Journal of Coastal Research	3	4	445-450	Charlottesville, Virginia	Autumn 1987

Comparison of Proximate Constituents in Two Seagrasses from the Gulf of Mexico, Florida Keys, and Belize, Central America

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ABSTRACT

KRAMER, R.J., and DAWES, C.J., 1987. Comparison of proximate constituents in two seagrasses from the Gulf of Mexico, Florida Keys, and Belize, Central America. *Journal of Coastal Research*, 3(4), 445-450. Charlottesville, ISSN 0749-0208.

The levels of soluble carbohydrate, protein, lipid, and ash in seagrasses *Thalassia testudinum* Banks *ex* Konig and *Syringodium filiforme* Kutzing were determined from collections made during a single month from subtropical populations on the west coast of Florida and the Florida Keys, and tropical populations from an atoll off Belize, Central America. A high similarity was found for proximate constituents when populations of *T. testudinum* from subtropical and tropical sites were compared. Larger differences in levels of proximate constituents occurred between species and plant components (blade, short shoot, rhizome) than between tropical and subtropical populations of *T. testudinum*. On the other hand, *S. filiforme* populations showed significant differences for all four proximate constituents when subtropical and tropical populations were compared. Total caloric values of plant segments, based on dry weight, were very similar between populations and species. The data are interpreted as demonstrating a strong uniformity in levels of proximate constituents between populations regardless of latitudinal distribution, although seasonal and plant components may vary.

ADDITIONAL INDEX WORDS: *Seagrasses, productivity,* Thalassia, Syringodium.

INTRODUCTION

Information on the chemical and calorific properties and thus nutritional value of seagrasses, especially in tropical species is limited (BIRCH, 1975; DAWES and LAWRENCE, 1983), yet the preponderance of seagrass species and biomass occur in the shallow subtropical and tropical seas (DEN HARTOG, 1970; MCCOY and HECK, 1976). Determination of seasonal levels of proximate constituents (protein, soluble carbohydrate, lipid, ash) and caloric values of the various plant parts can also provide insight into seagrass growth, reproduction, and adaptations to the marine environment. For example, seasonal studies on the tropical seagrass *Thalassia testudinum* Banks *ex* Konig in the Gulf of Mexico indicated that soluble carbohydrate in the rhizome sustained the plant during periods of blade regrowth (DAWES and LAWRENCE, 1979) and periods of low activity (DAWES and LAWRENCE, 1980; WALSH and GROW, 1972). On the other hand, *Syringodium filiforme* Kutzing and *Halodule wrightii* Acherson had a large proportion of their organic matter remaining in the blades at the end of the growing season and thus can be considered to be "r" strategists in growth habit (DAWES and LAWRENCE, 1983).

There is essentially no information regarding variations between populations or sites of a given species of seagrass for the chemical components of temperate, subtropical, or tropical seagrasses. In the present study, we collected a sufficient number of individuals (blades, short shoots, rhizomes) of *T. testudinum* and *S. filiforme* during the same month and year (July 1979) to permit statistical evaluation of variation. The sites ranged from Tampa, Florida (29°06'N) to Glover's Reef, Belize, Central America (16°50'N). Our goal was to compare constituents between mature populations to determine whether significant differences in ash, protein, carbohydrate, or lipid occurred between plant parts, populations, or sites.

[1]*86013 received 17 April, 1986; accepted in revision 28 September 1986.*

Methods and Materials

Samples of *Thalassia testudinum* and *Syringodium filiforme* were collected in July 1979 at four sites in Florida and six sites at Glover's Reef, Belize, Central America (Table 1). A mature short shoot with its cluster of blades (2-5 blades) and blade base at a 4 cm length of attached rhizome with associated roots were designated as a seagrass segment. Eight individual segments (replicates) of *T. testudinum* were analyzed for each collection. Because of the smaller size, a replicate of *S. filiforme* consisted of four mature segments in order to obtain sufficient biomass for analysis. The procedures used are similar to those described by DAWES and LAWRENCE (1983). A multiple analysis was done using the Statistical Package for the Social Sciences (SPSS) to compare the individual sites in Florida and in Belize and the individual sites of each area with the mean of the other. Differences were compared at both the 0.05 and the 0.1 level in the analysis of variance.

