HUMAN PREDATION ON THE GOPHER TORTOISE (*GOPHERUS POLYPHEMUS*) IN NORTH-CENTRAL FLORIDA

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ABSTRACT: Human predation on *Gopherus polyphemus* was investigated through personal observation of and participation in the process, hunter interviews, examination of butchered animals, and laboratory dissections of tortoises. Information was gathered about the hunters' methods, the results of their efforts, and the effects on local tortoise populations. Light predation probably does not have a strong adverse effect on a population. Intensive exploitation, however, may seriously affect the viability of populations of this species because of the tortoise's extremely low reproductive rate and the difficulty in replacing lost individuals. Approximately equal numbers of each sex are taken, and the size distribution of butchered animals reflects that of typical colonies. Predation on the gopher tortoise by man is widespread, despite the fact that the small edible portion of each animal leads to the relatively high cost of obtaining the flesh. The use of *G. polyphemus* as a food item is perpetuated by the culture of certain groups and their traditional exploitation of the species.

RESUMEN: La predación humana sobre tortugas *Gopherus polyphemus* fue investigada por observación personal, entrevistas con los cazadores, examen de ejemplares colectados y posteriormente disecados en el laboratorio. Se obtuvo información acerca de los métodos y resultados de caza así como de los efectos de ésta sobre las poblaciones locales de tortuga. Es probable que la predación leve no afecte a la población de tortugas de manera muy desfavorable. Sin embargo, la intensiva explotación podría afectar seriamente la viabilidad de las poblaciones de esta especie debido a su baja tasa de reproducción y por la dificultad de reemplazo de aquellos individuos predados. Se tomaron números aproximadamente iguales de ambos sexos y, la distribución de tamaño en ejemplares colectados refleja igualdad al de las colonias típicas. La predación de la tortuga por el hombre es extensiva a pesar del alto costo con relación a la parte comestible. El uso do *G. polyphemus* como alimento es perpetuado por la cultura de ciertos grupos y por la tradicional explotación de esta especie.

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INTRODUCTION

Numerous references to the use of the gopher tortoise (*Gopherus polyphemus*) as food by humans are found in the herpetological literature. Early North American herpetologists included brief statements about the capture or utilization of these animals (Daudin 1802; Holbrook 1836; LeConte 1836; Agassiz 1857). In this century, many authors have made reference to the exploitation of this species by man, and some have also commented upon the possible effects of this predation on tortoise populations (Fisher 1917; Roosevelt 1917; Hallinan 1923; Carr 1952; Oliver 1955; Auffenberg 1969, 1978; Ernst and Barbour 1972; Auffenberg and Franz in press). Many of these accounts, however, are based upon second-hand or anecdotal information and do not go beyond stating the basic fact that gopher tortoises are captured and eaten by man. Several popular articles have contained more detailed information about the procedure involved in capturing and preparing gophers for the table (Anderson 1949; Trowbridge 1952; Alberson 1953; Hutt 1967; Thomas 1978). Even these somewhat more detailed accounts, however, are still primarily concerned with the capture of the tortoise and its conversion into a meal.

This study is an initial attempt to take a comprehensive look at human predation on *G. polyphemus* in the Alachua County, Florida area in order to show more clearly how and to what extent the tortoises are utilized as a food source and the possible effects of this predation. The specific objectives of the investigation are to describe the human costs and benefits associated with collecting tortoises for food, and to evaluate the possible ecological effects upon local tortoise populations and the species as a whole. Additionally, an effort is made to define and examine the motivation of those individuals who look upon *G. polyphemus* only (or primarily) as an exploitable resource.

Status of *Gopherus polyphemus*

The gopher tortoise is classified as a game animal by the Florida Game and Fresh Water Fish Commission. The 1981-1982 summary of hunting rules and regulations published by that agency sets a possession limit of five tortoises per person. This means, for example, that a family of four persons could legally take 20 gopher tortoises each day for their own use. There are no restrictions on the size or sex of tortoises that may be taken. Since 1980 a closed season has been in effect from 1 April to 30 June each year. The sale or purchase of any gopher turtle is prohibited at all times.

Incongruously, *G. polyphemus* is also listed as a "Species of Special Concern" by the same state agency, due to its drastic decline in numbers during recent years and the uncertainty of its status. Auffenberg and Franz (in press) have documented the reduction in numbers over the spe-

cies' range, examined the causes of this decline, and predicted continuing population decreases.

The conflicting policies at the highest level of state wildlife management can only foster misunderstanding and disinterest among Floridians concerning the status of the gopher tortoise within the state and what management policies are appropriate. Fortunately, the Game and Fresh Water Fish Commission has recently undertaken a research program to investigate exploited reptiles and amphibians, with initial emphasis on *G. polyphemus* (Tommy Hines, pers. comm.). The results of that research program should provide a basis for the promulgation of appropriate management regulations based on sound biological data, which have been lacking up to this time.

Archaeological Perspective

Gopherus polyphemus has been consistently exploited by the inhabitants of Florida for 4000 + years. Bonnie McEwan of the Department of Anthropology, University of Florida, has compiled information about this exploitation based on material in the Zooarchaeology collection of the Florida State Museum and has generously allowed me to present it here.

Based primarily on the contents of refuse deposits (middens), archaeological excavations in Florida reveal gopher tortoise remains in 75% of the sites examined. This value is probably conservative since the highly domed shape of the carapace (which is the skeletal element most often found) could lead to its use in other activity areas of a given site. For example, if used as a vessel or rattle those shells would for the most part not be included in these data.

A substantially higher proportion of coastal sites have been excavated than inland occupation areas. Despite this, when present, *G. polyphemus* averages 3.7% of the faunal assemblage based on number of individuals. Additional data from sites where these turtles would have been more easily accessible (along the central ridge of the state) would undoubtedly increase this value.

The level of utilization of the gopher tortoise by aboriginal peoples reflects the relative importance of terrestrial and aquatic resources in their societies. Data from the Palmer site in west-central Florida, which has been analyzed for three distinct time periods spanning 3000 years, indicates that a reduction in utilization of this species follows the development of a sophisticated fishing technology or more likely closer access to aquatic habitats through time. The trend toward a greater reliance on freshwater and marine resources, and the consequent de-emphasis of terrestrial fauna exploitation is observed in most of the archaeological sites analyzed. Not until the time of European contact and the subsequent

reliance on domesticated animals is the terrestrial fauna represented to the same degree as the aquatic in coastal sites.

