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苦苣苔科植物远缘杂交亲和性初探

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摘 要: 该研究对苦苣苔科的蛛毛苣苔属[*Paraboea* (C. B. Clarke) Ridley]、马铃苣苔属(*Oreocharis* Bentham)、报春苣苔属(*Primulina* Hance)、吊石苣苔属(*Lysionotus* D. Don)、台闽苣苔属(*Titanotrichum* Soleredder)、半蒴苣苔属(*Hemiboea* C. B. Clarke)、长蒴苣苔属(*Didymocarpus* Wallich)、光叶苣苔属(*Glabrella* Mich. Moller & W. H. Chen)进行属间远缘杂交,对马铃苣苔属的马铃苣苔组、川滇马铃苣苔组、大叶石上莲组进行组间远缘杂交,统计不同杂交组合的结实情况及播种后的种子萌发情况,以明确不同属(组)间远缘杂交亲和性,为通过远缘杂交进行苦苣苔科种质资源的创新奠定基础。结果表明:(1)不同属作为父本,与同一母本进行杂交,以及同一属内不同种作为父本,与同一母本进行杂交,结实情况差异显著。(2)不同属作为母本,与同一父本进行杂交,以及同一属内不同种作为母本,与同一父本进行杂交,结实情况同样存在显著差异。(3)相同两个种正反交杂交成功率也并不一致。(4)马铃苣苔属与半蒴苣苔属,报春苣苔属与吊石苣苔属,吊石苣苔属与报春苣苔属和半蒴苣苔属,光叶苣苔属与报春苣苔属和吊石苣苔属之间部分种进行远缘杂交能够正常结实,且杂交种子能够正常萌发。(5)马铃苣苔属内组间杂交无明显生殖隔离的现象。

关键词: 苦苣苔, 远缘杂交, 亲和性, 正反交, 种子

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Compatibility of intergeneric cross in gesneriaceae

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Abstract: Species belong to Gesneriaceae have great potential for developing to potted flower, and are also important breeding resources. There was no report on the intergeneric cross in Gesneriaceaeis, which was the important means of germplasm resources innovation. To investigate the compatibility of intergeneric cross in Gesneriaceae, the intergeneric cross was attempted between different species in Gesneriaceae family, which included *Primulina* genus, *Paraboea* genus, *Oreo-*

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charis genus, *Lysionotus* genus, *Didymocarpus* genus, *Glabrella* genus, *Hemiboea* genus and *Titanotrichum* genus . The fruit-setting was calculated in different interspecific crosses. In addition, hybrid seed germinations were observed. The results were as follows: (1) Species in the different genra and same genus as the female parent, cross with the same male parent all showed significant difference in fruit-setting. (2) Species in the different genra and same genus as the male parent, cross with the same female parent all showed significant difference in cross-compatibility. (3) The differences of fruit-setting between positive and reverse crosses were significant. (4) Mature seeds were easily obtained from intergeneric cross between some species of *Oreocharis* genus and *Hemiboea* genus, *Chirita* genus and *Lysionotus* genus, *Lysionotus* genus and *Hemiboea* genus or *Primulina* genus, *Glabrella* genus and *Primulina* genus or *Lysionotus* genus. (5) Compatibility of intergeneric crosses between sect. *Oreocharis*, sect. *Orthoanthera* and sect. *Stomactin* were observed.

Key words: Gesneriaceae, distant hybridization, compatibility, positive and reverse crosses, seed

苦苣苔科(Gesneriaceae)植物,形态千姿百态,花色变化多样,大部分种对弱光条件下的散射光利用效率高,同时也能够适应稍强的光照,极具开发为室内观赏盆花的潜力(韦毅刚等,2004;温放,2008;郑月萍等,2012;徐慧,2013;刘北辰,2014;孙国胜,2015)。目前,已经市场化的苦苣苔科观赏植物大部分都是以原产南美、非洲和东南亚热带地区的原种为基础的原生种选育而来,如非洲紫罗兰(*Saintpaulia ionantha*)、大岩桐(*Sinningia speciosa*)、喜阴花(*Episcia cupreatasri*)等。

我国苦苣苔科植物资源丰富,约有 43 属 683 种(Moller et al,2016),大部分种类具有较高观赏价值,然而我国苦苣苔科资源基本处于野生状态,对苦苣苔科的研究主要集中在资源调查、分类及药用栽培上,关于该科植物杂交、品种培育方面的研究较少,至今没有一个真正意义上,完全由我国自行培育并形成产业化的商品化品种(李振宇等,2004;温放等,2005;吕惠珍等,2009;艾春晓,2013;杨文光等,2014;温放等,2014)。因此培育具有中国自主知识产权的苦苣苔科观赏新品种具有重要意义。

1 材料与方法

2013 年,广西植物研究所培育的报春苣苔属植物两个种间杂交品种“紫月”(*Primulina* ‘Purple Moon’)和“古铜小伙”(*Primulina* ‘Tan Boy’)获得国际认证;2014 年和 2015 年华南植物园培育的报春苣苔属植物新品种“黄钻”(*Primulina* ‘SCBG Huangzuan’)和“紫霞”(*Primulina* ‘SCBG Zixia’),‘红蝴蝶’(*Primulina* ‘SCBG Red Butterfly’)、‘彩虹’(*Primulina* ‘SCBG Rainbow’)、‘皇冠’(*Primulina* ‘SCBG Crown’)和‘紫云’(*Primulina* ‘Purple Cloud’),陆续获得国际认证。李振宇(1996)认为,长蒴苣苔族内杂交通常可育,但并未见有属间杂交的报道。因此,关于苦苣苔科不同属之间的远缘杂交亲和性尚未见有报道。本研究以苣苔科观赏价值较高的报春苣苔属、蛛毛苣苔属、吊石苣苔属、长蒴苣苔属、马铃苣苔属、半蒴苣苔属、台闽苣苔属、光叶苣苔属为材料,进行属(组)间远缘杂交试验,较为系统地研究了中国苦苣苔远缘杂交亲和性,为今后更好开展苦苣苔杂交育种提供理论依据。

