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Epiphytic diatoms of *Enhalus acoroides* (L.F.) Royle

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Abstract. In the study of the distribution of epiphytic diatoms on the leaves of the seagrass *Enhalus acoroides* (L.f.) Royle from the Sungai Pulai estuary, Johor, Peninsular Malaysia, the average density of diatoms on the seagrass blades was found to be 1147 cells cm^{-2} and 30 species. The 30 species represent 10 genera and they belong to 9 families. The diatom flora was composed mainly of *Amphora angusta, Cocconeis placentula*, *Navicula gracilis*, *Nitzschia palea* and *Nitzschia sigma*. The highest density of diatoms was found in the middle region of the leaves whereas the apical and basal regions supported only a a low density of diatoms.

Abstrak. Dalam kajian taburan diatom epifit pada daun rumput laut *Enhalus acoroides* (L.f.) Royle dari muara Sungai Pulai di Johor, Semenanjung Malaysia, purata kepadatan diatom atas daun rumpai laut tersebut didapati sebanyak 1147 sel cm^{-2} dan 30 species. Ketiga puluh spesies terdiri daripada 10 genus dan 9 famili. Species-species yang utama adalah *Amphora angusta, Cocconeis placentula*, *Navicula gracilis*, *Nitzschia palea* dan *Nitzschia sigma*. Kepadatan diatom adalah tertinggi pada kawasan tengah daun *E. acoroides* dan terendah pada kawasan apeks dan basal.

Introduction

Seagrasses are submerged marine angiosperms that form dense meadows in shallow coastal areas, and they are often associated with coral reefs and mangroves in tropical regions. They possess roots with erect leafy shoots and reproduce vegetatively or sexually by production of flowers and roots. Seagrasses are an important biotic component of the marine ecosystem as they play a major role in the recycling of nutrients, and marine animals such as fish, turtles and dugongs feed on seagrasses; major food chains are based on seagrass detritus. Seagrass beds also provide nursery grounds for fish and invertebrates. Seagrass transplant is a potential method for rehabilitation of degraded coastal areas due to erosion.

Malaysian waters harbour a diverse seagrass resource with 13 species of seagrasses from seven genera recorded; however, this natural resource has been greatly neglected [1,2]. The largest seagrass ecosystem in the Peninsular Malaysia is that found in the Sungai Pulai estuary in the southern part. The predominant species of this seagrass bed is *Enhalus acoroides* (L.f.) Royle, which possesses wide linear and thick strap-like leaves. The aboveground biomass of the seagrass sampled from August 1994 to March 1995 in the Sungai Pulai estuary ranged from 7.40 to 14.13 g dry weight m^{-2} [2].

Seagrass leaf blades and erect stems provide a substratum for colonisation by microorganisms such as bacteria and diatoms, and later by larger algae and invertebrates. Factors such as age, shape and orientation of the seagrass leaves, wave action and nutrient levels can affect epiphytisation [4]. Colonisation of epiphytes usually occurs on the tips and edges, subsequently spreading over the surfaces to the base [5].

The epiphytic flora can contribute significantly to the overall primary productivity of seagrass beds. Epiphytes contribute to about 48-56% of the primary productivity of a *Halodule wrightii* community [6]. Diatoms are one of the dominant epiphytic microalgae on seagrasses. For example, 74% of the epiphytic microalgae on *Zostera marina* consists of diatoms [7]. Diatoms cover 20 to 60% of the colonised surface of *Posidonia oceanica* [8]. Epiphytic diatoms serve as an important food source for marine animals. Some fish may feed on the epiphytic algae but not on the seagrass itself [9].

Only limited studies have been conducted on seagrasses in Malaysia and they are mainly concerned with ecological and taxonomical aspects [1,3]. Studies on seagrass epiphytes mainly concentrate on macroalgae [9,10] and reports on epiphytic diatoms are mainly concerned with temperate species but not on *E. acoroides* [11,12]. This paper reports the distribution of epiphytic diatoms on the seagrass blades of *E. acoroides* from the Sungai Pulai estuary.

