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A Checklist of Lekki Lagoon Diatoms

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Abstract: The diatoms of Lekki lagoon for the first time were studied at monthly intervals for two years (June 2003-May 2005). Two hundred and thirty seven (203 pennate and 34 centric forms) diatom species belonging to 50 genera were recorded. Among the pennate diatoms, the most frequent species were *Achnanthes conspicua*, *Bachysira follis*, *Bacillaria paradoxa*, *Craticula cuspidata*, *Cymbella ventricosa*, *Decussata placentula*, *Eunotia incisa*, *Frustulia rhomboides*, *Gyrosigma balticum*, *Luticola mutica*, *Nitzschia radiosa*, *Pinnularia biceps*, *P. gibba*, *Placoneis exigua*, *Plagiotropis* sp., *Sellophora pupila* and *Synedra ulna* var. *longissima.* The holoplanktonic forms included *Synedra ulna* (Nitz.) Ehr., *Synedra acus* Kutzing and *Tabellaria fenestrata* (Lyng.) Kutzing. The centrals were ably represented by *Aulacoseira* and its varieties, *Cyclotella* and *Terpsinoe musica*. In this study, fifty new diatoms species were recorded for Lagos lagoon complex while *Aulacoseira herzogii* is new record for Nigeria. Community structure analysis shows a highly diverse environment.

Key words: Diatoms, tropical freshwater, Lagos lagoon complex, diversity

INTRODUCTION

Diatoms are valuable indicators of environmental conditions, since they respond directly and sensitively to many physical, chemical and biological changes that occur in the aquatic environment. Among unicellular microalgae, diatoms probably represent one of the most diverse groups, with a number of species estimated to be between 10000 and 100000 (Paula *et al*., 2005) hence, they constitute an ideal group to study its biodiversity. The diversity, abundance and distribution of phytoplankton within any lagoon have a direct correlation with the water quality and consequently the whole community structure. This is due to the fact that phytoplankton forms the base of any aquatic food chain and organic production in the lagoon and coastal ecosystem (Carol and Timothy, 1993). According to Van-Dam *et al.* (1994), the composition of diatom communities reflects an entire complex of ecological parameters at a particular site. Lagoon and coastal ecosystems are the most productive zone of any marine environment due to the high anthropogenic inputs and shallowness of this zone which allows effective light penetration for photosynthesis by phytoplankton. The bulk of local fish production comes from the artisanal sector operating within this zone in Nigeria. Yet, the lagoonal environments are being highly influenced by ecological factors and human actions mainly from refuse and sewage dump, as well as agricultural wastes coming from river discharges and industrial effluents. The Nigerian coastal zone experiences a tropical climate consisting of rainy season (April to October) and dry season (November to March), it is low lying with heights of not more than 3.0 m above sea level and is generally covered by fresh water swamp, mangrove swamp, lagoonal mashes, tidal channels, beach ridges and sand bars. Lorghurst (1964) reported that the Nigerian coastal surface water is uniformly warm (about 28°C) and of low salinity (<32%). The vegetation is also characterized by Mangrove forests, Brackish swamp forests and Rain forests. At present, there is no such checklist for Lekki lagoon diatoms hence this study lists diatoms species of this lagoon and also mentioned the species that is first record to Nigeria coastal waters.

DESCRIPTION OF STUDY AREA

Lekki lagoon (Fig. 1), a large expanse of shallow freshwater extends between Lagos and Ogun States. It covers an area of about 247 km^2. A greater part of the lagoon is shallow (<3.0 m), while some areas are up to 6.4 m deep. It lies between longitudes 4°00' E and 4°12' E and latitude 6°25' N and 6°37' N. The lagoon is fed by river Oni in the North eastern part, while rivers Osun and Saga flow into the North western part. Two peaks of rainfall are associated with this lagoon, a major peak in July and a lesser peak in September. There are two peaks of sunshine hours which approximately correspond to the equinoxes. The mainstay of communities that live around this environment is artisanal fishing.

