HYBRIDIZATION IN *ACACIA NILOTICA* COMPLEX

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Abstract

Morphological studies of the members of Acacia nilotica *complex indicate that the vast amount of variability encountered in this group is because of hybridization between* A. nilotica *ssp.* indica *and* A. nilotica *ssp.* hemispherica. *This hybrid population may backcross either with the first or the second parent producing ssp.* adansonii *and ssp.* subalata *type plants respectively. Human influence in creating disturbed habitat seems to be the most important factor in the promotion of hybridization.*

The members of the *Acacia nilotica* complex commonly known as kikar are among the most important forest trees of the plains of West Pakistan. Starting from the coast, the kikar forests follow the Indus river and its tributaries for more or less one thousand miles inland. Since these plants grow mostly at river banks, canal banks, flood plains or road sides, their area has extended with the building of roads and canals in the former provinces of Sind and Punjab. In West Pakistan four taxa belonging to this complex are met with. One of these (ssp. *hemispherica*) is purely coastal and grows in the dry river beds near the sea. It has a characteristic dome shaped habit, and morphologically it is comparatively less variable than other members of *A. nilotica* complex found in West Pakistan. The second taxon represents the most commonly occurring member of this complex. It extends throughout the plains of former Sind and Punjab both in the form of scattered trees on cultivated lands as well as forming almost pure riverine forests. This form is highly variable and the present study is mostly confined to this taxon. Some forms of this agree with ssp. *subalata*.

A third taxon that also forms a part of this complex is *A. nilotica* ssp. *cupressiformis*. This taxon although sympatric with subspecies *adansonii* is found only scattered by the cultivated lands, but it is never present in pure formation anywhere in this area. The concentration of this subspecies in W. Pakistan seems to be in Jhelum and Gujrat area. This subspecies could be separated from the other members of this complex on the basis of its fir like habit. Its original home is likely to be somewhere in the North West of Pakistan.

A nomenclatural treatment of *A. nilotica* complex is given by Hill (1940) and Brenan (1957, 1959), but these treatments have not recognized all the taxa distributed in West Pakistan. Although Khan (1958) has given a taxonomic treatment of the species occurring in West Pakistan, he did not recognize all the taxa distinguishable in this area. Moreover, the variational pattern of this complex has not been studied properly. In view of this, a detailed study of this complex has been made in order to delimit the taxa objectively. Some reasons have also been advanced for a proper understanding of the evolutionary mechanism responsible for the vast amount of variation exhibited by this complex.

Materials and Methods

The representative samples of *Acacia nilotica* complex were collected randomly from five different stations between Karachi and Thatta. A total of ninety-eight collections was analysed for morphological studies. Out of these, fifteen plants were from Paradise Point at Hawksbay, Karachi, thirty-two belonged to the University Campus which is about 20 miles from Hawksbay. Eleven plants came from Gharo which is 35 miles east of Karachi, 20 from Ghullamullah and 20 from Pattan, Thatta; the latter two localities are at an approximate distance of 45 and 65 miles east of Karachi (Fig. 8).

