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SEASONAL VARIATIONS IN THE ABUNDANCE OF TESTUDINE SPECIES HARVESTED AND SOLD IN SELECTED MARKETS IN BAYELSA AND DELTA STATES, NIGERIA

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Abstract
This study examined the seasonal variations in the abundance of testudine species sold in selected markets in Bayelsa and Delta states. Data were collected through field survey, personal observation and in-depth interview with hunters, fishermen and marketers in selected markets where testudine species are sold in the study area for two years. A total of 51 respondents were sampled. Data collected were analyzed using descriptive statistics, T-test, One-way ANOVA, Simpson and Shannon-wiener diversity indices. Four testudine species (Pelusios niger, Pelusios castaneus, Kinixys homeana and Kinixys erosa) observed were identified and recorded. Among the four species Pelusios niger was the most abundant testudine species captured and sold in dry and wet seasons in all the study sites. Markets in Aven are rich in testudine species with a relative abundance of 36.81 % and 39.85% in dry season and wet season respectively for 2022, and 35.24 % in dry season of 2023. In the wet season of 2023, Egiegie is richer with a relative abundance of 36.67%. Seasonal variation in the quantity of testudine species harvested and sold in the study area shows that there is significant difference ($p < 0.05$) in species population between dry and wet season in 2023. Variation in species population on annual basis shows that there was significant difference ($p< 0.05$) among the population of the four species in 2022. In 2023, there was no significant difference ($p > 0.05$) between Pelusios niger and Pelusios castenus. Across locations (Zarama, Aven and Egiegie markets), there was significant difference between Pelusios niger, Kinixys homeana and Kinixys erosa ($p < 0.05$). There was no significant difference ($p > 0.05$) within the species in the study locations. Pelusios niger has the highest population mean in Aven (109.75±66.71), Egiegie (103.75±78.51) and Zarama (83.50±46.08). The observed quantity of testudine species harvested and sold in the study area shows the level of uncontrolled exploitation of testudine species from the wild. Intensifying the pressure from commercialization and unfavourable seasonal variations in climatic factors will lead to local extinction of testudine species in the study area.
Keywords: seasonal variation, testudine, Zarama, Aven, Egiegie

Introduction

Testudine is an order in the class of reptilian which comprises of turtles, tortoise and terrapin (Turtle Taxonomy Working Group, TTWG, 2017). Testudine species are not poisonous in nature unlike other category of reptiles that are harmful (Pough *et al.,* 1998). These species are of economic importance to man as products from these species can satisfy some of the basic needs of man such as protein supply, health care delivery and source of livelihood. These characteristics among others make testudines to be widely accepted for decades by all social class around the world especially in area where these species are diverse, abundant and way of utilization is known. The diversity and abundance of testudine species in an area differs base on location (Oruh *et al*., 2023); and this in most cases is reflected in the quantity of testudine species sold in roadside and bush markets (Ijeomah and Oruh, 2012). In Niger delta region, Studies (Luiselli 2003b; Luiselli and Diagne, 2014; Ohimain *et al*., 2014) have shown that the population status of some testudine species is declining. According to Rhodin *et al*., (2018), this reduction is as a result of over exploitation and habitat loss which are the major threat to the survival of testudine species.
Although Testudine species have unique body features, lifestyle and are considered to have the longest lifespan among other wildlife species in the world (Pough *et al*., 2009), testudines are slow in behaviour and growth as it takes several years for the species to be sexually mature (for reproduction to take place). In most cases, testudine species experience reduction in population growth, as not all hatchlings survived to sub adults (Pough *et al*., 2009). According to Heppell *et al*., (1996) a population of testudine species can take almost a decade to recover from a significant mortality event and over exploitation or the population will decline (Moll and Moll, 2004). Populations of testudine species are susceptible to mortality at every stage of their life. Changes in the population of testudine species whether through mortality, exploitation, habitat loss and migration can be influenced by human developmental activities, pollution, accidental capture or bi-catch and change in season or climatic condition in an area which can

result in flooding, increase in temperature and rise in sea level. Seasonal variations can affect the population of testudine species in an area either positively or negatively. According to Luiselli, (2003a), variations in dry and wet seasons also affect the activity pattern and food habits of testudine species especially Kinixys species.