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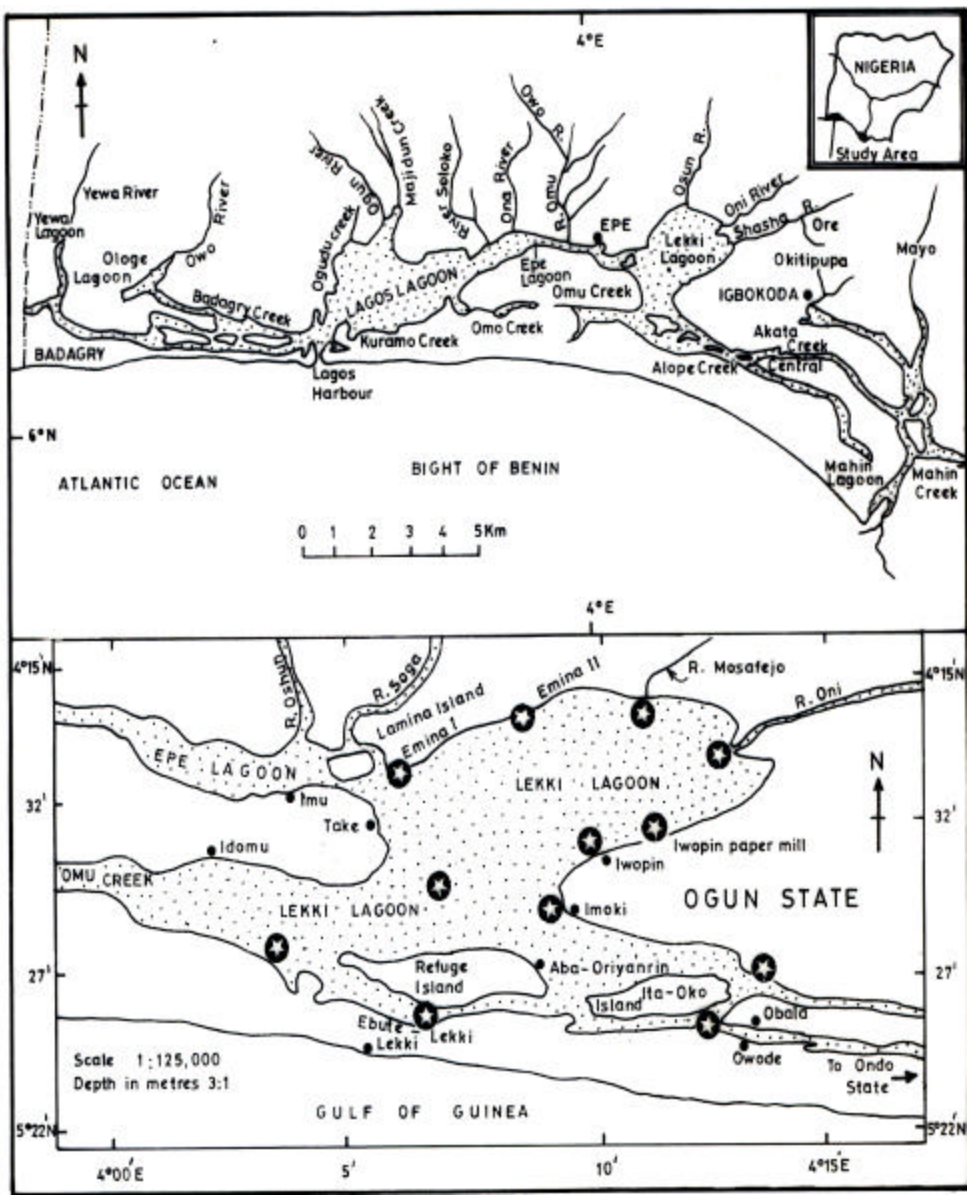

Fig. 1: Lekki lagoon showing sampling stations

MATERIALS AND METHODS

A motorized boat and a Global Positioning System (GPS) were used during the 24 months sampling period (June 2003-May 2005). The sampling stations were presented in Table 1 and these stations were chosen to reflect differences in biological characteristics which exist in the same body of water. All samples were taking using standard plankton net of 55 μm mesh size towed steadily for 10 min at low speed and preserved in 4% unbuffered formalin in appropriately labeled

