to be sought in the shading from the sun in the spring, and the obstruction afforded by the grass to the spread of the spores in the fall.

The second instance that came to notice was that of two adjoining plantations of Spruces separated only by a wagon trail. In the one on the north side of the dividing road no cover was afforded, and blight in that plantation was markedly prevalent. The plantation to the south of the road was covered by a rank growth of weeds and grass, and the trees on it were remarkably free from blight. True, its soil was richer and better prepared, but the explanation for comparative freedom from blight is probably the cover. This is doubtless an important factor governing the distribution of Phacidium Blight in the native forests.

(g) *Constant watchfulness*

In conclusion let me reiterate that maintenance of a blight-free nursery is the first consideration. Then in regions liable to Phacidium Blight the young coniferous plantations should be inspected annually, preferably in the springtime, for the first few years of their existence—until the leaders get well above the snow-cover of winter. If sporadic cases of blight appear in them the diseased plants should be thoroughly sprayed with lime sulphur in the late fall, or pulled out by hand and burned. Just as Phacidium Blight can be economically controlled and prevented in nurseries, so too, I doubt not, can it be in the plantations.

Pathological Laboratory, Arnold Arboretum,
Harvard University.

CHROMOSOMES AND PHYLOGENY IN CAPRIFOLIACEAE

Karl Sax and D. A. Kribs

Plate 24

The family Caprifoliaceae contains thirteen genera, most of which are distributed in the north temperate zone. *Lonicera* is the largest genus with about one hundred and eighty species while *Heptacodium*, *Linnaea* and *Kolkwitzia* are monotypic. The Arnold Arboretum contains representative species of eight genera, and in the larger genera both Asiatic and American forms are represented.

With the possible exception of *Sambucus* the family seems to be a natural one and taxonomists have generally agreed in the grouping of the various genera. There is, however, considerable variation in the degree of specialization of floral parts and in wood structure.

From the standpoint of the geneticist the family is of interest because of the occurrence of natural species hybrids in the genera *Sambucus*, *Viburnum*, *Symphoricarpus*, *Diervilla* and *Lonicera*. The family contains many of our most valuable ornamental shrubs and additional hybrids between certain species should be of considerable horticultural value.

A cytological study of the more important genera of Caprifoliaceae has been made by the senior author to determine the chromosome number and size relationships. A study of wood structure has been made by the junior author in an attempt to determine the phylogenetic changes in structural specialization of these genera. Such studies should throw some light on the relation between chromosome variation and phylogenetic development in this family.

Chromosome counts were obtained from root tips of young plants in the greenhouse and from pollen mother cells of mature plants in the Arboretum. The pollen mother cells were smeared on a dry slide, fixed in Navaschin's solution for about 30 minutes and stained in crystal violet iodine. In some cases the young buds were fixed in absolute alcohol and acetic acid and later used for aceto-carmine preparations.

The taxonomic classification of sections and species of the various genera of Caprifoliaceae is based on Rehder's Manual (1).

The genus Sambucus contains about 20 species which are divided into two sections. Of the seven species described by Rehder three are of Asiatic or European origin while four are natives of North America. Chromosome counts have previously been obtained for *S. nigra* and *S. racemosa* (2). Both species have eighteen pairs of chromosomes. Permanent smears of the pollen mother cells of the American species *S. canadensis* show that this species also has eighteen gametic chromosomes. *Sambucus nigra* and *S. canadensis* belong to the section Eusambucus while *S. racemosa* belongs to the section Botryosambucus. The chromosome number is the same for both European and American species and in all cases the chromosomes are comparatively large. Somatic figures of *S. racemosa* have also been obtained from plants in the Arboretum greenhouses and the size and approximate number of the chromosomes are shown in figure 1. The average length of the chromosomes is about 4 microns.

