Contents

Part 3

ORIGINS OF THE FLORA OF SOUTHERN BRAZIL

Lyman B. Smith

Ever since the first land plants evolved, the face of the earth has been changing constantly, so that we may safely assume that the flora of any given region today has arrived from somewhere else. In the case of land recently risen out of the sea, it is relatively easy to see whence its flora came, but in the case of a great center of distribution like the Amazon Basin it is difficult if not impossible to reconstruct its past.

Southern Brazil, which is to say the states of São Paulo, Paraná, Santa Catarina, and Rio Grande do Sul, is an intermediate case. The area is not recently exposed except for a narrow coastal fringe, but on the other hand, most of its plant families have their greatest development elsewhere. Thus there are some fairly obvious lines of migration (fig. 1), and the continuity of some ranges and the discontinuity or disjunction of others indicate that these migrations have taken place at different times. The flora of the coastal rain forest is a direct continuation and attenuation of that centering on Rio de Janeiro, while the flora of the campos or rolling prairies of the planalto has a similarly direct origin from the central states of Minas Gerais and Goiás. There is another continuous migration pattern from northern Argentina and Paraguay eastward and a considerable amount from the Andes. We have a few wide ranging maritime species extending from the north into the area, but from due south there is relatively little evidence of immigration, possibly because this area may not have emerged from the sea until a later date.

The discontinuous ranges follow much the same migration routes as the continuous ones from the north, but these are suspect as being due to gaps in collecting. Of those based on fairly firm evidence the most important by far are the Andean, with only a few species each for the Austral, coastal plain, and African.

It may seem presumptuous and reckless to discuss ranges at all on the basis of such meager evidence as we now have, and probably we

still need several hundred years of collecting and classifying before the flora of Brazil is really well known. However, there are certain broad physiographic regions that are readily recognizable even if they do blend at the boundaries, and while collecting and classifying we become aware of phytogeographic patterns that correlate with them, like a picture slowly coming into focus. Furthermore we cannot afford to wait indefinitely because the rapid advance of agriculture is eliminating the native flora over much of Brazil.

Maritime Zone

There is always a seacoast and the highly specialized halophytic flora closely follows its extremely narrow and infinitely long zone. For thousands of miles one can pick a stretch of Brazilian coast at random and know that he can find *Ipomoea pes-caprae* (pl. 1) and *Remirea maritima* (fig. 2) on the sand just above high-tide mark or *Rhizophora mangle* (pls. 1, 2) at the seaward end of an estuary. Higher up in the restinga or scrub forest zone or on saltmarsh will be *Hibiscus tiliaceus*. If we had complete records of these species their ranges would form an almost continuous line on the map. This assumption is one of the safest that we will make because maritime conditions are much the same the world over.

However, the maritime flora of southern Brazil has one unusual feature when compared to those familiar in the Northern Hemisphere. So far as present evidence shows, its wide ranging species are all of tropical derivation and none of circumpolar. The list of such strictly or predominantly maritime species would include:

Sporobolus virginicus (Gramineae)
Stenotaphrum secundatum
Remirea maritima (Cyperaceae)
Salicornia virginica (Chenopodiaceae)
Canavalia rosea (Leguminosae)
Hibiscus tiliaceus (Malvaceae)
Rhizophora mangle (Rhizophoraceae)
Conocarpus erecta (Combretaceae)
Laguncularia racemosa
Hydrocotyle bonariensis (Umbelliferae)
Ipomoea pes-caprae (Convolvulaceae)
Scaevola plumieri (Goodeniaceae)

Some of the above like *Sporobolus virginicus* and *Stenotaphrum secundatum* (fig. 3) although predominantly maritime also occur inland. Species like *Rhizophora mangle* on the Ilha de Santa Catarina, reach their limits in southern Brazil, while others extend beyond, but apparently none are found south of the province of Buenos Aires.

There are a number of subtropical species that are common in the

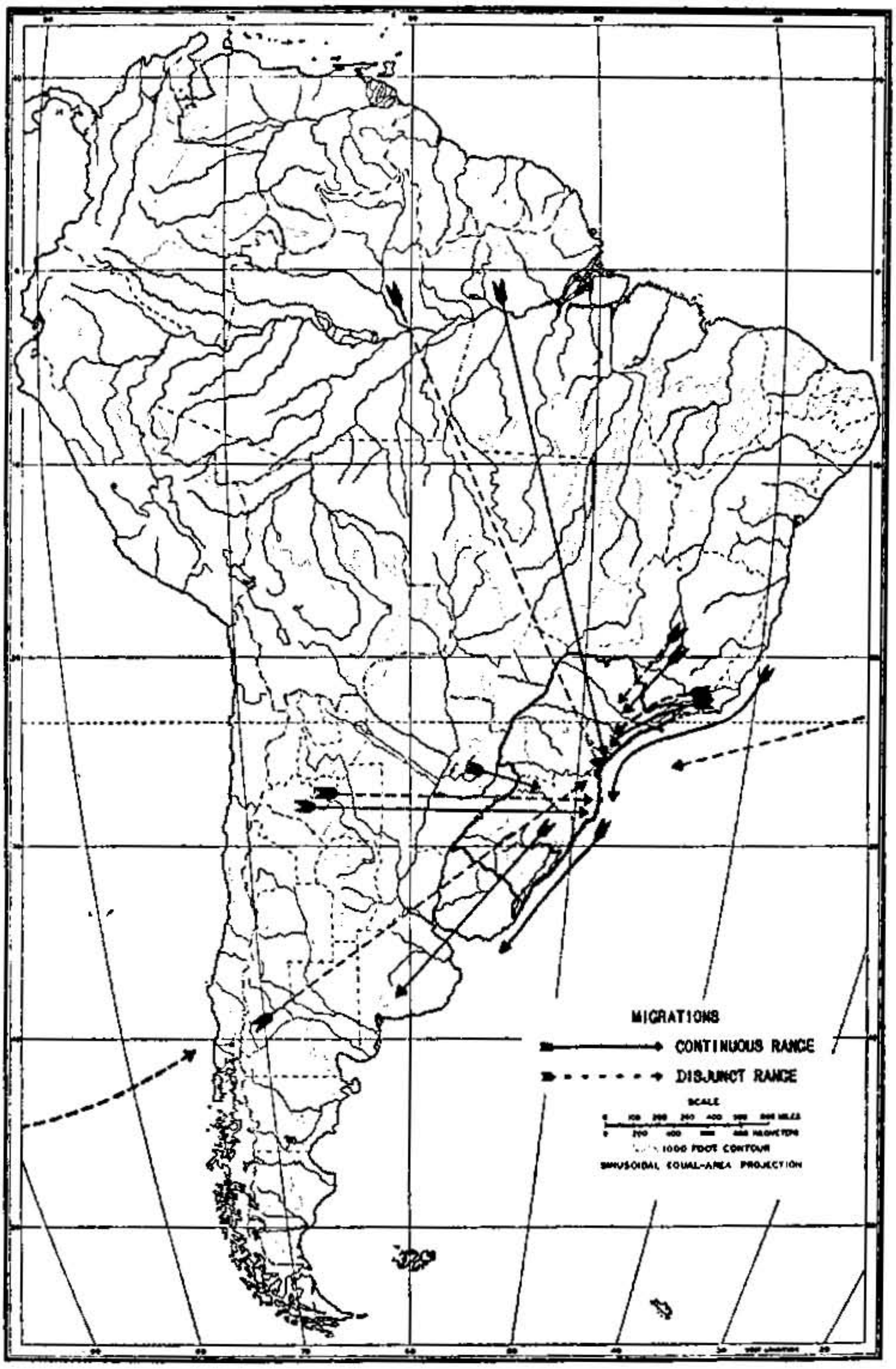

FIGURE 1.—Different types of migration into southern Brazil.

maritime zone from southern Brazil to Uruguay and the province of Buenos Aires. Among them may be noted:

Triglochin striata (Scheuchzeriaceae)
Androtrichum trigynum (Cyperaceae)
Chenopodium retusum (Chenopodiaceae)
Alternanthera maritima (Amaranthaceae)
Acicarpha spathulata (Calyceraceae)

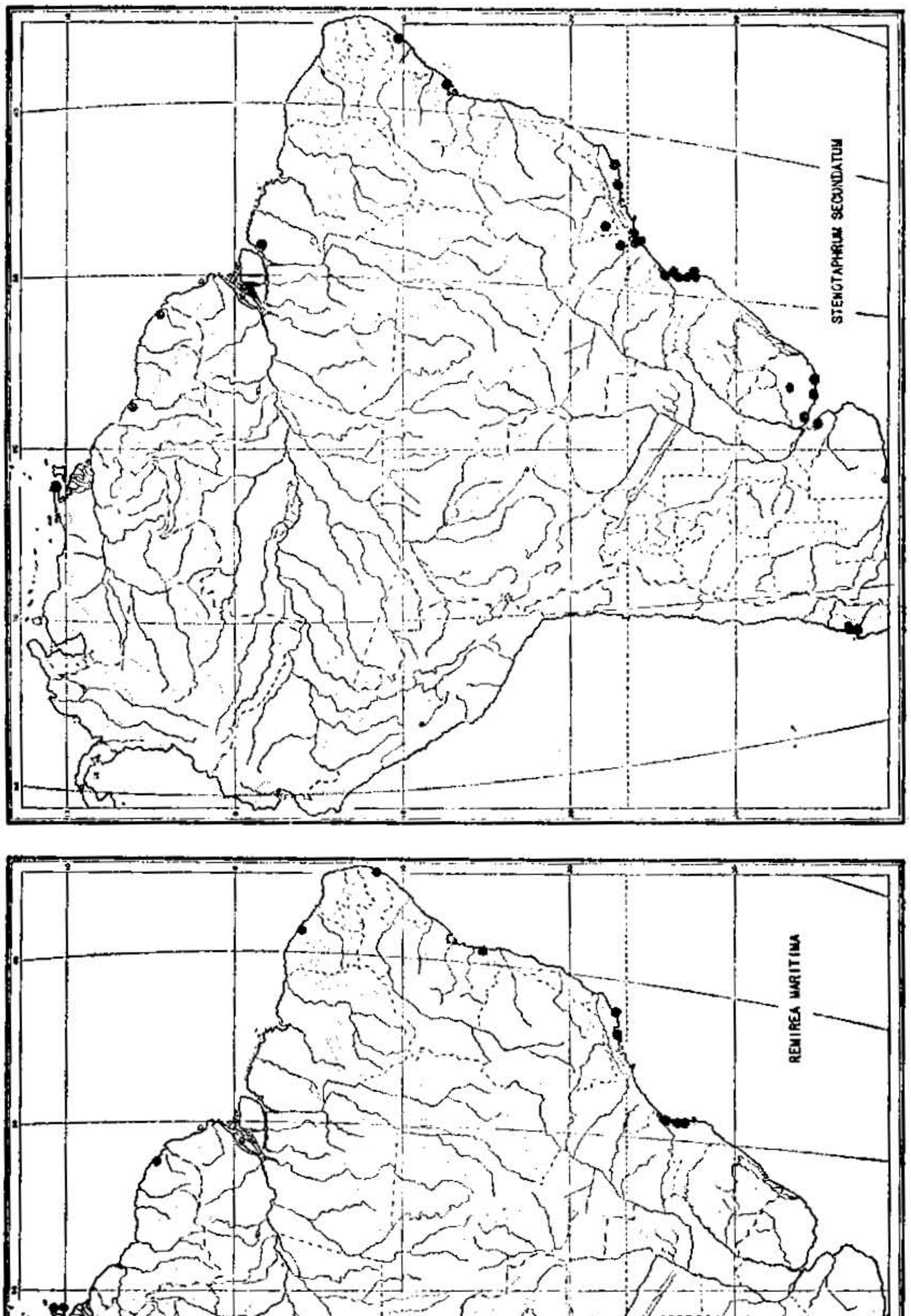

FIGURE 3.—Maritime migration: *Stenotaphrum secundatum.*

FIGURE 2.—Maritime migration: *Remirea maritima.*

PLATE I. Santa Catarina. *Rhizophora mangle* in estuary, Florianópolis. Beyond: Sea beach at Itaiaia; prevailing winds of *Ipomoea pes-caprae* in foreground.

PLATE 2. *Rhizophora mangle*, showing pendulous viviparous fruit. Burnt Coastal rain forest, from top of the Spitzkop pt. B' mountain, Santa Cruz Is.

PLATE 8. Pedra da Gavea, Rio de Janeiro, an outpost for plateau flora in the heart of coastal rain forest. Bottom: Plateau type vegetation on crest of Pedra da Gavea. Flowers of *Barbacenia saxorum* just above top of collector's pole.

PLATE 4. Santa Catarina. Gallery forest along streams in campo of planalto, near Lajes. Background: *Araucaria* forest.

At first glance one might suppose that some of these arrived from the south, but in each case checking reveals that more likely the migration was in the opposite direction or from the west across northern Argentina. Whether southern Argentina was submerged in recent times or not, its present climate appears to be too arid to allow any trace of southern connections below the province of Buenos Aires.

The maritime zone is unlike any of those that follow in that it includes no disjunct ranges. This situation is no more than might be expected from the continuous and constant ecological conditions that it provides.

Coastal Rain Forest

The coastal rain forest (pl. 2) extends some 2000 miles or 3200 kilometers from extreme northern Rio Grande do Sul to the Herval and Tapes Ranges in Rio Grande do Norte. Thus it is about the same length as the Amazonian rain forest though only a fraction of the width. A flight from Trinidad to Rio de Janeiro takes several hours to cross the Amazonian forest but only minutes to cross the coastal. In general the western boundary of the coastal forest is the height of land from which the sea is visible from many points. Only in Santa Catarina does this zone extend inland to a depth of about 100 miles or 160 kilometers.

In relation to its area the coastal rain forest must be fully as rich in species as the Amazonian but the representation by families differs greatly. Some families like the Vochysiaceae (Stafleu, 1948) are obviously remnants of much larger ones of the Amazonian forest, while others like the Bromeliaceae (Smith, 1934) have formed a new center in the coastal forest and evolved many new species and genera. The center of speciation of the coastal rain forest is very close to Rio de Janeiro, now the state of Guanabara. From there the flora deteriorates north and south, so that in the area we are considering the species decrease regularly from São Paulo to northern Rio Grande do Sul.

For example the species of the genus *Vriesea* (Smith, 1955) in the Bromeliaceae are distributed from north to south as follows:

	Species
Espirito Santo	31
Rio de Janeiro and Guanabara (former Federal District)	54
São Paulo	31
Paraná	26
Santa Catarina	28
Rio Grande do Sul	7

The areas of rain forest are not all commensurate, but the comparison between the first three is fairly close on this score. Paraná has much less rain forest and Santa Catarina with its westward bulge much

more, and Rio Grande do Sul only a remnant. If these scores were to be weighted by areas there would be a fairly regular gradation from Rio de Janeiro southward. On the other hand, Rio de Janeiro enjoys the advantage of the greatest amount of collecting, so if this factor could be weighted also, Rio would not stand quite so high above the others.

More graphic pictures of the situation, though unfortunately for a smaller area, are given by Reitz (1953, 1957) for the Palmae (fig. 4) and Araceae (fig. 5) of Santa Catarina. Both show an overlapping pattern of southern species limits like wave marks on a strand or tiles on a roof, presumably due to the differential tolerance of the various species to minimum temperatures. The point was made dramatically when the boom of southward expansion of coffee cultivation was stopped by a severe winter with unexpected frosts.