Table 1: Average depth (m) and geographical position of sampling stations

Stations	Average depth	Longitudes	Latitudes
Emina 1 (A)	2.77	4°5.080E	6°32.754N
Emina II (B)	1.61	4°7.511E	6°34.070N
Entrance of River Mosafejo (C)	1.51	4°10.239E	6°35.344N
Entrance of River Oni (D)	1.80	4°12.153E	6°35.090N
Iwopin 1 (E)	1.80	4°13.153E	6°32.309N
Iwopin 11 (F)	2.69	4°9.6510E	6°32.137N
Imoki (G)	2.17	4°10.048E	6°31.253N
Ise 1 (H)	1.81	4°13.413E	6°26.833N
Ise 11 (I)	2.41	4°9.788E	6°26.181N
Ebute lekki (J)	1.29	4°5.353E	6°26.685N
Entrance of Omu creek (K)	1.88	4°7.604E	6°28.867N
Lagoon center (L)	2.23	4°3.348E	6°28.577N

plastic container. All samples were collected during the hours of daylight to minimize variations due to diurnal migration. To enhance diatom identification sub samples of the original samples were acid-cleaned using nitric acid and investigation was made using Olympus BX51 photomicroscope at the Bowling Green State University, Ohio, USA. Taxanomic keys employed in the identification included Hustedt (1930, 1937, 1942, 1971), Patrick and Reimer (1966, 1975), Prescott (1961, 1973, 1982), Cox (1996), Round *et al.* (1990), Krammer and Lange-Bertatot (1986, 1988, 1991a, b, 2000) and John and Robert (2003).

Community structure analysis: Three indices of statistical analysis were used to obtain estimates of species diversity in the samples analyzed; species richness index (Margalef, 1970), Shannon and Weaver (1963) and species evenness (J) (Pielou, 1975).

RESULTS

A total of 237 diatom taxa belonging to fifty genera were observed in this study (Table 2), two hundred and three were pennates while thirty four are centric forms.

Table 2: Diatoms checklist with composition abundance (mL^{-1}) and community structure of Lekki lagoon

	Stations											
Community structure	A	B	C	D	E	F	G	H	I	J	K	L
Division: Bacillariophyta												
Class: Bacillariophyceae												
Order 1: Aulacoseirales												
Family 1: Aulacoseiraceae												
Aulacoseira distans (Ehrenb.) Simonsen	2527		148	1898	5554	8413	611		6092	189	4500	744
A. granulata (Ehrenb) Ralfs.	2465	3839	4942	8086	4042	5709	3902	2274	6371	2763	7789	1055
A. granulata var. *angustissima* O.Muller	1045	2955	4240	5660	3105	3748	3196	1043	4371	2089		8429
**A. granulata* var. *angustissima f. curvata* (Hust.) Simon	9280	1838	3198	1065	3866	1003	6382	3201	4836	2606	1205	3163
**A. granulata* var. *angustissima f. spiralis* (Hust) Czar.*et* Reinke	1035	2167	2961	7139	2905	7717	3501	2608	3611	134	6930	5420
***A. herzogii* Lemmermann	5699		178									
A. islandica O.Muller	1775	3240	3684	4932	3168	5183	2929	1079	3952	2227	6843	8459
A. muzzanensis (Meister) Krammer		6775		1105			178		595			573
Family 2: Cocconeidaceae												
Cocconeis disculus Schum.	223	856	591	1005	148		275			199	703	75
C. fluviatilis Wallace	223	1489							148		223	230
C. placentula Ehrenb.	223	112						223	174		1250	
C. scutellum Ehrenb.	1005	1034	703	74	194	74	130	1038	297	136	859	2486
Cocconeis sp. 1	148	1109	186	297	372	632	372		260			
Cocconeis sp. 2		7817		402				558		37		
Order 2: Thalassiosirales												
Family 1: Thallassiosiraceae												
Thalassiosira sp.1					245	484	37	223	1176			
Thalassiosira sp. 2												
Detonula schroderi Gran												
Family 2: Stephanodiscaceae												
Coscinodiscus lineatus Grunow.	37	8190		0								
C. pediculosus				112								37
C. rothii (Ehrenb.) Grunow	74		37	223	7445	112			297			
Coscinodiscus sp. 1		148	186		234	186	112	186				745
**Cyclotella cryptica* Reimann, Lewin and Guillard	446											
**C. cunita* (Ehrenb.)		148										
C. meneghiniana Kutzing	111	611	409	856	141		781	74	670	37		
Discotella stelligera Cleve and Grunow) Houk and Klee	111	633	74	279								
Discotella sp. 1	174	156	431	137	275	193	413	967	670			
**Stephanocyclus atomus*					372							
**Stephanocyclus meneghiniana* (Kutzing) Skabitschevsky												
**Stephanodiscus astraea* (Ehrenb.) Grunow				372				74				
**S. minutulus* (Kutzing) Cleve and Moller												
Stephanodiscus sp.		257							186	37		
Sub division: Biddulphiophycidae												
Order 1: Biddulphiales												
Family: Biddulphiaceae												
Terpsinoe musica Ehrenb.	297		5077	856	521	219	967	2393	521		104	
Order 2: Triceratiales												
Family: Triceratiaceae												
Triceratium sp. 1		37	230		2978	149		37	150			112
Triceratium sp. 2							893					

