Size Composition, Growth Pattern and Sexual Maturity of the Blue Crab, *Callinectes amnicola* (De Rocheburne, 1883) in three interconnecting tropical lagoons.

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Abstract: The size composition, growth pattern, sex ratio and gonadal stages of *Callinectes amnicola* (De Rocheburne) in three interconnecting tropical lagoons were investigated over 18 months. The major ecological variable in the lagoons was salinity. The crabs exhibited negative allometric growth. The largest sized crabs were obtained in the freshwater Lekki Lagoon. The males were significantly more abundant than the females in the freshwater Lekki Lagoon while the sex ratio was nearly 1:1 in the brackish Badagry and Lagos Lagoons. Five stages of gonadal maturity were recorded for both males and females in the three lagoons. Fecund females carrying eggs underside of the abdomen were obtained only in the high brackish water Lagos Lagoon. The salinity gradient and occurrence of the blue crab throughout the year in the three interconnecting lagoons makes them a suitable environment for completion of its life history in the lagoons.
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Introduction

The Badagry, Lagos and Lekki Lagoons with surface areas of 15km^2, 208km^2 and 247km^2 respectively lie between longitude 2° 30" - 4° 15" E and latitude 6° 10" - 6° 47" N; the latter two are the largest lagoons in West Africa (FAO Report 1969). The three lagoons are interconnected and open to the Atlantic Ocean (Gulf of Guinea) via the Lagos Harbour (Fig. 1). The three lagoons support a crab fishery based on the blue crab *Callinectes amnicola* a very popular food item in the diet of the coastal communities in West Africa.

Publications on aspects of the biology of this very important resource in the West African sub-region are limited to the works of Kwei (1978) on the growth and maturity in two Ghanaian Lagoons, Chindah *et.al.* (2000) on the food habits in the New Calabar River, Lawal-Are and Kusemiju (2000) on growth and food habits in Badagry Lagoon, Lawal-Are (2009) on the food habits from three different interconnecting lagoons in the south-west, Nigeria and Lawal-Are (2010) on the reproductive biology in Lagos Lagoon.

Lagos Lagoon is high brackish, Badagry is very low brackish, while Lekki Lagoon is freshwater (Fagade and Olaniyan, 1974; Kusemiju, 1981; Ezenwa and Kusemiju, 1985). This paper provides information on the physico-chemical parameters of the lagoons, size composition, growth pattern and sexual maturity of *C. amnicola* in the three lagoons that may help understand the ecology and life history of *C. amnicola* and its future development in the lagoon and estuarine systems in the tropical West African sub-region.

Materials And Methods.

Bi-monthly samples of *C. amnicola* were collected in the Badagry, Lagos and Lekki Lagoons from fisherfolks who were mainly women. The study was carried out between May 2003 and October 2004. The fishing was done using circular liftnets as described by Nedelec (1982) and Solarin *et. al.* (2003) and reported by Lawal-Are (2010).

Selection of the crabs was done randomly as they were brought out from the liftnets. The crabs were preserved in an ice-chest with ice blocks and later transferred into a deep freezer (-20 °C) in the laboratory prior to analysis.

The physico-chemical parameters of each of the three lagoons were measured 'in-situ' at the fishing locations. Salinity and temperature were measured using a Beckman Induction Salinometer (Model R55-3) and a refractometer (BIOMARINE Aqua Fauna Model)

Dissolved oxygen (DO) was determined using a Jencons Oxygen meter while pH was measured with a Khalisco digital mini pH meter (Model 114 WB 150). An 8-inch diameter Secchi disc with alternating black and white quadrants was used to measure transparency.

A total of 4177 crabs were studied. Sex was determined using the method described by Kwei (1978). The carapace length (CL) of the crabs was measured from the edge of the frontal region near the eye to the base of the carapace backwall with a 0.05cm precision Vernier caliper, while the carapace width with spine (CW) was taken from the tip of the left dorsal spine to the tip of the right dorsal spine and

recorded to the nearest tenth of a centimeter. The total weight of the crab was taken on a Sartorius top loading balance (Model 1106) to the nearest tenth of a gram.

