SELECTED ASPECTS OF THE ECOLOGY OF THE CENTRAL AMERICAN MUD TURTLE, *Staurotypus salvinii*

A Thesis

by

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Approved as to style and content by:

(Chairman of Committee)

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(Head of Department)

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ABSTRACT

Selected Aspects of the Ecology of the Central American Mud Turtle,
Staurotypus salvinii. (August 1980)
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Chairman of Advisory Committee: Dr. John W. Bickham

A population of the neotropical kinosternid turtle, *Staurotypus salvinii*, was studied during the seasonal wet period (May to August, 1979) and the dry period (January, 1980), at Cabeza de Toro, Chiapas, Mexico, to obtain ecological information on this relatively unknown species. *Chrysemys scripta grayi* and *Kinosternon scorpioides cruentatum*, found to be sympatric with *S. salvinii*, were also studied.

S. salvinii was found to have a density of 63.9 individuals per ha with *C. scripta* having a density of 58.2 individuals per ha and *K. scorpioides* having 48.2 individuals per ha. Sex ratios indicated that for *S. salvinii* males outnumber females 1.36 to 1. Males are outnumbered by females .52 to 1 for *C. scripta* while males outnumber females for *K. scorpioides* 2.33 to 1.

The three species were found to be active during the wet season and apparently in estivation during the dry season. *S. salvinii* and *K. scorpioides* were found to be nocturnal while *C. scripta* was diurnal. *C. scripta* was found to be the most active mover and to have the greatest home range. S. salvinii and K. scorpioides appeared to be more sedentary with smaller home ranges.

Analysis of foods for S. salvinii showed it to be an opportunistic omnivore. Foods included vegetation, insects, fish, shrimp, crabs, and carrion.

Temperatures were analyzed for S. salvinii and C. scripta and found to be near that of the water temperature. Carapacial algal growth was analyzed with 78% of the S. salvinii population being covered while 100% of the C. scripta population was covered.

Shell abnormalities were analyzed and were assumed to be the result of some predator's attack or intraspecific aggression. No nest predation was noted. C. scripta exhibited a 40% incidence of damage while S. salvinii showed only an 8% incidence.

Growth and reproduction were analyzed for S. salvinii. By measuring growth rings, it was found that most growth occurred during the second growth period. S. salvinii was found to have a reproductive potential of 11.3 potentially ovulatory follicles. Limiting factors for S. salvinii were also discussed.

DEDICATION

My parents, Mrs. Marjorie B. Dean and Mr. Harold J. Dean, have been a continual source of encouragement and support. They have offered sound advice when needed and supported my decisions, participated in my victories and my defeats, and tolerated my shortcomings. I am proud to dedicate this thesis to them.

ACKNOWLEDGEMENTS

This study required time, effort, money and the support of many individuals whom I will try to acknowledge. Those individuals I fail to mention through a careless memory are no less thought of.

My committee, Drs. John W. Bickham, James R. Dixon, R. Douglas Slack, and David W. Owens, is to be commended for their support and tolerance of this study and for allowing me a relatively free hand throughout. To them I am grateful.

The following individuals in some way aided and encouraged me throughout this study. It was truly an honor to work with them.

Dr. James R. Dixon inspired, endured, questioned, answered, supported, and guided me during this entire effort. He provided a means of escape via the volleyball court. Jefe, I am grateful.

Dr. John W. Bickham, my committee chairman, did no less and provided funds as well as aid in the field in Puerto Arista. He also gave freely his time and knowledge. He allowed me to do this study with little supervision. It was an absolute pleasure to work for and with him. Thank you, I am grateful.

My colleague, John L. Carr, tolerated me for three months in the field at Puerto Arista. Without him this study would not have been possible. Juanboy, I am grateful.

My colleague and office mate, Dr. Christopher P. Kofron, introduced me to Puerto Arista and provided valuable assistance in the field. He also provided worthwhile discussion throughout this study. Chris, I am grateful.

My colleague and office mate, Dr. Jack W. Sites, Jr., has been a constant source of knowledge as well as a valuable friend. He helped me with my figures and provided assistance with the text. With Jack's help, I learned the system of law in Mexico. Yak, I am grateful.

My colleagues, Duke Rogers, Mark Engstrom, Bob Dowler, and Tim Houseal, aided me in the field. Duke and Mark heightened my interest in mammals. Bob gave me respect for the medical facilities of Mexico. Tim endured two weeks with me during January, 1980, a time of no turtles. Gents, thank you.

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Finally, I owe everything to my wife, Margaret. She allowed all this to happen. She provided a shoulder to cry on and put up with more than anyone can imagine. She aided in the field. She is my inspiration. Thank you Marg.

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INTRODUCTION

The ecology of certain species of turtles has been intensively studied. However, these have mostly been temperate forms and very little is known about tropical turtles. Curiously, two of the most detailed studies of tropical turtles were carried out on broadly distributed species that occur in both tropical and temperate areas (Moll and Legler, 1971; Medem, 1977). This present study was designed to provide ecological information on Staurotypus salvinii a member of the strictly tropical radiation, the kinosternid subfamily Staurotypinae.

An ecological study of the Central American mud turtle, Staurotypus salvinii Gray, was conducted from May to August, 1979 and January, 1980. A naturally occurring population located 1.8 km south of Cabeza de Toro, Chiapas, Mexico was chosen. Cabeza de Toro is a small fishing and agricultural village located 2.5 km west of Puerto Arista, Chiapas, Mexico (lat. 15°56'N, long. 93°48'W). Two other species of turtles, Chrysemys scripta and Kinosternon scorpioides, also occurred at the study site.

Specific objectives of the study were to analyze population size, movements, sex ratios, and food items of S. salvinii. Secondary objectives included analyzing carapacial algal growth, predation, reproduction, temperature relationships, and growth. In addition, this study attempted to determine those factors limiting S. salvinii

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The citations herein follow the style of the journal, Copeia.

to the tropical ecosystem. Where applicable, these objectives were also applied to C. scripta and K. scorpioides.

The genus Staurotypus contains two species, S. triporcatus and S. salvinii, and is included in the family Kinosternidae, a group of primarily Central and South American cryptodiran turtles. Along with the genus Claudius, Staurotypus comprises the subfamily Staurotypinae and are sometimes incorporated into a separate family Staurotypidae (Pritchard, 1967). The subject of this study, S. salvinii, was named for the collector, Osbert Salvin (1835-1895); Staurotypus is Greek for cross-shaped (Borror, 1971).

The genus Staurotypus is strictly neotropical. S. salvinii occurs on the Pacific versant from Chiapas to El Salvador. S. triporcatus occurs from Veracruz, Mexico to Guatemala and British Honduras along the Atlantic drainages.

Notable characteristics of the genus Staurotypus are a tricarinate carapace, a reduced plastron lacking gular and humeral laminae, presence of an entoplastral bone, and a large head (Fig. 1). Smith and Smith (1979) noted that key differences between S. salvinii and S. triporcatus include length and shape of the anterior plastral lobe, bridge size, shape of plastral laminae, jaw markings, head and carapace pattern, and maximum length.

As noted by Mlynarski (1976), staurotypines are older than kinosternines dating from the Oligocene in Middle and North America and Pliocene in North and South America, respectively. Sites et al. (1979) noted that this is consistent karyotypically suggesting a phylogenetic line. The staurotypine chromosome number is 2n=54

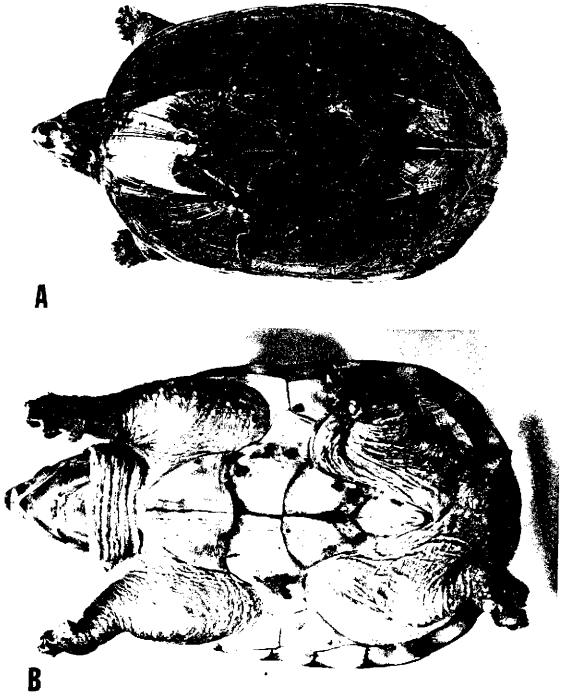

Figure 1. Dorsal (A) and ventral (B) view of S. salvinii from Cabeza de Toro, Chiapas, Mexico.

differing from kinosternines with 2n=56 (Bull et al., 1974).

The natural history and general ecology of several U.S. kinosternids has been studied by Mahmoud (1969), Skorepa and Ozment (1968), Tinkle (1958) and others. Further studies of feeding behavior and food habits of U.S. kinosternids have been conducted by Folkerts (1968), Hulse (1974), and Mahmoud (1968). Berry (1975) conducted gut analysis of Sternotherus sp. in Florida and Legler (1966) analyzed the diet of K. angustipons in Central America. A few thorough, descriptive studies have been done on neotropical turtles. Moll and Legler (1971) studied C. scripta in Panama, and Medem (1977) studied Chelydra serpentina in Columbia.

Alvarez del Toro (1973) noted that little is known of the natural history of the staurotypine turtles. He described them as medium sized, aggressive turtles with enormous heads, inhabiting fresh water, and feeding on clams, snails, and crustaceans. S. triporcatus in Guatemala occurs in clear water streams and rivers and in Yucatan mostly inhabits lakes (Duellman, 1963, 1965). Claudius angustatus in Guatemala inhabits muddy waters (Duellman, 1963). Reproductive studies on captive S. salvinii have been done by Sachsee and Schmidt (1976) and Schmidt (1970). Holman (1963) reported captive S. triporcatus from Veracruz fed on meat and fish, and fecal examination revealed the presence of fresh water clam shells. He further noted that C. angustatus fed on meat but refused fish.

The staurotypine turtles are commonly sold in the market places in southern Mexico (Breen, 1974, Moll and Legler, 1971). Alvarez del Toro (1973) reported that S. salvinii in Chiapas is edible and

Bickham (pers. comm) related that the Chiapan locals often capture turtles for food. Staurotypus salvinii known locally as the Cruzalluchi or Crucilla, is rarely eaten by the Chiapan locals, however, other fresh water turtles are eaten.