Survey on the population of tortoise and sea turtle has been studied comprehensively at both local and international levels (Davis, 2005; Godfrey and Godley, 2008), and to some extent in some parts of Nigeria like in Brass in Bayelsa and Andoni in River states of Niger delta region (Akani and Luiselli, 2009), Seasonal variation in species population, abundance and diversity of testudines species harvested and sold are yet to be addressed in Zarama in Bayelsa state, Aven and Egiegie in Delta state despite the fact that these areas are riverine areas which are rich in mangrove and wildlife species that can respond to periodic changes in season. Studying the population of testudine species sold on high ways and bush markets in the study area at different season can give an insight on the seasonal variation in population of testudine species in the study area. This study therefore, identifies the testudine species; determine the species abundance, diversity and seasonal variations in the population of the species in the study area.

Methodology

Study Area

The study was carried out in Bayelsa and Delta states (Figure 1). Bayelsa state is located in the southern part of Nigeria which lies between longitude 6º 04 and 60º 00 East and latitude 4º 44 and 59º 99 North. According to Bekewuru and Agbai (2021), about three quarters of Bayelsa State total area is surrounded by water. The vegetation in the state is made up of mangrove and lowland rainforests. The main occupation of the indigenous people are fishing, hunting, farming and trade in seafood and bush meat.

Delta state which is an oil and agricultural producing state is also located in southern part of Nigeria. It lies between longitude 5º00' and 6º45' East and latitude 5º00' and 6º30' North (Ofuoku, 2012). It has a population of 5,663,362 and covers an area of 16,698km^2 (NPC, 2006). Delta state is blessed with mangrove forest, freshwater swamp forest and lowland rain forest types which is home to testudine species, bird's species, primates, amphibians, reptiles and mammals.

