Distribution of *Argostemma* Wall. (Rubiaceae), with special reference to Thailand and surrounding areas

KITICHATE SRIDITH* & CHRISTIAN PUFF**

ABSTRACT. *Argostemma* Wall. (Rubiaceae), a disjunct genus (Africa: 2 spp.; SE Asia: > 95 spp.), has 31 taxa in Thailand of which 17 are endemic. Their distributions within the Thai floristic regions are: Northern (N) — 11 spp. (of which six are endemic to the region); North-eastern (NE): 1 sp.; Eastern (E): 3 spp.; South-western (SW): 4 spp.; Central (C): 3 spp.; South-eastern (SE): 5 spp. (of which one is endemic to the region); Peninsular (PEN): 18 taxa (of which seven are endemic to the region). Some species are endemic to Thailand but have wider distributions within the country e.g. *A. concinnum* (N+E+SE), *A. monophyllum* (NE+E+C+SE), and *A. parvum* (E+SE). The 14 non-endemic taxa fall into three categories: (1) "northern" species, also occurring in Myanmar, India and/or China (Yunnan); (2) "southern" species, also in the Malay Peninsula [and/or S. Myanmar (Tenassermin), or also on Sumatra or the Andaman Is.]; (3) widespread species (*A. neurocalyx* only), distributed from Borneo, Sumatra, and the Malay Peninsula to Indochina (and also widespread in Thailand: N+C+SE+PEN). An attempt is made to correlate distribution patterns with morphological "species groups" distinguishable within the genus.

INTRODUCTION

Argostemma Wall. is an essentially paleotropical genus. The highest concentration of species is found in within the tropics, but some do extend into northern subtropical areas; see below for details).

Its distribution range shows a remarkable disjunction: the overwhelming majority of species (ca. 100; Mabberley, 1987) is confined to Asia, but two species are endemic to tropical West Africa (Hepper, 1963), see Fig. 1. Although such an Asian-African disjunction is uncommon, it, nevertheless, also occurs in other (non-Rubiaceous) plant groups. Examples have previously been pointed out by Hepper (1965).

In Asia, *Argostemma* occurs in the (1) Indian, (2) Indo-Chinese, (3) Malesian and (4) Papuan regions of the Indo-Malesian subkingdom sensu Takhtajan (1969). However, some taxa extend to (or largely occur in) subtropical areas. For example, the type species of the genus (*A. sarmentosum* Wall.), is recorded from the Himalaya area of Nepal, other taxa are recorded from Yunnan (China). Also, taxa confined to northernmost Thailand (and Myanmar) are, strictly speaking, no longer purely "tropical".

*Department of Biology, Faculty of Science, Prince of Songkhla University, Hat Yai, Songkhla 90112, Thailand.

**Institute of Botany, University of Vienna, Rennweg 14, A-1030 Vienna, Austria.

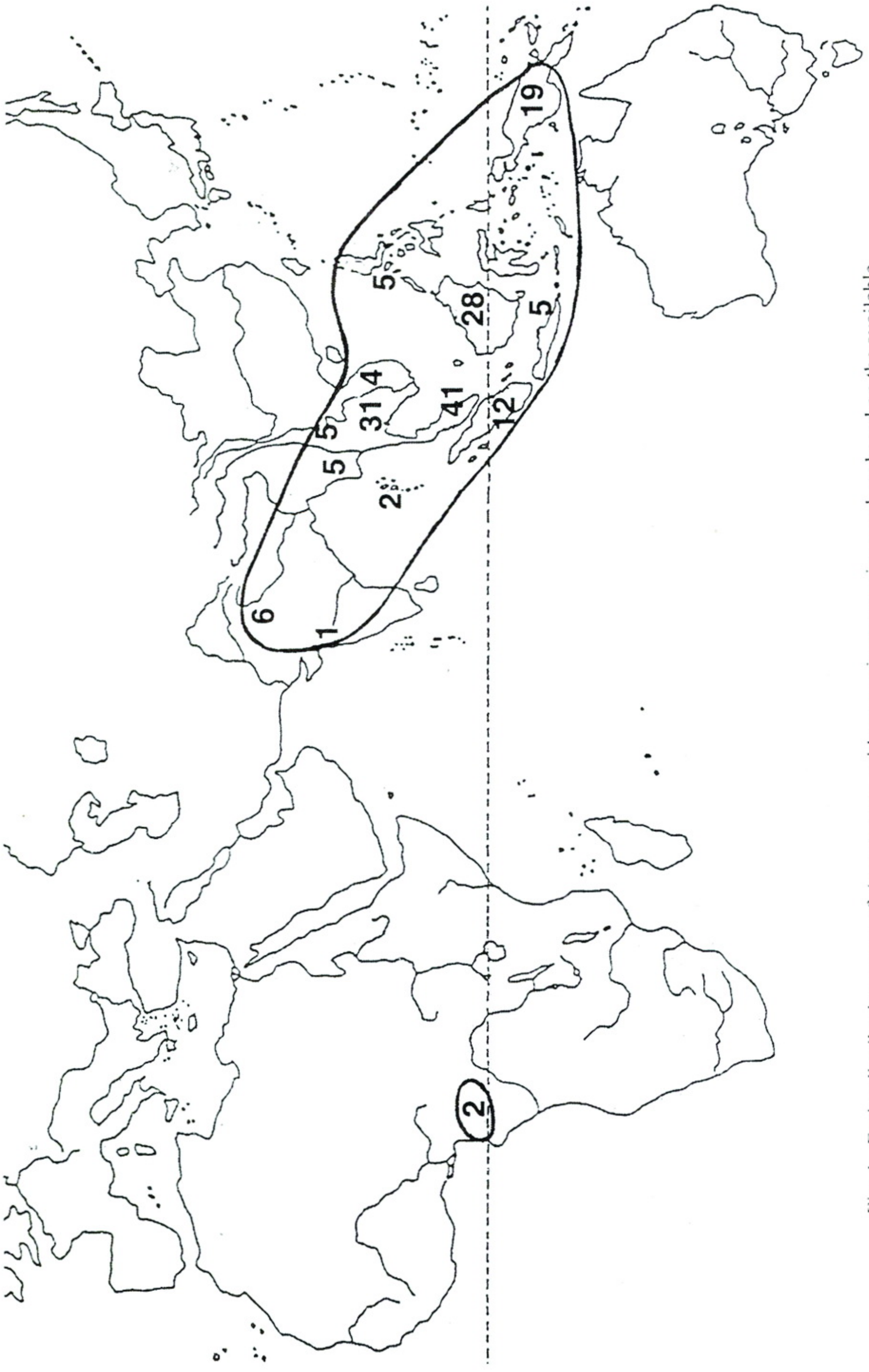

Fig. 1. Entire distribution range of *Argostemma*, with approximate species numbers based on the available literature (see text for details).

Apart from Thailand (Sridith, 1999) and Borneo (revision by Bremer, 1989), detailed and up-to-date information on the distribution of individual species is largely unavailable, because no recent treatments are available. According to Hooker (1880), India has nine species of *Argostemma.* Six occur in the subtropical region of the Himalayas and on Mt Khasia in the north, another, *A. courtallense* Arn., in the western Peninsula, and two species are described from the Andaman Islands. In Myanmar, about five species are found throughout the country (Kurz, 1877; Hooker, 1880). According to Lo (1986), all five Chinese species occur in the province of Yunnan. Based on Pitard (1922), *Argostemma* in Indochina (Laos, Cambodia and Vietnam) has two species in Cambodia and two in Vietnam (there is no record from the botanically little-known Laos). As for the Malesian region, it is rather difficult to estimate the number of species, since many different species have been described from different places. Nevertheless, it seems certain that the highest concentration of species is in the Malay Peninsula (41 taxa according to Ridley, 1923). Borneo has 28 species (Bremer, 1989). Backer & Bakhuizen van den Brink (1965) mention five species for Java. Miquel (1856), recorded 12 species from Sumatra. At least five species occur in the Philippines (Elmer, 1906a, b, 1913; Merrill, 1915). In the Papuan region, 19 species are described (Valeton, 1925a, b). Except for Borneo, these numbers are likely to change drastically, once revisional work has been carried out. At present, it seems that *Argostemma* has widely distributed taxa (e.g. *A. neurocalyx*: from Borneo, Sumatra, the Malay Peninsula to Thailand and Indochina), as well as narrowly endemic species (e.g. *A. laxum*: confined to Doi Inthanon, northern Thailand).

In order to understand the distribution patterns of *Argostemma*, it is necessary to give a brief explanation of the ecology of the genus: The entire genus can be ecologically characterised as occurring in shady, moist to wet places with high humidity, such as on wet, moss-covered rocks or rock faces by waterfalls, or on large boulders in or along streams, or in sandy places in steep gullies or around streamlets. Moreover, most *Argostemma* species are not substrate-specific. For example, out of the 31 taxa recognised for Thailand (Sridith, 1999), only four appear to be restricted to limestone habitats.

Microhabitats of the kind described above are (1) not restricted to wet types of (evergreen) forest but are also found in drier types of vegetation, such as dry evergreen forest, bamboo forest or mixed deciduous forest and (2) occur in a wide altitudinal range (from about sea level to well over 2000 m).

The "azonal" nature of the microhabitats of *Argostemma* (i.e. that fact that there is no direct correlation between the microhabitats of the plants and a particular vegetation type), is of great importance for understanding the (often scattered) distribution patterns.