Experimental

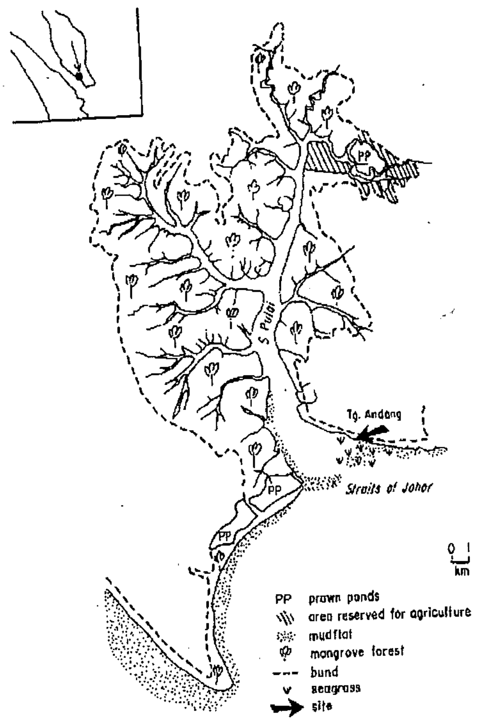

Figure 1. Map of Sungai Pulai estuary in Johor, Malaysia. Arrow indicates site of the seagrass bed.

The *E. acoroides* (L.f.) Royle samples were collected during low tide from the Sungai Pulai estuary at south west Johor (between latitudes 1°15' and 1°30'N) in October 1994. The seagrass bed was located in front of the mangrove at the eastern side of the estuary (Figure 1).

The seagrass blades (about 45 cm long) were cut into sections from the tip to the base, measuring about 3 cm long and 1 cm wide. The sections were separately sonicated in 10 mL ethanol (70%) for 4 min to remove the epiphytes. The epiphytic diatoms were observed under the light microscope and counted using an improved double-Neubauer haemacytometer. Two subsamples were removed for counting from each sample. The diatoms were identified based on taxonomic descriptions available [13-16].

The Shannon-Weiner Diversity Index (H) was calculated [17] by assuming $H = -\sum p_i \log p_i$, where p_i is the proportion of each species in each segment. The distribution of epiphytic diatoms along the seagrass leaves was compared using the Sorensen's Quotient of Similarity (S), calculated by assming $S=[2C/(A+B)] \times 100$, where A and B represent number of species in sections A and B, and C is the number of species found in both sections.

Results and Discussion

Species density and composition

The average density of diatoms on *E. acoroides* was 1147 cells cm^{-2}. Some 30 species of epiphytic diatoms, representing ten genera and belonging to nine families were identified (Figure 2). The most abundant diatom found was *Amphora angusta* (243 cells cm^{-2}); other diatoms which occurred at high densities were *Cocconeis placentula* (193 cells cm^{-2}), *Navicula gracilis* (155 cells cm^{-2}), *Nitzschia palea* (81 cells cm^{-2}) and *Niztschia sigma* (58 cells cm^{-2}) (Figure 3).

Distribution of diatom flora on different sections of E. acoroides *leaves*

The density of diatoms increased from the tip to the middle part then decreased towards the base of the leaves (Figure 4). Highest density of diatoms was found in the middle region, about 21- 27 cm from the tip. The diatom flora was most diverse around the middle region of the leaves, as indicated by the high diversity index.

The checklist of epiphytic diatoms and their density in different sections of the seagrass leaves are shown in Table 1. The composition of diatom flora varies from the tip to the base in the different sections of the leaves. The common diatoms found in most sections of the leaves were *Amphora angusta*, *Cocconeis placentula*, *Navicula gracilis* and *Nitzschia palea*. Species such as *Nitzschia vitrea*, *Surirella linearis*, *Surirella spiralis* and *Cyclotella meneghiniana* were less abundant.

The Sorensen Quotient of Similarity Index (Table 2) further indicated the difference in the composition of the diatom flora. Sections 2 and 3 (between 6 -12 cm from the tip) were similar in the composition of their diatom flora. In contrast, the diatom flora of section 14 (42-45 cm from the tip) was different from the other sections.

