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On the Sex Ratio of Juvenile *Lepidochelys kempii* in Georgia

Carol Ruckdeschel[1], C. Robert Shoop[1,2,3], and Robert D. Kenney[4]

[1]*Cumberland Island Museum, P.O. Box 796, St. Marys, Georgia 31558 USA [E-mail: cimuseum@yahoo.com];*
[2]*University of Rhode Island, Kingston, Rhode Island 02881 USA;* [3]*Deceased;*
[4]*Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island 02882 USA*
[E-mail: rkenney@gso.uri.edu]

Abstract. – Sex was determined from stranded Kemp's ridley sea turtles (*Lepidochelys kempii*) on Cumberland Island, Georgia, between 1983 and 2001. During that period, over which there was an apparent increase in the annual numbers of stranding, there was a shift in the sex ratio. During 1983–1989, the sex ratio was slightly male-biased but not significantly different from 1:1, but the strandings from 1990 to 2001 were significantly female-biased.

Key Words. – Reptilia; Testudines; Cheloniidae; *Lepidochelys kempii*; sea turtle; sex ratio; strandings; Georgia; USA

Reports of the sex ratio for Kemp's ridley sea turtle (*Lepidochelys kempii*) are highly variable depending upon years sampled (Denton and Prescott, 1988; Stabenau et al., 1996), location sampled (Shaver, 1991; Morreale et al., 1992), and segment of the population examined (Wibbels et al., 1989; Shaver, 1991; Coyne, 2000). The ratio has been reported as equal (Denton and Prescott, 1988; Shaver, 1991; Coyne, 2000), male-biased (Wibbels et al., 1989; Shaver, 1991), and female-biased (Morreale et al., 1992; Stabenau et al., 1996; Gregory and Schmid, 2001). Kemp's ridley is the most endangered sea turtle, and for 40 years most eggs from the nesting beach at Rancho Nuevo, Mexico, have been placed in a hatchery, which has the potential to modify the sex of hatchlings (Carrasco et al., 2000). We present data and interpretations of findings on the sex ratio of juvenile Kemp's ridley sea turtles stranded on Cumberland Island, Georgia, USA over a 19-year period.

METHODS

Beginning in 1979, the 26-km ocean beach of Cumberland Island, Georgia, USA, was surveyed at least weekly for stranded dead or dying sea turtles. We also responded to notification of strandings from National Park Service personnel and island residents. All Kemp's ridleys were necropsied, their gut contents collected and preserved, and the skeletons prepared as museum specimens. Carapace measurements to the nearest 0.5 cm were taken over the curve from the center of the nuchal notch to the longest terminal marginal scute with a flexible tape (Shoop and Ruckdeschel, 1986). Following Shoop et al. (1998), only intact, non-distorted specimens measured by CAR were included in statistical analyses of size. Sex was identified by direct observation of the gonads (Wolke and George, 1981) beginning in 1983.

Most statistical analyses were done using Statistical Analysis System software (SAS for Windows, version 6.12, SAS Institute Inc., Cary, NC). Sex ratios were tested for statistically significant departures from the expected 1:1 ratio using continuity-corrected Chi-square tests (df = 1) run on an on-line interactive Chi-square goodness-of-fit calculator (http://faculty.vassar.edu/lowry/csfit.html).

RESULTS

From 1979 through 2001, 200 stranded Kemp's ridley carcasses were recovered from the beach on Cumberland Island. Most individuals appeared to have been healthy prior to death based upon general physical condition, amount of food in the gut, and amount of body fat.

Sizes of the stranded ridley turtles ranged from a curved carapace length (CCL) of 22.5 cm to 62.0 cm, and width of 23.0 to 64.5 cm. Mean length and width were 39.9 cm (SE = 0.71, n = 160) and 41.5 cm (SE = 0.75, n = 164), respectively. Some specimens were damaged so that one or both measurements could not be taken. All of the recovered individuals were juveniles; only one was over 60.0 cm CCL, but the necropsy showed that it was not mature. The majority of specimens were in the intermediate size classes, with 70.6% between 30.0 cm and 49.5 cm CCL (113 of 160; Fig. 1). There was no correlation between size and sex. Mean lengths and widths were 39.2 cm and 41.0 cm, respectively, for identified males (n = 31) and 41.6 cm and 43.6 cm for females (n = 63). The differences were not statistically significant (Wilcoxon Rank Sum test: p = 0.278 for length and 0.281 for width).

During the 19-year period from 1983 through 2001, 101 of 181 (56%) juvenile Kemp's ridley carcasses from Cumberland Island were intact and fresh enough for sex to be unambiguously identified (19 carcasses were recovered during 1979–82, prior to the beginning of the sex identification component of the study). Only one identified head-started turtle was found, in 1994, but its sex could not be determined. Overall, the sex ratio was female-biased at 65% female, with 66 females and 35 males, significantly different from a 1:1 ratio (adjusted χ^2 = 8.92, p = 0.003; Table 1).