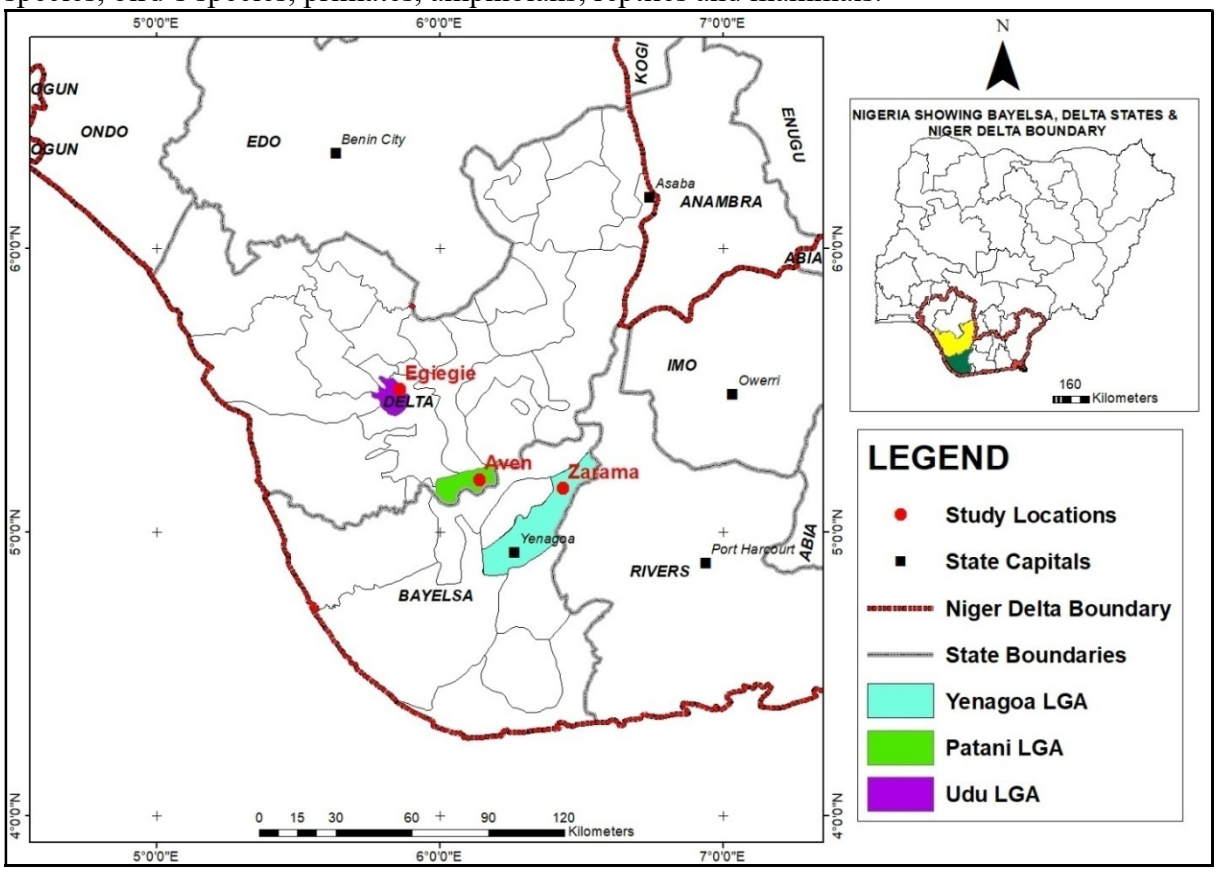

Fig 1: Map of Niger Delta States Showing the Study Area.

Sampling techniques

The study areas were purposively selected and stratified into areas with the presence of testudine species in roadside markets and bush market. On this basis, suppliers (hunter and fishermen) and marketers

associated with supplying and selling testudines in three communities such as Zarama in Yenagoa Local Government Area in Bayelsa State, Aven and Egiegi communities in Patani and Udu Local Government Areas, Delta State, were sampled. Through the market union, all the suppliers and marketers in the study area were counted. In all, a total population of fifty-one (51) respondents which comprises of twenty-one (21) suppliers and thirty (30) marketers were sampled in the study area.

Data Collection

Data for the study were acquired through field survey, observation, and in-depth interview. The field survey was carried out every two weeks in each month during wet (May to October) and dry (Nov to April) season for the period of two years. Data were acquired from hunters at the landing site, fishermen at the fishing settlement and traders in roadside and bush markets on the type and quantity of testudine species captured and sold in dry and wet season. The testudine species observed were identified using identification keys by Ernst and Barbour (1986). Individual testudine species were physically counted and recorded. During the field survey, a total of two thousand four hundred and ninety-nine (2,499) individual testudine species which comprises of four testudine species (*Pelusios niger, Pelusios castaneus, Kinixys homeana and Kinixys erosa*) were recorded. Observations and in-depth interviews were conducted with the suppliers and marketers who have been capturing and selling testudine species in the study area for a minimum period of five years and therefore are knowledgeable about the seasonal variation in the population of testudine species captured and sold in the study area.

Data Analysis

Data collected were analyzed using descriptive statistics (tables, frequency, charts and percentage), while T-test was used to compare the variation in population in terms of season and year. One-way analysis of variance (ANOVA) was used to compare the variation in the population of testudine species in terms of locations.

T-test was calculated using the formula

$$t = \frac{\bar{x}_1 - \bar{x}_2}{\sqrt{s^2\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}}$$

$$s^2 = \frac{\sum_{i=1}^{n_1}(x_i - \bar{x}_1)^2 + \sum_{j=1}^{n_2}(x_j - \bar{x}_2)^2}{n_1 + n_2 - 2}$$

Where:

x_1 and x_2 = sample means,

s^2 = pooled sample variance

n_1 and n_2 = sample sizes

$n_1 + n_2 - 2$ = degrees of freedom.

One-way Analysis of variance (ANOVA)

$$F = \frac{MST}{MSE}$$

$$MST = \frac{\sum_{i=1}^{k}\left(T_i^2/n_i\right) - G^2/n}{k-1}$$

$$MSE = \frac{\sum_{i=1}^{k}\sum_{j=1}^{n_i} Y_{ij}^2 - \sum_{i=1}^{k}\left(T_i^2/n_i\right)}{n-k}$$

where:

F = variance ratio for the overall test

MST = mean square due to groups (between groups)

MSE = mean square due to error (within groups, residual mean square)

Y_{ij} = observation

T_i = group total

G = grand total of all observations

n_i = number in group

i and n = total number of observations.