Argostemma appears to be very sensitive to microclimatic changes (e.g. to removal of shade trees, which results in too much sun and most probably also leads to a lesser humidity). Subsequently, *Argostemma* populations are normally only found in primary, undisturbed habitats. Disturbance of the ecological balance will soon cause a population to die. This sensivity most likely is the reason that some species are only known from very few – and only old – collections.

Distribution patterns of the taxa of *Argostemma* occurring in Thailand

Based on the recent revision by Sridith (1999), 31 taxa of *Argostemma* are found in Thailand; their composite distribution is shown in Fig. 2. If distribution ranges of the individual taxa are correlated with the seven Thai floristic regions the following pattern emerges (Fig. 3; Table 1: summary 1): 11 taxa occur in the Northern region, one in the North-eastern, three in the Eastern, four in the South-western, three in the Central, five in the South-eastern, and 18 in the Peninsular.

Seventeen of the 31 taxa (i.e. ca. 55% of the *Argostemma* taxa occurring in Thailand) are endemic to the country.

Taxa endemic to Thailand

Six taxa are endemic to the Northern region. This represents ca. 55 % of the taxa that occur in that region, and about 20% of the taxa which occur in Thailand. Two of the endemic taxa in the Northern region have very restricted distribution ranges, being confined to a solitary mountain: *Argostemma laxum* is only known from Doi Inthanon in Chiang Mai Province, and *A. fragile* was only collected once from Doi Papoe in Mae Hong Son province *A. thaithongae*, apparently one of the few calcareous endemics in the genus, is confined to Doi Chiang Dao and nearby Doi Ang Kang in Chiang Mai. The remaining endemic species in the Northern region (*A. plumbeum*, Fig. 4; *A. ebracteolatum,* and *A. stellatum*) have a somewhat wider range, and are recorded from two or more provinces.

The distribution range of the endemic *Argostemma concinnum* extends beyond the Northern region to Khao Yai National Park in both the Eastern and South-eastern regions (Fig. 5).

Although the Peninsular region has the highest number of taxa known from any Floristic region of Thailand (18), only 7 taxa are endemic to that region. Amongst them is a new endemic on limestone, *Argostemma puffii*, so far only known from a single coastal hill in Satun. *A. rotundicalyx* occurs at low altitudes (< 300 m) both in Phangnga and Surat Thani. Both varieties of *A. lobulatum* are confined to the more northern parts of the Peninsula (var. *lobulatum* to Khao Luang in Prachaup Khiri Khan; var. *variabile* more widespread). *A. laeve* subsp. *setosum* occurs on both the E and W slopes of the Nakhon Si Thammarat Range (subsp. *laeve* is known only from the Malay Peninsula). *A. condensum*, at present, is only known from the Satun and Yala, both bordering Malaysia (Fig. 6). Hence, it can be expected also from the Malay Peninsula. *A. dispar* is a somewhat critical case; the species sensu stricto is at present considered a Thai endemic, but there are indications that it close resembles a Malay Peninsula species (since the Malayan taxa are not revised, it is impossible to offer a final solution at this stage). The remaining (non-endemic) taxa recorded from various regions in Thailand and neighbouring countries (notably the Malay Peninsula, or southern Myanmar).

Argostemma pulchellum is the only species endemic to the coastal areas of the South-eastern region (Fig. 7). It is also can be expected from Cambodia.

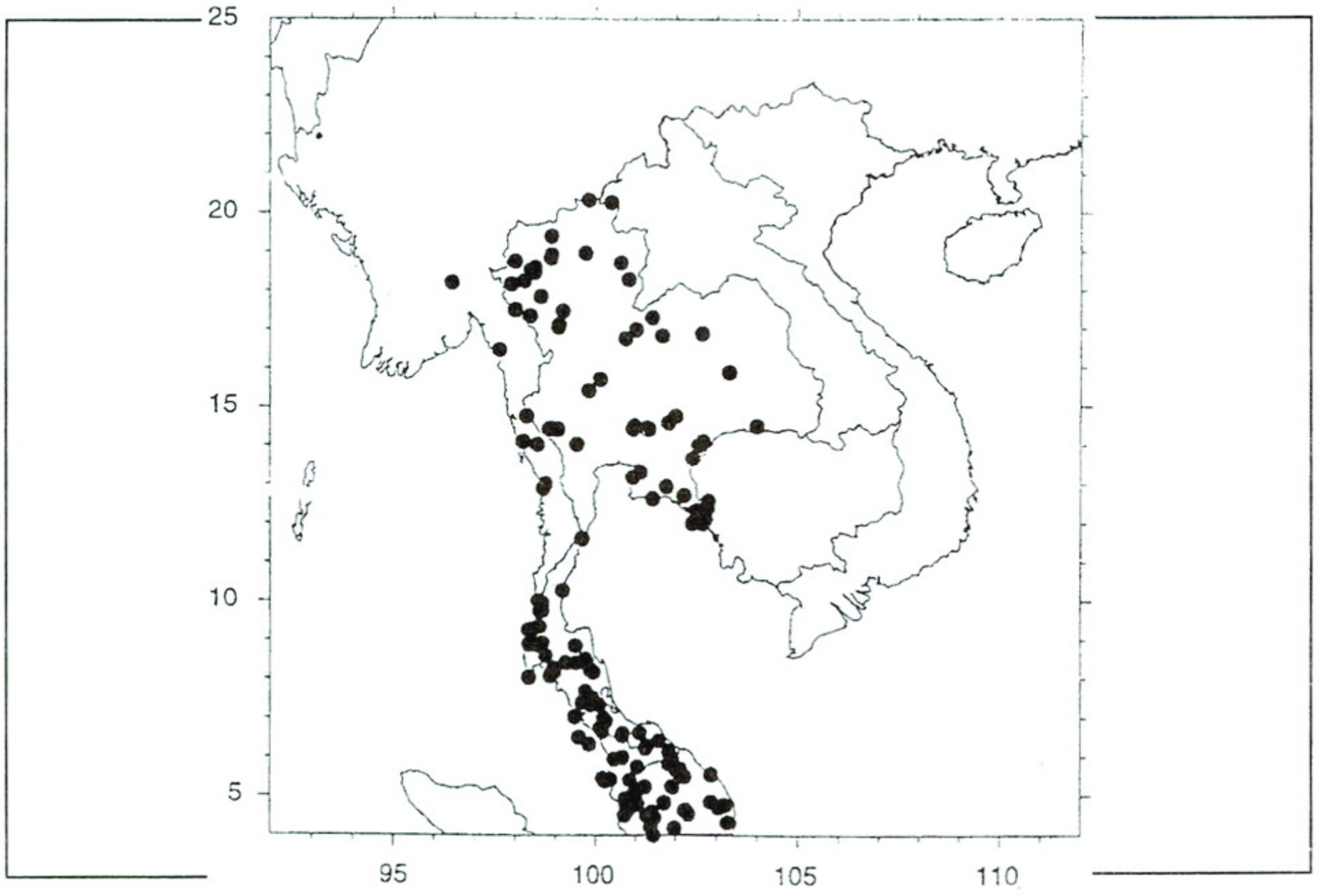

Fig. 2. Distribution of *Argostemma* in Thailand and surrounding areas, compiled from locality data for all taxa.