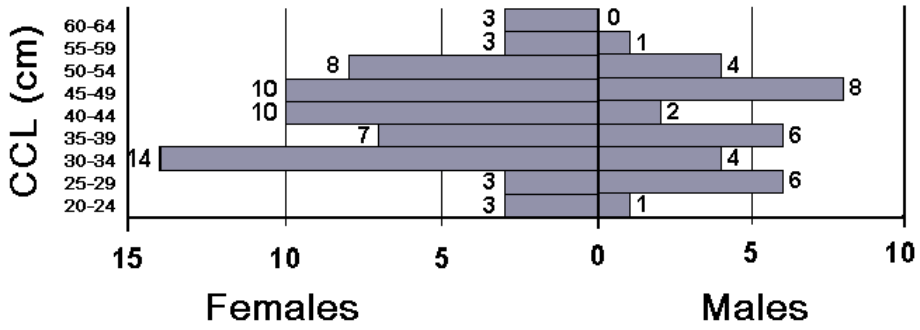

Figure 1. Distribution of curved carapace lengths (CCL) in 5-cm size classes, by sex, in stranded juvenile *Lepidochelys kempii* from Cumberland Island, Georgia (n = 93).

Females outnumbered males in every month except October, December, and January (Table 2), although sample sizes were too small to show significant departures from a 1:1 ratio in any single month except for May. Pooling months into approximate seasons (winter = Jan–Mar, etc.), the sex ratio was significantly female-biased in spring and summer (75.6% and 73.1% female, respectively), 1:1 in winter, and very slightly but not significantly male-biased in autumn (46.9% female; Table 2). October stands out as the only month with a reasonable sample size and a male-biased sex ratio; without October, the autumn sex ratio was more like spring and summer at about 59.1% female, though still not significantly different from 1:1.

There was an apparent change in sex ratio over the period of our study that is relatively conspicuous when looking at the temporal pattern (Fig. 2). From 1983 through 1989, males outnumbered females by 1.6 to 1, but the sample size was small and the ratio did not differ significantly from 1:1 (adjusted $\chi^2 = 0.96$, $p = 0.327$, $n = 26$; Table 1). From 1990 through 2001, females outnumbered males in every year, with an average sex ratio of 2.9 females to 1 male, significantly different from 1:1 (adjusted $\chi^2 = 17.28$, $p < 0.0001$, $n = 75$). A linear regression of percent female versus year showed the proportion of females increasing by 2.28% each year (SE = 1.21), although the trend was not quite statistically significant ($p = 0.076$). In addition, inspection of the data suggested that it was not a continuous trend, rather that there were two, or perhaps even three, intervals with differing patterns (Fig. 2, Table 1). During 1983 through 1989, sex ratios were male-biased with a possible increase in females over the period. A linear regression using that interval only showed that the proportion of females increased by 4.25% per year, but the trend was not statistically significant ($p = 0.386$). During 1990 through 2001, linear regression showed a significantly declining trend in the proportion of females of 4.09% per year ($p = 0.005$). However, it appears from the data (Fig. 2) that an alternative view might be that there were actually two relatively stable six-

Table 1. Sex ratios of juvenile Kemp's ridley turtles stranded on Cumberland Island, Georgia, 1983 through 2001, including the results of continuity-corrected Chi-square tests for departures from an expected 1:1 ratio.

Year	*n*	Males	Females	% Female	χ^2	*p*
1983	4	3	1	0.25	0.26	0.610
1984	0	0	0	—	—	—
1985	2	1	1	0.50	0.00	1.000
1986	2	2	0	0.00	0.50	0.480
1987	5	3	2	0.40	0.00	1.000
1988	8	5	3	0.38	0.12	0.729
1989	5	2	3	0.60	0.00	1.000
1990	4	0	4	1.00	2.26	0.133
1991	4	0	4	1.00	2.26	0.133
1992	2	0	2	1.00	0.50	0.480
1993	2	0	2	1.00	0.50	0.480
1994	7	2	5	0.71	0.58	0.446
1995	8	0	8	1.00	6.12	0.013
1996	8	3	5	0.63	0.12	0.729
1997	3	1	2	0.67	0.00	1.000
1998	12	4	8	0.67	0.76	0.383
1999	4	2	2	0.50	0.00	1.000
2000	7	1	6	0.86	2.28	0.131
2001	14	6	8	0.58	0.08	0.777
1983-1989	26	16	10	0.38	0.96	0.327
1990-2001	75	19	56	0.75	17.28	<0.0001
1990-1995	27	2	25	0.93	17.92	<0.0001
1996-2001	48	17	31	0.65	3.52	0.061
Total	101	35	66	0.65	8.92	0.003

Table 2. Monthly and seasonal sex ratios of juvenile Kemp's ridley turtles stranded on Cumberland Island, Georgia, 1983 through 2001. Seasons were defined as winter = January–March, spring = April–June, summer = July–September, and autumn = October–December.

