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Morphologic Variation in the Genus Brassica

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Morphologic Variation in the Genus *Brassica*

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The genus *Brassica,* a member of the Family Cruciferae, contains approximately fifty species, including experimental forms. It is one of the more important genera of the family, and includes such economic plants as cabbage, turnip, kale, rutabaga, cauliflower, broccoli and table mustards. The entire genus is indigenous to the Old World, and many species have been cultivated since very early times.

Six species have been introduced into the United States and live here primarily as weeds in waste places. They often occur in great abundance in cultivated fields and are very troublesome. These introduced species *B. nigra, B. rapa, B. kaber, B. juncea, B. napus* and *B. hirta,* have a wide distribution on the North American continent. The combined range extends from the east coast to the Pacific, northward to Alaska on the west and Labrador on the east and southward into Mexico.

Although most of the floras and manuals do not include all of the species, in areas where extensive collections of the genus have been made, most of the species are found to occur. The greater part of the specimens dealt with here are from areas near the coasts and the north central states.

A large percent of the herbarium labels carry the information that the specimens were taken from waste places, such as railroad ballasts and dumping areas. Grain fields are of considerable importance as habitats. Many of the specimens were noted as escapes from cultivation, others were undoubtedly introduced with imports of seeds or other plant products.

The members of *Brassica* are annual or biennial herbs with yellow flowers and terete or four-sided siliques. The beak is generally heavy and may be one-seeded. The seeds are globose, black or brown, and are borne in a single row. The leaves are mostly lyrate with the lower ones incised or pinnatifid. The sepals are erect or spreading. The petals vary from deep to pale yellow and are about 1 cm. long. The filaments are slender with oblong anthers, and the ovary is nearly cylindric.

The purpose of the present studies has been to determine the nature of geographic variation in *Brassica* through an analysis of morphologic characters. This information is beneficial in the interpretation

of the taxonomy of *Brassica* and may lead to a better understanding of its evolutionary history.

Measurements and data for the present study were taken entirely from herbarium specimens. Appreciation is expressed to the curators of the Gray Herbarium and the herbaria of the University of Wisconsin, the University of Minnesota, the State University of Iowa, Coe College, and Grinnell for making available the material used in this study. In all there were approximately 1,000 specimens of the six species. The material was primarily from the coasts and the north central states, with almost no specimens from the south and the eastern Rockies. The number of specimens is rather small for yielding variation patterns over such a large area, but the results indicate that enough data were obtained to show large geographic trends in some of the species.

All the data on the herbarium labels were taken and the determinations were checked. The largest and most valuable set of specimens was from the Gray Herbarium. These had been annotated by Dr. Reed Rollins. In most cases the species are fairly easy to distinguish, although there may be some confusion between *B. rapa* and *B. napus*. These are distinct species however and can be determined by careful examination. No evidences of hybridization were seen and therefore each species has been dealt with as a separate entity.

Ten measurements were made on each specimen: on the pods, the leaf attachment and the vesture. The pods were chosen for a large percentage of the measurements because they seemed to be the most variable within each species and therefore significant for a study of this type. The characters measured were:

1. Total length of pod—from the base of the peduncle to the tip of the beak. The pods measured were any of the four lowest on the stem.

2. Length of beak—from the tip of the beak to the point at which it meets the body of the pod.

3. Width of pod—at the point of greatest diameter.

4. Form of pod—1-square, 2-terete.

5. Length of peduncle—from the base of the peduncle to the point at which it meets the body of the pod.

6. Pod pubescence—1-none, 2-a few hairs, 3-a dense coating, often bristly.

7. Pod attachment—1-appressed, 2-divergent, having an angle of intersection with the stem of greater than 30°.

8. Leaf clasping—1-none of the leaves clasping, 2-some of the leaves clasping, 3-all or almost all clasping.

9. Leaf pubescence—1-completely glabrous, 2-with slight and scattered vestiture, 3-with a fairly heavy cover, 4-very dense.

