

## Estimation of mating-compatibility of the wild service tree (*Sorbus torminalis* (L.) Crantz) by observing pollen tube germination

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**Abstract.** Cross-compatibility and self-compatibility in trees of *Sorbus torminalis* (L.) Crantz were evaluated. Degree of mating-compatibility between three trees was determined by means of fluorescence microscope. Self-compatibility evaluated on the basis of the pollen tube germination index showed that one tree is fully self-incompatible and the other two are self-compatible. Observations of pollen tube germination showed full cross-compatibility between trees under investigation.

**Key words:** fluorescence, mating-compatibility, self-incompatibility, *Sorbus torminalis*.

The genus *Sorbus* L. comprises about 250 species, which are widespread in the Northern Hemisphere (PHIPPS et al. 1990). Of the 91 species occurring in Europe (PHIPPS et al. 1990), there are only five primary, diploid taxa: *S. aucuparia* L., *S. aria* (L.) Crantz, *S. chamaemespilus* (L.) Crantz, *S. torminalis* (L.) Crantz and *S. domestica* L. (HEDLUND 1901). According to KOVANDA (1961) these species have the same basic chromosome number ( $x = 17$ ) and the unusual chromosome numbers (e.g. 51, 68) are explained by aneuploidy. The others are thought to have been derived from these primary species, mostly by hybridisation; an exception is *S. domestica* as there are no known hybrid species which originate from this species (HEDLUND 1901, LILJEFORS 1953, GABRIELIAN 1961, KOVANDA 1961, PHIPPS et al. 1990).