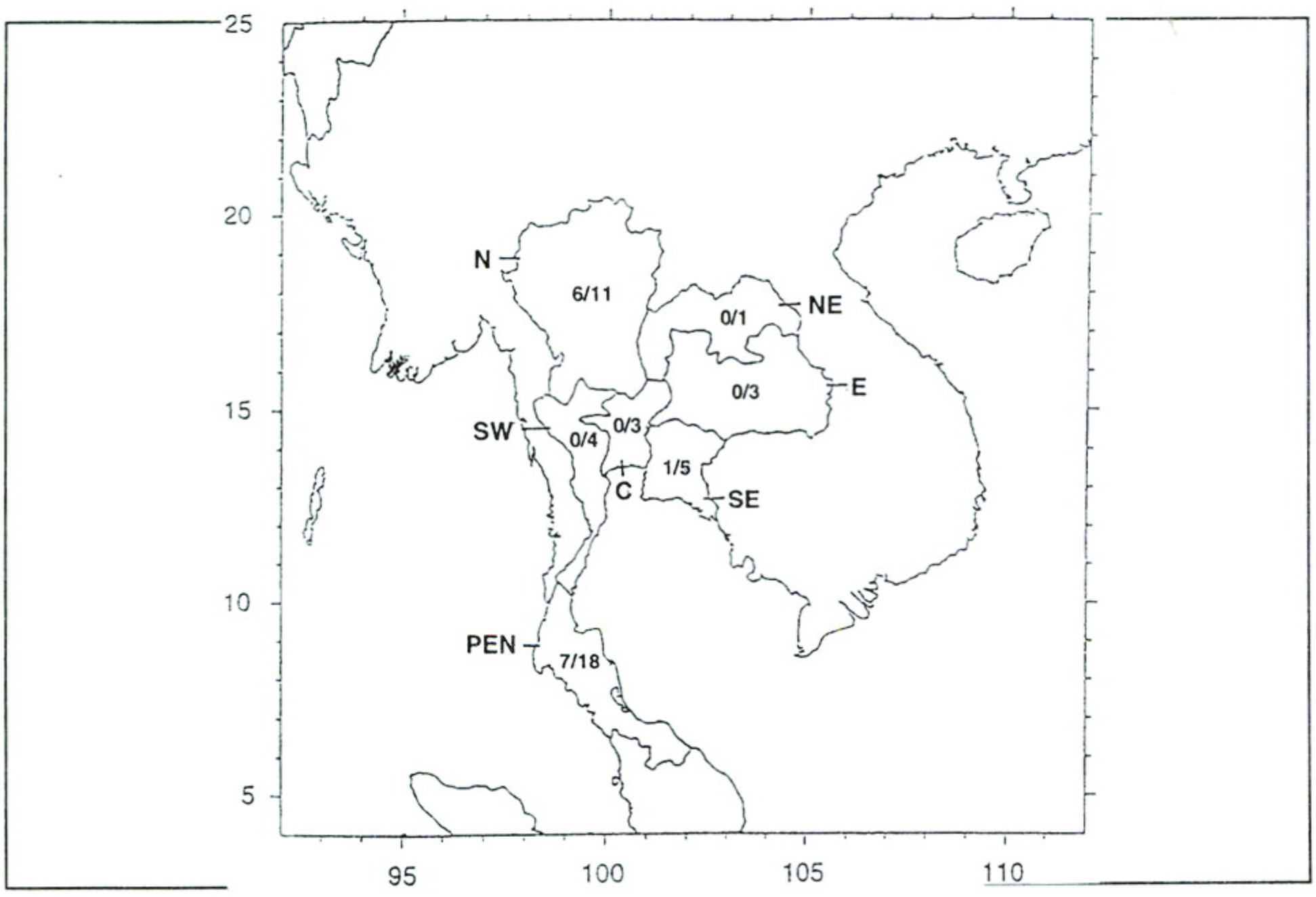

Fig. 3. Numbers of the Thai taxa of *Argostemma* in different floristic regions in Thailand (numbers of endemic taxa above line, total number below line).

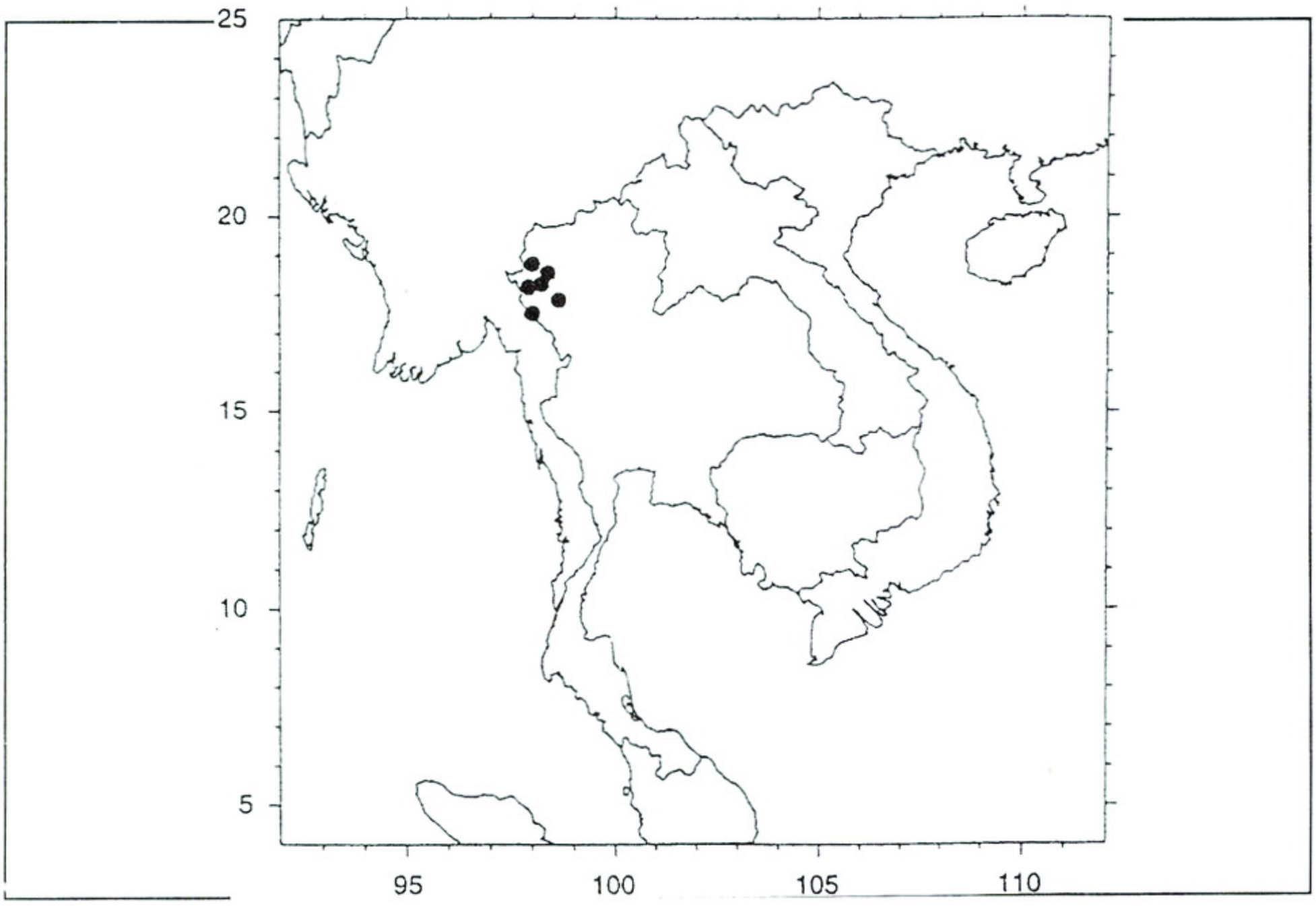

Fig. 4. Distribution of *Argostemma plumbeum*.

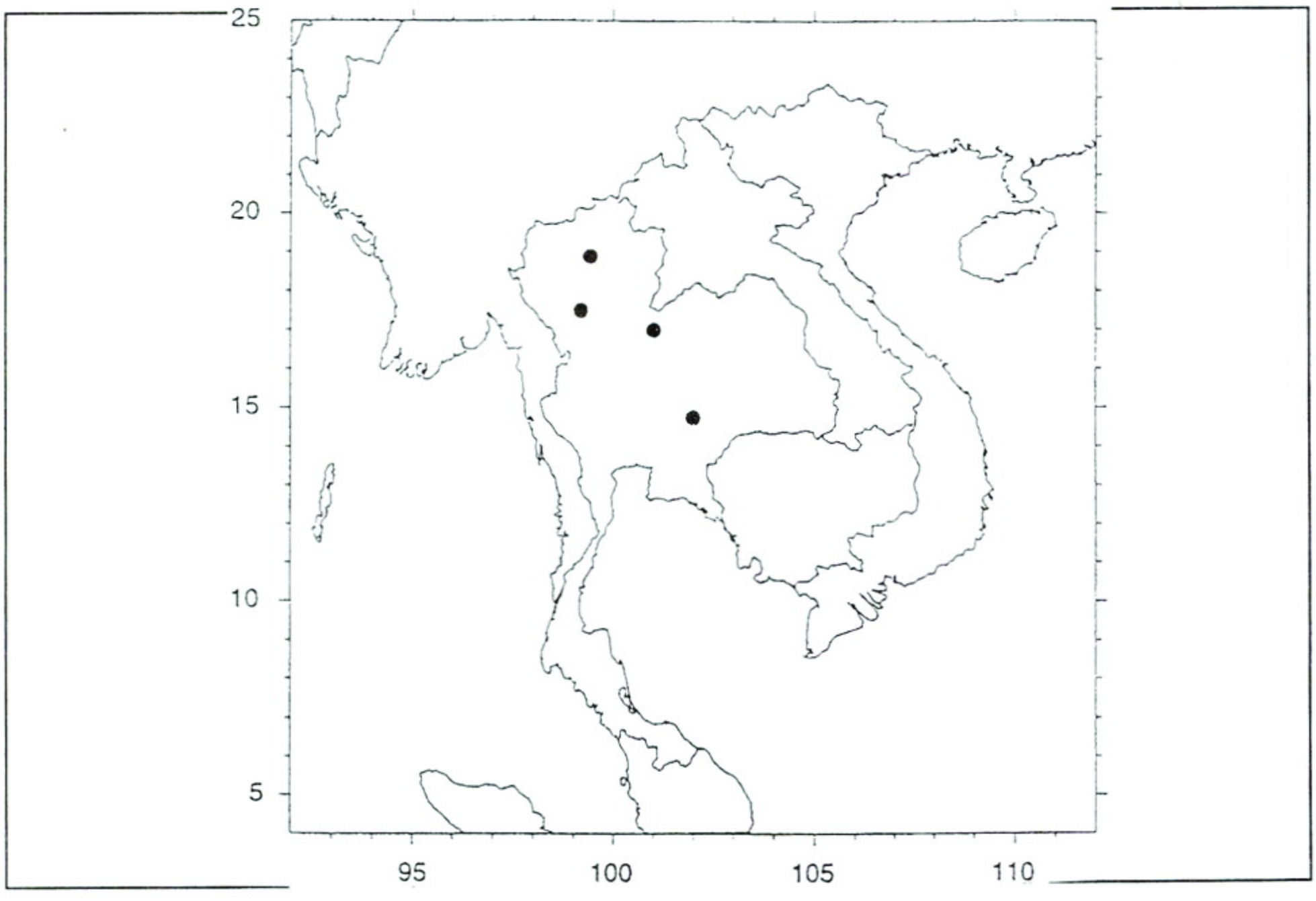

Fig. 5. Distribution of *Argostemma concinnum*.

