猕猴桃研究进展（IV）
Advances in *Actinidia* Research (IV)

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内 容 简 介

本书系中国园艺学会猕猴桃分会学术及产品发展研讨会论文集，是继《猕猴桃研究进展》前三集之后出版的第四集。全书共分为资源及保护利用、育种与新品种试验、高效栽培与病虫害防治、生物技术与生理生化、贮藏保鲜与深加工、国内外市场开拓、新技术应用七个专题，较全面地反映了国内及世界猕猴桃主产国近年来猕猴桃研究与产业发展的动态。

本书可供从事猕猴桃产业及科研的人员、农业院校师生、果树推广和管理工作者参考。

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《猕猴桃研究进展(IV)》编委会

序　中国猕猴桃科研和产业的崛起及可持续发展

世界猕猴桃的科研和生产正发生着巨大而深刻的变化，中国作为猕猴桃属植物的原产地和栽培猕猴桃品种的源头资源发祥地，曾孕育了全球猕猴桃产业的发端。虽然在猕猴桃引种驯化100余年的历史中，我国曾经在相当长的时期落后于新西兰和意大利等猕猴桃科研及生产大国，但近20年来，中国的猕猴桃科学家和企业家已经改变了当今全球猕猴桃的科研和产业格局。

在科研方面，20年前在猕猴桃科学文献中几乎很难查到中国的资料和信息，如今出自中国的猕猴桃科学论文和研究报告占到了全球的约 1/4。在猕猴桃属植物生物学研究的许多方面，中国被公认为是世界的研究中心(Huang and Ferguson，2007)。在猕猴桃产业方面，中国目前栽培面积约6万公顷，占世界栽培总面积12万公顷的50%，已经远远超过了意大利(2.1万公顷)、新西兰(1.2万公顷)和智利(8千公顷)。在全球猕猴桃150万吨的年产量中，我国猕猴桃的年产量约40万吨，占27%，与意大利产量(约40万吨)持平，且超过了新西兰(28万吨)和智利(15万吨)(Belrose Inc，2005)。其产量较低的原因除了我国目前有20%的幼年果园外，是我们猕猴桃果园的管理水平离高产优质还有一定差距。

中国猕猴桃科研和产业崛起将更深远地影响世界猕猴桃产业还在于，我国20年来立足于本土猕猴桃遗传资源研究及其新品种的选育，中国选育的中华猕猴桃(*Acitindia chinensis*)黄肉新品种在全球范围广泛栽培，彻底改变了世界猕猴桃产业单一品种格局，推动了猕猴桃市场多样化和消费的多元化、改变了全球猕猴桃产业依赖单一新西兰品种——‘海沃德’的局面(Huang and Ferguson，2003；Huang and Ferguson，2007)。中国人花了20年时间成功实现了中华猕猴桃由野生到大规模商业栽培的驯化过程。世界猕猴桃栽培品种的构成已由20多年前的单一物种和品种(*A. deliciosa*‘Hayward’)改变至如今15%为中华猕猴桃品种、85%为美味猕猴桃(*A. deliciosa*)品种。国内猕猴桃生产，中华猕猴桃品种栽培则高达24%。具有我国自主知识产权的中华猕猴桃新品种——‘金桃’(*A. chinensis*‘Jintao’)通过专利使用权转让，在欧洲及南美地区广泛栽培有效地均衡了新西兰20世纪70年代通过获取中国猕猴桃资源，选育的中华猕猴桃新品种——‘Hort16A’控制全球黄肉猕猴桃品种生产的局面。虽然目前新西兰国内栽培的中华猕猴桃黄肉品种(*A. chinensis*‘Hort16A’)通过高接换种和新建果园达到了20%的产量；而我国选育的红肉猕猴桃新品种——‘红阳’，再次异军突起，逐步形成了国际猕猴桃市场中绿果、黄果、红果的多样化格局。我国在猕猴桃遗传资源发掘及其新品种选育的成就将引领国际猕猴桃科研及产业发展，对世界猕猴桃产业的可持续发展具有极其重要的意义。

但是，我们必须清醒认识到我国猕猴桃产业中还存在众多问题，我国在果园管理及其优质高产栽培技术还落后于新西兰和意大利；相关遗传改良研究、基因组及其基因调控研究、果树生理生化研究、整型修剪技术、科学管水和施肥技术、果园病虫害防治、果品营养与健康等研究缺乏长期稳定的科研投入机制，支撑产业升级的研发体系相对薄弱。总体看我国猕猴桃科研与产业存在如下问题：① 我国作为猕猴桃资源和栽培的双重大国，针对产业发展的应用性基础研究滞后，研究部署不合理、针对产业升级的研究有待加强；② 我国丰富而宝贵

的猕猴桃资源依然流失国外，而国内在农业作物遗传改良研究的科研投入则主要集中在粮棉油大田作物，对诸如猕猴桃等经济作物的自我研发支持力度不够，丰富的资源优势远没充分发挥，资源发掘的广度和深度有待加强；③ 产业规划滞后、产业目标导向有待提高；④ 以企业为主体的技术研发体系尚未形成，制约了产业的可持续发展，尤其是中国猕猴桃产业面向世界的合力急待改善；⑤ 我国目前虽然具有栽培品种多的优势，但市场品牌和精品意识不够，中国猕猴桃产品面向世界市场的推介及市场战略相当薄弱，中国猕猴桃产品在国内外市场基本处于无序状态，同时，猕猴桃消费导向研究及消费市场培育基本空缺。

促进我国猕猴桃科研和产业稳步健康发展，是我国猕猴桃工作者义不容辞的责任。我国猕猴桃科研和产业的可持续发展急需解决如下问题：

(1) 加强以企业为主体的技术研发体系的建设，鼓励科研院所、大学积极参与企业发展相关的研发活动，引导科研单位与企业的共建猕猴桃研发中心，致力于猕猴桃产业发展的研发和产品升级的全球竞争，全面推进中国猕猴桃产业高水平、高起点的进入国际市场。

(2) 充分发挥我国的猕猴桃资源优势，加强野生资源研究、发掘优异基因型和研发特异新品种。立足我国资源优势、建立优异基因型资源库(圃)、掌握品种育种改良资源的源头是我国长期主导国际猕猴桃产业发展的立足点。

(3) 加强我国猕猴桃产业以企业为主体的产业规划、明确产业目标是我国目前猕猴桃产业发展的当务之急。通过规划，形成全国产业协会—研发支撑体系—市场营销协调的整体部署。加强精品战略、形成特色市场，同时，加强猕猴桃消费导向及消费培育的相关研究。

(4) 加强针对产业发展的应用基础研究，重点解决中国特定气候条件下的果园优质高产栽培技术、采后包装、储运技术及加工技术，形成中国产业技术规范体系，支撑产业的可持续发展。

(5) 以国家及地区重大计划为牵引，如新农村建设，组织联合攻关项目，加强能力建设、培养猕猴桃科研人才及生产第一线果园管理技术人才，造就我国面向新世纪全球猕猴桃产业的科研和产业的人才队伍。

中国猕猴桃科研及产业崛起举世瞩目，我国的猕猴桃科研工作者、企业家和种植者为当今猕猴桃产业作出了巨大贡献，未来世界猕猴桃产业的可持续发展很大程度上将依赖于中国丰富的猕猴桃资源和中国人的智慧。中国猕猴桃科研工作者将任重道远。

中国园艺学会猕猴桃分会理事长　黄宏文
2007 年 10 月 4 日于武汉东湖磨山

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（一） 资源及保护利用

种质资源性状描述和评价的必要性

——以猕猴桃为例

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摘　要　遗传资源能为育种和植物改良提供原材料，那些有一定的或者完全没有改良经验的植物育种专家都倾向于最大限度地利用所收集的原始的或未经过人工改良的种质资源来进行育种。猕猴桃跟其他植物有些特别，经过人工选择的影响力很小，即仍然很接近野生植物。为了充分利用猕猴桃属植物的遗传多样性，育种专家需要更深入地了解物种的多样性，同样也要能够鉴别他们所使用材料的正确性。试验中所采用的所有植物都应制作实物标本。对猕猴桃属不同植物的繁殖生物学掌握得越多，越有利于将野生猕猴桃种质合理应用到猕猴桃育种计划中来。新西兰园艺研究所猕猴桃资源收集圃已证明了它在猕猴桃有价值新品种开发中的作用。

关键词　猕猴桃属(*Actinidia*)　育种　种质资源　繁殖生物学　倍性

The Need for Characterisation and Evaluation of Germplasm: Kiwifruit as an Example

1　Introduction

Germplasm collections provide the raw material for programmes of plant breeding and crop improvement. This is often their prime function, the main reason for their initial collection, usually by breeders, and it is the genetic diversity and the occurrence of particular desirable genes that are of greatest interest to plant breeders. However, germplasm collections are not used solely by breeders: other biologists will have different interests and possibly different requirements (van Treuren and van Hintum, 2003). While breeders will focus on characters of immediate perceived value, other biologists may be more interested in the potential variation or will use the collections to understand better the properties and behaviour of the plant, especially at the genomic level.