10. Stem pubescence—1-the entire stem devoid of hairs or spines, 2-only the lower half with hairs or spines, 3-hairs or spines along the entire stem.

A pod breadth-length ratio was calculated for all the specimens. The averages for all the data for each species are shown in Table 1. This chart suggests that although there is geographic variation, as will be shown, the individual species are quite distinct from each other. The species cannot be distinguished on the basis of a single character, but by several taken in combination. There is a high degree of overlapping, particularly in the characters which have been measured in a large number of specimens.

Table 1
Average Measurements for the Six Species of *Brassica*

	napus	*rapa*	*juncea*	*kaber*	*nigra*	*hirta*
Length of Pod	5.17	4.53	3.82	3.02	1.99	2.96
Length of Beak	.96	.97	.66	.79	.30	1.03
Width of Pod	.17	.13		.13		.27
Pod Form	2.00	1.83	1.50	1.90	1.22	2.00
Length of Peduncle	1.43	1.39	.89	.51	.39	.85
Pod Pubescence	1.00	1.01	1.00	1.0+	1.0+	3.00
Pod Attachment	2.00	2.00	1.95	1.90	1.20	2.00
Leaves Clasping	2.80	2.94	1.20	1.00	1.10	1.00
Leaf Pubescence	1.28	1.26	1.59	1.98	1.86	2.00
Stem Pubescence	1.00	1.20	1.50	2.36	1.74	3.00
Breath/Length	.35	.36	.46	.46	.60	.95

A map (Figure 1) was constructed for all the specimens for which locations were given on the herbarium labels, to determine whether there were any areas in which a species was noticeably lacking.

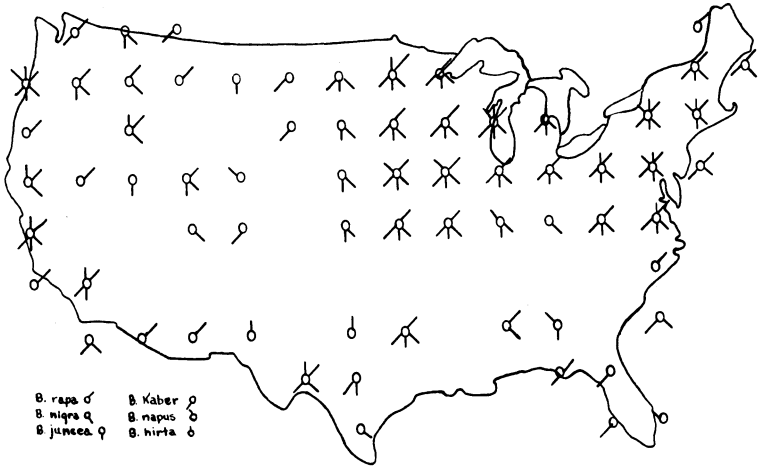


Figure 1. Distribution of the *Brassica* specimens dealt with in this study.

It will be seen that in areas where extensive collections have been made, most of the species appear. There are relatively few specimens of *B. napus* and *B. hirta,* but they occur across the United States. The six species of *Brassica* have a nationwide distribution, but some are more common than others, and some are more prevalent in one area than others.

For convenience in handling the data, the map was divided into squares, each approximately 200 miles on a side. In determining geographic variation each square was treated as a separate unit. Data for a square having less than four specimens of a species were not considered. Therefore, many areas in which a species was found are not included in the variation studied because of a lack of specimens. A description and preliminary analysis of each of the North American species follows.

Brassica rapa L. (Figure 2.)