The relative abundance of the species in the study area was calculated using the formula: species Abundance /total abundance x 100

For species diversity, Simpson and Shannon-wiener diversity indices were used.

Simpsons diversity index (D)

$$=\frac{\sum_{i=1}^{q} ni\,(ni-1)}{N(N-1)}$$

Where: ni = (the no of individuals in the i^{th} species of the testudines

N= the total no of individuals encountered

q = no of different species enumerated.

Shannon-weiner diversity index (H)

$$=\sum_{i=1}^{s} pi-1npi$$

Where: pi – the proportion of individuals in the ith species of testudines

S = total no of testudines species

Result

Species Abundance, Diversity and Variation in Population of Testudine Species Captured and Sold in The Study Area

Results on species abundance, diversity and variation in population of testudine species harvested and sold in the study area are presented in table 1 to 4. Observed testudine species that were captured and sold in dry and wet season in two years are *Pelusios niger, Pelusios castaneus, Kinixys homeana and Kinixys erosa.* Markets in Aven are rich in testudine species with a relative abundance of 36.81 % and 39.85% in dry season and wet season respectively for 2022 and 35.24 % in dry season of 2023. While in wet season 2023, Egiegie is richer with a relative abundance of 36.67% (table 1). This shows that testudine species with thriving markets is more in Aven and Egiegie communities in the study area.

As presented in table 2, variation in population among species in different season (dry and wet) in each year show that there was no significant difference ($p > 0.05$) in the population of all the four species during the dry season of 2022. In the wet season of 2022, there was no significant difference ($p > 0.05$) between *Pelusios niger* and *Pelusios castaneus* (fresh water species). Also, between *Kinixys homeana* and *Kinixys erosa* (Land tortoise), there was no significant difference ($p > 0.05$) (table 2). In the dry season of 2023, there was significant difference between *Pelusios niger* and *Pelusios castaneus* ($p < 0.05$) with *Pelusios niger* recording a high significant number (45.33±7.37) of individuals than *Pelusios castaneus* (32.67±3.06) while between Kinixys *homeana* and *Kinixys erosa* there was no significant difference ($p > 0.05$).

Generally, there was significant different among the species population in the dry season for 2023 ($p < 0.05$). In the wet season in 2023, there was no significant difference between *Pelusios niger* and *Pelusios castenus.* Also, between *Kinixys homeana* and *Kinixys erosa,* there was no significant difference ($p > 0.05$). Among the species population in the wet season, there was significant difference at $p < 0.05$ level of significant. In 2022, there was no significant difference in the population of *Pelusios species (Pelusios niger and Pelusios castaneus)* between dry and wet season. For the population of Kinixys species (*Kinixys homeana* and *Kinixys erosa*), there was significant difference ($p < 0,05$) between dry and wet season with more population of *Kinixys homeana* (42.67± 8.96) and *Kinixys erosa* (30.67± 3.06) in the dry season than the population of *Kinixys homeana* (23.00 ± 11.36) and *Kinixys erosa* (10.67±6.35) in the wet season.

This indicates that Kinixys species were accessible during the dry season in 2022. This could be as a result of the incidence of flood that occurred in 2022 as kinixys species uses flood to float out of its hiding place. In 2023, for the population of *Pelusios niger*, there was no significant difference between the dry and wet season. The population of *Pelusios castaneus, Kinixys homeana* and *Kinixys erosa* showed a significant difference ($p < 0,05$) between dry and wet season in 2023 with a high population of *Pelusios castaneus* (119.00±26.89), in wet season than 32.67±3.06 in dry season. On the other hand, there was a high population of *Kinixys homeana* (15.67±5.51) and *Kinixys erosa* (11.33±0.58) in the dry season than the wet season which had a low population of *Kinixys homeana* (12.00±2.65) and *Kinixys erosa* (10.00±2.00). High population of Kinixys species in the dry season may be as a result of the extra hunting activities, searching for these species in burrows, under trees, nesting beaches, holes in dried

swamp and in area where these species are considered as sacred species. In all the testudine species sold in the study area, *Pelusios niger* was abundant in both seasons especially in the wet season of the studied years. This implies that the *Pelusios niger* comes out and is active during the wet season. This is probably to source for food, breeding and nesting activities. This makes the species to be accessible by hunters and readily available in bush and roadside markets.

