CYTOLOGICAL AND MORPHOLOGICAL VARIATION IN SEDUM ACRE L. IN WESTERN EUROPE

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SUMMARY

Within *Sedum acre* L. s.l. a polyploid series occurs with the chromosome numbers 2n= 40, 2n= 60, 2n= 80, 2n= 100 and 2n= 120. The plants with 2n= 40 and 2n= 80 chromosomes have different areas.

When cultivated under uniform conditions the cytotypes 2n= 40, 2n= 60 and 2n= 80 show differences in some morphological characters. It seems likely that these three cytotypes correspond with *Sedum acre* L. subsp. *neglectum* Ten., var. *majus* Masters, and subsp. *acre*, respectively.

1. INTRODUCTION

Sedum acre L. s.l. has a very extensive distribution in Europe, ranging from the Caucasus and the Balkan Peninsula to northern Scandinavia and Iceland. It also occurs in northern Morocco. The species is exceedingly polymorphic (HUBER 1936). Since the description of the species by LINNAEUS (1753) about 20 subspecies and varieties have been described. The area of *Sedum acre* L. subsp. *acre* is northern and western Europe. The majority of the infraspecific taxa, however, occur in the Balkan Peninsula (BERGER 1930; HUBER 1936). In the south-western part of the area BERGER (1930) distinguished three different forms, viz. *Sedum acre* L. subsp. *neglectum* Ten. [= *Sedum acre* L. var. *neglectum* (Ten.) Vis.], *Sedum acre* L. subsp. *glaciale* Clar. [= *Sedum acre* L. var. *glaciale* (Clar.) Duby], and *Sedum acre* L. var. *majus* Masters [= *Sedum maweanum* Hort.]

Sedum acre L. subsp. *neglectum* Ten. has lanceolate, less fleshy, less appressed leaves without acrid taste and broad, lanceolate petals. It occurs in Spain, the South of France, Italy and along the Dalmatian coast. FRÖDERSTRÖM (1932), in a taxonomic survey of the genus *Sedum* L., did not recognize this subspecies. *Sedum acre* L. subsp. *glaciale* Clar. has a creeping, rooting stem, short erect branches and 3–4 rather large flowers in a dense inflorescence. It occurs in the French Alps and the Pyrenees. *Sedum acre* L. var. *majus* Masters is a very robust plant with light green leaves in seven ranks and larger flowers. It occurs in Morocco and is also known from cultivation. In Hegi's Flora von Mitteleuropa and in Flora Europaea *Sedum acre* L. is not subdivided into smaller taxa; only mention is made of its extreme variability.

For *Sedum acre* L. s.l. the following chromosome numbers have been reported: 2n = 16 (TOYOHUKU 1935), 2n= 24 (LÉVÊQUE & GORENFLOT 1968), 2n= 40

(UHL 1961; GADELLA & KLIPHUIS 1968); 2n= 48 (LÖVE & LÖVE 1944, 1956; SORSA 1962; LÉVÊQUE & GORENFLOT 1968); 2n= 60 (GADELLA & KLIPHUIS 1967), and 2n= 80 (UHL 1961). As far as could be checked, all chromosome counts were based on the study of roottip mitoses, except those of Sorsa which were based on the study of squash preparations of pollen meioses.

In order to arrive at a better understanding of the variability of *Sedum acre* L. s.l. combined cytological and morphological studies were carried out. The result of these studies are described below.

2. MATERIAL AND METHODS

The plants were collected in nature in different parts of Europe and cultivated in pots under uniform conditions in the experimental garden of the State University of Utrecht. Voucher specimens of cultivated material were preserved in alcohol 70%. For the purpose of comparison seeds were also collected.

The determination of the chromosome numbers was based on the study of roottip mitoses. The roottips were fixed in Karpechenko's fixative, embedded in paraffin, sectioned at 15 micron, and stained according to Heidenhain's haematoxylin method.

Table 1. Chromosome number, place of origin and collection number of the plants studied.