Reitz's map of the Araceae shows another feature of distribution, the evolution or isolation of local species in a wide ranging genus, *Anthurium*, thus bringing in the element of time in migrations. The other species of *Anthurium* have expanded southward into Santa Catarina without essential change, while the ancestral stock of *A. lacerdae* and *A. pilonense* has not only migrated over the same route but developed new species as well. Whether their present restricted range is due to newness or shrinking from a wider area, it still indicates an earlier arrival for the parent stock than the species that are

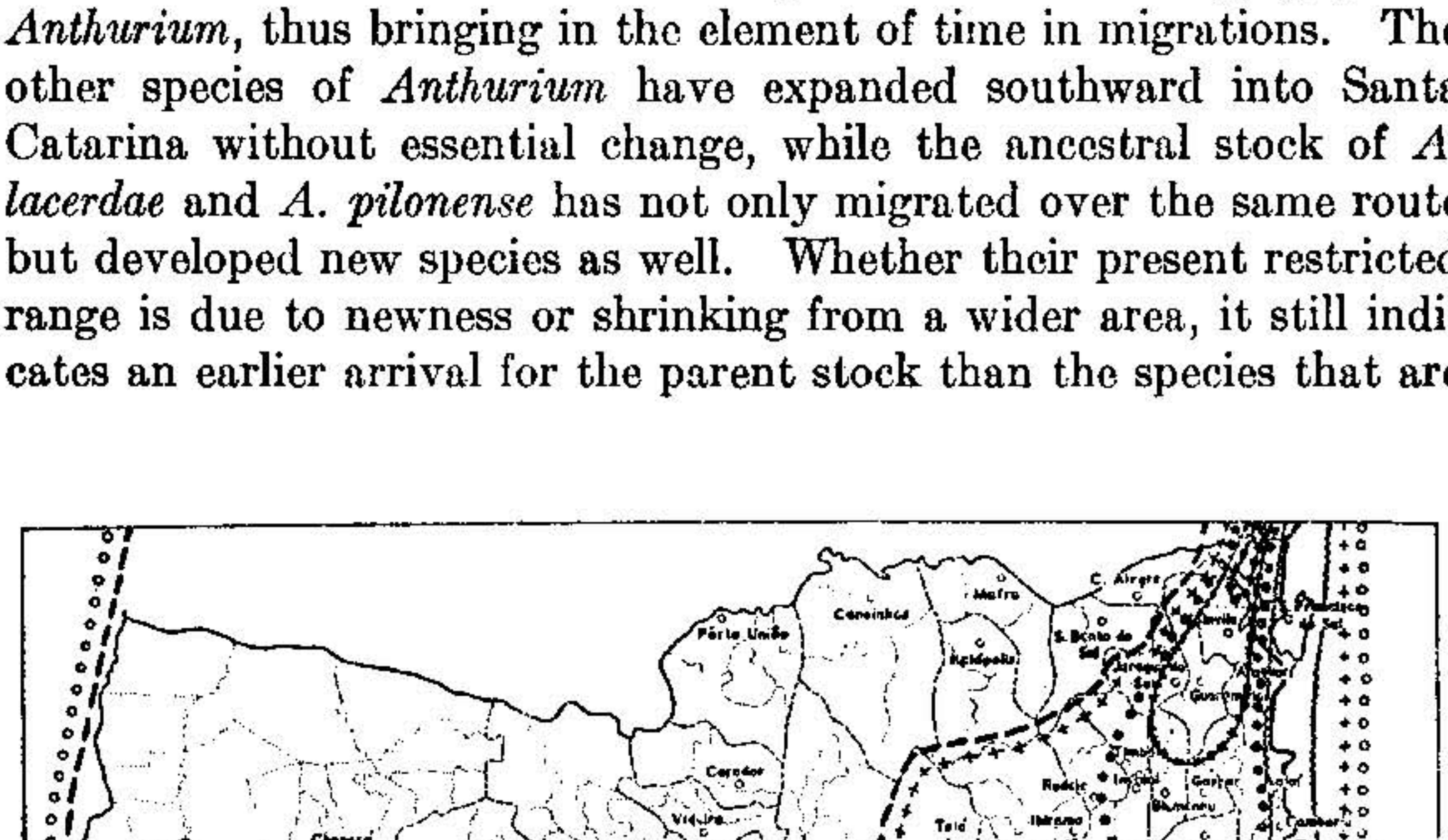

FIGURE 4.—Rain forest migration: Palmae. After R. Reitz 1953.

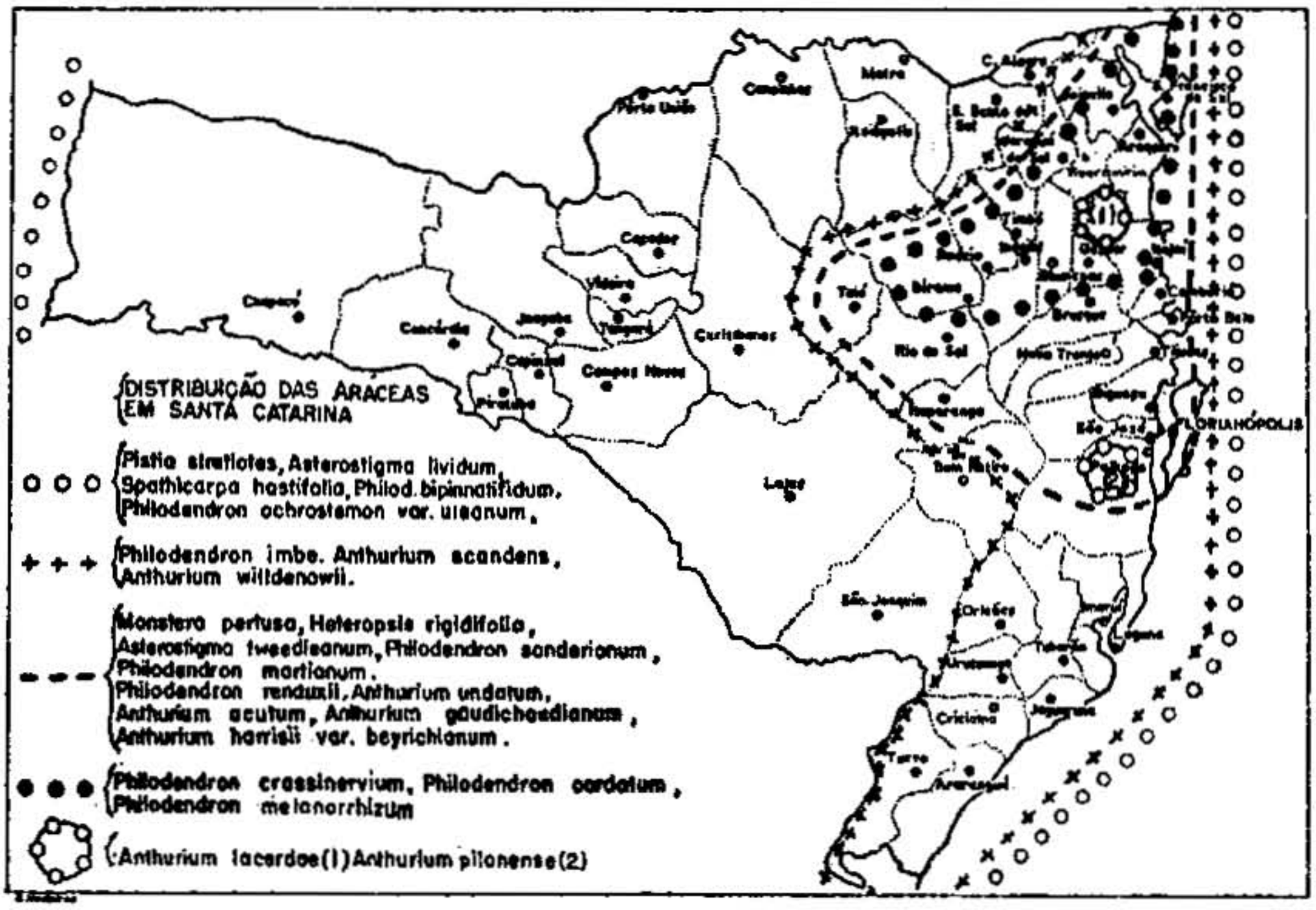

FIGURE 5.—Rain forest migration: Araceae. After R. Reitz 1957.

unchanged. Admittedly there is a possibility that in some cases species have evolved at different speeds, otherwise we should not have any primitive forms of life left in the world. However, within the same genus it would seem less likely for such a difference to be large. The same comparison may be found between genera in different families, where *Vantanea compacta* (fig. 6) is the sole representative of the Humiriaceae (Cuatrecasas, 1961) from Rio de Janeiro to Santa Catarina, while *Quesnelia* (fig. 7) of the Bromeliaceae (Smith, 1955) is represented by several species in Rio de Janeiro and Guanabara, a different set in São Paulo, and still another in Paraná and Santa Catarina. The probability is that *Vantanea* arrived in the rain forest of Santa Catarina ahead of *Quesnelia*, the year to year change of position in migration being more perceptible than the change of form in evolution.

The rain forest of southern Brazil also shows evidence of migration from the Amazonian rain forest (fig. 1), though of course to a much lesser degree than from the much closer center of Rio de Janeiro. The smallness of the Amazonian element is easy to understand when one considers the extensive barrier interposed by the high dry planalto area that lies between the two rain forests for a minimum distance of over 700 miles or 1100 kilometers. For many genera and even some families this climatic barrier is as effective as an ocean. Others, however, have found a bridge across through the network of gallery

forests (pl. 4) that break up the area. The extent and effectiveness of this planalto barrier has fluctuated in the past and is still visibly fluctuating now. As has long been pointed out, new young tree growth invades the campo or prairie of the planalto as the climate grows moister or dies back as it grows drier. This is comparable to the constantly shifting division between long grass and short grass prairie in central United States and Canada.

The different patterns of migration from the Amazonian rain forest would indicate that there have been major fluctuations in the climate so that the barrier of the planalto has been bridged at different times for different groups of plants. Beginning with the migrations that appear most recent because the species extend across northern and central South America without any noticeable change or at most with forms that show no geographic correlation, we have (figs. 8–10):

Protium heptaphyllum (Burseraceae—fig. 8, Swart, 1942)
Tapirira guianensis (Anacardiaceae—fig. 9)
Amaioua guianensis (Rubiaceae—fig. 10, Smith & Downs, 1956)

These trees must have migrated by gallery forest or there may have been continuous broad rain forest between the Amazon and the east coast under more favorable conditions.

Other species combine Amazonian and Andean distribution and appear to have spread southward through thinner forest at higher elevations. Such are (figs. 11–13):

Chlorophora tinctoria (Moraceae—fig. 11)
Casearia silvestris (Flacourtiaceae—fig. 12)
Psychotria carthagenensis (Rubiaceae—fig. 13, Bacigalupo, 1952)

On present evidence they have flanked the planalto rather than crossed it, but further collecting in the interior could change this picture considerably.

There are also certain weedy species that are not truly Amazonian but show much the same overall distribution, not because they are characteristic of the forest but because they immediately take advantage of any break in it, however small. Such are (figs. 14–16):

Axonopus compressus (Gramineae—fig. 14, Black, ined.)
Xyris caroliniana (Xyridaceae—fig. 15, Smith & Downs, ined.)
Polygonum punctatum (Polygonaceae—fig. 16)

At the other extremity of distributional types is the case of the genus *Vochysia* (fig. 17). Here nearly the same area has been covered, but the migration has been so slow that there has been time for the evolution of a completely new set of species on the planalto and almost another in the coastal rain forest. There is also the disjunct of *Quiina* (fig. 18, Pires, ined.) with one species, *Q. glaziovii*, on the coast and the remainder confined to the Amazon basin. This may indicate a still older migration because of the absence of planalto species, although there is always the possibility of others turning up there.

The migration appears to have taken place at different points all across the planalto judging by the occurrence of some species over nearly the entire length of the coastal rain forest. A very few like *Chlorophora tinctoria* (fig. 11), *Casearia silvestris* (fig. 12), and *Psychotria carthagenensis* (fig. 13) have even connected with the Rio Paraguay Basin and entered southern Brazil across the top of Rio Grande do Sul, meeting the final segment of the coastal rain forest in the northeast corner of the state. However, the Amazonian element is minor, the Paraguayan Basin having developed a flora of its own to an even greater extent than has the coastal rain forest.

Paraguayan Rain Forest

The rain forest of the Rio Paraguay Basin is not a continuous area comparable to the Amazonian or the coastal rain forests but a collection of gallery forests that are so broad that they merge when large rivers lie close together as in the Misiones Territory of Argentina. A comparison of Richards's description of typical rain forest (Tropical Rain Forest, pp. 2–7) and Hauman's of that in Misiones (La Vegetacion de la Argentina, pp. 14–41) shows agreement in all details, yet Richards in his figure 2 follows A. C. Smith and Johnston (Verdoorn, Plants and Plant Science in Latin America, pp. 12, 13) in ignoring this area on his map. Hoehne (Ind. Pl. Com. Rondon, p. 12) and Rambo (Sellowia, No. 7, p. 185) both emphasize the gallery character of this rain forest and their view is much broader than Hauman's, so that Richards after all would seem justified in not including this area had he not included similar fragments in northern South America.

Be that as it may, the southern part of the Paraguayan forest extends over eastern Paraguay, Misiones, and the extreme western parts of Paraná, Santa Catarina, and Rio Grande do Sul, and has developed a very distinctive flora. It has invaded southern Brazil up the Rio Uruguay and its tributaries, and its migration shows the same overlapping pattern of distribution as that of the coastal rain forest but with an eastward instead of a southward direction. In Santa Catarina where it is known as "mato branco" the forest is quite obviously expanding up the river valleys and invading the Araucaria and campo zones (personal field observation and Klein, 1960). Rambo notes the same movement in Rio Grande do Sul. Of the four hundred species listed for the upper Rio Uruguay by Rambo (1956a, pp. 191–207) special mention might be made of the following to illustrate the type of ranges in the Paraguayan forest flora (figs. 19–26):

Pseudoplantago friesii (Amaranthaceae—fig. 19, Smith & Downs, 1960)
Balfourodendron riedelianum (Rutaceae—fig. 20, Cowan, 1960)
Holocalyx balansae (Leguminosae—fig. 21, Burkart, 1943)
Bernardia pulchella (Euphorbiaceae—fig. 22, Smith & Downs, 1959)

Euphorbia sciadophila (Euphorbiaceae—fig. 23)
Diatenopteryx sorbifolia (Sapindaceae—fig. 24, Radlkofer, 1931–34)
Patagonula americana (Boraginaceae—fig. 25)
Dunalia breviflora (Solanaceae—fig. 26, Sleumer, 1950)

Some species have rather restricted ranges like *Pseudoplantago friesii* and *Holocalyx balansae*, while others such as *Bernardia pulchella* and *Dunalia breviflora* have crossed the planalto and the divide and entered the coastal rain forest. It has been claimed that new or isolated species do not occur in the Paraguayan forests of southern Brazil, which would indicate a recent migration. Certainly they are not so evident as in the coastal rain forest. On the other hand, such monotypic endemics as *Pseudoplantago* (fig. 19), *Aphaerema* (Flacourtiaceae), and *Schenckia* (Rubiaceae), would argue a rather distant origin for the Paraguayan forest flora as a whole.

Northern Campo Flora

The campo or prairie flora of southern Brazil derives in part from the central Brazilian highland or planalto and in part from the Andes. It is a crazy quilt cut by a fine dendritic pattern of angiosperm gallery forest in much of São Paulo and Rio Grande do Sul and occurring only as isolated openings in the Araucaria formation of Paraná, Santa Catarina, and northern Rio Grande do Sul. It is considered by some to be the oldest of the large formations and the lack of a well defined pattern of distribution would support the idea. Several families and many genera center in Minas Gerais on the planalto, but it is even more difficult than in the Amazonian flora to find species with a continuous distribution into southern Brazil.

The Velloziaceae (fig. 27), one of the most characteristic families of Minas Gerais, well illustrates this situation. The plants grow on dry barren slopes and crests and the species in most cases have small ranges. The few that reach southern Brazil are isolated species known from a single locality each. Incidentally this family also illustrates a fallacy of some plant geographers. Its world range has been shown as a line enclosing the whole Amazon basin, while its true occurrence there is limited to a few bare peaks near the edge of it. Similarly the points indicated for Velloziaceae in the area of the coastal rain forest all represent bare granite peaks rising above the forest (pl. 3).

Perhaps *Dyckia* (fig. 28) in the Bromeliaceae is a better example because it ranges over the planalto of all southern Brazil and beyond, though it does include more species on the coast and in open spots in the coastal rain forest. Again the species are mostly narrow endemics. There are 28 species in Minas Gerais against only 2 in Rio de Janeiro and Guanabara showing that it is truly a genus of the planalto, and

the numbers hold up well southward with 7 in São Paulo, 8 each in Paraná and Santa Catarina, and 9 in Rio Grande do Sul.

The Eriocaulaceae are undoubtedly the most extreme case of high concentration in Minas Gerais rapidly dwindling out in southern Brazil as the distribution of the species of *Paepalanthus* illustrates (from Moldenke, 1959 a–b, 1960):

	Species
Minas Gerais	660
Rio de Janeiro and Guanabara	21
São Paulo	27
Paraná	9
Santa Catarina	8
Rio Grande do Sul	5
Paraguay	2
Argentina	0
Uruguay	0

It has been difficult to find single species to illustrate the full sweep from the central planalto south, which is probably another indication that the flora is old and that its genera have had time to break up by evolving new species to fit local conditions. Either the ranges are too limited to give a good illustration or they spread out into the coastal zone taking advantage of open areas and thus are not wholly typical of the planalto. However, the following give some idea of the situation (figs. 29–33):

Esterhazya splendida (fig. 29—partly coastal) (Barroso, 1952)
Baccharis anomala (fig. 30—partly coastal)
Baccharis megapotamica (fig. 31—not known to be coastal)
Vernonia nitidula (fig. 32—partly coastal)
Vernonia platensis (fig. 33—not known to be coastal)

Some species like *Lobelia camporum* are found throughout the campo of southern Brazil up to the highest points but are indifferent to altitude and occur also at low levels along the coast. Even such species of general distribution in the area are disjuncts in a sense because the campo itself is disjunct and does not provide the means of a continuous range.

