Studies of fruit and seed characters of selected *Euonymus* species

Bernd Schulz, translated by Wolfgang Bopp

Summary

Euonymus species are particularly prized for their decorative fruits. This work describes and illustrates (in water colour), the fruits and seeds of 30 commonly cultivated species found in Central European plant collections. The text discusses the criteria for species differentiation. As well as the shape of the fruits and seeds, seed colouration is described and compared to several published accounts in an attempt to correct previous misconceptions.

This paper was originally published in German in 2006 (Schulz, 2006a). This translation contains some minor additions and adjustments to the original text and has been translated to the best of our ability, albeit not being a 100% accurate translation.

1 Introduction

The German common name of *Euonymus europaeus*, is "Pfaffenhütchen" which translates as priest's hat or mitre, in reference to its shape. In past centuries, the wearing of such a hat was a status symbol, showing the belonging to a professional group. Priests in Germany have, since the sixteenth century, been wearing the so-called biretta[1],"a stiff and square-shaped head covering as worn by priests, also found in a wider and bigger version" (Loschek 1993). In Germany today certain clerics wear a very similar head covering, closely resembling the shape of *Euonymus europaeus* fruits.

While I never intended to get as closely involved with this genus, the very attractive nature of the fruits and seeds captivated me, and led me to produce this work. Prior to turning to the fruits of woody broadleaves, I primarily studied the winter buds and twigs of deciduous trees and shrubs (Schulz 1999, 2004, 2006b), a subject which was then little published, apart from the works by Schneider (1903) and Trelease (1931). In stark contrast, the specific characters of many attractive fruiting plants have been widely published over the years. This paper takes account of and includes the less obvious characters for species differentiation, such as the shape of seeds or the seed colour under the aril, such as found in *Euonymus* species. By closely studying fruit and seed colour, some differences and mistakes have been exposed in various accounts, which appear to have gone unnoticed for several decades.

2 Material and methods

In *Dendrologischen Winterstudien* Camillo Schneider (1903) argued that in descriptive botany, the illustrations were an important part of the description, as these showed the anatomical differences, that were less visible from written descriptions. The

[1] biretta = a square cap worn by clerics of the Roman Catholic and Anglican Churches

tradition of botanical illustration is much older (see Nissen 1951/52 and Blunt & Stern 1994). Only the onset of photography and the belief in its objectivity seemingly devalued the use of drawings to describe nature. The value of illustrations is however particularly high for the person undertaking it, as it requires a very intense and detailed observation of the subject, much more so than photography. Furthermore, independent of the resulting illustration, the action of creating it, gives one a deeper understanding of the form and shape of the subject.

In summer and autumn of 2004 and 2005, I sketched, in pencil and watercolour, fruits and seeds of all available *Euonymus* species. This study was made possible by the support of many plant collections across Europe, who supplied me with fresh plant material. My thanks go to all the following colleagues and gardens for their help. I especially would like to thank Eike Jablonski for providing me with a range of contacts.

The plant material came from the following collections:
Arboretum Lenoir, Rendeux (Belgium), Charles Snyers [AL]
Arboretum SGGW Rogów (Poland), Piotr Banaszczak [AR]
Botanischer Garten der Johann Wolfgang Goethe-Universität Frankfurt, Anna-Maria Lenk [BF]
Botanischer Garten der Johannes Gutenberg-Universität Mainz, Siegfried Gand [BM]
Botanischer Garten der TU Dresden [BD]
Botanischer Garten der Freien Universität Berlin, Thomas Raus [BB]
Botanischer Garten der Philipps-Universität Marburg, Andreas Titze [BMg]
Forstbotanischer Garten Tharandt der TU Dresden, Ulrich Pietzarka [FT]
Forstbotanischer Garten der Göttingen, Volker Meng [FG]
Nationaler Botanischer Garten und Arboretum von Belgien in Meise, Dirk De Meyere [NM]
Sir Harold Hillier Gardens, Hampshire, England, Wolfgang Bopp [HG]
Stadtgebiet und Umgebung von Dresden [SD]

[ ] can be found with the illustrations to give the material source.

To keep the text short, few sizes are given. The illustrations however have a scale: the double line is 10 mm while the single line is 1 mm.

3 The genus *Euonymus*

The genus contains deciduous and evergreen species from low growing shrubs, self-clinging climbers to tall shrubs and small trees. They are found primarily in the temperate zones of the northern hemisphere, as well as in Central America, Madagascar and Australia.

The published numbers of species range from 129 to 176. Loesener (1942) listed over 170 species, while Blakelock mentioned 176 species in 1951. These numbers are consistently followed by most authors (Fitschen, Roloff/Bärtels, Krüssmann). Blakelock made reference to various possible synonyms, thus

illustrating that his species numbers may not be accurate.

Ma (2001) took a broader view of the species, although he was not always consistent. Despite additional new species from China, he recognised 129 species. Germany has seven or eight commonly cultivated species, however, when including specialist collections these rise to 25.

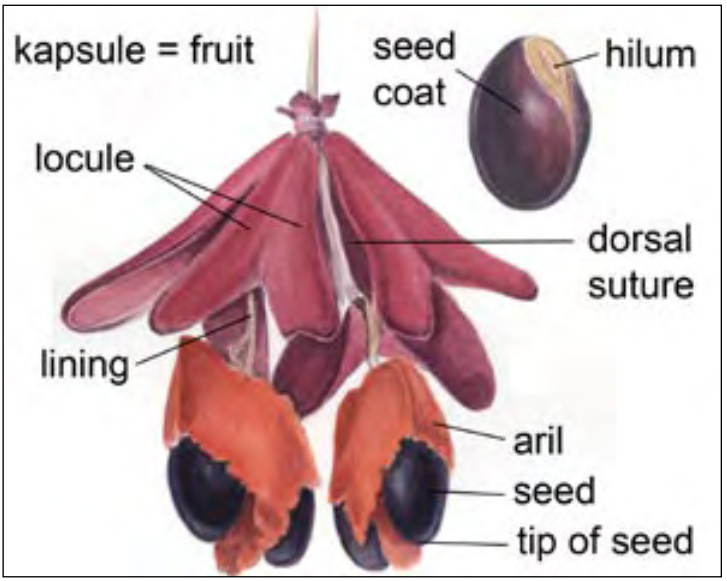
3.1 General characteristics

Most species have opposite leaves, with the petiole bases not meeting across the twig, i.e. as in *Acer.* Often the bases are not directly opposite each other and there are a few cases with alternate leaves, e.g. *E. nanus.* There are deciduous and evergreen species, with the former dominant in this paper. The text refers to the few evergreen species discussed.

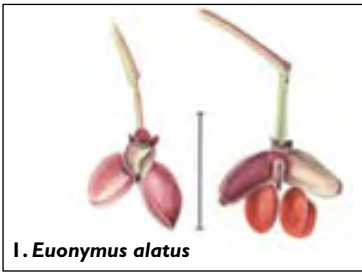
The buds are an important character. While all have bud scales, their size and shape differ between the species. The buds in subgenus *Euonymus* are mostly compact, round to oblong-ovoid, while those in subgenus *Kalonymus* are often large, oblong and spindle-shaped. The one exception in the genus is *E. occidentalis* (a species as yet unplaced in a subgenus; see under section 4, species 22).

