960s [1,2]. As the most highly toxic pesticide with no specific antidote, PQ has caused more deaths than any other herbicidal agents with the lethal dose (LD_{50}) about 20–40 mg/kg of body weight in humans [2,3]. PQ cytotoxicity involves with reactive oxygen species (ROS) generation, inflammation, and improper epithelial to mesenchymal transition (EMT) [4]. Many reports showed that multiple organ dysfunction syndrome (MODS) caused the mortality of patients induced by paraquat ingestion [5]. With the lack of effective regulations, acute paraquat self-poisoning becomes a significant issue in many parts of the world [6]. More and more countries have realized the risk of PQ usage [2,7]. In some countries like China, Malaysia, Finland, Sweden and Austria, usage of paraquat in agricultural production is illegal and banned [8–10]. However, surveys in some countries still showed paraquat related poisoning incidents every year even though the paraquat sales have been prohibited [11,12]. A study indicated that left-behind children in rural areas are at a higher risk of paraquat poisoning. The retrospective analysis of the report showed at least 123 children were admitted to the hospital between 2012 and 2017 with paraquat poisoning [13]. The responsibility for these accidents of PQ rested on the manufacturer that produced illegally [14]. Low manufacturing cost and high effectiveness of herbicides which contain paraquat compared with other non-paraquat products normally is the main incentive for the manufactures to hide the usage of paraquat in production. As a result, people are poisoned after exposure to the products contaminated with paraquat. Hence, the demand for effective

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Nitrogen budgets for freshwater aquaculture and mariculture in a large tropical island – A case study for Hainan Island 1998–2018

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ABSTRACT

Nitrogen is an essential nutrient in aquaculture. It is also an important factor in coastal and river eutrophication. We present an island-scale model to study the nitrogen flows in different aquaculture systems in Hainan Island during 1998–2018. The result indicated that nitrogen losses associated with pond sludge, wastewater discharge and gaseous emission increased by a factor of 1.4, 4.6 and 3.2, respectively. Sludge and wastewater account for 84% of the total losses to the environment. During the past 20 years, aquacultural yields and the nitrogen use efficiency (NUE) improved considerably in Hainan Island. Nevertheless, nitrogen losses to the environment increased significantly as well, with negative effects for local ecosystems. In the future, sustainable aquacultural practices are needed to improve NUE and to reduce nitrogen losses to the environment.

Rapid population growth and dietary changes have greatly increased the demand for meat protein in China (Luo et al., 2018a). Aquatic products are known for their high quality proteins. However, natural aquatic systems have a limited productivity. As a result, aquaculture gained more and more attention. In recent decades, China has made great achievements in aquaculture. China has become the world's largest producer, consumer, processor and exporter of aquatic products (Zou and Huang, 2015). The rapid development of aquaculture industry, however, has caused serious problems in the local ecological environment through water pollution, eutrophication, and acidification (Edwards, 2015; Shi et al., 2015).

Nitrogen (N) is necessary for the biosynthesis of key cellular components such as proteins and nucleic acids (Kuypers et al., 2018). There are different forms of N that cause pollution, including ammonium (NH_4^+), ammonia (NH_3), different nitrogen oxides (NO_2^-, HNO_2, NO_3^-) and organic N. In recent years, studies have been published on global and country-scale aquaculture from the perspectives of economics, food security, climate change and the environment (Merino et al., 2012; Gentry et al., 2017; Wang et al., 2015; Golden et al., 2021; Edwards, 2015). In addition to these studies, models to analyze temporal and spatial changes in aquaculture can provide new perspectives on N balances and losses. Most available N-related modeling studies on aquaculture focus on the national scale, and on quantifying N production and losses from a process-based perspective. For example, Bouwman et al. (2011) established a model to evaluate the N and phosphorus (P) emissions from aquaculture for shellfish and algae production. Guo et al. (2008). conducted a study to evaluate the effects of cage aquaculture on the dynamics of N and P in shallow lakes in China. Papatryphon et al. (2005) used a nutrient balance model to assess environmental emissions from trout farming. Xia et al. (2004) reported on N and P cycling in shrimp ponds in Taihu region of China. Gu et al. (2013,2015) studied China's N footprint, in which the contribution of aquaculture was discussed, Zhang et al. (2015) reported the N and P discharge from China's aquaculture industry and associated environmental impacts by collecting the data from 51 peer-reviewed publications. *However, modeling nitrogen flows in aquaculture at the global or country (China) scale does not*