STUDY AREA

Chiapas, the southernmost state in Mexico, occupies more than 74,000 sq. km and is bordered by the states of Oaxaca and Veracruz to the west, Tabasco on the north, the country of Guatemala on the east, and the Pacific Ocean on the south (Fig. 2). The climate ranges from semidesert to rain forest and coastal swamp lands to 4000 m peaks with sub-alpine vegetation (Breedlove, 1973).

Mulleried (1957) divided Chiapas into seven physiographic regions (Fig. 3). The study area is situated in the Pacific coastal plain, a flat region that is dry in the north and wet in the south. Along the Pacific coast, mangrove swamps are intermixed with coastal strand. Following Beard (1944), this region is considered a wet-land forest formation. The swamp forms a continuous belt of low forest cover inhabiting the entire Pacific coast in brackish, swampy conditions (Breedlove, 1973). Breedlove (1973) further described this swamp as several kilometers wide in the north in the region of Mar Muerto, but only a few hundred meters wide along the rest of the coast. He further noted the vegetation dominants are the Black Mangrove, *Avicennia nitida*; Buttonwood, *Conocarpus erecta*; White Mangrove, *Laguncularia racemosa*; and Red Mangrove, *Rhizophora samoensis*. Vegetational description and analysis of the seasonal swamp is relatively incomplete.

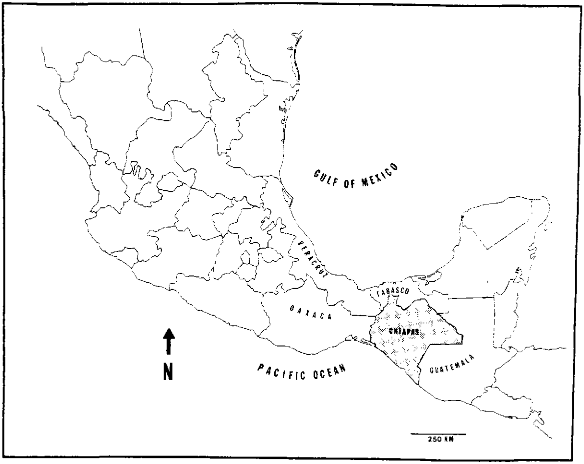

Figure 2. Map of Mexico and Central America (in part) with Chiapas denoted.

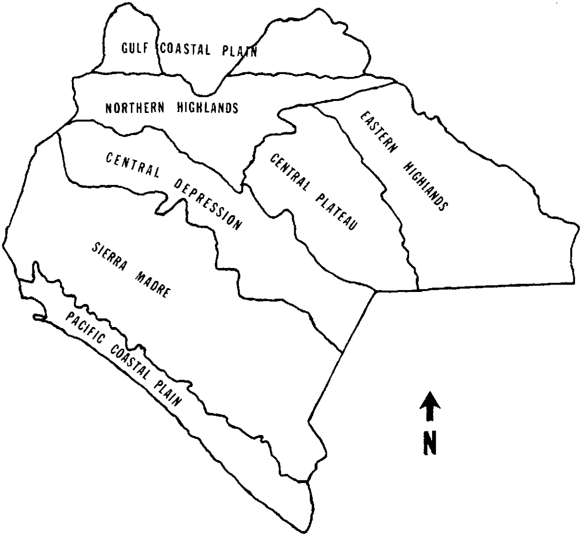

Figure 3. Map of Chiapas as divided into seven physiographic regions (after Mulleried, 1957).

Geohistory of the Area

The geohistory of the area is interesting in that the state of Chiapas is typically Central American. As indicated by Maldonado-Koerdell (1971), Chiapas is composed of Archeozoic strata of a crystalline and metamorphic basal complex. During the Paleozoic, strong tectonic activity formed a complex arc, the western portion forming the states of Guerrero and Oaxaca in Mexico and the eastern portion covering Guatemala to northern Nicaragua with the state of Chiapas in between. The Mesozoic stratigraphy is relatively well known in this area, a time during which Middle America entered a phase of intense mountain building. The Cenozoic era was marked with the continual emergence of land throughout most of the Tertiary with occasional subsidence in the isthmic regions. The Middle Pliocene was characterized by a period of volcanic stability and intense erosion. Volcanic activity began again by the Upper Pliocene, subsided, and was followed by intense erosion. The present land configuration of Middle America has remained relatively the same since the Quaternary.

In essence, the study area was under water ca. 25 MYBP with major upheavals occurring prior to and after the innundation.

The surface configuration of the Pacific coastal plain consists of alluvium occasionally interrupted by remnant igneous hills. The plain is several km wide in the north to 35 km wide at the Guatemala border. The plain has been formed by stream alluvium from adjacent mountains.

Chiapas is bisected by the continental divide which produces the Atlantic watershed and Pacific watershed. The study area is set in the Pacific watershed which is characterized by surface streams of relatively small discharge. The streams are generally short and slow during the summer rains and are dry during the winter. Under Koppens system of classifications, the study area is classified as Aw' or a tropical wet-dry climate with the maximum rainfall in September and October. The dry season begins in November and continues into May; occasional thunderstorms may occur during the dry season. Maximum temperatures and dryness occurs in March and April prior to the beginning of the rains.

Study Site

The study site is situated on Rancho San Marcos, a privately owned ranch 1.8 km south of Cabeza de Toro (see Fig. 4). The ranch has an area of 26 ha, supports about 20 head of cattle on pasture and has mango and coconut groves. The ranch is fenced and bounded by neighboring ranches north, east, west and the Pacific Ocean to the south.

Situated near the center of the ranch is a "J" shaped estero or swamp of approximately 1.5 ha with varying water depths to about 1.5 m (see Fig. 5). This altered mangrove swamp continues northward for an undetermined distance and presumably connects with an estuary north of Cabeza de Toro. This area has been disturbed due to farming and ranching and is occasionally burned to promote grass growth. The ranch estero has been cleared of all mangroves but mangroves continue

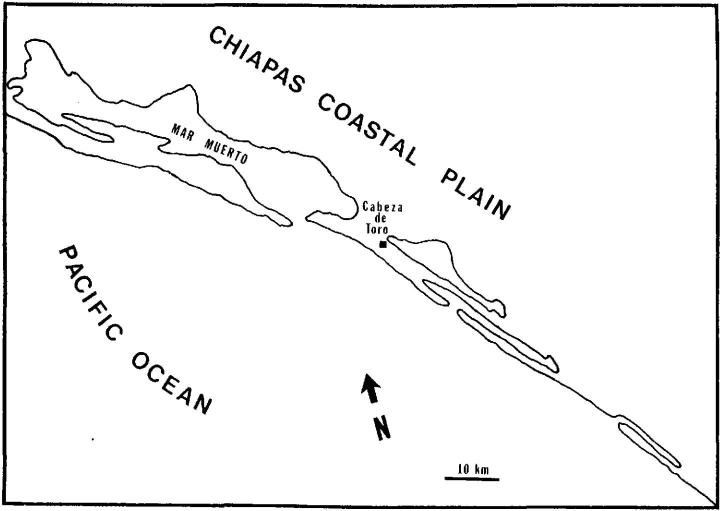

Figure 4. Pacific coastal plain of Chiapas (in part) denoting the study site at Cabeza de Toro (black square).

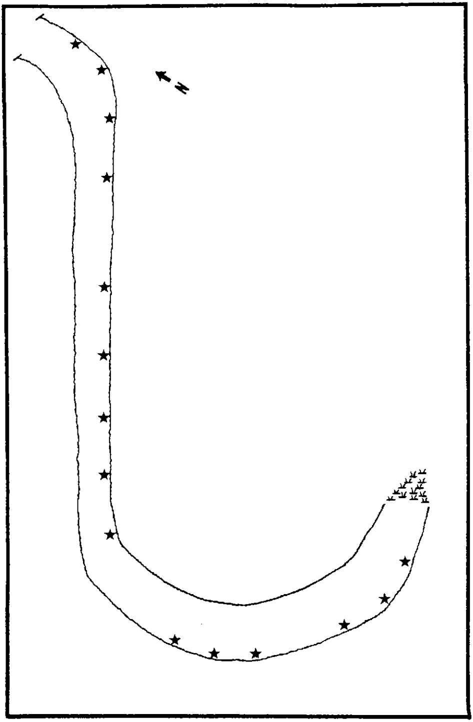

Figure 5. Schematic drawing of the estero at Rancho San Marcos, Cabeza de Toro, Chiapas, Mexico. Stars indicate trapping localities.

to grow northward at the ranch boundary. The ranches adjacent to the study site are continually being cleared to provide for more usable pasture.

The estero is a permanent, presumably freshwater swamp set in sandy soils. There is no known intrusion of salt water and the estero water is fresh to taste with livestock occasionally drinking from it. The presence of mangroves indicate that at one time the estero was brackish or that there is a small amount of salt present. The water level fluctuates with the seasons rising as much as 20 cm during the wet season. A high water level allows for numerous wells on the ranch, several located within 5 m of the estero.

The estero supports a wide variety of wildlife including three species of turtles--S. salvinii, Chrysemys scripta grayi, and Kinosternon scorpioides cruentatum. The largest vertebrate found in the estero is a crocodillian, Caiman crocodilus.

Figure 6 details typical habitat at the estero on Rancho San Marcos.

Figure 6. Typical habitat at the Rancho San Marcos estero.

MATERIALS AND METHODS

Data were obtained from a total of 216 individuals of S. salvinii, C. scripta, and K. scorpioides trapped at the study site near Cabeza de Toro. The procedure at the study site consisted of recording time and location of capture, as well as environmental and body temperatures. On return to camp, the turtles were sexed, marked, weighed, and measured. Also noted were distinguishing characteristics, growth rings and algae.

Turtles were captured utilizing 4-ringed hoop traps with 1½" or 2" mesh, baited with canned sardines, fresh fish, or occasionally rodent bodies. Bait was placed in small (1½ x 3") plastic containers with holes, and suspended in the trap. Traps were placed along the water's edge deep enough for the funnel mouths to be covered and not completely submerged, about 10 m apart, and checked twice daily. Searches were also made by seining in areas of shallow, debris-free water and sounding with machetes in muddy areas and at the base of tree roots. Water and cloacal temperatures were taken as soon as the turtles were removed from the traps. A Yellow Springs multiprobe telethermometer was used. Water temperature was taken at mid-trap depth and recorded to the nearest .5°C. Cloacal temperature was taken in the shade immediately after capture and recorded to the nearest .5°C.