Breeders of plant species that have little or no history of improvement tend to make the greatest use of collections of raw or unimproved germplasm. Kiwifruit (*Actinidia*) are one such crop in that they have been subjected to little selection pressure and are still very similar to plants in the wild. The most widely grown commercial cultivar, ‘Hayward’ (*A.deliciosa*), is only two or three generations from the wild as is ‘Hort16A’ (*A.chinensis*). The current Chinese kiwifruit cultivars are nearly all selections directly from the wild and are not the products of planned breeding programmes (Huang and Ferguson, 2007). Kiwifruit breeders are therefore in a very different situation from, for example, maize breeders where the inbred lines used today are the

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product of several centuries of germplasm enhancement and recurrent selection (Anderson and Brown, 1952).

Effective exploitation of wild or unimproved germplasm for crop improvement demands comprehensive studies of its reproductive biology (Stalker, 1989). Although the recent advances in population genetics, genomics and bioinformatics improve our understanding of diversity and will change the ways in which we exploit that diversity, there is a danger that we will forget the fundamentals. We still need botanists, horticulturists, agronomists, plant breeders and plant pathologists. We need to know about genes, genomes and the gene pools, but we still need to know about the plants as well, we need to know what diversity exists, just as we need to know which aspects of that diversity should be chosen for incorporation into breeding programmes. The HortResearch *Actinidia* (kiwifruit) germplasm collection in New Zealand is used as an example to justify why I believe it is so important for us to continue studying both the basic biology and the commercial prospects of the plants we are using in breeding programmes.

2 The HortResearch *Actinidia* germplasm collection

The first introduction of *Actinidia* germplasm into New Zealand was in 1904 and, although some other material was imported at about the same time, probably indirectly from the same source in China (Ferguson and Bollard, 1990), the next documented importation was in 1955 by the Department of Scientific and Industrial Research when several different *Actinidia* species were imported from Hillier’s nursery in England. Since about 1975, there has been an active policy of improving our germplasm collections and we now have an extensive range of material that we want to conserve on a long-term basis:

- genotypes raised from seed or budwood of species in the wild;
- genotypes from other *Actinidia* germplasm collections;
- cultivars from New Zealand or elsewhere in the world, irrespective of whether they are still grown commercially;
- elite breeding lines;
- advanced selections from our breeding programmes;
- genotypes, no matter what their origin, which are kept simply because they show interesting or unusual characteristics.

To date, 300 accessions have been imported from overseas by purchase, by gift or by exchange (Table 1), there is material of another 40 accessions waiting clearance through quarantine (Table 2), and almost 360 further seed accessions still held in bond. These accessions have been imported from countries where *Actinidia* grow wild, such as China, Japan, Korea and Russia, as well as different countries to which *Actinidia* material was sent early last century, although in such cases the original provenance is usually not known. Currently the collection holds about 3500 distinct genotypes of which nearly 1000 have been selected for long-term retention.

Nearly all these selections are from importations of unimproved germplasm and the HortResearch kiwifruit breeding programmes are largely dependent on these wild plants whereas breeders of many other crops are much more reliant on existing collections, especially on proven elite breeding lines or on old commercial cultivars. Programmes of progeny testing mean, however, that we are now at the stage of accumulating good breeding lines and elite parents. There are also about 80 cultivars and named selections, some of which came from overseas. In addition, we hold budsports or mutations which have appeared on commercial kiwifruit orchards. These have very little value in their own right but can be of great potential value for breeding programmes. A good example would be the “fruiting males” or “inconstant males”, which produce very small fruit as well as viable pollen (McNeilage, 1991). The fruit are too small to have any commercial value as such but the fruiting males were the starting point for the programme to produce truly hermaphroditic kiwifruit cultivars (McNeilage et al., 2006). It is therefore important to conserve such gender variants. Another example would be the occasional budsports of *A.chinensis* ‘Hort16A’ that have spontaneously doubled in chromosome number: again, these seem to have little obvious commercial value but could allow greater flexibility in breeding programmes.

Table 1　Imported *Actinidia* plants released from quarantine and established in the HortResearch *Actinidia* germplasm collection

Taxon	Accessions	Genotypes	Selections	Taxon	Accessions	Genotypes	Selections
A.arguta	27	171	31	*A.hypoleuca*	1	1	1
A.arguta purpurea	6	80	4	*A.indochinensis*	1	18	18
A.callosa henryi	2	22	1	*A.kolomikta*	3	3	3
A.chinensis	90	955	456	*A.lanceolata*	1	9	9
A.chrysantha	3	12	12	*A.latifolia*	1	17	17
*A.deliciosa deliciosa**	131	1975	258	*A.macrosperma*	4	5	5
A.deliciosa chlorocarpa	1	7	7	*A.melanandra*	5	5	5
A.deliciosa coloris	1	17	17	*A.polygama*	13	70	17
A.eriantha	5	60	37	*A.rufa*	4	28	16
A.fortunatii	1	1	1	*A.setosa*	2	2	2
A.fulvicoma lanata	2	2	2	*A.valvata*	1	2	2
A.guilinensis	4	19	19	Total	310	3482	941
A.hemsleyana	1	1	1				

* Including 13 accessions and 339 genotypes of a possibly distinct but closely related variety or species

Table 2　*Actinidia* plants requiring virus testing before release from quarantine for establishment in the HortResearch germplasm collection

Taxox	*A.callosa*	*A.chinensis*	*A.deliciosa*	Total
Accessions	2	6	34	42
Genotypes	30	81	383	494

Other *Actinidia* germplasm collections in China hold a greater range of *Actinidia* species but the HortResearch collection would be easily the most comprehensive for the two most important commercial species, *A.chinensis* and *A.deliciosa*. We have 90 accessions of *A.chinensis* released from quarantine, three new accessions requiring virus testing and 273 further accessions of seed held in bond; in total, we have about 1000 genotypes of *A.chinensis* in our germplasm collection. There are also 120 accessions of *A.deliciosa* released with living genotypes established, 34 new accessions requiring virus-testing, and a further 73 accessions of seed held in bond. We have about 2000 genotypes of *A.deliciosa* in the collection, but most of these come from two provinces of China, Chongqing and Sichuan, whereas the species occurs naturally in at least seven other provinces (Liang, 1983). In theory, it is desirable to collect from wild populations that are well dispersed and that occur in different environments. In practice, however, the collections are not necessarily representative of what is in the wild: instead, they are simply what it has been possible to acquire.

Apart perhaps from *A.arguta*, *A.eriantha* and *A.polygama*, the collections of other species are very patchy and in some cases we have only a single plant or have plants of only one gender. There is a danger that when we have only a very small number of genotypes for a particular taxon, those genotypes may be incorrectly assumed to be typical of the taxon as a whole.

For many years the emphasis in kiwifruit breeding was very strongly on *A.chinensis* and *A.deliciosa* and other species were often considered as being primarily of academic interest. It is now better accepted that these other species could be the source of attributes which might lead to the production of completely new and different types of kiwifruit: we need more representatives of these species.

