TRAPA : FOSSIL RECORD, DISTRIBUTION AND SYSTEMATICS

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ABSTRACT

The paper presents a record of the fossils of *Trapa* described so far. Distribution of the living species has been tabulated and listing of these species has been done therein. A short account of the systematics with reference to its placement in three different families has been given. MIKI's (1952) views regarding its evolutionary status and basis of speciation have been discussed. Relationships of *Trapa* with *Eotrapa*, *Trapella* and *Hemitrapa* have also been discussed.

INTRODUCTION

The floating aquatic angiosperm—*Trapa*, the only genus belonging to the family Trapaceae, was first described by LINNAEUS in his "*Genera Plantarum*" in the year 1754. The distribution of *Trapa* has attracted attention of many workers, and data regarding it have been published by ARESCHOUG (1873), PURI (1951), ARBER (1963) and several others. The evolutionary status of the genus and many of its species has been discussed in detail by MIKI (1952). The systematic position of *Trapa* has been argued by several taxonomists who have placed the genus in three different families, viz., Hydrocaryaceae, Onagraceae and Trapaceae. MIKI (1953, 1967 & 1968) has discussed the relationships of *Trapa* with the fossil genera—*Hemitrapa*, *Eotrapa* and *Trapella*.

FOSSIL RECORD

Fossils of *Trapa* fruits and pollen have been recorded from the Cretaceous to the Quaternary Period.

T.? cuneata Knowlton and *T.? microphylla* Lesq. are the earliest known species and have been reported from the Cretaceous of North America by BERRY (1914 b). However, in view of the question mark qualifying the generic name it is uncertain if these oldest fossils were of *Trapa*. BERRY (1914 a) has described two species, *T. wilcoxensis* and *T. alabamensis* from the Eocene and Pliocene, respectively, of North America.

The above four species and three others from North America have been recorded by KNOWLTON (1919).

1. *Trapa? microphylla* Lesquereaux (Cretaceous)
2. *T.? occidentalis* Knowlton (Miocene)
3. *T. americana* Knowlton (Miocene & Pliocene)
   (also reported by BROWN, 1937 from the Miocene of North America.)
4. *T.? cuneata* Knowlton (Cretaceous)
5. *T. alabamensis* Berry (Pliocene)
6. *T. wilcoxensis* Berry (Eocene)
7. *T. borealis* Heer (Eocene)

Fruits of 18 fossil species have been described by MIKI (1938, 1952, 1961 & 1962). These species listed below have been collected from fossil beds belonging to the Pliocene and Pleistocene of Japan :

1. *Trapa macropoda* Miki (1938, 1962)
2. *T. bicerata* Miki (1938)
3. *T. incisa* S. *et* Z. (Miki, 1938)
4. *T. manschurica* Flerov var. *bispinosa* Flerov (Miki, 1952)
5. *T. maximowiczii* Korsh. (Miki, 1952, 1962).
6. *T. deformata* Miki (1952, 1962)
7. *T. octotuberculata* Miki (1952, 1961, 1962)
8. *T. mammillioides* Miki (1952, 1962)
9. *T. mammillifera* Miki (1952, 1962)
10. *T. anteformata* Miki (1952)
11. *T. angusticerata* Miki (1952, 1962)
12. *T. tetragona* Miki (1952)
13. *T. discoidpoda* Miki (1952)
14. *T. macrohilum* Miki (1952)
15. *T. platycerata* Miki (1952)
16. *T. stipulicerata* Miki (1952)
17. *T. pulvinipoda* Miki (1952)
18. *T. dolichocarpa* Miki (1952)

Out of the above species nine were widely distributed in Japan ; they are *T. manschurica*, *T. mammillioides*, *T. deformata*, *T. macrohilum*, *T. macropoda*, *T. mammillifera*, *T. maximowiczii*, *T. octotuberculata* and *T. angusticerata*.

Fossil fruits of two species—*T. bispinosa* Roxb. and *T. natans* Linn., have been collected from the Pleistocene of Kashmir by PURI (1951). SAHNI (1938) collected several fossil fruits of *T. natans* from Bothapathri and the Ningal Nala situated at 2,897m in Kashmir.

HEER (1869) described *Trapa borealis* from Alaskana, which is the first fossil record.