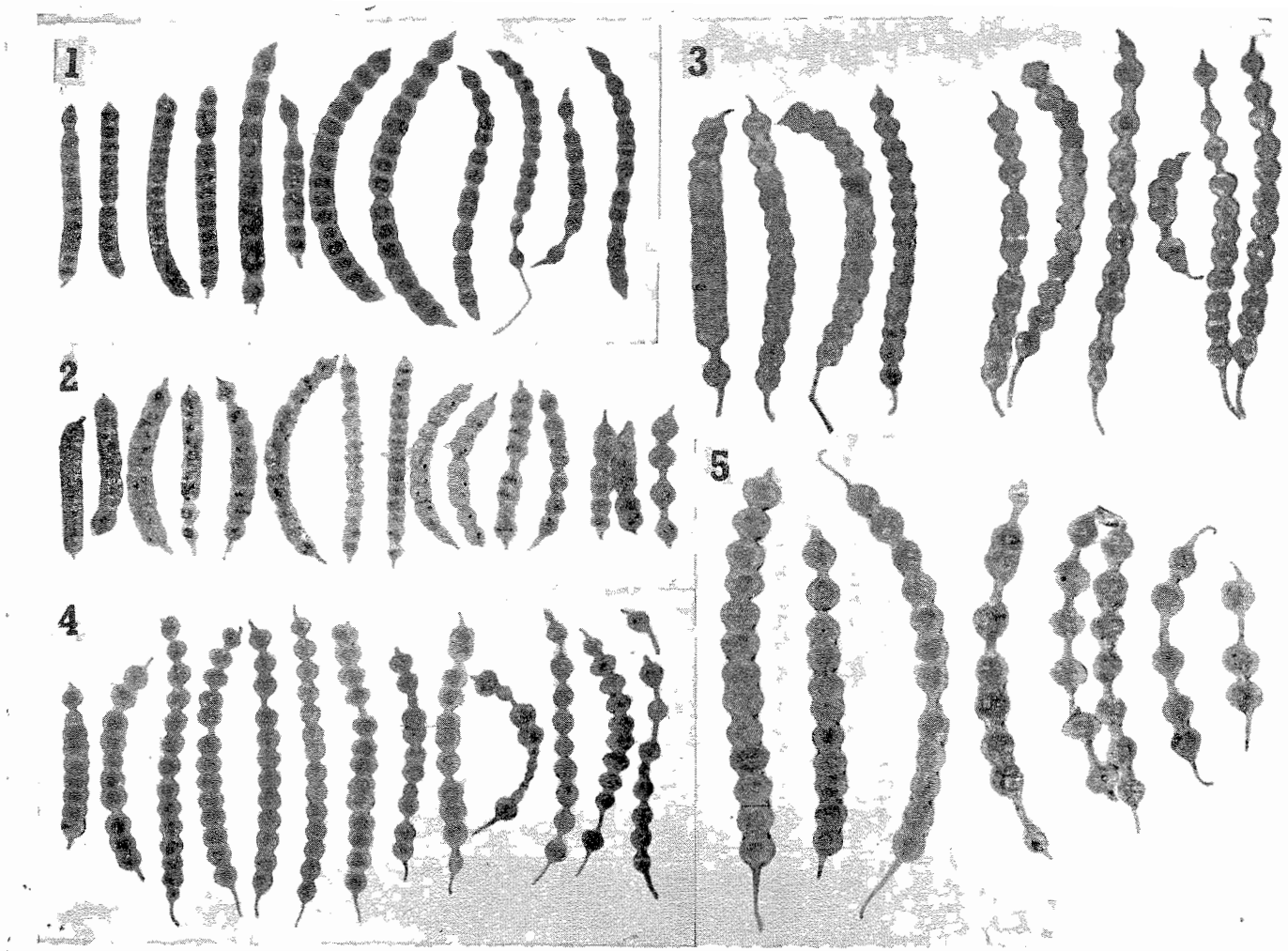
Fifteen characters were analysed morphologically. The mean value and range were calculated on the basis of approximately ten measurements, except the measurements of maximum and minimum width of individual mericarp which were based on approximately 30-100 measurements.

The characters studied were 1. length of leaf rachis, 2. length of rachis branches, 3. length of leaflet, 4. breadth of leaflet, 5. no. of leaflet pairs, 6. fruit length, 7. fruit pubescence, 8. maximum fruit breadth, 9. minimum fruit breadth, 10. no. of cremocarp (seed chambers), 11. length of pedicel, 12. thickness of pedicel, 13. fruit curvature, 14. length of fruit stipe and 15. length of fruit beak.

Frequency histograms were made to show the variability of individual characters in different populations. For correlation of various characters both photographs and scatter diagrams were prepared.