Although 300 accessions may seem very few to those used to dealing with crop germplasm collections often containing tens of thousands of accessions, the HortResearch *Actinidia* collection would be amongst the larger of such fruit tree germplasm repositories. For example, the staff of the German Fruit Gene bank at Dresden-Pilnitz consider that, with about 350 accessions of nearly all *Malus* species, they have one of the largest ex situ collections of *Malus* wild species in the world (Geibel and Hohlfeld, 2003). There are, of course, other large collections of *Malus* cultivars.

The kiwifruit germplasm plants are routinely grown on T-bar structures and they are trained as if they were commercial kiwifruit vines. Most species grow very well under such conditions. The collection is held on HortResearch orchards and occupies about 6.2 ha (1.1 ha at Kerikeri, 3.83 ha at Te Puke, 1.27 ha at Riwaka), including the area occupied by populations of seedlings from seed accessions. Many genotypes are replicated at the different orchards. This reduces the risk of losing significant parts of the collection to disease or natural disasters. So far, the possibility of longterm storage of *Actinidia* as seed, in vitro, or cryogenically has not been investigated.

The collection is supported by a comprehensive, relational, computer-based database system which contains information on individual accessions such as source, provenance, date of acquisition, quarantine status, import permit number, taxonomic status, voucher specimen numbers, genders, ploidy determinations, and precise geographic location in the research orchards. Accessions are given a coding based on taxon and chronological order of introduction for that taxon. Individual genotypes within an accession are given a selection number and their gender, ploidy, and fruit characteristics (for female vines) are recorded. This is all time-consuming but makes the collection that much more useful.

3 The need for germplasm

3.1 History of kiwifruit as a cultivated plant

Kiwifruit are amongst the most recently domesticated of fruit plants (Ferguson and Bollard, 1990; Huang and Ferguson, 2007). Apart from a few unimportant exceptions, the first *Actinidia* were taken into cultivation towards the end of the 19th century and the early years of the 20th century. The most important commercial species of kiwifruit, *A.deliciosa*, was apparently in cultivation by 1899 and the first seed of this species were brought to New Zealand in 1904. Until about 10 years ago, most kiwifruit grown commercially anywhere in the world were descended from that first importation of seed, and could be traced back to one male and two female kiwifruit plants (Ferguson and Bollard, 1990). Worse, commercial orchards almost everywhere grew exclusively one fruiting cultivar, 'Hayward'. The only important exceptions at that time were the polliniser or male used in Californian kiwifruit orchards and the cultivars then being planted on a small scale in China. An industry based on such a narrow genetic base, with a single, vegetatively propagated fruiting clone, is very vulnerable to new pests and diseases.

This has been demonstrated in other cultivated plants with similar dangerously narrow genetic bases. Virtually all the coffee plants that are grown in the Americas, *Coffea arabica*, are descended from a single plant taken from Java to Amsterdam in 1706. One consequence was that the cultivars grown through Central and South America had little or no resistance to coffee leaf rust (*Hemileia vastartrix*) when it arrived in Brazil in 1970 (Wrigley, 1995). Another salutary example is the susceptibility of the many maize cultivars containing a form of male cytoplasmic sterility to a race of the fungus *Helminthosporium maydis* (Goodman, 1995). A closer parallel is the recognised vulnerability in the United States of tree or vine fruit crops such as almonds, apples, apricots, cherries, grapes, nectarines, peaches and walnuts, because of their limited genetic bases and because only a few cultivars of each are grown (Committee on Managing Global Genetic Resources: Agricultural Imperatives, 1993). Geographic concentration, as is the case of the New Zealand kiwifruit industry, combined with genetic uniformity also increases vulnerability to adverse weather (Iezzoni, 2005).

The vulnerability of the main commercial cultivar of kiwifruit to pests or diseases remains, fortunately, a potential threat although it should not be dismissed. A more immediate threat a decade ago was that as kiwifruit cultivation spread around the world; New Zealand was losing its competitive advantage: it was going from being the only producer of exported kiwifruit to becoming only one of the countries all growing and exporting kiwifruit of the one cultivar, 'Hayward'. This problem was partially overcome by the introduction of the ZESPRI^{TM} branding (Beverland, 2001). There was another threat, however, that fickle consumers might become bored with the traditional kiwifruit with its brown hairy skin, green flesh and mild, but rather acid flavour. The solution to this problem was more radical: take advantage of the diversity within the rest of the genus *Actinidia* and produce distinctive, new, protectable cultivars.

3.2 Genetic diversity in *Actinidia*

Within *Actinidia* there is great diversity in infructescence size, and in fruit characteristics such as size, shape, skin colour, skin hairiness, skin toughness and palatability, flesh colour and texture, flesh flavour and chemical composition, time of maturity (and hence harvest), storage life and shelf life as well as changes in skin or flesh colour and in flesh texture during ripening (Huang et al., 2004; Huang and Ferguson, 2007). There is likewise great diversity in other attributes such as growth habit and vigour, climatic and edaphic requirements, time of budbreak and of flowering, disease susceptibility and yield potential; even ease of vine management. Furthermore, within a single species there can be considerable diversity. Although genotypes of the one species might be indistinguishable morphologically, they might still vary significantly in physiological responses and such variation could be important in allowing the industry to respond to changes in climate or in allowing kiwifruit to be grown in new areas. A breeding programme that is genetically broadly based should provide steadier gains under selection and allow more rapid responses to changes in environment, diseases and economic trends (Simmonds, 1962).

By taking advantage of this diversity in the genus *Actinidia*, it seems very likely that breeding programmes could produce new and different types of kiwifruit: fruit of different sizes and shapes, with different skin colours not only green and yellow as at present but also orange, red, purple or even multicoloured. Fruit might change colour as they ripen or they might have peelable or edible skins, attributes that would make them that much more convenient for consumers. The fruit might have different flavours or they might have much higher contents of desirable nutrients such as vitamin C. The first such new and different type of kiwifruit to be developed in New Zealand is *A.chinensis* ‘Hort16A’, the fruit of which have been commercialised under the name ZESPRI^{TM} GOLD Kiwifruit.

The very first step in developing such new types of kiwifruit is recognising the existence of such diversity so that germplasm can be collected to bring together representatives of the diversity. To gain this understanding requires extensive and detailed work in herbaria and in libraries. We have built up a basic knowledge of the genus *Actinidia* (e.g., Ferguson, 1990a; Huang and Ferguson, 2007) through our own studies, by cooperating with Chinese institutes that have made detailed studies of wild *Actinidia* or that have their own germplasm collections (e.g., the Wuhan Institute of Botany, CAS, the Sichuan Provincial Natural Resources Research Institute, and the Guangxi Institute of Botany) and by collecting the very scattered literature, much of which is in Chinese with other useful information in English, French, German, Italian, Japanese and Russian.

3.3 In situ versus ex situ collections of *Actinidia* germplasm

Agriculture, horticulture, and most forestry in both Australia and New Zealand are almost entirely dependent on introduced species. This is not really surprising as only a very restricted number of plants have been exploited with about 100 species providing 90% of the world food plant needs, but it does mean that our breeding and improvement programmes are consequently almost all based on ex situ collections, collections in which biodiversity is preserved outside its natural habitat. Although conservation of the natural diversity in situ might be preferable, such in situ diversity is increasingly threatened by human activity and, moreover, is often difficult to access.

Ex situ collections have a number of advantages (Smekalova et al., 2003): plant diversity is safely preserved and concentrated in a small number of controlled places under consistent environmental conditions and is readily accessible to breeders. There are also disadvantages: only a very small part of the diversity of the population can be preserved; collecting and maintaining germplasm is very expensive and requires skilled staff; there may be restrictions on collection. Furthermore, although our agriculture and horticulture are based on the exploitation of only a very few plants, our germplasm collections should also include diversity amongst the wild relatives of the cultivated plants, relatives that may have contributed to the development of the crop or may in the future contribute usefully to new developments or improvements. This makes potential germplasm collections that much larger.

The genus *Actinidia* (Actinidiaceae) includes 50-70 species largely confined to southern China but with a few outlying species in northern China and in neighbouring countries (Ferguson, 1990a; Huang and Ferguson, 2007). The centre of species diversity and, probably, of current evolution is in southern China, mainly south of the Yangzi River. The very broken topography of this region has probably encouraged geographic isolation and speciation (Huang and Ferguson, 2007) by providing at a given latitude, sites at a variety of altitudes and microclimates.