This is one of the most common members of the genus, found abundantly along the coasts, but also widely distributed across the U. S. The stem is glabrous to slightly covered on the lower half, succulent, and up to 10 dm. tall. It may be simple or widely branching. The leaves are glabrous to slightly pubescent and mostly clasping. The upper ones are petioled in some cases, and lyrate pinnatifid with the margins entire or dentate. The flowers are yellow, from 6-7 mm. wide with pedicels 15-25 mm. long and spreading. The fruits are 2-9 cm. long with a slender beak up to 2 cm. long. They are divergent, terete or nearly so, and contain dark brown seeds 1.5-2 mm. in diameter.

The maps show changes which occur in four of the characters. There is a similar degree of correlation in the others; however all are not presented here. Large blocks of territory have been used. North-south strips 200 miles wide along the west coast, and east-west strips 200 miles wide and 600 miles long along the east coast and down the Great Lakes area. Mapping was done in several ways but this was the only one which showed directional variation for all of the characters. East-west clines are indicated in western United States and north-south clines in the Great Lakes area.

Along the east coast there seems to be evidence of change from the seaports outward. A similar phenomenon occurs on the west coast, but since the points of possible introduction are widely scattered the movement is essentially eastward. There seems to be a definite change southward from the Great Lakes area, which indicates that Great Lakes cities were important centers of introduction of *Brassica rapa.*

As only 175 specimens were examined, the above hypotheses must be considered very tentative. If more data were gathered for the United States, patterns of morphologic change in relation to geography might be found to be somewhat diverging.

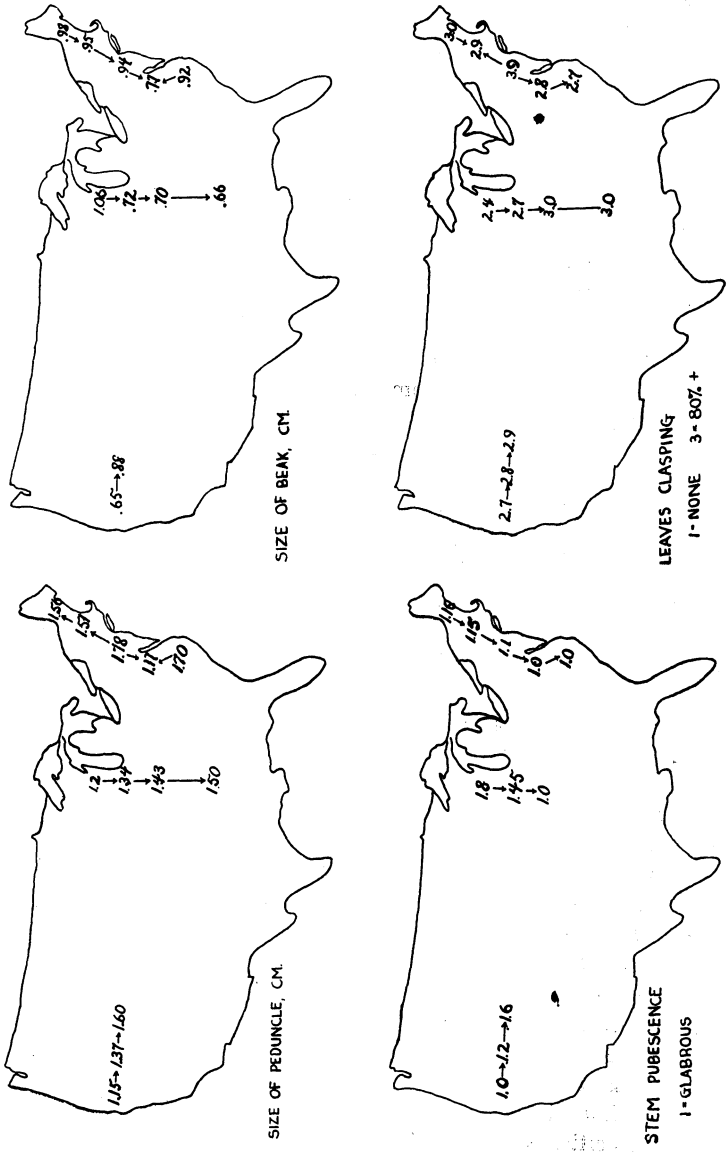


Figure 2. *Brassica rapa* L.