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According to HEDLUND (1948) and GUSTAFSSON (1947) in the primary species propagation is sexual and of hybrid origin it is asexual. HEDLUND (1948) also came to a conclusion that although pollination may assist seed formation, it is not indispensable and seeds are quite often formed by apomixis (especially in polyploids). The observation made was confirmed by studies of CAMPBELL et al. (1987) and JANKUN (1993), who furthermore proved that apomictic mode of reproduction in *Sorbus* is more frequent than sexual. As a rule (in the Rosaceae) diploid taxa are self-incompatible and polyploids are self-compatible, but exceptions have been reported (CAMPBELL et al. 1991).

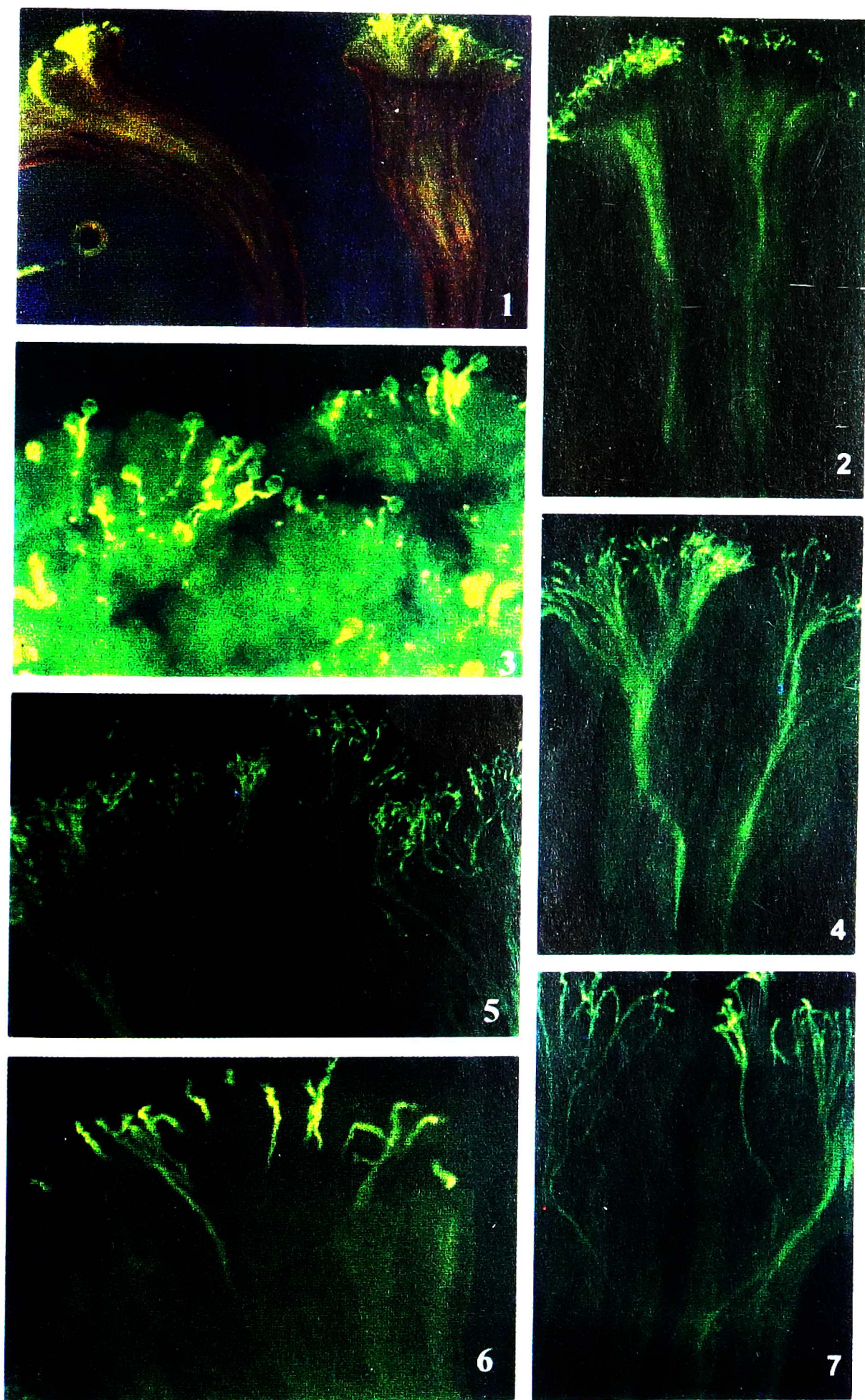
*S. torminalis* is one of a few woody species protected by law in Poland. Its localities are dispersed and scanty, and the species is considered to be in decline, not only in Polish forests but all over Central Europe (STECKI 1950, PACYNIK 1991). That situation might be caused by different factors but in this case reproductive biology of the species seems to be important. Hence, the aim of this study was to explain whether seed set in *S. torminalis* could be affected by existence of self-incompatibility.