Actinidia seem most at home in the hills and mountains where they prefer more protected, damper areas such as under the forest canopy, in clearings, at the edges of forests or in stream beds. However, the mountains and hills could also be considered refuges and the populations occurring there as relict populations with many vines lost because of human activities such as deforestation or brutal harvesting of fruit, a loss that is accelerating. It is likely that the *Actinidia* resources now remaining in China are discontinuous remnants of what were previously much more extensive distributions and this could lead to population differentiation. Although large quantities of kiwifruit are still harvested from the wild in many parts of China, the in situ diversity must be considered at serious risk and some taxa have become locally extinct. In Sichuan and Chonqing, for example, many of the wild *Actinidia* resources recorded only 25 years ago have now disappeared (Li and Lowe, 2006). Reliance on the in situ diversity is therefore not a realistic option.

HortResearch has cooperated with institutes in China in exploring the natural resources of *Actinidia* and in developing *Actinidia* germplasm repositories in China (e.g., Li and Lowe, 2006). We have also introduced much new material as seed into New Zealand, believing that it was by growing plants under our particular climatic conditions and by carrying out progeny testing that we could best assess their potential contributions to our breeding programmes. Unpredictable characteristics often appear in progenies of hybrids with wild forms (Rick in Gerrish et al., 1981) meaning that accessions of unimproved germplasm should not be evaluated directly as their potential may become apparent only in subsequent generations. Unfortunately, the strictures of the 1993 Biosecurity Act and the 1996 Hazardous Substances and New Organsisms Act (Douglas, 2005) have made it very difficult to introduce any new *Actinidia* taxa into New Zealand. Furthermore, the recent discovery of viruses in some *Actinidia* plants (e.g., Clover et al., 2003) means that what seed or budwood we can import is subject to rigorous and very expensive virus testing. The introduction of a much more extensive and much more representative range of *Actinidia* germplasm is therefore effectively prevented. In the future, we will probably have to shift much of our *Actinidia* germplam evaluation offshore. Plant breeders may, with difficulty, be able to adapt but such a shift would be a severe limitation to other potential users of the germplasm.

3.4 Nomenclature and taxonomy

The taxonomy and nomenclature of cultivated plants are notoriously fraught with difficulties. The tetraploid wheat, *Triticum turgidum* (L.) Thell., for example, has had at least 14 other names (Chapman, 1989). Fortunately, in *Actinidia* we are currently dealing with plants that are not very different from those occurring in the wild: that is, we are essentially dealing with the taxonomy of wild populations, albeit remnant ones. The genus has undergone three major revisions in the past 50 years, one yet to be published. The two most recent revisions have considered only species from China and the taxonomists involved have not always had access to the type specimens. In addition, *Actinidia* vines can be very variable morphologically, even between leaves and shoots from different parts of the one plant, and some of the species described, especially many of those described most recently, are based on inadequate sampling of populations, sometimes even on individual genotypes. Taxa that are widely distributed may show considerable morphological variation across the geographic range. However, taxonomic fashions change and there has been an increasing tendency in recent years not to attempt formal descriptions of such infraspecific variation (McNeill, 2004). Nomenclature consequently changes.

Thus the taxon that includes the traditional green kiwifruit ‘Hayward’ has been variously treated over the past 100 years (Ferguson, 1990b; Li et al., 2006):

- as a variant of *A.chinensis* Planch., but not formally distinguished;
- as a variety of a different species as *A.latifolia* var. *deliciosa* A.Chev.;
- more appropriately, as *A.chinensis* var. *deliciosa* (A.Chev.) A.Chev.;
- likewise as a variety of *A.chinensis* but with a different varietal synonym, *A.chinensis* var. *hispida* C.F.Liang;
- as a distinct species *A.deliciosa* (A.Chev.) C.F.Liang et A.R.Ferguson;
- and then, most recently, again as a variety as *A.chinensis* var. *deliciosa* (A.Chev.) A.Chev.

Many breeders and perhaps most of the other biologists studying kiwifruit will find this confusing as they may have had little formal taxonomic training and have slight understanding or appreciation of the niceties of botanical nomenclature. This may not be so important: what really is important is that it be realised that a biological entity may have been given a series of different names and that a particular botanical name may be applied by different authors in rather different ways encompassing different assemblages of the natural diversity. Over time, this may result in ambiguity in non-taxonomic literature as to exactly which biological entity is being discussed (Ferguson, 1990b).

4 Characterisation, evaluation and reproductive biology of *Actinidia* germplasm

For germplasm to be of use to breeders it must be characterised and evaluated. There is often a delay between collection of germplasm and its evaluation, particularly of fruit trees because of the time required for them to reach maturity. Evaluation is most useful if it considers the traits wanted by plant breeders. We are fortunate in that our programme of germplasm acquisition and evaluation is very closely linked to our programme of kiwifruit breeding with usually the same people involved in both. Preliminary evaluation can indicate those accessions that warrant more detailed evaluation, but those that appear not to be of immediate value should not be simply discarded.

I will not consider the more obvious characteristics such as fruit size, fruit shape, flavour, storage life, and nutritional composition or vine disease resistance, climatic adaptability, ease of management and nutrient requirements except to note that there are not always easy but reliable methods to analyse complex quality traits. Instead, I discuss why it is essential to develop a good understanding of some aspects of the underlying biology of the plants, especially if we want to take advantage of widely diverse germplasm with collections of genes that could be incorporated into crop development. Managed hybridisation between *Actinidia* species is frequently possible but not always successful. We need to be aware of the relationships between species, and some of the barriers to successful crossing such as differences in ploidy and lack of chromosome pairing and recombination. This is important as the New Zealand kiwifruit industry does not currently accept the possibility of developing new cultivars using molecular biological techniques.

4.1 Botanical identification

The identity of all material entering a germplasm collection should always be checked and it should never be assumed that material is true to label. We have used the treatments of *Actinidia* by Li (1952) and Liang (1984) but these both have deficiencies. For example, we were misled for a long time by Li following earlier authors in treating *A.rufa* simply as a synonym for *A.arguta*, whereas a study of more recent Japanese literature and of the actual plants shows that they are quite different, sufficiently unlike that they should probably be placed in separate sections of the genus (Huang and Ferguson, 2007). Liang (1984) had not considered *A.rufa* because his treatment was limited to the *Actinidia* found in China and at that time *A.rufa* was not known from Taiwan. This example simply indicates that best use of a germplasm collection requires some understanding of the taxonomy of the plants being collected and that the literature cannot be relied on uncritically.

We have a few plants which we cannot confidently ascribe to any one taxon and they are possibly natural hybrids. Many *Actinidia* species hybridise freely and open-pollinated seed from an *Actinidia* germplasm collection is of very limited value. Our experience shows that there is a similar, if lesser, risk that seed collected from wild plants may not be true to type.

On a number of occasions we have imported scionwood of cultivars only to find that, under our conditions, the plants resulting are nothing like the original descriptions. Frequent synonymy or confusion of cultivar names is an added difficulty. Once again, this demonstrates the importance of detailed analysis of the plants being collected and the need for extensive bibliographic work.

The converse is that other workers should not necessarily accept our plant identifications. The taxonomic and nomenclatural confusion relating to *Actinidia* means that any publications on genetic diversity in *Actinidia* species must be supported by voucher specimens for the plants used (Goldblatt et al., 1992). If a voucher or the *exact* position of the plant in a permanent germplasm repository is not cited, it is very difficult, if not impossible, for subsequent workers to verify the identity of the plant used. Voucher specimens are far more useful. We have started a programme of collecting voucher specimens for each accession derived from budwood and from at least one male and one female from those accessions introduced as seed. We collect flowering specimens of males and females and preserve fruit in alcohol. We need to start collecting voucher specimens of individual genotypes.