Brassica napus L. (Turnip)

This species is similar to *B. rapa* but often greener, with a thickened, tuber-like base. The petals are smaller and a deeper yellow. The pods are from 2.5 to 9 cm. long, with a 5.2 cm. beak and a peduncle 2.5-7 cm. long. The pods are cylindrical and divergent. The leaves are almost all clasping and only slightly pubescent if at all. The stems are entirely smooth.

Brassica napus is persistent after cultivation and is found as an escape in widely scattered parts of the country. Measurements were made on only about 25 specimens, which is not a sufficient number for studying patterns of morphologic change.

Brassica juncea (L.) Coss. (Figure 3.)

B. sinapistrum Boiss

This is an annual or biennial herb with an erect stem 3-17 dm. tall. It may be slightly branching, and is somewhat pubescent and pale in color. The leaves are 5-17 cm. long. The lower ones are oblong to oval, lyrate-pinnatifid, coarsely toothed, and petioled. The upper leaves are narrow, entire or dentate, progressively reduced in size upward, and short-pediceled to somewhat clasping. All are somewhat pubescent but not densely so. The flowers are produced on elongated racemes. The petals are yellow, 8-12 mm. long, and broadly spatulate. The pedicels are erect at maturity. The sepals are from 4-6 mm. in length. The fruits are 2-6 cm. long, with the pods ascending, not appressed to the stem. They are nearly terete, and the valves are strongly one-nerved. The seeds are brown, and about 2 mm. in diameter.

Brassica juncea is widely distributed across the United States, and occurs frequently in the areas considered here. Regional variation for four characters is shown in this species. There seems to be a diagonal trend in variation for each character, indicating the primary area of introduction of this species was New England. Variation trends in other characters, not mapped here, are only in partial agreement with the results shown here.

Brassica nigra (L.) Koch. (Figure 4.)

Brassica nigra is one of the most common members of the genus. It is widely distributed and particularly abundant in the midwest. The stems are simple or branched, 1-2 m. high, bristly below and glabrate or glabrous above. The leaves are 5-20 cm. long, with slender petioles. The upper leaves are narrow or lanceolate, short-petioled to sessile, entire or simply toothed. The lower ones have a large terminal lobe and 2-4 small, lateral lobes and are pinnatifid. The flowers are 8-10 mm. wide, yellow, with spatulate petals and are borne on pedicels that are erect at maturity. The fruits are erect