3.2 Fruit

The fruit is a variously shaped capsule, consisting of (1—3) 4 or 5 carpels which are fully or hardly fused. In *E. alatus* and *E. verrucosoides* the carpels are virtually free. The carpels open along both sutures. The majority of deciduous species have broadly fused carpels, with each carpel often bulging and sometimes bearing a wing, thus constricting the capsule to a greater or lesser extent. It is rare to find



Seed from a fresh fruit (left) and seed from a old fruit (right)
Euonymus nanus



1. *Euonymus alatus*

the capsule to be totally circular in cross section, or without any indentations, i.e. as in *E. oxyphyllus* or the evergreen *E. fortunei* and *E. japonicus*.

The locules of each fruit opens along the dorsal sutures, splitting in the middle. Each locule contains usually two seeds (in *E. grandiflorus* up to 10). Where several seeds develop in one locule, the aril is compressed so that the aril has a seed-like appearance. As the locule opens, part of the lining tears on which the seed hangs (Lens 2000).

3.3 Aril

The seed together with the aril represents an attractive and juicy offering for the birds. In other genera, like stone fruits, the fruit wall fulfils this function. In this case, however, the fruit wall forms the capsule. The juicy yellow-orange to deep red aril originates in the area of the hilum and covers the seed to the opposite side, enclosing the seed entirely or partially. The arils open on the side opposite the hilum.

The colouring of the aril is most likely from coloured plastids, which are denser in the upper cell layers. The lower cell layers such as the parenchyma, only contains small numbers of plastids. The aril itself is somewhat transparent. The colouring is more intensive where the white seed has only a thin aril covering. This is due to the same process of using water-colour on white paper, light is reflected by the white seed and thus passes twice through the coloured layer of the aril. Even the "black" seeds of *E. verrucosus* are white under the aril (see Illustration 11, p.37), as a black or brown aril colour would absorb all light, thus not giving the same colour brilliance.

Some species have red coloured seeds, giving the aril a red appearance. Deep red arils are particularly prevalent in species with light coloured capsules, i.e. *E. phellomanus* which has light pink capsules and *E. fimbriatus* with light green capsules, thus providing a much better contrast. The same can often be found in contrasting light orange arils with deep red-pink capsules, i.e. *E. latifolius*.

3.4 Seed colour

The colour of fresh seed within each species is relatively constant and so this is regarded by many authors as a valuable character. In contrast to the colour of the aril, which is not very variable, the seed colouring can vary from white to

pink, red, orange, deep red and partly or entirely black.

Despite the fact that seed colour is considered an important and consistent character, incorrect and imprecise information abounds.

Only fresh seed with the aril completely removed can be compared. Frequently the literature describes the seed colour as brown, a colour, which as my observations have shown, does not exist with fresh seed. Such observations are most likely due to describing older material, as some two to three weeks after the fruit has dehisced, the seed colour can change to brown, the aril wilts and thus looses its brilliance.

J.S. Ma (2001) made all his descriptions from herbarium specimens, i.e. from *E. verrucosus* (fresh seed black, aril covered parts white) to *E. europaeus* (fresh mostly white, rarely light pink), being listed as dark brown. A survey of the literature revealed that several authors agreed with these incorrect

Table. 1. Seed colour in literature

	Schneider 1907	Rehder 1940	Krüssmann 1977	Bärtels 2001	J.S. Ma 2001	Fitschen[1] 2002	Observed seed colour
E. alatus	brown	brown	brown	brown		brown	white to pink
E. atropurpureus	light brown	brown	white	white	dark brown		white
E. bungeanus	yellow or reddish-purple	white-pinkish	white-red	white-pink	dark brown	white-reddish	white-pink
E. europaeus	white	white	white	white	dark brown	white	white, rarely light pink
E. fortunei	yellowish-white[3]	white		white		white	white
E. grandiflorus	black		black	black	dark brown		black
E. hamiltonianus[4]	grey- brown	red[5]	red[5]	red[5], reddish[6]	dark brown	reddish	pink-reddish
E. latifolius		white	white	white		white	white
E. nanus	brown-purple	brown	brown	brown	dark brown		orange-red
E. oxyphyllus	light grey		bright red	grey		grey	white[7]
E. phellomanus			dark brown to nearly black	black	dark brown	black-brown	dark wine-red
E. sanguineus		black	black	black		black	white[7]
E. verrucosus	black	black	black	black	dark brown	black	white and black

(1) from the 11th edition. The 6th edition of Fitschen (1977) did not give any seed colour descriptions.
(2) as *E. maackii* (Ma described the typical form of *E. bungeanus*, combined it with *E. maackii* and listed it under the older name of *E. maackii).*
(3) *E. radicans.*
(4) inclusive of the variations of (5) *maackii* and (6) *yedoensis*, without var. *nikoense,* for which Blakelock and Krüssmann gave the seed as green.
(7) shortly before ripening.

observations, which can only be explained by the copying of the data without quality control. Occasionally one can also find correct information being unintentionally falsified. For instance Schneider (1907) described the near white seed of *E. oxyphyllus* as light grey. This is an understandable description, considering that white in this context is a natural white, which can not compete with the bleached white of paper. Bärtels (2001) and Fitschen (2002) shortened this to grey. According to my observations, there does not seem to be any difference in the natural white seed colour of *E. oxyphyllus* and *E. europaeus,* which was described as white by the same authors.

Coloured seed is mainly found in the species with only a partial aril covering. In species such as *E. nanus, E. phellomanus,* etc. the seed and aril colour are similar, i.e. orange to red. In others the seed and aril colour are in stark contrast, such as the black tipped species of *E. verrucosus, E. pauciflorus* and *E. verrucosoides.* Both types are bird distributed. In the former, the same colour can disguise the rather small juicy aril, while the latter gives an additional visual contrast, which also aids recognition.

The colour is caused by pigments in the cells of the seed coat. *Euonymus nanus* has bright orange-red seeds, with the seed coat as an epidermis, the pink-red colouring (anthocyanin) in the vacuoles[2], which visually mix with the yellow pigments, most likely contained in plastids, which are found in the same or lower cell layers. The colour is intensified by the underlying white, nourishing tissue, which contains starch grains. This is also responsible for the white 'coloured seeds', where other colour agents are absent. The black colours of *E. verrucosus* are based on two components. The cell wall is wine red-purple, while the cell centre is dark, which even under the microscope appears nearly black. The area of the red-purple cell walls is greater than the dark centres, thus causing the intermediate area between the black and the white part of the seed to appear to be reddish-purple.

3.4 Key for the investigated *Euonymus* species (based primarily on seed and fruit characters)

1 Fruits winged 25
- Fruits not winged, lobed 2
2 All fruits with four sepals, carpels 1—4 3
- Fruit in parts of five (at least the sepals), carpels 3 or 5 22
3 Fruits round or slightly angular, with smooth or densely warty surfaces 19
- Fruits lobed or with four pronounced ridges, surfaces not warty 4
4 Locules totally separate when ripe 5
- Locules fused, at least at the base 6
5 Seeds white to rose pink, mostly covered by the aril ..1. *E. alatus*, 2. *E.alatus* var. *pubescens*
- Seeds black when not covered by the aril ..... 3. *E. verrucosoides*
6 Seeds exposed at the tip 10
- Seeds totally enveloped by the aril 7

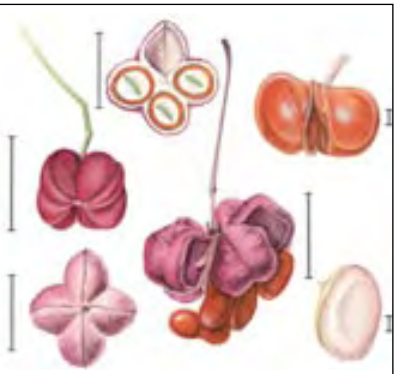
key continued on page 38

[2][vacuole = a cavity in the protoplasm of cells, which contain a watery liquid, the cell sap].