At the field station, turtles were sexed and females were palpated for eggs. Individuals were permanently notched in the marginal laminae with a tricorner file following Cagle (1939). The system uniquely identified each individual.

All individuals were weighed to the nearest tenth of a gram on a triple beam balance. Measurements of live turtles were made using a meter stick and dividers. Standard measurements taken were as follows: Length of carapace (CL)--from the most anterior point to the most posterior point of the carapace; Width of carapace (CW)--greatest width at right angle to midline; Height of carapace (CH)--greatest depth of shell from suture of abdominals to mid dorsal ridge of carapace; Length of plastron (PL)--from the most anterior point to the most posterior point of the plastron; Length of bridge (BL)--minimum length along abdominal suture where it meets the axillary and inguinal scute; Length of fore lobe (FLL)--from anterior most point of plastron along suture to anterior abdominal suture; Length of hind lobe (HLL)--from posterior most point of plastron to posterior abdominal suture; Width of plastron (PW 1, 2, 3, 4)--four transverse widths along sutures of plastron; Length of gular (GL)--length along suture of gular scute; Width of gular (GW)--width along humeral-gular suture; Length of interhumeral laminae (IHL)--length along suture of interfemoral laminae; Length of interabdominal laminae (IAbL)--length along suture of interabdominal laminae; Length of interanal laminae (IAnL)--length along suture of anal laminae; Length of first vetebral (1stVL)--greatest length along midline of first vertebral scute; Width of first vertebral (1st VW)--width along vertebral-marginal border. All measurements are straight line distances.

Distinguishing characteristics such as shell damage or missing extremities were recorded. Growth rings were counted and measured as described in Moll and Legler (1971). Algal growth was categorized according to abundance on carapacial scutes. The categories were: None--no algae noted; Light--algae noted on at least one scute but less than about 10% of total carapace area; Moderate--algae covers up to 50% of carapace total area; Heavy--algae covers greater than 50% of carapace total area. Determination of algae growth was subjective.

Population estimates were determined using the Lincoln Index and Schnabel methods (Schnabel, 1938). Movements and home range were based on recapture records and determined as the maximum straight-line water distance between trapping points. Initially, foods were collected by using Leglers (1977) stomach flushing method. Turtles were flushed as soon as possible after capture. Contents were collected in gauze and preserved in formalin. Due to the pugnacious temperment of S. salvinii this method was soon abandoned and individuals outside the study area were collected and preserved for gut analysis.

The entire gut and reproductive tracts were removed from sacrificed animals and preserved in alcohol. Analysis of food items was done using a dissecting scope in the lab. Food items were categorized by type--insect, shrimp, crab, vertebrate, and vegetation. Volume of food items was determined by water displacement. Percent frequency occurrence and percent volume were determined after Hamilton (1948).

Skulls were removed prior to preserving the animals, air dried, and cleaned by dermestid beetles. The following measurements were taken on skulls to the nearest 0.1 mm using dial calipers following Dalrymple (1977): Maximum skull width--width at quadrate articular surfaces; Least pterygoid width--minimum width of the pterygoid bone; Basicranial length--length from the snout to the condylus occipitalis; Total length--length from the snout to the posterior most point of the crista supraoccipitalis; Crest height--height of crista supraoccipitalis; Interorbital width--least distance ventrally between the left and right fossa orbitalis; Jaw width--maximum width at the articular processes.

All measurements and ratios were analyzed utilzing the Student's t test.

RESULTS AND DISCUSSION

Field work was accomplished from 17 May to 1 August 1979, and from 1 to 9 January 1980 at the Cabeza de Toro study site. The study area in May was dry with dead grasses and few flowering plants. Trapping indicated an absence of activity in turtles during this period. The first rains began on 21 May 1979 and ten days later the turtles were active. The vegetation grew around the study site and the water level raised about 20 cm during the initial rainy period. Throughout June and July the rains continued with seeds and fruits being abundant.

The January 1980 trip coincided with the middle of the dry season. According to local inhabitants, the last rain was in October 1979. Vegetation was dead and soil was dry to about 15 cm below the surface. Vegetation at the water's edge remained green but plants were not flowering and fruits and seeds were scarce.

Data were taken on 146 turtles, representing three species trapped at the Rancho San Marcos study site. Of 216 captures, 130 were marked, 19 were removed, and 70 were recaptures. Of the 19 turtles removed from the population, three were marked leaving 127 turtles presently marked in the population. These 19 removals from the population were necessary in order to determine food habits and reproductive data.

S. salvinii was the most abundant turtle species at the study site. Of the 78 individuals, 12 were removed, 68 were marked, and 51 were recaptures. Of the 12 removed turtles, two were marked, leaving 66 marked S. salvinii in the population.

A total of 47 C. scripta were trapped; four were removed, 44 were marked, and there were 16 recaptures. Of the four C. scripta removed, one was marked, leaving a total of 43 marked C. scripta in the population.

A total of 21 K. scorpioides were trapped; three were removed, 18 were marked, and there were three recaptures.

During the summer study period, 12 traps were set for 63 days for a total of 756 trap nights. An average of 3.4 turtles per day were trapped. During the January trip, 20 traps were set for eight days for a total of 160 trap nights with no turtles trapped at the study site.

Population Analysis

The total population estimate by the Schnabel method was calculated to be 216.8 turtles (all species). The study area was estimated to be 1.5 ha; this results in a density estimate of 144.5 turtles per ha. The total population estimate by the modified Lincoln Index method was calculated for three precensus periods (see Table 1). For the precensus period ending 10 June, the total population estimate was 253.3, a density of 168.8 per ha. For the precensus period ending 25 June, the total population estimate was 334.1 turtles, a density of 222.7 per ha. For the percensus period ending 12 July, the total population estimate was 495 turtles for a density of 330 per ha. See Table 2 for the Schnabel estimate of the total population.

The S. salvinii population, as estimated by the Schnabel method,

TABLE 1. TOTAL POPULATION, *S. SALVINII*, *C. SCRIPTA*, AND *K. SCORPIOIDES* ESTIMATES BY THE MODIFIED LINCOLN INDEX METHOD. M=# of animals marked during the precensus period; n=# of animals trapped during the census period; x=# of marked animals trapped during the census period; N=population estimate with one standard error.

	PRECENSUS PERIOD ENDING		
	10 June 1979	25 June 1979	12 July 1979
TOTAL	M=55 n=152 x=33 N=253.33 ± 49	M=73 n=119 x=26 N=334.12 ± 93	M=88 n=90 x=16 N=495 ± 203
S. salvinii	M=26 n=96 x=20 N=124.8 ± 24	M=40 n=67 x=13 N=206.15 ± 85	M=46 n=50 x=5 N=460 ± 369
C. scripta	M=22 n=41 x=12 N=75.17 ± 25	M=23 n=40 x=12 N=76.67 ± 26	M=27 n=34 x=11 N=83.45 ± 32
K. scorpioides	M=7 n=15 x=1 N=105 ± 188	M=10 n=12 x=1 N=120 ± 218	M=15 n=6 x=0 N=0

Table 2. TOTAL POPULATION ESTIMATE BY THE SCHNABEL METHOD. A=# of animals trapped per day; MARKED=# of animals marked per day; B=sum of marked animals in the population per day; RECAP=# of previously marked animals recaptured per day; C= sum of recaptures per day; $\frac{AXB}{C}$=population estimate per day; CI=lower and upper limits of 95% confidence interval. Superscripts indicate animals removed from the population.

DATE	A	MARKED	B	AXB	SUM AXB	RECAP	C	$\frac{AXB}{C}$	CI L	CI U
May										
31	5	5	0	0	0	0	0	0	0	0
June										
1	1	1	5	5	5	0	0	0	0	0
2	20	20	6	120	125	0	0	0	0	0
3	7	7	26	182	307	0	0	0	0	0
4	4	3	33	132	439	1	1	439	75	2558
5	1	1	36	36	475	0	1	375	81	2768
6	6	6	37	222	697	0	1	697	119	4062
7	6	4	43	258	955	2	3	318.33	106	955
8	9	6	47	423	1378	3	6	229.67	103	508
9	1	0	53	53	1431	1	7	204.43	97	428
10	4	2	53	212	1643	2	9	182.56	94	351
11	4	4	55	220	1863	0	9	207.00	107	398
13	2	0	59	118	1981	2	11	180.09	99	326
14	2	2	59	118	2099	0	11	190.82	105	345
15	6	1	61	366	2465	5	16	154.06	93	252
17	5	3	62	310	2775	2	18	154.17	92	249
18	2	1	65	130	2905	1	19	152.89	97	240
20	4[1]	1	66	264	3169	2	21	150.90	97	232
21	3	2	67	201	3370	1	22	153.18	100	233
24	3	2	69	207	3577	1	23	155.52	102	235
25	2	2	71	142	3719	0	23	161.70	106	244

Table 2. (Continued)

DATE	A	MARKED	B	AXB	SUM AXB	RECAP	C	AXB/C	CI L	CI U
June										
27	1	1	73	73	3792	0	23	164.87	108	249
28	1	1	74	74	3866	0	23	168.09	111	254
29	1	1	75	75	3941	0	23	171.35	113	259
30	4	2	76	304	4245	2	25	169.80	113	252
July										
1	1	0	78	78	4323	1	26	166.27	112	245
3	3[1]	2[1]	78	234	4557	1	27	168.78	115	247
4	2	2	79	158	4715	0	27	174.63	119	256
5	6[1]	5[1]	81	486	5201	1	28	185.75	127	270
7	2	0	85	170	5371	2	30	179.03	123	257
8	3	1	85	255	5626	2	32	175.81	123	249
10	4	1	86	344	5970	3	35	170.57	121	238
12	1	1	87	87	6057	0	35	173.06	123	242
13	12[10]	1[1]	88	1056	7113	2	37	192.24	138	266
14	11[4]	3	88	968	8081	4	41	197.10	144	269
16	13[2]	6	91	1183	9264	5	46	201.39	150	270
17	7	4	97	679	9943	3	49	202.92	152	269
19	11	8	101	1111	11054	3	52	212.58	161	280
20	17	6	109	1853	12907	11	63	204.87	159	263
21	3	2	115	345	13252	1	64	207.06	162	268
22	6	4	117	702	13954	2	66	211.42	165	270
23	7	5	121	847	14801	2	68	217.66	170	271
25	3	1	126	378	15179	2	70	216.84	170	275
	216		127							

was 95.4 for a density of 63.6 turtles per ha. The modified Lincoln Index density estimates for S. salvinii during the three precensus periods were: 10 June--83.2 per ha; 25 June--137.3 per ha; 12 July--306 per ha. See Table 3 for the Schnabel estimate of the S. salvinii population.