The carapace width frequency distribution and carapace length frequency distribution were determined monthly from the data of individual specimens collected.

The carapace width/weight relationship and carapace length/weight relationship was expressed as:

Log W = Log a + Log b (Log L) (Parsons, 1988).

where W= weight of crab in g, L= carapace width/carapace length in cm;

a=regression constant and b = regression coefficient.

Macroscopic maturity stage data were obtained for each specimen.

RESULTS

Physico-chemistry

The summary of mean physico-chemical parameters of Badagry, Lagos and Lekki Lagoons is presented in Table 1.

The major ecological variable in the lagoons was salinity (Fig. 2). Badagry Lagoon was low brackish (0.0 - 10.0‰), Lagos Lagoon high brackish (1.0 - 24.5‰) while Lekki Lagoon was freshwater (0.0 - 3.0‰).

Size composition and growth pattern

2042 specimens of *C. amnicola* were obtained from the Badagry Lagoon, 1417 from Lagos Lagoon and 718 from Lekki Lagoon.

The sizes of the blue crabs in the Badagry Lagoon ranged from 3.2 - 16.4cm carapace width (4.5 - 287.2g in weight), in Lagos Lagoon from 3.8 – 16.5cm carapace width (6.8 – 245.6g in weight) and in Lekki Lagoon from 3.5 – 16.1cm carapace width (4.6 – 293.1g in weight).

The growth pattern of the crabs showed a negative allometric growth (Table 2, Fig. 3)

Reproductive biology

Sex ratio

The 2042 specimens of *C. amnicola* collected from the Badagry Lagoon had a sex ratio of 1:1.03 (male/female). 1417 crabs collected from Lagos Lagoon had a sex ratio of 1:0.96 while 718 crabs obtained from Lekki Lagoon had a sex ratio of 1:0.72.

A χ^2-test indicated that the males were significantly more abundant than females in Lekki Lagoon, while the ratio was nearly 1:1 in the two other lagoons with no significant difference in the sex ratio at 5% level.

The monthly variations in sex ratios were examined and the results are shown in Table 3. In the Badagry Lagoon, the females were more than the males in the months of August to October 2003 and February, June and October 2004. In the Lagos Lagoon, the females were more than the males in the dry months of March, April, May and August. In the Lekki Lagoon, the males were more than the females almost throughout the year except in June, July and September.

Gonadal stages

Five stages- Stage I (immature), Stage II (developing), Stage III (ripening), Stage IV (ripe) and Stage V (spent) occurred in both male and female crabs in the three lagoons. Immature crabs (Stage I) were most prominent in the lagoons while the spent (Stage V) were least observed for both male and female crabs (Table 4).

The ripe females (Stage IV) were more than the males in Badagry and Lagos Lagoons while the ripe males were more than the females in the Lekki Lagoon.

The monthly occurrence of gonadal stages of *C. amnicola* from the three lagoons is shown in Table 5.

The juvenile crabs (Stage I) were predominant in Badagry and Lagos Lagoons throughout the year while in Lekki Lagoon, there was no clear-cut difference in the occurrence of juvenile (Stage I) and mature (Stage IV) crabs. Mature female crabs were recorded in the three lagoons. More mature female crabs with eggs inside their carapace were obtained in the Lagos Lagoon, 148 (60.2%). In the Badagry Lagoon, 116 (56.3%) while in Lekki Lagoon, 50 (25.9%) mature females were observed during the study period.

Fecund females carrying eggs underside of the abdomen were obtained only in the high brackish water Lagos Lagoon and details of the fecundity, gonadal histology and development are documented in Lawal-Are (2010).