1.1 材料

试验于 2015—2016 年在恩施冬升植物开发责任有限公司苦苣苔科植物引种驯化资源圃中进行,供试材料包括报春苣苔属的烟叶报春苣苔(*Primulina heterotricha*)、柳江报春苣苔(*P. liujiangensis*)、线叶报春苣苔(*P. linearifolia*)、牛耳朵(*P. eburnea*)、龙州报春苣苔(*P. lungzhouensis*)、永福报春苣苔(*P. yungfuensis*)、蚂蝗七(*P. fimbrisepala*);蛛毛苣苔属的蛛毛苣苔(*Paraboea sinensis*)、锈色蛛毛苣苔(*P. rufescens*);马铃苣苔属的绢毛马铃苣苔(*Oreocharis sericea*)、长瓣马铃苣苔(*O. auricula*)、川滇马铃苣苔(*O. henryana*)、湘桂马铃苣苔(*O. xiangguiensis*)、紫花马铃苣苔(*O. argyreia*)、皱叶后蕊苣苔(*O. fargesii*);吊石苣苔属的吊石苣苔(*Lysionotus pauciflorus*);长蒴苣苔属的闽赣长蒴苣苔(*Didymocarpus heucherifolius*);光叶苣苔属的革叶粗筒苣苔(*Glabrella mihieri*)、盾叶粗筒苣苔(*G. longipes*);半蒴苣苔属的半蒴苣苔(*Hemiboea subcapita-*

ta)、柔毛半蒴苣苔(*H. mollifolia*)、贵州半蒴苣苔(*H. cavaleriei*)、纤细半蒴苣苔(*H. gracilis*),台闽苣苔属的台闽苣苔(*Titanotrichum oldhamii*)。以上材料全部为从云南、贵州、广西、福建、湖北五个省(区)引种的原生种,通过 1 a 以上的驯化栽培,在栽培地生长良好,能够正常开花结果。

1.2 杂交组合筛选

在保证亲本双方花期相遇的前提下,根据基地现有不同种类苦苣苔的数量、群体可授花朵数量和花粉采集能力选择授粉组合。数量少于 3 株或可授花朵数小于 10 朵的种,一般只做父本;花朵数量和可授花朵数量较多的,即可作为母本,又可选作父本;花朵数量和花粉足够的情况下,同一时期开花的不同属的所有苦苣苔全部进行相互授粉。实验共设置 49 个杂交组合。

1.3 杂交

1.3.1 *去雄与授粉*　选择发育健壮的花序,每花序在开花前 2~3 d 雄蕊比较幼嫩时留取 2~3 朵即将开花的花蕾进行去雄,去雄的同时将花序上其余花朵摘除。去雄完成后立即套上隔离袋,用尼龙绳系紧袋口,挂牌,标明母本名称,去雄花朵数,去雄日期。在去雄后的 2~3 d,雌蕊花柱伸长,柱头表面开始湿润有粘液时进行授粉,授粉时间在上午的 9:00—10:00 间,为保证授粉效果,每朵花均重复授粉 3~4 次。授粉时,摘取父本成熟花药,用镊子在花冠背部轻轻挤压,使花粉落在白纸上,用牙签套上气门芯沾取花粉轻轻涂于母本柱头上,授粉完成后再套袋,并在吊牌上加注父本名称,授粉日期和授粉花数。授粉后 7~10 d,花冠脱落,柱头变为枯黄色萎蔫时即可去袋。从去袋至果实成熟期间定期观察子房发育情况,待果实开始枯黄但未开裂时及时采收,统计结实蒴果数量。

1.3.2 *杂交种子的播种*　杂交种子采收后立即进行播种,播种容器采用 128 穴的育苗盘,播种基质为草炭土∶珍珠岩=4∶1 的混合基质,每隔 7 d 观察出苗情况,记录出苗的杂交组合。

2　结果与分析

2.1 苦苣苔科属间杂交结实情况

以苦苣苔科观赏价值较高的报春苣苔属、蛛毛苣苔属、吊石苣苔属、长蒴苣苔属、马铃苣苔属、半蒴苣苔属、台闽苣苔属、光叶苣苔属为材料,进行属间远缘杂交试验。

2.1.1 *不同种作为父本与同一母本进行杂交的结实情况*　表 1 为不同种作为父本与同一母本进行杂交的结实情况。通过表 1 看出多数组中不同属作为父本与同一母本进行杂交的结实情况存在显著差异。以革叶粗筒苣苔作母本为例,分别与报春苣苔属的柳江报春苣苔和烟叶报春苣苔、半蒴苣苔属的柔毛半蒴苣苔和贵州半蒴苣苔、吊石苣苔属的吊石苣苔、马铃苣苔属的川滇马铃苣苔进行杂交,其中革叶粗筒苣苔 × 川滇马铃苣苔授粉后不久子房萎蔫,结实率为 0;而革叶粗筒苣苔 × 柳江报春苣苔、革叶粗筒苣苔 × 烟叶报春苣苔、革叶粗筒苣苔 × 柔毛半蒴苣苔、革叶粗筒苣苔 × 贵州半蒴苣苔、革叶粗筒苣苔 × 吊石苣苔授粉后子房发育迅速,结实率分别为 100%、100%、100%、71.4%、87.5%。其他组中以柳江报春苣苔、吊石苣苔、湘桂马铃苣苔、绢毛马铃苣苔、紫花马铃苣苔为母本与不同属进行杂交也存在结实情况差异显著的现象。