The C. scripta population was estimated to be 87.3 or a density of 58.2 turtles per ha, using the Schnabel method. The modified Lincoln Index density estimates for C. scripta during the three precensus periods were: 10 June--50.1 per ha; 25 June--51.1 per ha; 12 July--55.5 per ha. See Table 4 for the Schnabel estimate for the C. scripta population.

The K. scorpioides population was estimated by the Schnabel method to be 72.3 for a density of 48.2 turtles per ha. The modified Lincoln Index density estimates for the three precensus periods were: 10 June--69.9 turtles per ha; 25 June--80 per ha; 12 July--zero. See Table 5 for the Schnabel estimate of the K. scorpioides population.

S. salvinii made up 53.4% of the individual turtles trapped at the study site, while C. scripta made up 32.2% and K. scorpioides 14.4%. By comparison, the kinosternid S. odoratus was found to make up 5 to 40%, 34%, and 4.5% of the total population at several U.S. sites (Cagle, 1942; Wade and Gifford, 1965; Ernst, 1969). C. scripta made up 71 to 87% and 75% of the total population at different U.S. locations (Cagle, 1950; Ernst and Barbour, 1972). These data indicate that density of one species can be quite variable.

Table 3. _S. SALVINII_ POPULATION ESTIMATE BY THE SCHNABEL METHOD. A=# of animals trapped per day; MARKED=# of animals marked per day; B=sum of marked animals in the population per day; RECAP=# of previously marked animals recaptured per day; C=sum of recaptures per day; $\frac{AXB}{C}$=population estimate per day; CI=lower and upper limits of 95% confidence interval. Superscripts indicate animals removed from the population.

DATE	A	MARKED	B	AXB	SUM AXB	RECAP	C	AXB/C	CI L	CI U
May										
31	1	1	0	0	0	0	0	0	0	0
June										
2	8	8	1	8	8	0	0	0	0	0
3	5	5	9	45	53	0	0	0	0	0
4	2	2	14	28	81	0	0	0	0	0
5	1	1	16	16	97	0	0	0	0	0
6	4	4	17	68	165	0	0	0	0	0
7	4	2	21	84	249	2	2	124.50	33	464
8	5	2	23	115	364	3	5	72.80	30	173
10	3	1	25	75	439	2	7	62.71	29	131
11	3	3	26	78	517	0	7	73.86	35	154
13	2	0	29	58	575	2	9	63.89	33	122
14	2	2	29	58	633	0	9	70.33	36	135
15	6	1	31	186	819	5	14	58.50	34	99
17	4	2	32	128	947	2	16	59.90	36	97
18	2	1	34	68	1015	1	17	59.71	36	96
20	4[1]	1	35	140	1155	2	19	60.79	38	95
21	2	1	36	72	1227	1	20	61.35	39	95
24	3	2	37	111	1338	1	21	63.71	41	98
25	1	1	39	39	1377	0	21	65.57	42	101
27	1	1	40	40	1417	0	21	67.48	43	104
29	1	1	41	41	1458	0	21	69.43	45	107
30	4	2	42	168	1626	2	23	70.70	46	106

Table 3. (Continued)

DATE	A	MARKED	B	AXB	SUM AXB	RECAP	C	AXB / C	CI L	CI U
July										
1	1	0	44	44	1670	1	24	69.58	46	104
3	2[1]	1[1]	44	88	1758	1	25	70.32	47	104
5	3[1]	2[1]	44	132	1890	1	26	72.69	49	107
7	2	0	45	90	1980	2	28	70.71	48	102
8	3	1	45	135	2115	2	30	70.50	49	101
13	3[3]	0	46	138	2253	0	30	75.10	52	107
14	7[4]	3	46	322	2575	0	30	85.83	59	123
16	7[2]	3	49	343	2918	2	32	91.19	64	129
17	7	4	52	364	3282	3	35	93.77	66	131
19	7	5	56	392	3674	2	37	99.30	71	138
20	9	2	61	549	4223	7	44	95.98	71	129
21	1	0	63	63	4286	1	45	95.24	70	128
22	3	1	63	189	4475	2	47	95.21	71	127
23	4	2	64	256	4731	2	49	96.55	72	128
25	2	0	66	132	4863	2	51	95.35	72	126
	129									

Table 4. C. SCRIPTA POPULATION ESTIMATE BY THE SCHNABEL METHOD. A = # of animals trapped per day; MARKED=# of animals marked per day; B=sum of marked animals in the population per day; RECAP=# of previously marked animals recaptured per day; C=sum of recaptures per day; $\frac{A X B}{C}$=population estimate per day; CI=lower and upper limits of 95% confidence interval. Superscripts indicate animals removed from the population

DATE	A	MARKED	B	AXB	SUM AXB	RECAP	C	$\frac{AXB}{C}$	CI L	CI U
May										
31	4	4	0	0	0	0	0	0	0	0
June										
1	1	1	4	4	4	0	0	0	0	0
2	10	10	5	50	54	0	0	0	0	0
3	2	2	15	30	84	0	0	0	0	0
6	2	2	17	34	118	0	0	0	0	0
7	1	1	19	19	137	0	0	0	0	0
8	1	1	20	20	157	0	0	0	0	0
10	1	1	21	21	178	0	0	0	0	0
11	1	1	22	22	200	0	0	0	0	0
July										
5	2	2	23	46	246	0	0	0	0	0
10	3	1	25	75	321	2	2	160.50	43	321
12	1	1	26	26	347	0	2	173.50	46	647
13	6^{4}	1^{1}	27	162	509	2	4	127.25	48	333
14	4	0	27	108	617	4	8	77.13	38	154
16	6	3	27	162	779	3	11	70.82	39	128
19	4	3	30	120	899	1	12	74.92	42	132
20	7	3	33	231	1130	4	16	70.63	43	115
21	1	1	36	36	1166	0	16	72.88	44	119
22	3	3	37	111	1277	0	16	79.81	48	130
23	3	3	40	120	1397	0	16	87.31	53	143
	63		43							

Table 5. K. SCORPIOIDES POPULATION ESTIMATE BY THE SCHNABEL METHOD. A=# of animals trapped per day; MARKED=# of animals marked per day; B=sum of marked animals in the population per day; RECAP=# of previously marked animals recaptured per day; C=sum of recaptures per day; $\frac{AXB}{C}$=population estimate per day; CI=lower and upper limits of 95% confidence interval. Superscripts indicate animals removed from the population.

DATE	A	MARKED	B	AXB	SUM AXB	RECAP	C	AXB/C	CI L	CI U
June										
2	2	2	0	0	0	0	0	0	0	0
4	2	1	2	4	4	1	1	4	1	23
7	1	1	3	3	7	0	1	7	1	40
8	3	3	4	12	19	0	1	19	3	110
9	1	0	7	7	26	1	2	13	3	48
17	1	1	7	7	33	0	2	16.5	4	61
21	1	1	8	8	41	0	2	20.5	5	76
25	1	1	9	9	50	0	2	25	6	93
28	1	1	10	10	60	0	2	30	8	111
July										
3	1	1	11	11	71	0	2	35.5	9	132
4	2	2	12	24	95	0	2	47.5	12	177
5	1	1	14	14	109	0	2	54.5	14	203
10	1	0	15	15	124	1	3	41.3	13	124
13	3[3]	0	15	45	169	0	3	56.3	18	169
20	1	1	15	15	124	0	3	61.3	13	124
21	1	1	16	16	200	0	3	66.7	22	200
25	1	1	17	17	217	0	3	72.3	24	217
	24		18							

The Schnabel method best estimates the actual turtle population and will be the only method treated here. This method is continuous over the trapping period, allowing for larger samples for each day trapped. Also, it excludes biases set in the modified Lincoln Index method.

The total turtle population density estimate of 144.5 turtles per ha can be compared to Moll and Legler's (1971) estimate of 190 per ha for the neotropical C. scripta in Panama. Population size can be limited by a number of factors from size of area trapped to food availability. The Cabeza de Toro population is probably limited by available habitat, but other factors cannot be ruled out.

For S. salvinii, the population density estimate was 63.6 turtles per ha. This is the first population estimate for a staurotypine, but comparative data are available for several kinosternine species. Mahmoud (1969) found Sternotherus odoratus density estimates in Oklahoma to be 149.9 per ha and S. carinatus estimated at 228.7 per ha. He further estimated K. subrubrum to be 159.3 and 258.3 per ha in consecutive years in Oklahoma and found K. flavescens estimates to be 27.9 per ha.

The K. s. cruentatum population density was estimated to 48.2 turtles per ha. This is within the range of values reported for other kinosternines as noted above (Mahmoud, 1969).

For C. scripta the population density estimate was 58.2 turtles per ha. Moll and Legler (1971) estimated 190 turtles per ha for C. scripta in Panama while Gibbons (1968) and Sexton (1959) estimated C. picta at 575.5 and 410 per ha. Gibbons (1970) estimated 901.5 C.

scripta per ha in South Carolina.

Population estimates indicate that S. salvinii at 63.6 turtles per ha is nearly equal to C. s. grayi at 58.2 turtles per ha. Though the difference is negligible, the habitat probably favors S. salvinii. Moll and Legler (1971) list optimum habitat for C. scripta to be large bodies of slow moving water with large amounts of submergent vegetation, open areas adjacent to the waters, and abundant basking sites. The study site estero is a lentic body of water with very little submergent vegetation, thus favoring S. salvinii. The K. s. cruentatum population estimate may be small for several reasons, the main being habitat. This turtle has been found in abundant numbers near shallow, intermittant rain ponds and this may represent its preferred habitat.

Sex Ratios

Of 78 S. salvinii, 45 were males and 33 were females for a sex ratio of 1.36 males to 1 female or 58% to 42%. Of 47 C. scripta, 16 were males and 21 were females for a sex ratio of .52 males for 1 female or 34% to 66%. Of 21 K. scorpioides, 20 could be sexed with 14 being males and six being females with a sex ratio of 2.33 males to 1 female or 70% to 30%.