The material used for the study consisted of pistils after self- and diallel cross-pollination of three *Sorbus torminalis* (L.) Crantz trees. The pollination was carried out in the Dendrological Garden of the Agricultural University of Poznań in May 1999 at the temperature of about 24°C. The pollen was placed on stigmas immediately after emasculation which was done at the stage of flower bud just before its opening. Pistils for the microscopic observation were fixed 24 and 48 hours after pollination, in the alcohol-chloroform-acetic acid fixative (6:3:1). Then they were stained with aniline blue according to the methods of MARTIN (1959) and HAWKINS, EVANS (1973). In determining the degree of pollen grain germination a six degree scale was used: 0 = complete lack of tubes, 5 = the largest number (WOJCIECHOWSKI 1985). Five pistils were analysed from each combination and the numbers of pollen tubes were examined for stigmas, styles and ovaries by means of a fluorescence microscope. Mating compatibility of the trees under investigation was evaluated on the basis of the pollen germination index (PGI) according to MATSUZAWA (1983):

$$PGI = (b + 2c + 3d + 4e)/(a + b + c + d + e),$$

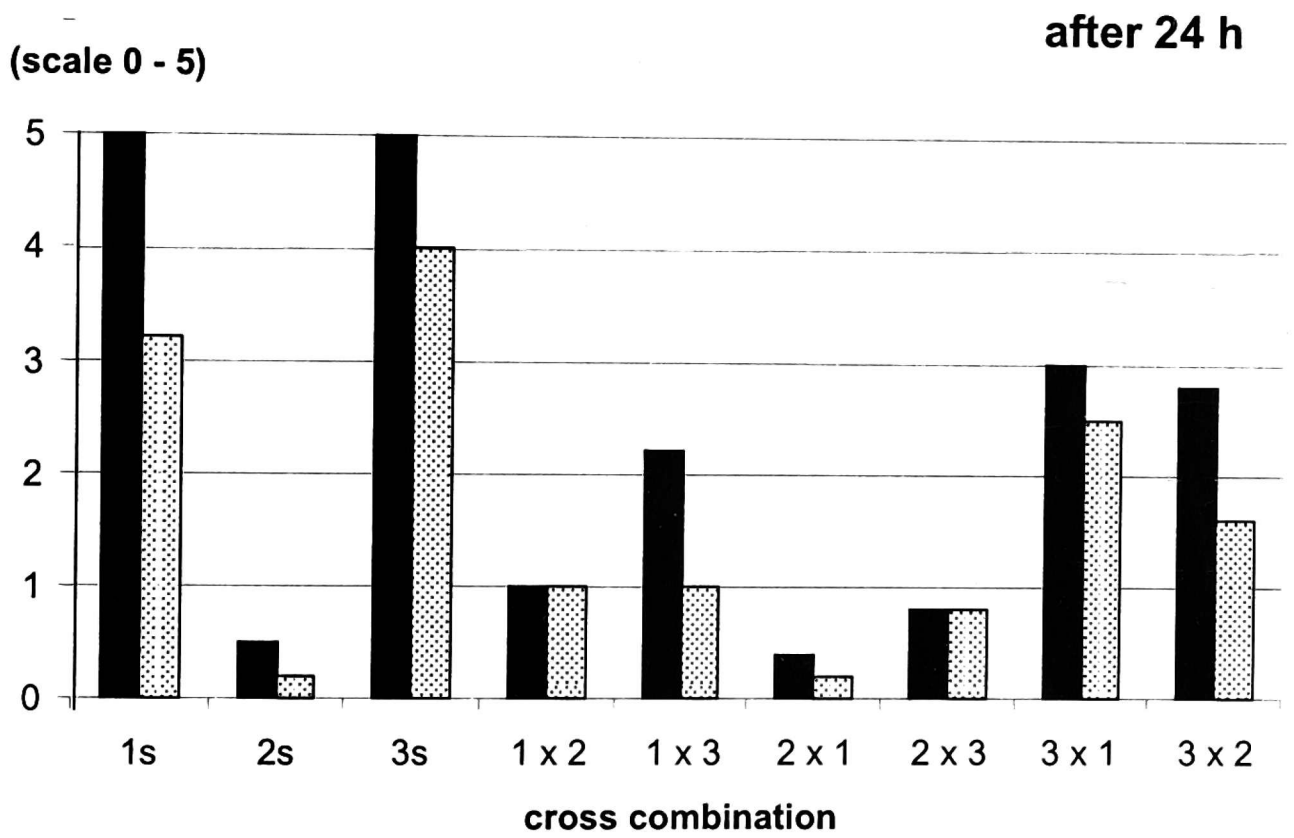
where: a = number of pistils without pollen grains, b = number of pistils on which pollen grains did not germinate, c = number of pistils in which pollen grains germinated on stigmas, d = number of pistils in which pollen tubes entered the style tissue, e = number of pistils in which pollen tubes penetrated near or entered the ovules. The trees which had PGI equal to or higher than 2 were regarded as compatible.

In all three trees of *S. torminalis* germination of pollen grains on stigmas occurred 24 h after self-pollination (Figures 1-3). After that time pollen tubes penetrating the style tissue were also observed (Figures 4-7). Some differences between tree 2 and two other trees occurred as regards the number of pollen tubes



Figures 1-3. Pollen grains germinating on the stigma of *Sorbus torminalis*. 1– tree No. 3, 24 h after self-pollination; 2 – tree No. 3, 48 h after self-pollination; 3 – tree No. 1, 24 h after self-pollination.

Figures 4-7. Pollen tubes on the stigma and in the style of the pistil. 4 – tree No. 1 × tree No. 3, 48 h after cross-pollination; 5-6 – tree No. 2, 24 and 48 h after self-pollination; 7 – tree No. 2 × tree No. 1, 48h after cross-pollination.