Table 2: Continued

Community structure	Stations A	B	C	D	E	F	G	H	I	J	K	L
Order 1: Rhizosoleniales												
Urosolenia sp.		298										
Rhisozelenia sp.				223								
Family: Acanthocerotaceae												
Acanthoceros sp.			1064			112						
Order 2: Achnanthales												
Family: Achnanthaceae												
Achnanthes conspicua A. Mayer						260						
A. conspicua var. *cryptocephala*						223						
A. lanceolata (Brebs.) Grunow.		298								100		
Achnanthes sp.	335							372		37	949	
Dimerogramma minor (Greg) Ralfs												
Order 3: Fragilariales												
Family: Fragilariaceae												
Asterionella gracilis Castr.			74		14146	967			223			595
Diatoma anceps (Ehrenb.) Kirchner									74			
Diatoma sp.												744
Fragilaria construens Ehrenb.		383	74		148			74		372		
F. construens var. *pumila* Grunow		37										
F. crotonensi (Kitton)		3313	4895	5595	4511	1570	1403	5993	219	372	1340	967
F. virescens var. *capitata* Strup.		112										
Fragilaria sp. 1		74										
Fragilaria sp. 2												
Fragilaria sp. 3								558				
Staurosirella sp.		223										
Synedra acus var. *radians* (Kutzing) Hustedt								223				
S. affinis Grunow						119						
S. delicatissima W.Smith		730	684	104	6254	2159		74				
S. falsicula (Agardh) Kutzing				320	5584	5182	3402	212	37	75		115
S. filiformis Grunow		37	513									130
S. minuscula Grun.		704		670	149	670			674			
S. nana Meister.	1898	871	3249	6864	2159	6998		186				
S. rumpens Kutzing		923	398	5714	2322	2345		573		111	37	75
S. tenera W.Smith								595				
**S ulna* var. *contracta* Ostrup								744				
**S. ulna* var. *longissima* (W.Smith) Brun	744		3037		6399	6187	4631	223	373	353		208
Synedra sp. 1	74	186	22									372
Synedra sp. 2							37	781				
Ulnaria acus Kutzing	792				4776							
Ulnaria ulna (Nitzsch) P. Compère		574	3689	1377		6552	588	1373	558	511	74	141
Order 4: Tabellariales		1861										
Order 4: Tabellariales												
Order 4: Tabellariales												
Family: Tabellariaceae												
Tabellaria fenestrata (Lyng.) Kutzing	74	212	3007	2483	2332	4407	4623	2386	819	299	457	2129
T. flocculosa (Roth) Kutzing	856	484	409	112	707	640	476		223		338	1228
Tabellaria sp. 1		133		134		372		558	223			
Tabellaria sp. 2		223						167				
Order 5: Bacillariales												
Bacillaria paradoxa Gmelin	387	562	301	174	967	871	472	1801	1280	1355	1254	5721
B. paxillifer (O. F Muller) Hendey (1958)		894	279									
Bacillaria sp.												
Cylindrotheca sp.		149										
**Denticula tenuis* var. *crassula* (Nageli) W. and G.S West		894						372				
D. thermalis Kutzing	483											
**D. valida* (Pedicino) Grunow in Van Heurck					536	148					446	
Denticula sp. 1	37								148			
Denticula sp. 2								595				
Nitschia acicularis W. Smith.	130	123		260			372				223	148
N. angustata (W. Smith.) Grun.				0								
N. apiculata (Gregory) Grun.			513									
N. closterium (Ehrenb.) W. Smith		261	29	148	1265		446	364		372	447	446
**N. decussis*												
**N. dieselbe* var. *victoriae*												
N. filiformis (W. Smith) Schutt					134			37	351		372	336
N. gracilis Hantzsch.	335	447		558		178					625	
N. ignorata Krassake					148					74		781