Results and Observations

Acacia nilotica ssp. *hemispherica* is a plant with dome shaped habit, curved fruits, with short beak, short stipe, broad constrictions and black colour (Fig. 1). The population from the University Campus is highly variable (Fig. 2). Although the trees are erect but there is definite evidence of branches at the base



Figs. 1-5. Representative samples of fruits showing variability in constriction, stipe and beak: (Fig. 1) *Acacia nilotica* ssp. *hemispherica* from Paradise Point, (Fig. 2) other members of *A. nilotica* complex from University Campus, (Fig. 3) Gharo, (Fig. 4) Ghullamullah and (Fig. 5) Pattan, Thatta.

of trunk. Such branches are usually chopped for firewood by the native. Highest degree of variability is found in fruit shape. The majority of plants of this population, however, have crenate fruit margin and they are recognized as ssp. *adansonii*. In certain members of the population, however, the fruit margin is smooth and both stipe and beak are comparatively shorter than that found in the populations of Gharo, Thatta and Ghullamullah. Apparently the fruits look much like *A. nilotica* ssp. *subalata*. But within the same population there are plants, although few, that look more like *A. nilotica* ssp. *indica*. The fruits of the latter plants are comparatively more constricted, with longer stipe as well as beak.

The populations from Gharo (Fig. 3), Ghullamullah (Fig. 4) and Pattan (Fig. 5) deviate more towards typical *indica* type. Consequently plants with narrow fruit constrictions, long beak and stipe are more common. These populations also include plants that fall within the characteristics of *A. nilotica* ssp. *adansonii*.

The study of populations on the basis of variability of individual characters showed that the coastal population was not as highly variable as the population

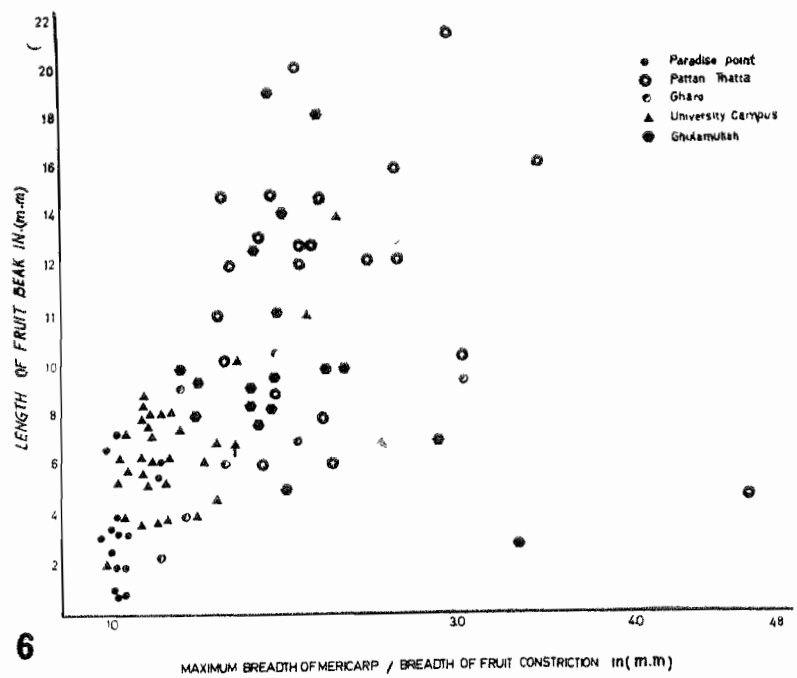


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Fig. 6. Scatter diagram of five populations of *Acacia nilotica* complex showing clinal type of variation.