Andean Flora

The genera that have invaded southern Brazil from the Andes show the greatest diversity in distribution of all that we have studied so far, indicating the longest time elapsed during the migrations from first to last. Some genera include single species that bridge the gap and go far beyond, while others are widely disjunct with few, localized, and distinct species on either side. The first represent extremely recent migrations and the second ancient ones and there are many intermediate cases.

The recent type of migration is shown by *Tillandsia usneoides* (fig. 34) of the subgenus *Diaphoranthema*. Its range is so large that it is thought of as neotropical. Yet its kindred are all represented and in some cases confined to a small area in northwestern Argentina and vicinity (Smith 1934, 1935). Further testimony of its Andean origin and preference for cool climate is shown by its avoidance of the Amazon basin and its extension in the United States as far north as Virginia, the extreme point in the Bromeliaceae by over 500 miles or 900 kilometers. Its recent evolution is shown by its highly specialized structure, with the inflorescence reduced to a single flower and the leaves taking over the functions of the lost roots. Everything points to *Tillandsia usneoides* having been the latest invader of southern Brazil from the Andes.

However, most genera of Andean origin do not include single species extending all across South America and have a maximum distribution in the east from slightly north of Rio de Janeiro to Uruguay. Almost all of these have the greater part of their eastern range in the four southern Brazilian states and many do not extend beyond. Also in the larger examples of this pattern there is a link across northern Argentina to the area of distribution in the Andes. The species of southern Brazil are plants of cool moist climates and have their center of speciation on the crests of the divide and from there extend westward on the planalto mingling and competing with the flora of the northern campo zone. The species connecting across northern Argentina are necessarily more tolerant of heat and aridity than those on either side of them. The ranges of the Andean genera have been pinched in the middle by the southward push of Amazonian heat and the northward push of Patagonian aridity (fig. 35). In many cases the link has been completely broken. This situation makes interesting comparison with North American disjunctions between east and west where glaciation has been used as an explanation. The most recent glaciation in South America preceded flowering plants, so that climate alone accounts for not only the occurrence of the disjunction but for its continuance also.

One of the best examples we know of a wide ranging Andean element in southern Brazil is the genus *Hypericum* (fig. 36). It has numerous species endemic to the Andes and 25 found only in eastern South America (Smith, 1958b). *Hypericum connatum* by a strange coincidence is the link across, its name referring not to this but to its perfoliate leaves. In addition to what is indicated on the map, there is *H. mutilum* of North America occurring on both sides of South America apparently from pre-Columbian times, *H. perforatum* recently naturalized from Europe, and *H. gentianoides*, a natural disjunct with North America.

The genus *Berberis* (fig. 37—Schneider, 1904–05) has an overall appearance in South America much like *Hypericum*, but has a single disjunct species, *B. montana*, occurring in central Chile and on Campo dos Padres, the highest peak in Santa Catarina. It is thus intermediate between *Hypericum* and the genera that are completely disjunct.

Herreria (fig. 38) is unusual in having more species in the east than in the west (Smith, 1958a) and unlike *Hypericum* and *Berberis* does not occur outside South America. It still has a link across northern Argentina. *Viviania* (fig. 39), however, has lost all connection and has no species common to both areas (Knuth, 1912). *Crinodendron* (fig. 40) is similar but its representation in southern Brazil is limited to *C. brasiliense* (Reitz & Smith, 1958), endemic to the peak of Campo dos Padres.

Araucaria (fig. 41) is represented by *A. angustifolia* in southern Brazil (pl. 4) and *A. araucana* in the southern Andes on the Argentine-Chilean boundary, and by a number of species in Australia and the southwestern Pacific region. The disjunction is the longest we have met of this type, some 1100 miles or 1800 kilometers, and at the same time the most certain. Herbs or low shrubs might be overlooked in some sheltered spot in the interval, but there is no chance of hiding the stately pinheiro. It still shows movement as its heliophile progeny slowly invade the campo, but on the other side it is losing at a much faster rate to the inroads of the Paraguayan forest and to man (Klein, 1960).

Cordyline (Baker, 1875) of the Liliaceae has a range much like that of *Araucaria* except that there is no Andean species known to link *C. dracaenoides* (fig. 42) of southern Brazil with the rest of the genus on the other side of the Pacific. It might equally well be classed with our overseas disjuncts except for this similarity.

Overseas Disjuncts

Under the title of overseas disjuncts we have a miscellany of odds and ends, some of which are probably pre-Columbian arrivals in southern Brazil and others that are not, but are obvious weedy newcomers. Sometimes it is difficult to decide which. *Arenaria groenlandica* on a single peak in Santa Catarina (Smith & Downs, 1960b) and known elsewhere from Georgia to Greenland in North America hardly seems likely to be a weed. *Hypericum gentianoides* of Rio Grande do Sul, Paraguay, and eastern United States (Smith, 1958b) might possibly be a recent introduction, but Rambo who found it in Brazil, thinks it unlikely because of the habitat. *Proserpinaca palustris* (Reitz, 1954) of Santa Catarina and Rio Grande do Sul is indistinguishable from the North American plant. The three taken together and compared with a more nearly continuous range such as that of *Utricularia subulata* make a fairly consistent pattern.

597430—62——2

Links with Africa, whether specific like *Xyris anceps* and *X. capensis* or generic like *Pitcairnia* and *Rhipsalis*, are indirect, with the South American center lying to the north of the area we are considering. The European links, so far as I have been able to ascertain, are all recent weedy introductions. Rambo has covered much of the details of this flora (1960) and its origin is too obvious to need discussion here. If his list is anywhere near complete it would indicate that southern Brazil is not so badly overrun with weeds as are equivalent latitudes in North America.

Acknowledgments

The present paper is an enlargement of one presented at the ninth International Botanical Congress at Montreal in 1959. Unless otherwise noted the range maps have been compiled from specimens in the United States National Herbarium. However, as indicated in the bibliography, I have leaned heavily on monographic and floristic works where available. Personal observations were made throughout the planalto of Santa Catarina in 1956–57 on a grant from the National Science Foundation. The coastal rain forest was studied in 1928–29 on a Sheldon Travelling Fellowship from Harvard University and in 1952 on grants from the Rockefeller Foundation and the Serviço Nacional de Malaria of Brazil. The two most recent expeditions were made jointly with the Herbário "Barbosa Rodrigues" of Santa Catarina.

Unless otherwise indicated, the maps shown in this paper are based on the Goode base map No. 103, copyright 1937 by the University of Chicago.

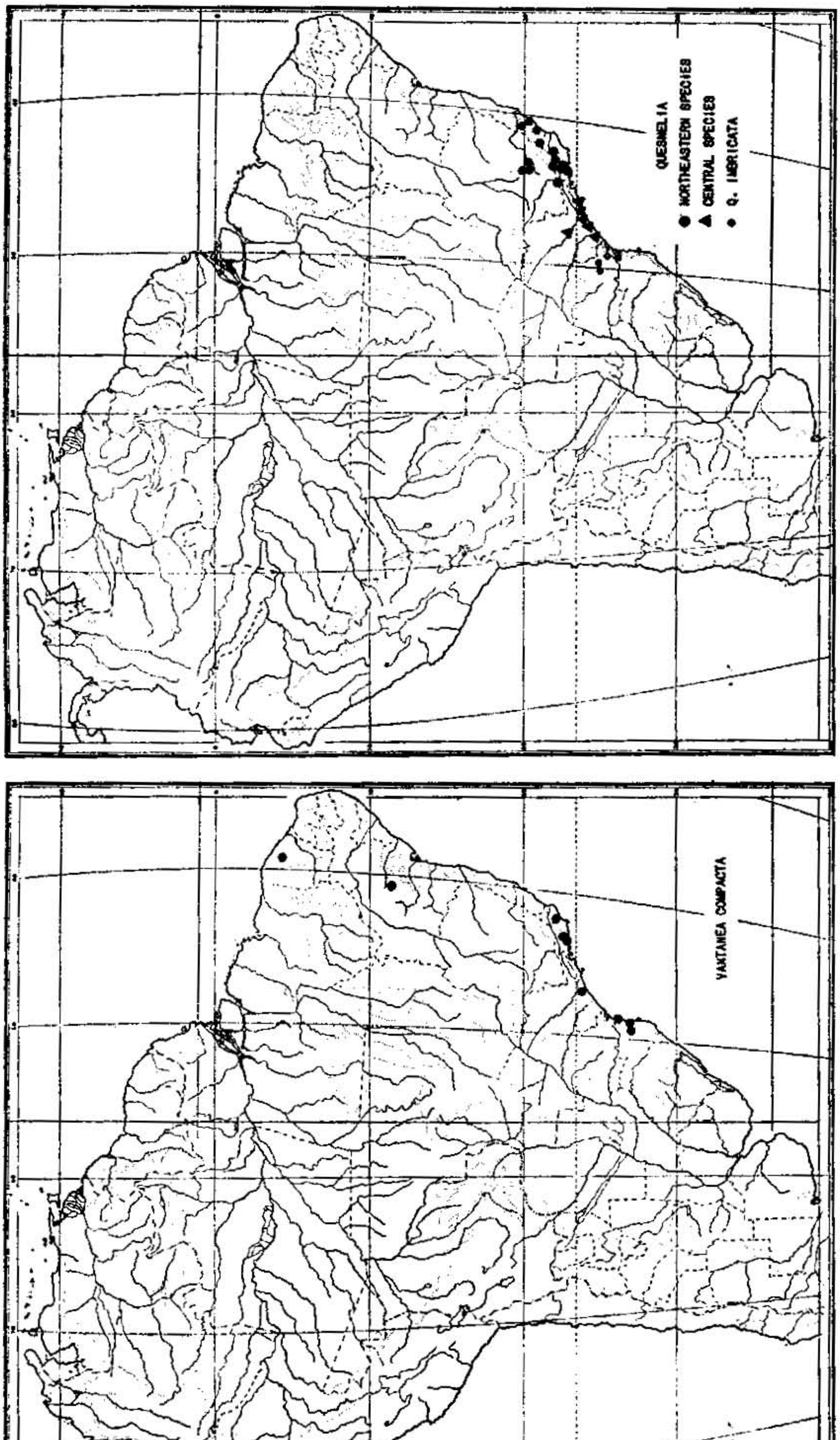

FIGURE 7.—Rain forest migration: *Quesnelia*.

FIGURE 6.—Rain forest migration: *Vantanea compacta*.

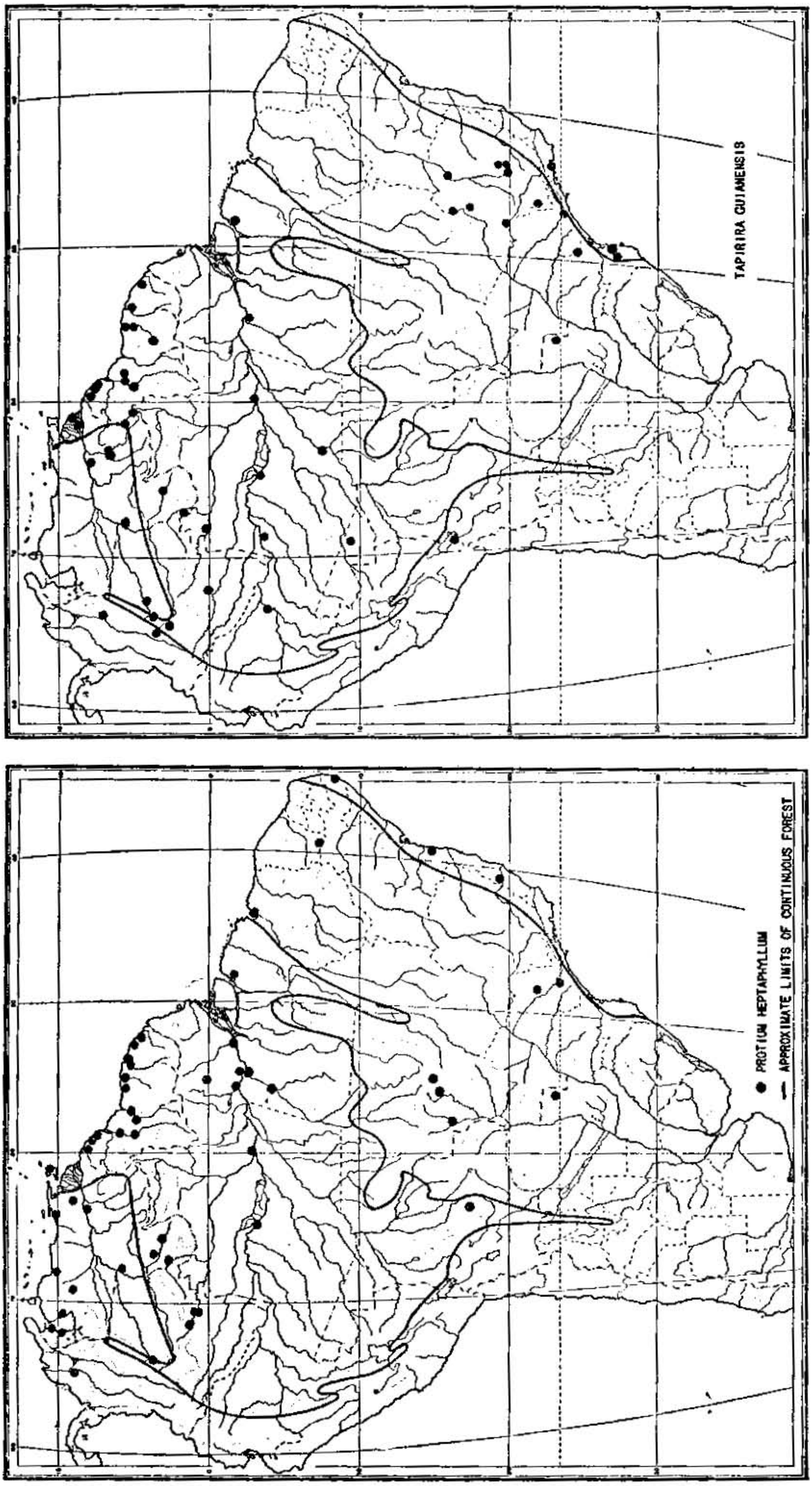

FIGURE 9.—Recent Amazonian migration: *Tapirira guianensis*.

FIGURE 8.—Recent Amazonian migration: *Protium heptaphyllum*.