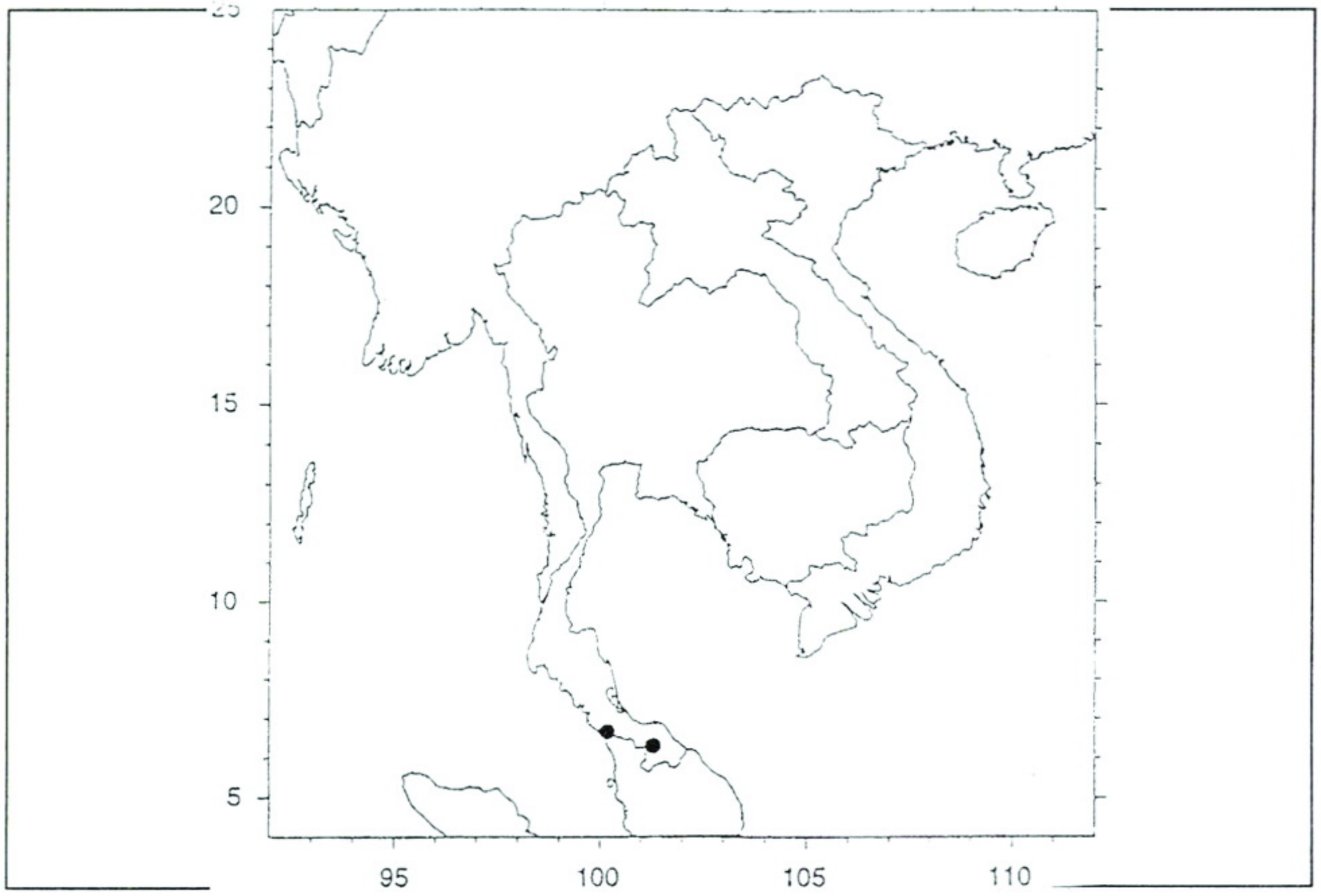

Fig. 6. Distribution of *Argostemma condensum*.

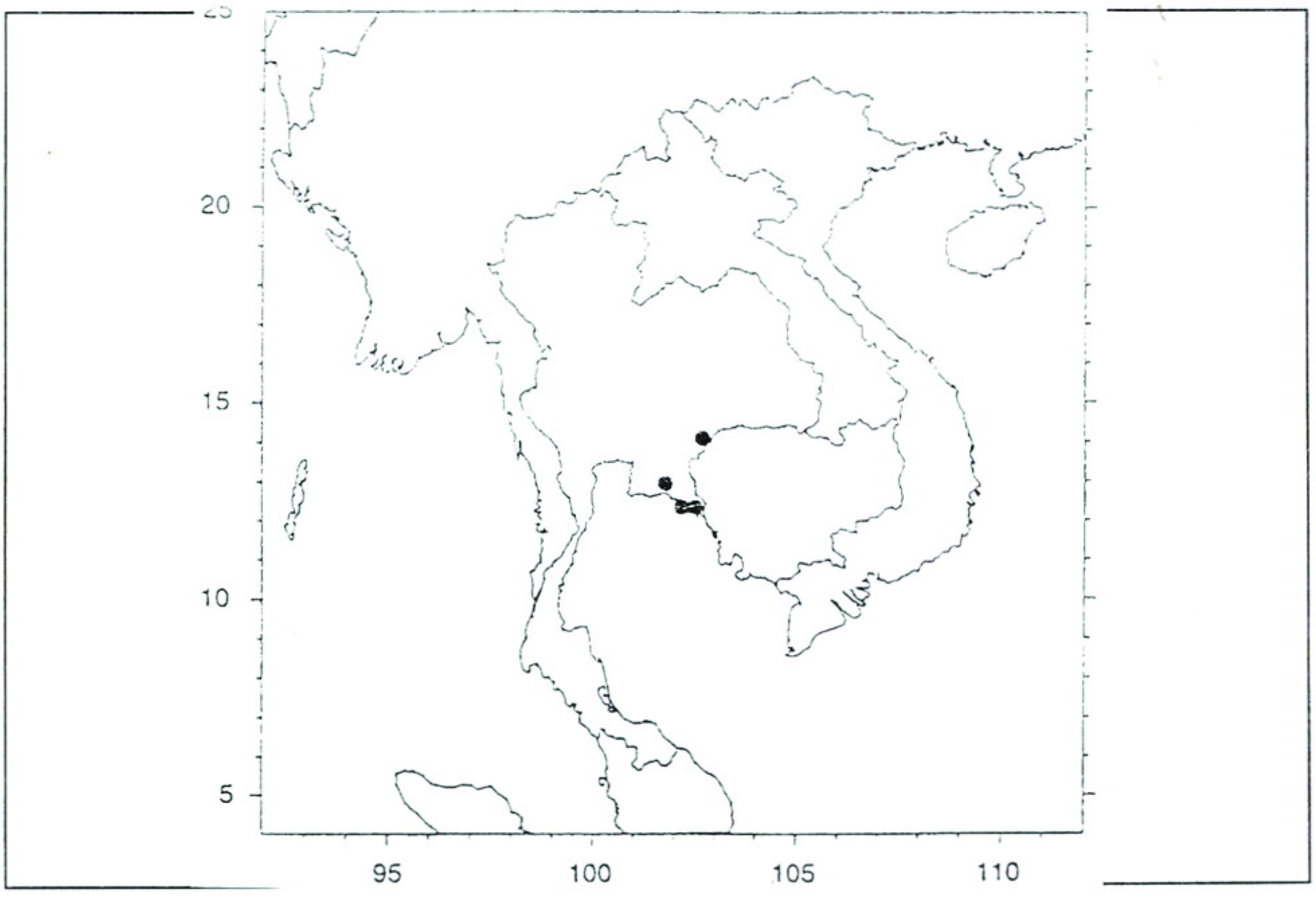

Fig. 7. Distribution of *Argostemma pulchellum*.

A number of endemic taxa occur in two or more floristic regions: *A. parvum* is known from both the Eastern and the South-eastern regions (as in the case of *Argostemma pulchellum*, see above, it may also extend into neighbouring parts of Cambodia). One new species, *A. monophyllum,* is widely scattered over the eastern half of the country (i.e. covering the North-eastern, Eastern, Central and the South-eastern regions) (Fig. 8). See also *A. concinnum*, discussed together with the taxa endemic to the Northern region.

Non-Endemic Thai taxa

Two of the *Argostemma* species occurring in the Northern region (*A. khasianum* and *A. verticillatum*) are also recorded from neighbouring Myanmar. Moreover, their distribution ranges continue to the subtropical Himalayas in India to China (Yunnan).

Argostemma lobbii, known from the Northern, Central and the South-western regions, also extends westwards to the east of Myanmar. *A. tavoyanum* (South-western and Peninsular Thailand) not only extends to Myanmar (occurring on both the eastern and Western slopes of the Tenasserim Range which borders Thailand and Myanmar), but also to the Andaman Is. (Fig. 9).