Discussion

The water temperature, salinity, pH, dissolved oxygen and transparency in the three interconnecting tropical lagoons were studied. The results were similar to those reported by Fagade and Olaniyan (1974), Kusemiju (1981), Solarin and Kusemiju (1991). The major ecological variable in the three lagoons is salinity. Badagry Lagoon is low brackish, Lagos Lagoon is high and low brackish while Lekki Lagoon is freshwater. The wide range of salinity gradients in the three interconnecting lagoons makes them a very suitable environment for the crabs. According to Guillory *et. al.* (1996), the blue crab utilizes various salinity regimes of an estuary, with various life cycle

stage occupying specific salinity levels. The authors also noted that blue crabs distributed seasonally with respect to salinity and sex. In general males predominate in the low salinity areas while females predominate in the high salinity areas. It is noted that male crabs were significantly more abundant than the females in the freshwater Lekki Lagoon, while the sex ration was nearly 1:1 in the saline Badagry and Lagos Lagoons.

The carapace width frequency distribution showed size group 8.5 – 9.4 cm was most abundant in Badagry Lagoon; the size group 5.5 – 6.4 cm was most abundant in Lagos Lagoon, while size group 12.5 – 13.4 cm was most abundant in Lekki Lagoon. Larger crabs were found in the freshwater Lekki Lagoon in agreement with Lipcius and Van Engel (1990) and Carmona-Suarez and Conde (2002) who noted that larger blue crabs were often found in areas of low salinity, suggesting a negative correlation of size with salinity.

The carapace width-weight relationship of the crabs showed negative allometric growth in the three lagoons indicating that the carapace width grows horizontally instead of vertically with increasing weight. High correlation(r) values of 0.9383 in Badagry Lagoon, 0.9431 in Lagos Lagoon and 0.9424 in Lekki Lagoon showed a strong indication that an increase in carapace width of the crabs gave a corresponding increase in body weight.

Five gonadal stages occurred throughout the year. Stage I (juveniles) were most prominent in the lagoons while Stage V (spent) were least observed for both male and female crabs. The stages of maturation were similar to those described by Marcus and Kusemiju (1984).

Mature blue crabs were not caught in the Lekki Lagoon during the months of January to April 2004. These were months when breeding in the blue crab in the Lagos Lagoon reached its peak (Lawal-Are, 2010). It would appear that the matured Lekki Lagoon populations have moved to the higher salinity of the Lagos Lagoon to breed.

These results show that based on the salinity results, these three interconnecting lagoons can be fully utilized for future blue crab aquacultural development programme.

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Table 1. Summary of mean (± SD) physico–chemical parameters of Badagry, Lagos and Lekki Lagoons (May 2003 – October 2004).

Parameters	Badagry Lagoon	Lagos Lagoon	Lekki Lagoon
Air temperature (^{o}C)	28.0 ± 2.12	27.9 ± 1.88	27.5 ± 1.63
	(25.0 - 31.2)	(23.8 - 30.4)	(24.0 - 30.0)
Surface water temperature (^{o}C)	29.4 ± 1.71	29.2 ± 1.85	29.2 ± 1.50
	(26.8 - 31.8)	(25.5 - 32.3)	(26.2 - 31.2)
Dissolved oxygen (mg/l)	6.9 ± 1.75	7.3 ± 2.04	7.5 ± 2.00
	(4.2 - 11.2)	(4.0 - 11.2)	(3.9 - 11.8)
Salinity (‰)	3.3 ± 2.91	9.8 ± 9.42	1.1 ± 1.19
	(0.0 - 10.0)	(1.0 - 24.5)	(0.0 - 3.0)
pH	6.4 - 7.8	6.5 - 8.0	6.3 - 7.6
Transparency (cm)	23.7 ± 14.25	15.0 ± 7.55	26.8 ± 13.65
	(7.3 - 51.1)	(6.3 - 35.7)	(9.8 - 61.0)

Range in brackets

Fig 1 shows Badagry, Lagos and Lekki Lagoons with map of Nigeria inserted.