The present study is probably the first report on the distribution of epiphytic diatoms on *E. acoroides*. The diatom flora of *E. acoroides* was characterised by species such as *Amphora angusta*, *Cocconeis placentula*, *Navicula gracilis* and *Nitzschia palea*. This differs from the epiphyton of *Zostera marina* from Roscoff, France, which consists predominantly of *Cocconeis scutellum*, *Cocconeis scutellum* var. *parva* and *Synedra investiens* [5]. In comparison, *Cocconeis scutellum*, *Navicula diserta*, *Synedra fasciculata* and *Fragilaria striatula* var. *californica* dominate the diatom flora of *Zostera marina* from Yaquina Estuary (USA) [18]. The diatom vegetation of *Zostera marina* from Beaufort, North Carolina (USA) is composed mainly of *Nitzschia longissima*, *Melosira* sp., *Gyrosigma* spp. and *Licmophora* spp. and *Cocconeis placentula* [7]. The diatom flora of seagrasses varies with host species and localities.

Cocconeis is one of the most common genera of epiphytic diatoms on seagrasses. Three species of *Cocconeis*, with the dominance of *Cocconeis placentula* was recorded in the present study. In comparison, some 19 taxa of *Cocconeis*, predominantly *Cocconeis scutellum*, were found growing on *Zostera marina* [12]. The blades of *Zostera marina* are first colonised by *Cocconeis* spp. before other pennate diatoms such as *Navicula*, *Pleurosigma*, *Amphora* and *Nitzschia* spp [19]. The crust formed by diatoms, especially *Cocconeis* spp. rarely enters the diet of microherbivores whereas other less abundant species play a greater role [20].

The region near the tip of *E. acoroides* leaves supported only low density of diatoms compared to sections towards the middle part. Such pattern contrasted with that shown in other studies. For example, the abundance of epiphytes increases towards the leaf tip of *Thalsssia hemprichii*, *Posidonia* and *Posidonia australis* [4]. The standing crop of epiphytic diatoms increases towards the older apical surface of *Zostera marina* in Karaoka Bay, Japan [21].

The apical regions have denser population of epiphytes because they have been exposed longest to colonisation by algae. The release of inhibitory products and the active cell division occurring at the basal regions prevent algal settlement [11]. However, the epiphyte density may decrease if there is intense grazing, as found in *Zostera marina* [22]. In the present study, the low density of diatoms at the apical regions of the leaves could be due to grazing. Holes on the tip of the leaves, presumably arising from grazing, were observed.

The species composition of the various sections from the leaves of *E. acoroides* differed. This could be resulted from the differential effects on epiphytisation by water movement, grazing, light exposure and age.

Acknowledgments

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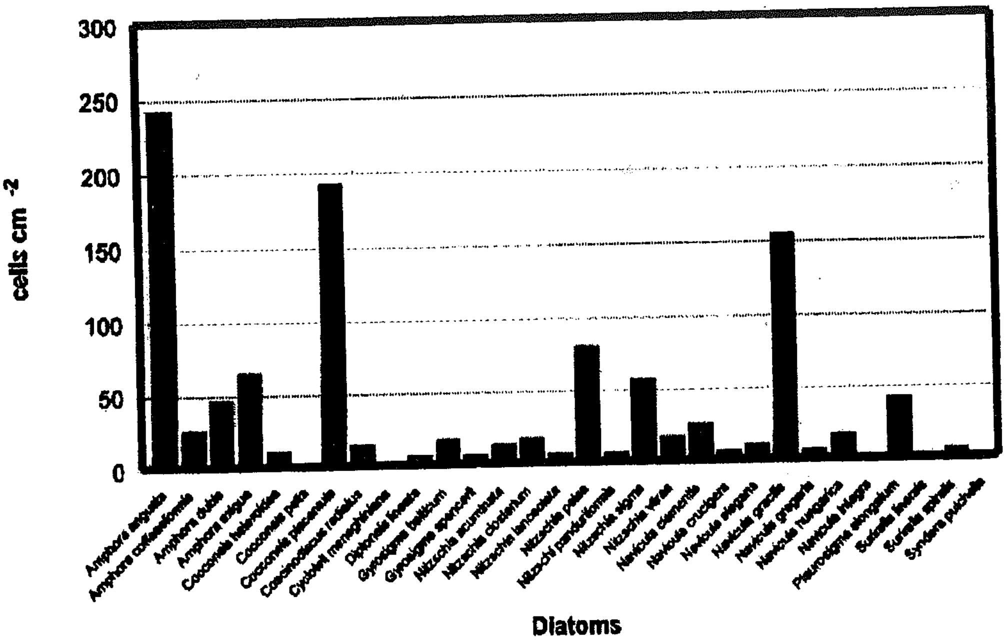

Figure 2. Average cell density of epiphytic diatoms on the leaves of *Enhalus acoroides*.