Sea turtles are represented to a greater degree in sites where they are found than are gopher tortoises, averaging 10.1% where they occur based on number of individuals. This greater intensity of use of Cheloniidae probably occurred because of the breeding or feeding congregations of these species and the opportunity to gather large numbers of them at the coastal sites, rather than the result of dietary preference.

The exploitation of *Gopherus polyphemus* as a food resource 4000 years ago was due to several factors that are still in effect today. Gopher tortoises represent a readily available food source which oftentimes requires only minimal procurement materials and skill. The location of their burrows is obvious, and their movements are often indicated by well-worn trails nearby. Their docile nature and slow movements do not serve them well during encounters with humans. Along with the opportunistic nature of man, these characteristics have facilitated human exploitation of the gopher tortoise in the past and continue to be important today.

Materials and Methods

Data were gathered between September 1978 and May 1980 in the following ways:

Interviews. – Thirty-three interviews involving a total of 41 persons were conducted in the Alachua County, Florida, area. All the persons interviewed used *Gopherus polyphemus* as an occasional or regular food item. Most of the individuals interviewed were contacted through previous informants or by being approached by the author. A few individuals were interviewed after the discovery during other conversations that they caught and ate gophers. Information gathered included where and how often tortoises were hunted, how the tortoises were caught, cleaned, and cooked, which parts of the animal were utilized as food, information about the sale and purchase of tortoises, and any other pertinent data.

Collection Trips. – Between September 1978 and April 1980, 32 gopher collecting trips took place. During 21 of these the author was in the company of one or more experienced gopher pullers. During these trips, data were gathered on capture methods and efficiency, numbers and characteristics of tortoises collected, and hook location and damage. It was during these trips that the essence of the "rural gopher puller" was delineated. Following these excursions the methods used to clean and cook the animals were observed. Although illegal, tortoises are regularly bought and sold by local residents. Price ranges for various sized tortoises were noted. The sale of individuals was observed on several occasions.

Dissections. – In order to accurately estimate the amount of edible flesh obtainable from a tortoise, dissections of 36 individuals were performed. These animals had been used in another research project and had been sacrificed. All edible portions of each tortoise were removed and weighed. This information was then used along with size data from the tortoises involved to determine the relationship between an animal's size and the proportion of that individual that could be eaten. A comparison was also made between the cost of tortoise flesh and that of commercially available domesticated animals.

Refuse Shells. – Groups of discarded, cleaned tortoise shells were sometimes found in rural regions near housing areas, or at certain locations in the forests where trash and garbage

are deposited (casual dumps). Whenever possible, these discarded shells were salvaged and returned to the lab for analysis in order to determine the size and sex of the individuals from which they came. Information about cleaning methods was also derived from examination of these remains. The sex of each individual was determined based on overall shell morphology after a subjective evaluation with respect to the following characters: plastral concavity, degree of anterior gular projection, degree of xiphyplastral thickening, extent of curvature of posterior carapacial margin, and shell thickness. Except for shell thickness, these variables are essentially those of McRae et al. (1981). An estimate of the distribution within size and sex classes was later made to assess the impact of capture techniques upon the species.

RESULTS

Interviews with persons who utilize *Gopherus polyphemus* as a food resource revealed a wide range in the frequency of their hunting activities. Average intervals between trips varied from a week to several months, but no individual claimed to adhere to any sort of regular schedule. Some persons would go every day if time permitted or if hunting was unusually good. Under most circumstances the physical effort required to capture tortoises is substantial, thereby reducing the number of trips that would otherwise be made by some persons and deterring others altogether. The latter is often the case with elderly individuals who, in their younger days, regularly hunted tortoises.

To successfully hunt tortoises, a person must first identify and have access to a site that is populated by the animals. Knowledge of possible hunting sites is gained either through personal experience, by word of mouth, or by actively searching. Active searching involves patrolling a possible area (usually in an automobile) and making exploratory trips into wooded areas, pastures, old fields, or other suitable habitats. Some persons are more respectful than others of land owners' rights and request permission before venturing onto private property. This is particularly true if a fence must be crossed. Many property owners are quite willing to allow gopher hunting on their land, especially those who have cattle or horses, or those with hayfields that must be cultivated and harvested with wheeled vehicles. The reason for refusal of a request to hunt tortoises on private property usually has nothing to do with concern for the tortoises' welfare, but is simply distrust of strangers on the property. A contributing factor in this regard may be that most landowners are white, while my experience indicates that most gopher-pullers are black. The problem of obtaining permission is avoided entirely on public land. In the Alachua County area, the largest tract of public land containing large gopher tortoise populations is the Ocala National Forest (primarily in Marion County) approximately 80 kilometers away. This area is hunted regularly by residents of Alachua and Putnam counties.

Once access to an area has been gained, the problem becomes one of actually securing the gophers. This is accomplished by one of three

general methods. The easiest way is simply to pick up individuals that are found away from their burrows. This procedure is almost a completely chance event, and surely accounts for a very small percentage of the total number of tortoises taken. Many more are probably run over or picked up by motorists while the animals are crossing the roads than are found by persons hunting them. Fisher (1917) and Ditmars (1946) reported making use of the animals' tracks in the sand to capture some individuals, and the tortoises' habit of following well defined trails through sufficiently dense vegetation is well known (Ernst and Barbour 1972). However, these aids are normally of little use, except possibly in an area with an unusually high tortoise density. During approximately 160 hours spent in the field collecting gophers over the past two years, I encountered only four tortoises away from their burrows.