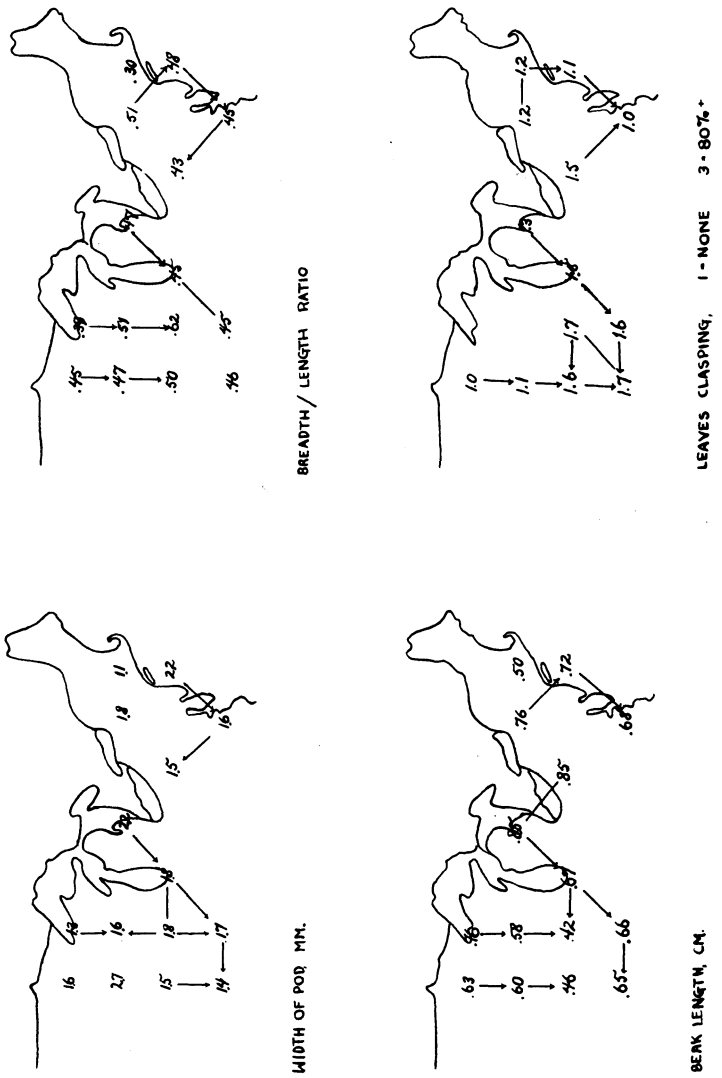


Figure 3. *Brassica juncea* (L.) Coss.

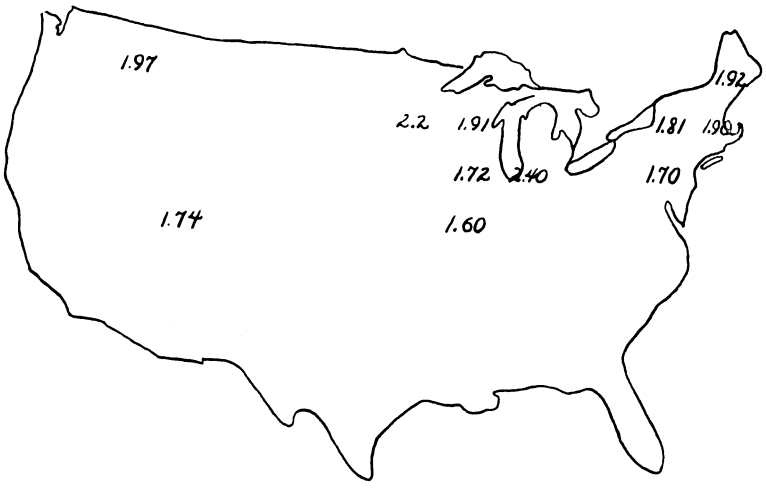


Figure 4. *Brassica nigra* (L.) Koch.

or appressed, overlapping at maturity, 1-3 cm. long with a slender beak. The pods are indistinctly quadrangular, and somewhat constricted between the seeds. They are generally smooth with a midvein that is almost as strong as the sutures. The peduncle is 2-7 mm. long. The seeds are brown to black, roughly reticulate and 1.5-2 mm. in diameter.

The means obtained for one character of this species are fairly typical of all the characters. If there is clinal variation, it is not disclosed by the methods applied here.

Brassica kaber (DC.) Wheeler. (Figure 5.)

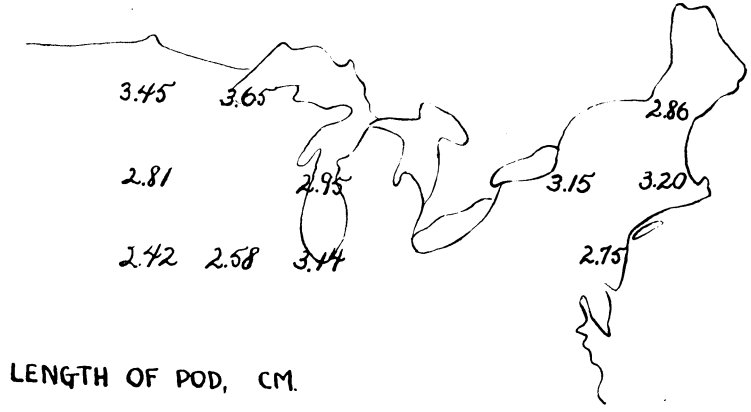
B. arvensis (L.) Ktze.