Fossils collected from the Tertiary rocks of various regions of the world have been recorded by PURI (1951) :

1. *T. aresthusae* Ung. from Eocene rocks of Monte Bolca in Italy (GOEPPERT, 1857).
2. *T. pronatans* Endo from the Upper Eocene Formation of South Manchuria (ENDO, 1934).
3. *T. credneri* Schenk from the Oligocene of Saxony by SCHENK.
4. *T. silesiaca* Goepp., and *T. teumeri* Menzel from the Miocene rocks of Niederlausitz by GOTHAN AND SAPPER.
5. *T. prenatans* Dorf (=*T. americana* Knowl.) from the Pliocene deposits of America (DORF, 1936).
6. *T. natans* from the Cromerian beds Pliocene of eastern England and *Trapa* fruits from Wilcox beds of Eocene age in South U.S.A. (SEWARD, 1959).
7. *T. natans* from the glacial and post glacial deposits of Scandinavia, Britain, Germany, Holland, France and Russia, and *T. muzzanensis* from Russia, (PRINCIPI, 1938).
8. *T. yokoyamae* Nathorst from post Miocene of Kayakusa, Japan (KRYSHTOFOVICH, 1920).

MASSALONGO (1858) has described leaves of *Trapa* from the Tertiary of Italy ; he has named them as *Trapophyllum europaeum*.

Pollen of *T. natans* Linn. have been recovered from two Flandrian (Holocene) deposits at Skipsea and North Humberside in Britain by FLENLEY *et al.* (1975). This is the first record of *Trapa* pollen in Britain.

The occurrence of *T. natans* fruits in the Interglacial and Postglacial deposits of several countries in Europe suggests that the species had, in the past (Preglacial times), flourished at very high latitudes. Its disappearance from the high latitudes is considered by ARBER (1963) to be probably due to lowering of the mean temperature.

MIKI (1952) has pointed out that the northern limit of *Trapa* is 50° N and hence the cause of extinction does not appear to be climatic. He has suggested that extinction of *Trapa* and many other arctic Tertiary plants seems to be due to topographical changes. Due to upheavals it is possible that the ponds in which *Trapa* species were growing came to lie at low levels and were flooded by sea waters which would naturally cause their extinction.