As indicated in Table 6, the females of kinosternids in nearly all cases outnumber the males. These data are based on turtles of the temperate areas. Both neotropical kinosternids show a ratio in favor of the males.

TABLE 6. SEX RATIOS OF *S. SALVINII*, *C. SCRIPTA*, *K. SCORPIOIDES* AND CONFAMILIAL SPECIES AS REPORTED IN THE LITERATURE.

KINOSTERNIDAE

SPECIES	% MALES	% FEMALES	AUTHORITY
S. odoratus	30%	70%	Risely, 1933
	41%	59%	Cagle, 1942
	48%	52%	Tinkle, 1961
S. carinatus	38%	62%	Mahmoud, 1969
	41%	59%	Tinkle, 1958
S. minor	49%	51%	Tinkle, 1958
	52%	48%	Tinkle, 1958
	24%	76%	Tinkle, 1958
K. subrubrum	40%	60%	Mahmoud, 1969
	40%	60%	Mahmoud, 1969
	24%	76%	Mahmoud, 1969
K. flavescens	40%	60%	Mahmoud, 1969
	42%	58%	Mahmoud, 1969
	61%	39%	Mahmoud, 1969
K. scorpioides	70%	30%	This Study
S. salvinii	58%	42%	This Study

EMYDIDAE

SPECIES	% MALES	% FEMALES	AUTHORITY
M. terrapin	14%	86%	Hildebrand, 1932
C. insculpta	57%	43%	Ernst and Barbour, 1972
T. ornata	31%	53%	Legler, 1960
G. pseudogeographica	20%	80%	Timkin, 1968
	7%	73%	Webb, 1961
C. scripta	66%	34%	Moll and Legler, 1971
	65%	35%	Moll and Legler, 1971
C. scripta	34%	66%	This Study

Differences in the sex ratios prove to be interesting as the effects of temperature as a sex determinant in turtles has been studied by Bull and Vogt (1979). They found in certain turtles high temperatures produce females and low temperatures produce males. That temperatures determine sex in kinosternids is unreported but S. salvinii and S. triporcatus have been reported to have an XY chromosome system (Bull et al., 1974). James J. Bull (pers. comm.) has informed us that in most kinosternids, sex is determined by temperatures. Bull and Vogt (1979) showed that a nest temperature difference of as little as four degrees can produce either males or females in Chelydra sp. Vivo Escoto (1971) noted that the yearly temperature in large plain areas below 1000 m, such as the Yucatan Peninsula, range from a high daytime temperature of 29°-32°C and a low nighttime temperature of 20°-24°C. These temperature differences and the choice of nesting sites could probably affect the sex ratios of tropical turtles. In that the sex ratio favors the female C. scripta and the male K. scorpioides (both species without sex chromosomes) in this study, possibly differences in nesting behavior between the two species is indicated. Additional field work is needed to answer this.

S. salvinii shows a sex ratio of nearly 1:1; slightly skewed in favor of males (x^2=1.84, no significant difference). This would be expected if sex is determined chromosomally.

The sex ratio of C. scripta showed .52 males to 1 female. Moll and Legler (1971) found this species in Panama to have a ratio of 1.93 males to 1 female. Moll and Legler (1971) explain the difference in their data as a possible result of differential mortality explaining that females are often caught at the nesting site for food. The Cabeza de Toro study site is relatively remote and turtle hunting is discouraged by the land owner. On one occasion, a local was noticed carrying a caiman and a female C. scripta from the study site. The owner and the ranch boss indicated that this was rare and that the people rarely eat C. scripta but prefer to eat K. scorpioides for medicinal purposes. In light of temperature dependent sex determination, Moll and Leglers (1971) explanation of skewed sex ratios can be questioned. It could be due to nest temperature. The difference in sex ratios of the Panama and Chiapas populations could be due to environmental differences in available nest sites, behavioral differences as to nest site preference, or sampling error.

Activity Period

The activity period for turtles is generally reported as an annual cycle and a diel cycle. Temperate turtles are generally active from spring to fall with estivation during the hot, dry periods and hibernation during the winter (Ernst and Barbour, 1972). The three species of neotropical turtles studied show a distinct similarity to the temperate forms in seasonal activity.

Turtles at the Cabeza de Toro study site became active at the initiation of the rainy season (May) and remain active presumably until October. The dry season (November - April) marks a period of supposed estivation as no turtles were trapped at the study site during the January visit. In January, two C. scripta were seen in the water at the study site and one was trapped at a site near Puerto Arista and in May, prior to the rains, four K. scorpioides were trapped at the same site near Puerto Arista. Apparently, not all turtles estivate during the entire dry season but activity in all species is low and S. salvinii may be entirely inactive.

Daily activity cycles have been studied in several aquatic, temperate forms. Chelydra serpentina was shown to be more active during the night and sluggish during the day (Ernst and Barbour, 1972). Sternotherus odoratus and K. subrubrum, temperate kinosternids, have been shown to be nocturnal, crepuscular, and diurnal (Lagler, 1943; Carr, 1952; Mahmoud, 1968; Mahmoud, 1969). The neotropical S. salvinii and K. scorpioides tend to be more nocturnal as 67% of both species (52 of 78 and 14 of 21 captures respectively) were trapped overnight. Moll and Legler (1971) indicated that C. scripta in Panama is diurnal. C. scripta in Chiapas is diurnal with 60% being trapped (28 of 47 captures) during the daylight hours. Chi square tests indicate that the S. salvinii value of 67% is significant whereas the C. scripta and K. scorpioides data was insignificant.

The common habit of basking has been reported for both kinosternids and emydids (Ernst and Barbour, 1972). Basking was never observed at the study site even though there was an abundance of basking sites. This may be due to the warm temperatures of the water (max - 34°C) thus negating the requirement to thermoregulate by basking. The cause and effect of basking behavior is not well understood. Moll and Legler (1971) noted that C. scripta in Panama frequently bask and they review the reasons proposed for this behavior.

They conclude that the synthesis of vitamin D may be the most valid. Turtles are very wary while they bask and it is possible that basking took place but was unnoticed, although I consider it unlikely that any of these three species bask frequently at Cabeza de Toro.

Movements and Home Ranges

As determined by trapping and recaptures, movements of S. salvinii show a maximum of 80 m with a minimum of zero m ($\bar{x}$ = 13.6 m, SD $\pm$ 21.1, n=32). C. scripta moved a maximum of 360 m and a minimum of 10 ($\bar{x}$ = 201 m, SD $\pm$ 140, n=11). K. scorpioides moved a maximum of 30 m and a minimum of zero m ($\bar{x}$ = 13.3 m, SD $\pm$ 15.3, n=3). Home ranges are estimated to be the maximum distance moved between traps x the average width of the estero: S. salvinii - 1200 m^2; C. scripta - 5400 m^2; K. scorpioides - 450 m^2. Table 7 summarizes movements and home ranges of these three species and related species.

Movements and home ranges of turtles are difficult to discern with any accuracy using trapping records. Home range is the area in which the animal normally lives and is not normally associated with any aggressive behavior. Stickel (1950) and Nichols (1939) define home range as distance between two furthest trapping points. A straight line assumption must be made between trapping localities. In actuality, movements are probably random within an area and limited by the boundaries of suitable habitat in that area. For this reason home range will be determined by the maximum distance moved x the mean width of the estero. The dimensions of the study area will allow this assumption.

Table 7. MOVEMENTS AND HOME RANGES OF S. SALVINII, S. SCRIPTA AND CONFAMIAL SPECIES AS REPORTED IN THE LITERATURE.

SPECIES	MOVEMENTS Min	Max	HOME RANGE		AUTHORITY
KINOSTERNIDAE					
S. odoratus	1.8 m	525.5 m	243 m^2	486 m^2	Mahmoud, 1969
S. carinatus	4.6 m	93.9 m	---		Mahmoud, 1969
K. subrubrum	.6 m	408.4 m	486 m^2	526 m^2	Mahmoud, 1969
K. flavescens	3.4 m	435.3 m	1053 m^2	1255 m^2	Mahmoud, 1969
K. scorpioides	0.0 m	30.0 m	450 m^2		This Study
S. salvinii	0.0 m	80.0 m	1200 m^2		This Study
EMYDIDAE					
C. concinna	---	640.0 m	---		Marchand, 1942
C. floridana	---	640.0 m	---		Marchand, 1942
C. scripta	---	336.0 m	32,977 m^2		Moll and Legler, 1971
C. scripta	10.0 m	360.0 m	5400 m^2		This Study

Movement and home range data on turtles appears to be determined by the size and shape of the area. Cagle (1955) and Sexton (1959) found that some turtles may occupy home ranges which include parts of several bodies of water and that overland migrations were also frequent. C. scripta was found to be the more active mover and to have the larger home range. It occasionally moved from one end of the study site to the other whereas the kinosternid populations appeared more sedentary with less movement and a more established home range.

Food Analysis

Stomach contents of 29 S. salvinii revealed that they are primarily omnivorous, opportunistic feeders. Foods were categorized and % frequency and % volume were determined (Table 8). Vegetation consisting of figs, berries, seeds, and leaves, was present in 79% of the stomachs examined and made up 23.4% of the total volume. Insects (Diptera, Homoptera, Coleoptera, Hymenoptera) were found in 66% of the stomachs and made up 6% of the total volume. The most common insect was a homopteran, Cicada. Fish (Dormitator latifrons) were found in 62% of the stomachs examined and constituted 6.3% of the volume. Other fish known to occur there and collected in seines and traps were Cichlosoma trimaculatum, Poeciliopsis fasciata, and Poecilia butleri. Crabs were found in 34% of the stomachs and made up 3.2% of the total volume. Shrimp (Macrobrachium sp.) were found in 31% of the stomachs and made up .7% of the volume. A lizard (Iguana iguana) was found in 10% of the stomachs and made up 1% of the total volume; this was assumed to be carrion due to size of food

TABLE 8. FOOD ANALYSIS OF *S. SALVINII* COMPARED TO OTHER KINOSTERNID TURTLES (THIS STUDY AND MAHMOUD, 1968).