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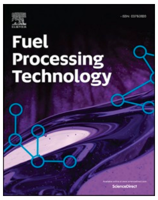

Separation of high added-value chemical compositions derived from biomass pyrolysis liquid via sequential multi-step pH adjustment

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ABSTRACT

The complexity of the components in pyrolysis liquid causes serious problems for its downstream utilization. In order to increase the added value and commercialization of pyrolysis liquid, a novel method was developed by combining the sequential multi-step pH adjustment and organic solvent extraction methods to separate the chemical components of crude pyrolysis liquid. The chemical composition of crude pyrolysis liquid was determined by fourier transform infrared spectrometry and gas chromatography–mass spectrometry. The results showed that acids (17.54%) and phenolics (57.44%) were the major constituents. The neutral compounds (e.g. ketones) (38.57%) were enriched at pH 14. Methoxyphenols (e.g., 2,6-dimethoxyphenol) were separated at pH 11, accounting for 63.4%. Phenol and maltol were mainly found at pH 9 and 7, with relative contents of 11.30% and 10.09%, respectively. At pH 6 and 4, acetic acid was the most abundant compound, with contents of 17.23% and 20.72%, respectively. The main compound at pH 2 was 2-methyl-propanoic acid anhydride (35.05%). Principal component analysis (PCA) results showed that the PC1 and PC2 components explained 38.8% and 26.2% of the chemical variance, respectively. The DPPH free radical scavenging rate showed positive correlation with the phenolic component, and was negatively correlated with the acid component. The highest DPPH free radical scavenging rate (88%) was obtained at pH 11. This study provided a theoretical reference for the separation of target components in pyrolysis liquid.

1. Introduction

Pyrolysis liquid (PA) is a brownish-yellow smoky aqueous liquid formed by the condensation of vapour from the pyrolysis of wood products and other agricultural residues, and is a by-product of thermochemical pyrolysis [1–3]. PA contains a complex mixture of organic acids, phenolics, alcohols, vanillins, furans, pyrans, carboxaldehydes, alkyl aryl ethers, nitrogenated derivatives and ketones [4]. PA has been utilised as a plant growth promoter, soil additive [5], adsorbent [6], antioxidant agent [7] and pollutant remediation additive [8], because of its excellent physical and chemical properties. Although many previous studies have focused on the application of PA because of its chemical composition and physical properties [9]. Few have been carried out on the direct separation of chemical components from PA. The separation of PA components could make related technologies more efficient and improve the isolation of valuable chemicals.

Distillation, adsorption, column chromatography, and solvent extraction are commonly used separation methods and fractionation technologies [10]. Distillation requires high energy to separate components based on differences in boiling points [11]. distillation performance is influenced by temperature and pressure. Because the chemical components of PA have similar boiling points, the exclusive separation

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Temporal variation of the coupling relationship between methanogens and biogeochemical process in soil-microbes-rice system

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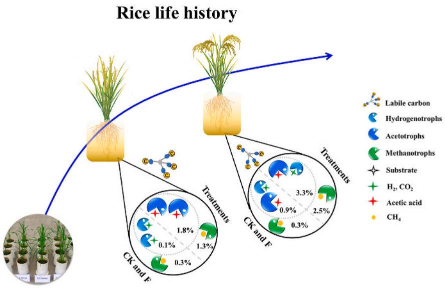
HIGHLIGHTS

- Primary methanogens changed from acetotrophs to hydrogenotrophs in the treatments.
- Methanogen composition was predominantly shaped by biogas slurry at heading stage.
- The contents of dissolved organic carbon in biogas slurry groups were significantly increased.
- The dominant phylum in the treatments was transformed from Proteobacteria to Bacteroidetes.