2a. *Euonymus alatus* var. *pubescens*

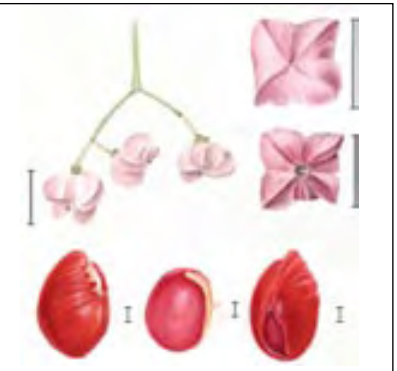
2b. *Euonymus alatus* var. *pubescens*

3. *Euonymus verrucosoides*



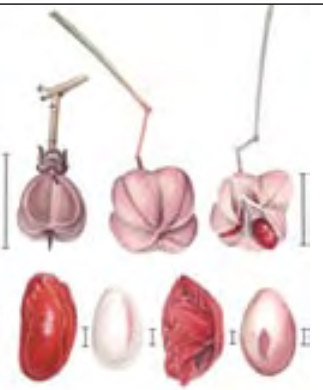
4. *Euonymus europaeus*

5. *Euonymus velutinus*



6. *Euonymus hamiltonianus* var. *yedoensis*

7. ***Euonymus hamilton* var. *maackii***



8. ***Euonymus bungeanus***

9. ***Euonymus phellomanus***

10. ***Euonymus atropurpureus***

11. ***Euonymus verrucosus***

12. ***Euonymus pauciflorus***

7 Seeds white, rarely light pink 8
- Seeds rose red ..... 7. *E. hamiltonianus* var. *maackii*
8 Locules constricted by 2/3rds, capsule pink to red 9
- Locules constricted by ¾'s, capsule dark wine red ..... 10. *E. atropurpureus*
9 Twigs glabrous, buds greenish ..... 4. *E. europaeus*
- Twigs hairy, buds brown ..... 5. *E. velutinus*
10 Exposed seed surface black 15
- Exposed seed surface pink, orange-red to dark red 11
11 Leaves over 10 mm wide, arils open but seeds not fully exposed 12
- Leaves less than 10 mm wide, base of seeds only covered by aril 17
12 Aril red, leaves with long petioles or twigs with corky wings 14
- Aril orange 13
13 Twigs glabrous ..... 6. *E. hamiltonianus* var. *yedoensis*
- Twigs densely hairy ..... *5. E. velutinus*
14 Aril red, seeds white to pink, leaves with long petioles ..... *8. E. bungeanus*
- Seeds and aril deep red, twigs with corky wings ..... 9. *E. phellomanus*
15 Twigs with black lenticels, two seed (ovules) per locule 16
- Twigs smooth, mostly more than two seeds (ovules) per locule 18
16 Leaves glabrous ..... 11. *E. verrucosus*
- Leaves hairy ..... 12. *E. pauciflorus*
17 Seeds pink, leaves opposite ..... 13. *E. oresbius*
- Seeds orange-red, leaves alternate, small ..... 14. *E. nanus*
18 Fruits 16—18 mm long, leaves over 100 mm long ..... 16. *E. carnosus*
- Fruits 12 x 12 mm, leaves small, less than 100 mm long ..... 17. *E. grandiflorus*
19 Capsule surfaces smooth 20
- Capsule surfaces warty 21
20 Upright shrub ..... 18. *E. japonicus*
- Prostrate and ascending or climbing shrub ..... 19. *E. fortunei*
21 Fruit in parts of five, upright shrub ..... 20. *E. americanus*
- Fruit mostly in parts of four, prostrate shrub ..... *21. E. obovatus*
22 Capsule surfaces smooth *23*
- Capsule surfaces warty *21*
23 Capsules entirely in five parts *24*
- Carpels in 3's, sepals in 5's ..... 22. *E. occidentalis*
24 Fruits globose ..... *27. E. oxyphyllus*
- Fruits slightly angular, slightly winged or lobed 25
25 Fruits angular or winged 26
- Fruits lobed ..... 15. *E. tingens*
26 Wings to 3 mm long ..... 24. *E. planipes*
- Wings longer 27
27 Fruits wine red 28
- Fruits yellow-green, with pink tinges 31
28 Wings more than 6 mm long, fruits in 4's 30
- Wings up to 5 mm long, fruits mostly or partly in 5's 29
29 Petiole with a channelled upper surface ..... *23. E. latifolius*
- Petiole with a flat upper surface ..... *25. E. maximowiczianus*
30 Wings small, narrowing, apical buds more than 20 mm long ..... 26. *E. macropterus*
- Wings wide, apical buds up to 12 mm long ..... 28. *E. sanguineus*
31 Fruits mostly in parts of four, aril red, leaves ovate ..... 29. *E. fimbriatus*
- Fruits in parts of five, aril orange, leaves lanceolate ....30. *E. cornutus* var. *quinquecornutus*

4 Description of *Euonymus* species

Subgenus *Euonymus* Beck

Section *Melanocarya* (Turcz) Nakai

The fruit capsule consists of four almost totally separate locules, that are rarely all fully developed.

1. *Euonymus alatus* (Thunb.) Sieb. [BD, SD] [See Illust. 1, p. 33]

The fruit usually has 1–2(-3) developed locules. Those containing seeds are 10–15 mm long, while empty locules are small and rudimentary. The seed is pearl white to light pink and totally enveloped by the light orange coloured aril.

Other characters: shrub 1–4 m tall, leaves small, 30–60 mm long, glabrous and finely toothed. Twigs with pronounced corky wings.

2. *Euonymus alatus* var. *pubescens* Maxim. (*E. sacrosanctus* Koidz.) [AR, FT] [See Illust. 2a, 2b, p. 36]

This is only distinguished by densely hairy leaf veins below. The Forstbotanischer Garten Tharandt (Germany) supplied a specimen as *E. sacrosanctus* (of garden origin, ill. 2a) with orange-red arils, covering the seed more or less. Where it is exposed, the seed is rose-red, thus the seed is hardly noticeable. Where the seed is covered by the aril, it is whitish in colour. Fruits supplied from Rogów in Poland (fruit from plants of known source from around Vladivostok, ill. 2b) have arils which totally envelop the seed. According to Banaszczak (2005), these plants exhibit an upright and tree-like habit, similar to *E. hamiltonianus*.

Distribution: central China to Korea, eastern Russia; var. *pubescens* occurs more in the north and east of the overall distribution.

3. *Euonymus verrucosoides* Loes. [NM, BD] [See Illust. 3, p. 36]

As in *E. alatus* the locules are separate. The seed tip is exposed from the orange aril. The visible part of the seed is black as found in *E. verrucosus*. Fruits examined in 2005 from the National Botanic Garden at Meise (Belgium) were not fresh and the white seed colour had turned brown in places, thus reducing the brilliance of the aril. Fresh seed from Dresden examined in autumn 2006 has, as suspected, a bright orange aril and pure white seed below.