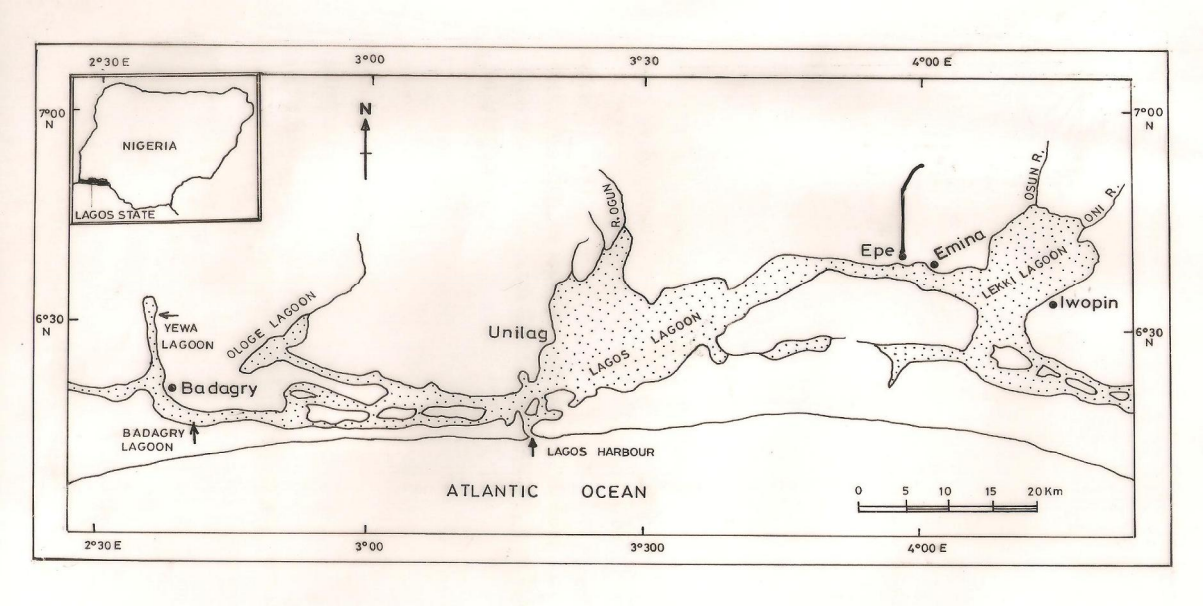

Fig. 1. Salinity variation in Badagry, Lagos and Lekki Lagoons (May 2003-October 2004)

Table 2: Growth pattern in *C. amnicola*.

Badagry Lagoon:	Male:	Log W = -0.8335 + 2.7164 Log CW (n = 1005, r = 0.9535)
	Female:	Log W = -0.7328 + 2.5435 Log CW (n = 1037, r = 0.9482).
	Combined sexes:	Log W = -0.7672 + 2.612 Log CW (n = 2042, r = 0.9383)
Lagos Lagoon:	Male:	Log W = -0.6821 + 2.5121 Log CW (n = 722, r = 0.9368).
	Female:	Log W = -0.6785 + 2.5282 Log CW (n = 695, r = 0.9492)
	Combined sexes:	Log W = -0.6875 + 2.528 Log CW (n = 1417, r = 0.9431).
Lekki Lagoon:	Male:	Log W = -0.9802 + 2.8298 Log CW (n = 421, r = 0.9429).
	Female:	Log W = -0.8817 + 2.6689 Log CW (n = 297, r =0.9547)
	Combined sexes:	Log W = -0.9469 + 2.7714 Log CW (n = 718, r =0.9424)