Table 1. Checklist and density (cells cm^{-2}) of epiphytic diatoms on different leaf sections of *Enhalus acoroides*.

Taxa	Section*														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Achnanthaceae															
Cocconeis heteroidea Hantzsch.	-	-	-	-	-	-	-	57	-	-	-	-	-	117	-
Cocconeis pelta Schmidt	-	-	-	57	-	-	-	-	-	-	-	-	-	-	-
Cocconeis placentula Ehrenberg	173	57	347	230	173	57	867	463	290	-	-	-	117	-	117
Coscinodiscaceae															
Coscinodiscus radiatus Ehrenberg	-	-	-	-	-	-	-	-	117	-	-	-	117	-	-
Cymbellaceae															
Amphora angusta Grunow	-	463	-	57	407	290	290	290	347	580	230	347	230	-	117
Amphora coffeaeformis (Ag.) Kutzing	-	-	-	-	-	117	-	173	-	-	-	-	-	117	-
Amphora dubia Gregory	-	-	-	-	-	-	-	230	117	117	-	117	-	-	117
Amphora exigua Gregory	117	57	-	-	57	173	463	-	-	-	-	-	-	-	117
Diatomaceae															
Synedra pulchella (Ralfs.) Kutzing	-	-	-	-	57	-	-	-	-	-	-	-	-	-	-
Naviculaceae															
Diploneis lineata (Donkin) Cleve	-	-	117	-	-	-	-	-	-	-	-	-	-	-	-
Gyrosigma balticum (Ehr.) Rabenhorst	57	-	-	-	-	-	-	-	117	-	-	117	-	-	-
Gyrosigma spencerii (W. Smith) Cleve	-	-	-	-	-	117	-	-	-	-	-	-	-	-	-

Table 1. Checklist and density (cells cm^{-2}) of epiphytic diatoms on different leaf sections of *Enhalus acoroides* (continued).

Taxa	Section														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Navicula clementis Grunow	-	-	-	117	-	117	57	-	-	-	117	-	-	-	-
Navicula crucigera (W. Smith) Cleve	-	-	-	-	-	-	-	-	117	-	-	-	-	-	-
Navicula elegans W. Smith	57	-	-	-	-	-	-	-	117	-	-	-	-	-	-
Navicula gracilis Ehrenberg	-	57	117	-	230	173	290	290	693	117	117	117	-	-	117
Navicula gregaria Donkin	-	-	-	-	-	-	-	-	-	-	-	117	-	-	-
Navicula hungarica Grunow	-	-	-	-	117	-	-	57	-	-	-	-	117	-	-
Navicula integra (W. Smith) Ralfs	-	-	-	-	57	-	-	-	-	-	-	-	-	-	-
Pleurosigma elongatum W. Smith	-	-	-	-	-	117	57	-	230	-	117	-	117	-	-
Nitzschiaceae															
Nitzschia acuminata (W. Smith) Grunow	-	-	-	-	-	57	57	-	-	-	-	-	-	117	-
Nitzschia closterium (Ehr.) W. Smith	-	57	230	-	-	-	-	-	-	-	-	-	-	-	-
Nitzschia lanceolata W. Smith	-	-	-	-	117	-	-	-	-	-	-	-	-	-	-
Nitzschia palea (Kutz.) W. Smith	117	57	230	117	-	57	-	290	117	117	-	-	-	-	117
Nitzschia panduriformis Gregory	-	-	-	-	-	-	-	-	-	117	-	-	-	-	-
Nitzschia sigma (Kutz.) W. Smith	-	173	230	-	-	57	-	57	-	-	117	230	-	-	-
Nitzschia vitrea Norman	-	-	-	-	-	-	290	-	-	-	-	-	-	-	-