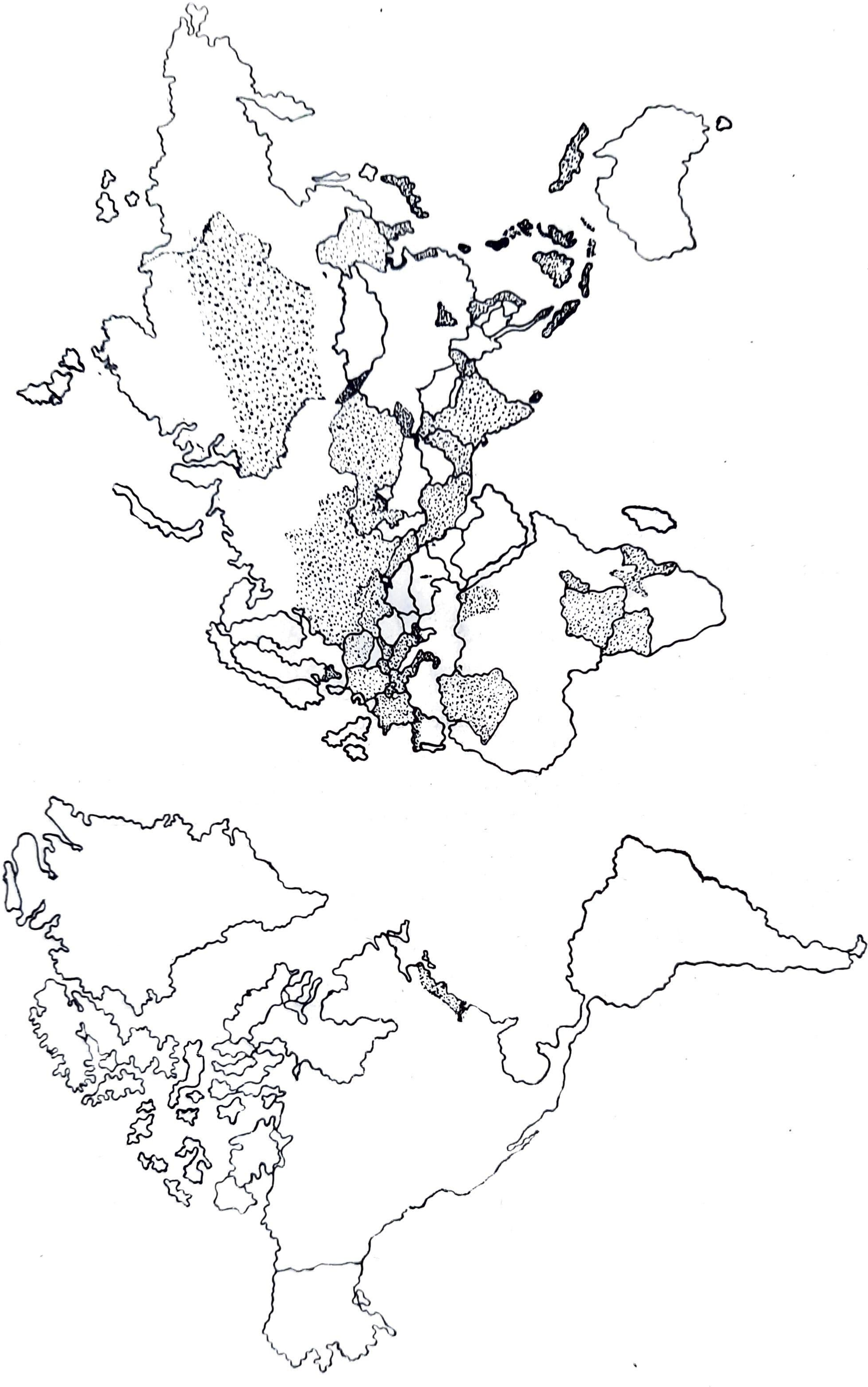
PRESENT DISTRIBUTION

The genus is widely distributed in the world in the tropical and temperate regions (Map 1). It does not occur in the continents of Australia and South America.

Living species of *Trapa* have been reported to occur in the following regions of the world :

(1) Africa : Upper Nile land, Algeria, Congo, Angola, Uganda, Zambia and Mozambique.
(2) Europe : north of Spain, north of Greece, Italy, Yugoslavia, Germany, Austria, Hungary, Poland, France, Switzerland and southern-most part of Sweden.
(3) USSR : European Russia, Ukraine, Kazakstan, Caucasus, Altai and Siberia.
(4) China : Manchuria, Chihii, Kiangsu, Taiwan, Szechwan and East Turkestan.
(5) Korea
(6) Japan
(7) Iran
(8) South Asia : India, Pakistan, Ceylon, Malaya, Indochina, Hawaii and Malesiana.
(9) Central-East USA : New England, New York and Maryland.

Distribution of 53 living species of *Trapa* listed by Index Kewensis, and 3 living species described by MIKI (1937, 1952) is recorded in Table 1. The most widely distributed species is *T. natans* Linn., which occurs almost throughout the northern hemisphere in the temperate region. In the tropical region of the northern hemisphere it occurs in Kashmir which, although belonging to the tropical region, has a temperate climate. Records of *T. natans* from the southern hemisphere are from Java, Upper Nile land and central West-Africa. (Information regarding the distribution of the 56 living species listed in Table-1 has been collected from ARBER (1963), ARESCHOUG (1873), AFANACHBEV (1949), BACKER (1963), BARANOV (1967), BRETSCHNEIDER (1935), COOK (1974), DURAVD AND JACKSON (1886—1895), HILL (1921—1940), HOOKER (1879), HOOKER AND JACKSON (1885), MIKI (1937, 1952), MUENSCHER (1944), OHWI (1965), OLIVER (1871), PAPOV (1957), PETER *et al.* (1977), PHAM-HOANG HO (1960), PURI (1951), SALISBURY (1941—1950), STEPHEN (1904—1910), TAYLOR (1951—1965) and VAN STEENIS (1948—1954).



Map 1. Present day distribution of the genus *Trapa* (Shaded portion showing presence).

Table 1—Present distribution of living species of *Trapa* Linn.