GRAPHICAL ABSTRACT



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ABSTRACT

Microbial community were most resilient option for methane associated mitigation strategies. Biogas slurry provides plant nutrition and affects microbial community. However, little is known about the changes of the functional guilds (methanogen and methanotroph) in the geochemical context after addition biogas slurry. For this purpose, a pot experiment was conducted. Six treatment groups were included in this study, four with biogas slurry: water ratio (1:4, T02; 2:3, T04; 3:2, T06; 4:1, T08), one with a chemical fertilizer (F), and a control (CK). The effective tiller and biomass significantly increased by 1.9 times and 2.1 times in T02 relative to CK. The relative abundance of Bacteroidetes in the biogas slurry treatments was 31.5%, while that in CK was 11.4%. The dominant methanogens in CK, F and treatments were different at heading and mature stages. CK and F were hydrogenotrophs with relative abundance of 0.09% and 0.06%, and the treatment group was acetotrophs with mean value of 1.21% at heading stage. Compared with CK, the number of methanotrophs in the treatments at heading stage increased by 4.1 times, while that at mature increased by 10.3 times. The methanogenic community in the treatments may be shaped by the amount of biogas slurry applied rather than by biogeochemical processes at heading stage. Nevertheless, there may be existed synergistic interaction in the soil-microbes-rice

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Research paper

Comparable and adaptable strategies to waterlogging stress regulated by adventitious roots between two contrasting species

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Cleistocalyx operculatus **and** ***Syzygium cumini*** **possess a certain waterlogging tolerance. However, the comparable and adaptable strategies to waterlogging stress between these two species on the basis of waterlogging adventitious root (AR) regulation were still unclear. In this study, the plant performance in response to AR regulation based on AR removal (AR-R) and exogenous hormone application was investigated in terms of plant morphology, physiology, photosynthesis and AR traits. Results showed that *C. operculatus* possesses stronger waterlogging tolerance than *S. cumini* based on waterlogging tolerance coefficient, which is mainly due to the higher root biomass, root porosity and length, and activity of ARs, and shorter emergence time of ARs in *C. operculatus* than in *S. cumini*. The AR-R treatment increased activity and porosity of primary root, and induced a large amount of up-vertical ARs from the primary root systems in *C. operculatus*, while similar adaptive morphological changes in roots did not occur in AR-R-treated *S. cumini*. Exogenous abscisic acid (ABA) application had better effects on alleviating waterlogging damages than exogenous auxin (IAA) in balancing endogenous hormones (ABA and zeatin riboside), promoting AR development (porosity and activity, and the ratio of cortex area to stele area), improving the photosynthesis process and the antioxidant system (soluble protein, free proline and peroxidase). Moreover, under waterlogging conditions, exogenous ABA application induced greater increases in net photosynthesis rate, stomatal conductance, chlorophyll b and carotenoid in *S. cumini* than in *C. operculatus*, which suggested that *S. cumini* responded more positively and efficiently to exogenous ABA application than *C. operculatus* under waterlogging conditions. Thus, the findings provided new insights into the waterlogging adaptable strategies in waterlogging tolerant woody species on the basis of ARs and could provide scientific guidance for the application of these two species during revegetation activities in wetlands.**

1. ***Cleistocalyx operculatus*** **could alternatively form a majority of up-vertical adventitious roots (ARs) from the primary roots after removing the normal ARs, but** ***Syzygium cumini*** **could not.**
2. ***Cleistocalyx operculatus*** **possessed positive strategies to waterlogging stress, while** ***S. cumini*** **used traditional passive strategies.**
3. **Exogenous abscisic acid (ABA) application had better effects on alleviating waterlogging damages in both species than exogenous auxin application.**
4. ***Syzygium cumini*** **could more positively and efficiently respond to exogenous ABA application than** ***C. operculatus.***
5. **Waterlogging tolerance coefficient was significantly controlled by the chlorophyll contents and AR factors in** ***C. operculatus*** **and the AR factors and O_2^- in** ***S. cumini.***