The second general method of capture involves the use of some sort of trap. The most common type of trap consists of a five gallon bucket placed in a hole dug immediately outside the burrow mouth, and often covered with paper or vegetation. As the tortoise enters or leaves the burrow it must cross the top of the bucket and will fall in. Agassiz (1857) reported that this method was effective, and I have captured many individuals in this way. A less commonly used type of trap (it was described to me only once) consists of a snare placed at the burrow mouth. A loop of heavy monofilament fishing line is supported in such a way that the tortoise's head must pass through it as he enters or leaves the burrow. One end of the line is secured to nearby sturdy vegetation or a stick deployed as an anchor. The loop closes around the tortoise's neck and holds the animal until removed by the trapper. Both of these trapping methods can easily lead to the death of the tortoises, even if the animals were not going to be killed anyway, as is sometimes the case with farmers desiring only to remove the animals from near their crops. A tortoise left in a bucket trap through midday during the Florida summer will almost certainly die because of heat stress, unless the day happens to be overcast. Likewise, the snare around the gopher's neck will get progressively tighter as the animal struggles to escape, leading to asphyxiation unless it is removed shortly after capture.

The capture method that accounts for the vast majority of gophers taken for human consumption involves the use of a gopher pulling "hook," and is described by Fisher (1917), Hallinan (1923), Anderson (1949), Alberson (1953), Hutt (1967), and Thomas (1978). These hooks vary in construction, but all consist of a long, flexible shaft, to the end of which is attached a sturdy bent metal piece. The long, flexible body of the hook allows it to be inserted into the deep, curved tortoise burrow, while the bent metal piece snags onto some part of the animal (usually the shell). The tortoise may then be physically pulled up the length of the burrow

and out the mouth. Many materials have been used as the main body of the gopher hook, including garden hoses, small diameter concrete reinforcing rods, appropriately shaped lumber products, and wild grapevines. Today, however, these hooks are made almost exclusively from a large diameter (6-7 mm) "wire" that is a structural component of modern box-spring bedding units. These wires support the periphery of the upper side of the box-spring unit, and are from 5.8 to 7.1 meters long, depending on the size of the bedding unit from which they are taken. These wires perfectly satisfy the required combination of flexibility needed to follow the sometimes highly curved gopher burrow, and stiffness needed to be pushed in and worked from outside the mouth. The tip of the wire is heated and bent around to create the required hook on the end. A wooden handle is attached to the other end of the wire to provide a secure handhold for the operator. The completed hook is usually 6.1 to 7.6 meters long. When not in use, the flexibility of the wire allows it to be coiled up into a circle about one meter in diameter, which makes storage or transportation in the trunk of a car relatively easy (Figs. 1 and 2).

To "pull" the gopher from its burrow the tip of the hook is inserted into the mouth and gradually worked down until the tortoise is encountered. With experience the operator can usually discriminate between a gopher and a root, rock, or other hard object. If a tortoise is felt, the tip of the wire is maneuvered back and forth, in and out ("fished"), until it

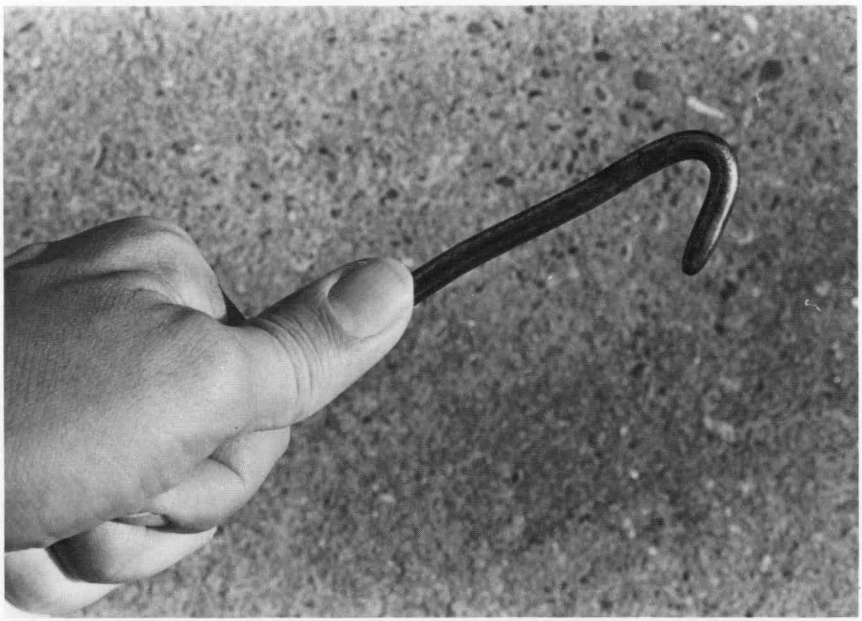

FIGURE 1. – Tip of gopher pulling hook.

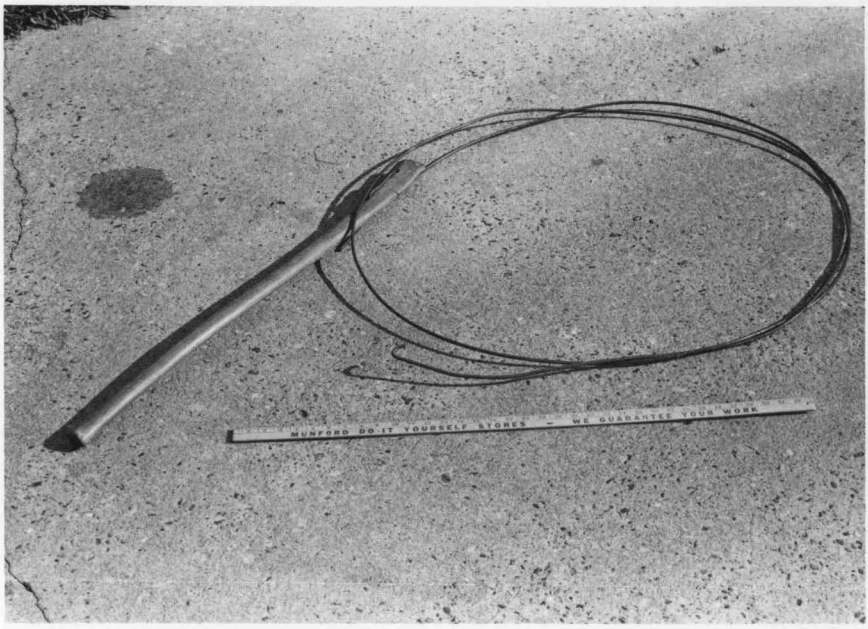

FIGURE 2. — Gopher pulling hook coiled up for transportation. Yardstick is for size comparison.

becomes hooked on some part of the gopher's body. At that point, the operator moves away from the burrow, pulling the hook from the hole, and dragging the tortoise to the surface (Fig. 3).