Results

Thalassia testudinum. The highest levels of ash occured in the short shoots at both Florida (35.8 to 55.7%; mean 46.5%) and Belize (44.5% to 49.7%; mean 46.5%) in part because of sand and shell accumulation in the leaf sheaths and the large amount of dead material found in this portion of the plant (Tables 2A, 2B). Lipids levels were low for all plant parts (0.5 to 7.4%) and the highest levels of protein were usually in blades (4.8 to 15.2%) regardless of site (Table 2A, 2B). Soluble carbohydrate levels were highest in rhizomes. Caloric levels were generally highest in the rhizome of both Belizian and Floridian sites.

Almost all of the significant differences between the four Florida sites occurred in plants collected at the most tropical habitat, Key West (Site 4).

At that site, lipid and protein levels of blades were higher than those from blades of plants from the other three sites. Protein levels of the short shoots were significantly lower at Florida sites 1 and 3 (3.4 and 2.9%) than at sites 2 and 4 (8.7 and 9.5%). Soluble carbohydrate levels in the short shoots were significantly higher (8.2%) at site 2 than at any of the other three Florida sites. Rhizomes from all four Floridian sites contained comparable amounts of ash (20.8 to 27.0%) and lipid (1.8 to 4.1%). Rhizomes from sites 1 and 3 in Florida showed significantly lower levels of protein (7.2 and 3.5%) than sites 2 and 4 (15.2 and 10.6%). Soluble carbohydrate levels were low, significantly lower at site 1 (5.8%) when compared to the other sites (9.0 to 12.0%).

Plants from the four sites at Glover's Reef off

Table 1. *Description of seagrass sites in Florida and Glover's Reef.*

Site Number	Location	Composition	Depth (meters)	Water Temp.	Comment
1	Indian Bluff Island, FL (28° 06.0'N, 82° 47.5'W)	Mixed *Thalassia, Syringodium,* and *Halodule.*	1	28°C	Quiet water along sea wall.
2	Cockroach Bay, FL (27° 41.5'N, 82° 31.5'W)	Pure stands of *Thalassia.*	2-3	30°C	Estuarine conditions.
3	Surprise Lake, Key Largo, FL (25° 10.5'N, 80° 22.6'W)	Mixed *Thalassia* and *Halodule.*	2-3	29°C	Protected, high salinity.
4	Southmost Beach, Key West, FL (24° 32.5'N, 81° 48.0'W)	Mixed *Thalassia* and *Halodule.*	1-2	30°C	Exposed, high salinity.
5	Glover's Reef, Belize (16° 50.0'N, 87° 41.0'W)				
5A	Channel between Long and Middle Cays. Behind reef flat.	Mixed *Thalassia* and *Syringodium.*	2	30°C	Rapidly moving water.
5B	Reef flat in front of Long Cay.	Pure stand of *Syringodium* and *Halodule.*	11-12	30°C	Deepest site sampled.
5C	Lagoon near eastern tip of Long Cay.	Mixed to pure stands of *Syringodium* and *Halodule.*	3-4	30°C	Near channel, some erosion and silting.
5D	Lagoon near center of Long Cay.	Pure stand of *Thalassia.*	3-4	31°C	Very sparse growth.
5E	Channel between Long and Little Cays.	Pure to mixed stands of *Thalassia* and *Syringodium.*	1-2	30°C	*Syringodium* was located seaward, while the *Thalassia* occupied the calmer water near the lagoon.
5F	Lagoon, behind western face of atoll.	Mixed stands of *Thalassia, Syringodium,* and *Halodule.*	2-3	30°C	Lowered visibility due to large amounts of sediment in the water.

Table 2A. *Proximate constituent levels for* Thalassia testudium blades (B), short shoots (SS), and rhizomes (R) from sites in Florida.