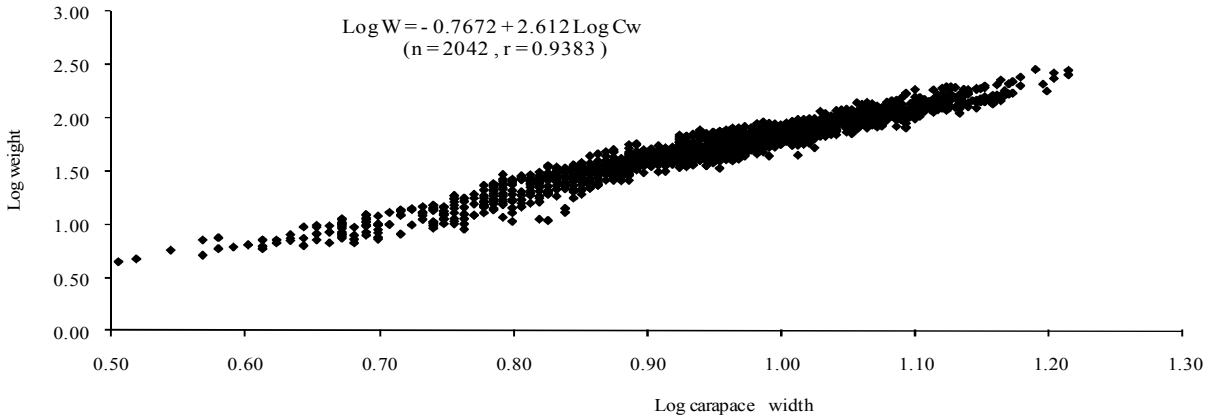

Fig 2a. Log carapace width – Log weight relationship of *C. amnicola* from Badagry Lagoon (May 2003 – October 2004)

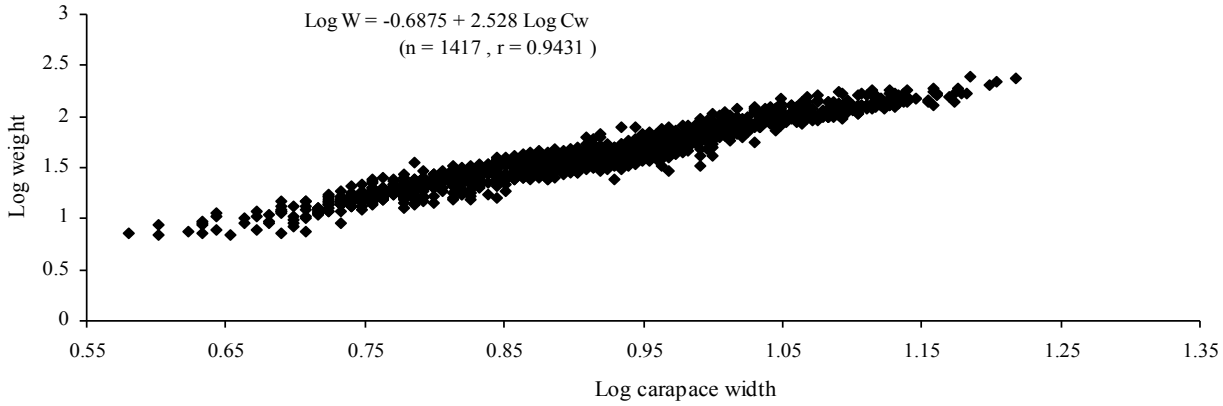

Fig 2b. Log carapace width–Log weight relationship of *C. amnicola* from Lagos Lagoon (May 2003 – October 2004)