The holding power of a tortoise inside the burrow is considerable. Many get hooked under the rear of the carapace while they are facing downward, as they would be if they had entered the burrow and not turned around. Upon being hooked these individuals often extend their front limbs and dig into the sides of their burrow. It is not the strength of their limbs that is overcome by the constant pressure being exerted by the human at the other end of the hook, but the side walls of the burrow, which give way under such stress. Extraordinary force is often required to pull the gopher out of the burrow (Fig. 3). The strength of two men is sometimes insufficient to dislodge a tortoise from its position.

During the 32 gopher collecting trips, I observed 130 tortoises pulled from their burrows ($\bar{X}$ = 4.1 tortoises/trip). The number of captures varied greatly however, depending upon whether I was alone and therefore attempting to pull the tortoises myself ($\bar{X}$ = 1.0 tortoise/trip), or relying on the abilities of an experienced puller who was present ($\bar{X}$ = 6.0 tortoises/trip). The time invested in these 32 trips varied from about two hours to most of the day, with a typical trip requiring four to six hours.

FIGURE 3. — Local hunter pulling gopher tortoise from burrow. Note extreme force that is required.

PULLING SUCCESS RATE. — During 12 collecting trips the number of active burrows of adults in the site was either counted exactly or estimated (six trips in each case). The number of tortoises collected from these sites was then used to calculate the pulling success rate for each site. The mean pulling success rate for the six sites for which systematic burrow counts were made was 21% (29, 27, 22, 17, 17, and 13 percent). The mean pulling success rate for the six sites for which the burrow count was estimated was 20% (26, 26, 24, 17, 13, and 12 percent). The success rate as it was calculated was slightly higher than it would have been if every burrow in the area (inactive and of juveniles) had been included in the total burrow count.

The number of tortoises pulled in one area can vary widely, depending upon whether they have been hunted there before, and the time and effort a hunter is willing to expend. Failure to capture any gophers may result if few are present to begin with, the hunter is unskilled, or the burrows are too long or crooked. At the other extreme, one hunter told me, one day after the fact, that he pulled 32 in 2.5 hours. An average number would surely lie somewhere in between. By working for a few hours in an area with a good number of tortoises a skilled hunter could expect to pull 5 to 15 animals. I have seen one person take from 8 to 13 gophers on 7 separate occasions.

The legal possession limit and closed season in Florida are for the most part misunderstood or ignored by gopher hunters. When asked about the regulations governing the taking of tortoises, most individuals could not correctly cite them, (although most knew that there were regulations of some kind), even if they have been hunting the animals for many years.

LOCATION OF HOOK.—The location of the hook on the body was recorded for 106 of the 130 tortoises included in the study as each individual was pulled from the burrow (Table 1). The hook locations for the other 24 tortoises were unknown. Most of these were individuals that became separated from the hook immediately after being pulled through the burrow mouth and before the hook site could be noted. The great majority (77.4%) of individuals for which the hook location was known were pulled with the hook either under the rear of the carapace (40.6%) or at the left or right axillary notch (35.8%). No significant difference in hook location between males and females was found. Body size, however, influenced what part of the body would be hooked. Of 40 individuals classified as large (greater than 270 mm total length), 24 (60%) were hooked under the rear edge of the carapace, while not a single small tortoise (less than 240 mm total length) was captured in that way. Conversely, only 7 (17.5%) large individuals were hooked at the axillary notch, whereas this location accounted for 12 of 21 captures (57.1%) among small tortoises. Frequencies of hook locations for medium-sized animals were approximately intermediate between the other two groups. The number of captures in which the hook was not at the rear of the carapace or axillary notch was low (n = 24, 22.6% of known), and there was no obvious effect of tortoise size on captures at these locations.

HOOK DAMAGE.—Of the 130 tortoises seen pulled, 27 (21.8%) suffered some kind of damage as a result of the pulling hook. Of those injuries, 15 (55.6%) involved damage to the tortoise's shell, while the remaining 12 were less serious wounds to the skin or flesh (Table 2). Three individuals suffered damage to the shell in two (n = 2) or three (n = 1) places, but in Table 2 are counted only as one injury each.

The axillary and inguinal notches of the bridge were particularly prone to damage by the pulling hook. Although comprising only 38.7% of the known hook locations (Table 1), they accounted for 59.3% of the injuries suffered by the tortoises (Table 2). Hooking at the front of the carapace resulted in an even greater chance of injury. Only 10 individuals were pulled with the hook at the location, but there was an equal number of tortoises with injuries in that area.

The size of the tortoise greatly influenced the incidence of damage to the animal during the pulling process. Table 3 contains the number of individuals and percent of the total injured that fall into each size category. Clearly, smaller individuals experienced a substantially higher rate of in-

TABLE 1. — Locations of pulling hook for tortoises taken from burrows, by sex and body size.

Location of hook	n	% of total	% of known	Sex			Body Size			
				Male	Female	Unknown	Sm	Med	Lg	Unknown
Rear of carapace	43	33.1	40.6	17	20	6	0	12	24	7
Axillary-notch	39	30.0	36.8	16	17	6	12	15	7	5
Front legs	10	7.7	9.4	1	4	5	0	3	3	4
Front of carapace	10	7.7	9.4	2	5	3	4	2	2	2
Inguinal notch	2	1.5	1.9	2	0	0	0	2	0	0
Xiphiplastron	1	0.7	0.9	1	0	0	0	0	1	0
Flesh of tail	1	0.7	0.9	1	0	0	0	0	1	0
Unknown	24	18.5	-	6	11	7	5	7	2	10
Totals	130			46	57	27	21	41	40	28

TABLE 2. – Injuries suffered by tortoises while being pulled from burrows.