Other characters: leaves small, 25–40 mm long, oblong-ovate, glabrous both sides, margins bluntly serrate, petioles short. Twigs round, green and not winged. Shrub 1–3 m, native to China and south-east Tibet.

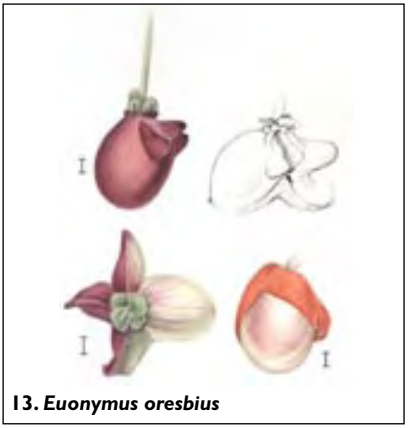
Section *Euonymus*

Flowers and fruits mostly in parts of four. Locules usually bulging and variously constricted between locules.

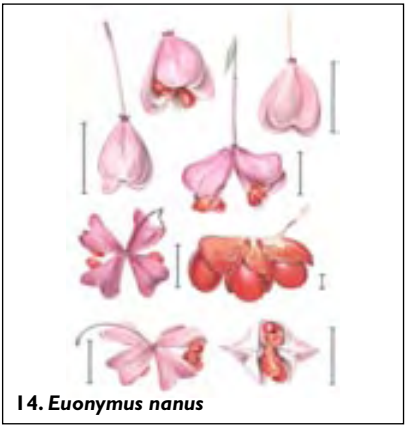
Series *Lophocarpi* (Loes.) Blakelock

4. *Euonymus europaeus* L. [BD, SD] [See Illust. 4, p. 36]

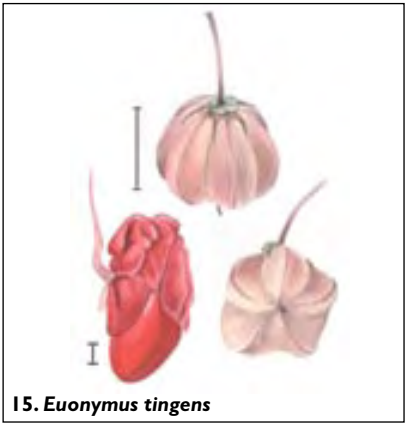
The pink-rose to red fruit is 10—15 mm diameter, consisting of four round



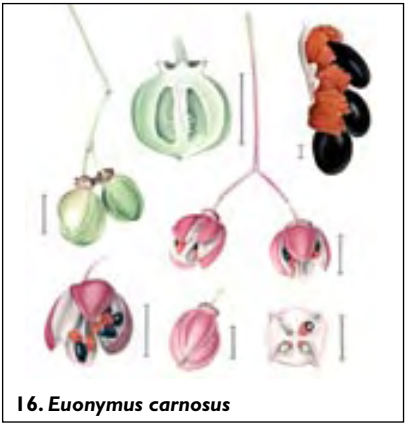
13. ***Euonymus oresbius***



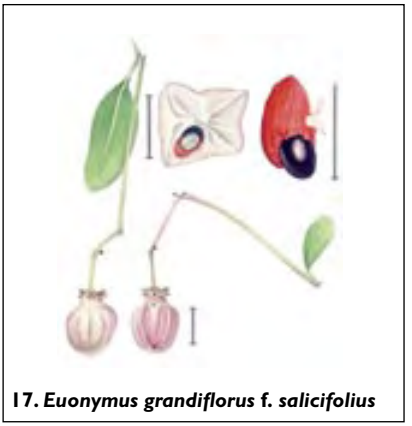
14. ***Euonymus nanus***



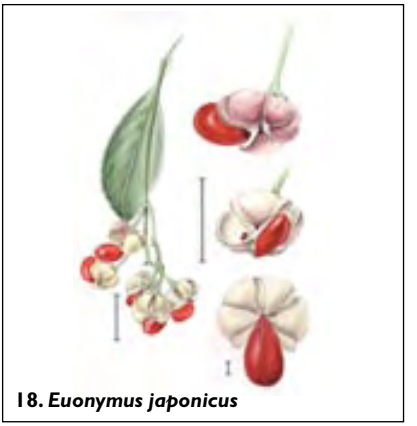
15. ***Euonymus tingens***



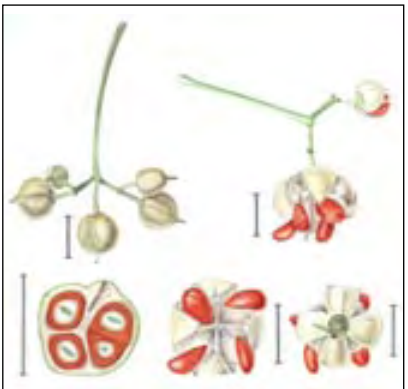
16. ***Euonymus carnosus***



17. ***Euonymus grandiflorus* f. *salicifolius***



18. ***Euonymus japonicus***



19. ***Euonymus fortunei***

20. ***Euonymus americanus***

21. ***Euonymus obovatus***

22. ***Euonymus occidentalis***

23. ***Euonymus latifolius***

24. ***Euonymus planipes***

bulging locules, separated by constrictions. The seed is mostly white (rarely with a pink tinge) and entirely enveloped by the orange aril.

Other characters: leaves have short petioles. A shrub usually to 3 m tall, rarely a small tree to 7 m. Native from Europe to Asia Minor and western Asia.

This species is closely allied to the Asiatic forms around *E. hamiltonianus*. Common characters are the small, green, ovate buds, which are covered by 3-4 paired scales, as well as the whitish to yellowish-green flowers. Several authors, i.e. Blakelock (1951) have noted that this species differed in having yellowish anthers, while the Asiatic species had purple to deep red anthers.

5. *Euonymus velutinus* (C.A. Mey) Fisch. & Mey. [AL, HG] [See Illust. 5, p. 36]

The capsules are in parts of 4, ochre yellow with a dirty pink tinge, 13 mm long and 14–18 mm wide and deeply constricted between the locules. The orange aril totally covers the seed, which is natural white. A specimen from the Sir Harold Hillier Gardens (source from a native habitat in Iran) has seeds not entirely covered by the aril, with the exposed seed part deep red.

Other characters: leaves coarse, dark glossy green above, lamina bullate, veins hairy. Undersides of leaves and young shoots grey-green, densely covered with spreading hairs. Bud scales brown, hairy, acuminate. This species is often sunk into *E. europaeus*. Native to the Caucasus and Asia Minor.

Euonymus hamiltonianus - Euonymus maackii - Euonymus bungeanus

Each taxon is quite variable and the boundaries between them have not been clearly defined, which has led to a wide range of opinions amongst the botanical experts. Maximowicz (1881) regarded *E. hamiltonianus* as a variety of *E. europaeus,* while Blakelock (1951) listed it as a species with six varieties. The closely related *E. bungeanus* with its long leaf petioles is mainly accepted by various authors as a separate species. Ma (2001) included *E. maackii* in *E. bungeanus*, while most others regarded *E. maackii* as a variety of *E. hamiltonianus* (Blakelock 1951, Krüssmann 1977, Bean 1973). *Euonymus maackii* is the older name, thus it takes priority over *E. bungeanus*. Schneider (1907) was the first to suspect that *E. maackii* and *E. bungeanus* were identical. This was supported in that both share the same natural distribution from Manchuria to Japan.