Three more species, *A. pictum* (Fig. 10), *A. diversifolium* and *A. neurosepalum*, in addition to their occurrence in Myanmar, are also recorded from the Malay Peninsula (the first mentioned species extends to the southern part of the Malay Peninsula, while the other two are confined to the northern half).

Several taxa occur only in Peninsular Thailand and (neighbouring) parts of the Malay Peninsula: *A. subcrassum* has a small distribution range stretching from Betong, the southern-most district of Yala Province to Perak State (Malaysia). Another taxon, *A. propinquum* is the only one species with a distribution range along the eastern coast of Peninsular Thailand and the Malay Peninsula (Fig. 11).

Three taxa of *Argostemma* clearly have their centre of distribution in the Malay Peninsula, and just barely reach Peninsular Thailand: *A. elatostemma* (fairly widely distributed in the Malay peninsula), *A. spinulosum* (Fig. 12), and *A. unifolioides* var. *glabra* (var. *unifolioides* is confined to the Malay Peninsula only).

A widely distributed species is *A. ophirense*, occurs along the Western coast of Peninsular Thailand and the Malay Peninsula and extends to the west of Sumatra.

The species with the widest range of distribution is *A. neurocalyx*. In Thailand, it is recorded from the Peninsular to the Northern regions, and also from the Central and South-eastern regions (Fig. 13). The species is distributed eastward to Cambodia, and south ward toward Malay Peninsula, Sumatra and Borneo.

DISCUSSION

More than half (17 out of 33, or 55%) of the taxa of *Argostemma* occurring in Thailand are endemic to the country. In view of this high endemism, and the high concentration of taxa in Thailand the following questions arise: Why is that so? Is Thailand the centre of origin of *Argostemma*? Is it the special ecological and/or geological conditions that favour speciation?

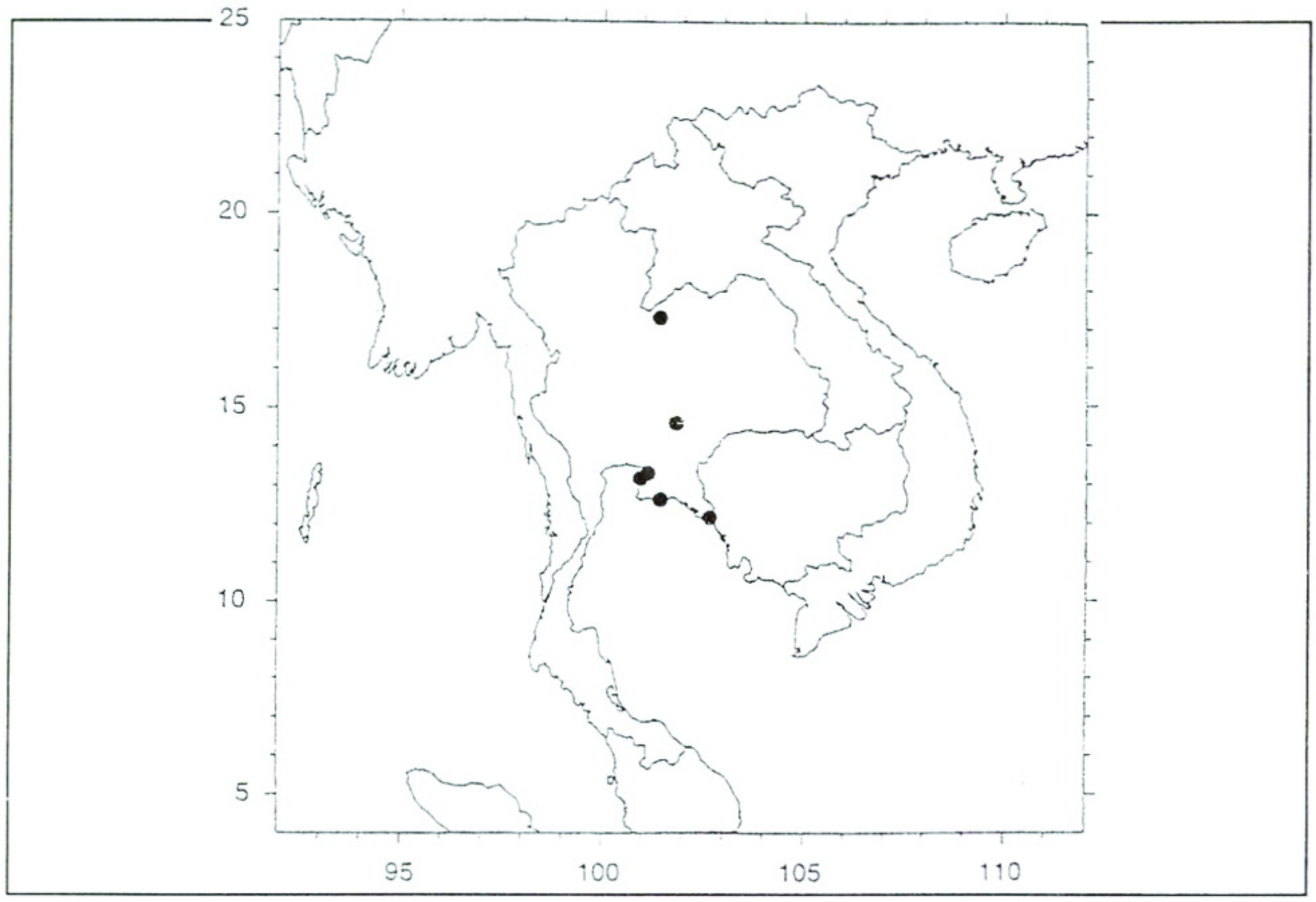

Fig. 8. Distribution of *Argostemma monophyllum*.

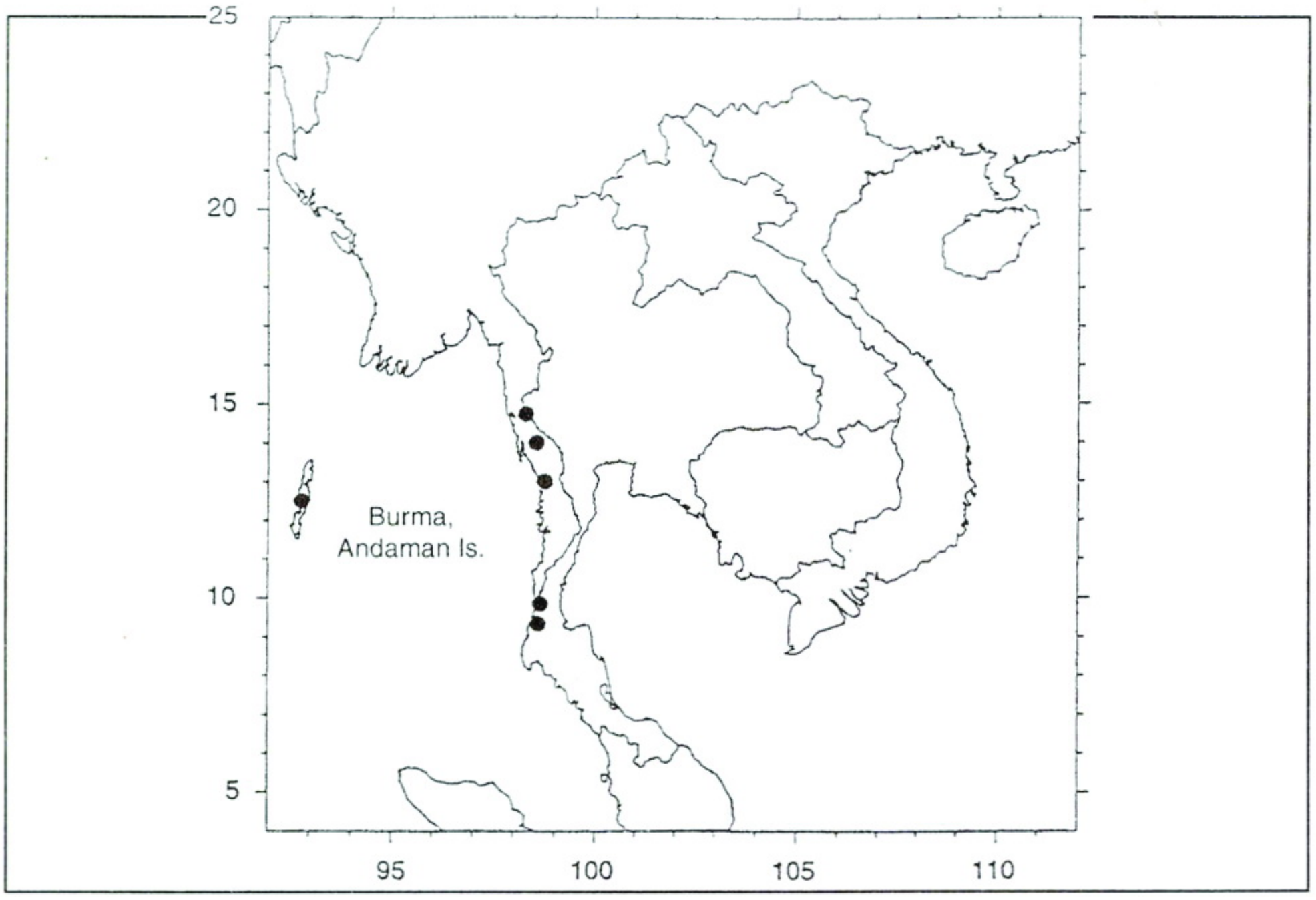

Fig. 9. Distribution of *Argostemma tavoyanum*.