Dissecting the below- and aboveground specific responses of two waterlogging tolerant arbor species to nutrient supply under waterlogging conditions

Nutrient supply alters the response of adventitious root to waterlogging

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姚小兰,周琳,吴挺勋,任明迅.海南热带雨林国家公园高速公路穿越段景观动态与生态风险评估.生态学报,2022,42(16):6695-6703.

Yao X L, Zhou L, Wu T X, Ren M X.Landscape dynamics and ecological risk of the expressway crossing section in the Hainan Rainforest National Park. Acta Ecologica Sinica,2022,42(16):6695-6703.

海南热带雨林国家公园高速公路穿越段景观动态与生态风险评估

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摘要:海南热带雨林国家公园被中线高速公路自东北-西南方向穿越,改变了局域景观分布格局,影响到生态系统完整性与原真性,可能存在潜在的生态风险。选取海南热带雨林国家公园高速公路穿越段两侧 3 km 作为研究区域,运用 GIS 技术、Fragstats 和景观生态学理论定量评价 2013 年(高速公路未建)、2016 年(高速公路在建)和 2019 年(高速公路竣工)三年的景观要素变化,解析景观变化趋势和可能带来的潜在生态风险。结果表明,2016 年高速公路建成面积(含动土区域)为 325.51 hm^2,林地面积略有减少,但林地斑块密度增加;耕地面积虽略有增加,但耕地最大斑块指数下降,耕地景观优势度降低。2019 年高速公路建成竣工后,由于路旁绿化,高速公路占地面积有所下降,林地面积和林地斑块密度增加,但林地和耕地斑块的内聚力指数下降,自然连通度略降低,破碎化程度加剧;高速公路穿越段中等生态风险区和较高生态风险区面积逐年增加。但隧道和高架桥路段在一定程度上维持了道路两侧的植被连通性,对局域生态系统没有明显影响。高速公路造成的生境隔离与破碎化可能累积产生远期的负面生态学效应。海南热带雨林国家公园高速公路穿越段位于生态敏感的水源涵养区,建议增设隧道式高架林地提升生境连通性和生态系统完整性、增加人工湿地汇聚和净化道路径流、设立长期生态监测样地对关键节点生态过程与生态系统功能特别是水源涵养与水质净化功能等开展监测与生态恢复。

关键词:道路生态学;国家公园;景观格局;生态风险;生态廊道;人工湿地

Landscape dynamics and ecological risk of the expressway crossing section in the Hainan Rainforest National Park

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Abstract: Hainan Rainforest National Park is cut across by the Middle-line Expressway of Hainan Island from northeast-southwest direction, which might affect the landscape pattern and ecosystem integrity and functions, and cause potentially ecological risk. In this paper, we chose the regions within 3 km at two sides of the expressway as the study area, and quantitatively evaluated their landscape patterns for three years, i.e. 2013 (before expressway construction), 2016 (expressway under construction), and 2019 (expressway completed), based on GIS, Fragstats and landscape ecology theories. We found that the expressway (including construction areas) in 2016 was 325.51 hm^2, forest cover decreased slightly but forest patch density increased. Farmland dominance decreased as a result of increased farmland fragmentation, although its area increased slightly. In 2019, when the expressway completed, the expressway area decreased slightly and