Site	Plant Part	% Ash	% Lipid	% Protein	% Soluble Carbohydrate	% Insoluble Carbohydrate	Calculated Total KCal	Joules
1	B	29.9 ± 0.2	2.8 ± 1.2	4.8 ± 2.7	4.1 ± 1.6	58.4	3.1	1,296.6
	SS	44.8 ± 0.3	2.7 ± 0.5	3.4 ± 2.0	3.8 ± 1.0	45.3	2.5	1,029.1
	R	27.0 ± 0.1	1.8 ± 0.5	7.2 ± 3.2	5.8 ± 1.3	59.2	3.2	1,355.0
						Totals	8.8	3,680.7
2	B	24.9 ± 4.8	3.5 ± 0.7	13.2 ± 3.4	5.3 ± 2.0	53.1	3.5	1,451.9
	SS	49.5 ± 8.0	7.4 ± 2.3	8.7 ± 2.1	8.2 ± 1.8	26.2	2.6	1,089.1
	R	26.9 ± 2.5	3.8 ± 0.3	15.2 ± 5.5	9.8 ± 2.1	44.2	3.4	1,463.3
						Totals	9.5	3,977.3
3	B	29.3 ± 0.1	2.4 ± 1.0	6.4 ± 2.8	3.1 ± 0.6	58.7	3.1	1,308.8
	SS	35.8 ± 0.0	2.9 ± 0.2	2.9 ± 1.7	4.3 ± 0.7	54.1	2.8	1,184.9
	R	25.4 ± 4.2	4.1 ± 2.0	3.5 ± 1.5	12.0 ± 3.2	55.0	3.3	1,393.7
						Totals	9.2	3,887.4
4	B	29.0 ± 1.9	4.1 ± 1.3	15.8 ± 3.2	3.8 ± 1.3	47.3	3.4	1,413.7
	SS	55.7 ±10.9	4.2 ± 2.4	9.5 ± 1.9	3.7 ± 1.2	26.8	2.2	915.9
	R	20.8 ± 3.6	3.4 ± 1.2	10.6 ± 2.0	9.0 ± 1.4	56.2	3.6	1,505.4
						Totals	9.2	3,835.0
Means of all Florida sites	B	28.3 ±12.8	3.2 ± 1.4	10.5 ± 5.4	4.1 ± 1.3			
	SS	46.5 ±11.9	4.3 ± 1.5	6.1 ± 3.4	5.0 ± 1.7			
	R	25.0 ±10.8	3.2 ± 1.7	9.1 ± 3.9	9.2 ± 3.5			

Table 2B. *Proximate constituent levels for* Thalassia testudium blades (B), short shoots (SS), and rhizomes (R) from sites at Glover's Reef, Belize.

Site	Plant Part	% Ash	% Lipid	% Protein	% Soluble Carbohydrate	% Insoluble Carbohydrate	Calculated Total KCal	Joules
5A	B	29.6 ± 0.0	2.9 ± 0.1	9.4 ± 1.2	4.1 ± 0.9	54.1	3.2	1,333.4
	SS	44.5 ± 3.7	3.3 ± 0.8	7.0 ± 1.4	3.8 ± 0.4	41.4	2.6	1,070.7
	R	19.3 ± 0.5	1.3 ± 0.0	11.1 ± 1.5	5.8 ± 1.4	62.5	3.6	1,485.7
						Totals	9.3	3,889.8
5D	B	32.4 ± 0.8	1.2 ± 0.1	25.2 ± 3.7	7.3 ± 2.8	33.9	3.2	1,348.5
	SS	46.0 ± 2.2	0.6 ± 0.3	19.2 ± 2.9	9.7 ± 4.0	24.5	2.5	1,063.2
	R	22.1 ± 1.9	0.5 ± 0.0	17.1 ± 1.9	11.3 ± 2.9	48.9	3.5	1,459.0
						Totals	9.2	3,870.7
5E	B	35.0 ± 3.5	1.4 ± 0.6	21.4 ± 1.5	4.3 ± 1.0	39.3	3.1	1,310.9
	SS	48.9 ± 1.1	1.4 ± 1.3	13.8 ± 2.4	6.0 ± 2.0	29.9	2.4	997.1
	R	24.0 ± 2.7	0.5 ± 0.2	19.9 ± 2.8	16.8 ± 2.1	38.8	3.5	1,445.2
						Totals	9.0	3,735.2
5F	B	27.1 ±10.0	1.7 ± 0.6	24.3 ± 1.8	7.8 ± 2.0	39.1	3.5	1,445.6
	SS	49.7 ± 2.9	1.0 ± 0.3	13.1 ± 2.5	6.2 ± 1.2	30.1	2.3	968.6
	R	24.2 ± 0.3	0.7 ± 0.4	21.8 ± 3.6	15.3 ± 3.1	38.1	3.5	1,455.6
						Totals	9.3	3,869.8
Means of all Belize sites	B	31.0 ± 3.5	1.8 ± 0.6	20.1 ± 7.0	5.9 ± 3.0			
	SS	47.2 ± 3.6	1.6 ± 1.7	13.3 ± 5.3	6.4 ± 3.3			
	R	22.4 ± 2.6	0.8 ± 1.0	17.5 ± 5.1	12.3 ± 6.0			

Belize, Central America were similiar in levels of proximate constituents except for rhizomes at site 5A where all constituents except lipid levels differed from the other sites. Plants in the open channel of site 5A in Belize had significantly lower levels of protein in all parts and soluble carbohydrates in the rhizome (5.8%) (Table 2B).