Ma gave the most prominent difference as being the relationship of leaf length to the petiole: *E. maackii* Rutt. (1857) (= *E. bungeanus* Maxim. 1859), has leaves 40–80 mm long, with 10–25 mm long petioles; *E. hamiltonianus* Wall. (1824), has leaves 80–180 mm long, with 9–20 mm long petioles. According to Ma, *E. europaeus* has the same leaf size as *E. maackii*, with much shorter (up to 5 mm long) petioles.

The observed examples of *E. hamiltonianus* (var. *yedoensis*), *E. hamiltonianus (*var. *maackii)* and *E. bungeanus* were easily distinguished with the aid of fruits, seed and leaf characters, while *E. maackii* appears to be an intermediate between *E. hamiltonianus* var. *yedoensis* and *E. bungeanus*. What has not become clear is what distinguishes var. *yedoensis* from the typical var. *hamiltonianus*.

Most accounts only list these two varieties (Fitschen, Roloff/Bärtels). Further research (including modern methods) is needed within this group to establish the evolutionary relationships.

Several attempts to find [live material] of ***E. hamiltonianus* var. *nikoensis* (Nakai) Blakelock** have failed. The only published distinguishing feature was that the seed is green (Blakelock, Krüssmann). The material I was able to observe from various collections [FG, BMg, BB] was found to be almost always var. *maackii* with red seeds and totally enveloping orange arils.

6. *Euonymus hamiltonianus* Wall. var. *yedoensis* (Koehne) Blakelock (non *E. sieboldianus* Blume) [BD, BB] [See Illust. 6, p. 36]

The young fruits with four locules are rose pink and constricted between each locule. As they ripen, the pink tones fade and turn to light ochre and whitish-pink. Where neighbouring locules contain developed seed, the constriction is lessened and with the bulging locule, the fruit appears square in cross section.

The orange-red aril is usually open, the seed is pinkish red, where the seed is exposed, it is darker and markedly lighter at the raphe [raphe = a ridge on the seed formed by the portion of the funiculus fused to the seed coat].

Other characters: leaves obovate to elliptical, 100⁺× 50 mm. Native to the Himalaya to Japan as a tall shrub or small tree.

Koehne, described this form as *E. yedoensis*, and repeatedly (1906, 1910) felt that it was not synonymous with *E. sieboldianus* Blume. Basing his opinion on original specimens as well as the description by Blume, he maintained that *E. sieboldianus*, in difference to *E. yedoensis*, was not constricted between the locules and had four vertical ridges down the capsule. Schneider (1907) suggested that these differences may be due to different stages of ripeness, which I think is very unlikely. There is, however, a strong resemblance of the drawing published by Koehne (1906) and Schneider with *E. carnosus*. Rehder (1940) agreed with the description of Koehne for *E. sieboldianus,* although he was of the opinion that this Japanese species was not in cultivation. If Koehne was right, Blume (1826) could have described *E. carnosus* (1886) as *E. sieboldianus*.

7. *Euonymus hamiltonianus* Wall. var. *maackii* (Rupr.) Blakelock [BD, BB] [See Illust. 7, p. 37]

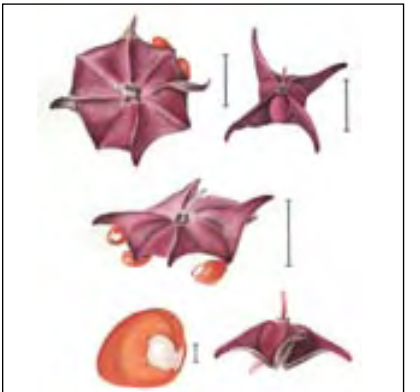
The 10–12 mm diameter pink capsule has four locules and is strongly constricted. The bright yellow-orange aril covers the seed entirely. The seed is an intensive red.

Other characters: leaves are elliptical, 50–80 × 30 mm, with the relationship of petiole to leaf being 1: 6.5–7.5. Compared to *E. bungeanus* this species has much shorter petioles for the same size leaf. A shrub to 5 m tall, native to East Asia (Ussuri, Amur, Manchuria, Japan).

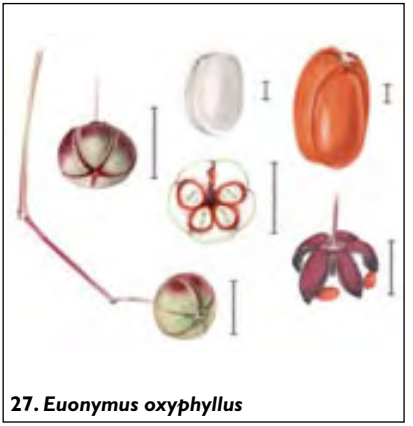
8. *Euonymus bungeanus* Maxim. [AL, BD, BB] [See Illust. 8, p. 37]

The capsule has four locules and is 10–13 mm wide. In very young fruits, the

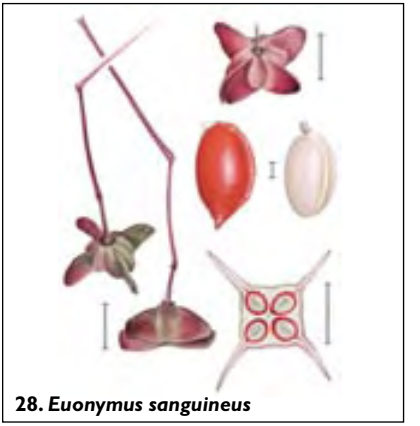
25. ***Euonymus maximowiczianus***



26. ***Euonymus macropterus***

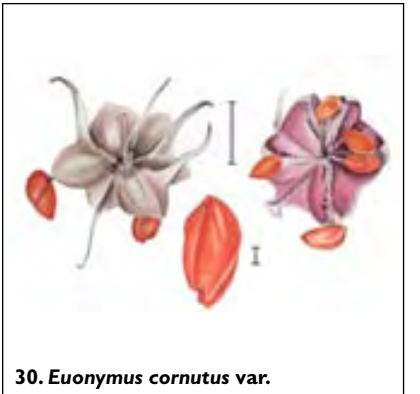


27. ***Euonymus oxyphyllus***



28. ***Euonymus sanguineus***

29. ***Euonymus fimbriatus***



30. ***Euonymus cornutus* var. *quinquecornutus***

receptacle[3] becomes a podium with the reflexed sepals and the remains of the stamens (see illustration 8). The ripe capsule is a light dirty pink to beige. The aril is orange-red to red and covers the seed entirely or with a little hole only. Seed is white with a light pink tinge, while the exposed seed sections are rose-red.

Other characters: leaves relatively wide with the tips acutely acuminate, petiole long. Petiole to leaf relationship 1: 4.1–5.6. (Manchuria, Korea, China).

9. *Euonymus phellomanus* Loes. ex Diels [FT, BB, BD] [See Illust. 9, p. 37]

The closed capsule is 13 mm wide, light rose-red when ripe. The aril is, in stark contrast, deep red. Where the seed is exposed it is a similar and hardly distinguishable deep red.