FOOD ITEM	*K. subrubrum* n=178	*K. flavescens* n=121	*S. odoratus* n=68	*S. carinatus* n=63	*S. salvinii* n=29
VEGETATION					
% freq	89.6	37.2	97.4	88.9	79.0
% vol	22.3	8.5	20.4	16.6	23.4
FISH					
% freq	0	0	0	0	66.0
% vol	0	0	0	0	6.3
INSECTS					
% freq	98.3	94.7	98.3	91.6	66.0
% vol	30.4	27.8	46.4	42.9	6.0
CRUSTACEANS					
% freq	15.0	99.2	61.1	38.7	65.0
% vol	1.4	27.7	5.0	2.8	3.9
MOLLUSCS					
% freq	93.1	93.7	96.2	96.7	0
% vol	31.8	23.5	23.7	24.3	0
CARRION					
% freq	68.6	13.2	37.4	61.2	10.0
% vol	11.9	3.2	3.4	10.6	1.0

item and absence in other stomachs. Unidentified mass was found in 100% of the stomachs and made up 60% of the total volume.

Foods of kinosternids have been analyzed by several authors (Hulse, 1974; Mahmoud, 1968 and 1979; Legler, 1966; Skorepa and Ozment, 1968; Tinkle, 1958) and they have been found to be omnivorous, opportunistic feeders. Mahmoud (1968) reported on the foods of S. odoratus, S. carinatus, K. subrubrum, and K. flavescens and found them to be omnivorous. Based on percent occurrence, he noted a strong preference for insects, crustaceans, and vegetation. This is due to abundance and availability of food items. K. bauri is reported by Ernst and Barbour (1972) to be omnivorous, feeding on insects, seeds, leaves, algae, snails, and carrion. Tinkle (1958) reported S. minor to be insectivorous as juveniles and molluscivorous as adults, occasionally being cannibalistic. Hulse (1974) reported K. sonoriense to be carnivorous shifting to omnivory depending on food availability. Legler (1966) reported the neotropical kinosternids K. augustipons, K. leucostomum, and K. scorpioides to be primarily opportunistic herbivores with small incidences of omnivory. Medem (1961) found K. dunni to prefer molluscs in captivity.

The foods of S. salvinii have not been reported; however, S. triporcatus is reported to have fresh water clam shells in fecal material (Holman, 1963). Owing to the large heads of the staurotypines, it was expected that S. salvinii would be a mollusc feeder. This expectation is based on Holmans (1963) and Alvarez del Toros (1973) observations of staurotypines being molluscivorous and the fact that the large headed kinosternid, S. minor is molluscivorous as an adult.

Molluscivory and enlarged heads have been correlated in Trionyx sp. and Graptemys sp. (Dalrymple, 1977; Ernst and Barbour, 1972).

Analysis of foods on S. salvinii show it to be an omnivorous, opportunistic feeder similar to the other members of the family. A preference for vegetation is apparent due probably to a high incidence of green vegetation, fruits, and seeds associated with the rainy season. Seasonality also plays an important part in the number of insects taken and available to the turtles. Fish, crabs, and shrimps are abundant during the wet and dry seasons and represent an additional food source during the active period. Carrion is incidental and represents an opportunistic strategy in that it was available and eaten. No molluscs were noted at the study site.

Temperature Relationships

Cloacal temperatures were taken on both S. salvinii and C. scripta and were found to be very close to the water temperature. S. salvinii had a mean cloacal temperature of 29.92 (n=95, SD ± 1.48) with a mean water temperature of 30.0 (n=95, SD ± 1.80). C. scripta had a mean cloacal temperature of 29.49 (n=50, SD ± 1.57) with a mean water temperature of 29.33 (n=50, SD ± 1.61). Figures 7 and 8 illustrate cloacal and water temperature of both species.

A linear relationship is indicated when cloacal temperatures of both S. salvinii and C. scripta are plotted against water temperatures suggesting that environmental temperatures are responsible for body temperatures. This is in general agreement with other findings on temperature relationships in reptiles (Punzo, 1975; Mahmoud, 1969;

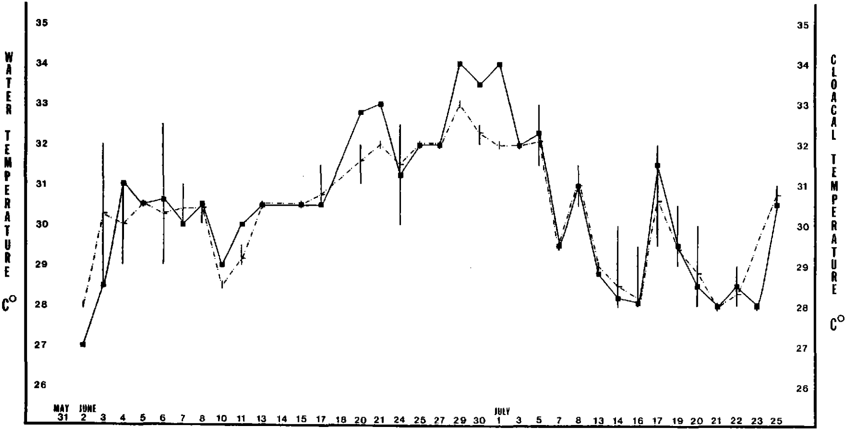

Figure 7. Mean daily cloacal temperatures of S. salvinii compared to mean daily water temperatures. Cloacal temperatures are connected by a broken line and water temperatures by a solid line. Vertical lines represent the range of cloacal temperatures in S. salvinii.

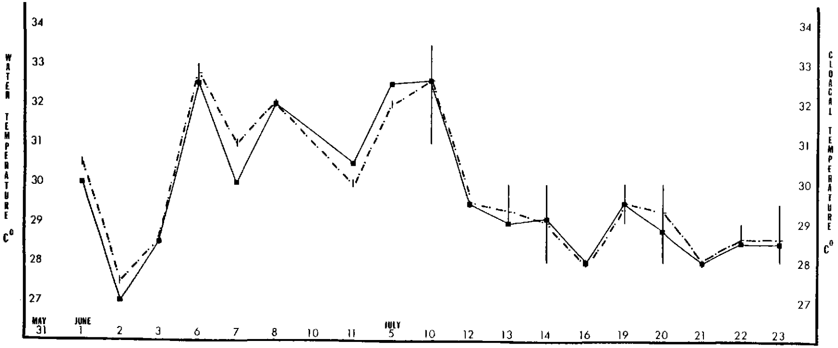

Figure 8. Mean daily cloacal temperatures of C. scripta compared to mean daily water temperatures. Cloacal temperatures are connected by a broken line and water temperatures by a solid line. Vertical lines represent the range of cloacal temperatures in C. scripta.

Hutchison and Kosh, 1965; Kosh and Hutchison, 1968; Ruibal, 1961; Moll and Legler, 1971).

Temperatures of temperate turtles have been studied by several authors. Brattstrom (1965) found S. odoratus to be active at body temperatures of 16.2 - 28.8°C with a mean of 21.2 °C. Edgren and Edgren (1955) found S. odoratus to exhibit a low body temperature in waters with a high temperature and warm body temperatures in waters with a low temperature. Mahmoud (1969) found a thermoactivity range of 16 - 36°C for K. subrubrum with a field preferred temperature of 23.65°C. K. flavescens was found to have a thermoactivity range of 18 - 32°C with a preferred field temperature of 25.06°C (Mahmoud, 1969). C. picta was found to have an activity range of 8 - 29°C with a mean of 22°C (Ernst and Barbour, 1972). Cagle (1950) reported an activity range for C. scripta to be 10 - 37°C. These data show that the temperature activity range can be variable and dependent on the distribution of the turtle species.

The water temperature at the study site ranged from 27 - 34°C during May to August. This may represent the temperature activity range for both S. salvinii and C. scripta. The mean January water temperature was 20.0°C with no turtle activity.

Algal Growth

Based on subjective analysis of algal growth, 22% of S. salvinii observed had no algae. Heavy algal growth was noted on 28% of S. salvinii while 17% were moderate and 33% were light. All C. scripta had algae with 39% being heavy growth, 16% moderate growth, and 45%

light growth. One individual was observed to have completely shed its scutes except the post marginals which were totally covered with algae. Table 9 details algal growth for these three species as well as related species.

Algae on turtles has been recorded by numerous authors (Dixon, 1960; Edgren et al., 1953; Ernst and Barbour, 1972; Proctor, 1958). The most frequently recorded algal genus is Basicladia. Both S. salvinii and C. scripta were found to have Basicladia sp. on the carapace. Ernst (1976) noted that algal growth became more prominent as spring advanced. This was also the case in both S. salvinii and C. scripta in Chiapas.

Algae was graded subjectively as heavy, moderate, light, and none. Those individuals with moderate, light or no algae were frequently recaptured with a higher grade of algal coverage. No shell necrosis due to algae was noted.

Predation

As no nests were located, nest predation could not be analyzed. Shell abormalities in S. salvinii and C. scripta were noted and assumed to be the result of intraspecific aggressive behavior or some predator's attack.

C. scripta exhibited a 40% incidence of marginal, plastral, carapacial, or soft part damage. Male C. scripta showed a 50% incidence of damage while females showed a 35% incidence. S. salvinii showed an 8% incidence of shell damage.

TABLE 9. ALGAL GROWTH ON *S. SALVINII* AND *C. SCRIPTA* AND OTHER SPECIES

SPECIES	% POPULATION COVERED	AUTHORITY
CHELYDRIDAE		
C. serpentina	75%	Proctor, 1958
	40%	Edgren et al., 1953
M. temminckii	75%	Proctor, 1958
KINOSTERNIDAE		
S. odoratus	54.6%	Edgren et al., 1953
	75%	Proctor, 1958
S. carinatus	69%	Dixon, 1960
	75%	Proctor, 1958
K. subrubrum	75%	Proctor, 1958
K. flavescens	65%	Dixon, 1960
	75%	Proctor, 1958
S. salvinii	78%	This Study
EMYDIDAE		
G. geographica	4.5%	Edgren et al., 1953
G. pseudogeographica	50%	Dixon, 1960
	50%	Proctor, 1958
C. picta	9.5%	Edgren, et al., 1953
	69%	Ernst and Barbour, 1972
	50%	Proctor, 1958
C. floridana	50-75%	Proctor, 1958
D. reticularia	33%	Dixon, 1960
	50-75%	Proctor, 1958
C. scripta	11%	Edgren et al., 1953
	50-75%	Proctor, 1958
	77%	Dixon, 1960
C. scripta	100%	This Study

Ernst (1976) reported C. guttata to exhibit 5.3% incidence of shell damage. C. picta was found to exhibit 13.4% shell damage (Ernst, 1971). These abnormalities are presumed to be the result of freezing of actively growing shell tissue during winter dormancy (Ernst, 1976). He further noted that predator attacks or lawn mower injuries account for 13.5% of damage in C. guttata. The predators' attacks are assumed to be by carnivores with the raccoon being the prime suspect.