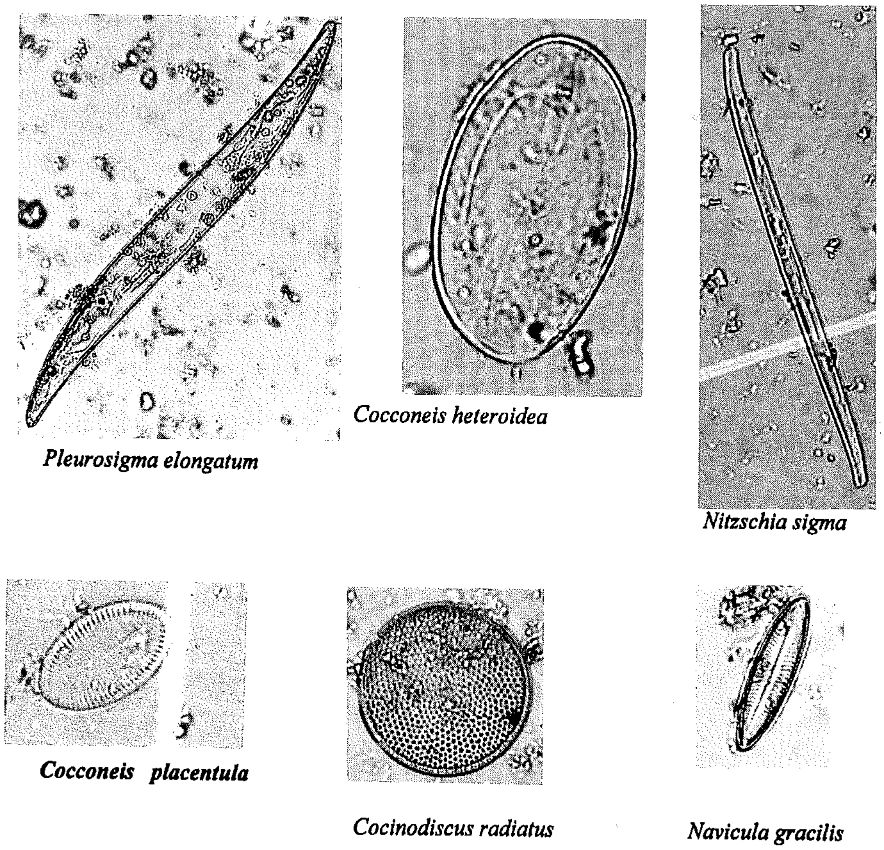

Figure 3. Epiphytic diatoms of *Enhalus acoroides*. Scale bar = 10 μm.

References

[1] Phang, S.M. (2000). *Seagrasses of Malysia*, Botanical Monographs No. 2, University of Malaya, 60 pp.

[2] Phang, S.M. (1990). *In*: Phang S.M., Sasekumar A. and Vickyneswary S. (eds), *Proc.12th Annual Seminar of the Malaysian Society of Marine Sciences*. Inst. Adv. Studies, Univ. Malaya, pp. 269-278.

[3] Ethirmannasingam, S., Phang, S.M. and Sasekumar, A. (1996). *In*: J. Kuo R.D. Phillips, D.I. Walker and H. Kirkman (eds.), *Seagrass Biology - Proc.Intl. Workshop*. Univ. Western Aust., Nedlands. pp. 33-40.

[4] Borowitzka, M.A. and Leithbridge, R.C. (1989). *In*: Larkum A.W.D., A.J. McComb and S.A. Shepherd (eds), *Biology of Seagrasses*, Elsevier Sci. Pub. Co. Inc., New York, pp. 458-499.

[5] Jacobs, R.P.W.M., Hermelink, P.M. and van Geel, G. (1983). *Aquat. Bot.* **15**: 157.

[6] Morgan, M.D. and Kitting, C.L (1984). *Limnol. Oceanogr.* **29**: 1099.

[7] Coleman, V.L. and Burkholder, J.A. (1995). *J. Phycol.* **31**: 36.

[8] Douby, P. and Poulicek, M. (1995). *Aquat. Bot.* **52**: 217.

[9] Kikuchi, T. (1974). *Aquaculture* **4**: 145.

[10] Brouns, J.J.W.M. and Hejis, F.M.L. (1985). *Aquat. Bot.* **25**: 71.