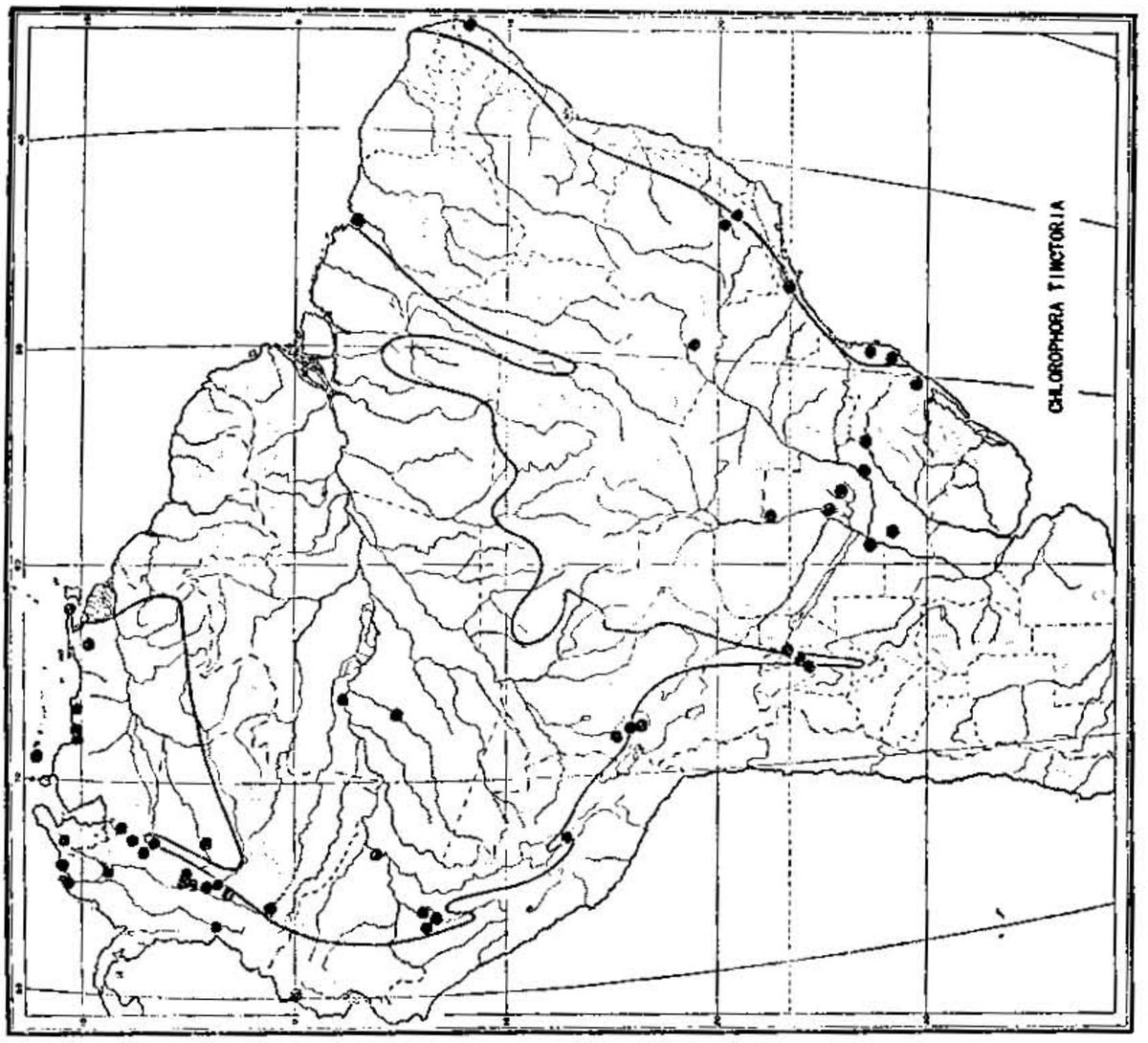

FIGURE 11.—Amazonian-Andean migration: *Chlorophora tinctoria*.

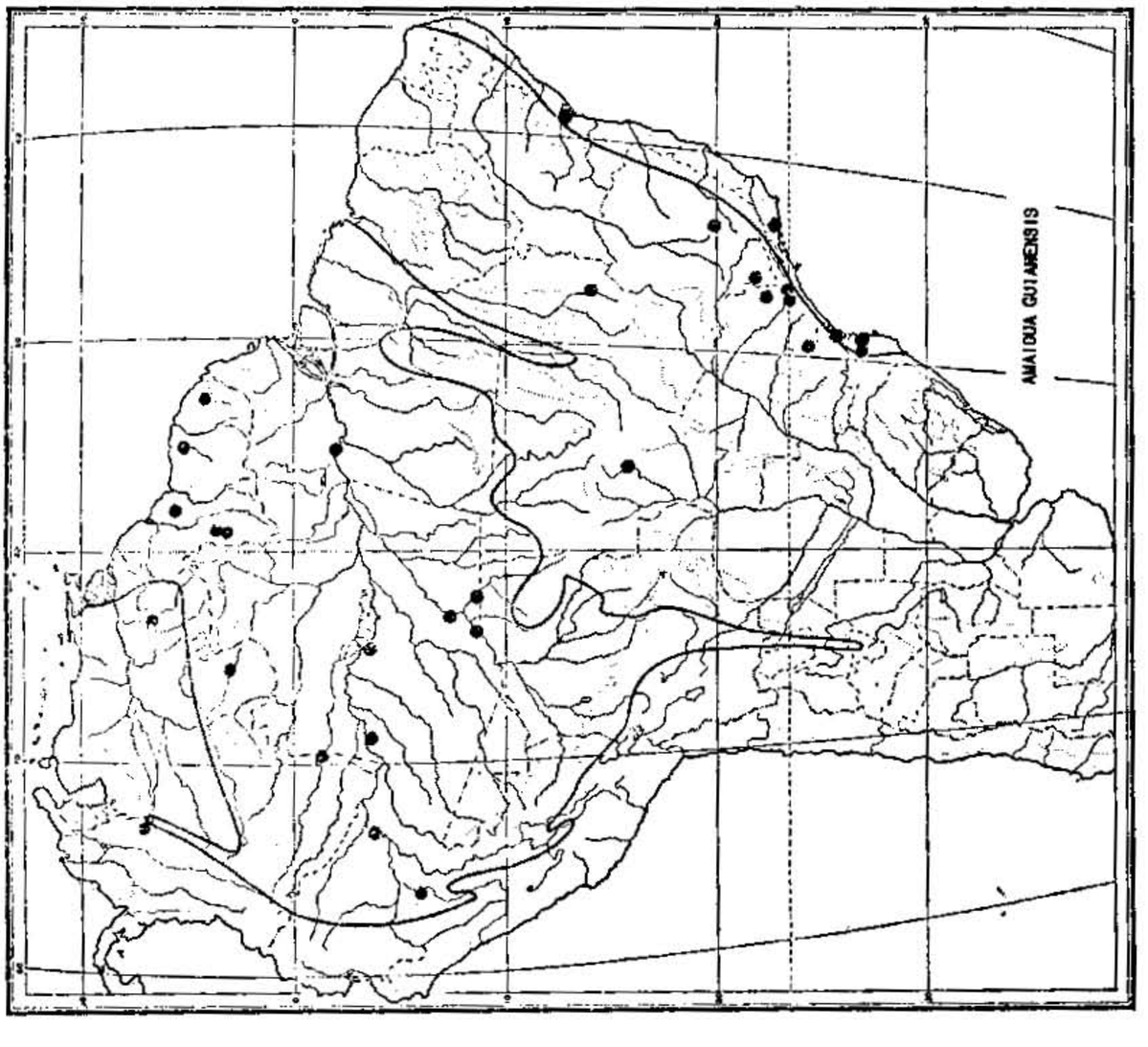

FIGURE 10.—Recent Amazonian migration: *Amaioua guianensis*.

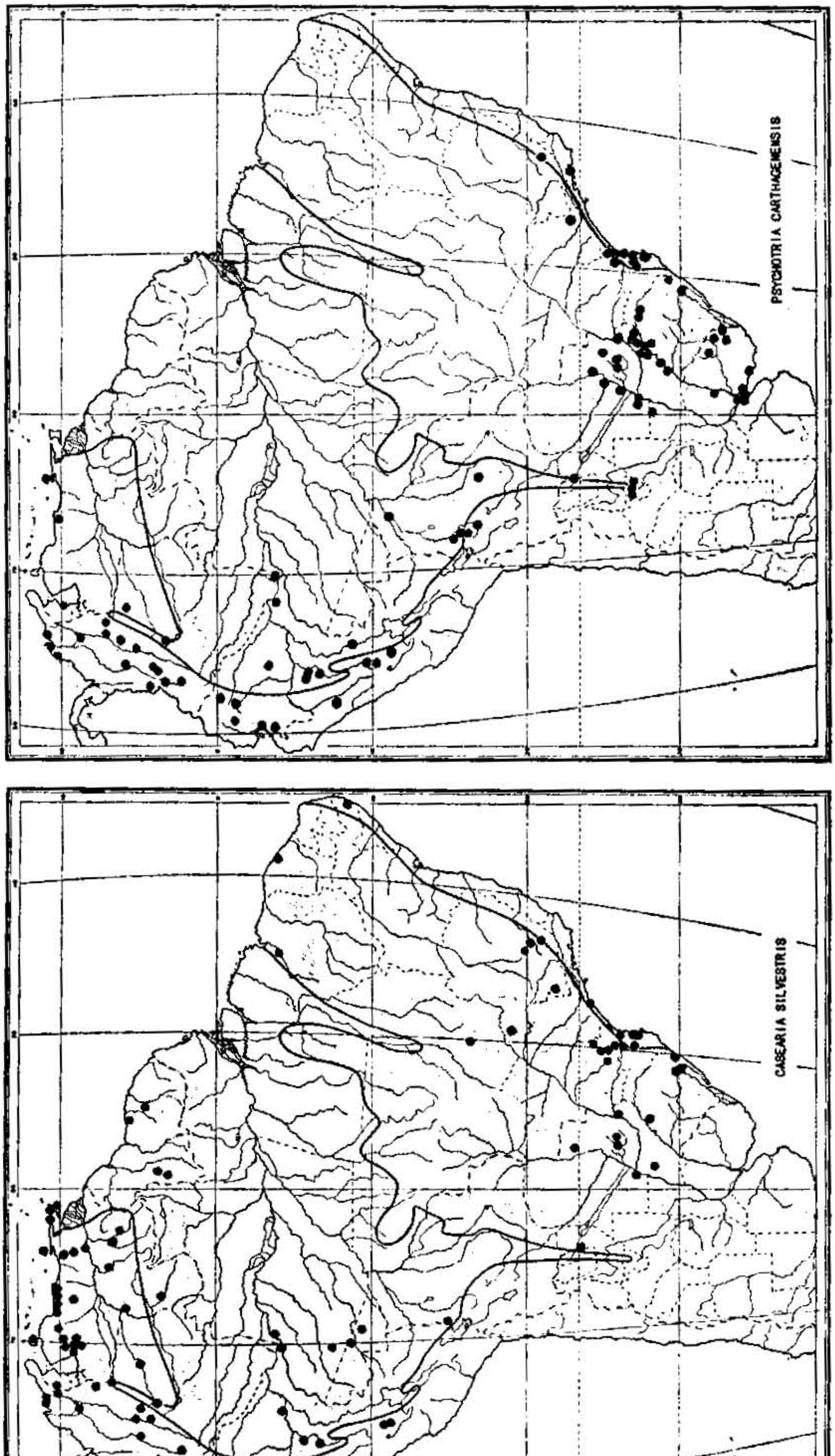

FIGURE 13.—Amazonian-Andean migration: *Psychotria carthagenensis*.

FIGURE 12.—Amazonian-Andean migration: *Casearia silvestris*.

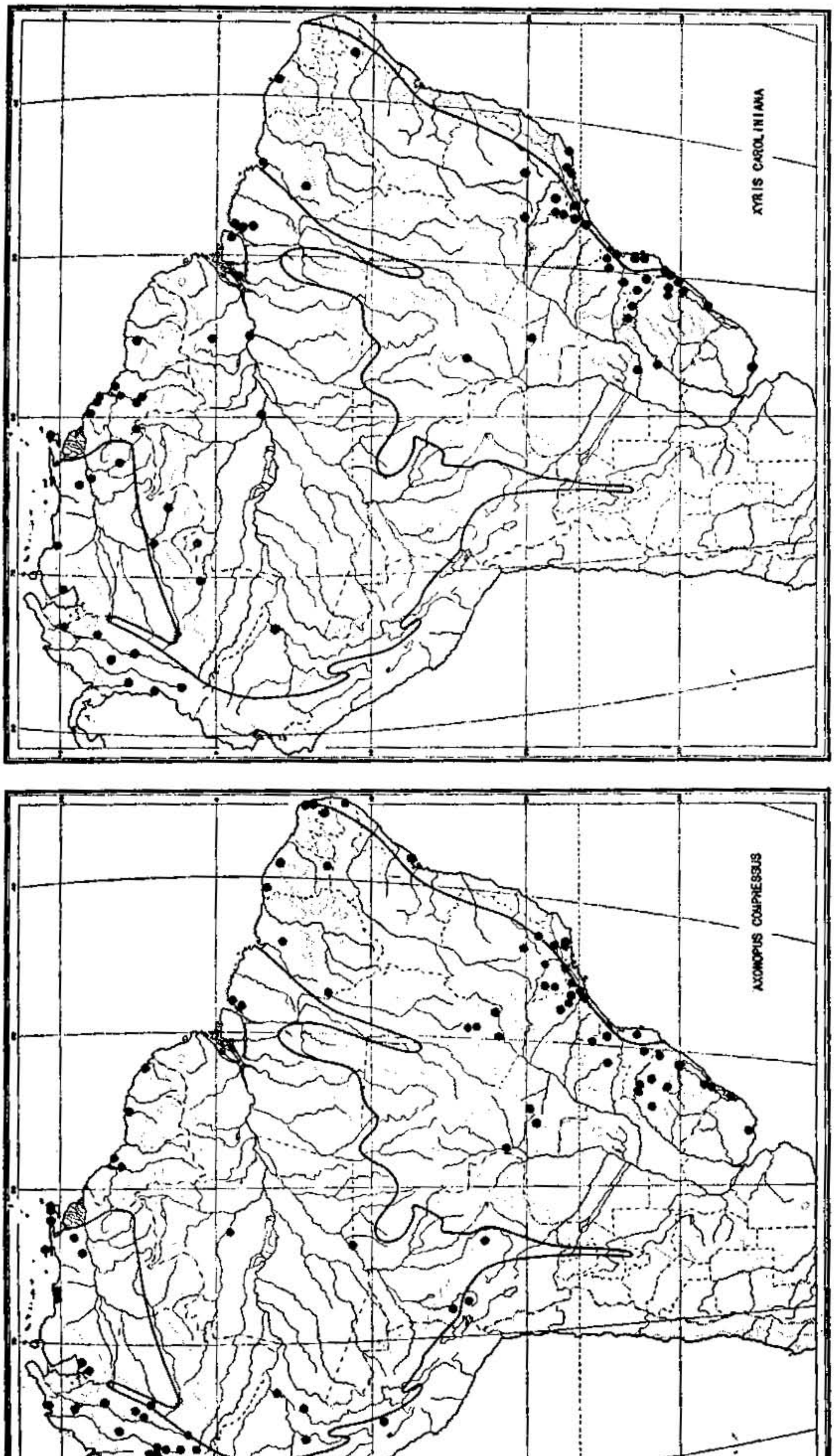

FIGURE 15.—Ruderal migration: *Xyris caroliniana*.

FIGURE 14.—Ruderal migration: *Axonopus compressus*.

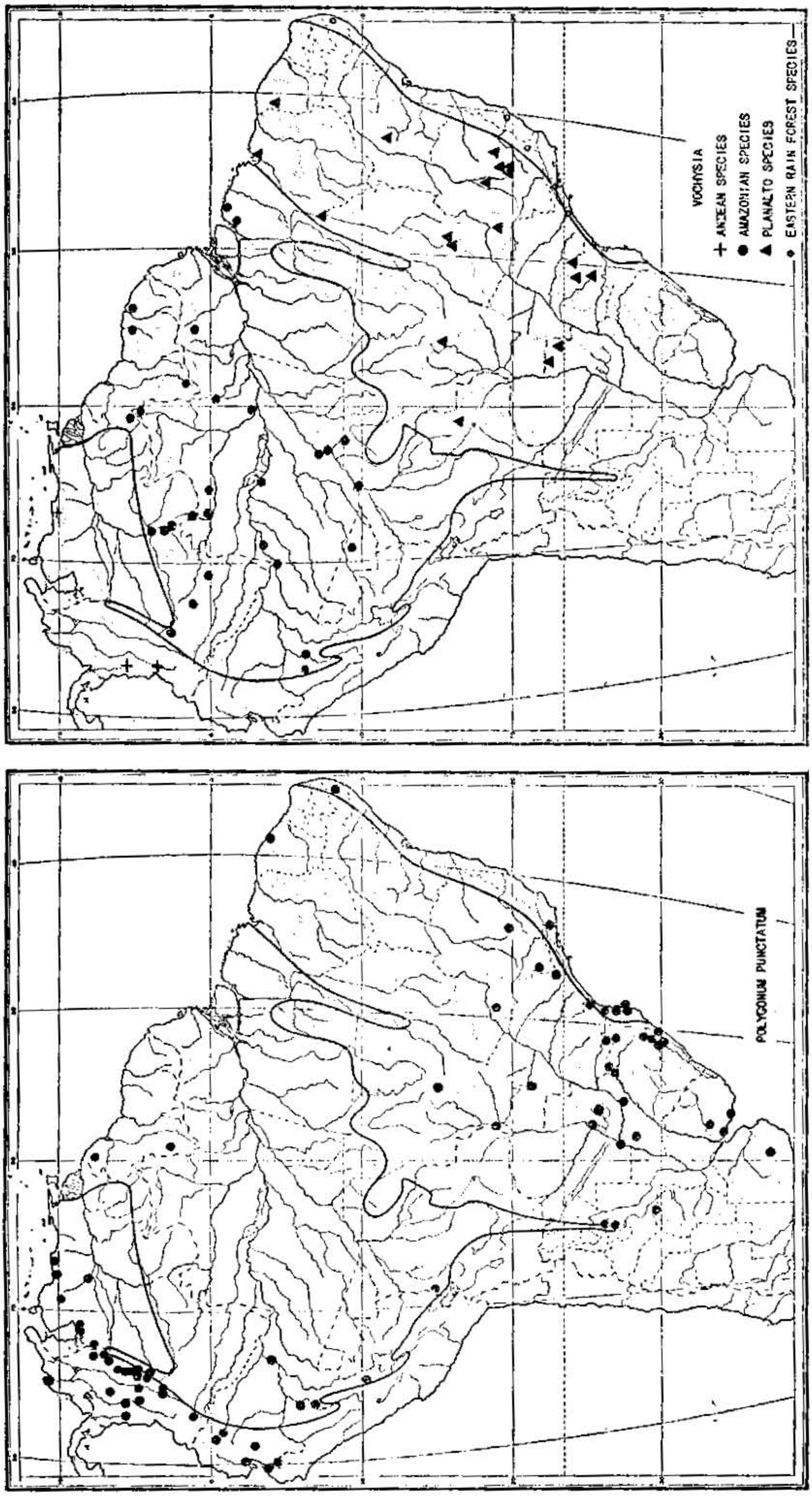

FIGURE 17.—Ancient Amazonian migration: *Vochysia*.