When the four individual sites in Belize (Table 2B) were compared with the mean of the four sites in Florida (Table 2A) protein levels in all three organs were found to be significantly higher in all plant structures from Belizian sites. This comparison was also true when the four individual Floridian sites were statistically compared to the mean of the four sites in Belize. No statistically relevant pattern was evident for levels of ash or lipid. Carbohydrate levels were statistically similar for all structures for both Floridian and Belizian sites.

Syringodium filiforme. The blades of *S. filiforme* usually showed the highest mean (except for site 1) and overall mean for ash (37.3%) when compared with blades of *Thalassia testudinum* from Florida (28.3%) and Belize (31.0%) overall means. Lipid levels were low in both Floridian (1.0% to 4.3%) and Belizian (0.5% - 5.9%) populations for all structures (Table 3). Protein levels were highest in the blades of plants from all sites (4.1-10.6%) and highest from Glover's Reef, Belize (9.9 to 10.6%).

Soluble carbohydrate was highest in the rhizome (up to 22.0%) in plants from all sites except 5A and 5C. No significant differences were noted in caloric levels between genera or sites, and in all but one instance (site 5C) the rhizome contributed the highest caloric level of the three plant parts.

Plant parts collected from Indian Bluff Island (Site 1) and Key West (Site 4) in Florida (Table 3) had significantly different levels of ash, lipid, and soluble carbohydrate. Plant parts from the four sites sampled at Glover's Reef, Belize (Table 3) had similar levels of lipid and protein, but carbohydrate levels in the rhizome were significantly different from site to site.

Syringodium filiforme from Belize (the four sites) showed signficantly different levels when the means of each proximate constituent in the short shoots and rhizomes were compared to means from plants collected at the two Florida sites. There were insufficient data for the comparison of blade constituents from the various sites.

DISCUSSION

Proximate constituents in the blades, short

Table 3. *Proximate constituent levels for* Syringodium filiforme *blades (B), short shoots (SS), and rhizomes (R) from sites in Florida (1 and 4) and Glover's Reef, Belize (5A, 5B, 5D, and 5F).*

Site	Plant Part	% Ash	% Lipid	% Protein	% Soluble Carbohydrate	% Insoluble Carbohydrate	Calculated Total KCal	Joules
1	B	28.2 ± 0.1	2.5 ± 0.3	4.2 ± 2.0	3.4 ± 0.6	57.7	3.0	1,245.8
	SS	42.1 ± 0.3	2.5 ± 0.8	3.5 ± 0.8	3.2 ± 1.1	55.6	2.8	1,190.2
	R	22.9 ± 0.1	1.6 ± 0.9	1.3 ± 0.1	4.8 ± 1.5	74.7	3.5	1,455.1
						Totals	9.3	3,891.1
4	B	34.7 ± 2.6	4.3 ± 1.0	4.1 ± 1.8	8.5 ± 1.3	47.3	3.0	1,241.7
	SS	31.6 ± 1.5	1.8 ± 0.2	6.2 ± 1.1	6.9 ± 1.0	53.5	3.0	1,253.4
	R	18.2 ± 0.2	1.0 ± 0.3	3.6 ± 1.6	14.6 ± 0.9	62.6	3.5	1,448.4
						Totals	9.5	3,943.5
5A	B	36.2 ± --	-- --	10.1 ± 2.8	5.4 ± --	48.3	2.8	1,159.8
	SS	34.9 ± --	0.5 ± --	7.0 ± 1.3	3.6 ± --	54.0	2.8	1,173.2
	R	18.8 ± --	1.3 ± 0.5	5.8 ± 0.6	2.2 ± --	71.9	3.5	1,458.8
						Totals	9.1	3,791.8
5B	B	36.8 ± --	2.2 ± 0.3	10.6 ± 2.8	10.5 ± 0.3	39.9	2.9	1,201.3
	SS	35.2 ± --	1.0 ± 0.7	9.2 ± 1.1	8.3 ± 1.4	46.3	2.9	1,192.7
	R	24.0 ± --	5.9 ± 1.7	8.2 ± 2.1	22.0 ± 2.6	39.8	3.6	1,489.2
						Totals	9.4	3,883.2
5C	B	38.9 ± --	2.7 ± 0.03	9.9 ± 1.2	8.0 ± 2.2	40.4	2.8	1,173.4
	SS	21.5 ± --	2.4 ± --	11.4 ± 1.3	13.0 ± 3.9	51.8	3.5	1,472.4
	R	29.1 ± --	2.5 ± --	11.5 ± 1.2	7.3 ± 2.5	49.7	3.2	1,346.0
						Totals	9.5	3,991.8
Means:								
All	B	37.3 ± --	2.0 ± --	12.6 ± --	8.1 ± --			
Belize	SS	30.5 ± 5.7	1.2 ± 0.7	12.3 ± 4.8	8.9 ± 4.8			
sites	R	24.0 ± 4.0	3.0 ± 1.7	11.5 ± 6.5	10.9 ± 6.9			