Type of injury	Location	n	% of total
Broken shell	Anterior edge of carapace	7	25.9
	Axillary notch	5	18.5
	Anterior carapace and plastron	2	7.4
	Anterior and posterior carapace, and posterior plastron	1	3.7
Punctured skin	Axillary notch	10	37.0
	Inguinal notch	1	3.7
Torn flesh	Tail	1	3.7
		27	

jury than did larger individuals. This is undoubtedly due to the much thinner and less ossified (and therefore weaker) shells of the smaller animals.

Additionally, the percentage of females injured during the pulling process was greater than that of males. Of 22 individuals injured for which the sex was known, 15 were females while only 7 were males (Table 3). When considering only severe damage (i.e. broken shell), the difference between the sexes was even more striking. Of the 15 individuals which suffered injury to the shell, 12 were females (7 small and 5 medium) while only 2 were males (1 small and 1 medium). The sex of one was unknown. This differential susceptibility to injury resulted from a difference in shell thickness (and strength) between the sexes. Identical circular plugs were cut from the shells of 36 freshly killed tortoises (16 males and 20 females) at the level of the third pleural bone, were air dried, and the scute removed. The weights of these bone plugs were compared by sex using a paired observation t-test. Fourteen pairs of observations were obtained in which the male and female value of total length differed by no more than 8 mm. The plug weights of these 14 pairs were then tested, and showed a significant difference at $P \leq 0.05$ (df = 12). This difference indicates that males have stronger shells than females and explains why the latter are injured more often during pulling.

Two additional factors influence the frequency of damage suffered by tortoises: the relative sharpness of the very tip of the gopher hook, and the length of this terminal portion. During manufacture of the apparatus most persons take care to file the end to a rounded point and not to have the bent portion too long. If either of these precautions is not taken the chance of puncturing or slicing into the shell or soft tissues is greatly increased. Also, if a root or other obstruction is encountered while pulling the tortoise from the burrow, a greater force is exerted on the animal's

TABLE 3. — Number and frequency of tortoises injured while being pulled from burrows. Both size and sex were not known for all individuals.

Category	Total pulled	No. injured	% injured
Small	21	11	52.4
Medium	41	9	22.0
Large	40	5	12.5
Female	66	15	22.7
Male	56	7	12.5

shell via the hook. This may cause the tip to puncture or tear a piece out of the shell if it is not blunt and of the proper length.

Although there is no way to determine the number precisely, some tortoises that are not successfully pulled are nonetheless injured. The tip of the hook ripping through the gopher's shell can be felt through the wire at the handle. This occurs regularly, particularly with small individuals that become hung on a root that passes through the burrow or lodged at a sharp bend. Several tortoises were observed with healed shell injuries (some quite severe) that looked as though they had been damaged by a pulling hook (Fig. 4).

SIZE AND SEX OF TORTOISES TAKEN. — An analysis of 162 butchered tortoise shells was performed to determine the sizes and relative numbers of males and females. These shells were either found in the field or were in the herpetological collection of the Florida State Museum (UF 34945, 42561, 42685, 44684-7).

First, linear regressions of total length on carapace and plastron lengths for each sex were computed for 20 male and 24 female intact tortoise shells. The resulting regression equations were used to transform carapace and plastron length measurements of butchered individuals to total lengths for purposes of uniformity. The presence or absence of the precentral and postcentral (carapace) and gular and anal (plastron) scutes greatly affected the value of a shell measurement. Therefore, regression equations were also developed for the relationship between carapace and plastron lengths (with scutes) and those same lengths with one or both of the scutes missing (Table 4). Seventeen carapaces (10 males and 7 females) and 16 plastrons (8 of each sex) were each measured in the possible conditions of: CLS — Carapace length with precentral and postcentral scutes intact; CLSB — Carapace length precentral intact and postcentral missing; CLBS — Carapace length precentral missing and postcentral intact; CLB — Carapace length with precentral and postcentral scutes missing; PLS — plastron length with gular and anal scutes intact; PLSB — plastron length with gular intact and anal missing; PLBS — plastron length with gular missing and anal intact; PLB — plastron length with gular and anal

FIGURE 4. — Old wound to carapace of gopher tortoise, probably caused by a gopher pulling hook. Although the wound went completely through the shell, it had healed and the tortoise seemed to be suffering no lasting effects from it.

scutes missing. By taking the sex of the butchered tortoise, the part of the shell being measured, and the presence or absence of the most anterior and posterior midline scutes into consideration, the total length of any individual could be predicted based on an incomplete shell. Table 5 summarizes the data on size and sex distribution of 162 butchered shells examined. Although considerably more females were found than males, the ratio was not statistically different from 1:1 at the $P \leq 0.05$ level ($\chi^2 = 3.16$, 1 df). The distribution of individuals within 20 mm size groupings was similar to the composition of naturally occurring populations in northern Florida (Alford 1980), differing only by a lack of very small individuals that are in most instances bypassed by gopher hunters. These findings indicate that human predation affects both sexes and all adult size classes to approximately the same degree.

The sex ratio of the tortoises pulled during the collecting trips was similar to that of the butchered shells. The number of females pulled was greater than the number of males (66 versus 56) but the ratio was not statistically different from 1:1 at the $P \leq 0.05$ level ($\chi^2 = 0.25$, 1 df). The sex of 8 individuals was not or could not be determined.

Although forbidden by state regulations, the sale of gopher tortoises is widespread. Not all persons who collect gophers will sell them, but the de-

TABLE 4. — Equations used to convert carapace and plastron lengths of butchered tortoises to total lengths. See text for character abbreviations.