There are nine sections and about 120 species in the genus *Viburnum*. Most of the species are natives of Asia, but the genus is well represented in North America. Representatives of six of the nine sections have been studied, including both Asiatic and American forms. The section, species, gametic chromosome number and native habitat are given as follows:

VIBURNUM

Section	Species	Chromo-some No.	Origin
Lantana	V. Lantana	9	Europe-Asia
Pseudotinus	V. alnifolium	9	N. America
Pseudopulus	V. tomentosum	9	Japan-China
Lentago	V. Lentago	9	N. America
	V. prunifolium	9	N. America
Odontotinus	V. hupehense	9	China
	V. acerifolium	9	N. America
	V. lobophyllum	9	China
Opulus	V. trilobum	9	N. America
	V. Opulus	9	Europe-Asia
	V. Sargenti	9	N. E. Asia

All of the Viburnum species investigated have nine pairs of chromosomes. The chromosomes of this genus are relatively large. The somatic chromosomes of *V. Opulus* are shown in figure 2. The average length of these chromosomes is about five microns.

Only one species of *Symphoricarpus* has been investigated although the genus contains about sixteen species, which with one exception are natives of North America. There are eighteen somatic chromosomes in *S. orbiculatus*. They are relatively small and slender and have an average length of approximately 1.5 microns (Fig. 3). *Symphoricarpus albus* is probably a hexaploid form but exact counts could not be obtained.

Abelia contains two sections and about twenty-eight species, most of which are natives of Asia. Chromosome counts of *A. Engleriana* were obtained from pollen mother cells. The gametic number is sixteen. Somatic chromosomes of *A. Schumannii* were also obtained and although an exact count could not be obtained it is probable that the number is thirty-two. The chromosomes are very small and have an average length of less than one micron (Fig. 4).

Kolkwitzia is a monotypic genus from China. In *K. amabilis* there are sixteen pairs of chromosomes. The somatic chromosomes are similar to those of *Abelia* but are somewhat larger (Fig. 5).

The genus *Diervilla* is divided into three sections and about twelve species. Of the ten species described by Rehder, three are of American origin while seven are natives of Eastern Asia. Species hybrids exist only in the Weigela section.

Chromosome counts have been obtained for three species in the Weigela section and for two species in the Eudiervilla section. There are eighteen pairs of chromosomes in the Asiatic species *D. praecox*, *D. florida* and *D. hortensis* and in the American species *D. sessilifolia* and *D. rivularis*. The somatic chromosomes of *D. hortensis* are shown in figure 6. The chromosomes are quite small and average only a little more than a micron in length.

The genus *Lonicera* is the most important one in the Caprifoliaceae. It contains two subgenera of which one is divided into four sections and about 180 species. Most of the species are natives of North America. Many species hybrids are described by Rehder, but no hybrids are known between species of different subgenera or sections of the genus.

Chromosome counts have been obtained for representative species of the genus. The species investigated include both subgenera, all sections, and both American and Asiatic forms. The subgenera, section, species, number of gametic chromosomes and native habitat of the species follow on page 150.

The chromosomes of *Lonicera* are rather small and have an average length of about 2 microns. The somatic chromosomes of *L. chrysantha* are shown in figure 7. In many cases trabants could be seen but they were not present in all species probably due to difference in fixing and staining.

LONICERA

Section	Species	Chromosome No.	Habitat
Subgenus 1. Chamaecerasus			
1. Isoxylosteum	L. thibetica	9–18	China
2. Isika	L. microphylla	18	E. Asia
	L. coerulea	9–18	Europe, Asia
	L. tenuipes	18	Japan
	L. fragrantissima	9	China
	L. Altmannii	9	Turkestan
	L. Ferdinandi	9	China
	L. orientalis	9	Asia Minor
3. Coeloxylosteum	L. Korolkowii	9	Turkestan
	L. tatarica	9	Russia–E. Asia
	L. chrysantha	9	N. E. Asia
	L. demissa	9	Japan
	L. Maackii	9	China
	L. prostrata	9	China
	L. quinquelocularis	9	Himalayas
4. Nintooa	L. Henryi	27	China
	L. alseuosmoides	18	China
	L. japonica	9	E. Asia
Subgenus 2. Periclymenum			
	L. dioeca	9	N. America
	L. prolifera	9	N. America