2n= 40
Andorra: Soldeu, 7209.
France: L'Esperon (Lozère), 4851; Bonneval (Savoie), 5319; Bessans (Savoie), 5342[x]; Col de l'Iseran (Savoie), 5365; Lac Mt. Cenis (Savoie), 5415; Massif de la Ste. Baume (Var), 6869[x].
Portugal: exact provenience unknown, 5017.
Spain: Artesa de Segre (Lérida), 6651[x], 6652[x]; Rubies (Lérida), 6660[x]; Sierra Nevada (Granada), 7220[x], 7221[x], 7224[x].
Yugoslavia: Čačak (Srbija), 6853[x]; exact provenience unknown, 6670[x].
2n= 60
Italy: Valle d'Aosta, between Valnontey and Vittorio Sella, 5509, 5511; Alberobello (Puglia), 6890[x], 6891[x].
2n= 80
Austria: Ruster Hügelland (Burgenland), 7022[x]; Zeilerberg (Burgenland), 7023[x].
Denmark: Ingerslev, 6674; Elsegaard, 6858[x]; Draby, 6861[x].
Finland: Rauma (Turku), 7056[x]; Laitila (Turku), 7058[x], 7059[x].
France: La Bernerie (Loire Atlantique), 7162[x], 7163[x]; Murat (Cantal), 7202[x].
Iceland: Blåfeldur, 6122.
Italy: Nago (Trentino), 6662.
Netherlands: Nunspeet, 4290; Oostvoorne, 4360, 4570; Bergen aan Zee, 4580, 5015; Heeren veen, 4584; Vissersweert, 4704; Ommen, 4730; Terschelling, 4759, 4770; Ramspol, 4828; Kraggenburg, 4829; Bloemendaal, 5012, Jisp, 5013; Culemborg, 6464, 6465; Vreeswijk, 6473; Schalkwijk, 6862[x]; Hellegatsplein, 7105[x].
2n= 100
Netherlands: Culemborg, 6466; Schalkwijk, 6863.
2n= 120
France: Bonneville (Haute Savoie), 7353.
Switzerland: Spiez, 7312.

3. RESULTS

3.1. Cytology

The chromosome numbers counted are listed in *table 1*, together with the collection number and the place of origin. From the table it may be observed that within *Sedum acre* L. s.l. there is a polyploid series with the chromosome numbers 2n= 40, 2n= 60, 2n= 80, 2n= 100 and 2n= 120. The chromosome numbers 2n= 100 and 2n= 120 were counted for the first time in this species. The chromosome numbers 2n= 16, 2n= 24 and 2n= 48, reported by the above-named authors, were not met with.

The cytotypes 2n= 40 and 2n= 80 were found in different areas. It can be stated that the cytotype 2n= 40 occurs by and large South of the 45th degree N. lat. and the cytotype 2n= 80 North of this line. (*fig. 1*). Both plants with 2n= 120 chromosomes originate from the western Alps were they occur above an altitude of 1000 m.