同一属内不同种作为父本与同一母本进行杂交的结实情况也存在显著差异。以吊石苣苔为母本,分别与报春苣苔属的烟叶报春苣苔、柳江报春苣苔、永福报春苣苔进行杂交,其中吊石苣苔 × 永福报春苣苔授粉后不久子房萎蔫,结实率为 0,而吊石苣苔 × 烟叶报春苣苔、吊石苣苔 × 柳江报春苣苔授粉后子房发育迅速,结实率分别为 50%、76.9%;分别与半蒴苣苔属的半蒴、柔毛半蒴、贵州半蒴进行杂交,其中吊石苣苔 × 柔毛半蒴苣苔、吊石苣苔 × 贵州半蒴苣苔授粉后不久子房萎蔫,结实率为 0,而吊石苣苔 × 半蒴苣苔苣苔授粉后子房发育迅速,结实率为 100%。

2.1.2 *不同种作为母本与同一父本进行杂交的结实情况*　表 2 为不同种作为母本与同一父本进行杂交的结实情况。从表 2 可以看出,多数组中不同属作为母本与同一父本进行杂交的结实情况存在显著差异。从贵州半蒴苣苔作父本来看,分别与报春苣苔属的柳江报春苣苔、吊石苣苔属的吊石苣苔、光叶苣苔属的革叶粗筒苣苔和盾叶粗筒苣苔进行杂交,其中吊石苣苔 × 贵州半蒴苣苔授粉后不久子房萎蔫,结实率为 0;而柳江报春苣苔 × 贵州半蒴苣苔、

表 1 不同种作为父本与同一母本进行杂交的结实及种子出苗情况

Table 1 Results of intergeneric distant hybridization of Gesneriaceae-species in the different genra and same genus as the female parents

母本 Female parent	父本 Male parent	授粉花朵数 No. of pollinated flowers	采收蒴果数 No. of fruit setting	结实率 Fruit-setting percentage (%)	子房发育特征 Characteristics of ovary development	播种是否出苗 Characteristics of seed germination
柳江报春苣苔 *Primulina liujiangensis*	川滇马铃苣苔 *Oreocharis henryana*	5	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	锈色蛛毛苣苔 *Primulina rufescens*	7	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	半蒴苣苔 *Hemiboea subcapitata*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	贵州半蒴苣苔 *H. cavaleriei*	5	4	80	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	吊石苣苔 *Lysionotus pauciflorus*	13	13	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	革叶粗筒苣苔 *Glabrella mihieri*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	盾叶粗筒苣苔 *G. longipes*	7	7	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	台闽苣苔 *Titanotrichum oldhamii*	9	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
烟叶报春苣苔 *Primulina heterotricha*	长瓣马铃苣苔 *Oreocharis auricula*	11	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
永福报春苣苔 *Primulina yungfuensis*	吊石苣苔 *Lysionotus pauciflorus*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	纤细半蒴苣苔 *Hemiboea gracilis*	5	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
锈色蛛毛苣苔 *Primulina rufescens*	烟叶报春苣苔 *P. heterotricha*	10	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	川滇马铃苣苔 *Oreocharis henryana*	12	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	半蒴苣苔 *Hemiboea subcapitata*	7	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
吊石苣苔 *Lysionotus pauciflorus*	锈色蛛毛苣苔 *Primulina rufescens*	8	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	蛛毛苣苔 *P. sinensis*	7	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	烟叶报春苣苔 *P. heterotricha*	8	4	50	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	柳江报春苣苔 *P. liujiangensis*	13	10	76.9	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	川滇马铃苣苔 *Oreocharis henryana*	9	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	革叶粗筒苣苔 *Glabrella mihieri*	6	4	66.7	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	半蒴苣苔 *Hemiboea subcapitata*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	柔毛半蒴苣苔 *H. mollifolia*	4	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	贵州半蒴苣苔 *H. cavaleriei*	4	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	永福报春柱苣苔 *Primulina yungfuensis*	5	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	台闽苣苔 *Titanotrichum oldhamii*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—

续表1

母本 Female parent	父本 Male parent	授粉花朵数 No. of pollinated flowers	采收蒴果数 No. of fruit setting	结实率 Fruit-setting percentage (%)	子房发育特征 Characteristics of ovary development	播种是否出苗 Characteristics of seed germination
革叶粗筒苣苔 *Glabrella mihieri*	柳江报春苣苔 *Primulina liujiangensis*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	烟叶唇柱苣苔 *P. heterotricha*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是
	柔毛半蒴苣苔 *Hemiboea mollifolia*	10	10	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	贵州半蒴苣苔 *H. cavaleriei*	7	5	71.4	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	吊石苣苔 *Lysionotus pauciflorus*	8	7	87.5	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	川滇马铃苣苔 *Oreocharis henryana*	10	0	0	授粉后子房萎蔫 Ovary wilting shortly after pollination	—
盾叶粗筒苣苔 *Glabrella longipes*	柔毛半蒴苣苔 *Hemiboea mollifolia*	3	3	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	贵州半蒴苣苔 *H. cavaleriei*	5	3	60	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	烟叶报春苣苔 *Primulina heterotricha*	4	4	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
闽赣长蒴苣苔 *Didymocarpus heucherifolius*	牛耳朵 *Primulina eburnea*	4	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	蚂蝗七 *P. fimbrisepala*	4	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	线叶报春苣苔 *P. linearifolia*	5	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
湘桂马铃苣苔 *Oreocharis xiangguiensis*	半蒴苣苔 *Hemiboea subcapitata*	10	10	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	台闽苣苔 *Titanotrichum oldhamii*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
川滇马铃苣苔 *Oreocharis henryana*	烟叶报春苣苔 *Primulina heterotricha*	12	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	锈色蛛毛苣苔 *P. rufescens*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	半蒴苣苔 *Hemiboea subcapitata*	14	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	台闽苣苔 *Titanotrichum oldhamii*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
绢毛马铃苣苔 *Oreocharis sericea*	革叶粗筒苣苔 *Glabrella mihieri*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	皱叶后蕊苣苔 *Oreocharis fargesii*	8	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
紫花马铃苣苔 *Oreocharis argyreia*	吊石苣苔 *Lysionotus pauciflorus*	5	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	革叶粗筒苣苔 *Glabrella mihieri*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
皱叶后蕊苣苔 *Oreocharis fargesii*	绢毛马铃苣苔 *O. sericea*	6	4	66.7	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	长瓣马铃苣苔 *O. auricula*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes

革叶粗筒苣苔 × 贵州半蒴苣苔、盾叶粗筒苣苔 × 贵州半蒴苣苔授粉后子房发育迅速，结实率分别为80%、71.4%、60%。其他组中以半蒴苣苔、吊石苣苔、革叶粗筒苣苔、烟叶报春苣苔、柳江报春苣苔、柔

表 2 不同种作为母本与同一父本进行杂交的结实及种子出苗情况

Table 2 Results of intergeneric distant hybridization of Gesneriaceae species in the different genra and the same genus as the male parent

父本 Male parent	母本 Female parent	授粉花朵数 No. of pollinated flowers	采收蒴果数 No. of fruit setting	结实率 Fruit-setting percentage (%)	子房发育特征 Characteristics of ovary development	播种是否出苗 Characteristics of seed germination
半蒴苣苔 *Hemiboea subcapitata*	柳江报春苣苔 *Primulina liujiangensis*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	锈色蛛毛苣苔 *P. rufescens*	7	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	吊石苣苔 *Lysionotus pauciflorus*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	湘桂马铃苣苔 *Oreocharis xiangguiensis*	10	10	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	川滇马铃苣苔 *O. henryana*	14	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
贵州半蒴苣苔 *Hemiboea cavaleriei*	柳江报春苣苔 *Primulina liujiangensis*	5	4	80	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	吊石苣苔 *Lysionotus pauciflorus*	4	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	革叶粗筒苣苔 *Glabrella mihieri*	7	5	71.4	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	盾叶粗筒苣苔 *G. longipes*	5	3	60	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
吊石苣苔 *Lysionotus pauciflorus*	柳江报春苣苔 *Primulina liujiangensis*	13	13	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	永福报春苣苔 *P. yungfuensis*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	革叶粗筒苣苔 *Glabrella mihieri*	8	7	87.5	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	紫花马铃苣苔 *Oreocharis argyreia*	5	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
革叶粗筒苣苔 *Glabrella mihieri*	柳江报春苣苔 *Primulina liujiangensis*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	吊石苣苔 *Lysionotus pauciflorus*	9	0	66.7	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	绢毛马铃苣苔 *Oreocharis sericea*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	紫花马铃苣苔 *O. argyreia*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
烟叶报春苣苔 *Primulina heterotricha*	锈色蛛毛苣苔 *P. rufescens*	10	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	吊石苣苔 *Lysionotus pauciflorus*	8	4	50	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	革叶粗筒苣苔 *Glabrella mihieri*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	盾叶粗筒苣苔 *G. longipes*	4	4	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	川滇马铃苣苔 *Oreocharis henryana*	12	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
柳江报春苣苔 *Primulina liujiangensis*	吊石苣苔 *Lysionotus pauciflorus*	13	10	76.9	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	革叶粗筒苣苔 *Glabrella mihieri*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes

续表2

父本 Male parent	母本 Female parent	授粉花朵数 No. of pollinated flowers	采收蒴果数 No. of fruit setting	结实率 Fruit-setting percentage (%)	子房发育特征 Characteristics of ovary development	播种是否出苗 Characteristics of seed germination
柔毛半蒴苣苔 *Hemiboea mollifolia*	吊石苣苔 *Lysionotus pauciflorus*	4	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	革叶粗筒苣苔 *Glabrella mihieri*	10	10	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否 No
	盾叶粗筒苣苔 *G. longipes*	3	3	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	否
台闽苣苔 *Titanotrichum oldhamii*	吊石苣苔 *Lysionotus pauciflorus*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	湘桂马铃苣苔 *Oreocharis xiangguiensis*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	川滇马铃苣苔 *O. henryana*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	柳江报春苣苔 *Primulina liujiangensis*	9	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
长瓣马铃苣苔 *Oreocharis auricula*	烟叶报春苣苔 *Primulina heterotricha*	11	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	皱叶后蕊苣苔 *Oreocharis fargesii*	3	2	66.7	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
锈色蛛毛苣苔 *Primulina rufescens*	柳江报春苣苔 *P. liujiangensis*	7	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	吊石苣苔 *Lysionotus pauciflorus*	8	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	川滇马铃苣苔 *Oreocharis henryana*	6	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
皱叶后蕊苣苔 *Opithandra fargesii*	长瓣马铃苣苔 *O. auricula*	14	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	绢毛马铃苣苔 *O. sericea*	8	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
川滇马铃苣苔 *Oreocharis henryana*	柳江报春苣苔 *Primulina liujiangensis*	5	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	锈色蛛毛苣苔 *P. rufescens*	4	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	革叶粗筒苣苔 *Glabrella mihieri*	10	0	0	授粉后子房萎蔫 Ovary wilting shortly after pollination	—
	吊石苣苔 *Lysionotus pauciflorus*	9	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
长瓣马铃苣苔 *Oreocharis auricula*	烟叶报春苣苔 *Primulina heterotricha*	11	0	0	授粉后不久子房萎蔫 Ovary wilting shortly after pollination	—
	皱叶后蕊苣苔 *Oreocharis fargesii*	3	2	66.7	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes

毛半蒴苣苔、长瓣马铃苣苔、绢毛马铃苣苔为父本与不同属进行杂交也存在结实情况差异显著的现象。

同一属内不同种作为母本与同一父本进行杂交的结实情况也存在显著差异。以吊石苣苔为父本，分别与报春苣苔属的柳江报春苣苔和永福报春苣苔进行杂交，其中永福报春苣苔 × 吊石苣苔授粉后不久子房萎蔫，结实率为 0，而柳江报春苣苔 × 苔吊石苣苔授粉后子房发育迅速，结实率为 100%；以半蒴苣苔为父本，分别与湘桂马铃苣苔和川滇马铃苣苔进行杂交。

2.1.3 相同两个种正反交杂情况　从表 3 可以看出，相同两个种正反交杂交成功率差异显著。革叶粗筒苣苔 × 柳江报春苣苔、革叶粗筒苣苔 × 吊石苣苔、皱

表 3 苦苣苔科远缘杂交相同两个种正反交杂情况

Table 3 Results of positive crosses and negative crosses between the same two species

正交 Positive cross	结实率 Fruit-setting percentage (%)	播种是否出苗 Characteristics of seed germination	反交 Reverse cross	结实率 Fruit-setting percentage (%)	播种是否出苗 Characteristics of seed germination
革叶粗筒苣苔 × 柳江报春苣苔 *Glabrella mihieri* × *Primulina liujiangensis*	100	是 Yes	柳江报春苣苔 × 革叶粗筒苣苔 *P. liujiangensis* × *Glabrella mihieri*	100	否 No
革叶粗筒苣苔 × 吊石苣苔 *Glabrella mihieri* × *Lysionotus pauciflorus*	87.5	是 Yes	吊石苣苔 × 革叶粗筒苣苔 *L. pauciflorus* × *Glabrella mihieri*	66.7	否 No
皱叶后蕊苣苔 × 绢毛马铃苣苔 *Oreocharis fargesii* × *O. sericea*	66.7	是 Yes	绢毛马铃苣苔 × 皱叶后蕊苣苔 *Oreocharis sericea* × *O. fargesii*	0	—
皱叶后蕊苣苔 × 长瓣马铃苣苔 *Oreocharis fargesii* × *O. auricula*	66.7	是 Yes	长瓣马铃苣苔 × 皱叶后蕊苣苔 *Oreocharis auricula* × *O. fargesii*	0	—

表 4 马铃苣苔属不同组间杂交组合结实及种子出苗情况

Table 4 Results of intersection distant hybridization of *Oreocharis*

母本 Female parent	父本 Male parent	授粉花朵数 No. of pollinated flowers	采收蒴果数 No. of fruit setting	结实率 Fruit-setting rate (%)	子房发育特征 Development characteristics of ovary	播种是否出苗 Characteristics of seed germination
湘桂马铃苣苔 *Oreocharis xiangguiensis*	长瓣马铃苣苔 *O. auricula*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	川滇马铃苣苔 *O. henryana*	14	14	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
川滇马铃苣苔 *O. henryana*	长瓣马铃苣 *O. auricula*	12	5	41.7	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	湘桂马铃苣 *O. xiangguiensis*	10	7	70	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	紫花马铃苣 *O. argyreia*	10	4	40	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
绢毛马铃苣苔 *O. sericea*	川滇马铃苣 *O. henryana*	13	13	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	紫花马铃苣 *O. argyreia*	7	6	85.7	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
紫花马铃苣苔 *O. argyreia*	绢毛马铃苣 *O. sericea*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
	川滇马铃苣 *O. henryana*	5	5	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes
长瓣马铃苣苔 *O. auricula*	川滇马铃苣 *O. henryana*	6	6	100	授粉后子房发育迅速 Ovules develop rapidly after pollination	是 Yes

叶后蕊苣苔 × 绢毛马铃苣苔、皱叶后蕊苣苔 × 长瓣马铃苣苔授粉后子房发育迅速,结实率分别为 100%、100%、87.5%、66.7%和 66.7%,且杂交种子能够正常出苗,而绢毛马铃苣苔 × 皱叶后蕊苣苔、长瓣马铃苣苔 × 皱叶后蕊苣苔授粉后不久子房萎蔫,结实率为 0,柳江报春苣苔 × 革叶粗筒苣苔、吊石苣苔 × 革叶粗筒苣苔授粉虽然促进了子房的发育,成熟蒴果与正常结实蒴果外观相似,但杂交种子并未出苗。

2.1.4 杂交种子的播种出苗情况 从杂交种子播种出苗的情况来看,虽然部分杂交能够结实,但播种后却不能正常萌发出苗,只有皱叶后蕊苣苔 × 绢毛马铃苣苔、皱叶后蕊苣苔 × 长瓣马铃苣苔、柳江报春苣苔 × 吊石苣苔、吊石苣苔 × 烟叶报春苣苔、吊

石苣苔 × 柳江报春苣苔、吊石苣苔 × 半蒴苣苔、革叶粗筒苣苔 × 柳江报春苣苔、革叶粗筒苣苔 × 烟叶报春苣苔、革叶粗筒苣苔 × 吊石苣苔、盾叶粗筒苣苔 × 烟叶报春苣苔、湘桂马铃苣苔 × 半蒴苣苔授粉后子房迅速膨大，结实率分别为 66.7%、66.7%、100%、50%、76.9%、100%、100%、100%、87.5%、100%和 100%，且杂交种子能够正常出苗，这说明马铃苣苔属和半蒴苣苔属，报春苣苔属与吊石苣苔属，吊石苣苔属与报春苣苔属和半蒴苣苔属，光叶苣苔属与报春苣苔属和吊石苣苔属之间部分种远缘杂交亲和。