From table 3, variation in species population on annual basis show that there was significant difference ($p< 0,05$) among the population of the four species in 2022. In 2023, there was no significant difference ($p > 0.05$) between *Pelusios niger* and *Pelusios castenus.* Similarly, there was no significant difference ($p > 0.05$) between *Kinixys homeana* and *Kinixys erosa.* Among the population of Pelusios species and Kinixys species there was significant difference at $p< 0.05$ level of significance in 2023 with a high population record for *Pelusios niger* (104.00±70.90) and *Pelusios castaneus* (75.83±50.29) than that of 2022 which had a population record of *Pelusios niger* (94.00±53.47) and *Pelusios castaneus* (64.67±42.07). This shows that the population of testudine species sold in 2023 increased more than the population of testudine species in 2022. Probably, this could be because of more effort made by the hunters in harnessing testudines to meet up with the high demand for testudine species in the markets in 2023 in the study area.

As presented in figure 2, seasonal population variations of testudine species harvested and sold in the study area shows that there is no significant difference ($p > 0.05$) in the species population between the dry and wet season of 2022. In 2023, there is significant difference ($p < 0.05$) in species population between dry and wet season. This implies that in the wet season of 2023, there was more species sold in the study area.

From table 4, the variation in the population of species within and across locations in the study area shows that across locations (Zarama, Aven and Egiegie communities), there was significant difference between *Pelusios niger*, *Kinixys homeana* and *Kinixys erosa* ($p < 0.05$). Within the species in the locations in the study area, there was no significant difference ($p > 0.05$). *Pelusios niger* has the highest population mean in Aven (109.75±66.71), Egiegie (103.75±78.51) and Zarama (83.50±46.08). This implies that *Pelusios niger* was mostly sold compare to the other species sold in all locations in the study area. This is probably because *Pelusios niger* is the most preferred testudines in the study area.

Discussion

The prevalence of testudine species in bush and roadside markets gives an insight on the abundance of testudines in the wild. Four testudine species observed in the study area were *Pelusios niger, Pelusios castaneus, Kinixys homeana* and *Kinixys erosa*. These species were more abundant in the markets in Aven, Delta State where the species are displayed for sale in both dry and wet season in 2 years. This is consistent with the report of previous studies (Luiselli, 2003b; Ohimain *et al*., 2014; Oruh *et al*., 2023) that Delta State is the centre of trade in testudine species in southern Nigeria. The markets for testudine species in Aven are mostly along highways, which makes it possible for travellers and consumers of testudine species to easily buy testudine species. This is the reason why many testudine species are brought to the market in Aven for sale.

Population of testudine species sold in the study area changes with season and year. In the wet season, the quantity of testudine species observed was high compared to the dry season. This implies that wet season influences the increase in the population of species in the wild which lead to the availability of more species captured and sold. Increase in the population of *Pelusios niger* and *Pelusios castaneus* in the wet season, was probably as a result of availability of water which supports the growth of vegetation and restore habitat thereby providing food and shelter for insects, snails and crustaceans that are eaten by testudine species. The wet season must have also increased the breeding and hatching rates of the species leading to increase in the number of the animals in the wild. This agrees with the report of Luiselli, (2003a), that wet season has a positive effect on the activity pattern and food habits of testudine species in the wild. This increase in the wild could probably influence high level of by-catch in the course of fishing, in addition to the usual hunting of testudines.