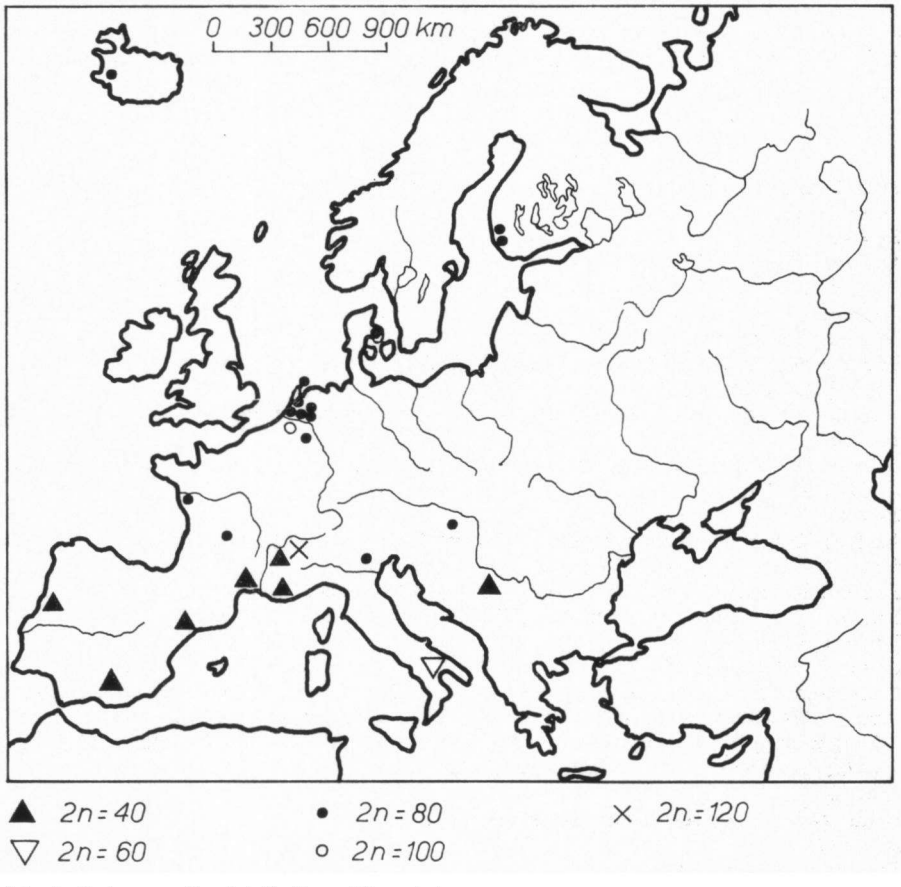

Fig. 1. *Sedum acre* L., distribution of the cytotypes.

3.2. Morphology

In the plants marked with an "x" in table 1, originating from different parts of the area of the species, the following characters were studied: A. Length of the flowering stem; B. Size of the leaves; C. Number of flowers per inflorescence; D. Size of the petals; E. Size of the seeds.

A. Length of the flowering stem

The erect part of the flowering branches was measured, i.e., the distance between the highest roots and the top of the inflorescence. The average length of the flowering stems of the cytotypes 2n= 40, 2n= 60 and 2n= 80 was 6.5 cm, 9.0 cm, and 6.0 cm, respectively. The flowering stem of the cytotype 2n= 60 proved to be significantly longer than the stems of both other cytotypes. When compared with the plants with 2n= 40 chromosomes the length of the stems of the plants with 2n= 80 chromosomes was more uniform.

B. Size of the leaves

The leaves of *Sedum acre* L. are semiterete, ovate to orbicular or deltoid, obtuse

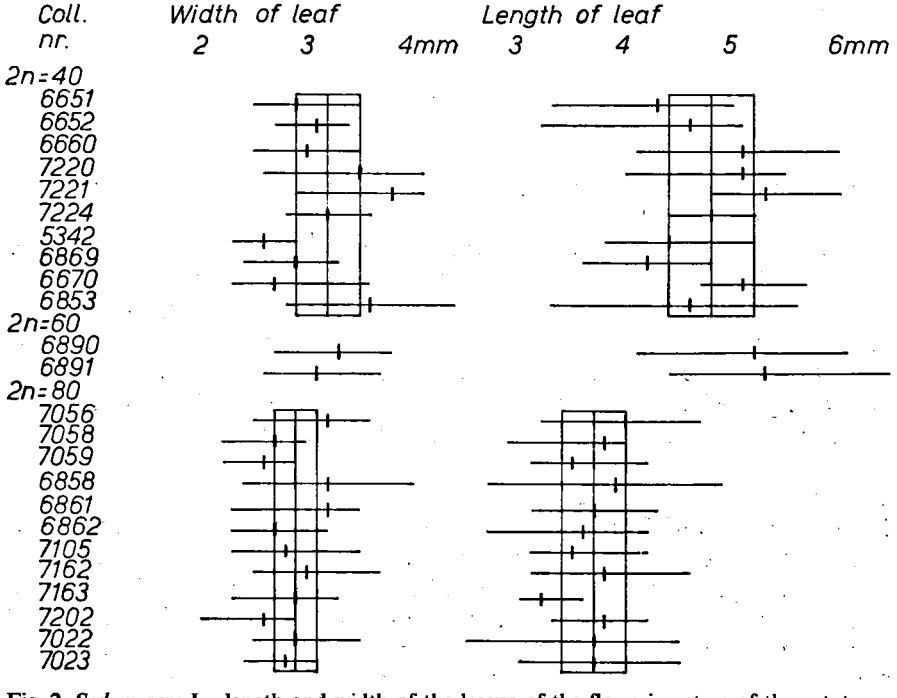

Fig. 2. *Sedum acre* L., length and width of the leaves of the flowering stem of the cytotypes 2n= 40, 2n=60 and 2n= 80. The horizontal lines represent the spreading within the samples, the small vertical lines the mean ($\bar{x}$) of every sample. The blocks show the mean ($\bar{x}$) and standard deviation of the groups.