shoots, and rhizomes of *Thalassia testudinum* showed more similarities (41 out of 60) than significant differences (19 out of 60) when mature plants from subtropical (Florida except Key West) and tropical populations (Key West and Glover's Reef) were compared in collections made in July. In fact, there were more significant differences between individual populations from Florida (17 out of 48) or Glover's Reef, Belize (30 out of 48) than between Floridian and Belizian populations, except for protein levels. Protein levels in blades at site 4 were significantly different from levels in short shoots and rhizomes. This study thus suggests that the levels of protein, carbohydrate, lipid, and ash in *T. testudinum* have larger differences occurring between plant parts (*i.e.*, blade and rhizome) than between latitudinally separated populations. The significantly lower levels of protein in Floridian populations may reflect slower growth rates.

Lipid and soluble carbohydrate levels in *Thalassia testudinum* showed smaller variations within each plant part (blade, short shoot, rhizome) irrespective of collection site. In general, soluble carbohydrate was highest in the rhizome of both species and most populations (*S. filiforme*, 3 out of 5; *T. testudinum*, 8 out of 8) suggesting the rhizome as a storage organ (DAWES and LAWRENCE, 1979; ZIEMAN, 1975). Protein levels were generally higher in all plant parts in samples from Belize. Protein levels are highest with blades during times of growth (DAWES and LAWRENCE, 1979) and perhaps reflect high growth rates for populations of *T. testudinum* at Glover's Reef where growth appears to be year around.

The lower levels of soluble carbohydrate in populations of *Thalassia testudinum* found in more shallow water sites (1, 4, 5A, 5E) may reflect stress due to fluctuating water temperatures, wave action, and possible exposure during spring tides. Beds of *T. testudinum* in Belize were found to die back to the short shoots during extreme low tides after only an hour or two exposure. In support of this, JAGELS (1973) reported *T. testudinum* blades will be damaged even after a brief exposure to air. It may be that populations found in deeper water (Sites 2, 3, 5B, 5C, 5D, 5F) suffer less blade damage so that less of the reserve soluble carbohydrate is used for plant maintenance. In this regard, ZIEMAN (1975) hypothesized, based on rhizome size, that *T. testudinum* should show a slow response to normal environmental stresses due to utilization of stored carbohydrate in the rhizome.

An increase in soluble carbohydrate also occurred in *Syringodinum filiforme* from deep sites (5B, 5C). Higher levels of protein were also observed in the rhizomes of the two deep water populations. *Syringodinum filiforme* has been described as a pioneer species based on growth rates in disturbed situations (PATRIQUIN, 1974), and as an opportunistic species based on a lower allocation of kilocalories to the rhizome (DAWES and LAWRENCE, 1983). The species does occur in a variety of stressed environments, such as high energy sites.