FIGURE 16.—Ruderal migration: *Polygonum punctatum*.

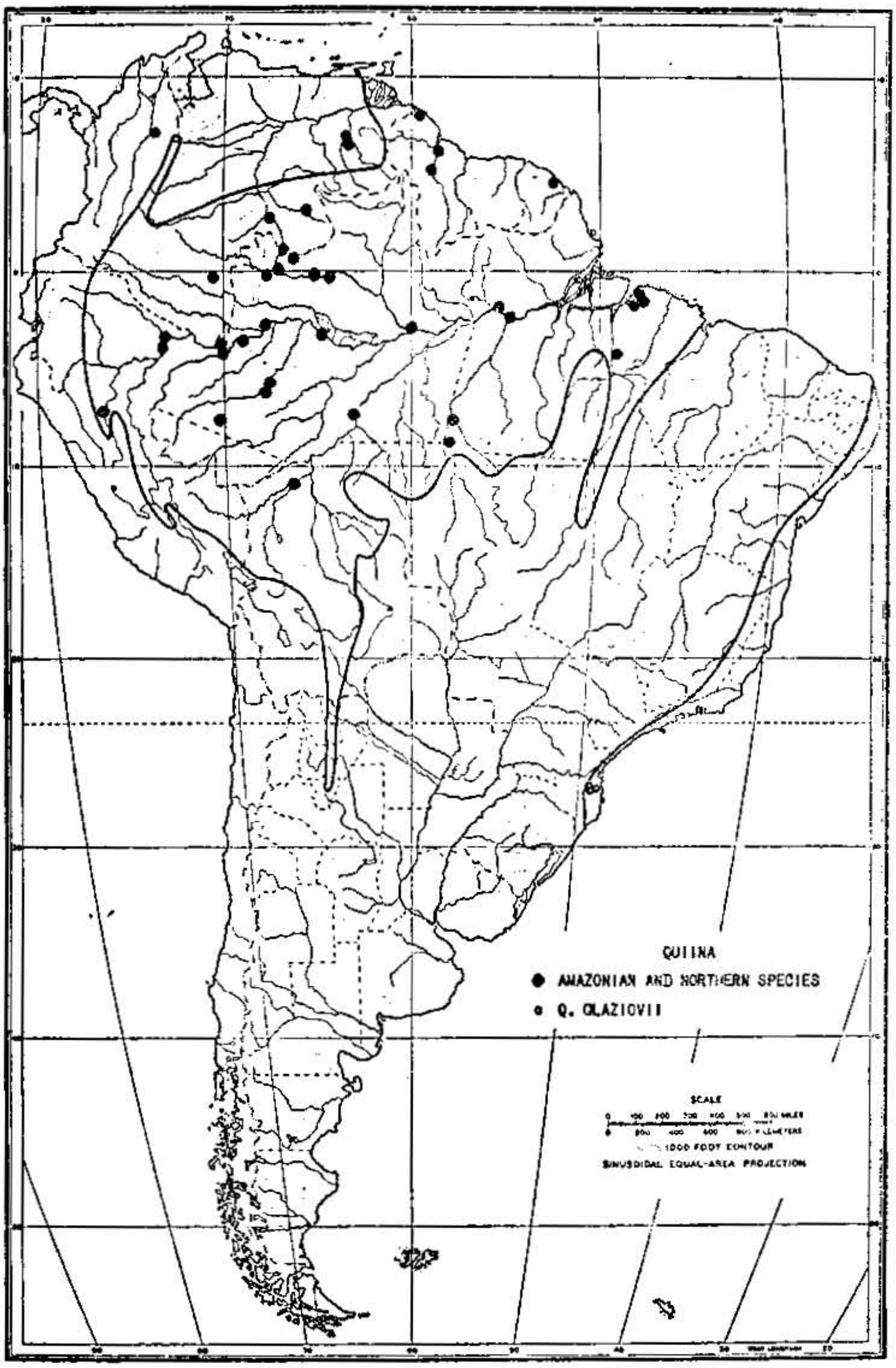

FIGURE 18.—Ancient Amazonian migration: *Quiina*.