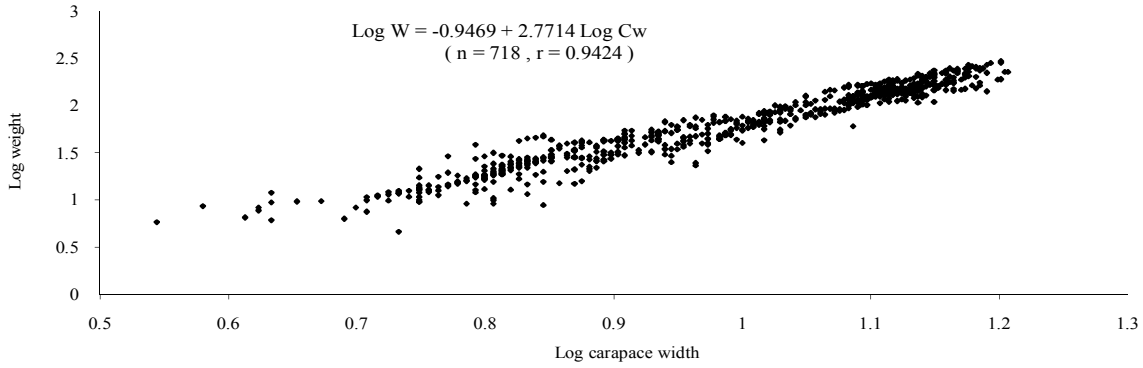

Fig 2c. Log carapace width – Log weight relationship of *C. amnicola* from Lekki Lagoon (May 2003 – October 2004)

Table 3: Monthly variation in sex ratio in *C. amnicola* from Badagry, Lagos and Lekki Lagoons.

	Badagry Lagoon				**Lagos Lagoon**				**Lekki Lagoon**			
	No examined		Sex ratio		No examined		Sex ratio		No examined		Sex ratio	
Month / Year	Male	Female	M / F	Chi-square(χ^2)	Male	Female	M / F	Chi-square(χ^2)	Male	Female	M / F	Chi-square(χ^2)
May, 2003	41	55	1/1.34	2.04	33	65	1/1.97	10.45*	17	12	1 / 0.71	0.86
June	96	122	1/ 1.27	3.1	50	64	1/1.28	1.72	60	39	1 / 0.65	4.45*
July	59	109	1/ 1.85	14.88*	37	24	1/0.65	2.77	18	12	1/0.67	1.2
August	70	48	1/ 0.69	4.10*	66	30	1/0.45	13.50*	59	56	1/ 0.95	0.08
September	111	81	1/ 0.73	4.69*	54	27	1/0.50	9.00*	32	25	1 / 0.78	0.86
October	14	13	1/ 0.93	0.04	21	19	1/0.90	0.1	22	1	1 / 0.05	19.17*
November	2	4	1/ 2.00	0.67	12	8	1/0.67	0.8	39	3	1 / 0.08	30.86*
December	62	47	1/ 0.76	2.06	16	10	1/0.63	1.38	16	1	1 / 0.06	13.24*
January, 2004	58	61	1/1.05	0.08	96	88	1/0.92	0.35	-	-	-	-
February	158	82	1/ 0.52	24.07*	55	48	1/0.87	0.48	-	-	-	-
March	93	121	1/ 1.30	3.66	64	105	1/1.64	9.95*	-	-	-	-
April	85	108	1/ 1.27	2.74	57	71	1/1.25	1.53	-	-	-	-
May	26	35	1/ 1.35	1.33	39	43	1/1.10	0.2	19	11	1/0.58	2.13
June	61	24	1/ 0.39	16.11*	28	18	1/0.64	2.17	19	22	1 / 1.16	0.22
July	29	42	1/ 1.45	2.38	20	20	1/1.00	0	18	31	1 / 1.72	3.45
August	13	17	1/ 1.31	0.53	13	17	1/1.31	0.53	62	48	1 / 0.77	1.78
September	7	7	1/1.00	0	24	15	1/0.63	2.08	12	19	1 / 1.58	1.58
October	20	61	1/ 3.05	20.75*	37	23	1/0.62	3.27	28	17	1 / 0.61	2.69
	1005	1037	1/ 1.03	0.5	722	695	1/0.96	0.51	421	297	1 / 0.72	21.42*

*Significant

Table 4: Gonadal stages of *C. amnicola* from Badagry, Lagos and Lekki Lagoons (May 2003 – October 2004).