In 2022 the population of *Pelusios niger* and *Pelusios castaneus* in the wet season was low compared to the wet season of 2023. The decrease in the population could be as a result of the incidence of flood experienced in 2022, which destroyed habitats, washed away nesting sites of the species and displaced the testudines. In the dry seasons for the two years, there was a decrease in the population of *Pelusios niger*

and *Pelusios castaneus* sold in the study area indicating that the species were scarce in the wild. This could be as a result of human activities, flood and the nature of the species. As a way of survival during dry season, these species while inhabiting swamps, creeks and rivers hide between aquatic plants, thus become inaccessible. Interview with suppliers (hunters and fishermen) revealed that to access and capture these species during dry season, one has to go the extra mile of searching between aquatic plants in marshes and swampy areas. This is similar with the findings of Luiselli *et al*., (2018), that hunters are able to capture turtles during dry season by using a machete or a simple piece of wood to probe aquatic plants in swamps.

Kinixys homeana and *Kinixys erosa* were among the testudine species captured and sold in the study area in dry and wet season in 2022 and 2023. Statistically, in the dry and wet season, there was no significant difference among the population of *Kinixys homeana* and *Kinixys erosa* sold in the study area. This shows that the population of *Kinixys homeana* and *Kinixys erosa* is not influenced by season. The population of Kinixys species captured and sold in dry and wet season was low. This is because *Kinixys homeana* and *Kinixys erosa* were scarce and were mostly sold by few marketers in the study area. This agrees with Luiselli *et al.,* (2013) that *Kinixys species* have nearly disappeared from the bush meat trade in nine markets of southern Nigeria, thus possibly indicating commercial extinction of wild populations at the local level. Interviews with the suppliers of testudine species in the study area revealed that *Kinixys species* are hard to find. This implies that the populations of *Kinixys species* are being threatened. This is not unconnected with the high rate of hunting for subsistence and trade in the study area.

Species population comparison by year of survey shows that in 2022, there was significant difference among the species population ($p< 0.05$) unlike in 2023, where there was no significant difference in the study area. The significant difference in 2022 could be as a result of the flood incidence which affected the population of species harvested and sold in the study area. Interviews with suppliers revealed that during the floods people encroached into nesting sites to search the nest and capture adults and eggs of *Pelusios species* in muddy burrows at the beach. This is in conformity with the report of Akani *et al.,* (2015) that every year, during flood season, people who know how to identify the nests of *Pelusios species* go along the shore to search and collect the eggs and adults of *Pelusios species*. Also, the population of *Kinixys homeana* and *Kinixys erosa* was high in 2022 compared to the population of Kinixys species sold in 2023 even as the Kinixys species is scarce. This increase in the population of Kinixys species sold in the year 2022 (a year with incidence of flood) could also be related to the way Kinixys species moves. Interview with hunters and fishermen reveal that Kinixys species uses floods as a way to disperses by floating, as a result during flood incidence people in the study area use the opportunity to benefit from this pattern of movement to access and capture Kinixys species. This is similar to the report of Luiselli *et al*., (2016), that people in areas with incidence of seasonal flooding take advantage of the movement of Kinixys species to capture the species.

Among the four testudine species sold in the study area, *Pelusios niger* statistically was significantly higher and it is the species that is mostly sold within and across the locations in the study area. This is because *Pelusios niger* is popular amongst the people and was seen in all the markets in the study area. This agrees with the reports of Luiselli *et al*., (2013); Akani *et al*., (2015); Lea *et al.,* (2003) that *Pelusios niger* is widespread and locally abundant in southern regions, inside the continuous rainforest vegetation zone, where it inhabits rivers, creeks, and permanent ponds surrounded by swamp forest and gallery forest. In the Niger Delta region, *Pelusios niger* is common in most of the perennial water bodies despite heavy hunting with fishing traps (Akani *et al.,* 2015).

Conclusion

Pelusios niger, *Pelusios castaneus, Kinixys homeana* and *Kinixys erosa* are the different types of testudine species observed in the study area. However, *Pelusios niger* is more abundant than other testudine species observed in all the markets visited in the study area. Variations in the season at different years affect level of abundance of testudine species available in these markets which is either increases or decreases as the season and year changes depending on the kind of species. Roadside markets on highways in Aven, Delta State are consistent with regular availability of testudine species especially the *Pelusios niger* at both dry and wet season. The observed quantity of testudine species harvested and sold in the study area shows the level of uncontrolled exploitation of testudine species from the wild. Seasonal changes in climatic condition which results in flooding in addition to human developmental activities like

land reclamation, dredging, oil and gas exploration and exploitation, waste accumulation, bush burning and deforestation can have negative implication on the survival and sustainability of viable population of testudine species in the future in the study area. Presently the quantity of Kinixys species available in the market is low which indicates that kinixys species is scarce. Intensifying the pressure from commercialization and unfavourable seasonal variations in climatic factors will lead to local extinction of testudine species in the study area.