Other characters: twigs with pronounced corky wings similar to *E. alatus*. Leaves larger, with 60–100 mm long and bluntly serrate. The capsule shape and aril colour easily distinguish it from *E. alatus*. A shrub 2–5 m tall, native to North and West China.

10. *Euonymus atropurpureus* Jacq. [BB] [See Illust. 10, p. 37]

The capsule is deeply constricted between the four locules. Krüssmann described the ripe fruit as light purple-red. The only specimens I was able to observe were on a dying branch and were partly deep wine red. The white seeds were totally covered by the orange aril.

Other characters: this North American species is differentiated from the Eurasian species by its purple-red flowers. The buds are a little longer than the previously discussed species but otherwise very similar. Shrubs to 7 m high, native to eastern and central North America.

Series *Pseudovyonemi* (Nakai) Blakelock

11. *Euonymus verrucosus* Scop. [FT, BB] [See Illust. 11, p. 37]

The ripe capsules are pale beige with a pink tinge, after opening they turn rose-pink. The aril is orange and clumped together (see illustration 11), covering the seed all over apart from the black tip whereas the covered part is more or less white.

Other characters: the green twigs are densely covered by warty, elongated blackish lenticels. Leaves glabrous, 30–50 mm long. Shrubs to 2 m tall and found from southeast Europe to the Caucasus and Asia Minor.

12. *Euonymus pauciflorus* Maxim. [AR][See Illustr. 12, p. 37]

The fruit capsules are larger than in *E. verrucosus*. The locule walls are deep pink-red when ripe and open, presenting the suspended orange–red arils, which cover most of the seed with the black tip exposed while the rest of the seed is deep wine red.

Other characters: often regarded as a form of *E. verrucosus*, its twigs are densely covered in warts. The branches are a little stronger, the leaves larger

[3]Receptacle = the end of the stem which bears the flower parts.

and up to 75 mm long, hairy on both sides, but thicker below. A shrub only a few meters high, from northeast Asia.

13. *Euonymus oresbius* W. W. Sm. [NM, AL] [See Illust. 13, p. 40]
The capsule has four locules, but rarely all contain ripe seed. A locule with seed is bulging, green when unripe which changes to a deep wine red. Inside is the light yellow seed with a pink tinge. The aril is orange and only covers the seed base (hilum area).

Other characters: the twigs are square and without lenticels. Leaves glabrous, coarse and small, 30 x 8 mm. A small shrub from China.

Series *Nanevonymi* (Loes.) Blakelock

14. *Euonymus nanus* Bieb. [BD] [See Illust. 14, p. 40]
A capsule in parts of four, clearly lobed and pear-shaped, 12mm long, rose-pink. Each locule contains 2–3 orange-red seeds, the orange aril only covering the base, the upper half, hardly differing in colour, is exposed.

Other characters: leaves alternate, small, lanceolate, to 50 mm long. Prostrate to 0.8 m high shrubs, native from eastern Europe to western China.

15. *Euonymus tingens* Wall. [HG] [See Illust. 15, p. 40]
Euonymus tingens differs to most of the other species in this subgenus by having a capsule with parts in 5s. It is ochre-yellow with rose-pink and dark pink tinges. The fruit is hardly constricted between the locules. The seed is orange-red, with the lower part covered by the red aril.

Other characters: leaves evergreen, small, ovate, 40–60 mm long. This frost tender shrub or small tree is 2–5 (–8) m high and native to the Himalaya and western China.

Section *Multiovulatus* Loes.

16. *Euonymus carnosus* Hemsl. [BF, AL] [See Illust. 16, p. 40]
The capsule is elongated, (16–18 mm long) and nearly round in cross section (13–14 mm), with four pronounced vertical ridges. The closed capsule is rose-pink, which fades after opening. Each locule has up to 10 ovules (visible in an longitudinal cross section of the green fruit). Most locules have 1–3 developed seeds, shiny black and only sitting on the orange aril, which does not cover the seed.

Other characters: leaves 150 x 70 mm, shrubs or up to an 8 m high tree, from eastern China and Japan. The observed specimens from the Botanic Garden in Frankfurt are from plants grown from seed collected in Nanjing Province, eastern China [Link 2005].

17. *Euonymus grandiflorus* Wall ex Roxb. f. *salicifolius* Stapf & Ballard [BM, HG] [See Illust. 17, p. 40]
The capsules are shorter than those of the previous species, 12 x 12 mm. Each

capsule contains only a few black seeds, sitting on the orange arils.

Other characters: leaves semi-evergreen, 40–100 × 20–40 mm. A tree to 15 m high, native to central China and the Himalaya.

Section *Ilicifolia* Nakai

18. *Euonymus japonicus* Thunb. [BD Kalthaus] [See Illust. 18, p. 40]
The round capsules start yellow-green, becoming tinged pink with age. Each has four locules and contain white seeds, covered in orange-red arils.

Other characters: an upright evergreen shrub to 2 m high; in its native habitat it can reach up to 8 m in height. Hardly differs from *E. fortunei* other than in habit.

19. *Euonymus fortunei* (Turcz.) Hand. Mazz. [SD] [See Illust. 19, p. 41]
The fruit is not different to *E. japonicus. T*he capsule is nearly round in cross section, not constricted between the locules and is little grooved. The white seeds are totally covered by the orange arils.

Other characters: leaves evergreen, leathery. This species is very variable, ranging from small leaved, climbing plants (with clinging aerial roots) which appear not to fruit in cultivation, to prostrate and upright plants with larger leaves, which are very close to *E. japonicus*. Native to China, Japan and other East Asian countries.

Section *Echinococcus* Nakai

20. *Euonymus americanus* L. [BD] [See Illust. 20, p. 41]
The capsule is pinkish-red and warty, round and flattened with mostly five locules. There are up to four seeds per locule, which are pressed together with their orange arils to form one unit, making it impossible to tell the number of seeds from the outside.

An unusual feature is how seeds are pushed out of the locules after opening. As the locules open, the inner lining detaches, staying only attached at the tips of the locules. With the locule tips opening outwards, the inner lining is pulled tight, re-enforced by the lining drying, which is the mechanism for the seeds being pushed out of the capsule.

Other characters: leaves small, lanceolate, 30–80 mm long. A shrub to 2.5 m tall, native to eastern USA and south to Texas.

21. *Euonymus obovatus* Nutt. [BD] [See Illust. 21, p. 41]
This species differs from the closely related *E. americanus* in having 3–4 locules per capsule. Some authors combine the two taxa (Ma 2001). The aril is darker than that of *E. americanus,* more an orange-red.

Other characters: leaves obovate, to 60 mm long. A prostrate shrub, up to 0.3 m high.

Undefined systematic position:

22. *Euonymus occidentalis* Nutt. ex Torr. & Gray [BB] [See Illust. 22, p. 41]

Rehder and Krüssmann regard this species as closely related to *E. atropurpureus,* although it is very different to any of the observed taxa in either of the subgenera.

The capsule has a long stalk and is composed of five sepals and three carpels. The space between the three locules is hardly constricted. The capsule is pink which fades after opening. The seeds are a natural white with light yellow and pink tints. They are covered by light orange arils; individual seeds including the aril are up to 6 mm, while the paired seeds and aril can be 9–12 × 7–8 mm.