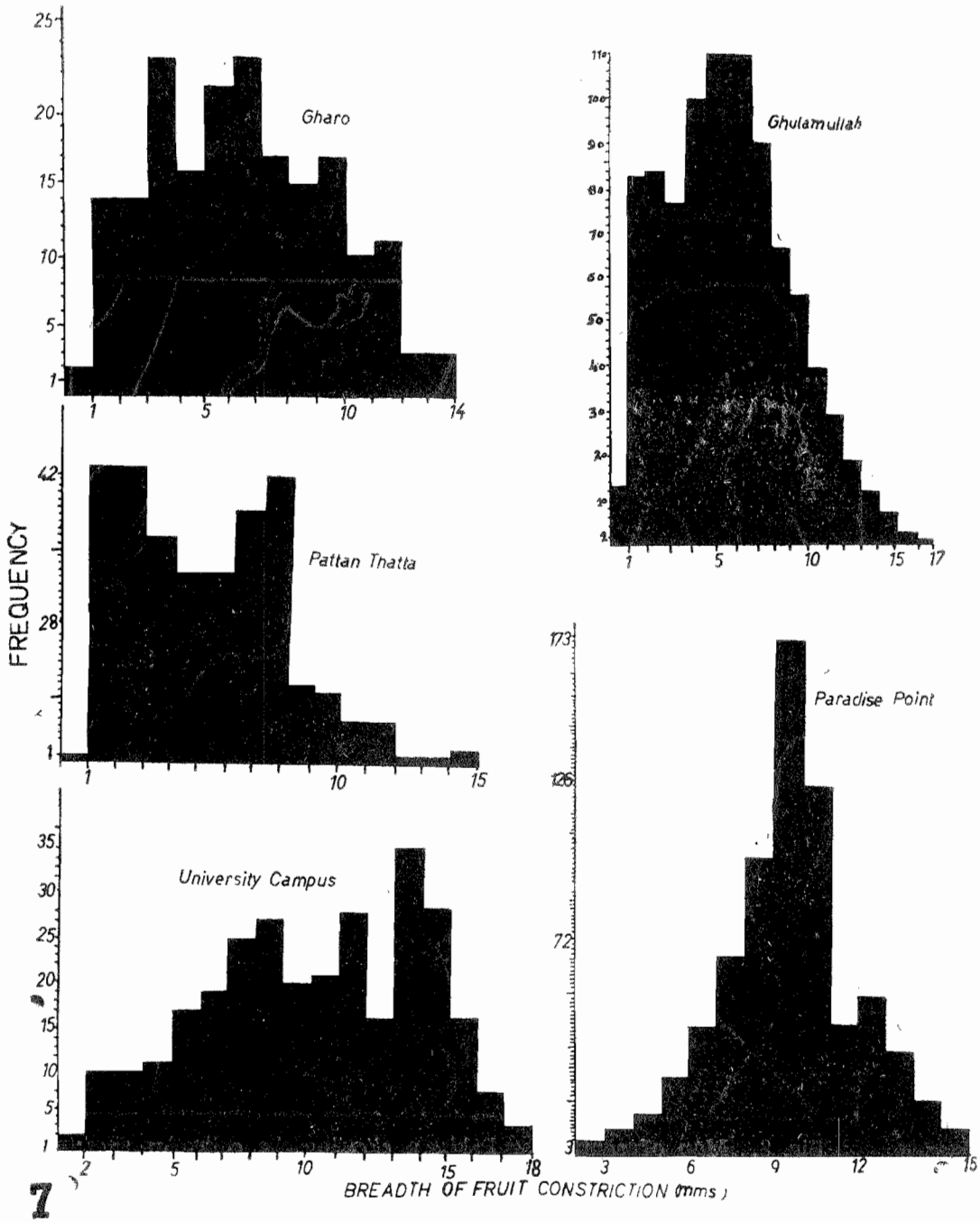

Fig. 7. Histograms of the populations of *A. nilotica* complex showing extent of variability in fruit constriction at different locations.

from the University Campus or the populations from Gharo or Pattan (Fig. 7). Further the variability gradually changes from west to east, indicating character gradients similar to clines (Fig. 6).

Breeding behaviour of this complex can be conceived from the observations of natural populations. Flowers of *Acacia* are found in heads each with 50 to 60 flowers, but in no case all the flowers form fruits. Usually only 2-5 flowers are able to produce fruits, while the rest are shed. This fact together with the