Table 2: Continued

Community structure	Stations A	B	C	D	E	F	G	H	I	J	K	L
N. longissima (Brebisson) Ralfs				595							112	
N. obtusa W. Smith.	74	171	14		152		74					
**N obtusa* var. *scalpelliformis* Grunow						595						
N. palea (Kutz.) W. Smith.	112	704	353	223	447	297	372				37	74
**N. punctata* (Grunow) Grunow		156	37			744						
N. pungens		149	74	186	990	297						
N reversa W. Smith				112								
N. sigmoidea Ehrenb. W. Smith.		37		272	632		148		100		112	
N. sublinearis Hustedt.		74		33		112						
N. substilis Grunow.	1787					744					335	
N. thermalis Kutz.	734	235	967	707	1764	484			74		260	
N. vermicularis (Kutzing.) Grunow	1292	343	457	491	1262	137	201	152	93	37	174	223
Nitzshia sp.		249	81	223				781				
**Tryblionella levidensis* (W. Smith) Grun.		171										
T. victoriae Grunow	112		141	75		115				37		
Tryblionella sp.									197		74	122
Order 6: Surirellales												
Family: Surirellaceae												
Surirella angustata Kutzing	4840		223	431					97			
S. biseriata var constricta Grunow		744								74		
S. capronii Breb.	74	148	543									
S didyma Hustedt									223			
S. elegans Ehrenb.	1899			379							593	
S. linearis W. Smith								148				
**S. linearis* var. *constricta*	670											
**S. linearis* var. *helvetica*												
S. ovalis Breb.	130	126	74	260		1117		744	74	37		186
S. patella Ehrenb.	671		100									
**S. patella* var. *neupaueri* (Pant) Cleve. Euler			14									
S. robusta Ehrenb.		834	55					189	6134	100	260	115
**S. robusta* var. *splendida* (Ehrenb.) Van Heurck		744							186	245	484	677
S. splendida Ehrenb.								223				
**S. tenera* var. *nervosa* (Ehrenb.) Kanttuerck				204								
Surirella sp.								297				
Order 7: Naviculales												
Family 1: Naviculaceae												
**Brachysira follis* (Ehrenb.) Cleve	447	145	44									
Brachysira sp.												
**Craticula cuspidata* (Kutz) D. G. Mann	224		29				74					297
**Decussata plancentula* (Ehrenb). Grun.			74									
Decussata sp.												
Frustulia rhomboides Ehrenb.			74	573	115	6701	74				1250	74
**F. rhomboides* var. *capitata* (A.Mayer) Patrick												
**F. rhomboides* var. *saxonica* (Rabh.) de Toni		521						112				
**F. rhomboides* var. *viridila* (Breb.) Cleve					148							
F. vulgaris Thwaites	37				74							
**F. vulgaris* var. *capitata* Krasske	149											
F. weinholdii Hustedt		223										
Frustulia sp.		126	89	261								
Gyrosigma attenuatum (Kutzing) Rabenhorst		171									104	
*G. balticum (*Ehrenb.) Rabh.	37					260	148				443	112
G. obtusatum (Sulliv.) Boyer	26				1489						52	
G. scalproides (Raph.) Cleve.											156	
G. spencerii (W. Smith.) Cleve			44									
**G. spencerii* var. *nodifera* Grunow											29	
Gyrosigma sp.		74		37								112
**Hippodonta capitata* (Ehrenberg) lange-bertalot, metzeltin and witkowski				670					67			594
Hippodonta sp.												
Luticola mutica Kutzing.	112	717	37	223	454	18	14	409	781	1991	1444	745
**Luticola mutica* var. *tropica* Hustedt			14					37			416	
Navicula angusta Grunow		186				44		37				
N. braunii Grunow								14				
N. crucicula W. Smith	74	148						37				
N. cryptocephala Kutzing.	484	521		632			137	115	74		1276	28
N. decussis Ostrup							275		175			
N. plancentula Ehrenb. Grun								74				