2.2 马铃苣苔属不同组间杂交结实情况

通过对马铃苣苔属进行不同组间远缘杂交，结果表明（表 4）大叶石上莲组的紫花马铃苣苔和湘桂马铃苣苔、川滇马铃苣苔组的川滇马铃苣苔、马铃苣苔组的长瓣马铃苣苔和绢毛马铃苣苔之间杂交均可获得成熟饱满种子，且杂交种子播种后能够正常出苗。

3　讨论与结论

植物种间或属间远缘杂交是育种的主要手段之一，该方法在多种花卉品种的改良上获得了成功（张志胜等，2001；胡禾丰等，2014），但苦苣苔科不同属间的远缘杂交亲和性还未可知。本研究表明苦苣苔科不同的种类作为父本或母本时，结实率相差较大。李桂芬等（2006）以大渡河枇杷，栎叶枇杷、野生普通枇杷和‘解放钟’作母本，平均坐果率高 36.2%~58.2%；而以台湾枇杷及其两个变型和椭圆枇杷作母本，平均坐果率仅为 2.9%~16.3%，作父本时，平均坐果率为 22.4%~43.1%。蔷薇属、菊属、百合以及李与杏的远缘杂交也出现同样现象（杨红花，2004；汤访评，2009；杨利平等，2011；杨涛等，2015）。亲本的育性是影响远缘杂交结实率的主要因素之一，选择自交亲和性强及自然结实高的品种（系）及种为杂交母本，容易克服远缘杂交不亲和，选择花粉活力或萌芽率高的品种（系）作父本，容易提高坐果率（杨红花，2004；杨涛等，2015）。亲本的倍性也会影响杂交亲和性，同倍性的亲本杂交，更易得到杂交种（汤访评，2009）。除了这些客观原因外，环境条件也会对杂交亲和性产生影响（李辛雷等，2008；李智等，2015）。可见，影响杂交亲和性的因素复杂多样，今后还需进一步从机理方面深入研究阐明苦苣苔远缘杂交亲和性差异的原因。

亲缘关系远近是影响远缘杂交亲和性的主要因素之一（曹后男等，2003；胡禾丰等，2014）。苦苣苔新的分类系统将后蕊苣苔属并入马铃苣苔属（温放等，2001；Moller et al，2011；胡广勇，2012；冯翠元，2015），本研究中原马铃苣苔属的绢毛马铃苣苔和长瓣马铃苣苔与原后蕊苣苔属皱叶后蕊苣苔杂交亲和性均较好，进一步验证了二者之间较近的亲缘关系。本研究发现马铃苣苔属与半蒴苣苔属，报春苣苔属与吊石苣苔属，吊石苣苔属与报春苣苔属和半蒴苣苔属，光叶苣苔属与报春苣苔属和吊石苣苔属之间部分种进行远缘杂交能够正常结实，且杂交种子能够正常萌发，说明这些属之间的部分种之间可能具有较近的亲缘关系，这对远缘杂交开发中国苦苣苔科观赏花卉品种具有重要意义。然而由于每个属内所选做授粉的种类有限，今后有必要增加苦苣苔科属以及属内的种数进一步研究验证苦苣苔科远缘杂交亲和性关系。

植株的远缘正反交结实率差异很大，杂交亲和程度存在一定的单向性（陈劲枫等，2002；曹后男等，2003；杜文文等，2012）。本研究也得到了相似结论，革叶粗筒苣苔 × 柳江报春苣苔、革叶粗筒苣苔 × 吊石苣苔、皱叶后蕊苣苔 × 绢毛马铃苣苔、皱叶后蕊苣苔 × 长瓣马铃苣苔授粉后子房发育迅速，结实率分别为 100%、100%、87.5%、66.7%和66.7%，且杂交种子能正常出苗，而其反交组：绢毛马铃苣苔 × 皱叶后蕊苣苔、长瓣马铃苣苔 × 皱叶后蕊苣苔存在受精前障碍，授粉后未见子房发育，结实率为 0，柳江报春苣苔 × 革叶粗筒苣苔、吊石苣苔 × 革叶粗筒苣苔存在受精后障碍，虽然获得了杂交种子，但杂交种子并未萌发。以芸苔属植物为母本，诸葛菜为父本的杂交组合亲和性大于它们的反交组合，在其它植物如番茄、曼陀罗等种类也存在种间杂交单向不亲和性（王爱云等，2006）。在苦苣苔科的远缘杂交育种工作中可以通过选择合适的亲本获得杂种后代。

本研究还发现马铃苣苔属内生活形态相差较远的不同组间杂交均可获得成熟饱满种子，且杂交种子播种后能正常出苗，说明马铃苣苔属的不同组

之间杂交具有一定亲和性。Moller et al(2011)指出异蕊马铃苣苔是亲缘关系较远的马铃苣苔组的大齿马铃苣苔和大叶石上莲组的紫花马铃苣苔自然杂交种,这与本研究的结论相一致。

综上所述,苦苣苔科属间远缘杂交关系较为复杂,不同远缘杂交组合亲和性差异较大。不同属作为父本,与同一母本进行杂交,以及同一属内不同种作为父本,与同一母本进行杂交,结实情况差异显著;不同属作为母本,与同一父本进行杂交,以及同一属内不同种作为母本,与同一父本进行杂交,结实情况同样存在显著差异;相同两个种正反交杂交成功率并不一致,加上国内这方面研究较少,目前仍未有突破性进展,今后仍应加强这方面研究。马铃苣苔属与半蒴苣苔属,报春苣苔属与吊石苣苔属,吊石苣苔属与报春苣苔属和半蒴苣苔属,光叶苣苔属与报春苣苔属和吊石苣苔属之间部分种进行远缘杂交能正常结实;马铃苣苔属内不同组间杂交均可获得成熟饱满种子,这为苦苣苔远缘杂交育种工作提供了新的参考。然而由于该研究选取的属及种数有限,且受开花限制,每个授粉组合的样本数量较少,今后仍需继续开展大量重复试验,对该研究结果进一步验证和补充,明确苦苣苔科远缘杂交亲和性,为苦苣苔远缘杂交育种提供科学可信的理论依据。

参考文献:

AI CX, 2013. Research on commercialized production technology of 4 potted *Primulina* [D]. Beijing: Beijing Forestry University. [艾春晓, 2013. 4 种报春苣苔属植物的盆花商品化生产技术研究 [D]. 北京:北京林业大学.]