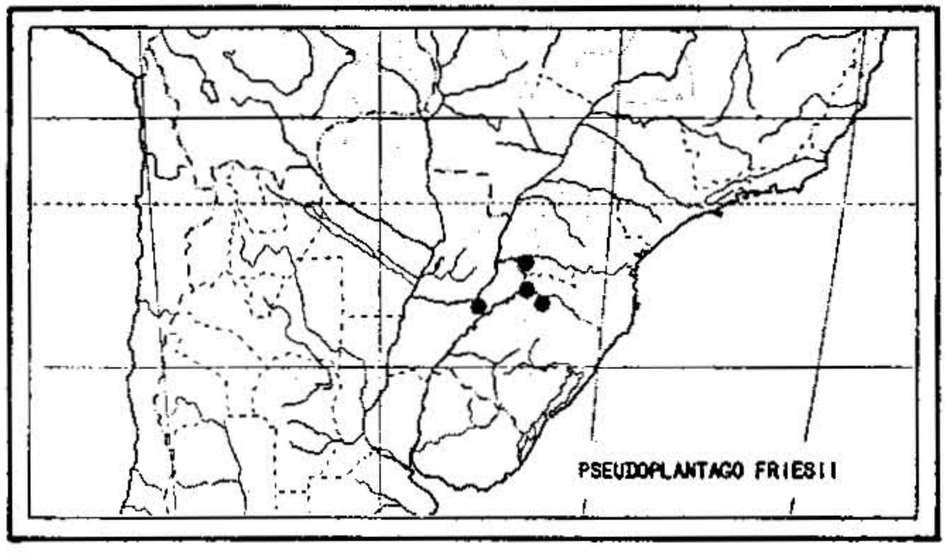

FIGURE 19.—Paraguayan migration: *Pseudoplantago friesii.*

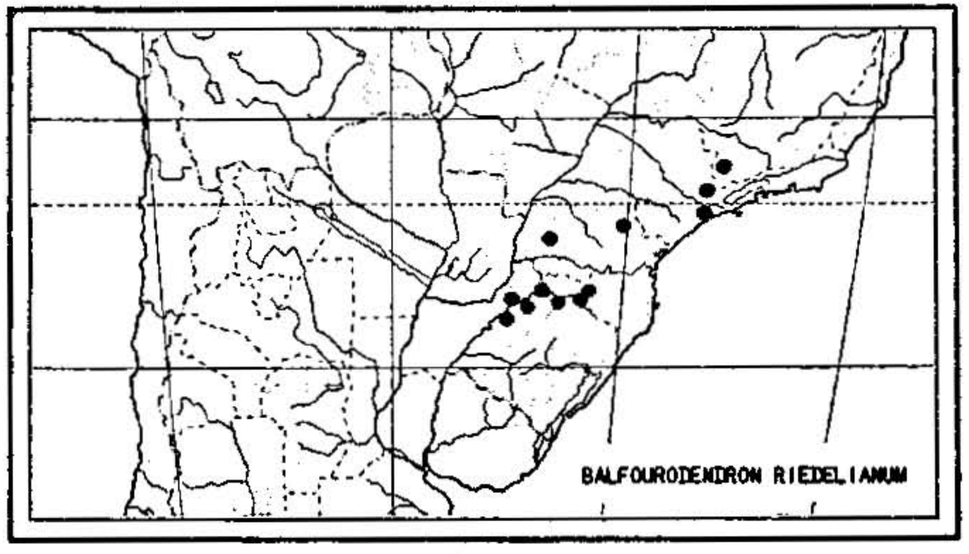

FIGURE 20.—Paraguayan migration: *Balfourodendron riedelianum.*

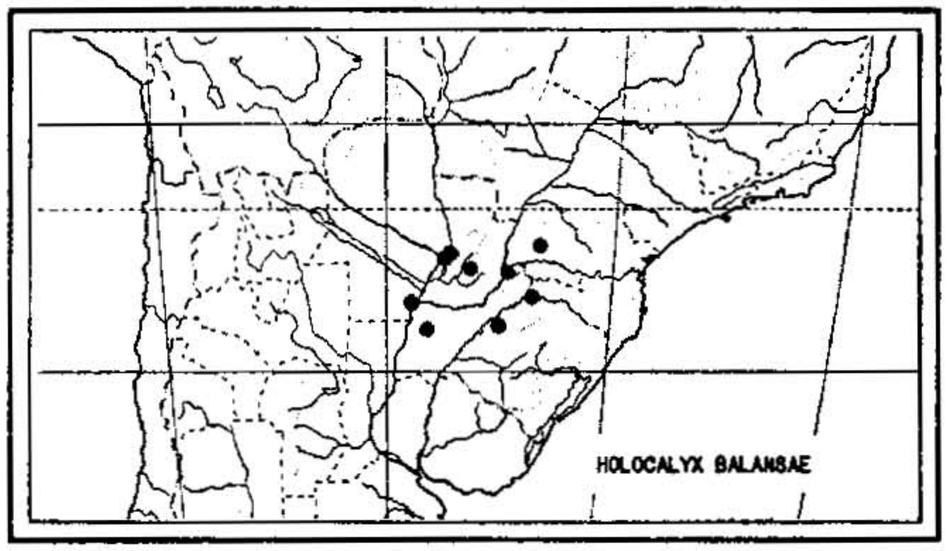

FIGURE 21.—Paraguayan migration: *Holocalyx balansae.*

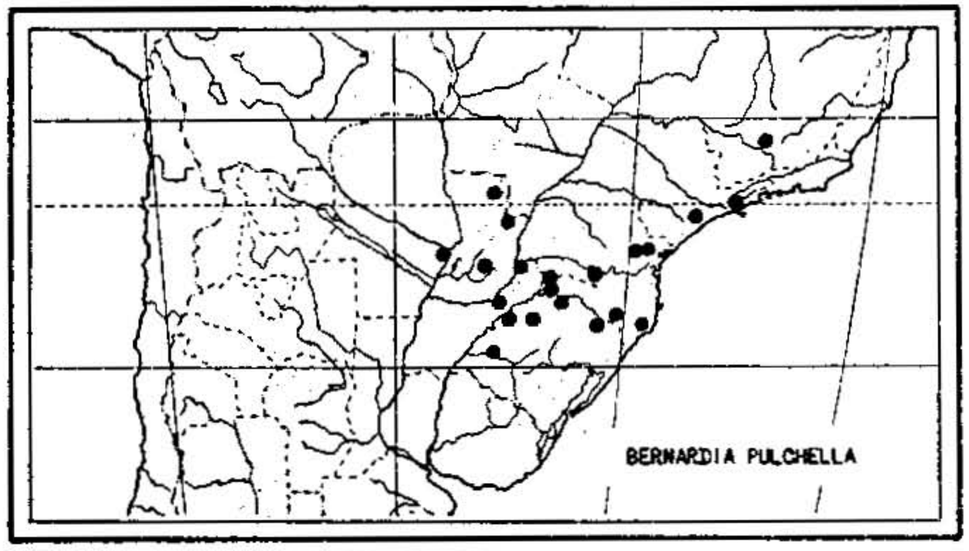

FIGURE 22.—Paraguayan migration: *Bernardia pulchella.*

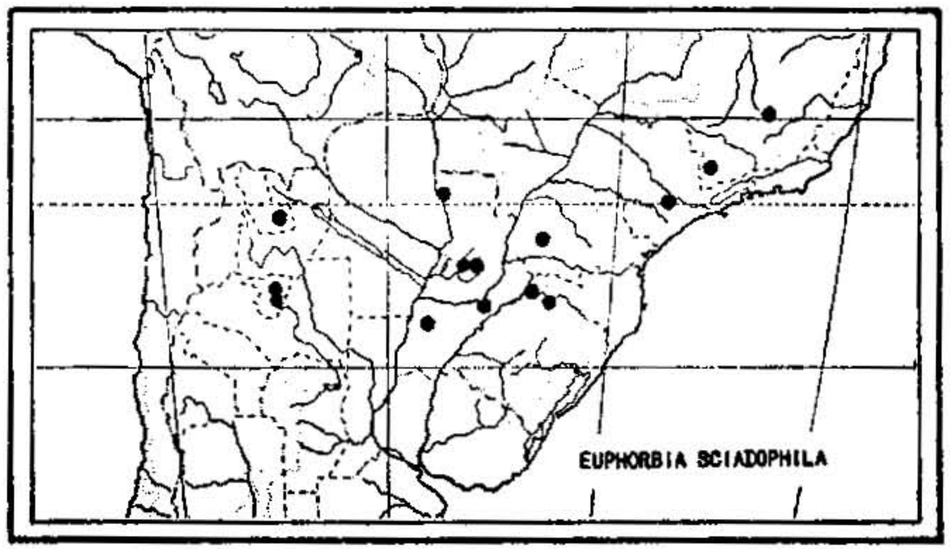

FIGURE 23.—Paraguayan migration: *Euphorbia sciadophila.*

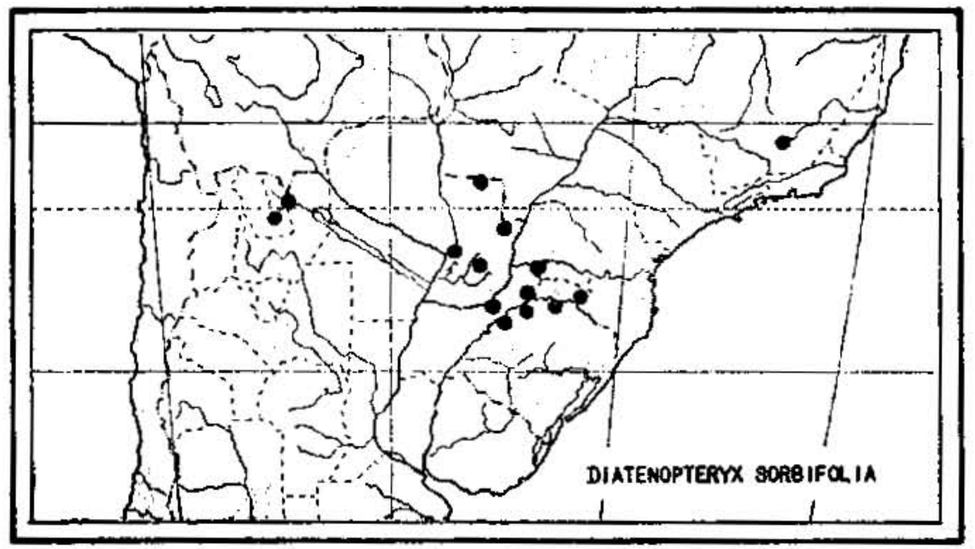

FIGURE 24.—Paraguayan migration: *Diatenopteryx sorbifolia.*

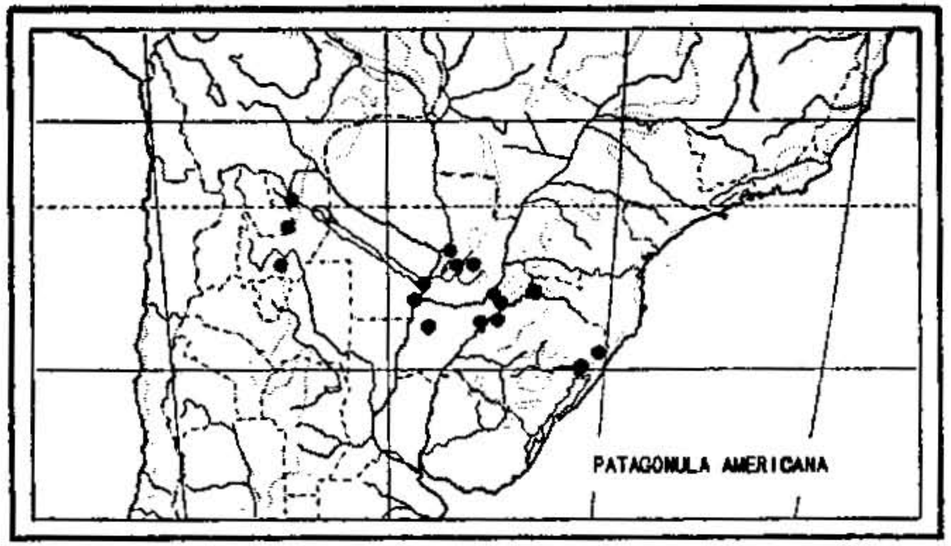

FIGURE 25.—Paraguayan migration: *Patagonula americana.*

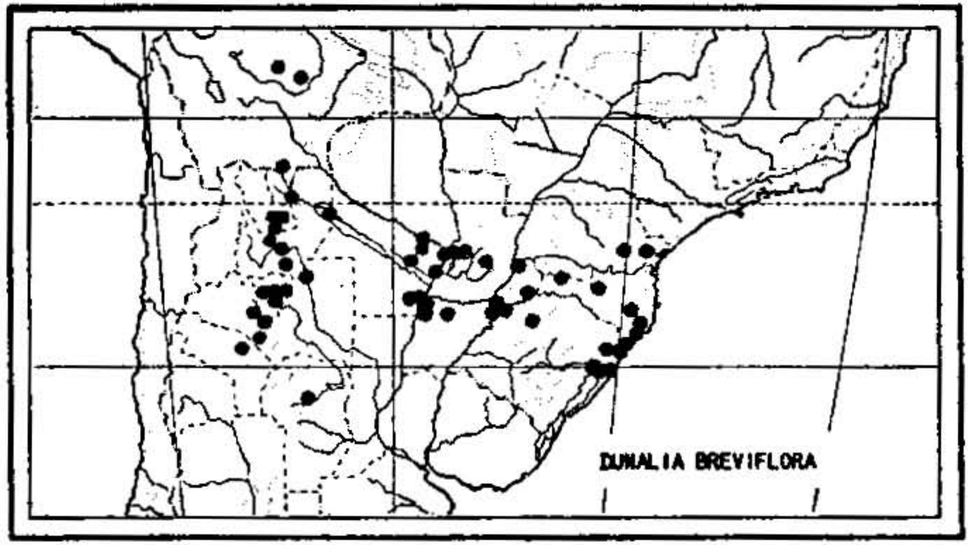

FIGURE 26.—Paraguayan migration: *Dunalia breviflora.*

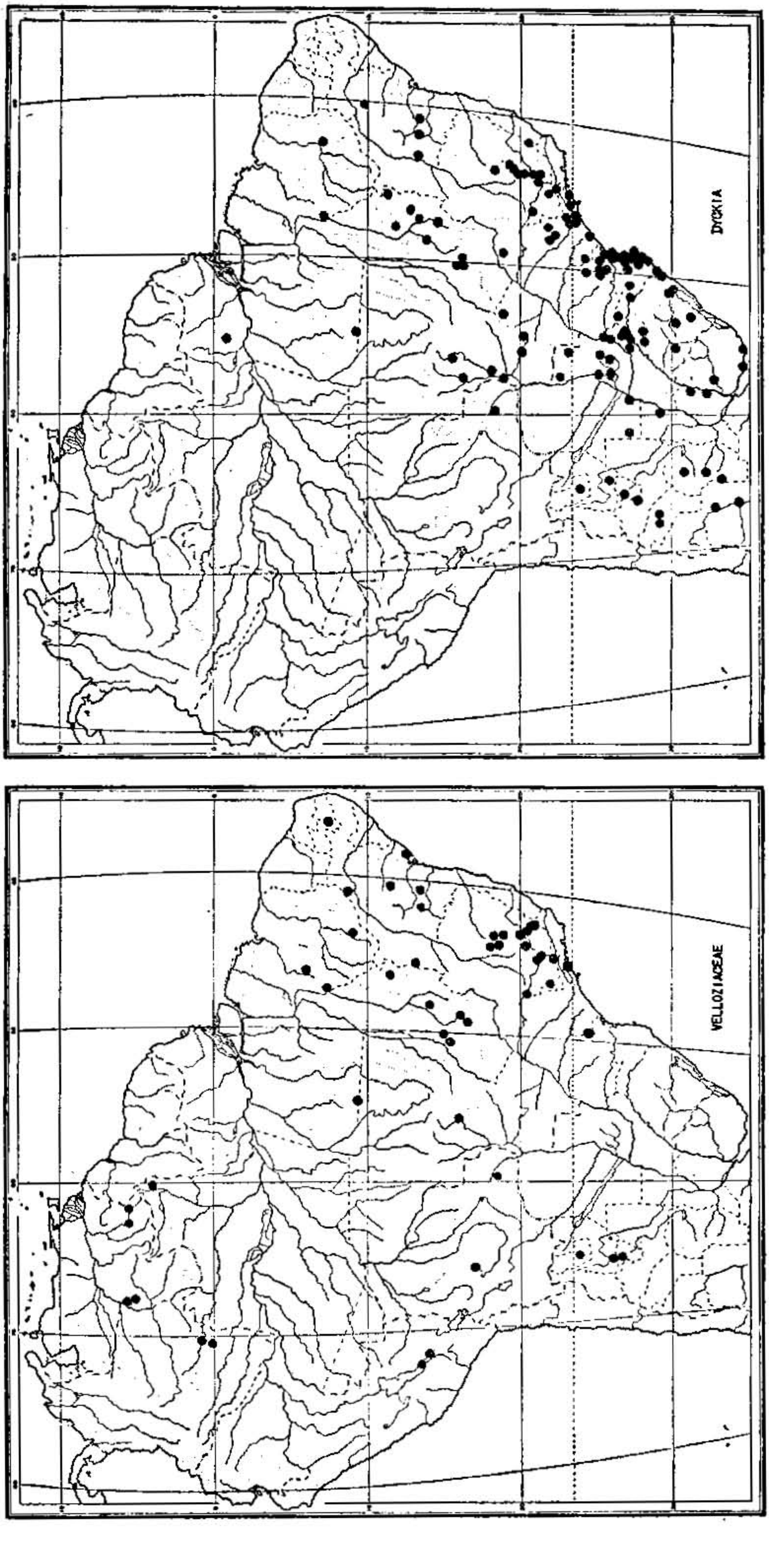

FIGURE 28.—Planalto migration: *Dyckia*.

FIGURE 27.—Planalto migration: Velloziaceae.

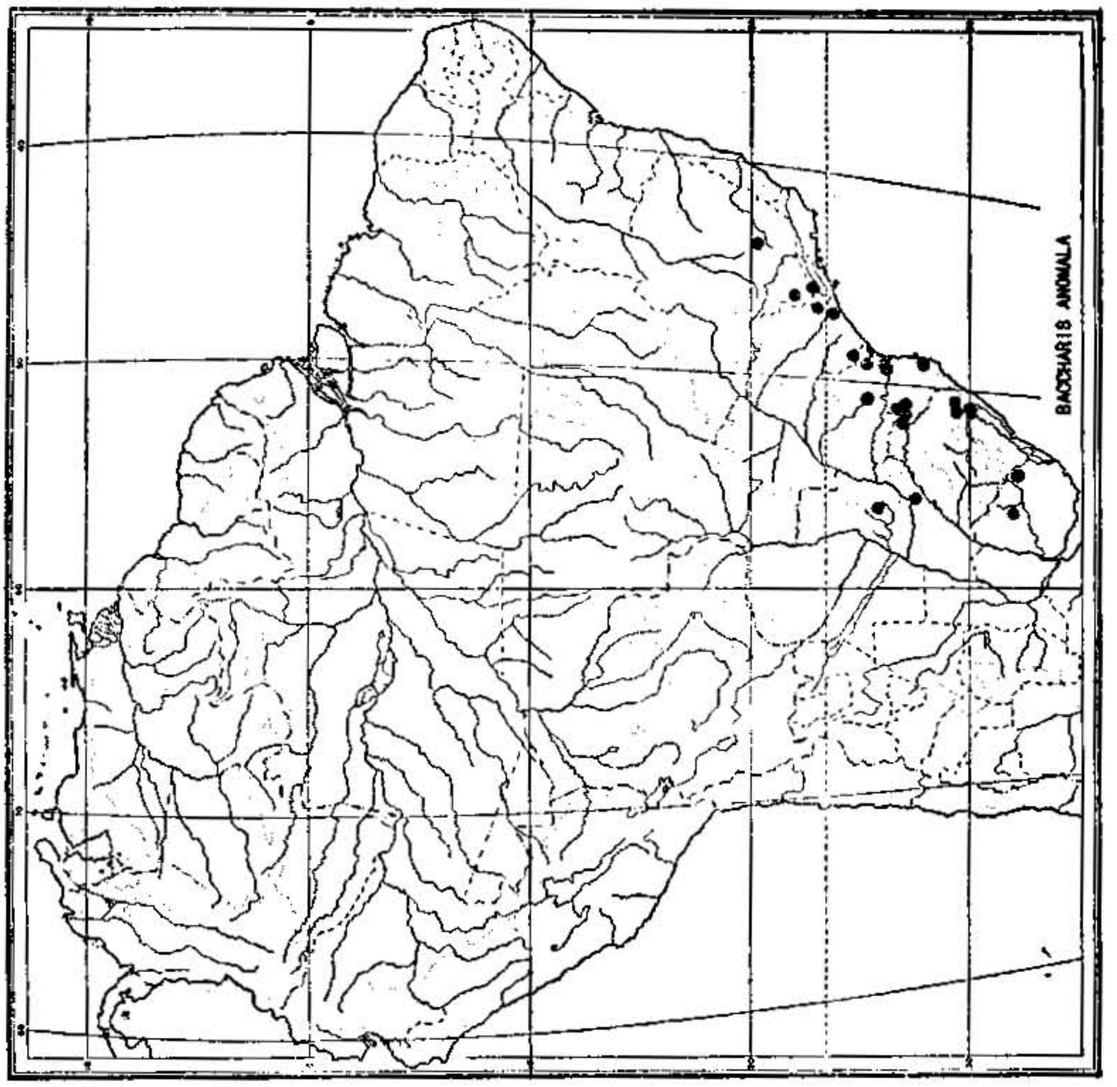

FIGURE 30.—Planalto-coastal migration: *Baccharis anomala*.

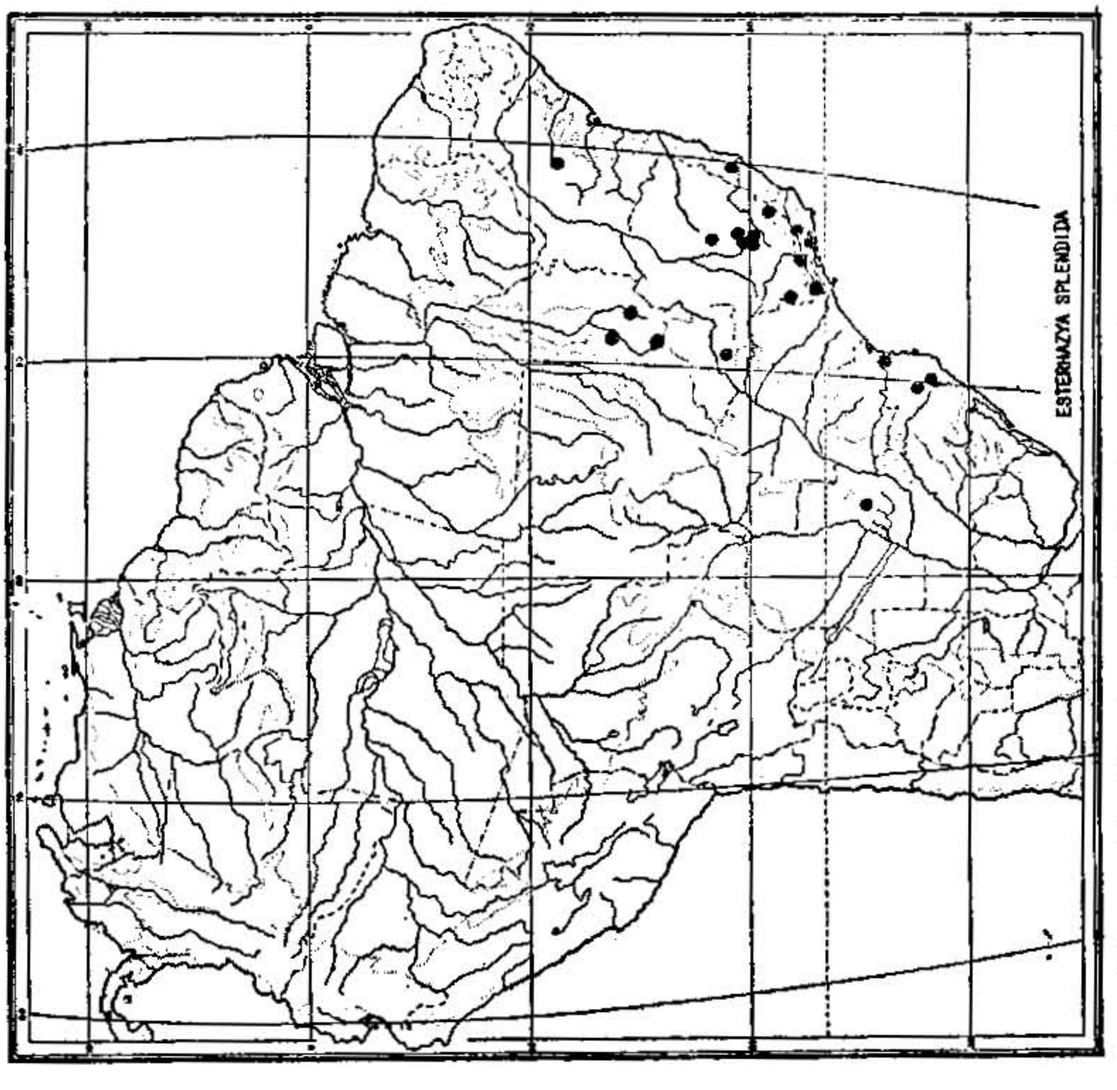

FIGURE 29.—Planalto-coastal migration: *Esterhazya splendida*.