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海南羊山湿地的传粉网络及其季节动态

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摘 要 传粉网络是植物和传粉者之间形成的网状相互作用关系, 为理解群落物种多样性形成与维持机制提供了全新的视角。湿地是典型的群落交错区, 环境异质性与物种多样性都很高, 传粉网络可能比草地和森林等生态系统具有更复杂的结构。该研究针对海南岛海口市南郊的羊山湿地, 比较4个样地在旱季(5月)与雨季(8月)的传粉网络及其动态变化, 揭示湿地生态系统的传粉网络结构特征以及在干湿季的变化规律。结果表明, 羊山湿地传粉网络共有71种开花的植物, 131种传粉者, 传粉网络呈现低连接度、高嵌套度、中等网络特化程度的结构特征。在季节动态方面, 4个样地旱季的植物与传粉者种类高于雨季; 而传粉网络的连接度、嵌套度与网络特化程度没有明显的季节差异。白花鬼针草和水角等多个物种可同时在雨季和旱季开花, 使得植物-传粉者的种间关系虽然存在季节变化, 但传粉网络在旱季与雨季间的动态变化不大。总体而言, 羊山湿地物种多样性较高, 边缘效应较明显, 传粉网络结构较稳定。

关键词 湿地; 传粉适应; 物种多样性; 保育; 边缘效应

曾凯娜, 孙浩然, 申益春, 任明迅 (2022). 海南羊山湿地的传粉网络及其季节动态. 植物生态学报, 46, 775-784. DOI: 10.17521/cjpe.2021.0281

Pollination network and seasonal dynamics of Yangshan Wetland in Hainan Island, China

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Abstract

Aims Wetland is a typical ecotone between terrestrial and aquatic ecosystems, with very high levels of habitat heterogeneity and biodiversity. The complex community structure and species interactions may have unusual pollination networks as compared to other ecosystems such as meadows and forests, which will affect species coexistence and community assembly. Our objective was to determine the pollination network and its seasonal dynamics in a tropical wetland.

Methods In this research, we studied pollination networks in four plots of Yangshan Wetland on Hainan Island, in dry seasons (May) and rainy seasons (August) respectively. Two 10-m-long walked line transects were set in each plot to sample pollination events. Both pollinators and their visitation times on each flower (plant) were recorded to determine the pollination networks.

Important findings The results showed that the species of plants and pollinators in the dry season were richer than that in the rainy season. The pollination network structure was not different between two seasons, and the visitation relationship between plant and pollinator species was relatively stable in the two seasons. There was no seasonal difference in connectance, nestedness and network specialization (H_2') on pollination network. The nestedness and H_2' of Plot 4 with higher species diversity fluctuated less in seasonal dynamic, and species relationships was stable in the community of 4 plots.

Key words wetland; pollination adaptation; species diversity; conservation; edge effect

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传粉网络是群落内植物与传粉者之间相互作用形成的关系网络(Bascompte & Jordano, 2007; Dupont *et al*., 2009)。传粉网络为理解群落的结构和动态以及花部特征的进化提供了全新的视角, 较以

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海南热带雨林国家公园道路分布及其对景观完整性的影响

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摘　要: 为揭示高速公路、国道、省道等不同类型道路对海南热带雨林国家公园生态系统完整性和景观格局的影响, 选取 2000、2010 和 2019 年海南热带雨林国家公园涉及的道路分布和土地利用数据, 运用缓冲区分析法获取不同等级道路两侧的景观变化趋势。结果表明: (1) 2000—2019 年, 海南热带雨林国家公园内道路长度增加 2 134.6 km, 道路密度增加了 0.500 km·km^{-2}。2010 年, 乡道及以下道路长度增加 2 030 km; 2019 年, 新增高速公路, 省道 310 升级为国道 361。(2) 高速公路、国道、省道两侧的斑块密度指数及景观形状指数分别在 0 ~ 500 、0 ~ 300 和 0 ~ 250 m 范围呈下降趋势, 随后趋向于平缓, 聚集度指数则表现相反; 高速公路、国道、省道的最大影响范围分别为 500 、300 和 250 m。(3) 2000—2019 年, 道路影响范围内的耕地、有林地、草地、疏林地面积减少, 其中高速公路、省道附近的有林地、草地面积降幅最大, 国道附近的耕地面积降幅最大; 水域、灌木林、建设用地、其他林地 (含果园) 面积增加, 高速公路、国道、省道周边的其他林地 (含果园) 面积增幅最大。(4) 道路影响范围内, 景观形状指数、斑块密度指数和分离度指数略有增加, 蔓延度指数则稍有下降; 目前道路对国家公园景观的影响较小, 但由于道路存在较明显的累加效应及传播作用, 仍然需要注意道路对国家公园生态系统原真性和完整性的可能影响, 建议加强大型道路如高速公路道路径流的汇流与净化、道路两侧生态廊道、长期环境监测等方面的研究。