CAO HN, ZONG CW, JING YS, et al, 2003. Cross-Compatibility between peach and plum [J]. J Agric Sci Yanbian Univ, 25(1):1-7. [曹后男, 宗成文, 金英善, 等, 2003. 桃李间交配亲和性 [J]. 延边大学农学学报, 25(1):1-7.]

CHEN JF, ZHUANG FY, LOU QF, et al, 2002. Studies on reciprocal differences in interspecific hybridization in *Cucumis* [J]. Acta Hortic sin, 29(5):30-33. [陈劲枫, 庄飞云, 娄群峰, 等, 2002. *Cucumis* 属植物种间正反杂交差异的研究 [J]. 园艺学报, 29(5):30-33.]

DU WW, WANG XY, WU LF, et al, 2012. Difference analysis on the degree of positive and negative hybridization affinity for Asian Lily and Longiflorum Lily [J]. Sci Agric Sin, 45(23): 4854-4861. [杜文文, 王详宁, 吴丽芳, 等, 2012. 亚洲百合和铁炮百合正反杂交亲和程度的差异性分析 [J]. 中国农业科学, 45(23):4854-4861.]

FENG CY, 2015. A study on the phylogenetics of *Oreocharis* and related allies in Gesneriaceae [D]. Zhengzhou: Henan Agricultural University:. [冯翠元,2015. 药用植物马铃苣苔属和近缘类群的系统学研究 [D]. 郑州:河南农业大学.]

HU HF, ZHANG YL, GUO WZ, et al, 2014. Compatibility in the interspecies cross between some sections in *Camellia* [J]. Acta Agric Univ Jiangxi, 36(2):338-343. [胡禾丰, 张亚利, 郭卫珍, 等, 2014. 山茶属部分组间远缘杂交亲和性初探 [J]. 江西农业大学学报, 36(2):338-343.]

HU GY, 2014. Reconstruction of molecular phylogenetic tree and evolution of breeding system in *Opithandra* [D]. Guangzhou: South China Normal University. [胡广勇, 2014. 后蕊苣苔属分子系统树重建与繁育系统演化的研究 [D]. 广州:华南师范大学.]

KANG M, LIU J, NING ZL, et al, 2014. New varieties vultivated by South China Botanical Garden Obtain International certification [J]. J Seed Ind Guid, (11): 30. [康明, 刘娟, 宁祖林, 等, 2014. 华南植物园两新品种获国际植物新品种登录 [J]. 种业导刊, (11): 30.]

LI JM, 2007. A study on the phylogenetics of *Chirita* and related allies in Gesneriaceae [D]. Beijing: Institute of Botany, Chinese Academy of Siciences. [李家美, 2007. 唇柱苣苔属及其近缘类群(苦苣苔科)的系统发育研 [D]. 北京:中国科学院植物研究所.]

LI GF, YANG XH, QIAO YC, et al, 2016. Study on interspecific intergeneric hybridization compatibility of *Eriobotrya* and related genura [J]. Acta Hortic Sin, 43(6): 1069-1078. [李桂芬, 杨向晖, 乔燕春, 等, 2016. 枇杷属植物种间及近缘属杂交亲和性研究 [J]. 园艺学报, 43(6): 1069-1078.]

LI XL, CHEN FD, ZHAO HB, et al, 2008. Compatibility of interspecific cross in *Dendranthema* genus [J]. Acta Hortic Sin, 35(2):257-262. [李辛雷, 陈发棣, 赵宏波, 等, 2008. 蔷薇属远缘杂交亲和性评价 [J]. 园艺学报, 35(2):257-262.]

LI Z, ZHAO HE, LI YQ, et al, 2015. Evalution on compatibility of interspecific cross among several species of *Rosa* [J]. Guangdong Agric Sci,(8):29-36. [李智, 赵惠恩, 李亚奇, 等, 2015. 蔷薇属远缘杂交亲和性评价 [J]. 广东农业科学,(8):29-36.]

LI ZJ, WANG YZ, 2004. Plant of Gesneriaceae in China [M]. Zhengzhou: Henan Science and Technology Press:1-702. [李振宇, 王印政,2004. 中国苦苣苔科植物 [M]. 郑州:河南科学技术出版社:1-702.]

LI ZY, 1996. The geographical distribution of the subfamily Cyrtandroideae Endl. Emend. Burtt (Geseeriaceae) [J]. Acta Phytotax Sin, 34(4):341-360. [李振宇,1996. 苦苣苔亚科的地理分布 [J]. 植物分类学报, 34(4):341-360.]

LIU BC, 2014. Research on the adaptability in three species of

medicinal plants in Gesneriaceae after artificial cultivation [D]. Nanning: Guangxi University. [刘北辰, 2014. 三种苦苣苔科药用植物在人工栽培条件下的适应性研究 [D]. 南宁:广西大学.]

LÜ HZ, PAN CL, 2009. Bitter radicchio moss families and general situation of research and utilization of plant resources distribution [C]. Guangxi Botanical Garden (Ⅻ), (12). [吕惠珍, 潘春柳, 2009. 苦苣苔科植物资源分布及其研究利用概况 [C]. 中国植物园,(12).]