FIGURE 31.—Planalto migration: *Baccharis megapotamica.*

FIGURE 32.—Planalto-coastal migration: *Vernonia nitidula.*

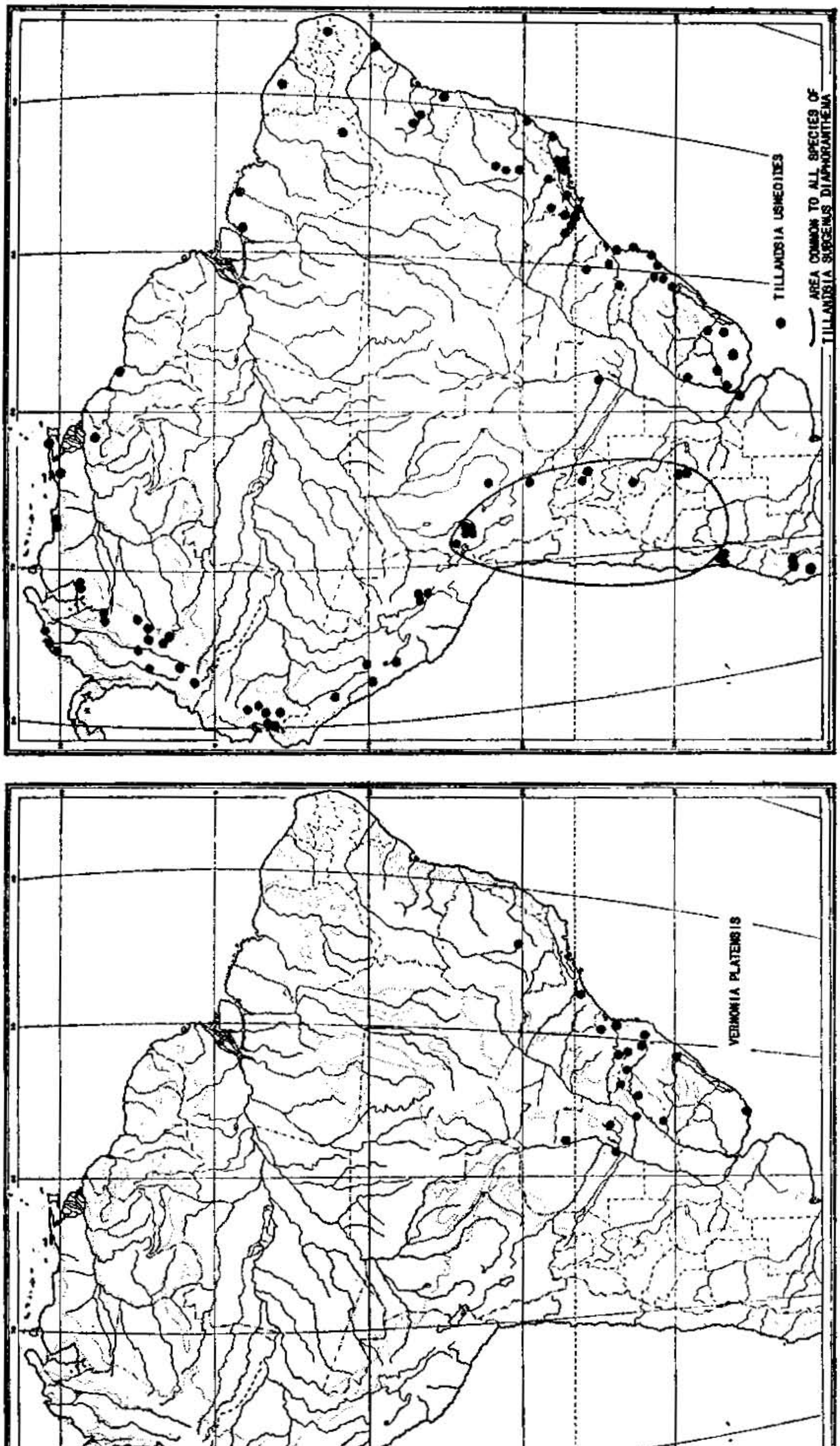

FIGURE 34.—Recent Andean migration: *Tillandsia usneoides.*

FIGURE 33.—Planalto migration: *Vernonia platensis.*

FIGURE 35.—Climate and topography effecting disjunction of ranges between the Andes and southern Brazil.

FIGURE 36.—Andean migration: *Hypericum.*

597430—62——3

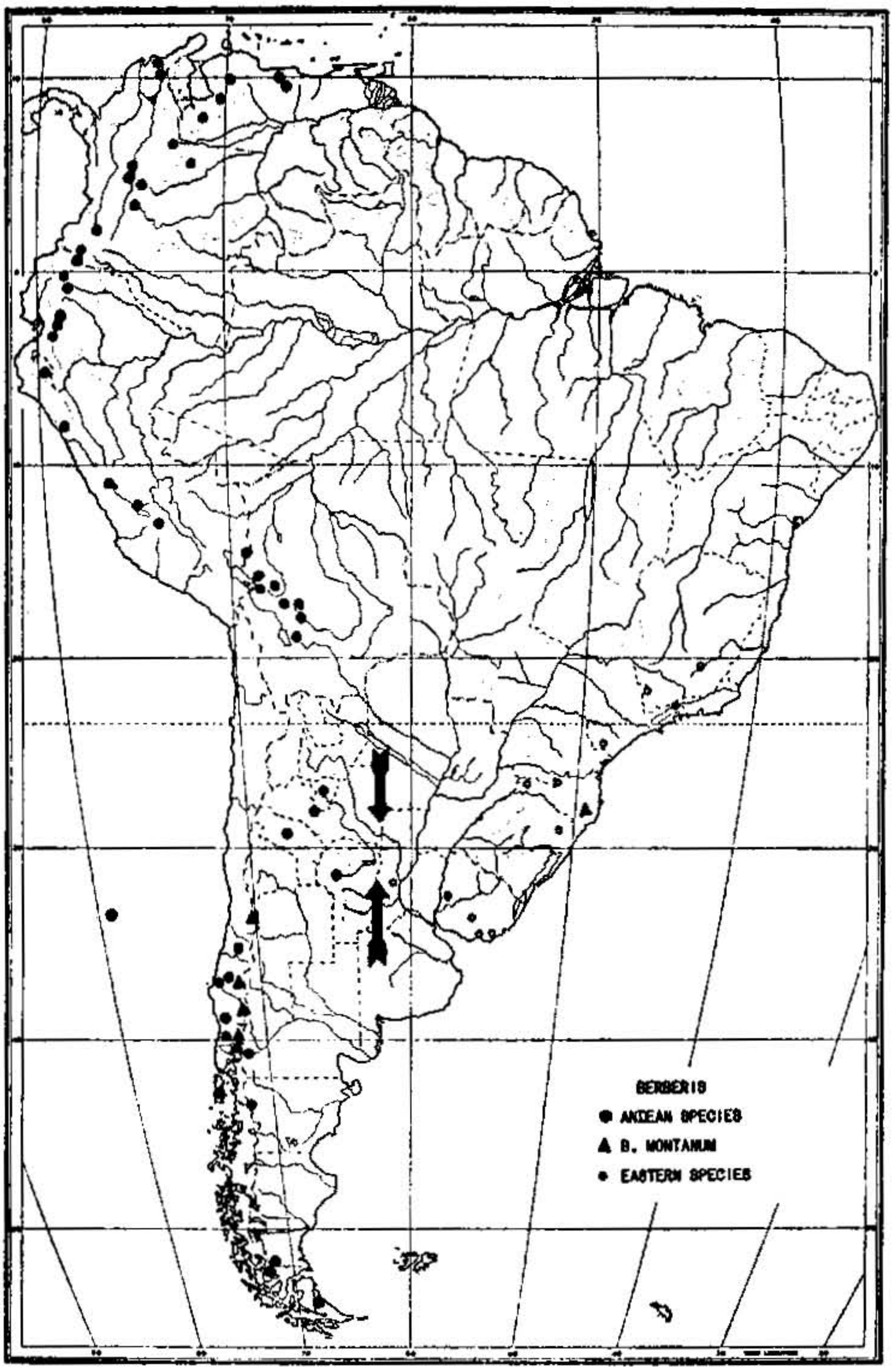

FIGURE 37.—Andean migration: *Berberis*.

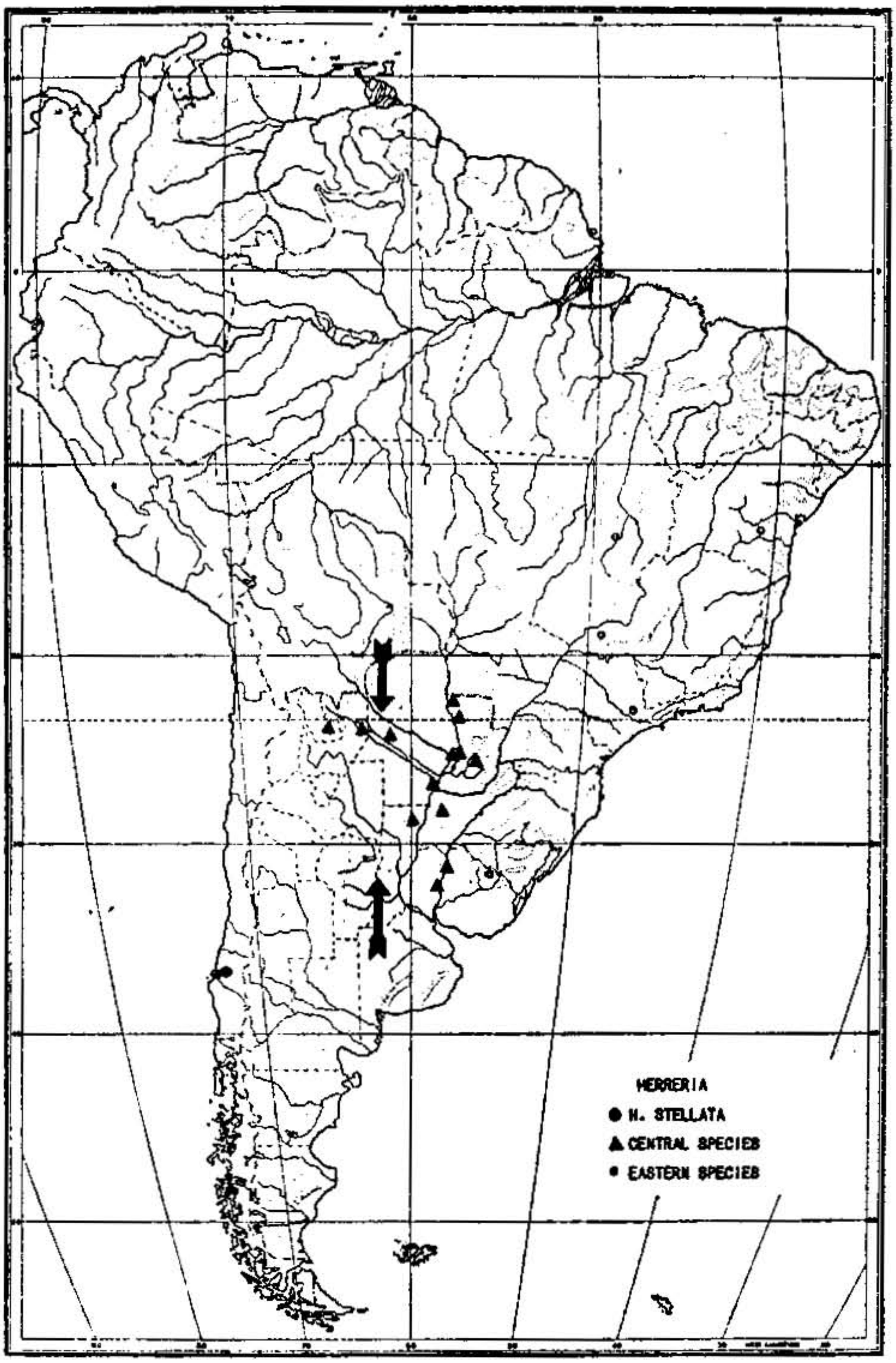

FIGURE 38.—Andean migration: *Herreria*.