	Conversion	P<	r	n
Females:	CLS = 0.965 × CLSB + 11.84	0.0001	0.998	7
	CLS = 0.984 × CLBS + 9.05	0.0001	0.996	7
	CLS = 0.938 × CLB + 22.61	0.0001	0.994	7
	PLS = 1.051 × PLSB − 8.15	0.0001	0.995	8
	PLS = 1.003 × PLBS + 4.52	0.0001	0.982	8
	PLS = 0.947 × PLB + 24.63	0.0001	0.978	8
	TL = 1.026 × CLS + 12.36	0.0001	0.989	24
	TL = 1.023 × PLS + 13.51	0.0001	0.983	24
Males:	CLS = 0.986 × CLSB + 5.92	0.0001	0.999	10
	CLS = 1.003 × CLBS + 3.69	0.0001	0.999	10
	CLS = 0.982 × CLB + 10.33	0.0001	0.999	10
	PLS = 0.996 × PLSB + 6.55	0.0001	0.998	8
	PLS = 0.990 × PLBS + 9.16	0.0001	0.997	8
	PLS = 0.964 × PLB + 19.97	0.0001	0.995	8
	TL = 1.061 × CLS + 3.99	0.0001	0.958	20
	TL = 0.967 × PLS + 26.30	0.0001	0.976	20

mand for the animals' flesh is sufficient to encourage many to do so. The economic reward resulting from these illegal sales will generally be proportional to the number of tortoises collected, and is related to tortoise size. Prices vary somewhat depending on the particular location of the sale (urban or rural), local supply and demand conditions, possible desire for a quick sale by the seller, and any "favors owed" by the seller. The normal range of selling prices for tortoises in the Alachua County area is: small (up to 1.8 kg) — 1 to 2 dollars; medium (1.8 to 3.2 kg) — 2 to 4 dollars; large (over 3.2 kg) — 4 to 6 dollars. Damaged individuals are avoided whenever possible, but especially by those persons who illegally sell their catch, because a disfigured or bloody animal is less desirable to potential buyers, and therefore commands a lower price.

The term "large scale predation" can be used to refer to instances in which large numbers of tortoises (up to 100 or more) are captured by one or more persons, often for the purpose of selling the animals. This may be the case with individuals who travel from an area of the state where the tortoises have been extirpated to those relatively few counties where population sizes remain fairly high. Under these circumstances it would be expected that the selling prices of the animals would be substantially higher than those quoted above. The frequency of this type of predation is difficult to determine, and the overall effect (relative to smaller scale but

TABLE 5. — Size and sex distribution of butchered shells examined.

Tortoise total length	Females	Males	Total
less than 180.0 mm	2	0	2
180.0 to 199.9 mm	3	1	4
200.0 to 219.9 mm	8	1	9
220.0 to 239.9 mm	13	7	20
240.0 to 259.9 mm	21	31	52
260.0 to 279.9 mm	19	12	31
280.0 to 299.9 mm	23	9	32
300.0 to 319.9 mm	7	4	11
greater than 319.9 mm	1	0	1
Totals	97	65	162

more widespread predation) is unknown. Trowbridge (1952) stated that "as late as the 1920's schooners would come from Cuba and gather gophers from the Naples and Marco coast and take back several hundred at a time." It is undoubtedly more difficult to obtain such large numbers of tortoises today, but reliable first-hand reports of this illegal activity are regularly heard (Walter Auffenberg, Richard Franz, and Barry Cook, pers. comm. and Anonymous 1981). In the interviews conducted during this study there were occasional reports of large groups of people going into an area and taking gophers by the hundred, and of persons who support themselves primarily through the sale of these animals. These reports should not be taken to mean that *G. polyphemus* is still plentiful or that its protection is unwarranted. Skillful hunters who have sufficient time and knowledge of good hunting areas will continue to be able to take rather large numbers of gophers, even if the total numbers of the species continue to fall drastically. As long as hunting of the animals remains legal, and the demand for their flesh remains high, this type of predation may be expected to continue in those few areas where the tortoises are available.

Regardless of whether a pulled tortoise is sold or not, its fate is the same. The butchering process is a very standardized procedure, with only occasional variations being reported. First, with the live tortoise turned over onto its carapace, the plastron is removed by breaking the bridge with a hammer or ax and cutting the attached muscles with a long knife. Once the gopher is thus opened, the desired portions are removed (limbs, pectoral and pelvic girdles, liver and sometimes the heart, stomach muscular mucosa, and neck muscles). Shelled eggs that may be found are also eaten.

Results of interviews and the examination of discarded butchered shells indicate that some persons make the job of cleaning the gopher somewhat easier by smashing the carapace with the hammer or ax at the

point of attachment of the pectoral and pelvic girdles. One informant reported that he was able to remove the edible portions of a tortoise without separating the plastron from the rest of the body. He claimed to clean gophers regularly using only a knife and by extracting the contents of their shells through the anterior and posterior openings, leaving the shells intact. As was indicated above, most hunters do not kill the animals before cleaning them.

The flesh of the gopher tortoise tends to be tough and chewy unless well-cooked. The most common methods of preparation are either as a stew, or by browning over high heat, then covering and simmering slowly. Sometimes the flesh that remains attached to the plastron after butchering is salvaged by baking the entire plastron in the oven and then eating the cooked meat off the shell. Published recipes incorporating tortoise flesh are found in Trowbridge (1952) and Hutt (1967). Probably the most widely distributed recipe utilizing the meat of the gopher is for "Minorcan Gopher Stew" presented by Rawlings (1942).

References to the use of the tortoise's shell for ornamentation or other purposes were uncommon in interviews of this study. Although shells may be occasionally used as flower planters, door stops, or other decorative purposes, the vast majority are discarded. The bowl-like shape of the shell may have previously led to its use for other purposes to a much greater extent during Pre-Columbian times.

During this study, 36 tortoises were dissected during a 12 month period (May 1979 to April 1980). Measurements of the edible portions of the tortoises were made in two ways. First, all the edible tissues were removed from the shell in a manner similar to which they would have been if the animal had been butchered by a local hunter. The front and hind limbs, liver, muscular layer of the stomach, heart, neck retractor muscles, and incidental pieces of flesh were all weighed to the nearest gram. Each of these portions was removed carefully, and therefore probably was subjected to less waste than would be the case if the tortoise was being cleaned by a hunter using a hammer and butcher knife. As a result, these measurements would represent the maximum amount of meat that could be recovered. All 36 tortoises were dissected and measured in this way. A second procedure was to remove completely all flesh from the front and hind limbs (and their associated girdles) of seven of the individuals. This allowed a determination to be made of the skeletal muscle mass of each limb (total weight minus bones and other non-edible tissue). Using these measurements would obviously result in a lower mean value for the "edible percentage" of each tortoise than would using the weights for the entire limb and girdle. For the 36 tortoises dissected in the first manner, the mean edible percentage of initial live weight was 34.5% (range: 28.0% to 41.3%). Considering only the seven individuals for which the flesh was stripped from the appendicular skeleton and then

only the skeletal muscle was included with the other edible tissues, the mean edible percentage dropped to 20.6% (range: 16.9% to 24.0%). When including the entire limbs and girdles in the calculations rather than only the edible flesh of those units, the total edible percentage increased by an average of 43.0%. This was due to the overwhelming contribution made to the edible portion of each animal by its appendicular skeleton. Of the total edible weight of the 36 tortoises dissected by the first method, an average of 83.3% of that weight (range: 80.7% to 90.2%) was made up of the limbs and girdles.