关键词: 海南热带雨林国家公园; 高速公路; 景观格局; 生境破碎化

中图分类号: TU 986.5; Q 149　　　**文献标志码:** A

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国家公园是我国自然保护地体系的主体, 对保护生物多样性与生态服务功能、建设生态文明等具有重要意义[1－3]。海南热带雨林国家公园是我国首批正式设立的 5 个国家公园之一, 是海南省区域生态安全和我国南方生态屏障的重要组成, 保护着热带雨林及其自然资源[4－7]。在国家公园试点建设之前, 海南中线高速公路 (G9811) 于 2018 年年底全线贯通运行, 穿越了整个海南岛中南部山区[8]。海南热带雨林国家公园的范围包括了高速公路两侧的国家级自然保护区和国家森林公园等重要自然保护地, 并将高速公路的隧道上方林地及周边林地都纳入进行统筹管理和整体保护。因此, 海南热带雨林国家公园成为了我国目前唯一分布有高速公路的国家公园, 另还有国道 G224、G361 等大型道路穿行其中。虽然, 这些道路在修建的时候都充分考虑到了尽量降低对环境和生态的影响, 但大型道路长期存在的物理隔离和快速扩散等作用, 可能带来较长时间尺度的环境压力。

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•研究报告•

海南热带雨林国家公园不同植被类型的大型真菌多样性

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摘要: 为揭示海南热带雨林国家公园大型真菌多样性及不同植被类型对真菌群落的影响, 本研究于2020年和2021年湿季对海南热带雨林国家公园内7个管理局辖区开展了大型真菌多样性调查, 比较了不同植被类型(山地雨林、低地雨林、低地雨林次生林、人工林)的大型真菌生活型(共生型、腐生型)组成差异。从设置的58条1 km长的样带内采集到1,869份子实体标本, 根据子实体形态与ITS rDNA序列分析, 从中鉴定出562种真菌, 涉及17目64科174属, 其中80%以上的物种由伞菌目、牛肝菌目、红菇目、多孔菌目、鸡油菌目、锈革孔菌目和炭角菌目构成。大型真菌的营养型以腐生型(占48.2%物种)和共生型(44.8%)为主。每条样带的平均物种丰富度和多度以中海拔的山地雨林最高, 分别为28 ± 5种和33 ± 6个, 而人工林最低, 分别为11 ± 1种和11 ± 2个。植被类型主要影响共生型大型真菌物种丰富度($P = 0.026$)和子实体多度($P = 0.019$)及Shannon-Wiener多样性($P = 0.028$), 但对腐生型大型真菌的影响并不显著。多响应置换过程(multiple response permutation procedure, MRPP)检验结果表明, 不同植被类型对共生型与腐生型大型真菌群落物种组成均有显著影响(腐生型: $P = 0.004$, 共生型: $P = 0.041$)。冗余分析(redundancy analysis, RDA)的结果表明, 植被类型对腐生型和共生型真菌群落物种组成差异的解释度均较低(共生型: $R^2 = 0.068$, $P = 0.004$; 腐生型: $R^2 = 0.067$, $P = 0.004$)。海拔仅对腐生型真菌群落物种组成产生微弱影响($R^2 = 0.029$, $P = 0.001$), 而对共生型真菌影响不显著($R^2 = 0.024$, $P = 0.072$)。在不同保护地之间, 共生型($R^2 = 0.148$, $P = 0.001$)与腐生型($R^2 = 0.123$, $P = 0.002$)真菌物种组成均具显著差异; 基于样带–真菌矩阵的网络图显示, 海南热带雨林国家公园内尖峰岭、霸王岭、五指山等国家级自然保护区的山地雨林是共生型大型真菌多样性较高区域, 应作为共生型真菌与宿主的优先保护区域。