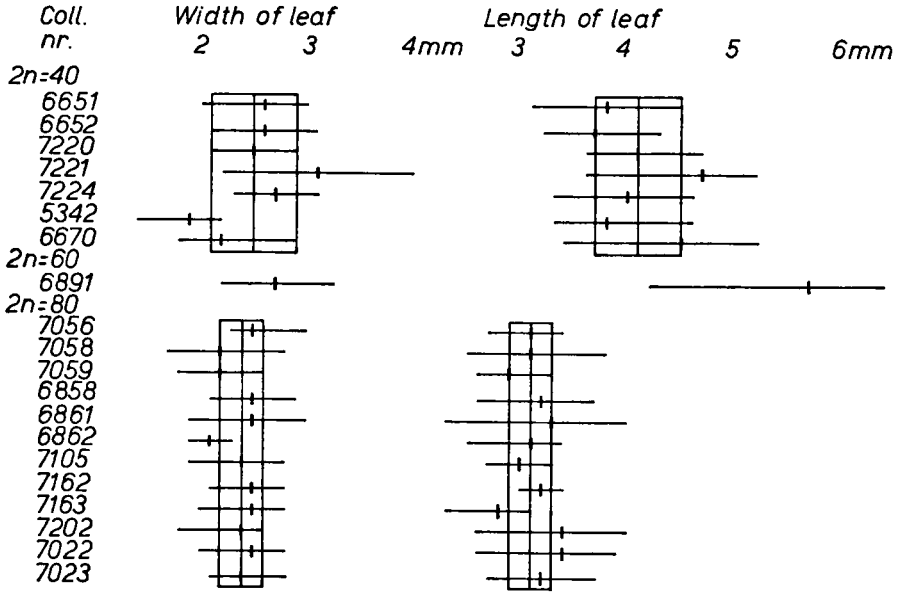

Fig. 3. Length and width of the leaves of the non-flowering stem.

or subacute, and broadly spurred. Length and width of 25 leaves from the flowering stem as well as the same number of leaves from the non-flowering stem of each plant were measured. For that purpose all undamaged leaves in one vertical rank from top to bottom were taken off from four to six branches of every plant. The mean length and width of the leaves, from the flowering stem as well as from the non-flowering stem, proved to be different in the three cytotypes. (*fig. 2* and *3*) Only the difference in the length of the leaves of the three cytotypes proved to be significant. Although the individual data overlap to a certain extent, the size of the leaves is a distinctive character.

C. Number of flowers per inflorescence

The inflorescence of *Sedum acre* L. is a terminal, more or less flattened cyme, consisting of 1–3 branches arising directly under the terminal flower of the main axis. Approximately 85% of the inflorescences was dichasial. The number of flowers per inflorescence varied from 2–16. In each plant the number of flowers of five to fifteen inflorescences was counted. The average number of flowers per inflorescence of the cytotypes 2n= 40, 2n= 60 and 2n= 80 was 9, 9, and 5 flowers, respectively (*fig. 4*). The number of flowers per inflorescence proved to be a means for readily distinguishing the cytotypes 2n= 40 and 2n= 60 from the cytotype 2n= 80.

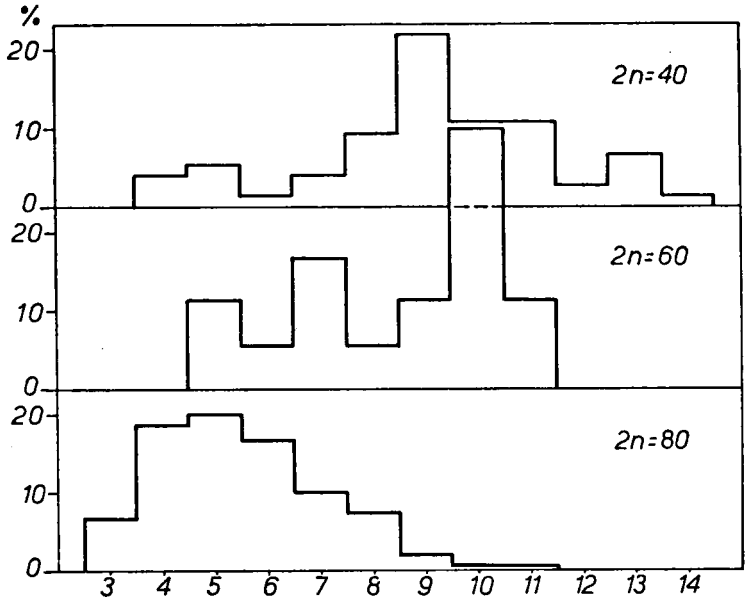

Fig. 4. *Sedum acre* L., histogram of the number of flowers per dichasium of the cytotypes 2n= 40, 2n= 60, and 2n= 80.