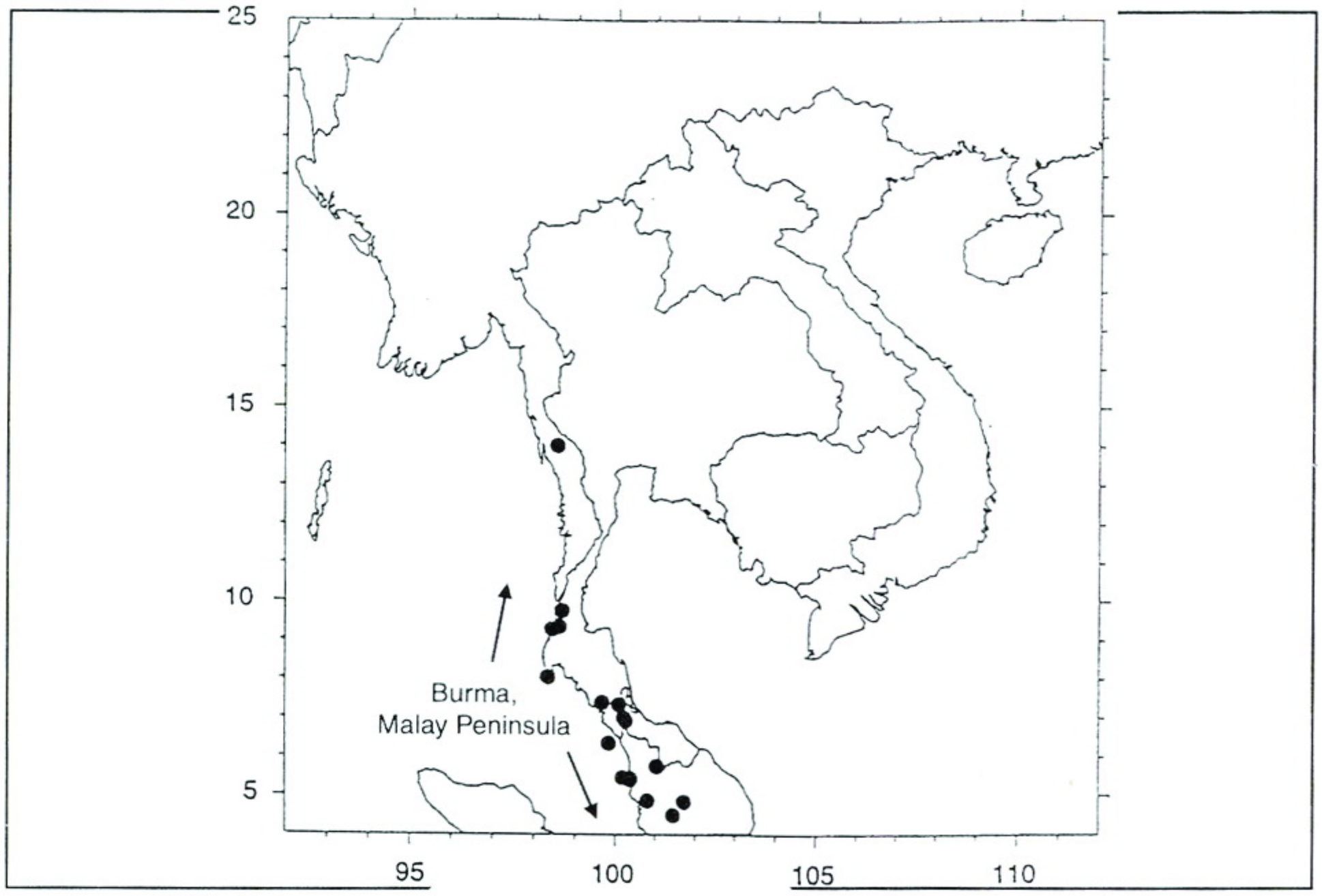

Fig. 10. Distribution of *Argostemma pictum* (Malay Peninsula localities partly outside the map area).

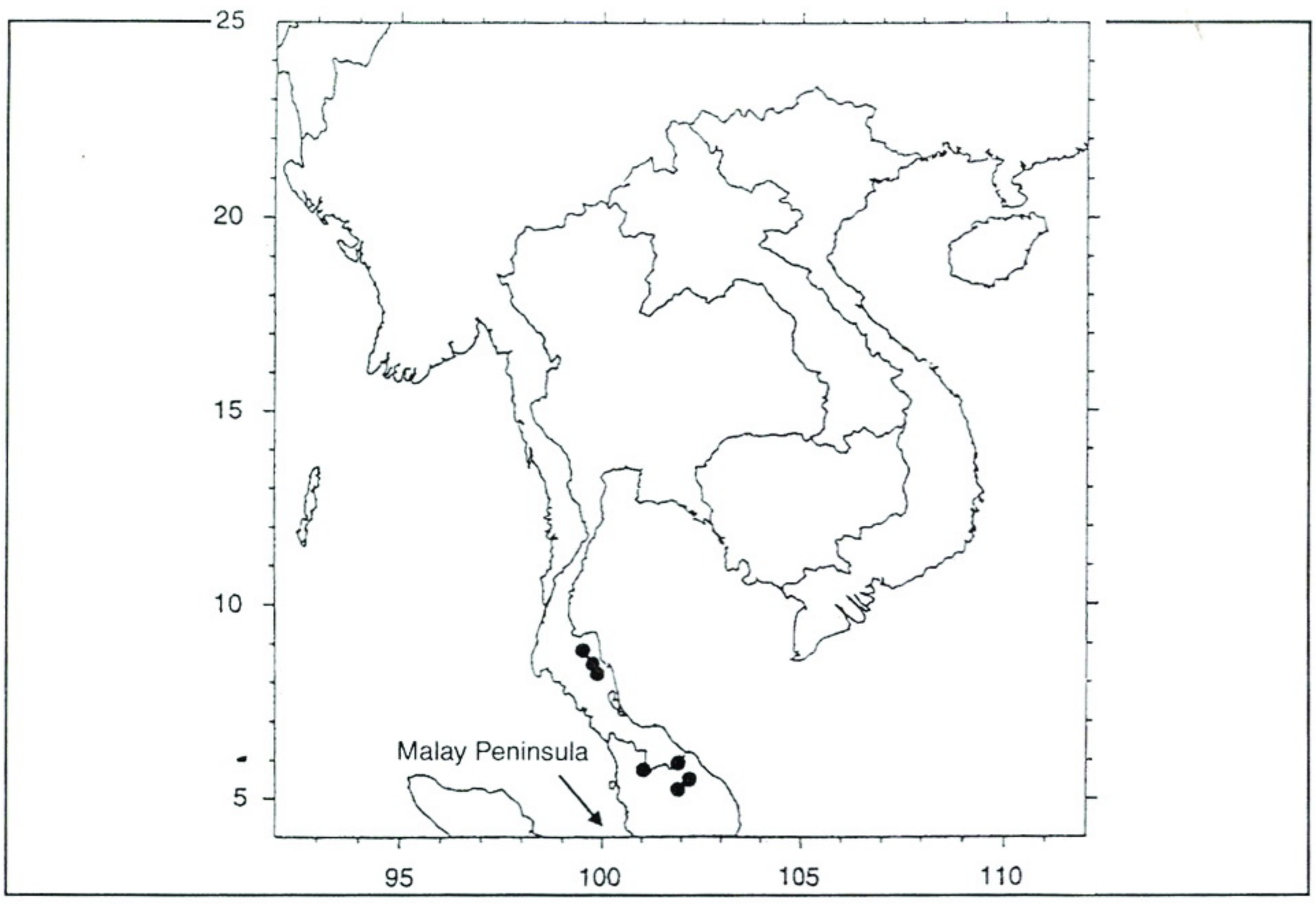

Fig. 11. Distribution of *Argostemma propinquum* (Malay Peninsula localities partly outside the map area).