MöLLER M, WEI YG , WEN F, et al, 2016. You win some you lose some: updated generic delineations and classification [J]. Guihaia, (1):44-60. [MöLLER M, 韦毅刚, 温放, 等, 2016. 得与失: 苦苣苔科新的属级界定与分类系统——中国该科植物之变迁 [J]. 广西植物, 36(1):44-60.]

MöLLER M, MIDDLETON D, NISHII K, et al, 2011. A new delineation for *Oreochair* incorporating an additional ten genera of Chinese Gesneriaceae [J]. Phytotaxa, 23:1-36.

SUN GS, DENG M, FANG J, et al, 2015. Physiological response light environment [J]. N Hortic, (22):69-73. [孙国胜, 邓敏, 方俊, 等,2015. 牛耳朵对不同光照环境的生理响应 [J]. 北方园艺, (22):69-73.]

TANG FP, 2009. Distant hybridization between*Dendranthema* and four allied genera [D]. Nanjing: Nanjing Agricultural University. [汤访评,2009. 菊属与四个近缘属植物远缘杂交研究 [D]. 南京:南京农业大学]

WANG AY, LI X, HU DY, et al, 2006. Compatibility in the interspecies cross between *Orychophragmus violaceus* and *Brassica* [J]. J Chin Oil Crop Sci, 28(1):7-10. [王爱云, 李枸, 胡大有, 等, 2006. 诸葛菜与芸薹属属间杂交亲和性研究 [J]. 中国油料作物学报, 28(1):7-10.]

WEI YG,ZHONG SH, WEN HQ, 2004. Studies of the flora and ecology Gesneriaceae in Guangxi Province [J]. Acta Bot Yunnan, 26(2):173-182. [韦毅刚, 钟树华, 文和群, 2004. 广西苦苣苔科植物区系和生态特点研究 [J]. 云南植物研究, 26(2):173-182.]

WEN F, WEI YG, 2014. New hybrid varieties in Guangxi obtain international certification [J]. J Guangxi Acta Sci, (1):20-21. [温放, 韦毅刚,2014. 广西苦苣苔科植物杂交品种获国际认证 [J]. 广西科学院学报, (1):20-21.]

WEN F, 2008. Studies on investigation and introduction of wild ornamental resources of Gesneriaceae in Guangxi [D]. Beijing:Beijing Forestry University. [温放,2008. 广西苦苣苔科观赏植物资源调查与引种研究 [D]. 北京:北京林业大学.]

WEN F, LI ZD, 2005. Germplasm resourses and industrial prospect of the Gesneriaceae in Hainan [J]. Guangxi Hortic, 16(4):56-59. [温放, 李湛东,2005. 广西苦苣苔科植物资源及其产业化前景 [J]. 广西园艺, 16(4):56-59.]

WEN F, WEI YG, MICHAEL MS, et al, 2011. New classification system of Gesneriaceae in China [C]. Collected papers of the tenth youth academic seminar of national system and evolutionary botany, Kunming: compilation of plant institute in Yunnan Province:117-118. [温放, 韦毅刚, Michael MS,等, 2011. 中国苦苣苔科植物新分类系统 [C]. 2011 年全国系统与进化植物学暨第十届青年学术研讨会论文集, 昆明:云南省植物学会汇编:117-118.]

XU H, ZHONG HD, LIU BY, 2013. Introduction and cultivation of 10 kinds of wild Gesneriaceae and landscape value analysis [J]. Chin Hortic Abstr, 29(12):1-4. [徐慧, 钟汉东, 刘宝勇,2013. 10 种野生苦苣苔科植物的引种栽培及园林应用价值分析 [J]. 中国园艺文摘, 29(12):1-4.]

YANG WG, CHU JL, ZHANG YG, et al, 2014. Assessment on the endangered status of Gesneriaceae in China [J]. J Henan Agric Univ, 48(6):746-751. [杨文光, 储嘉琳, 张耀光, 等,2014. 中国苦苣苔科植物濒危状况评估分析 [J]. 河南农业大学学报, 48(6):746-751.]

YANG T, SONG D, ZHANG XY, et al, 2015. Evaluation on compatibility of interspecific cross in part of the genus Rosa [J]. J Dongbei Agric Univ,(2):70-77. [杨涛, 宋丹, 张晓莹, 等, 2015. 部分蔷薇属植物远缘杂交亲和性评价 [J]. 东北农业大学学报, (2):70-77.]

YANG HH, 2004. Evalution on compatibility of interspecific cross among *Prunus* genus and *Armeniaca* genus [D]. Tai'an: Shandong Agricultural University. [杨红花, 2004. 李、杏属间远缘杂交及种质创新的研究 [D]. 泰安:山东农业大学.]

YANG LP, LI R, CHENG QD, et al, 2011. Wide cross breeding of lily and identification of authenticity [J]. J Plant Genet Res,(8):29-36. [杨利平, 李蕊, 程千钉, 2011. 百合远缘杂交育种及其真实性鉴定 [J]. 植物遗传资源学报, 12(6):896-903.]

ZHENG YP, SHEN ZG, JIANG B, et al, 2012. Comparative study on the photosynthesis and chlorophyll of four Gesneriaceae species [J]. J Zhejiang Norm Univ (Nat Sci Ed) ,35(4):446-452. [郑月萍, 沈宗根, 姜波, 等,2012. 4 种苦苣苔科植物光合特性的比较 [J]. 浙江师范大学学报(自然科学版) , 35(4):446-452.]

ZHANG ZS, HE QY, FU XL, et al,2001. Studies on the wide cross of Chinese Orchids and the germination of their hybrid seeds [J]. J S Chin Agric Univ, 22(2):62-65. [张志胜, 何琼英, 傅雪琳, 等, 2001. 中国兰花远缘杂交及杂交种子萌发的研究 [J]. 华南农业大学学报, 22(2):62-65.]