stigma
  style
  ovary

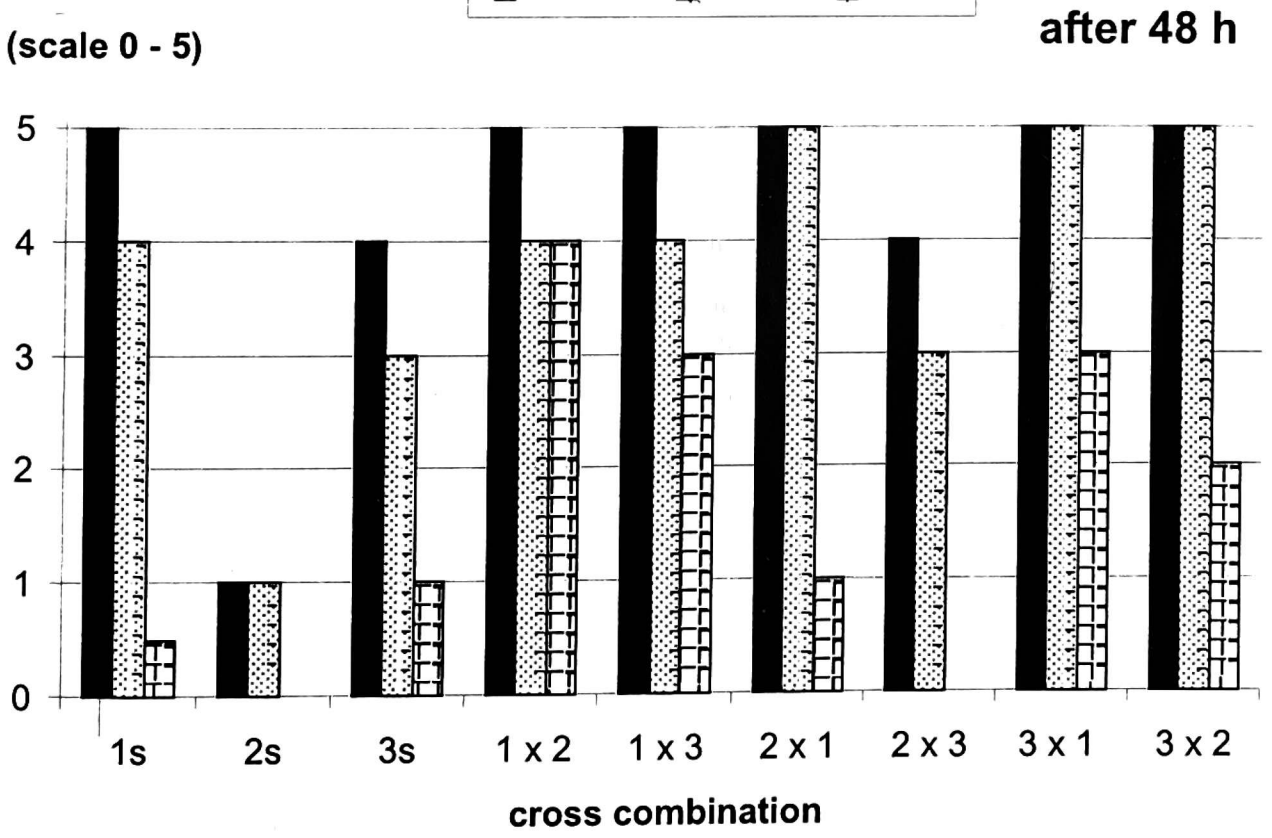


Figure 8. Intensity of pollen tube germination on stigmas, in styles and in ovaries in diallel crosses of three trees of *S. torminalis* (Nos. 1, 2, 3) and after their self-pollination.

and rate of their germination and penetration of the styles. These processes were the slowest in tree No. 2. In this tree, pollen grains germinate as a result of self-pollination about 24 hours after pollination but after 48 h the pollen tubes were not found in the ovaries (Figure 8) and few of them were present in the upper and mid parts of the style (Figure 6). The lack of pollen tubes in the ovary was probably caused by an existing system of self-incompatibility which was active in the style. PGI in this tree was low and ranged from 1.0 to 1.2 (Table 1). In the other two trees PGI was higher and after self-pollination ranged from 2.4 to 2.5.

In the case of cross-pollination all the processes were somewhat more intensive than after self-pollination. However, certain differences occurred as regards the speed with which the pollen tubes were reaching the ovaries. The highest mating compatibility was observed in the crosses tree 1  $\times$  tree 2 and tree 3  $\times$  tree 1, where PGI was equal to 2.8. Within other cross combinations PGI ranged from 2.3 to 2.5 (Table 1).

**Table 1.** Pollen germination index (PGI) in diallel crosses of three trees of *S. torminalis* and after their self-pollination

Combination	Pollen germination index	
	after 24 h	after 48 h
Tree 1, self-pollination	2.4	2.4
Tree 2, self-pollination	1.0	1.2
Tree 3, self-pollination	2.4	2.5
Tree 1 $\times$ tree 2	2.6	2.8
Tree 1 $\times$ tree 3	2.3	2.5
Tree 2 $\times$ tree 1	2.3	2.4
Tree 2 $\times$ tree 3	2.3	2.3
Tree 3 $\times$ tree 1	2.7	2.8
Tree 3 $\times$ tree 2	2.3	2.5

Among angiosperms there are over 3000 species which are self-incompatible (DARLINGTON, MATHER 1949). In BREWBAKER'S (1959) opinion, self-incompatibility observed in angiosperms can be homomorphic or heteromorphic (gamethophytic or sporophytic). Type of self-incompatibility usually is the same in all species belonging to one family. For instance the Cruciferae and the Compositae most often exhibit a homomorphic-sporophytic system. But there are examples of families within which a mixed system exists. BREWBAKER (1959) and VUILLEUMIER (1967) give examples of at least six families displaying both homomorphic and heteromorphic systems of incompatibility. In the family Rosaceae, to which *S. torminalis* belongs, the most common is heteromorphic system (CAMPBELL et al. 1991).