Table 2: Continued

Community structure	Stations A	B	C	D	E	F	G	H	I	J	K	L
N. pupila Kutzing.							37	186				119
N. radiosa Kutz.	74		18	409	580	268	74	148	29		755	
N. radiosa var tenera (Breb.) Cleve		484	37				37	967	37		1180	74
N. rhynchocephala Kutz.		74			1861			37				
**N viridis* var. *rostellata* Kutz								372				
Navicula sp. 1	74	112	223	74	1489	7445		37				
Navicula sp. 2							122					
Navicula sp. 3										56		
Navicula sp. 4	32											
Neidium affine (Ehrenb) Pfitzer											78	
N. iridis (Ehrenb) Cleve					78							
**N iridis* var. *vernalis* (Reichelt)					14							
**N. ladogense* (Cleve) Stoermer and Yang			134						190			
**N. ladogense* var. *densistriatum* (Str.) Foged.											13402	37
Neidium sp. 1					52							37
Neidium sp. 2												
Pinnularia acrosphaeria Breb.				447					22			
P. biceps Gregory	186			893	308	413	74				268	
**P.bisulcatum var biacalense* Schy. and Meyer Reimer				260								
P. debesii Hustedt	74											
P. gibba Ehrenb.	74			148								
P. legumen Ehrenb.												
P. major Kutzing.			346	149				37	112			
P. mesolepta (Ehrenb.) W.Smith.	223	37						37				
Pinnularia sp. 1		372			56				112			
Pinnularia sp. 2		223					148			100		
Pinnularia sp. 3		149		409				148				37
**Placoneis exigua* (Greg.) O. Muller.	74	223	22	223	394	745		22	93	32	89	18
Placoneis sp.												
Pleurosigma strigosum W. Smith											152	
Pleurosigma sp. 1	37				37	1489		372				
Pleurosigma sp. 2			52									
Sellophora pupila Kutz.	149	171	74	502	14							
**Stauroneis anceps* var. *hyalina* Brun and M. Peragallo											755	
**S. phoenicentrum forma gracilis* Hustedt	37			37								
S. shroderi											390	
Family 2: Diploidaceae												
Diploneis interupta (Kutzing) Cleve		148										
D. ovalis (Hilse) Cleve	149				18		74	186				
D. puella (Schum.) Cleve.				245				372				372
Diploneis sp.	74	74		856	282	126	745	37				
Family 3: Eunotiaceae												
**Amphicampa hemicyclus* (Ehrenb.) Karsten												
Eunotia dieselbe var. *fallax*		171										
E. glacialis Meister.										44		
E. incisa W. Smith	633				78		40	372				
**E. lunaris* var. *subarcuata* (Nag.) Grun								93				
E. monodon Ehrenb.							372		526			74
E. pectinalis (O. Muller) Rabenhorst		171			268	469	591	29	137	271		37
E. pectinalis var. *minor* (Kutzing) Rabenh.												223
**E. pectinalis* var. *ventricosa* Grun												
E. praerupta Ehrenb.		223										
**E. spincisa* W. Smith					268							
**E. sudetica* O. Muller							745	1615	67			
Eunotia sp. 1		22		74	63			833				
Eunotia sp. 2			29						82			
Family 4: Catenulaceae												
Amphipleura alata (Ehrenb.) Kutzing								112				37
Amphipleura sp.				223				74				
Amphora ovalis (Kutzing) Kutzing	238	148		167			413	294			29	107
A. ovalis var. *affinis* Kutz							37			22		
A. perpussila (Grunow) Grunow							0					
A, pediculus var. *minor* Grunow												232
A. pusillum	74											
Amphora sp. 1					223				112			
Amphora sp. 2				223			126					
**Fallacia* sp.												