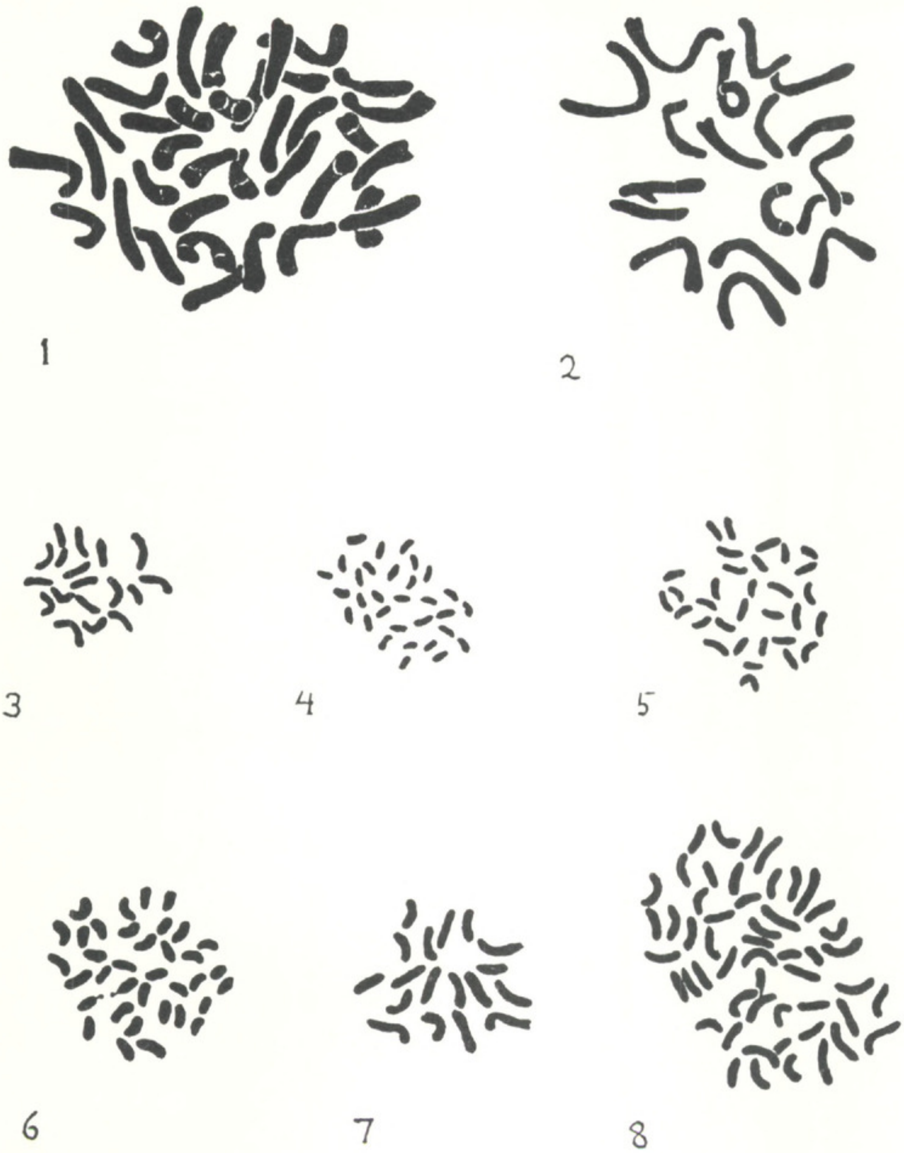
In the hexaploid species *L. Henryi* the chromosomes are about the same size as those of the diploid forms (Fig. 8).

Most of the species of *Lonicera* examined have nine pairs of chromosomes. The tetraploid and hexaploid species have probably originated through chromosome duplication since both diploid and tetraploid forms are occasionally found in the same species, and the hexaploid *L. Henryi* resembles the tetraploid species *L. alseuosmoides*. In no case is there any evidence of species formation by crossing of diploid with tetraploid forms. Polyploidy has apparently been of little importance in species formation in *Lonicera*.

Species with nine (9) gametic chromosomes are found in both subgenera and all sections of *Lonicera* but species hybrids are known only between species of the same section. During the past summer crosses were made between sections and subgenera but no seeds were obtained.

The chromosome numbers found in the genera of Caprifoliaceae suggest that nine is the basic number for the family, although *Abelia* and *Kolkwitzia* with sixteen gametic chromosomes do not agree with this interpretation, unless they are tetraploids which have lost two pairs of chromosomes. *Sambucus* and *Diervilla* have eighteen pairs of chromosomes while *Viburnum*, *Symphoricarpus* and *Lonicera* have nine chromosomes as the basic number. In view of the occurrence of polyploidy in *Lonicera*, and probably also in *Symphoricarpus*, it seems possible that *Sambucus* and *Diervilla* are tetraploid forms with nine chromosomes as the original basic number.