Sl. No.	Name of species	North Asia	South Asia	Europe	Africa	America (USA)
1.	*T. acicularis* Vassi.				Uganda	
2.	*T. acornis* Nakano	Kiangsu (China)				
3.	*T. algeriensis* Vassi.				Algeria	
4.	*T. amurensis* Fler.	Manchuria (China), Siberia (Russia)				
5.	*T. annosa* Jankovic			Yugoslavia		
6.	*T. antennifera* Leveille	Japan				
7.	*T. araborum* Vassi.				Algeria	
8.	*T. austroafricana* Vassi.				Zambia	
9.	*T. bicornis* Linn.	China, Japan	Ceylon, Vietnam (Indo-China), Hawaii, Malesiana			
10.	*T. bispinosa* Roxb.	Taiwan	India, Pakistan, Ceylon & Malaya		Tropical Africa	
11.	*T. borysthenica* Vassi.	European Russia		Germany, Italy, Austria		
12.	*T. brevicapa* Jankovic			Yugoslavia		
13.	*T. caucasica* Fler.	Caucasus (Russia) Iran				
14.	*T. cochinchinensis* Lour. Fl.		Indo-China			
15.	*T. colchica* Alboff.	Caucasus (Russia)				
16.	*T. congolensis* Vassi.				Congo	
17.	*T. danubialis* Dobroez	Ukraine (Russia)				
18.	*T. europaea* Fler.	Russia				
19.	*T. europea* Jankovic, *non* Fler.			Europe		
20.	*T. flerovii* Debroez	Ukraine (Russia)				
21.	*T. hyrcana* Woronow	Caucasus (Russia)				
22.	*T. incisa* Sieb. & Zucc.	Japan				
23.	*T. insperata* Vassi.	European Russia			Angola	
24.	*T. jankovicii* Tacik					
25.	*T. japonica* Fler.	Japan, Korea, North East China, Taiwan.				
26.	*T. jeholensis* Nakai	Manchuria (China)				
27.	*T. kasachstanica* Vassi.	Kazakhstan & Siberia (Russia)				
28.	*T. komarovii* Vassi.	Manchuria (China), Siberia (Russia)				
29.	*T. korshinskyi* Vassi.	Manchuria (China), Siberia (Russia)				
30.	*T. litwinowii* Vassi.	Manchuria & Chihli (China), Siberia (Russia)				

Table 1—(*continued*)

Sl. No.	Name of species	North Asia	South Asia	Europe	Africa	America (USA)
31.	*T. longicarpa* Jankovic			Yugoslavia		
32.	*T. longicornis* Vassi.	Siberia (Russia)				
33.	*T. macrohilum* Miki	Japan				
34.	*T. macrorhiza* Debroez	Ukraine (Russia)				
35.	*T. macropoda* Miki	Japan				
36.	*T. maeotica* Woronow	Caucasus (Russia)				
37.	*T. maleevii* Vassi.	Caucasus (Russia)				
38.	*T. manchurica* Fler.	Manchuria (China), Japan				
39.	*T. maximowiczii* Korchinchy	Russia, Japan	Malesiana			
40.	*T. natans* Linn.	Japan, China, Siberia (Russia), Iran	Java, Kashmir (India)	Southernmost part of Swe-den, Central Europe & Northern part of Spain & Greece	Upper Nile land, Central Africa	New England, New York & Maryland, Mohawk & Hudson River-Mas-sachusetts, Lower part of Potomac River-bet-ween Mary-land and Virginia, Algeria
41.	*T. numidica* Vassi.					
42.	*T. pectinata* Vassi.	Altai (Russia)				
43.	*T. platycerata* Miki	Japan				
44.	*T. potaninii* Vassi.	Szechuan & Manchuria (China)				
45.	*T. pseudincisa* Nakai	Korea, Manchuria (China)				
46.	*T. pseudocolchica* Vassi.	European Russia				
47.	*T. pyramidalis* Vassi.	European Russia		Hungary		
48.	*T. raciborskii* Jent			Poland		
49.	*T. rossica* Vassi	Russia				
50.	*T. septentrionalis* Vassi.	Russia				
51.	*T. sibirica* Flerov	Siberia Russia				
52.	*T. spryginii* Vassi.	Russia, Kazakstan (Central Asia)				
53.	*T. taiwanensis* Nakai	Taiwan				
54.	*T. tranzschelii* Vassi.	Siberia (Russia) China				
55.	*T. tuberculifera* Vassi.	Siberia (Russia) Manchuria (China)				
56.	*T. varbanensis* De			Italy		

SYSTEMATICS

The systematic position of *Trapa* has been a subject of controversy. According to LAWRENCE (1951), the oldest name for the family in which *Trapa* was placed is Trapaceae, first validly published by DUMORTIER in 1829, in Analyse des Families.