Knowledge of the identity of the germplasm taxa used, of their phylogenetic relationships, and of the genetic distances between them, should assist the development of breeding strategies (Rajapakse, 2003). The traditional infrageneric division of *Actinidia* has long been considered artificial. Use of different molecular markers (Huang and Ferguson, 2007) indicates that the current *Actinidia* taxa have arisen through recurrent hybridisation and reticulate evolution as affected by geographic patterns of distribution and heterogeneous environments. Molecular markers can also be used to detect relationships between the various accessions of an individual taxon (Dehmer, 2003).

4.2 Ploidy measurements

The genus *Actinidia* has a reticulate polyploid structure with diploids, tetraploids, hexaploids and octoploids occurring naturally in diminishing frequency. As more plants are studied, an increasing number of taxa are found to contain ploidy races and it seems likely that ploidy races are the rule in *Actinidia* rather the exception. There is usually no clear morphological distinction between ploidy races although they may be geographically restricted. For example, of the different accessions of *A.chinensis* checked, about 60% were diploid and 40% tetraploid. In this particular species, flowering time is generally a reliable indicator of ploidy but this may be coincidence as the tetraploid genotypes of known provenance come from a limited area in China.

The basic chromosome number is 29 and there is increasing evidence (Huang and Ferguson, 2007) that *Actinidia* are cryptic polyploids or rediploidised palaeopolyploids. Chromosome numbers have been counted in about 120 *Actinidia* genotypes, some of them intra- or interspecific hybrids between different ploidy levels. There is thus a series of plants that are $2x$, $3x$, $4x$, $5x$, $6x$ and $8x$: these plants are preserved in the germplasm collection and are used as standards for the determination of ploidy by flow cytometry (Ferguson et al., 1997). This allows rapid and reliable estimates of ploidy in large numbers of plants. So far, flow cytometry has been used to determine ploidy in more than 3400 genotypes in our collections, essentially every genotype that is large enough to sample, as well as several thousand more in breeding populations. We have done this because we have found with *Actinidia* that it is unwise to make any assumptions as to the ploidy of any individual genotype.

Ploidy variation between taxa and the existence of ploidy races within taxa can make crossing in *Actinidia* difficult. Triploid offspring are often sterile but those at higher, but uneven, ploidies can be at least partially fertile. Interploidy crosses could also be facilitated by using plants that produce numerically unreduced gametes, as has been observed in *A.chinensis* (Yan et al., 1997). Production of numerically unreduced gametes could explain why offspring of interploidy crosses are not always at the expected ploidy. There could be new opportunities in interspecific *Actinidia* breeding by doubling ploidy with colchicine or by adopting some of the other strategies or techniques that have proved rewarding with, for example, peanuts (Stalker, 1989) or potatoes (Carputo et al., 2005).

Actinidia chinensis and *A.deliciosa* are accepted as being closely related but the genomic relationships between the diploid and tetraploid races of *A.chinensis* and hexaploid *A.deliciosa* are not clear. Tetraploid races of *A.chinensis* can be split into at least two groups having different evolutionary histories (Murray, 2002): some genotypes appear to be autotetraploid, others allopolyploid. Evidence on *A.deliciosa* is equivocal: it may be autopolyploid, being derived entirely from *A.chinensis*, or it is possible that it is allopolyploid (Huang and Ferguson, 2007). A better understanding of autoployploidy versus allopolyploidy, and of tetrasomic gametic segregation in tetraploid *A.chinensis*, could give useful indications of the breeding strategies that should be used.

4.3 *Actinidia* reproductive biology

Incorporation of germplasm, especially of species other than *A.chinensis* and *A.deliciosa*, into programmes of kiwifruit improvement is greatly facilitated by detailed studies of *Actinidia* reproductive biology and of the relationships between the species. Such studies cannot really be considered as part of germplasm characterisation or evaluation, but they do make the collections that much more useful.

1. *Dioecy*. All *Actinidia* species appear to be functionally dioecious, irrespective of ploidy, and exhibit "cryptic dioecy" (Schmid, 1978) in that the stamens of the unrewarding pistillate flowers mimic pollen-producing staminate flowers. However, gender inconstancy is well-documented in *A.deliciosa* (McNeilage, 1997) and has occasionally been observed in other *Actinidia* species. All genotypes in the collection are therefore being screened for pollen stainability as a first step to checking whether any of the males retained is sterile and whether any apparently functionally pistillate plants may produce some viable pollen. The sex determination mechanism appears to be of the X_nX/X_nY type and He et al. (2003) have described what appear to be sex chromosomes at an early stage of differentiation.

Having only a male or female representative of a particular taxon in the collection is an obvious limitation. Furthermore, breeding programmes can become protracted if pollen parents have to be progeny tested since fruiting characteristics are not expressed in the male. Fusion of protoplasts from two female genotypes of known fruit characteristics would add considerable flexibility to our breeding programmes and this possibility is currently being investigated. It is fortunate that *Actinidia* respond well to tissue culture techniques.

2. *Polymorphism and heterozygosity*. Kiwifruit show considerable polymorphism in numerous characters despite many of the plants studied having a common origin in the first seed brought to New Zealand. This is due, at least in part, to their being obligatorily outcrossing, to their being polyploid and to their high chromosome number allowing extensive recombination. Heterozygosity could also be due to chromosome duplication during evolution (He et al., 2005): chromosome duplication is indicated by the remarkably high microsatellite and allozyme polyallelism in diploid species (Huang and Ferguson, 2007). Hexaploid *A.deliciosa* genotypes are more heterozygous than tetraploid *A.chinensis* genotypes which are, in turn, more heterozygous than diploid *A.chinensis* genotypes (Zhen et al., 2004). It seems that polyploidy has helped maintain diversity in *Actinidia*. The high degree of heterozygosity has to be considered when breeding strategies are formulated. As *Actinidia* are outcrossing, considerable genetic diversity within seed accessions might also be expected. This could be investigated further using molecular markers especially when choosing genotypes from seed accessions for permanent retention. However, the variation revealed by genetic markers is essentially neutral unless the markers used are focussing on specific genes (van Treuren and van Hintum, 2003) and the extent to which molecular diversity accurately reflects functional diversity has been questioned. Nevertheless, it seems that the genetic potential of germplasm cannot be assessed on phenotype alone and that

marker methods will assist evaluation (Garris et al., 2004; Rajapakse, 2003).

3. *Plastid inheritance*. In *Actinidia*, unlike most other higher plants examined, chloroplasts are usually inherited from the pollen parent (Cipriani et al., 1995; Matsunaga et al., 1996), although in certain interspecific crosses chloroplasts appear to be inherited from the mother (Jung et al., 2003). Flesh colour in mature or ripe *Actinidia* fruit is determined by the degree to which pigments are revealed as masking chlorophyll is degraded (McGhie and Ainge, 2002) and chloroplasts are converted to chromoplasts. The extent to which chlorophyll degradation is under chloroplastic control and the parental origin of those chloroplasts is therefore important for breeding programmes having fruit flesh colours other than green as one of their main objectives.

4. *Chromosome pairing and recombination*. Cytological studies are being used to help to determine appropriate breeding strategies. The transfer of genes between *Actinidia* species requires the production of fertile F_1 hybrids. If recombination between the parental genomes occurs during the production of gametes, segregation of the desired characters can be obtained by backcrossing (Datson et al., 2006). Genomic in situ hybridisation (GISH) is being used to distinguish parental genomes in such *Actinidia* hybrids to determine the levels of chromosome pairing and whether recombination during meiosis is occurring within or between parental genomes. The results will be used to decide whether it is more efficient to backcross F_1 hybrids with one or other of the parental species or instead to concentrate on producing F_2 hybrids.

5. *Genetic linkage map and applicability of marker-assisted selection*. Good progress is being made with the preparation of a genetic linkage map of *A.chinensis* using microsatellites taken from an EST (expressed sequence tag) database (Fraser et al., 2004). One of the main reasons for preparing such a map is to select for phenotypic traits using markers tightly linked to the genes controlling those traits, especially traits controlled by a relatively large number of loci (Quantitative Trait Loci, QTLs). The potential usefulness of these markers is enhanced by their transferability across many *Actinidia* taxa (Tsang et al., 2006).