	Badagry Lagoon				Lagos Lagoon				Lekki Lagoon			
Gonadal	Male		Female		Male		Female		Male		Female	
Development	No	%	No	%	No	%	No	%	No	%	No	%
Stage I	653	65.0	591	57.0	439	60.8	433	62.3	179	42.5	136	45.8
Stage II	162	16.1	278	26.8	103	14.3	97	14.0	32	7.6	51	17.2
Stage III	79	7.9	45	4.3	76	10.5	13	1.9	43	10.2	57	19.2
Stage IV	91	9.1	115	11.1	98	13.6	148	21.3	143	34.0	50	16.8
Stage V	20	2.0	8	0.8	6	0.8	4	0.6	24	5.7	3	1.0
Total	1005		1037		722		695		421		297	

Table 5. Monthly gonadal stages of *C. amnicola* from Badagry, Lagos and Lekki Lagoons.

Year / Month	Sex	Stage I			Stage II			Stage III			Stage IV			Stage V		
		Badagry	Lagos	Lekki	Badagry	Lagos	Lekki	Badagry	Lagos	Lekki	Badagry	Lagos	Lekki	Badagry	Lagos	Lekki
May, 2003	M	31	27	7	5	1	2	3	0	2	2	5	3	0	0	3
	F	36	41	3	8	2	6	1	0	0	10	22	3	0	0	0
June	M	67	29	33	4	5	7	15	1	8	6	14	8	4	1	4
	F	75	24	13	16	3	7	7	0	1	24	35	16	0	2	2
July	M	46	17	12	1	7	2	6	7	1	6	6	3	0	0	0
	F	61	17	12	15	3	0	12	3	0	21	1	0	0	0	0
August	M	54	40	15	13	8	2	0	10	15	2	6	24	1	2	3
	F	38	19	15	10	2	9	0	1	28	0	6	4	0	2	0
September	M	84	22	2	13	10	1	9	16	2	5	6	24	0	0	3
	F	62	18	3	11	9	2	7	0	16	1	0	3	0	0	1
October	M	14	19	0	0	1	0	0	0	0	0	1	17	0	0	5
	F	13	17	0	0	2	0	0	0	1	0	0	0	0	0	0
November	M	2	9	0	0	1	3	0	0	7	0	1	25	0	1	4
	F	4	5	0	0	3	2	0	0	1	0	0	0	0	0	0
December	M	34	4	0	11	6	0	7	5	1	5	1	13	5	0	2
	F	31	3	0	14	7	0	0	0	1	2	0	0	0	0	0
January,2004	M	33	88	0	9	7	0	4	1	0	7	0	0	5	0	0
	F	35	73	0	20	15	0	1	0	0	5	0	0	0	0	0
February	M	80	40	0	48	1	0	10	5	0	20	8	0	0	1	0
	F	50	43	0	21	5	0	4	0	0	5	0	0	2	0	0
March	M	53	27	0	23	17	0	9	5	0	8	15	0	0	0	0
	F	53	39	0	63	14	0	3	1	0	2	51	0	0	0	0
April	M	51	39	0	18	10	0	9	4	0	6	4	0	1	0	0
	F	46	67	0	36	3	0	1	1	0	20	0	0	5	0	0
May	M	19	21	14	4	6	3	3	7	1	0	5	1	0	0	0
	F	18	18	8	12	14	2	0	3	1	4	8	0	1	0	0
June	M	38	14	17	4	4	0	1	2	2	15	7	0	3	1	0
	F	15	9	18	7	3	4	0	0	0	2	6	0	0	0	0
July	M	20	6	13	3	3	5	2	4	0	3	7	0	1	0	0
	F	25	4	8	3	1	10	5	0	6	9	15	7	0	0	0
August	M	12	2	59	1	4	1	0	3	0	0	4	2	0	0	0
	F	15	11	48	2	1	0	0	3	0	0	2	0	0	0	0
September	M	7	13	7	0	2	3	0	2	1	0	7	1	0	0	0
	F	5	13	8	2	0	3	0	1	0	0	1	8	0	0	0
October	M	8	22	0	5	10	3	1	4	3	6	1	22	0	0	0
	F	9	12	0	38	10	6	4	0	2	10	1	9	0	0	0
Total		1244	872	315	440	200	83	124	89	100	206	246	193	28	10	27

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