The results of the present work indicate that two of three investigated trees of *S. torminalis* are fully self-compatible and one tree is self-incompatible. In all crosses of these trees cross compatibility was shown. The highest cross-com-

patibility existed in combinations in which tree no. 1 was used as maternal or paternal form. According to HERMSEN and RAMANNA (1976) cross-compatibility evaluated on the basis of the number of germinating pollen tubes cannot always be confirmed by the number of formed seeds. This will be subject of further studies.

## REFERENCES

- BREWBAKER J.L. (1959). Biology of the angiosperm pollen grain. *Indium. J. Genet.* 19: 121-133.
- CAMPBELL C.D., GREENE C., BERGQUIST S.E. (1987). Apomixis and sexuality in three species of *Amelanchier*, shadbush (Rosaceae: Malloideae). *Amer. J. Bot.* 74: 321-328.
- CAMPBELL C., GREENE C., DICKINSON T. (1991). Reproductive biology in subfam. Maloideae (Rosaceae). *Systematic Botany* 16(2): 333-349.
- DARLINGTON C.D., MATHER K. (1949). *The elements of genetics*. Allene and Unwin Ltd. London.
- GABRIELIAN E. (1961). The genus *Sorbus* in Turkey. Notes from the Royal Botanic Garden, Edinburgh 4: 483-496.
- GUSTAFSSON A. (1947). Apomixis in higher plants, Vols. II-III. *Acta Univ. Lundensis*: 43(2): 71-178 and 43(12): 183-370.
- HAWKINS C.F., EVANS A.M. (1973). Elucidating the behaviour of pollen tubes in intra and interspecific pollinations of *Phaseolus vulgaris*. *Euphytica* 22: 378-385.
- HEDLUND T. (1901). *Monographie der Gattung Sorbus*. Kongl. Sv. Vet. Akad. Handl. 35: 1-147.
- HEDLUND T. (1948). Om uppkomsten av nya livstyper inom släktet *Sorbus*. *Bot. Not. Lund* (quotation after Liljefors 1953).
- HERMSEN J.G., RAMANNA M.S. (1976). Barriers to the hybridisation of *Solanum bulbocastanum* and *S. verrucosum* and structural hybridity in their F<sub>1</sub> plants. *Euphytica* 25: 1-10.
- JANKUN A. (1993). Role of apomixis in the evolution of the genus *Sorbus* (Rosaceae). *Fragm. Flor. Geobot.* 38, 2: 627-686.
- KOVANDA M. (1961). Spontaneous hybrids of *Sorbus* in Czechoslovakia. *Acta Universitatis Carolinae, Biologia* 1: 41-83.
- LILJEFORS A. (1953). Studies on propagation, embryology, and pollination in *Sorbus*. *Acta Horti. Bergiani* 16, 10: 277-329.
- MARTIN F. (1959). Staining and observing pollen tubes by means of fluorescence. *Stain Technology* 34: 125-128.
- MATSUZAWA Y. (1983). Studies of the interspecific hybridisation in genus *Brassica*. II. Crossability in interspecific crosses, *B. oleracea* x *B. campestris*. *Japan J. Breed.* 33: 321-330.
- PACYNIAK C. (1991). Let us introduce *Sorbus torminalis* to woodlands (in Polish). *Las Polski* 6: 10-11.
- PHIPPS J.B., ROBERTSON K.R., SMITH P.G. & ROHRER J.R. (1990). A checklist of the subfamily Maloideae (Rosaceae). *Can. J. Bot.* 68: 2209-2269.

- STECKI K. (1950). *Sorbus torminalis*: endangered tree of our woodlands (in Polish). *Chrońmy Przyrodę Ojczystą*. (Ed. Polska Akademia Umiejętności, Kraków), 1-2: 3-11.
- VUILLEUMIER B.S. (1967). The origin and evolutionary development of heterostyly in the angiosperms. *Evolution* 21: 210-226.
- WOJCIECHOWSKI A. (1985). Interspecific hybrids between *Brassica campestris* L. and *B. oleracea* L. I. Effectiveness of crossing. Pollen tube growth. Embryogenesis. *Genetica Polonica* 26, 4: 1-10.