RAIMANN (1898) placed the genus *Trapa* in a new family Hydrocaryaceae. RAIMANN's view was supported by WETTSTEIN (1935). However, PULLE in 1938 suggested that in the absence of any genus named *Hydrocarya* the family name Hydrocaryaceae was not valid, and he shifted the genus back into the family Trapaceae.

BENTHAM AND HOOKER (1883), RENDLE (1925) and HUTCHINSON (1926) placed *Trapa* in the family Onagraceae while TACKHOLM, G. (1915), on the basis of the embryo sac structure, emphasized the distinctness of *Trapa* from the other Onagraceae and placed it in the Trapaceae. MANASI RAM (1956) studied the embryology of *Trapa bispinosa* Roxb. in detail, and has reported in it a *Polygonum* type of embryo sac. On the basis of embryological grounds she justified the removal of *Trapa* from the family Onagraceae, and its placement in the family Trapaceae.

The evolutionary status of *Trapa* has been of little interest. However, MIKI (1952) has suggested that the Myrtifloreae are the possible ancestors of *Trapa*. He has pointed out that the morphological features of *Trapa* are common with the Myrtifloreae and that amongst the Myrtifloreae the genus is more closely related to Lythraceae. The features that it shares with the Lythraceae are : presence of a calyx tube, tetramerous flower, 8-celled embryo sac, and occurrence of crystals of calcium carbonate in the cells. Within *Trapa*, he has suggested that the species without spines are the most highly evolved ones.

So far, the species have been differentiated on the basis of morphological characteristics. MIKI's (1952) basis of speciation is entirely morphological, and features he has used for identification are : nature and shape of calyx tube ; nature of the margin of the apical carona (i.e. marginal expansion encircling the horns) ; presence or absence, nature, shape and size of tubercles ; nature of the horns—broad or narrow, spiny or soft, long or short, straight or curved ; level of horns or relative level of two pairs of horns ; fruit axis—long or short ; size and shape of fruit ; presence or absence and nature of scar of peduncle.

Study of chromosomes of the various species may reveal additional useful parameter for delimitation of species.

Among the presumed relatives of *Trapa* were *Eotrapa*, *Trapella* and *Hemitrapa*. However, MIKI (1967) has suggested that *Eotrapa* and *Trapella* are more closely related to each other having spindle-shaped fruits and 5 bristle-like appendages on the top of the fruits. He is of the opinion that *Trapa* is not related to *Eotrapa* and *Trapella* as it lacks spindle-shaped fruits and does not possess the 5 bristle-like appendages on the top of the fruits.

MIKI (1953) has pointed out that *Hemitrapa* is also more closely related to *Trapella*, having peduncles, spindle-shaped receptacles, inconspicuous horns, and no apical crown on the top of the receptacle like *Trapella*. *Trapa* has broad fruits ; the fruits have conspicuous horns, apical crowns on the top, and no peduncles. He has shifted 4 fossil species viz., *T. borealis* Heer, *T. yokoyamae* Nathorst, *T. sachalinensis* Okutsu, and *T. hokkaidoensis* Okutsu to the genus *Hemitrapa* as they possess spindle-shaped or expanded egg-shaped fruits, no apical crowns, and have their right and left appendages, and front and rear ones grown in the same plane like *Hemitrapa*.

MIKI (1968) considers *Hemitrapa* to be more primitive as compared to *Trapa*.

Hemitrapa has usual seeds with 2 equal cotyledons whereas *Trapa* seeds are heterocotylous with very unequal cotyledons—a character which is advanced.

CONCLUSION

Occurrence of *T.? cuneata* and *T.? microphylla* in the late Cretaceous of North America may lead us to think that *Trapa* originated in the late Cretaceous in North America. However, the question mark qualifying these genera collected from the Cretaceous of North America, and the occurrence of other fossil fruits of *Trapa* from Eocene of north and south U.S.A., Alaska, Italy and South Manchuria suggest that *Trapa* may have originated during the Eocene.

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