Other characters: The buds are long (> 10 mm) and covered by a single pair of scales, with the tip of the outer scale enclosing the inner. Kolster (2005) suspected that due to the bud size, it belonged to subgenus *Kalonymus*. A shrub 3–5 m high, native to the western USA.

Subgenus *Kalonymus* Beck

Some authors divide this into two series. The first series is called *Macrogemmi* and refers to the large buds of several of the taxa. All observed species in this subgenus have elongated buds, more than twice as long and as wide. In some species, the spindle-like terminal buds are more than 20 mm long (*E. latifolius*, *E. planipes* and *E. macropterus*). All have 4–5 visible pairs of bud scales. However, *E. occidentalis* has similarly large, though differently shaped buds (see above).

The fruits of the observed taxa in this subgenus are either deep wine-red and without wings *E. oxyphyllus*), to the long-winged (*E. macropterus*) or yellow-green and long-winged (*E. fimbriatus*). All the species have 60–100 mm long fruit stalks. All the observed seeds are white and are usually entirely covered by the orange arils (the exception is *E. fimbriatus* with a red aril).

23. *Euonymus latifolius* (L.) Mill. (BD, FT) [See Illust. 23, p. 41]

Linnaeus (1753) described this as a variety of *E. europaeus*, while Miller (1768) gave it specific status. It is the best known species of this subgenus and was even given generic rank by the Russian author Prokhanov in 1949. The species has relatively big, carmine red capsules and stalks 50–75 mm long. It has mostly five locules and is clearly winged. The closed fruit is strongly constricted, but after opening it becomes flatter and the wings are far less visible. The aril is orange and the seeds white.

Other characters: the terminal buds are over 20 mm long, the petioles have a channelled upper surface The leaves have rounded bases, are serrate with teeth pointing inwards and overlapping the margin. A 5 m high shrub, commonly found from central Europe to Turkey.

Euonymus planipes – Euonymus sachalinensis

Both of the above ephithets appear to have caused great uncertainty in the

literature. At times they have been cited by several authors as separate taxa Bärtels 2001), while Ma (2001) has put them in synonymy. The history of both names is as follows: in 1868 F. Schmidt described *E. latifolius* var. *sachalinensis*, as a form with stiff, upright branches "which are shorter, thicker and more irregular" than those of *E. macropterus,* which occur in the same region. According to many authors (Schmidt, Maximowicz, Schneider, Woroschilow, etc.) var. *sachalinensis* differed in having purple or dark red flowers, and according to Bean (1973) is not in cultivation in Europe. Maximowicz (1881) raised this variety to *E. sachalinensis*, referring to var. *sachalinensis* previously described by Schmidt (as the basionym[4]). Among the specimens which Maximowicz cited, appear some which fit under *E. planipes* i.e. those with yellow-green flowers. Each taxon has a type specimen, thus the Schmidt cited type is also binding for Maximowicz. Other cited specimens which belong to a different taxon, are not valid under this name.

Schneider (1907) keyed out *E. sachalinensis* with a grooved petiole and a winged capsule as close to *E. latifolius*. Koehne first described *E. planipes* in 1904 as a variety of *E. latifolius*, giving it specific status in 1906. *Euonymus planipes* is differentiated by its flattened petiole, the leaf serration and the strongly winged capsule of *E. latifolius.*

Prokhanov (1949) in the USSR Flora maintained that Maximowicz listed two taxa under *E. sachalinensis.* He therefore divided *E. sachalinensis* into two distinct species and elevated the subgenus to generic level, creating *Kalonymus maximowicziana* Prokh. (*Euonymus maximowiczianus* (Prokh.) Vorosch. 1954) and *K. sachalinensis* (F. Schmidt) Prokh.; it is surprising not to find *E. planipes* mentioned either as a synonym or a species, as the typical *E. planipes* is not identical to either of these two taxa, which according to Prokhanov have pronounced winged fruits. Only Woroschilow (1982) listed *E. sachalinensis* with red petals and *E. planipes* with green petals, in his Flora of the Russian Far East.

I only observed cultivated plants with yellow-green flowers for which *E. planipes* Koehne is the correct name. *Euonymus maximowiczianus* appears to be closely related to *E. planipes* and could be classified as a variety of the same. Unfortunately I was unable to observe any flowers [see 24 below].

24. *Euonymus planipes* (Koehne) Koehne 1906 [See Illust. 24, p. 41] (non *E. sachalinensis* (F. Schmidt) Maxim. 1881, non *E. latifolius* var. *sachalinensis* F. Schmidt 1861).

The fruit occurs mostly in parts of 4 or 5 on the same plant. It has wings 1–3 mm long which look like blunt triangles glued onto the capsule. The ends are not fused to the tip and base of the capsule as shown in *E. latifolius*. The wings are blunt and rounded at the edges, which are easily seen in a cross section. *Euonymus latifolius* has flat extensions to its wings. Where the capsule has four locules, the wing bases balance the roundness of the fruit to the extent that it appears square in cross section.

[4] A basionym is the original name of a genus or epithet in the name of a taxonomic unit of lower rank than genus published in a new combination.

Other characters: leaves with wedge-shaped bases, bluntly serrate, but the teeth do not extend beyond the margin Shrub 2–3 m high, native in East Asia from China to eastern Russia and Japan.

25. *Euonymus maximowiczianus* (Prokh.) Vorosch. [AR, AL] [See Illust. 25, p. 44]

This species differs from *E. planipes* by having a more markedly winged fruit (4–5 mm), but has four to five loculed fruits just as *E. planipes.* Ma (2001) wrote that many species in this subgenus reduce their locule numbers from 5 to 3–4 in the north of its natural range, which would render this character useless to define the species.

Other characters: the twigs are graceful and the terminal buds are short compared to the group, around 10–12(–16) mm long. The leaf bases are rounded to wedge-shaped, mostly wider in the lower half and the tips acuminate. Petioles are flat at the base, as in *E. planipes* and *E. macropterus,* while the serration is similar to *E. planipes*.

The fruit appears to be similar to *E. latifolius,* according to photographs from Rogów (Banaszczak 2005) and internet images from the Dutch Plant Collections Boskoop (Kolster 2005). Material observed from the Arboreta Rogów (Poland) and Lenoir (Belgium) show a close relationship to *E. planipes*, especially based on leaf characters. The illustrations here are based on material from the Arboretum Rogów, grown from seed from the Vladivostock region.

26. *Euonymus macropterus* Rupr. [BM, NM] [See Illust. 26, p. 44]

Fruits deep wine-red, parts in 4s, wings 10–12 mm long, narrow and downwards pointing. The arils often do not cover the seed entirely. Seneta (1996) described the seed of *E. macropterus* from Arboretum Rogów as "white seed, covered by an orange aril with opening". The same is true for plants in the Botanic Garden in Mainz. Gand (2005) had also observed the partly exposed seeds (BM). A specimen of *E. planipes* from the Forstgarten Göttingen appears identical in its partly covered seeds, although this species normally has fully covered seeds (BD, BB). A possible explanation is that there is a physiological problem.

Other characters: leaves obovate, base wedge-shaped and lightly rounded, tip, acuminate, margins serrate, petioles flat above, terminal buds 23–26 mm long. A shrub 2–3m tall from East Asia.

27. *Euonymus oxyphyllus* Nutt. [BB, AL] [See Illust. 27, p. 44]

The capsules in parts of five are rounded and 12–14 mm across. They are without wings and the edges have a slightly different tinge, especially when unripe. The cross section shows that the fruits are slightly constricted at the back sutures. The ripe fruit is a deep wine-red. The white seeds are totally covered by the orange arils.