Table 2: Continued

Community structure	Stations A	B	C	D	E	F	G	H	I	J	K	L
Family 5: Cymbellaceae												
Cymbella affinis Kutzing.	149	599			745		372	577	388		1552	148
C. delicatula (Kutzing)												
C. ehrenbergii Kutzing.								93				
C. gracilis (Rabh.) Cleve	260						550					
**C. gracilis* var. *lunata* W. Smith												
C. laevis Nageli				186								
C. lanceolata (C. Agardh) C. Agardh.				74							67	
**C. naviculiformis* Auerswald								93				
C. perpusilla A. Cleve												
C. turgida (Greg.) Cleve		148			29	223	189	1503		63	1466	148
C. ventricosa Kutzing.	114	379	74	804	309	402	18	1042		52	2081	524
Cymbella sp.	856	372	245	148	372			37	14			
Family 6: Gomphonemataceae												
Gomphonema blancheana R. Maillard											1355	
**Gomphonema constrictum var capitata* (Ehrenb.) Van Heurck			75									
G intricatum var pumila Grunow											1302	
G. montanum Schumann		148										
G. parvulum (Kutzing) Kutzing						59						
Gomphonema sp. 1		514			12							37
Gomphonema sp. 2												37
Order 8: Rhopalodiales												
Family: Plagiotropidaceae												
**Plagiotropis lepidoptera v. proboscidea* (Cleve) Reimer												
Plagiotropis sp.					603							
No. of species	72	94	68	76	69	57	56	80	58	38	57	60
Total No. of individual species	50609	71096	54379	72372	103783	97086	52915	47333	49775	17646	69500	51321
Margalef Species Diversity (d)	6.55	8.32	6.14	6.70	5.89	4.88	5.06	7.34	5.27	3.78	5.02	5.44
Shannon-Weaver (H^1)	5.57	3.63	3.18	3.34	3.35	3.22	3.08	3.65	2.99	2.69	3.09	2.95
Species Evenness	1.30	0.80	0.75	0.77	0.79	0.80	0.76	0.83	0.74	0.74	0.76	0.72

*: New record to Lagos lagoon complex, **: New record for Nigeria

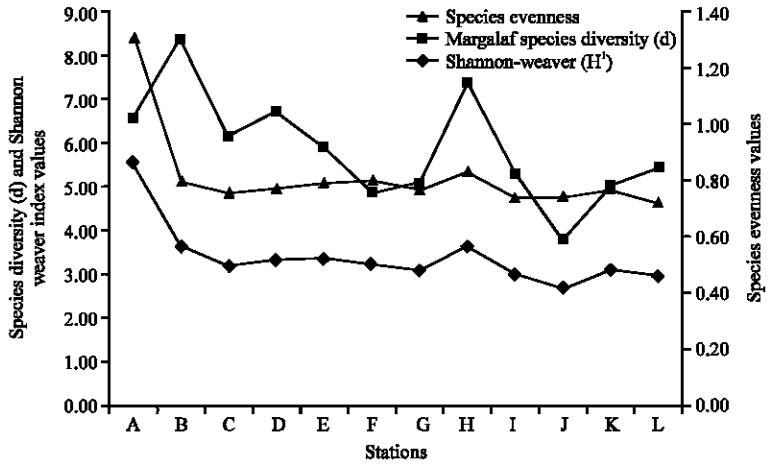

Fig. 2: Variations between diversity indices at Lekki lagoon

The pennate diatoms observed include *Fragilaria construens*, *Bachysira follis*, *Bacillaria paradoxa*, *Craticula cuspidata*, *Synedra ulna* var. *longissima* and *Tabellaria fenestrata* (Araphidineae) while centrals were ably represented by *Aulacoseira granulata*, *A. granulata* var. *anguitussima*, *A. granulata* var. *anguitissima f. curvata*, *A. granulata* var. *anguitissima f. spiralis*, *Cocconeis disculus*, *C. scutellum* and *Cyclotella stelligera*. Since, Margalefs d-value is influenced by the number of species and individuals, high d values period reflected high species number and relatively low numbers of individuals. The Shannon-Weaver diversity index (H^1) is influenced by both number of species and equitability. In Lekki lagoon, higher H^1 values observed could be attributed to high j at that period (Fig. 2).

DISCUSSION

The number of diatoms taxa (237 species) observed in Lekki lagoon is very high compare to other published study from other lagoons and rivers so far. This checklist is the first that will record such large number of diatoms. The pennales recorded higher number of taxa followed by centrals. This is different from the species composition and phytoplankton abundance density found for some diatom Lagos lagoon (Nwankwo, 1990), some coastal waters of Nigeria (Kadiri, 1999) and Bonny River during complex research study concerning ecosystem of Niger Delta (Onuocha, 1985; RPI Report, 1985). It was the bottom dwelling species that are more prevalent and could be as a result of rainfall which introduces flooding thereby mixing up the water, boat navigation since artisanal fishing is the mainstay of the people living around the area or may be due to their possession of raphe with which they adhere to suitable substrate. From the checklist it can be stated that Lekki lagoon is highly diverse floristically with *Aulacoseira* sp. being abundant species all through the stations.

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