[11] Harlin, M.M. (1980). *In*: R.C. Phillips and C.D. McRoy, C.D. (eds), *Handbook of Seagrass Biology: an Ecosystem Perspective*, Garland STPM Press, New York, pp.117-151.
[12] Jacobs, R.P.W.M and Noten, T.M.P.A. (1980). *Aquat. Bot.* **8**: 355.
[13] van den Werff, A. and Huls, H. (1957-1974). Diatomeenflora van Nederland. De Hoef, Abcoude, The Netherlands.
[14] Wah, T.T. and Wee, Y.C. (1988). *Bot. Mar.* **31**: 317.
[15] Wah, T.T., Wee, Y.C. and Phang, S.M. (1992). *Gardens Bull.* **44**: 73.
[16] Giffen, M.H. (1975). *Bot. Mar.* **18**: 71.
[17] Shannon, C.E. (1948). *Bell Syst. Tech. J.* **27**: 237.
[18] Main, S.P. and McIntire, C.D. (1974). *Bot. Mar.* **17**: 89.
[19] Sieburth, J.M. and Thomas, C.D. (1973). *J. Phycol.* **9**: 46.
[20] Mazzella, L. (1996). *In*: J. Kuo, R.D. Phillips, D.I. Walker and H. Kirkman (eds.), *Seagrass Biology - Proc. Intl. Workshop.* Univ. Western Aust., Nedlands, p. 374.
[21] Kita, T. and Harada, E. (1962). *Publ. Seto. Mar. Biol. Lab.* **10**: 245.
[22] van den Ende, G. and Haage, P. (1963). *Bot. Mar.* **5**: 105.

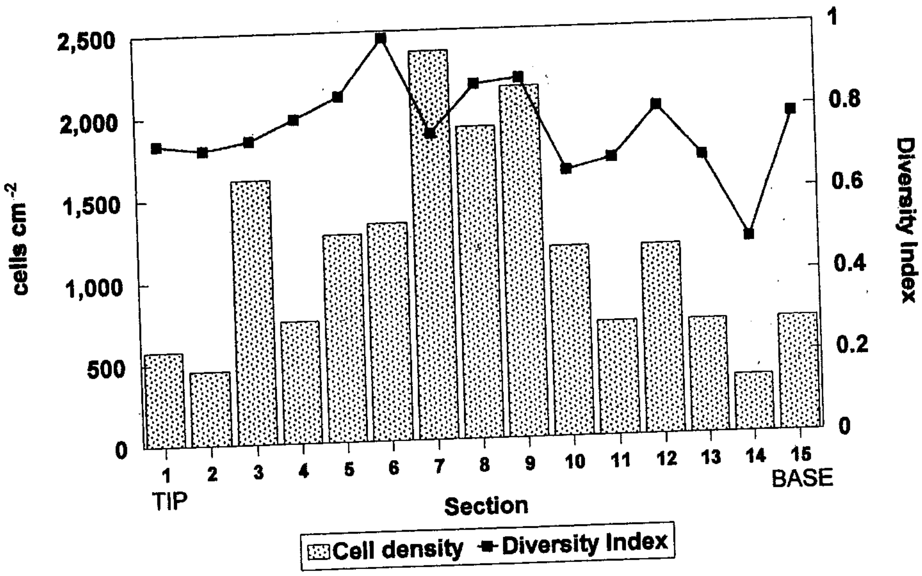

Figure 4. Cell densities and diversity indices of epiphytic diatoms on different sections of the leaves of *Enhalus acoroides*. Each section was 3 cm by 1 cm, and the sections are numbered accordingly from the tip to the base.

Table 1. Checklist and density (cells cm^{-2}) of epiphytic diatoms on different leaf sections of *Enhalus acoroides* (continued).

Taxa	Section														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Surirellaceae															
Surirella linearis W. Smith	57	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Surirella spiralis Kutzing	-	-	-	-	-	-	-	-	-	-	-	117	-	-	-
Thalassiosiraceae															
Cyclotella meneghiniana Kutzing	-	-	-	-	57	-	-	-	-	-	-	-	-	-	-
Total	578	458	1617	750	1272	1332	2371	1907	2145	1165	698	1162	698	351	702

* Each leaf section is 3 cm by 1 cm; the sections are numbered accordingly from the tip to the base of the leaf.