Sinapis arvensis L.

Brassica kaber is a common species, abundant in the midwest and also found along both coasts. The stems are more or less hispid, especially at the base. They are 2-8 dm. tall. The lower leaves are borne on hispid petioles. They are obovate, lyrate-pinnatifid and sometimes lobed. The upper leaves are nearly sessile, oblong to ovate, acute, dentate, slightly pilose, and borne on short, thick, ascending petioles. The flowers are about 15 mm. wide, also on ascending pedicels. The fruits are from 2.5-3.5 cm. long with beaks of about 1 cm. They are nearly terete. The seeds are dark brown, smooth, and about 1-1.5 mm. in diameter.

There are two varieties, var. *pinnatifida* (Stokes) L. C. Wheeler and var. *schkuhriana* (Reichenb.) L. C. Wheeler. In this study they were treated together.

This species shows no noticeable pattern of variation. However, similar readings occur together in several cases. It will be necessary to obtain more specimens from over its range before any final conclusions can be drawn.



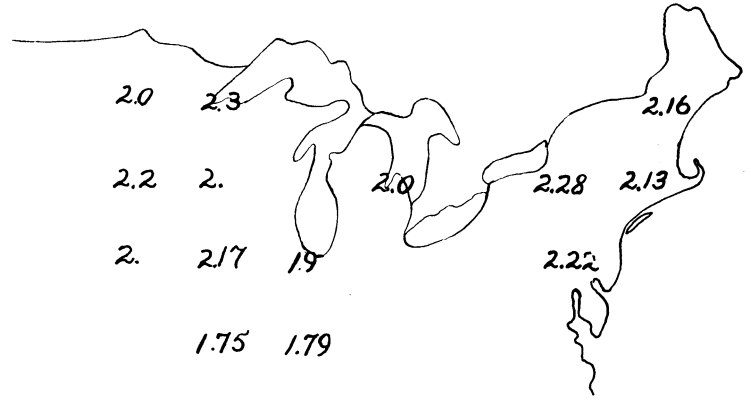


Figure 5. *Brassica kaber* (DC.) Wheeler.

Brassica hirta Moench.

Brassica alba (L.) Boiss

This species is easily recognized because of the stiffly pubescent stem and pods. It is fairly widely distributed in the United States and is often found as an escape from cultivation.

The stems are 3-8 dm. tall, often branched and heavily pubescent. The leaves are variable, the upper ones generally oblong to lanceolate with coarsely toothed blades and short to sessile pedicels. The lower leaves are obovate, pinnatifid, about 2 dm. long with long petioles. The flowers are about 15 mm. wide, on widely divergent pedicels about 1 cm. long. The petals are yellow and much longer than the sepals. The fruits are 8-15 mm. long with a flat beak that is as long or longer than the pod. The fruits are borne on horizontally diverging peduncles. They are covered with heavy bristles and have 3 nerved valves. The seeds are pale, smooth and about 2 mm. in diameter. Insufficient specimens were available for studying variation in this species.

Summary

Measurements were made on approximately 1,000 herbarium specimens of the six United States species of *Brassica*. It was found that *B. rapa* showed morphologic variation southward from the Great Lakes, eastward from the Pacific and patterned from the eastern seaports. *Brassica juncea* showed a diagonal pattern indicating introduction from New England; however all characters were not in agreement. *Brassica nigra* and *B. kaber* showed no discernable patterns of geographic variation and there were insufficient specimens for studying *B. hirta* and *B. napus* in this manner.

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