Sex markers for early sex determination have also been developed (Oliveira and Fraser, 2005). These markers can be applied to many accessions of *A.chinensis* and *A.deliciosa* and could, with some technical modifications, be used in the large-scale screening of seedling populations either from new accessions or from breeding programmes.

5 Use of the HortResearch Actinidia germplasm collection

The effort to obtain germplasm, maintain it and evaluate it can be justified only if the collection is used. Many research workers within HortResearch make use of the plants to expand our knowledge of the genus as a whole, so that we can better appreciate the potential and the limitations of what is currently available and predict what might be possible. The ultimate use is for kiwifruit breeding and improvement, for the production of new cultivars that will give the New Zealand industry a competitive advantage.

All kiwifruit cultivars recently released by HortResearch are based on material originally introduced simply to increase the diversity of the kiwifruit germplasm collection. The rootstock, ‘Kaimai’, is derived from seed of an *A.eriantha* × *A.hemsleyana* cross introduced in 1975. The

A.deliciosa cultivar ‘Tomua’ came from a cross between ‘Hayward’ and males from an accession of *A.deliciosa* seed introduced to New Zealand in 1975, the first introduction since the original *A.deliciosa* seed were imported in 1904. The corresponding males, ‘Ranger’ and ‘King’ are siblings of ‘Tomua’. ‘Hort16A’ came from a cross between plants derived from accessions of *A.chinensis* seed in 1977 and 1981 and the associated males, ‘Sparkler’ and ‘Meteor’ came from seed accessions introduced in 1979 and 1981, respectively. Four cultivars of *A.arguta* released came from germplasm of *A.arguta* and *A.melanandra*.

There is thus a long lag between importation of new germplasm and incorporation of that material into any new fruiting cultivars. The cultivars released so far are based on material introduced about 20 years previous. Since then, a much greater diversity of germplasm has been imported and we hope that exciting new cultivars of *A.chinensis*, *A.deliciosa* and of other *Actinidia* species will emerge from the use of this new germplasm.

Germplasm collections are our legacy for future generations. It is the responsibility of our generation to protect that germplasm and acquire the knowledge that will make these collections most easily and most effectively used.

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崂山野生猕猴桃资源调查及嫁接亲和性试验

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摘　要　通过几十次深入崂山山脉腹地，历时近 10 年的实地考察和查阅大量文献资料，发现崂山有软枣猕猴桃和葛枣猕猴桃两个野生猕猴桃，而且明确了两个种类的分布区域，澄清了文献上的模糊概念。通过嫁接试验表明，葛枣猕猴桃与美味猕猴桃和中华猕猴桃有良好的亲和性，可作为美味猕猴桃和中华猕猴桃的砧木应用，而软枣猕猴桃与美味猕猴桃和中华猕猴桃嫁接不亲和。

关键词　崂山　软枣猕猴桃　葛枣猕猴桃　砧木　亲和性

1　自然生态环境条件

崂山位于山东半岛南部的黄海之滨，地处北纬 36°03′～36°24′、东经 120°07′～120°43′。崂山的最高峰名为巨峰，海拔高度 1133 m，山区面积 446 km^2。崂山属暖温带大陆性季风气候，四季变化和季风进退均较明显，具有雨水丰富、年温适中、冬无严寒、夏无酷暑、气候温和的特点。历年平均气温在 11.0～12.5 ℃ 之间，极端最高气温 36.9 ℃，极端最低气温 –20.5 ℃。历年平均降水量为 800～1000 mm，最大 2100 mm (主峰)。平均无霜期为 179 d。由于崂山地处亚热带之终、北温带之始，又濒临黄海，故气候温和湿润，适于南北方多种植物生长繁衍，又因地形复杂，植物种类繁多。据记载有种子植物 156 个科，近 1500 个种和变种，其中有木本植物 72 科、156 属，近 400 个种和变种。

2　崂山野生猕猴桃资源调查

2.1　背景

关于崂山(或山东)野生猕猴桃的种类，文献上的记载一直比较混乱。其中主要焦点是狗枣猕猴桃(*A.kolomikta*)，即崂山(山东)究竟有没有狗枣猕猴桃。一般均记载有两个种，一个是葛枣猕猴桃；另一个有的文献记载是软枣猕猴桃，有的记载是狗枣猕猴桃(深山木天蓼)。记载有狗枣猕猴桃的文献有《中国猕猴桃》、《山东果树志》和《崂山县志》。其中后两者记载只有葛枣猕猴桃和狗枣猕猴桃，而没有软枣猕猴桃。记载崂山有软枣猕猴桃和葛枣猕猴桃，没有狗枣猕猴桃的文献是《中国植物志》(第四十九卷第二分册)、《中国果树分类学》、《山东树木志》、《山东植物志》、《山东省果树资源和区划》。为了彻底搞清其原因，首先分别与《中国猕猴桃》的主编，原农业部猕猴桃科研协作组负责人崔致学老先生和《山东果树志》的主编、山东省农科院果树研究所的陆秋农老先生联系，得到的答案是一样的，即他们均是参考了《崂山县志》中有关果树资源的部分内容。最后与负责编写《崂山县志》果树资源部分的原崂山区农业局果树站的于志堂老先生交流，于老先生承认把软枣猕猴桃误当作狗枣猕猴桃了，并且于老先生希望我们这一代一定要把这个问题搞清楚，以澄清对这一问题的模糊认识。

除查阅大量文献和与有关专家交流外，自 1998 年至 2005 年近 10 年来，我们几乎走遍了崂山主峰(巨峰)和周边的主要山谷沟溪，实地采样调查了枝条、叶片、花和果实的性状，对崂山猕猴桃的种类区别和分布特点进行了系统调查，彻底搞清了分布于崂山的猕猴桃种类，

即只有软枣猕猴桃和葛枣猕猴桃，没有发现狗枣猕猴桃。

2.2 崂山猕猴桃的种类特征及分布

1. 软枣猕猴桃(*Actinidia arguta*) 小枝无毛或幼嫩枝散生柔软绒毛或茸毛。二年生枝灰褐色、无毛或呈灰色皮屑状。髓白色至淡褐色，片层状。叶片膜层至纸层，椭圆卵形至宽卵形，长 10.0～12.1 cm、宽 6.6～8.3 cm，先端渐尖，基部圆形或亚心形，边缘具锐锯齿；上面深绿色，无毛；下面色稍淡，无毛或被褐色绒毛至刺毛；下面侧脉腋有时有白色或黄色簇毛。叶柄长 3.5～6.0 cm。花呈腋生聚伞花序，雄花多朵，雌花 1～3 朵。花绿白色，芳香，花径 2.7～3.2 cm。萼片 4～6 枚，卵圆形至长圆形，先端圆钝，边缘有毛、无毛或稀为外被短柔毛。花瓣 4～6 片，楔倒卵形或瓢状倒阔卵形。雄花多数，药囊黑色或暗紫色，长圆形箭头状。子房瓶状，无毛。果实卵球形，绿色或黄绿色，光滑无毛，无斑点，先端喙状。种子褐色，千粒重 1.55 g。单果重 3.5～4.9 g，果皮薄，果肉浅绿色，软而多汁，味酸甜适度，鲜果肉含可溶性固形物 17.3%～20.0%，每百克鲜果肉含维生素 C 56.0 mg。萌芽期 3 月中旬，花期 5 月底至 6 月上旬，果实成熟期 9 月中下旬。嫁接试验表明用软枣猕猴桃作砧木与中华猕猴桃、美味猕猴桃嫁接不亲合。