Total kilocalories per gram dry weight were quite similar regardless of species or site. Thus, while values for specific organic constituents might vary from one species or plant part to another, there was a balance in the total amount of organic material of a plant segment when expressed per gram dry weight. This comparative study demonstrates a clear uniformity in the levels of proximate constituents in *Thalassia testudinum* and *Syringodinum filiforme* collected at two latitudinally distinct areas, Florida and Belize. Seasonal conformations of such uniformity are still needed.

ACKNOWLEDGEMENTS

The authors wish to thank Dr. Norman Engstrom for his assistance in collecting and Drs. John Lawrence and Larry Strong for use of some laboratory equipment.

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☐ RESUMEN ☐

Se han determinado los niveles de carbohidratos solubles, proteinas, lipidos y cenizas en algas *Thalassia testudinum* Banks *ex* Konig y *Syringodium filiforme* Kutzing de muestras realizadas durante un mes en poblaciones subtropicales de la costa Oeste de Florida y poblaciones tropicales del atolón de Belize, Centroamérica. Se ha encontrado una alta similaridad de constituyentes inmediatos cuando se comparan poblaciones de *T. testudinum* de lugares tropicales y subtropicales. Por otro lado, las poblaciones de *S. filiforme* muestran grandes diferencias en los cuatro constituyentes inmediatos si comparamos poblaciones tropicales y subtropicales. El valor calórico total, basado en el peso seco, en similar entre poblaciones y especies. Los datos son interpretados como demonstración de una gran uniformidad en niveles de constituyentes inmediatos entre poblaciones, a pesar de la distribución longitudinal aunque los componentes estacionales pueden variar.--*Miguel A. Losada, Universidad de Cantabria, Santander, Spain*

☐ ZUSAMMENFASSUNG ☐

Die lösliche Kohlehydrat-, Protein-, Lipid- und Aschniveaus der Meergräser *Thalassia testudinum* Banks *ex* Konig und *Syringodium filiforme* Kutzing werden von Sammlungen genommen, die unter subtropischen Einwohnerzahlen in der Nähe der westlichen Küste Floridas und Florida-Keys und auch tropischen Einwohnerzahlen in der Nähe Belize, Mittelamerika, gesammelt (im Lauf eines Monats). Wenn die Niveaus der subtropischen und tropischen Einwohnerzahlen der *T. testudinum* verglichen wurden, gab es eine höhe Ähnlichkeit für unmittelbaren Bestandteile. Es gab grössere Unterschieden der Niveaus zwischen den Spezies und den Pflanzteile (Halm, Rhizome, *usw.*) also zwischen subtropischen and tropischen Einwohnerzahlen der *T. testudinum*. Andererseits zeigten die Vergleichung der Niveaus zwischen subtropischen und tropischen Einwohnerzahlen der *S. filiforme* grosse Unterschieden. Gesamte Kalorienwerte der Pflanzteile (die stützen sich auf trockenem Gewicht) waren sehr ähnlich zwischen Spezies und Einwohnerzahlen. Die Daten scheinen eine starke Gleichförmigkeit der Bestandteilniveaus zwischen Einwohnerzahlen zu darstellen; Breitenverteilung spielt keine Rolle, obwohl saisonbedingte und Pflanzbestandteile sich ziemlich unterscheiden.--*Stephen A. Murdock, CERF, Charlottesville, Virginia, USA*

☐ RÉSUMÉ ☐

Les niveaux de dioxyde de carbone soluble, protéine, lipides et résidus dans les herbiers à *Thalassia testudinum* Banks *ex* Konig et *Syringodium filiforme* Kutzing ont été déterminés à partir de collections constituées pendant un mois sur des populations subtropicales de la côte de Floride et les Florida Keys, et sur des populations tropicales d'un atoll situé au large de Belize en Amérique Centrale. La comparaison des sites tropicaux et intertropicaux donne une grande ressemblance des constituants immédiats des populations à *T. testudinum*, bien que de grandes différences existent dans les niveaux des constituants des espèces et des composantes de la plante (rhizome, taille de la pousse, limbe). D'aute part, la comparaison des mêmes sites montre des différences significatives pour tous les constituants immédiats de *S. filiforme*. Les valeurs caloriques totales des segments de plante, basées sur le poids sec, s'avèrent très semblables pour les diverses populations et espèces. Ces données démontrent la solide uniformité entre les populations, des niveaux des constituants immédiats quelque soit la latitude, malgré les saisons et les variations des composantes de la plante.--*Catherine Bressolier, EPHE, Montrouge, France*