Variation in chromosome size is much more striking than variations in chromosome number. *Sambucus* and *Viburnum* have relatively large



Chromosome number in Caprifoliaceae

chromosomes. The chromosomes of *Lonicera* are about half the length of those of *Sambucus* while the chromosomes of *Diervilla*, *Kolkwitzia* and *Abelia* are only about one-fourth as long as those of *Sambucus* and *Viburnum*. In volume the chromosomes of *Sambucus* and *Viburnum* are from twenty to forty times as large as those of *Abelia* and *Kolkwitzia*.

In *Lonicera* there is no great difference in the size of chromosomes in different species although those of the hexaploid *Henryi* are somewhat smaller than those of the diploid forms. In some genera, such as *Carex* there is considerable decrease in chromosome size as the numbers increase due apparently to the inability of the nucleus to produce more than a certain amount of chromation. Even where the chromosome number is the same, there may be considerable variation in size of chromosomes of related species.

WOOD STRUCTURE

In the primitive vascular plants, the secondary xylem is composed of tracheary elements of a single general type, the so-called tracheids. This type of wood has persisted in certain Dicotyledonous genera and a remarkably complete record of the evolution and differentiation of more complex types of tracheary tissue is preserved in the xylem of other living representatives of the Dicotyledons. The evidence is so comprehensive that it is possible to arrange the wood of Dicotyledons in a phylogenetic sequence of increasing structural specialization. When this is done it becomes evident that the evolutionary modification of the stem does not usually parallel that of the flower and leaf.

From the standpoint of wood structure the Caprifoliaceae contain primitive, specialized and transitional genera.

The genera with relatively primitive wood structure include *Viburnum*, *Diervilla*, and *Kolkwitzia*. *Abelia*, *Symphoricarpus* and *Lonicera* are intermediate or transitional in structural specialization, while *Sambucus* is highly specialized.

The genus *Lonicera* is a transitional form. The species with more primitive vascular structure include *L. coerula*, *Maackii*, *fragrantissima*, *prolifera* and *tenuipes*. The more specialized species include *L. dioica*, *Henryi*, *thibetica*, *chrysantha*, *tatarica* and *alseuosmoides*.

It is evident that specialization in wood structure does not parallel floral specialization since *Sambucus* with highly specialized wood structure is the most simple and primitive in floral development.

It is also clear that there is no correlation between either chromosome number or size with the degree of vascular specialization in the Caprifoliaceae. The following table will simplify comparisons.

There is more or less variation in wood specialization in the genus *Lonicera*, but there is little or no relation between degree of specialization and chromosome number of the various species. Since polyploidy is probably of little significance in species formation in *Lonicera* little or no correlation would be expected between chromosome number and morphological characters.

Genus	Chromosome number	Chromosome size[1]	Wood Structure	Number of species
Sambucus	18	2.00	specialized	20
Viburnum	9	1.25	primitive	120
Symphoricarpus	9	.14	intermediate	15
Abelia	16	.05	intermediate	28
Kolkwitzia	16	.09	primitive	1
Diervilla	18	.20	primitive	12
Lonicera	9–18–27	.50	intermediate	180

[1] Approximate volume in cubic microns.

The age and area hypothesis is probably of little value in determining the relationship between the different genera of Caprifoliaceae. *Viburnum* is widely distributed in Europe, Asia and North America and is probably an old genus as indicated by fossil remains and wood structure. *Lonicera*, however, contains more species and is just as widely distributed as *Viburnum*, but is much more specialized in vascular anatomy. *Abelia* might appear to be a relatively young genus since most of the species are found only in Asia, but the presence of two species in Mexico indicated a wide distribution at some time in the past. Since most genera are most abundant in Asia and certain genera are found only in China, it would seem probable that the family is of Asiatic origin. *Symphoricarpus*, however, is represented by only one species of very limited distribution in China; the other species are all natives of North America. Does this mean that the genus is so old that the original Oriental forms have disappeared and only the newer American species remain?