Month(s)	*n*	Males	Females	% Female	χ^2	*p*
January	1	1	0	0.00	0.00	1.000
February	0	0	0	—	—	—
March	1	0	1	1.00	0.00	1.000
April	11	2	9	0.82	3.28	0.070
May	19	4	15	0.79	5.26	0.022
June	11	4	7	0.64	0.36	0.549
July	11	4	7	0.64	0.36	0.549
August	11	3	8	0.73	1.46	0.227
September	4	0	4	1.00	2.26	0.133
October	10	8	2	0.20	2.50	0.113
November	19	7	12	0.63	0.84	0.359
December	3	2	1	0.33	0.00	1.000
Winter	2	1	1	0.50	0.00	1.000
Spring	41	10	31	0.76	9.76	0.002
Summer	26	7	19	0.73	4.66	0.031
Autumn	32	17	15	0.47	0.04	0.841
Nov–Dec	22	9	13	0.59	0.40	0.527
Total	101	35	66	0.65	8.92	0.003

year intervals, each with single-year excursions: 1990–95, when the proportion of females was 100% in five of six years, and 1996–2001, when the proportion of females was somewhat lower and still female-biased, although not quite significantly (adjusted $\chi^2 = 3.52$, $p = 0.061$; Table 1).

DISCUSSION

The major cause of sea turtle mortality along the Southeast US Coast is incidental capture in commercial trawl nets (National Research Council, 1990). Offshore winds often delay carcasses from stranding, and sharks dismember many carcasses thereby hastening decomposition. Only 50% of the total number of stranded Kemp's ridleys provided gender information for this report. The other carcasses were either not intact or too decomposed for sex to be determined.

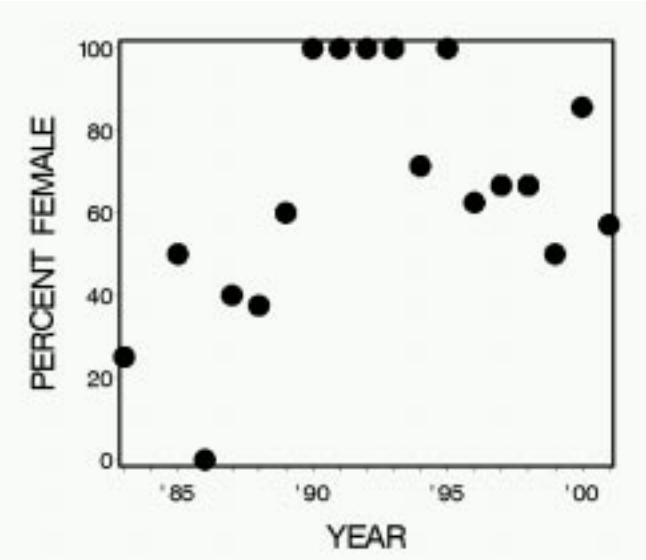

Figure 2. Interannual variation in sex ratios of juvenile *Lepidochelys kempii* stranded on Cumberland Island, Georgia, 1983–2001.

Our data for all 19 years combined reveal a significantly female-biased sex ratio, but a different picture emerges if the data for discrete periods are inspected. Prior to 1990 males predominated in our entire stranding sample, although the low numbers were not statistically different from an even ratio (1.6M:1F, $\chi^2 = 0.96$; $p = 0.327$; $n = 26$). Data from 1990 through 2001 showed a significantly female-biased sex ratio (2.9F:1M, $\chi^2 = 17.28$; $p < 0.0001$; $n = 75$). Within that 12-year span, there appeared to be one 6-year period with almost no males, followed by another 6-year period with a possible moderately female-biased sex ratio. While the sample sizes were very small within four of the six years when almost every Kemp's ridley turtle seen on Cumberland was a female, it is not likely that the near absence of males was simply a result of small numbers. There were six other years with low sample sizes (≤ 5) and with both sexes encountered, but only one with a low sample size and only one sex seen (1986, $n = 2$ males). The fact that the pattern persisted for six consecutive years argues strongly that there was something occurring beyond random small-sample effects.

If stranded animals are to be considered representative of the local population, some assumptions are required. We assumed that the juvenile males and females did not widely segregate, that they foraged in similar habitats, and that they were equally vulnerable to mortality in commercial fishing gear. Our observations of gut contents of the sexes supported this assumption (unpubl. data).

The data suggest that the number of Kemp's ridley strandings has increased with time (the long-term trend will be analyzed separately in more detail). Such an increase may reflect an increasing population due to conservation efforts, or a change in the overlap of turtle occurrence and commercial fishing in the vicinity of Cumberland Island. Since 1966, most of the ridley nests at Rancho Nuevo, Mexico, have been moved to a protected hatchery area (USFWS and NMFS, 1992). The 60-km nesting beach at Rancho Nuevo hosts the majority of nesting of the entire Kemp's ridley sea turtle

population, so practices there presumably govern the status of the species. Since the proportion of the Kemp's ridley sexes is apparently changing in favor of females, and human manipulation of the species continues, the ratio should be considered dynamic at this time.

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