The injuries of S. salvinii and C. scripta are assumed to have been caused by attacks by predators or attacks from intraspecific competitors. All injuries had healed and were represented by scarring. The injuries do not appear to be the result of ontogenetic defects. Moll and Legler (1971) present a good review of the predators on fresh water turtles. Potential predators seen in the area include Caiman crocodilus and several predaceous birds such as anhingas (Anhinga anhinga), herons (Casmerodius albus, Bubulcus ibis), bitterns (Tigrisoma sp., Botaurus sp.) and kingfishers (Chloroceryle americana). Suspected predators not seen but assumed to be in the area include raccoon, coati, and skunk.

Roze (1964) mentioned that caimans and birds prey on young Podocnemis expansa. Bent (1922, 1940) listed turtles as food items for anhingas and kingfishers. Caimans, regardless of size, are capable of damaging a hatchling or small turtle with a misjudged bite or misjudgment in prey size. Damage to the carapace and plastron could be inflicted by birds that strongly grasp in a scissors-like fashion or drop on their prey from a height. Marginal damage could result from pecking or stabbing at hatchlings or young turtles. As

C. scripta is more agile and diurnal, they probably are preyed upon more heavily than the sedentary, more nocturnal S. salvinii.

One further possibility as to the damages could be by attacks on juvenile turtles by S. salvinii. S. salvinii is an aggressive and pugnacious turtle that will bite hard at objects or other turtles near it. As previously noted, some kinosternids may be cannibalistic. Bickham (pers. comm.) observed in captivity a large adult Kinosternon sp. bite a juvenile C. decorata with the resulting damage being a piece missing from the marginals. The degree to which S. salvinii preys on other turtles is unknown.

Growth

Sixteen S. salvinii with discernable growth rings were measured. These rings in older individuals are usually worn smooth and it is not known if they represent annual periods of growth. Measurements of the left abdominal laminae, length and width, and the anal laminae, length only, were taken. Tables 10, 11, 12, 13, 14, and 15 summarize these data.

Shell and skull measurements were taken to distinguish sexual differences or dimorphism. Sexual differences in turtles usually include body size and/or tail length. Males are generally smaller in size and have longer tails than females. Kinosternid turtle sexual differences can be determined by tail length. In S. salvinii, the sexes are very similar with males having a longer, thicker tail. The sexes also differ in two other characters--height and inter-orbital width. On the average, female S. salvinii were thicker

TABLE 10. MEAN LENGTH PER GROWTH PERIOD OF THE LEFT ADBOMINAL SCUTE FOR *S. SALVINII*.

GROWTH PERIOD	N	$\overline{X}$ (mm)	SD (mm)	RANGE (mm)
0	14	3.82	±0.32	(3.0 - 4.0)
1	14	6.96	±0.87	(6.0 - 8.0)
2	14	10.79	±2.49	(8.0 - 15.0)
3	10	12.45	±3.03	(9.0 - 17.5)
4	7	14.57	±2.99	(11.0 - 19.0)
5	3	15.50	±2.78	(12.5 - 18.0)

TABLE 11. MEAN WIDTH PER GROWTH PERIOD OF THE LEFT ABDOMINAL SCUTE FOR *S. SALVINII*.

GROWTH PERIOD	N	$\overline{X}$ (mm)	SD (mm)	RANGE (mm)
0	14	9.82	±2.0	(6.0 - 12.0)
1	14	19.32	±3.35	(10.0 - 22.5)
2	14	27.32	±6.01	(15.0 - 38.0)
3	10	30.15	±7.12	(17.0 - 41.5)
4	7	34.36	±3.75	(27.0 - 39.0)
5	3	36.00	±5.20	(30.0 - 39.0)

TABLE 12. MEAN ABDOMINAL SCUTE WIDTH INCREASE PER GROWTH PERIOD FOR *S. SALVINII*.

GROWTH PERIOD	N	$\overline{X}$ (mm)	SD (mm)	RANGE (mm)
0-1	14	3.14	±0.77	(2.0 - 4.0)
1-2	14	4.04	±2.01	(1.0 - 7.5)
2-3	10	2.85	±1.65	(1.0 - 5.5)
3-4	7	3.21	±1.68	(1.0 - 5.5)
4-5	3	3.67	±2.52	(1.0 - 6.0)

TABLE 13. MEAN ABDOMINAL SCUTE LENGTH INCREASE PER GROWTH PERIOD FOR *S. SALVINII*.

GROWTH PERIOD	N	$\overline{X}$ (mm)	SD (mm)	RANGE (mm)
0-1	14	9.50	±3.13	(3.0 - 15.5)
1-2	14	10.86	±7.84	(4.5 - 29.5)
2-3	10	5.50	±3.06	(2.0 - 8.0)
3-4	7	5.29	±2.16	(2.0 - 8.0)
4-5	3	4.17	±1.26	(3.0 - 5.5)

TABLE 14. MEAN LENGTH PER GROWTH PERIOD OF THE ANAL SCUTE FOR *S. SALVINII*.

GROWTH PERIOD	N	$\overline{X}$ (mm)	SD (mm)	RANGE (mm)
0	13	6.42	±0.98	(5.0 - 9.0)
1	13	10.96	±2.23	(7.5 - 13.0)
2	13	17.31	±3.45	(12.0 - 23.0)
3	10	20.55	±5.08	(14.5 - 29.0)
4	6	20.58	±4.01	(16.0 - 27.0)
5	3	22.33	±5.13	(18.0 - 28.0)

TABLE 15. MEAN ANAL SCUTE LENGTH INCREASE PER GROWTH PERIOD FOR *S. SALVINII*.

GROWTH PERIOD	N	$\overline{X}$ (mm)	SD (mm)	RANGE (mm)
0-1	13	4.46	±1.76	(2.0 - 7.0)
1-2	13	6.35	±3.53	(2.5 - 14.5)
2-3	10	4.65	±2.79	(1.0 - 8.0)
3-4	6	3.67	±2.75	(1.5 - 9.0)
4-5	3	4.00	±2.00	(2.0 - 6.0)

bodywise or had more height than males. This may be an adaptation to accommodate egg production.

Male S. salvinii had a greater interorbital width than the females even though the skull widths were not significantly different. Ratios which showed differences were $\frac{HLL}{CL}$, $\frac{CH}{CL}$, $\frac{BL}{CL}$, $\frac{PL}{CL}$, $\frac{FLL}{CL}$, and $\frac{\text{Least Pterygoid Width}}{\text{Skull Width}}$ (Figs. 9-14). Tinkle (1958) found the following ratios to show differences in Sternotherus sp.: $\frac{PL}{I\ an}$, $\frac{PL}{BL}$, $\frac{CL}{PL}$, $\frac{TL}{PL}$, and $\frac{PL}{PL}$. The ratios $\frac{HLL}{CL}$, $\frac{FLL}{CL}$, and $\frac{BL}{CL}$ for S. salvinii show differences probably due to the egg supporting requirement of the females. Plastral lengths tended to be greater in females probably for the same reason.

Turtles show indeterminate growth with growth generally decreasing in older animals. Measurements of growth rings, when these rings are discernable, can indicate the amount of growth in a growing season. Temperate turtles generally show a growing trend during the summer months with abundant food resources and a cessation of growth during the winter months. Tropical turtles appear to show this trend during the wet-dry periods.

The original abdominal scutes of the hatchling do not increase in size but remain constant with new growth added to the edges of the original scute. In S. salvinii no more than six growing periods were observed due to the plastron being worn with age.

As indicated in Tables 12, 13, and 15, the greatest increase in growth occurred between the first and second growth periods. This is evident in both the abdominal and anal scutes. The hatchling period is the most vulnerable to predation (Ernst and Barbour, 1972)

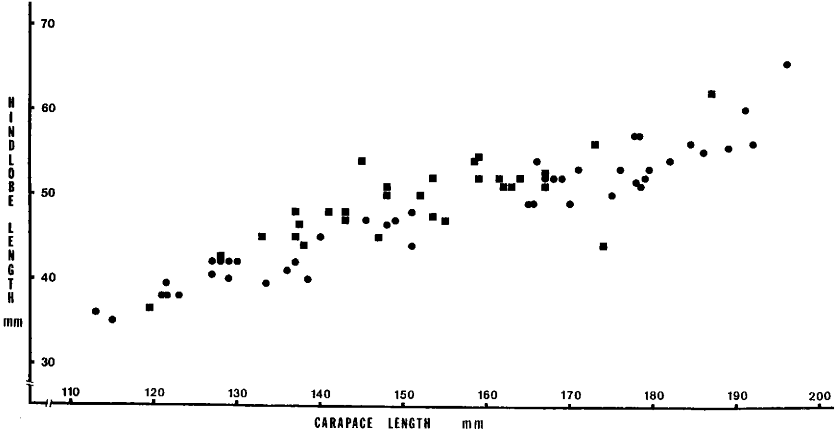

Figure 9. Graph of $\frac{HLL}{CL}$ for S. salvinii. Solid circles are males and solid squares are females.

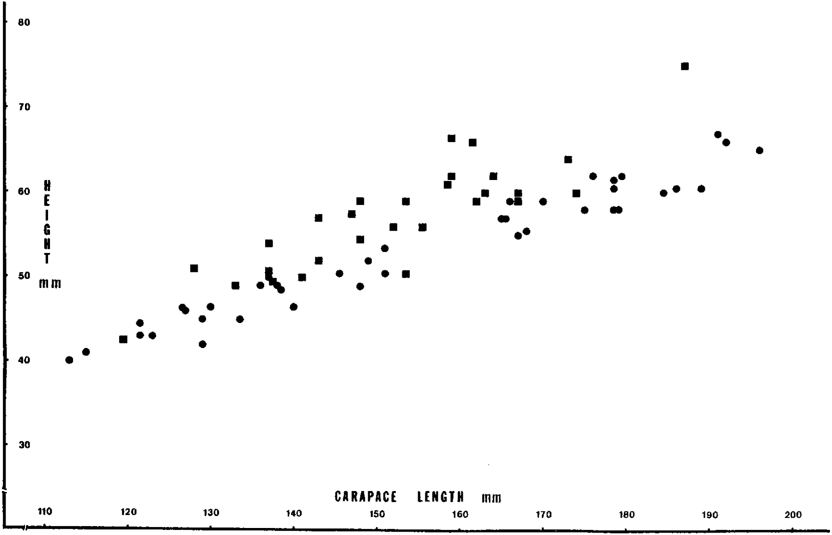

Figure 10. Graph of $\frac{CH}{CL}$ for S. salvinii. Solid circles are males and solid squares are females.