The calculation of mean edible percentage based on dissection by the first method (34.5%) included some tissue that certainly would not have been eaten. The mean obtained by the second method (20.6%), however, is too conservative since a small amount of tissue other than the skeletal muscle of the limbs was not included but could have been eaten. A realistic value of the edible portion of a typical tortoise would lie somewhere between those two values, probably about 25 percent of the animal's live weight. However, due to differences in cleaning techniques and waste during butchering, most hunters do not realize this maximum yield. An edible value of 25% for the gopher tortoise compares to a mean of about 50% for many other wild animal species (data from Zooarchaeology Lab, Florida State Museum). The dressing percentages of commercially reared cattle, sheep, and hogs average 60, 49.5, and 58 percent respectively (Ensminger 1977).

The initial weight of the tortoise determines the percentage that is edible, but that percentage is not the same for all size classes (Fig. 5). The regression equation for the relationship between total edible percentage and live weight ($\gamma = -1.85 \times 10^{-5} X + 0.396$; $P \leq 0.0101$, $r = 0.423$, $n = 36$) shows that as tortoise size increases the relative amount of edible tissue decreases. This relationship can also be shown by dividing the 36 dissected tortoises into 3 groups, based on their live weights, and calculating the mean edible percentage for the individuals in each of the size categories. The 12 individuals with the smallest live weights had a mean edible percentage of 36.1%, the 12 medium-sized individuals averaged 34.2%, and the 12 largest individuals had a mean of only 33.1%. After performing an arcsin transformation of the percent data, the values of the three groups were compared using student's t-test. The smallest individuals (group A) were tested against the medium- (group B) and large-sized (group C) classes. Group B was also tested against group C. The A-B and B-C tests were not significant, but the A-C comparison was significant at $P \leq 0.05$. It was concluded that gopher tortoises provide relatively less edible tissue as their size increases. The dissected animals ranged in weight from 1233 to 4654 grams. Time of year and sex of the tortoise had no significant effect on total edible percentage. Shelled eggs

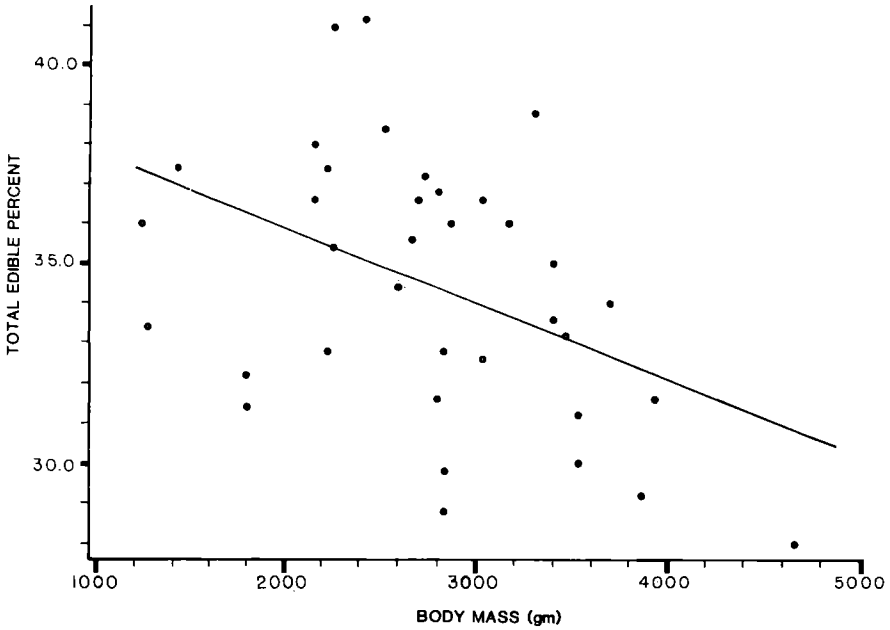

FIGURE 5. — Relationship between body mass and total edible percent for 36 gopher tortoises. Regression equation: $\gamma = -1.85 \times 10^{-5} X + 0.396$; $r = 0.423$; $P \leq 0.0101$.

would slightly increase the edible percentage of those females that possessed them, but they were not included in the calculations.

DISCUSSION

CHANGES IN POPULATION SIZE

The number of gopher tortoises has declined dramatically throughout the species' range in recent years (Auffenberg and Franz in press). This decline in numbers has been primarily the result of man's destruction of prime tortoise habitat through urbanization and agriculture and the exploitation of the species for its edible flesh. (Auffenberg 1969).

It would be difficult to determine whether human development of former tortoise habitat or outright predation on the animals has had the greater effect in reducing the total numbers of *Gopherus polyphemus*. However, the effect of these two factors upon individual populations can be assessed. The construction of large scale housing developments and the conversion of natural areas into intensively cultivated farmland reduce local tortoise populations to near zero. The chance of an affected tortoise

colony recovering in these places is nonexistent. An episode of "gopher pulling" on the other hand results in only a minority of the individuals being removed from a population (about 20% of the larger tortoises based on this study).

Repeated attempts by the same or different individuals to catch tortoises from a single population would be likely to cause the success rate to decrease even more with each successive episode, due to the likelihood that remaining individuals would be harder to capture (more crooked burrows, more difficult locations, etc.). Replacement of the removed individuals through reproduction could still occur as long as a sufficient number of adults are left behind, and small individuals would tend not to be removed at all. This is not to say that intensive predation pressure could not reduce a population's size to a point from which it could not recover, but it does mean that exploitation of a colony as a human food source is not necessarily the death knell for that colony.