D. Size of the petals

The petals of *Sedum acre* L. are lanceolate, about the same size (difference in length up to 0.7 mm), connected with each other at the base over a length of about 0.1 mm, and acuminate. Of each plant the length and width of 25 petals were measured. The petals were taken off in pairs and mounted in glycerin-gelatin on mounting slides. The length was determined along the costa of the petal from the tip up to the point where the petal was connected with its neighbour, the width in a direction at right angles to the costa. The size of the petals proved to be very variable. Only in the cytotype 2n= 60 length and width of the petals differed significantly from those of the other two cytotypes. The mean length of the petals, their mean width, and their standard deviation, of the three cytotypes are as follows:

	2n= 40	2n= 60	2n= 80
	$\bar{x}$ SD	$\bar{x}$ SD	$\bar{x}$ SD
length	6.9 ± 0.4	8.2 ± 0.8	6.2 ± 0.3
width	1.9 ± 0.2	2.5 ± 0.7	2.1 ± 0.2

The number of secondary veins in the petal is correlated with the width of the petal. Usually the petals of the cytotype 2n= 40 have a smaller number of secondary veins, 2–4 (–8), than the cytotype 2n= 80, 4–6 (–8).

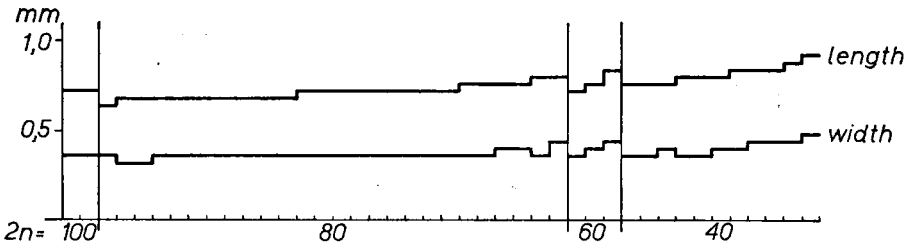

Fig. 5. *Sedum acre* L., mean (x) length and width of the seeds of 11 plants with 2n= 40, 3 plants with 2n= 60, 26 plants with 2n= 80 and 2 plants with 2n= 100.

E. Size of the seeds

The seeds of *Sedum acre* L. are small (0.62–0.85 mm × 0.32–0.47 mm), ovate, yellow to brown, and reticulate by a thickening of the lateral walls of the flat, approximately hexagonal cells of the testa. The size of the seeds of the three cytotypes studied does not differ considerably. However, the chromosome number and the size of the seeds appeared to be inversely correlated (*fig. 5*).

3.3. Flowering period

During the summer of 1968 the number of plants flowering in the experimental garden was recorded every five days. Beginning and end of the flowering period were marked by the opening of the first bud and the wilting of the last flower, respectively. The plants with 2n= 40 chromosomes started to flower 10 days earlier than those with 2n= 80 chromosomes; the climax of the flowering period was also reached about 10 days earlier and the same could be observed for its end (*fig. 6*). Of the cytotype 2n= 60 only three plants flowered. They flowered in the period from the 10th of June to the 10th of July.

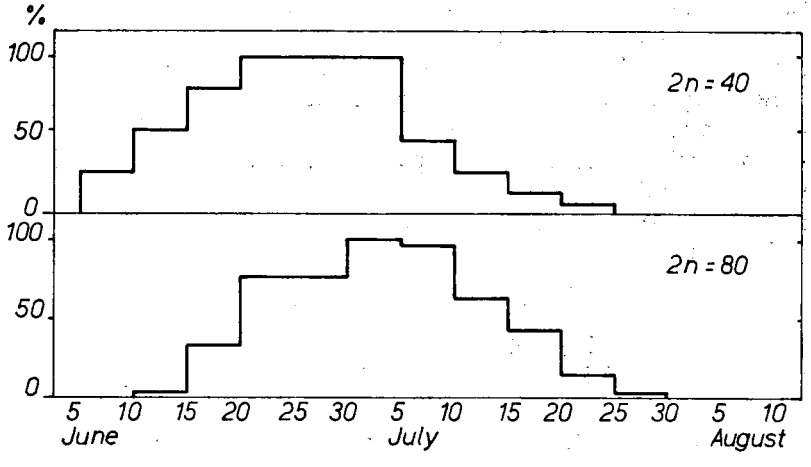

Fig. 6. *Sedum acre* L., histogram of the percentage of plants flowering during the summer of 1968.

4. DISCUSSION

Within *Sedum acre* L. s.l. a polyploid series with the chromosome numbers 2n= 40, 2n= 60, 2n= 80, 2n= 100 and 2n= 120 occurs.