软枣猕猴桃主要分布于崂山主峰的东、北、西侧的山谷沟溪，垂直分布海拔高度 700～1000 m。在主峰西侧海拔约 900 m 处有一片上万平方米的软枣猕猴桃。

2. 葛枣猕猴桃(*Actinidia polygama*) 枝无毛或幼时具短绒毛，髓白色、实心。叶片膜质，初夏部分叶片全叶或上半部变为银白色，卵形或椭圆形，长 10.3～12.7 cm、宽 6.5～8.3 cm, 顶端急渐尖至渐尖，基部圆形或阔楔形，叶缘有细锯齿，叶正面绿色，无毛或有稀疏刺毛，叶背面色较浅，沿中脉及有时侧脉上有刺毛。叶柄长 2.8～4.6 cm，无毛或被稀疏刺毛。花单生于叶腋，稀 2～3 个。萼片 5 枚，卵形，先端急尖，边缘有毛。花白色，芳香，花瓣 5 枚，倒卵形至长卵形。药囊黄色，卵形箭头状。子房瓶状，无毛。果实柱状卵球形，无毛，无斑点，顶端有缘，基部有宿存萼片。果实成熟时橙黄色。种子褐色，千粒重 0.62 g。单果重 3.7～6.2 g。果肉淡黄色，味甜酸，有辛辣。每百克鲜果肉含维生素 C 81.0 mg。萌芽期 3 月中旬，花期 5 月底至 6 月上旬，10 月上、中旬果实成熟。葛枣猕猴桃抗逆性强，与中华猕猴桃、美味猕猴桃嫁接亲和力好，可作为砧木应用。葛枣猕猴桃主要分布于崂山主峰北部的山谷沟溪灌丛中，垂直分布海拔高度约 400～700 m。

葛枣猕猴桃很容易区别，只要看枝条髓部的结构(是否实心)就能区别。软枣猕猴桃与狗枣猕猴桃较难区分，由于两者枝条的结构都呈片层，必须参照其他植物学特征。如在花期观察药囊的颜色就可区分，软枣猕猴桃的药囊呈黑色或暗紫色，而狗枣猕猴桃的药囊呈黄色。此外，从开花后的叶片的尖端的色斑，也很容易区别，叶片尖端至前半部为白色或粉色的是狗枣猕猴桃，叶片没有色斑的是软枣猕猴桃。而从果实性状较难区分，但由于过去搞野生猕猴桃资源时，没有从开花期开始，只是到秋季时调查枝条、叶片、果实，造成失误，造成混乱(表 1)。

3 崂山野生猕猴桃嫁接亲和性试验

原产崂山的软枣猕猴桃和葛枣猕猴桃，长期以来处于自生自灭的深山河谷中，没有得到利用和保护。软枣猕猴桃和葛枣猕猴桃具有很强的抗逆性(抗寒、抗旱)，能否作为砧木嫁接优良的猕猴桃品种，以扩大优良猕猴桃品种在山东(或北方)的适应范围，2001 年以来我们进行试验。

试验于 2001～2004 年分别在崂山北九水猕猴桃园和青岛市农科院试验园进行。砧木是葛枣猕猴桃扦插苗和 1999 年培育的软枣猕猴桃实生苗，嫁接的品种是‘秦美’、‘陕猕 1 号’、‘通山 5 号’、‘武植 3 号’等。嫁接试验表明：葛枣猕猴桃与美味猕猴桃品种秦美亲和力好，嫁接成活率 70.9%～76.8%，生长良好，新梢平均长 71.9～83.0 cm，叶片大嫩绿；而与中华猕猴桃品种‘通山 5 号’、‘武植 3 号’的亲和力较差，嫁接成活率只有 12.6%，并且新梢生长弱，只有 8～10 cm，叶片弱小(表 2)。同时于 2002～2004 年连续三年，在青岛市农科院果茶所北宅试验基地和青岛市农科院试验园做了软枣猕猴桃嫁接试验，分早春、初夏和秋季三个时期嫁接，品种是美味猕猴桃‘秦美’、‘陕猕 1 号’、‘金魁’；中华猕猴桃‘通山 5 号’、‘武植 3 号’、‘魁蜜’等。实验结果表明，无论采用不同嫁接方法、嫁接时期、品种等均不成活；即软枣猕猴桃与美味猕猴桃和中华猕猴桃不亲和。

表 1　野生猕猴桃种类特征

名称	枝	叶	花	果 实	产 地
软枣猕猴桃 (*A.arguta*)	二年生枝灰褐色，无毛或部分表皮呈灰色皮屑状。髓部白色至淡褐色。	卵形、长圆形至宽卵形，叶面深绿色，无毛，有光泽，叶背淡绿色，无毛或被褐色绒毛至刺毛；下面侧脉腋有时有白色或黄色簇毛。	腋生聚伞花序，雄花多朵，雌花 1～3 朵。花绿白色、芳香，花瓣 4～6 片。药囊黑色或暗紫色。子房瓶状、无毛。	卵球形、扁圆形或近圆形，绿色，无毛，无斑点，先端喙状。果肉绿色，酸甜适度。种子褐色。	崂山北九水
葛枣猕猴桃 (*A.polygama*)	无毛或幼时具短柔毛，髓部白色、实心。	卵形或椭圆卵形，叶面淡绿色，叶背面色淡，沿中脉或有时侧脉上有刺毛。初夏部分叶片全叶或上半部变为银白色。	单生于叶腋，稀 2～3 朵，花白色，芳香，花瓣 5 枚，药囊黄色。子房瓶状，无毛。	柱状卵珠状，成熟时橙黄色，无毛，无斑点，先端喙状，萼片宿存。果肉浅黄色，味甜酸，稍有辛辣味。种子褐色。	崂山北九水
狗枣猕猴桃 (*A.kolomikta*)	暗灰色，无毛，髓部黄褐色，片层状。	卵形至长圆卵形，边缘有紫红色细锯齿。花后部分叶片尖端或前半部呈白色或粉色。叶柄细，紫红色。	聚伞花序，1～3 朵，白色或桃红色，芳香，花瓣 5～6 枚，萼片 4~5 枚。雄蕊多数，药囊黄色。子房卵球形至长圆柱形，无毛。	柱状长圆形或卵形，暗绿色，无毛，无斑点，稍有纵纹。花萼常脱落，偶有宿存。果肉淡绿色，味酸甜。种子褐色。	《中国果树分类学》(俞德浚编著)和《北京果树志》等记载

表 2　崂山野生猕猴桃嫁接试验调查

砧 木	品 种	嫁接株数	成活株数	成活率/%	新梢长度/cm
葛枣猕猴桃	秦美	246	189	76.8	83.0
	陕猕 1 号	165	117	70.9	71.7
	通山 5 号、武植 3 号	182	23	12.6	10～16

4　小结与讨论

经多年系统调查，搞清了崂山有软枣猕猴桃和葛枣猕猴桃，没有狗枣猕猴桃，并且明确了水平分布和垂直分布范围：软枣猕猴桃主要分布在崂山主峰东、北、西侧的山谷沟溪，垂直分布海拔高度 700～1000 m；葛枣猕猴桃主要分布在崂山主峰北侧的山谷沟溪灌丛中，垂直分布海拔高度 400～700 m。葛枣猕猴桃可作为美味猕猴桃和中华猕猴桃的砧木应用，以扩

大猕猴桃在山东境内的适应性。美味猕猴桃品种与葛枣猕猴桃嫁接亲和力好、成活率高，中华猕猴桃次之。软枣猕猴桃不能做中华猕猴桃和美味猕猴桃的砧木应用。

关于崂山野生猕猴桃种类资源，有专家提出，是否因近十几年来不合理的旅游开发，使本来就稀少的狗枣猕猴桃灭绝了，或者就是没有发现。我们认为上述看法不符合实际。其理由是，除了《崂山县志》和《中国猕猴桃》记载崂山有狗枣猕猴桃外，在此之前的文献资料没有记载崂山(或山东)有狗枣猕猴桃。此外，近几年我们十几次进入《崂山县志》中记载有狗枣猕猴桃的地点，进行反复地考察，只发现软枣猕猴桃，没有狗枣猕猴桃。但是《崂山县志》中只记载有狗枣猕猴桃，而没有软枣猕猴桃。从而可知，把软枣猕猴桃误认为是狗枣猕猴桃。

文献资料记载河北、山西、北京、辽宁等省(市)有狗枣猕猴桃，而生态自然环境条件较优越的山东(崂山)境内，没有狗枣猕猴桃是何原因？该问题有待植物学工作者和果树科技工作者进一步地研究。

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Investigation of Kiwifruit Resources to Laoshan Mt. and the Compatibility Study as Rootstock for *Acitinidia deliciosa* and *A.chinensis*

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Abstract　There were two species found in Laoshan Mt. in Qingdao, Shangdong province through many times of exploration to the central area in the last decade, and the two species are *Acitnidia arguta* and *A. polygama*. This investigation gave the clear distribution of the two species, and *A. polygama* can also been used as rootstock for *A.deliciosa*, or *A.chinensis*, but *A.arguta* is uncompatibility with *A.deliciosa*, or *A.chinensis*.