The important unknown when trying to assess the impact of human predation is the minimum number of individuals necessary to sustain a colony. Auffenberg and Iverson (1979), Iverson (1980), and Alford (1980) presented data that define *Gopherus polyphemus* as a slow-growing species, the females of which produce a mean of only five eggs per year, and which suffers a high level of mortality during the egg and hatchling stage. Populations of such a species might be particularly affected by a rapid, drastic reduction in size (as would follow intense human predation) resulting in reproductive failure during ensuing years. If a colony's size is reduced below a critical level, that population will be doomed to extinction even though not all individuals were removed by man. Reports have been published by Auffenberg (1966) on the gopher's courtship behavior, by Rose (1970) and Rose et al. (1969) on the species' integumentary chin glands and their role in behavior, by Weaver (1970) on its courtship and combat behavior, and by Douglass (1976) on its mating system, but very little other information about the reproductive physiology and detailed behavior of male and female gopher tortoises is available. Until more is known of the social organization of their colonies and the roles played by intra- and intersexual encounters prior to and during the reproductive period, population sizes should be maintained at normal levels, and therefore a conservative policy regarding the taking of tortoises should be followed.

Bases of Human Predation

Three reasons can be advanced to explain why humans prey upon the gopher tortoise. Any one person may get involved for any or all of these factors.

SUBSISTENCE. — The basic cause of human predation (and the only one that could be justified) is to provide food, especially for rural and economically disadvantaged persons. The names "cracker chicken" (Alberson 1953), "Florida chicken" and "Georgia bacon" (Carr 1952), and "Hoover chicken" (Hutt 1967) allude to the role played by the flesh of the gopher tortoise during the past. In previous years, when tortoises were more abundant and people less numerous, a rural resident living in suitable habitat could probably make periodic use of the surrounding gopher population as a food source for himself and his family and not seriously threaten its existence. Today however, urbanization and agriculture have eliminated a large portion of the tortoise resource, so that predation pressure has gradually become concentrated in fewer locations. As a result, even subsistence hunting can today exert severe pressure on the remaining colonies. Additionally, the economic cost of the flesh obtained is increasing dramatically when the costs of transportation and fuel are included, since localities with suitable tortoise populations are becoming less common and more distant from human population centers. If present trends continue, human predation will effectively eliminate the gopher tortoise from more and more localities, while at the same time the increasing costs of finding and capturing the animals makes their flesh so expensive as to defeat the purpose of subsistence hunting.

ECONOMIC GAIN. — Some persons hunt gopher tortoises primarily as a source of cash. This practice is forbidden by state game management regulations, but my experience indicates that most people are not aware of this prohibition or simply choose to ignore it because the possibility of being penalized is extremely remote. The economic gain that can be realized by a hard working (although criminal) individual is impressive. A person with access to a healthy gopher population may be able to pull as many as 10 to 20 tortoises on a good day. Depending upon their size, these tortoises may sell for an average of perhaps 4 dollars, or up to 80 dollars total. Even after deducting expenses, a handsome profit has been made. This financial reward is a powerful incentive for human predation to continue as long as suitable tortoise colonies can be found.

The buyer, on the other hand, ends up with very expensive table fare. A tortoise weighing 8 pounds would cost about 5 dollars. Since a maximum of about 25% of the live weight of the animal is edible flesh, this tortoise would provide up to 2 pounds of meat that costs $2.50 or more per pound. From an economic point of view, anyone who buys gopher tortoises would be better off buying less expensive cuts of beef, poultry, or pork in the supermarket.

CULTURE / PERSONAL ENJOYMENT. — Among many groups of people (particularly rural and black) there is the historical and cultural use of the gopher tortoise as a food source that must be considered. Many persons

who would never consider going out to the "gopher woods" themselves will readily purchase the animals from someone willing to collect them, and will pay a premium price. They will do so because the gopher tortoise has been a traditional part of their diet for many years, and was in many instances regularly included in the meals they ate when they were younger. Although the cost may be comparable to a T-bone steak, many persons willingly pay it because they would rather have a gopher stew than a T-bone steak. The occasional purchase of a few gophers is an extravagance that is readily indulged in by a large number of persons.

Some people also believe that the flesh of the gopher tortoise is an aphrodisiac or general aid to health. Some of those who do not ordinarily eat the turtle will make a special effort to obtain some during periods of sickness. The prominent role played by the gopher tortoise in the culture of certain groups of people will make its successful management by the state game agency all the more difficult.

A related factor that results in a certain amount of human predation is simply that people like to catch them. Just as with other types of hunting or fishing, the activity may not be economically justifiable, and the amount of food resulting from it may be meager, but the practice still flourishes because many persons enjoy getting outdoors and stalking wildlife. This desire alone is enough to result in a certain amount of "recreational" gopher pulling, and may be a contributing factor when other motivations (food and money) are of primary importance.

SUMMARY AND CONCLUSIONS

The use of the gopher tortoise as a meat source in the diets of persons in North-Central Florida is widespread. Such use is intimately tied to the social customs of those individuals involved. Many persons who utilize gophers do so only occasionally as the result of a chance capture or seeing one offered for sale by another individual who has "pulled" a number of them. An unknown but relatively large number of persons, however, regularly hunt the animals. The captured tortoises are either eaten by the hunters or are sold to someone else, although such sales are expressly forbidden by state game regulations. The cultural background involving the use of the gopher tortoise as food outweighs the fact that tortoise flesh is much more expensive than many types of domestic meat.

The long-term effects of human predation pressure on gopher tortoise colonies are unknown. Unlike urbanization or agricultural practices, predation does not remove every individual from the population, but will result in a variable number of individuals (especially the smaller ones) remaining as a possible future source of population replenishment. It is not known, however, what effect the removal of a large percentage of the individuals from a colony has on the future viability of that colony,

especially since large (sexually mature) individuals are selectively taken. Based on recent history, however, human predation seems to be having a dramatic deleterious effect upon the overall numbers of tortoises found in North-Central Florida.

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