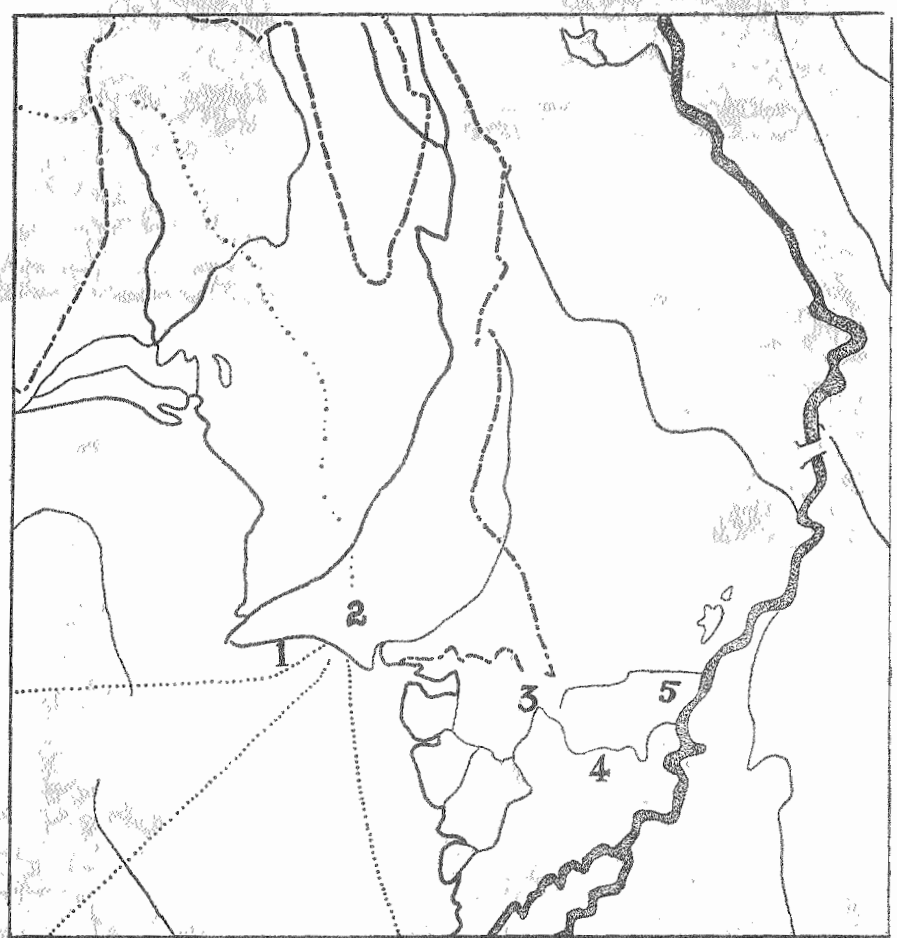

Fig. 8. Map of south-west Pakistan showing the collection sites: 1. Paradise Point, 2. Karachi University Campus, 3. Gharo, 4. Ghullamullah and 5. Pattan, Thatta.

presence of compound pollen grains and numerous stamens provide ample evidence that the members of *A. nilotica* are cross pollinated.

Discussion

The variation pattern of *Acacia nilotica* complex from coast to inland shows a clinal variation (Fig. 6). This type of variation in outbreeding populations has been demonstrated in a number of forest trees such as *Pinus nigra* (Davis and Heywood 1963) and *P. sylvestris* (Carlisle 1958, Langet 1936). Similarly in the outbreeding grass species *Agrostis tenuis* clinal variation is described by Bradshaw (1959). In all such cases, however, the continuous variation is made up of series of local populations which suggests some kind of effective isolation that permits differentiation in response to local environmental conditions. The examples presented above, however, are not only a product of selection, but also the result of limited gene exchange among the open pollinated plants. Similar clinal variations through hybridization between species and subspecies have been observed in animals also, producing genoclines (Beebe 1921, Sumner 1932). Since Karachi University population is intermediate (Figs. 2 & 6) between the coastal *hemispherica* and inland *indica* types both in distribution as well as in morphology, it may be a product of hybridization. Moreover, moving towards Gharo and Pattan there is a gradual transfusion of *indica* type genes resulting in longer stipe as well as beak and moniliform lomentum indicating introgression. But gradually changing populations may be an outcome of selection on a climatic gradient or it may be on account of gradual genic diffusion from one population to the other. Anderson (1953) claims that intermediate populations are not ancestral to two extreme forms and in all the cases they are a product of introgression. Barbar and Jackson (1957) challenge this view on the basis of their observation on clinal variation in *Eucalyptus*, and also suggest that many of the examples of introgression suggested by Anderson, especially from *Juniperus* and *Oxytropis* should be interpreted as clines. But as suggested by Davis and Heywood (1963) there is plenty of room for both processes together.

In the case of *A. nilotica* complex, however, the present status of variation cannot be explained on the basis of climatic gradient mainly. Since in all the samples and more so in the Karachi University Campus (Figs. 2 & 6) there are a few plants that come quite near to one or the other parental types indicating genetic segregation, or a backcross progeny. Moreover, the variability is not as great in the coastal population of *hemispherica* (which is one of the assumed parents) as in the intermediate populations (Figs. 1-7). It may also be pointed out that the latter are present on highly disturbed habitats. These points reinforce the view of hybrid origin of intermediate forms.