Other characters: leaves irregular, ovoid to elongated quadrangular, partly doubly serrate. The terminal bud is 6 mm long. A shrub 3–4 m tall, native to southeast Asia.

28. *Euonymus sanguineus* Loes ex Diels ELS [BB, FG, AL] [See Illust. 28, p. 44]

The fruits are in 4s, wings broad and bluntly rounded, 6–8 mm long, wine-red when ripe. The observed fruits were not fully ripe, greenish but with a strong red tinge. The aril is bright orange and the seed white. I cannot confirm the frequently documented black seed but it is also unlikely to find black seed under an orange aril covering which completely covers the seed.

Other characters: leaf shape variable, from ovate to rounded rectangular, with wedge-shaped bases and always an acuminate tip. Petiole flat, leaf margins sharply serrate, deep wine-red underneath (in mid September) and dark green above. Twigs on the sunny side deep wine-red to nearly black. The terminal bud is 10–12 mm long. A shrub 2–3 m tall, native to China.

29. *Euonymus fimbriatus* Wall. [BB] [See Illust. 29, p. 44]

Fruits round, in parts of 4–5 with small pointed wings. The ripe capsule is light green with a light rose-pink tinge, which strongly contrasts with the fully enveloping red aril. The seed is a natural white (light, dirty ochre) with a few black spots on the smooth shiny surface.

Other characters: leaves are elongated ovate, with sharply, sometimes doubly serrate margins, and acuminate tips. The terminal buds are to 10 x 3 mm. A tree to 15 m, native to central Asia.

30. *Euonymus cornutus* Hemsl. var. *quinquecornutus* (H.F. Comber) Blakelock [AL] [See Illust. 30, p. 44]

Fruits small in parts of five, with five narrow pointed, 8–12 mm long wings. Observations seem to agree with photographs by Kolster (2005) in that overripe fruits are yellow-green tinged with various shades of pink. The inside of the locules are rose-pink.

Other characters: twigs graceful, leaves very narrow, lanceolate to 80 x 12 mm. The single terminal buds are 5 mm long and less than 2 mm thick (one assumes that stronger buds are to be found). A shrub 2–3 m tall, native to China and India.

Literature and references

BANASZCZAK, P., E-mail exchange. 2005.

BÄRTELS, A., *Enzyklopädie der Gartengehölze.* Stuttgart 2001.

BEAN, W. J., *Trees and shrubs hardy in the British Isles.* Vol. II. D-M. London 1973.

BLAKELOCK, R. A., A synopsis of the genus *Euonymus* L., *Kew Bulletin* 210–288, 1951.

BLUNT, W. & STEARN, W. T., The art of botanical illustration. Suffolk 1994.

FITSCHEN, J.(Begr.), *Gehölzflora.* 6. Aufl. 1977.

FITSCHEN, J.(Begr.), *Gehölzflora.* 11. Aufl. 2002.

GAND, S., Verbal exchange 2005.

KOEHNE, E., Drei kultivierte *Euonymus.* In: *Gartenflora.* (53) S. 29—34, Berlin 1904.

KOEHNE, E., Über neue oder interessante Holzgewächse. (*Euonymus planipes, E. oxyphylla, E. sieboldiana, E. hians, E. patens, E. yedoensis*) In: *Mitt. d. DDG,* S. S. 63—65, 1906.

KOEHNE, E., Neue oder interessante Holzgewächse. *Euonymus*: die kultivierten ostasiatischen Arten mit dunkelroten Staubbeuteln. In: Mitt. d. DDG, S. 104—113, 1910.

Kolster, H., http://www.hkolster.nl/euonymus/index.html 2005. (Nederlandse Plantencollecties (Dutch Plant Collections). An initiative of the Royal Boskoop Horticultural Society).
Krüssmann, G., *Handbuch der Laubgehölze.* 2. Aufl. Bd. II. Berlin und Hamburg 1977.
Leins, P., *Blüte und Frucht - Morphologie, Entwicklungsgeschichte, Phylogenie, Funktion, Ökologie.* Stuttgart 2000.
Link, A.-M., E-mail exchange. 2005.
Loesener: *Evonymus*. In: Engler, A. (Begr.), *Die natürlichen Pflanzenfamilien.* Bd. 20b. S. 115–124, 1942. *Unveränderter Nachdruck* 1960.
Loschek, I., *Accessoires. Symbolik und Geschichte.* München 1993.
Ma, J.S., A Revision of *Euonymus* (*Celastraceae*). Thaiszia, *Journal of Botany* 11: 1—264. 2001.
Maximowicz, C. J. I., Diagnoses plantarum novarum asiaticarum. VI. In: *Bulletin de l'Académie Imperiale des Sciences de St. Pétersbourg* 27: 446. 1881.
Nissen, C., Die botanische Buchillustration. Stuttgart 1951/52.
Prokhanov., "*Euonymus*" S. 549—566 und "*Kalonymus* (G. Beck) Prokh." S. 566—573. In: Komarov (Hrsg.) *Flora URSS.* Bd. XIV. Moscow-Leningrad 1949.
Rehder, A., *Manual of cultivated trees and shrubs hardy in North America.* 2. Aufl. 1940.
Roloff, A; A. Bärtels, Gehölze. *Gartenflora* Bd. 1. Stuttgart 1996.
Schmidt, F., Reisen im Amur-Lande und auf der Insel Sachalin, im Auftrage der Kaiserlich-Russischen Geographischen Gesellschaft ausgefuehrt. In: *Mémoires de l'Académie de Sciences de St.-Pétersbourg*. sér. 7, T. 12, Nr. 2. 1868.
Schneider, C., *Dendrologische Winterstudien.* 1903.
Schneider, C., *Illustriertes Handbuch der Laubholzkunde.* Bd. II Jena 1907.
Schulz, B., *Gehölzbestimmung im Winter.* Stuttgart 1999.
Schulz, B., Taschenatlas Knospen und Zweige. Stuttgart 2004.
Schulz, B., Studien zu den Früchten und Samen ausgewählter Euonymus-Arten. Mitt. d. DDG, 91, 127–145, 2006a.
Schulz, B., Sommergrüne Gehölze im Winter - Schlüssel zur Bestimmung der Gattungen im unbelaubten Zustand. In: Roloff, A.; Bärtels, A.: *Flora der Gehölze.* Stuttgart 2006b.
Seneta, W., Drzewa i krzewy li ciaste. (Laubbäume und –sträucher.) Bd. III, D-H. Warsaw 1996.
Trelease, W., *Winter Botany.* New York, 1931.
Woraschilow, W. N., *Opredelitel rastenii sowjetckogo dalnego wostoka.* Moscow 1982.

Author: Bernd Schulz, TU Dresden, Institut für Botanik, 01062 Dresden
E-Mail: bernd.schulz@tu-dresden.de
Translation: Wolfgang Bopp, Curator of the Sir Harold Hillier Gardens and Arboretum, Ampfield, Romsey, Hampshire SO51 0QA

Acknowledgements
I am grateful for the support of Wolfgang Bopp for finding a suitable English publication for this paper and offering to translate it. I am also grateful to Susyn Andrews for her invaluable technical assistance and to Petra Hoffmann for her advice.