关键词: 国家公园; 大型真菌; 腐生型; 共生型; 热带山地雨林; 人工林

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Macrofungal diversity in different vegetation types of Hainan Tropical Rainforest National Park

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ABSTRACT

Aims: To reveal macrofungal diversity and how different vegetation types affect the fungal community, an inventory of macrofungal diversity was carried out in seven management units within the Hainan Tropical Rainforest National Park

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基于 SSR 标记的无翼坡垒遗传多样性研究

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摘　要: 为了解无翼坡垒 (*Hopea reticulate* Tardieu) 的遗传多样性和不同龄级间的遗传结构, 利用 11 对微卫星标记评估海南省甘什岭保护区的无翼坡垒的遗传多样性, 并根据胸径将无翼坡垒划分为幼龄、中龄和成熟龄 3 个龄级, 明确不同龄级间的遗传差异, 探究其濒危机制, 并从遗传角度提出保护策略。结果表明: 无翼坡垒的等位基因数（N_a=3.636）和期望杂合度（H_e=0.599）低于同属的非濒危种 *H. dryobalanoides*（N_a=5.600, H_e=0.678）, 明显高于同属且同域分布的另一濒危种坡垒（N_a=2.417, H_e=0.432）, 但不同龄级的遗传多样性没有明显差异。无翼坡垒低频等位基因的比例明显低于龙脑香科的非濒危种, 揭示种群很可能经历了瓶颈, 种群规模缩小导致大量低频等位基因丢失。由于本种在甘什岭集中分布, 现存个体数量比零星分布的坡垒更多, 因此, 遗传多样性较坡垒略高。基于微卫星变异研究的结果, 建议在维持无翼坡垒现有变异的基础上, 通过人工抚育, 促进种群更新, 恢复遗传多样性和进化潜力, 实现无翼坡垒的稳定续存。

关键词: 无翼坡垒; 微卫星; 遗传多样性; 种群瓶颈; 保护

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热带雨林分布在赤道附近降雨充沛的热带地区, 是 1 种具有独特外貌和群落结构, 物种多样性很高的森林生态系统[1−2]。热带雨林在调节局部与全球气候、维持生物多样性和生态平衡等方面发挥着重要作用[3]。我国热带地区位于亚洲热带北缘, 是东南亚热带雨林向北延伸的边界, 主要包括西藏东南部、云南和广西南部、台湾南部和海南岛, 其中, 海南岛具有我国分布最集中、连片面积最大的热带雨林[4−6]。龙脑香科 (Dipterocarpaceae) 是海南岛热带雨林的标志性树种, 广泛分布在海南岛 700 m 以下的低海拔山地[7]。胡玉佳[7] 根据群落结构和生态外貌特征, 将海南岛的龙脑香群落分为混合群落与单优群落, 后者包括单优青皮林与单优无翼坡垒林。与原生演替形成的单优青皮林不同, 单优无翼坡垒林是经过多次人为干扰破坏后, 通过次生演替形成的[8]。自 20 世纪 70 年代在甘什岭发现无翼坡垒以来, 许多学者围绕单优无翼坡垒林开展了种群、群落和区系研究。胡玉佳[7] 在 1983 年调查了无翼坡垒林的物种组成, 发现群落的物种数较少, 森林尚处于更新阶段。最近, 邢福武等[9] 和漆良华等[10] 再次调查了无翼坡垒群落, 发现物种数有所增长, 表明甘什岭保护区在物种保护上发挥了积极的作用。杨小波等[11−13] 研究了无翼坡垒的种群结构, 分布格局, 物种多样性和空间配置, 确定无翼坡垒为增长型种群, 但自疏作用强烈, 生长到一定阶段后个体数量减少, 种群的集群程度变小。胡璇等[14] 针对无翼坡垒种群结构与动态的最新研究显示, 老龄树的比例较 25 年前有所增长, 种群结构在向好的方向发展, 但无翼坡垒的幼龄树对病害敏感, 且生长受磷元素限制[15−17]。光合生理特性研究显示, 虽然无翼坡垒为耐阴树种, 但到一定时期后需要充足的光照