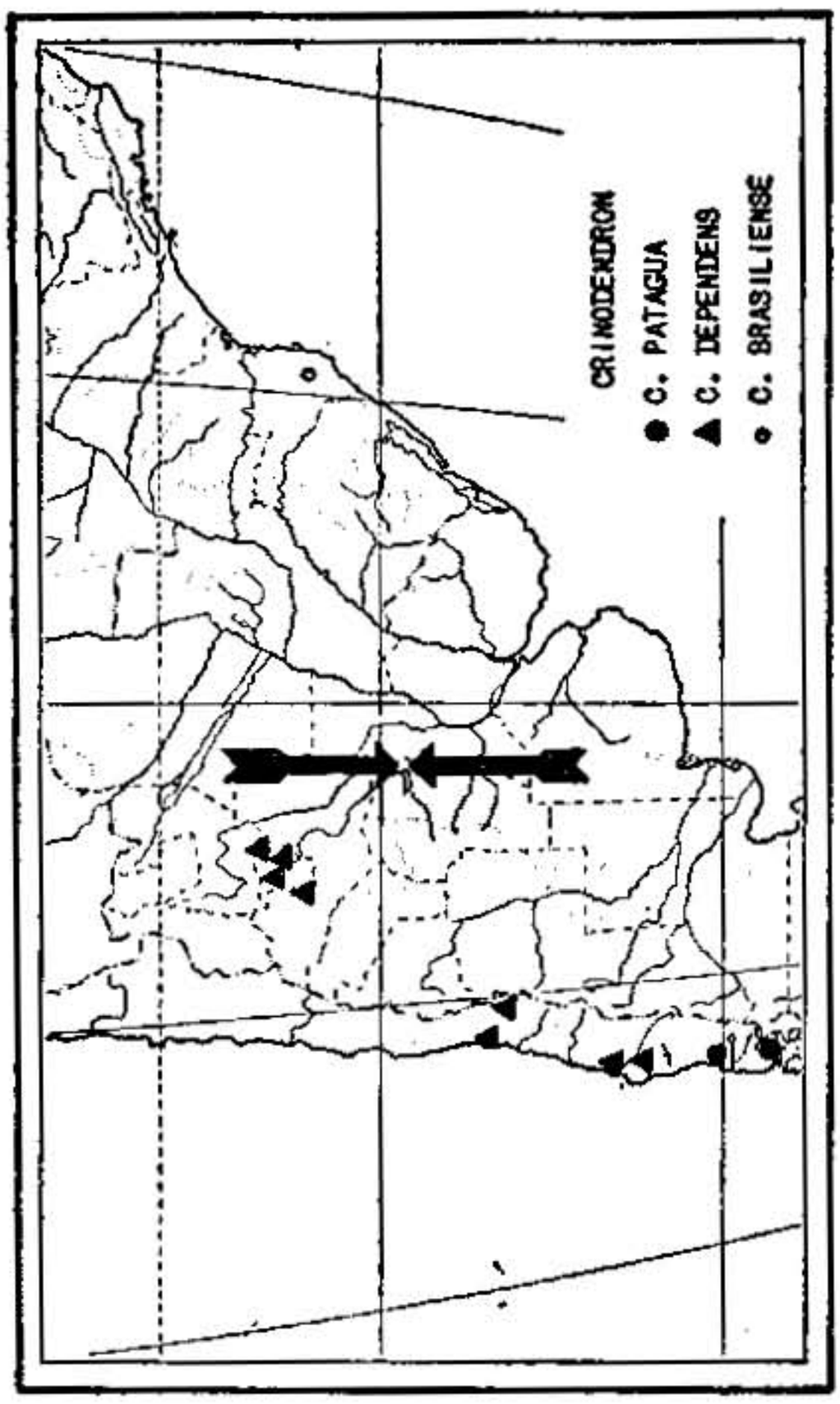

FIGURE 39

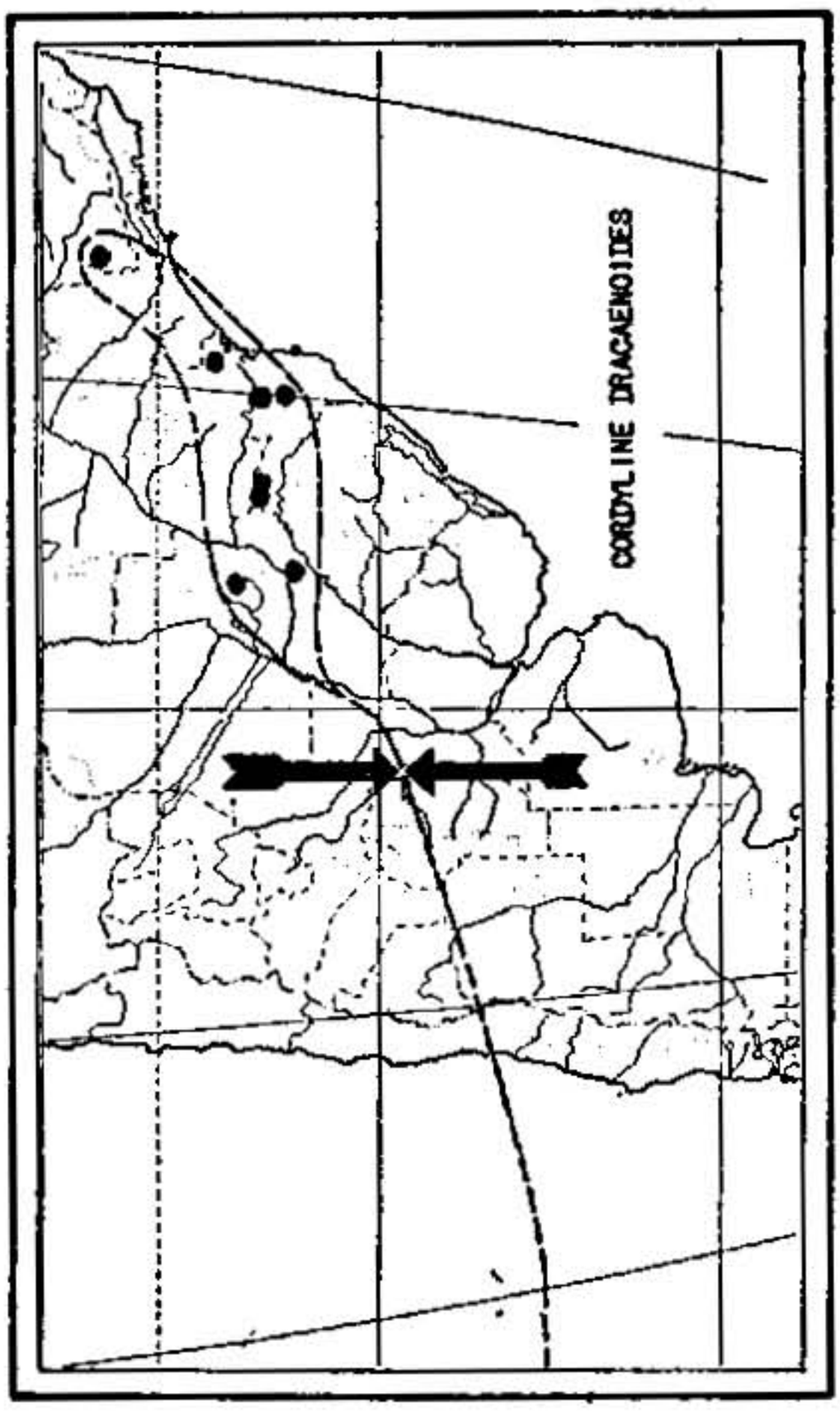

FIGURE 40

FIGURE 41

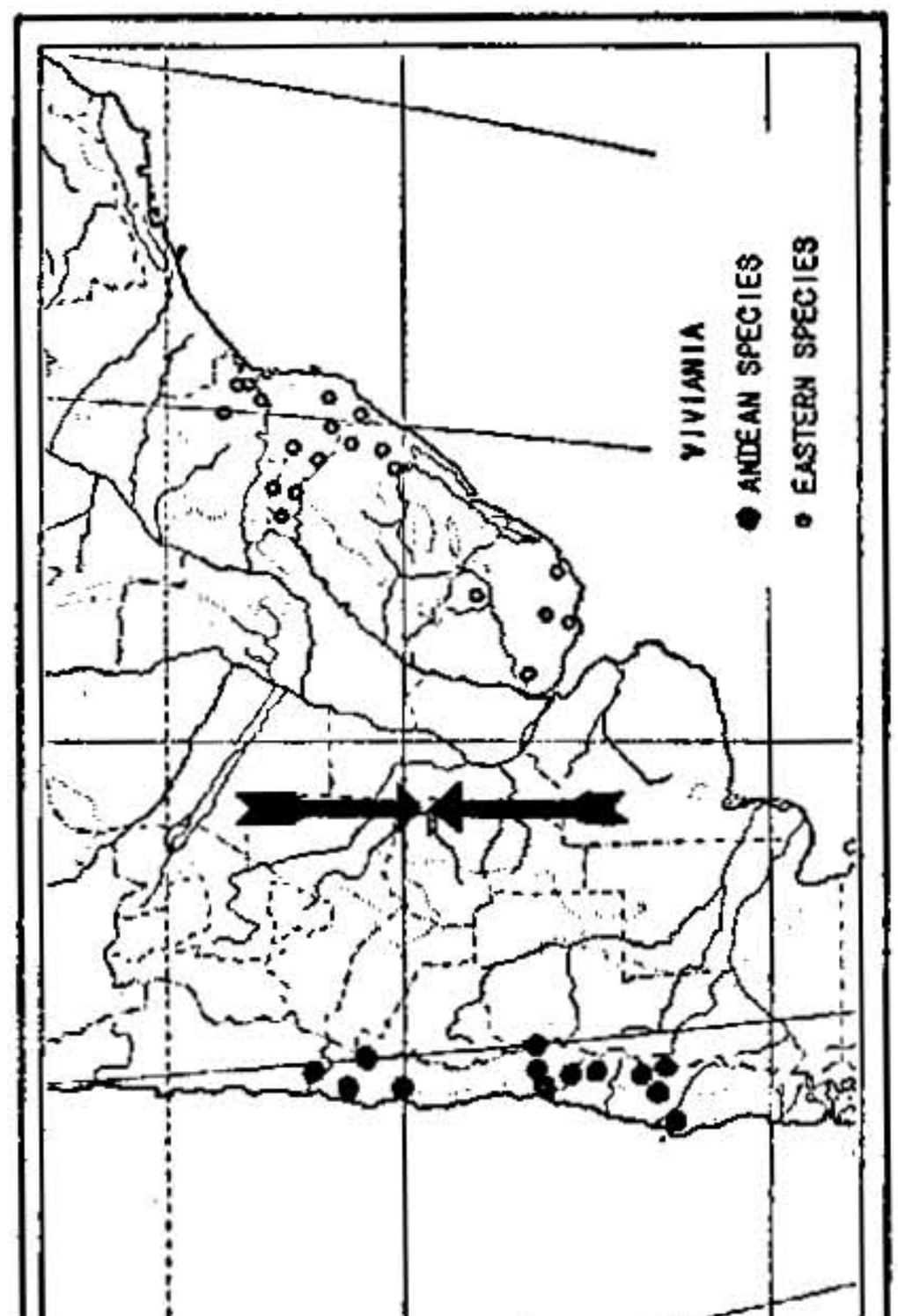

FIGURE 42

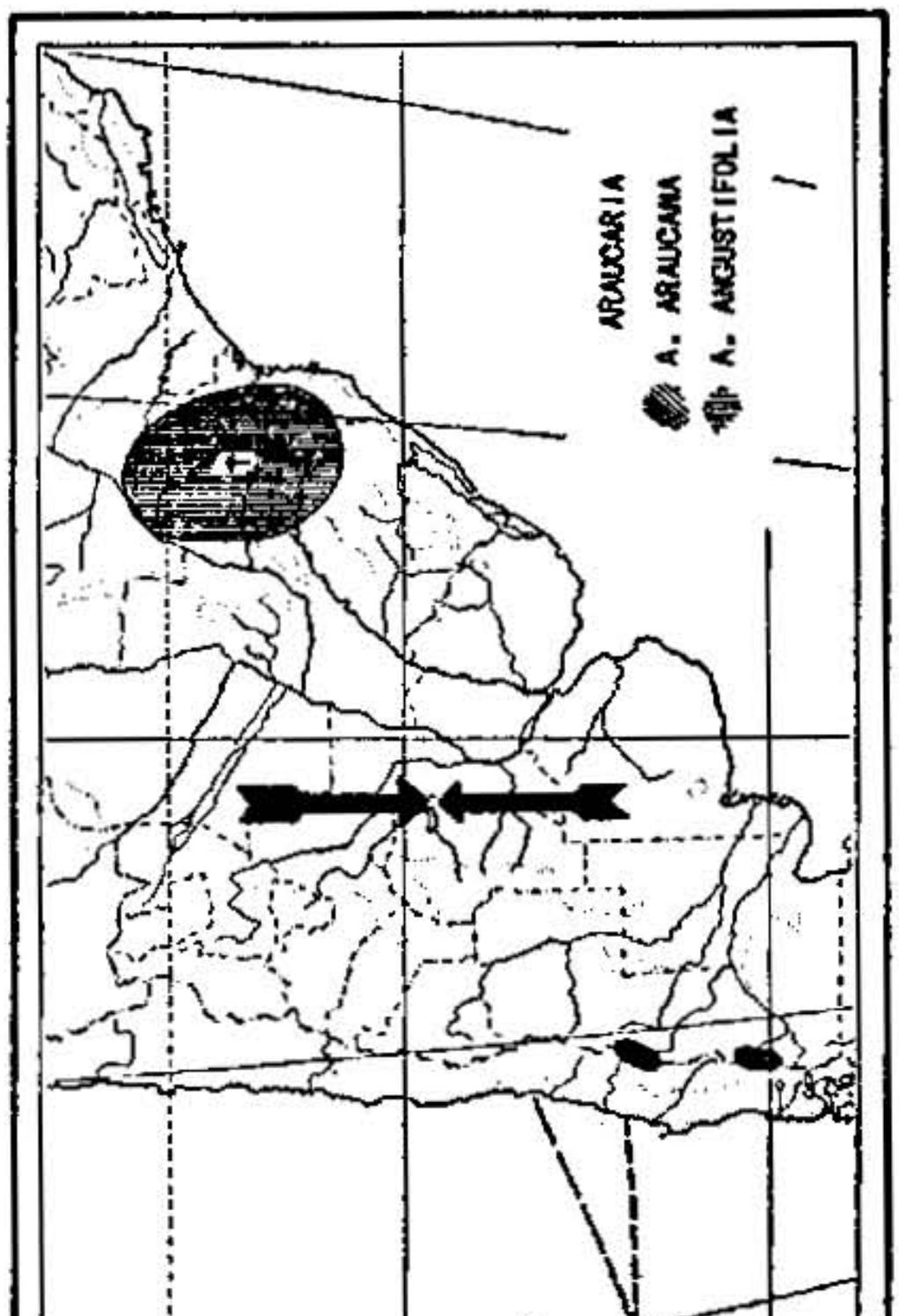

FIGURE 39.—(Top left) Andean migration: *Viviania.*

FIGURE 40.—(Top right) Andean migration: *Crinodendron.*

FIGURE 41.—(Bottom left) Western Pacific migration: *Araucaria.*

FIGURE 42.—(Bottom right) Western Pacific migration: *Cordyline dracaenoides.*

Bibliography

Some of the following works are referred to directly in the text, while others have been used indirectly as background material, but they all add to our information on the subject.

BACHIGALUPO, NÉLIDA MARÍA. Las especies argentinas de los géneros *Psychotria*, *Palicourea* y *Rudgea* (Rubiaceae). Darwiniana, vol. 10, pp. 31–64. 1952.

BAKER, J. G. Revision of the genera and species of Asparagaceae. Journ. Linn. Soc., vol. 14, pp. 508–632. 1875.

BARROSO, G. M. Scrophulariaceae indígenas e exóticas no brasil. Rodriguésia, vol. 15, No. 27, pp. 9–64. 1952.

BLACK, GEORGE A. A taxonomic treatment of the genus *Axonopus*. Doctoral thesis, The George Washington University.

BURKART, ARTURO. Las leguminosas argentinas silvestres y cultivadas, pp. 1–590. 1943.

CABRERA, ANGEL LULIO. Manual de la flora de los alrededores de Buenos Aires, pp. 1–589. 1953.

CAIN, STANLEY A. Foundations of plant geography, pp. 1–556. 1944.

CHODAT, R. La végétation du Paraguay, pp. 1–157. 1916.

COWAN, R. S. Rutaceae of Santa Catarina. Sellowia, No. 12, pp. 79–97. 1960.

CUATRECASAS, J. A taxonomic revision of the Humiriaceae, Contr. U.S. Nat. Herb., vol. 35, pt. 2, pp. 25–214. 1961.

DANSEREAU, PIERRE. Biogeography an ecological perspective, pp. 1–394. 1957.

FERNALD, M. L. Persistence of plants in unglaciated areas of boreal America. Mem. Amer. Acad. Arts & Sci., vol. 15, pp. 295–317. 1925.

GLEASON, H. A. The progress of botanical exploration in tropical South America. Bull. Torrey Bot. Club, vol. 59, pp. 21–28. 1932.

HAUMAN, L., BURKART, A., PARODI, L. R., & CABRERA, A. L. La Vegetación de la Argentina, pp. 1–349. 1947.

HOEHNE, F. C. Phytophysionomia do estado do Matto-Grosso (with map), pp. 1–104. 1923.

———. Indice bibliográphico e numérico das plantas colhidas pela Comissão Rondon, pp. 1–400. 1951.

KLEIN, R. M. O aspeto dinâmico do pinheiro brasileiro. Sellowia, No. 12, pp. 17–44. 1960.

KNUTH, R. Geraniaceae. Engler, Pflanzenreich, IV. Fam. 129, pp. 1–640. 1912.

LAWRENCE, GEORGE H. M. Taxonomy of Vascular Plants, pp. 1–823. 1951.

MARTIUS, K. F. P. VON. Flora Brasiliensis, 15 vols. 1804–1906.

MOLDENKE, H. N. A résumé of the Verbenaceae, Avicenniaceae, Stilbaceae, Symphoremaceae and Eriocaulaceae of the world as to valid taxa, geographic distribution and synonymy, pp. 1–495. 1959a.

———. Supplement I, pp. 1–26. 1959b.

———. Supplement II, pp. 1–16. 1960.

PIRES, J. MURÇA. Monografia Quiinaceae, ined.

RADLKOFER, L. Sapindaceae. Engler, Pflanzenreich, IV. Fam. 165, pp. 1–1539. 1931–34.

RAMBO, BALDUINO. A imigração da selva higrófila no Rio Grande do Sul. Sellowia, No. 3, pp. 55–91. 1952.

———. Der Regenwald am oberen Uruguay. Sellowia, No. 7, pp. 183–233. 1956a.

———. A flora fanerogamica dos aparados Riograndenses. Sellowia, No. 7, pp. 235–298. 1956b.

———. A fisionomia do Rio Grande do Sul. Jesuitas no sul do Brasil, ed. 2, vol. 6, pp. 1–456. 1956c.

———. Die Europäischen Unkräuter in Südbrasilien. Sellowia, No. 12, pp. 45–78. 1960.

REITZ, RAULINO. As palmeiras de Santa Catarina e a sua distribuição geográfica. An. Bot. Herb. "Barbosa Rodrigues," No. 5, pp. 233–252. 1953.

———. As Halorrhagaceae de Santa Catarina. Sellowia, No. 6, pp. 237–242. 1954.

———. Aráceas catarinenses. Sellowia, No. 8, pp. 20–70. 1957.

REITZ, RAULINO, AND SMITH, LYMAN B. Crinodendron no Brasil. Sellowia, No. 9, pp. 19–21. 1958.

RICHARDS, P. W. The tropical rain forest, an ecological study, pp. 1–450. 1952.

ROJAS, TEODORO, AND CARABIA, J. P. Breve reseña de la vegetación Paraguaya. *In* Verdoorn, Plants and plant science in Latin America, pp. 121–125. 1945.

SAMPAIO, A. J. DE. Phytogeographia do Brasil, ed. 3, pp. 1–372. 1945.

SCHNEIDER, C. K. Die Gattung Berberis (Euberberis), Vorarbeiten für eine Monographia. Bull. Herb. Boiss. II. vol. 5, pp. 33–48, 133–148, 391–403, 449–464, 655–670, 800–831. 1904–05.

SCOGGAN, H. J. The flora of Bic and the Gaspé Peninsula, Quebec. Nat. Mus. Canada, Bull. 115, pp. 1–399. 1950.

SLEUMER, H. Estudios sobre el genero "Dunalia" H. B. K. Lilloa, vol. 23, pp. 117–142. 1950.

SMITH, A. C., & JOHNSTON, I. M. A phytogeographic sketch of Latin America. *In* Verdoorn, Plants and plant science in Latin America, pp. 11–18. 1945.

SMITH, LYMAN B. Geographical evidence on the lines of evolution in the Bromeliaceae. Bot. Jahrb., vol. 66, pp. 446–468. 1934.

———. Studies in the Bromeliaceae—VI. Proc. American Acad. Sci., vol. 70, pp. 147–220. 1935.

———. The vegetation of Brazil. *In* Verdoorn, Plants and plant science in Latin America, pp. 297–302. 1945.

———. The Bromeliaceae of Brazil. Smithsonian Misc. Coll., vol. 126, pp. 1–290. 1955.

———. Notes on South American phanerogams—I. Journ. Washington Acad. Sci., vol. 9, pp. 282–284. 1958a.

———. Notes on South American phanerogams—II. Journ. Washington Acad. Sci., vol. 48, pp. 310–314. 1958b.

SMITH, LYMAN B., AND DOWNS, ROBERT J. Resumo preliminar das Rubiáceas de Santa Catarina. Sellowia, No. 7, pp. 13–86. 1956.

———. Resumo preliminar das Euforbiáceas de Santa Catarina. Sellowia, No. 11, pp. 155–231. 1959.

———. Resumo preliminar das Amarantáceas de Santa Catarina. Sellowia, No. 12, pp. 99–120. 1960a.

———. Resumo preliminar das Cariofiláceas de Santa Catarina. Sellowia, No. 12, pp. 121–133. 1960b.

———. The Xyridaceae of Brazil. (In preparation.)

STAFLEU, F. A. A monograph of the Vochysiaceae, I. Salvertia and Vochysia. Rec. Trav. Bot. Néerl., vol. 41, pp. 397–540. 1948.

SWART, J. J. A monograph of the genus *Protium* and some allied genera (Burseraceae). Rec. Trav. Bot. Néerl., vol. 39, pp. 211–446. 1942.

WULFF, E. V. Introduction to the historical geography of plants. Bull. Appl. Bot. Gen. & Pl. Breeding. Suppl. 52. (translation Brissenden, E.): An introduction to historical plant geography. pp. 1–223. 1943.