A comparison of the morphological characters of the cytotypes 2n= 40, 2n= 60 and 2n= 80, after cultivation under uniform conditions, showed that they differ in their combination of characters. These three cytotypes differ in the

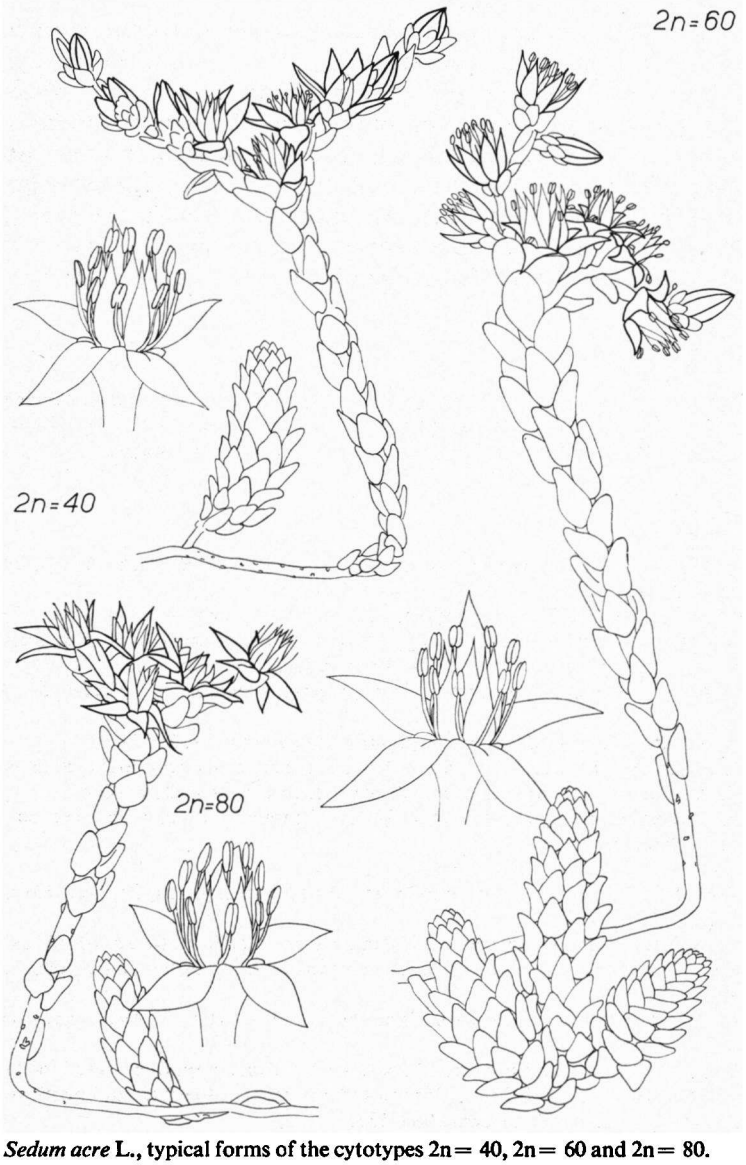

Fig. 7. *Sedum acre* L., typical forms of the cytotypes 2n= 40, 2n= 60 and 2n= 80.

size of the leaves and of the seeds. The plants with 2n= 60 chromosomes differ from the plants with 2n= 40 and 2n= 80 chromosomes in the length of the flowering stem and the size of the petals. The cytotypes 2n= 40 and 2n= 60 differ from the cytotype 2n= 80 in the number of flowers per inflorescence. The cytotype 2n= 40 was less uniform in its morphology than the cytotype 2n= 80 and started its flowering period about 10 days earlier.

Since the cytotypes 2n= 40 and 2n= 80 are morphologically distinct, differ in their flowering period and occur in different areas, they should be treated as subspecies. Both the origin of the population samples and the morphological characters of the cultivated plants are in favour of regarding the cytotype 2n= 40 as *Sedum acre* L. subsp. *neglectum* Ten. For the same reasons the cytotype 2n= 80 is probably *Sedum acre* L. subsp. *acre*. The plants with 2n= 60 are morphologically very distinct, being more robust than both other cytotypes, and closely match the description of *Sedum acre* L. var. *majus* Masters, which occurs in Morocco; it is often cultivated, and may possibly have escaped locally, see PRAEGER (1921). In view of the places of origin the cytotype 2n= 120 may be *Sedum acre* L. subsp. *glaciale* Clar., but this needs further investigation.

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