Key words　Laoshan Mt.　*Acitnidia arguta*　*A. polygama*　Rootstock　Compatibility

云南文山州麻栗坡、西畴县的猕猴桃资源及利用评价

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摘　要　云南省文山壮族苗族自治州的麻栗坡、西畴两县位于云南省的东南部，由于其特殊的自然条件，蕴藏了丰富的猕猴桃资源，经过 20 世纪 80 年代的猕猴桃资源系统调查和 2003～2005 年的补充调查，基本查清两县共有猕猴桃资源 21 个种、变种及云南特有种。资源种类涵盖猕猴桃的四个组，其中净果组 1 个；斑果组 12 个；糙毛组 4 个；星毛组 4 个；变种 11 个；云南特有种 9 个。确定了资源分布的垂直高度为 1100～2010 m，集中分布为 1200～1700 m；在地理分布范围上，两县的 22 个乡中有 19 个乡有猕猴桃资源的分布。两县的猕猴桃资源均处于野生状态，基本无商业性栽培。本文根据对猕猴桃的生态环境的调查结果，对两县猕猴桃的生存现状、资源的利用等进行了初步的评价。

关键词　西畴县　麻栗坡县　猕猴桃　资源　利用评价

猕猴桃是当前世界上的一种新兴水果，我国是猕猴桃果树的起源中心，而云南又是我国猕猴桃资源的集中分布地区和多样性中心。云南的猕猴桃资源主要分布在滇东北、滇西和滇西南地区。为进一步摸清滇西南的猕猴桃资源，在 20 世纪 80 年代对全省猕猴桃资源系统调查的基础上，我们又经过三年时间对滇西南文山壮族苗族自治州(简称文山州)的西畴与麻栗坡两县的猕猴桃资源进行了补充调查。通过调查，对两县的野生猕猴桃种和变种的数量有了基本的了解。西畴和麻栗坡两县的野生猕猴桃属资源共有 21 个种和变种，其中种为 10 个，占云南 31 个种的 32.25%；变种 11 个，占云南 23 个变种的 47.82%；云南特有种 9 个，占云南 18 个特有种的 50.0%。

在这 21 个种与变种涵盖猕猴桃的 4 个组，两县均有分布。其中，净果组有 1 个种；斑果组有 12 个种及变种；糙毛组有 4 个种及变种；星毛组有 4 个种及变种。

1　西畴、麻栗坡两县的自然条件概况

云南省文山州的西畴县与麻栗坡县位于文山州的中南部。西畴县位于北纬 23°06′～23°37′和东经 104°22′～104°58′，总面积 1545 km^2。与文山、砚山、麻栗坡、马关、富宁五县相邻。该县地处滇东南岩溶高原的东南部，岩溶地貌广泛分布，喀斯特地貌占全县面积的 75.4%，地势中部高，东北、西南低。县城海拔高度 1413 m，县内最低海拔 645 m，最高海拔 1962 m，境内属中亚热带高原季风气候，年平均气温 15.8 ℃，年降水量 1245 mm，年相对湿度 83%。

麻栗坡县位于北纬 22°48′～23°33′和东经 104°32′～105°18′之间，总面积 2395 km^2，东面、南面与越南接壤。该县地处滇东南岩溶高原的南部边缘的斜坡地带，东北及中部高，东南低。县城海拔高度 1127 m，县内最低海拔 107 m，最高海拔 2579 m，相对高差 2472 m，境内属中亚热带湿润季风气候，年平均气温 17.7 ℃，年降水量 1054 mm，年相对湿度 86%，无霜期 349 d。

西畴与麻栗坡两县以山区为主，是典型的喀斯特岩溶地区，地势起伏较大，河谷深切，山峰突起，陡峻、孤耸直立，由无数的独立山峰组成，促成了环境的复杂化，具备了多种多

样的小气候，气候类型的复杂和多样性给猕猴桃属植物不同的种、变种、变形生长提供了不同的生态环境，这些气候也成为了各种猕猴桃赖以生存的条件。

2　西畴、麻栗坡两县的野生猕猴桃资源

通过云南省农业科学院园艺研究所果树资源课题 2003～2005 年连续三年对西畴、麻栗坡两县的野生猕猴桃资源进行的补充调查收集，参考原有的标本，确定两县共分布有圆果猕猴桃、簇花猕猴桃、楔叶猕猴桃、红茎猕猴桃、革叶猕猴桃、硬齿猕猴桃、尖叶猕猴桃、异色猕猴桃、驼齿猕猴桃、毛枝京梨猕猴桃、中越猕猴桃、京梨猕猴桃、伞花猕猴桃、肉叶猕猴桃、奶果猕猴桃、多齿猕猴桃、粗齿猕猴桃、红毛猕猴桃、黄毛猕猴桃、阔叶猕猴桃、长绒猕猴桃 21 个野生猕猴桃种及变种，见表 1。

表 1　西畴、麻栗坡两县野生猕猴桃的种类和数量

组别	序号	种(变种)名	学　　名	备注
净果组	1	圆果猕猴桃	*A.globosa* C.F.Liang	
斑果组	2	簇花猕猴桃	*A.fasciculoides* C.F.Liang	特有种
	3	楔叶猕猴桃	*A.fasciculoides* var. *cuneata*	特有种
	4	红茎猕猴桃	*A.rubricaulis* Dunn	
	5	革叶猕猴桃	*A.rubricaulis* var. *coriacea* (Fin.et Gagn) C.F.Liang	
	6	硬齿猕猴桃	*A.callosa* Lindl.	
	7	尖叶猕猴桃	*A.callosa* var. *acuminata* C.F.Liang	特有种
	8	异色猕猴桃	*A.callosa* var. *discolor* C.F.Liang	
	9	驼齿猕猴桃	*A.callosa* var. *ephippioidea* C.F.Liang	特有种
	10	毛枝京梨猕猴桃	*A.callosa* var. *pubiramula* C.Y.Wu	特有种
	11	中越猕猴桃	*A.indochinensis* Merr	
	12	京梨猕猴桃	*A.callosa* var. *henryi* Maxim	
	13	伞花猕猴桃	*A.umbelloides* C.F.Liang	特有种
糙毛组	14	肉叶猕猴桃	*A.carnosifolia* C.Y.Wu	
	15	奶果猕猴桃	*A.carnosifolia* var. *glaucescens* C.F.Liang	
	16	多齿猕猴桃	*A.henryi* var. *polyodonta* Hand-Mazz	
	17	粗齿猕猴桃	*A.hemsleyana* var. *Kengiana* (Met.) C.F.Liang	特有种
星毛组	18	红毛猕猴桃	*A.rufotricha* C.Y.Wu	特有种
	19	黄毛猕猴桃	*A.fulvicoma* Hance	
	20	阔叶猕猴桃	*A.latifolia* (Gardn.et.Champ.) Merr	
	21	长绒猕猴桃	*A.latifolia* var. *mollis* (Dunn)Hand-Mazz	特有种

3　西畴、麻栗坡两县野生猕猴桃资源的地理分布

西畴、麻栗坡两县的 21 个种及变种野生猕猴桃资源种类，分布的面积较广，且多呈零星分布状况。在平面分布上，两县 22 个乡镇中，19 个乡镇有猕猴桃资源的分布。

西畴县野生猕猴桃资源的地理分布：兴街镇、蚌谷乡、莲花塘乡、新马街乡、柏林乡、坪寨乡、法斗乡、董马乡、鸡街乡。

麻栗坡县野生猕猴桃资源的地理分布：大坪镇、董干镇、南温河乡、猛硐乡、下金厂乡、八布乡、六河乡、杨万乡、铁厂乡、新寨乡。

在垂直分布上，两县猕猴桃资源分布的垂直高度为海拔 1120～2010 m，但集中分布的海拔高度为 1200～1700 m，见表 2。