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圆唇苣苔属(*Gyrocheilos*)花柱侧偏弯折现象及其传粉适应机制

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摘要：圆唇苣苔属(*Gyrocheilos*)是苦苣苔科的中国特有属，约 5 种，全部狭域分布在我国西南及广东的高海拔山区。圆唇苣苔属所有物种的花柱侧偏且花柱顶端呈 90°弯折，使得柱头位于花开口的中央位置。这种独特的侧偏弯折花柱结构，说明圆唇苣苔属可能有着特殊的演化历史和适应机制。为揭示这种特殊的花柱侧偏弯折现象的发生范围、发育过程及其传粉适应机制，该文首先在圆唇苣苔(*Gyrocheilos chorisepalus*)、折毛圆唇苣苔(*G. retrotrichus*)和微毛圆唇苣(*G. microtrichus*)3 个物种中开展了花部综合征观察，然后研究了广东大雾岭保护区内的折毛圆唇苣苔花发育过程、花部特征和繁育系统以及传粉过程。结果表明：（1）微毛圆唇苣苔只有花柱左偏弯折现象；而圆唇苣苔和折毛圆唇苣苔虽然大部分花是花柱左偏弯折，但在部分个体出现了少量的花柱右偏弯折现象(占种群总花数的 2%~3%)。（2）传粉观察发现折毛圆唇苣苔在花蕾期即出现了花柱弯折现象，2 个可育雄蕊的花药合生、位于花冠筒喉部中央位置，与侧偏花柱不存在左右镜像对称关系。（3）折毛圆唇苣苔的花粉/胚珠比率(P/O)为 456.98±15.55，属于兼性异交繁育系统。折毛圆唇苣苔存在一定的花粉限制、自交授粉可以结实，但异交种子萌发率更高，可能存在近交衰退。（4）折毛圆唇苣苔的访花昆虫较少，访花频率较低，主要访花昆虫有熊蜂、隧蜂、食蚜蝇等。熊蜂体型较大，访花时降落在弯折花柱和花瓣下唇，胸部侧面及下部能有效接触到柱头。（5）反射率结果显示折毛圆唇苣苔花瓣反射波长范围集中在紫光和蓝紫光区域，花冠的反射波长范围与蜂类视觉范围一致，且花冠筒外侧和花瓣下唇的反射强度最大，更容易吸引蜂类落置在花冠宽大的下唇。圆唇苣苔属的花柱侧偏弯折现象可能来源于近缘的长蒴苣苔属(*Didymorcarpus*)的花柱下弯现象或镜像花(mirror-image flowers)。这种侧偏弯折的花柱，可能通过提供昆虫降落平台和使得柱头位于花开口中央和花瓣下唇的上方位置，提高了柱头接触访花昆虫的几率，是适应高海拔地区低频率访花者的一种机制。

关键词：花部综合征，镜像花，传粉机制，繁育系统，苦苣苔科

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Style lateral bending and its pollination adaptation in *Gyrocheilos* (Gesneriaceae)

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Abstract: *Gyrocheilos* is a small genus of Gesneriaceae endemic to mountains in southwest China, with only five species and two varieties. This genus is characterized by laterally bending style, which curves at the top of the style and positions the stigma right at the mouth of floral tube. This unusual floral trait had never been described elsewhere and its pollination mechanism remains unexplored. In this paper, three *Gyrocheilos* species, i.e. *G. chorisepalus*, *G. retrotrichus*, *G. microtrichus* were

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羊山湿地
植被与景观

申益春　任明迅　著

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