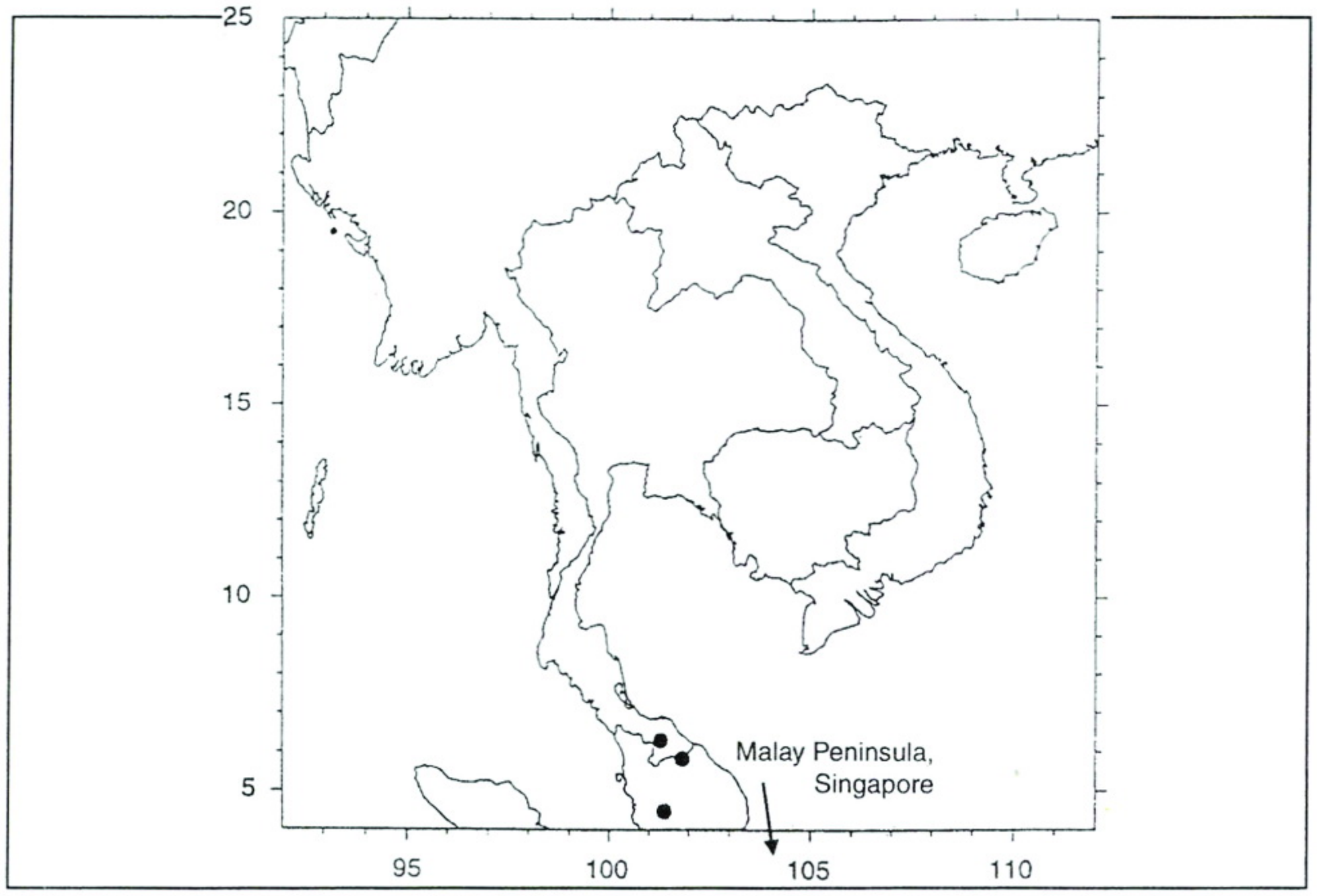

Fig. 12. Distribution of *Argostemma spinulosum* (Malay Peninsula localities partly outside the map area; extending S to Singapore).

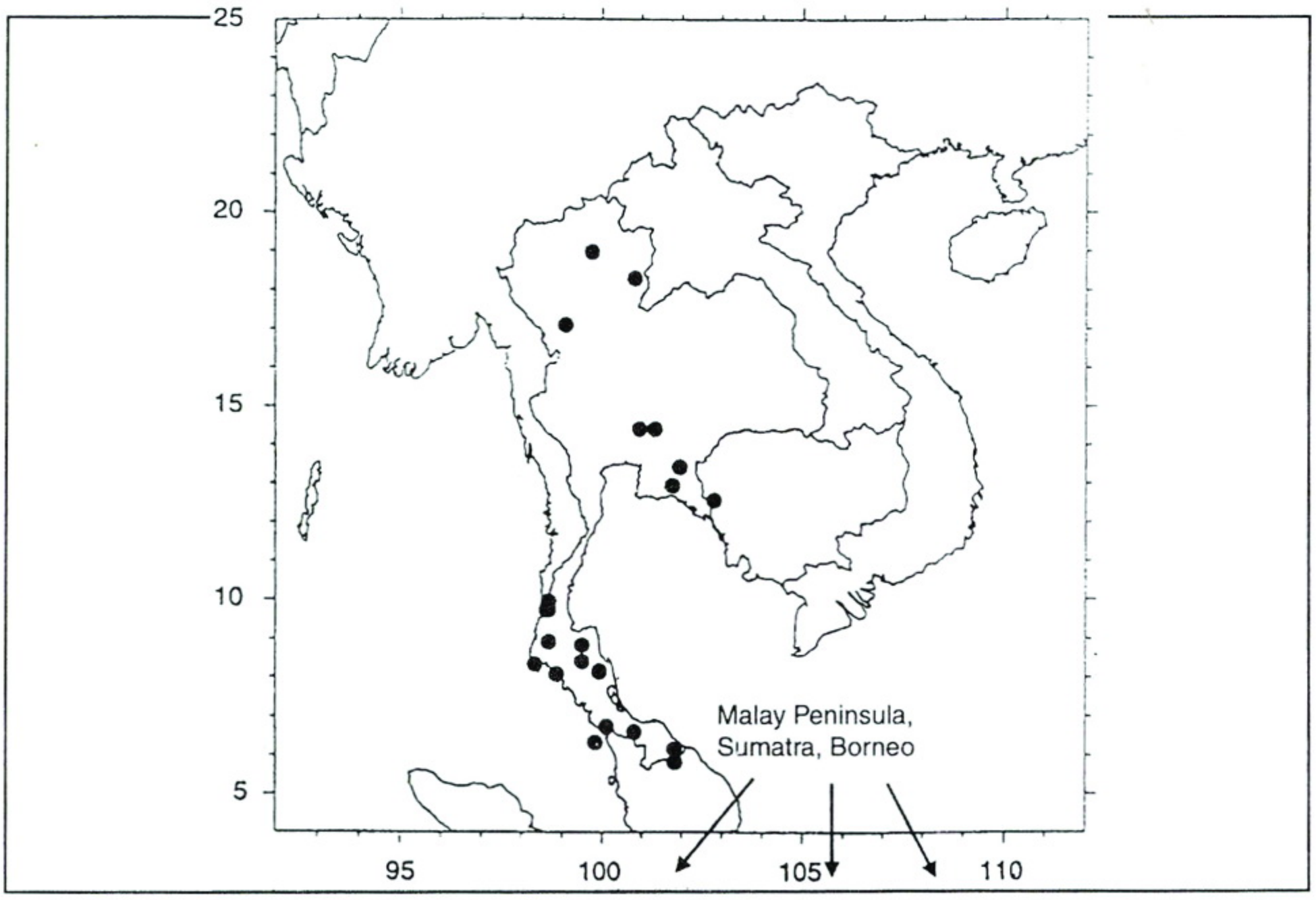

Fig. 13. Distribution of *Argostemma neurocalyx* (also in the Malay Peninsula, Sumatra and Borneo)

With regard to ecological conditions, the answer very likely is no. As noted in the introduction above, practically all species occur in specific microhabitats (i.e. shady, moist to wet situations). With regard to geological conditions, it is noteworthy that three of the four species possibly restricted to limestone are endemics (*A. lobulatum*, *A. puffii*, and *A. thaithongae*, the first two are confined to the Peninsular, the third to Northern regions).

However, if morphological characters (notably the growth form of the plants), are taken into account, an interesting pattern emerges: *Argostemma* species fall into two groups: (a) taxa with a distinct leafy stem (i.e. several to many leaf-pairs, separated by well developed internodes; here referred to as "leafy stem" taxa), and (b) taxa with one to few leaf-pairs which, due to shortened internodes, are in close proximity to each other and thus appear as if they were in whorls (here referred to as "pseudo-verticillate" taxa). The latter type is undoubtedly more derived, and occurs in no less than 14 of the 17 endemics. Only three species (*A. condensum*, *A. dispar*, *A. laeve* subsp. *setosum*) are "leafy stem" taxa, and all of them are confined to the Peninsula.

Of the 14 "pseudo-verticillate" endemic taxa, ten occur in the Northern region of the country (see first ten endemic taxa - in bold print - in Table 1), of which six are entirely confined to that region. Only four of the "pseudo-verticillate" endemic taxa are confined to the Peninsular region (the two varieties of *A. lobulatum*, *A. puffii* and *A. rotundicalyx*).

Assuming a strictly tropical origin of *Argostemma* (and the ancestral stock being a "leafy stem" herb), it is tempting to conclude that *Argostemma* experienced a secondary "species explosion" in the part of the country that is characterised by a more seasonal climate, or – in other words – at the no longer strictly tropical "fringes" of the genus' distribution range.

If the growth form types discussed above are correlated with the two distinct flower (corolla) types found in *Argostemma* [bell-shaped corollas on the one hand, and star-shaped corollas (*Solanum*-like flowers) on the other], and with other flower features, such as androecium arrangement and anther dehiscence (and pollen morphological data), the emerging picture is less distinct. Nevertheless, in an analysis of the floral diversity in *Argostemma* (Sridith & Puff 1999), the conclusions reached were the same as those presented here.