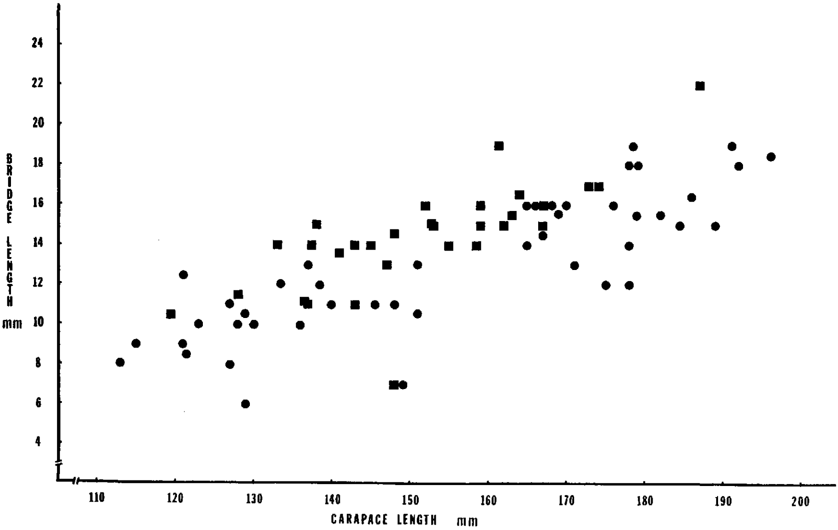

Figure 11. Graph of $\frac{BL}{CL}$ for S. salvinii. Solid circles are males and solid squares are females.

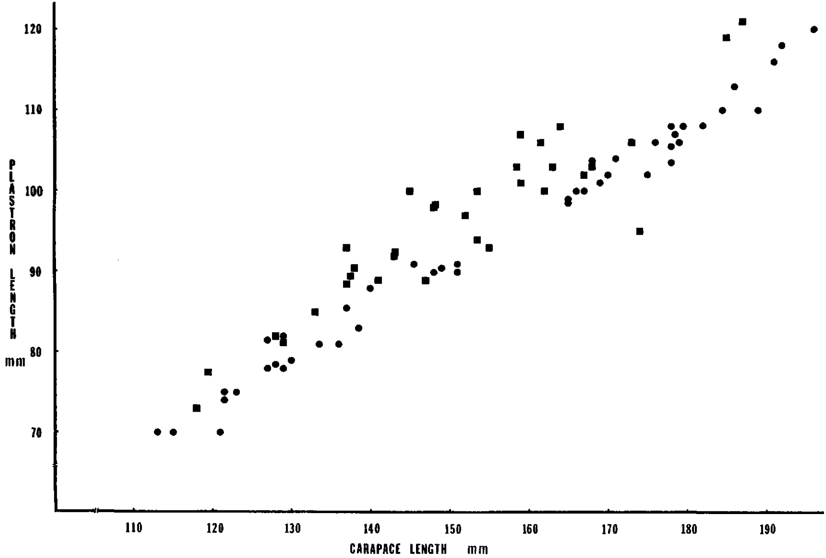

Figure 12. Graph of $\frac{PL}{CL}$ for S. *salvinii*. Solid circles are males and solid squares are females.

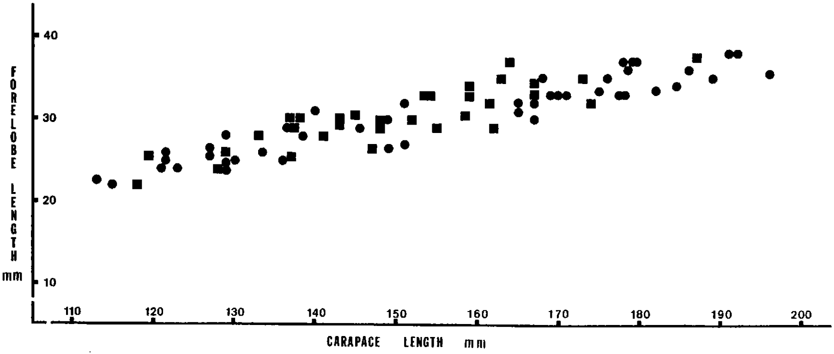

Figure 13. Graph of $\frac{FLL}{CL}$ for S. salvinii. Solid circles are males and solid squares are females.

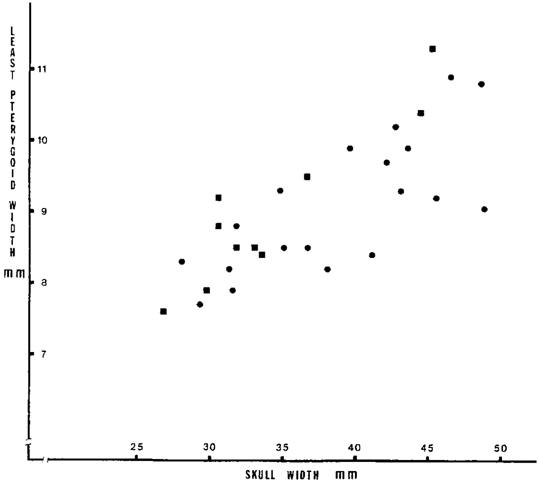

Figure 14. Graph of $\frac{\text{Least Pterygoid Width}}{\text{Skull Width}}$ for *S. salvinii*. Solid circles are males and solid squares are females.

and most energy is probably expended feeding and avoiding predation. The following growing season is probably the most important as it represents the period of most growth in the young turtle. Predation on second year turtles may be less allowing these juveniles to concentrate on feeding thus allowing for maximum growth during this period.

Reproductive Analysis

Ten female S. salvinii reproductive tracts were examined for yolked follicles, unyolked follicles, and corpora lutea. Table 16 lists carapace length, number of yolked follicles, diameter range, (mean and standard deviation) of yolked follicles in mm. Three individuals were noted with no yolked follicles.

The mean number of potentially ovulatory follicles is 11.3 (n=7, SD $\pm$ 4.46) for those individuals with yolked follicles. This small sample size precludes accurate estimate. No corpora lutea were noted.

Data on reproductive potential in kinosternids are few. Tinkle (1958) reported reproductive potential for S. minor and S. carinatus to be 6.3 and 7.3, respectively. For S. salvinii the reproductive potential of 11.3 may be an overestimate as the smaller yolked follicles may not be ovulatory size; however, the potential to become ovulatory size cannot be precluded. Alvarez del Toro (1973) noted that the staurotypines lay 6 eggs per clutch. Sumicrast (1880) noted that 2 eggs are laid in September. Sachsee and Schmidt (1976) noted that a captive female S. salvinii laid seven clutches with a

Table 16. NUMBER OF YOLKED FOLLICLES FOR TEN FEMALE *S. salvinii* WITH FOLLICLE DIAMETER RANGE, MEAN, AND STANDARD DEVIATION IN MM.

CARAPACE LENGTH	# YOLKED FOLLICLES	RANGE (mm)	MEAN (mm)	S.D. (mm)
185	12	11.6 - 6.2	9.6	2.04
182	20	18.1 - 7.4	13.4	2.97
145	10	17.9 - 8.4	12.6	2.98
138	7	15.1 - 8.8	12.6	2.02
137.5	0	---	--	--
136.5	13	16.1 - 7.2	11.1	3.93
136	10	11.2 - 6.8	8.8	1.43
134	0	---	--	--
129	7	15.2 - 11.5	13.5	1.54
118	0	---	--	--

total of 61 eggs ($\bar{x}$ = 8.7 per clutch, range 10 to 7 eggs). Number of clutches and size in a natural population of S. salvinii is unknown.

Schmidt (1970) reported a 207-day hatching record for captive S. salvinii. Sachsee and Schmidt (1976) reported that eggs were laid in winter (European) prior to estivation with an average of 145-day hatching record. These are laboratory experiments and there is probably some variation in the population. Assuming S. salvinii enters estivation at the beginning of the seasonal dry period, egg deposition would occur probably just prior to estivation (September-October?). If the ca. 200-day hatching is correct, the eggs would hatch at the beginning of the rainy season. The hatchlings would then have the entire six-month rainy season to exploit the abundance of insects, fruits, and seeds in preparation for the dry estivation period. If eggs are deposited at the beginning of the rainy season or even during the mid-rainy season, egg hatching would probably occur during the dry season when there is a paucity of foods available for the hatchlings. The ca. 200-day hatching record is apparently an adaptation to the tropics.

Limiting Factors

Geographically, S. salvinii is a Pacific coastal form occurring from Guatemala to El Salvador. Those factors limiting the distribution of S. salvinii will not be extensively considered, but moisture, temperatures, and barriers to dispersal are probably the major factors limiting distribution.

It is unlikely that food availability is a limiting factor in that, with the exception of insects and vegetation (fruits and seeds), food is available year round in the form of fish, shrimps, and crabs. Competition is probably not a limiting factor for S. salvinii due to sympatry with K. scorpioides and C. scripta. Competition may limit K. scorpioides where it occurs with S. salvinii due to niche similarities, but the degree to which their niches are similar is not known.

Duellman (1966) noted that temperature and moisture are the principal limiting environmental factors particularly affecting reptile and amphibian distributions in Central America. He further noted that as temperature differences are slight in some areas moisture plays an important role. S. salvinii occurs in areas of seasonal wet-dry periods, and moisture may be a prime limiting factor.

CONCLUSIONS

1. *S. salvinii* is active during the wet season (May-October) of Chiapas.

2. *S. salvinii* in Chiapas tends to be nocturnal in its daily movements and exhibits sedentary tendencies.

3. *S. salvinii* in Chiapas is an opportunistic omnivore feeding on vegetation, fruits, seeds, fish, insects, shrimps, crabs, and carrion.

4. *S. salvinii* juveniles in Chiapas show the greatest growth increase during the second growth period.

5. The principal factor limiting activity for *S. Salvinii* in Chiapas appears to be moisture.

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