Neither wood structure nor geographic distribution offers any clear indication of the phylogenetic development in the family Caprifoliaceae. It appears that differentiation of genera has been associated with changes in chromosome size, and that changes in chromosome number are probably of minor significance.

SUMMARY

1. The gametic chromosome number in the Caprifoliaceae has been determined as follows: Sambucus 18, Viburnum 9, Symphoricarpus 9, Abelia 16, Kolkwitzia 16, Diervilla 9, and Lonicera 9, 18 and 27.

2. The chromosomes of different genera may vary greatly in size.

3. There is no correlation between either chromosome number or chromosome size and the amount of vascular specialization of the genera in this family.

LITERATURE CITED

1. Rehder, A. (1927). Manual of Cultivated Trees and Shrubs. McMillan Co., New York, 930 pp.
2. Tischler, G. (1926). Pflanzliche Chromosomen-Zahlen. *Tabulae Biologicae* **4:** 1–83.

DESCRIPTION OF PLATE

All figures are from somatic chromosomes obtained in root tips.

Fig. 1. Sambucus racemosa.
Fig. 2. Viburnum Opulus.

Fig. 3. Symphoricarpus orbiculatus.
Fig. 4. Abelia Schumannii.
Fig. 5. Kolkwitzia amabilis.
Fig. 6. Diervilla hortensis
Fig. 7. Lonicera chrysantha.
Fig. 8. Lonicera Henryi.

CYTOLOGICAL LABORATORY, ARNOLD ARBORETUM,
HARVARD UNIVERSITY.

NEW SPECIES, VARIETIES AND COMBINATIONS FROM THE HERBARIUM AND THE COLLECTIONS OF THE ARNOLD ARBORETUM[1]

ALFRED REHDER

Rhapis excelsa (Thbg.) Henry in litt., comb. nov.

Chamaerops excelsa Thunberg, Fl. Jap. 130 (1784).—Non Martius.
Rhapis flabelliformis L'Héritier apud Aiton, Hort. Kew. III. 473 (1789).—Willdenow, Spec. Pl. IV. 1093 (1806).—Sims in Bot. Mag. XXXIII. t. 1371 (1811).—Martius, Hist. Nat. Palm. III. 253, t. 144 (1849).
Trachycarpus excelsus H. Wendand in Jour. Soc. Bot. France, VIII. 429 (1861), quoad syn. *Chamaerops excelsa* Thunb., non *C. excelsa* Martius.

Though Martius, when describing a Japanese species of *Chamaerops*, adopted Thunberg's name for that species, he was nevertheless aware, as his citations and remarks show, that Thunberg understood under the name *C. excelsa* the plant published later as *Rhapis flabelliformis* by Aiton. The type specimens in Thunberg's herbarium of which I have photographs before me represent *Rhapis* and his description is clearly based on these specimens. Only Kaempfer's synonyms "Siguro et Sodio" which he cites under α), and "Soo Tsiku, vulgo Sjuro Tsiku" which he cites under β) do not belong here. The former represents *Trachycarpus* and the latter *Rhapis humilis* Bl. Thunberg's *C. excelsa* must obviously be considered as resting on his description and on the type specimens in his herbarium and not on Kaempfer's names cited as synonyms. The name *Chamaerops excelsa* Thunb. was by Aiton and later authors up to 1849 correctly referred to *Rhapis* and cited as a synonym of *Rhapis flabelliformis*, but in 1849 Martius in his Historia Naturalis Palmarum for the reason that the Japanese synonym "Sjuro et Sodio" represented it gave Thunberg's name to a plant later referred by Wendland to *Trachycarpus*. This view, however, can hardly be upheld and, as *Chamaerops excelsa* is the oldest name for the plant described as *Rhapis flabelliformis*, the specific name according to our rules of nomenclature, must be transferred to *Rhapis*.

In publishing the combination *R. excelsa* I am fulfilling a wish of the late Dr. A. Henry, who requested me in his letter of October 31, 1929, to publish this combination in the Journal of the Arnold Arboretum.

The plant described by Martius as *Chamaerops excelsa* and transferred by Wendland to *Trachycarpus* is apparently conspecific with *T. Fortunei*

[1] Continued from vol. x. 136.