Table 1. Distribution of the taxa of *Argostemma* in Thailand.— Taxa endemic to Thailand (total: 17) are shown in bold.— Regions [N (Northern) ... PEN (Peninsula)] according to Flora of Thailand; column "outside Thailand" (applying to Non-endemics): IC – Indochina; MP – Malay Peninsula; B – Myanmar; SGP – Singapore; SUM – Sumatra.— SUMMARY 1: total number of taxa *per region,* and as percentage of the total no. of taxa *in Thailand* ($\sum$ 31); SUMMARY 2: number of taxa *endemic* to an individual region, and as percentage of the total no. of taxa *in the region.*

Taxa	N	NE	E	SE	C	SW	PEN	outside Thailand
A. ebracteolatum	+							---
A. fragile	+							---
A. laxum	+							---
A. plumbeum	+							---
A. stellatum	+							---
A. thaithongae	+							---
A. concinnum	+		+	+				---
A. khasianum	+							B, India
A. verticillatum	+							B, Yunnan
A. lobbii	+				+	+		B
A. neurocalyx	+			+	+		+	MP, SUM, Borneo; IC (Cambodia)
A. monophyllum		+	+	+	+			---
A. parvum			+	+				---
A. pulchellum				+				---
A. diversifolium						+	+	MP, B
A. neurosepalum						+	+	MP
A. tavoyanum						+	+	B, Andaman
A. condensum							+	---
A. dispar							+	---
A. laeve* subsp. *setosum							+	---
A. lobulatum* var. *lobulatum							+	---
A. lobulatum* var. *variabile							+	---
A. puffii							+	---
A. rotundicalyx							+	---
A. pictum							+	B, MP
A. propinquum							+	MP
A. subcrassum							+	MP
A. unifolioides var. *glabra*							+	MP
A. elatostemma							+	MP, SPG
A. spinulosum							+	MP, SGP
A. ophirense							+	MP, SUM
Summaries:	**N**	**NE**	**E**	**SE**	**C**	**SW**	**PEN**	
SUMMARY 1: no. of taxa per region; as % of *total* no. of taxa *in Thailand*:	**11** **35%**	**1** **3%**	**3** **10%**	**5** **16 %**	**3** **10%**	**4** **13%**	**18** **58%**	
SUMMARY 2: taxa *endemic* to region; as % of *total* no. of taxa *in the region*:	**6** **55%**	**0** **0%**	**0** **0%**	**1** **20%**	**0** **0%**	**0** **0%**	7 **39%**	

REFERENCES

Backer, C.A. and R.C. Bakhuizen van den Brink, Jr. 1965. Flora of Java 2. N.V. P. Noordhoff, Groningen.

Bremer, B. 1989. The genus *Argostemma* (Rubiaceae-Argostemmateae) in Borneo. Ann. Missouri Bot. Gard. 76: 7–49.

Elmer, A.D.E. 1906a. Philippine Rubiaceae. Leafl. Philipp. Bot. 1: 1–41.

Elmer, A.D.E. 1906b. Additional new species of Rubiaceae. Leafl. Philipp. Bot. 1: 63–73.

Elmer, A.D.E. (1913). Rubiaceae from Mount Urdaneta. Leafl. Philipp. Bot. 5: 1855–1905.

Hepper, F.N. 1963. Rubiaceae (*Argostemma*). In: Hepper, F.N. (ed.), Flora of West Tropical Africa, ed. 2, 2: 207–208. Crown Agents, London.

Hepper, F.N. 1965. Preliminary account of the phytogeographical affinities of the Flora of West Tropical Africa. Webbia 19: 593–617.

Hooker, J.D. 1880. Rubiaceae. In: Hooker, J.D. (ed.), The Flora of British India 3: 17–210. Reeve & Co., London.

Kurz, S. 1877. Knowledge of the Burmese flora. J. As. Soc. Beng. 46: 131–206.

Lo, H.-S. 1986. Material for Chinese Rubiaceae 1 [in Chinese]. Bull. Bot. Res. North-East. Forest. Inst. 6: 31–53.

Mabberley, D.J. 1987. The plant-book. [reprinted with corrections 1989]. Cambridge University Press, Cambridge.

Merrill, E.D. 1915. Studies on Philippine Rubiaceae, II. Philipp. J. Sci., C. Bot. 10: 100.

Miquel, F.A.W. 1856. Flora Indiae Bataviae (Flora van Nederlandsch Indie) 2. Amsterdam.

Pitard, J. 1922. Rubiaceae. In: Lecomte, M.H. (ed.), Flore Générale de l'Indo-Chine 3, 1. Masson, Paris.

Ridley, H.N. 1923. The Flora of the Malay Peninsula 2. L. Reeve & Co., London.

Sridith, K. 1999. Revision of the genus *Argostemma* Wall. (Rubiaceae) in Thailand. Thai For. Bull. 27: 86–137.

Sridith, K. & C. Puff. In press. Floral diversity in *Argostemma* Wall. (Rubiaceae). Proceedings 4th International Flora Malesiana Symposium, Kuala Lumpur July 20–24, 1998.

Takhtajan, A. 1969. Flowering Plants, Origin and Dispersal. Oliver and Boyd, Edinburgh.

Valeton, T. 1925a. Die Rubiaceae von Papuasien. Erster Teil: Cinchonoideae. In: C. Lauterbach, C., Beiträge zur Flora von Papuasien. XIII. Bot. Jahrb. Syst. 60: 1–104.

Valeton, T. 1925b. Rubiaceae. Neue Nachträge. Nova Guinea 14, Bot.: 229–274.

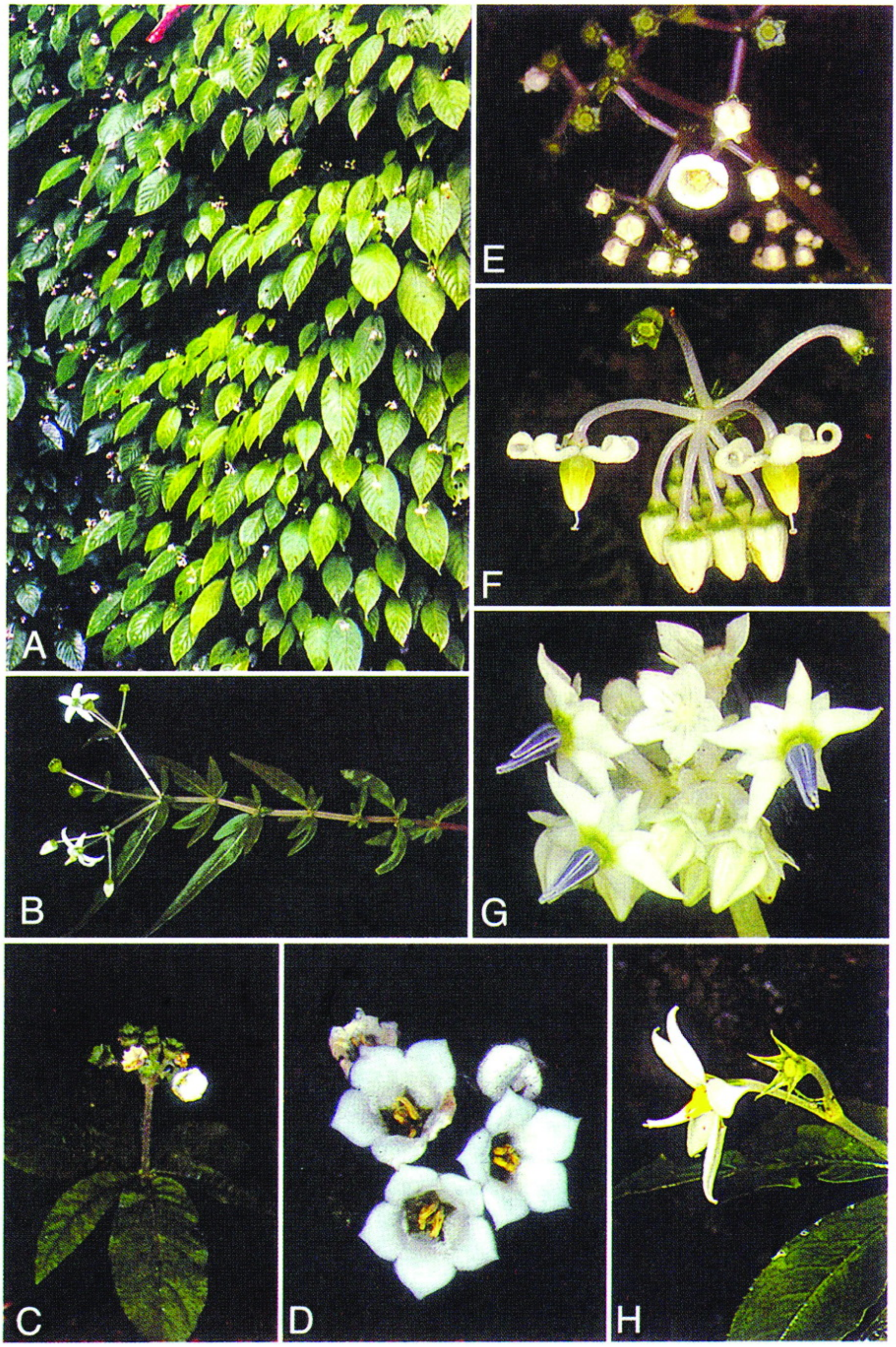

Fig. 14. *Argostemma* Wall.: A. *A. monophyllum* (Rayong; TH-1310); B. *A. lobbii* (Kanchanaburi; TH-6788); C-D. *A. ebracteolatum* (Kamphaeng Phaet; TH-6649 & -6653); E. *A. puffii* (Satun; TH-4166); F. *A. pictum* (Trang; TH-1872); G. *A. diversifolium* (Surat Thani; TH-2262); H. *A. laeve* subsp. *setosum* (Phattalung; TH-2220). All photographs C. Puff (colour slide numbers in brackets).