The pattern of clinal variation is obvious when we start from coastal region to inland up to about 45 miles, after which the general pattern remains more or less the same. If the characters, which were chosen to show the clinal variation were highly selective, their selection should have proceeded and populations after 45 miles should have shown more and more gradient towards the characters of the other parent. But this is not the case in *A. nilotica* because the variation is not ecotypic or ecoclinal but rather it is due to exchange of genes between two populations.

Since man had been disturbing the habitat, the hybrids with greater genetic plasticity got established in the riverine forests and other habitats of Southern West Pakistan. There is evidence that the seeds from the southern zone of West Pakistan were distributed to the northern part by the Forest Department. This may have contributed to the establishment of *A. nilotica* complex in the riverine forests of the north where one of the parents is absent.

Owing to natural as well as artificial migrations the hybrids now occupy almost the entire plains of former Sind and the Punjab. But these hybrids have not entered into the areas of ssp. *hemispherica* which are coastal and which thrive well in a specialized and comparatively undisturbed area in pure formations mostly. The dome shaped habit of this subspecies is highly streamlined from the point of aerodynamics, as selection has taken place in an area of very high wind velocity.

The subspecific differences in the *A. nilotica* complex are based mostly on fruit characters. While describing the *A. nilotica* complex Brenan (1959) recognized *A. nilotica* ssp. *indica* on the basis of its moniliform lomentum, the subspecies *adansonii* on the basis of wavy margins of fruits, while ssp. *subalata* by straight fruit margin. The population of Karachi University Campus includes plants that resemble either *subalata* or *adansonii* and rarely *indica*. While the populations of Gharo, Ghullamullah and Pattan do not have plants that are similar to *subalata*. On the basis of our observation both *adansonii* and *subalata* seem to have originated as a result of hybridization between ssp. *indica* & ssp. *hemispherica*. Plants recognized as *adansonii* may have been the result of greater infiltration of *indica* genes and those recognised as *subalata*, through infiltration of *hemispherica* genes. Thus it seems likely that both ssp. *subalata* and *adansonii* have originated as a result of backcross, in the first case with *hemispherica* and in the other case with *indica*.

The occurrence of plants similar to *A. nilotica* ssp. *indica* both in Sind and Punjab indicates that in the past this plant was distributed in this area and now it

is replaced by hybrid populations. The replacement of parental *indica* by hybrid seems to be on account of disturbed habitat created through rigorous human activity.

The area of distribution of *A. nilotica* complex is both in Africa and Asia, the two continents with the longest period of human history. The agricultural practices could follow only after the destruction of riverine forests at the flood plains of rivers which also have been the area of *Acacia* forests. The complete isolating barriers in these groups of plants could never fully develop and the breeding system together with the human intervention seem to be major causes in this respect. This in its turn, has led to the difficulties that are encountered in the taxonomic delimitation of the members of *A. nilotica* complex. Since fuel and implements of human need came from wood, man from time immemorial used *Acacia* plant for both.

The importance of *Acacia nilotica* forests was fully realized by the Forest Department during the British rule of Indo-Pakistan sub-continent. There is definite information available from the Department of Forestry that seeds from Hyderabad have been transported to the plains of the Punjab for reforestation purposes and this practice is still going on. This may be the reason why almost all the riverain and nonriverain plantations of *Acacia nilotica* of both Sind and the Punjab are composed of *Acacia nilotica* hybrids. Some of the hybrid plants examined come very close to ssp. *subalata* and ssp. *adansonii* indicating a possible origin of these taxa through hybridization. But a true reappraisal of these hybrids in West Pakistan is very difficult, because of probable contribution of some genes by ssp. *cupressiformis*.

Today, owing to water-logged conditions of many places in West Pakistan, the kikar plants are dying. Some of the hybrids from the segregating populations therefore may offer a hope for certain genotype that is able to survive in the water-logged conditions of West Pakistan. It may be realized that riverine kikar forests remain under water for weeks together at the time of flood.

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