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Table 1: Species of Testudines found in the Study at Different Seasons

Species	**Dry Season**			**Wet Season**		
	Zarama	**Aven**	**Egiegie**	**Zarama**	**Aven**	**Egiegie**
2022						
Pelusios niger	51	57	41	127	177	111
Pelusios castaneus	34	44	23	52	118	117
Kinixys homeana	37	38	53	36	18	15
Kinixys erosa	28	34	30	18	7	7
Species Abundance	150	173	147	233	320	250
Rel. Abundance (%)	31.91	36.81	31.28	29.02	39.85	31.13
Simpsons (1-D)	0.737	0.740	0.726	0.623	0.554	0.579
Shannon	1.965	1.972	1.931	1.662	1.357	1.421
2023						
Pelusios niger	37	48	51	119	157	212
Pelusios castaneus	32	36	30	102	150	105
Kinixys homeana	21	16	10	13	14	9
Kinixys erosa	11	11	12	12	10	8
Species Abundance	101	111	103	246	331	334
Rel. Abundance (%)	32.06	35.24	32.70	27.00	36.33	36.67
Simpsons (1-D)	0.710	0.677	0.647	0.589	0.567	0.497
Shannon	1.876	1.783	1.708	1.470	1.373	1.211

Table 2: Variations of Population among Species at Various Seasons in each Year

Species	Population (Mean±SD)	
	Dry Season	**Wet Season**
2022		
Pelusios niger	49.67±8.08[a]	138.33±34.43[a]
Pelusios castaneus	33.67±10.5[a]	95.67±37.82[a]
Kinixys homeana	42.67±8.96[a]	23.00±11.36[b]
Kinixys erosa	30.67±3.06[a]	10.67±6.35[b]
2023		
Pelusios niger	45.33±7.37[a]	162.67±46.76[a]
Pelusios castaneus	32.67±3.06[b]	119.00±26.89[a]
Kinixys homeana	15.67±5.51[c]	12.00±2.65[b]
Kinixys erosa	11.33±0.58[c]	10.00±2.00[b]

Species Population Means with same alphabet are not significantly different at $p<0.05$

Table 3: Species Population Comparison by Year of Survey

Species	Population (Mean±SD)		
	2022	**2023**	**Mean**
Pelusios niger	94.00±53.47[a]	104.00±70.90[a]	99.00±60.10[a]
Pelusios castaneus	64.67±42.07[ab]	75.83±50.29[a]	70.25±44.59[a]
Kinixys homeana	32.83±14.13[bc]	13.83±4.36[b]	23.33±14.07[b]
Kinixys erosa	20.67±11.83[c]	10.67±1.51[b]	15.67±9.59[b]

Means with same alphabet on are not significantly different at $p \leq 0.05$

Table 4: Mean Population Comparison between Species within and across Locations

Species	Population (Mean±SD)		
	Zarama	**Aven**	**Egiegie**
Pelusios niger	83.50±46.08[aA]	109.75±66.71[aA]	103.75±78.51[Aa]
Pelusios castaneus	55.00±32.60[abA]	87.00±55.92[abA]	68.75±49.11[abA]
Kinixys homeana	26.75±11.73[bA]	21.50±11.12[bcA]	21.75±21.00[Ba]
Kinixys erosa	17.25±7.80[bA]	15.50±12.45[Ca]	14.25±10.72[Ba]
Mean	**45.63±37.32[A]**	**58.44±57.85[A]**	**52.13±56.92[A]**

Means with same lowercase alphabet are not significantly different within locations and means with same uppercase alphabet are not significantly different within species at $p \leq 0.05$

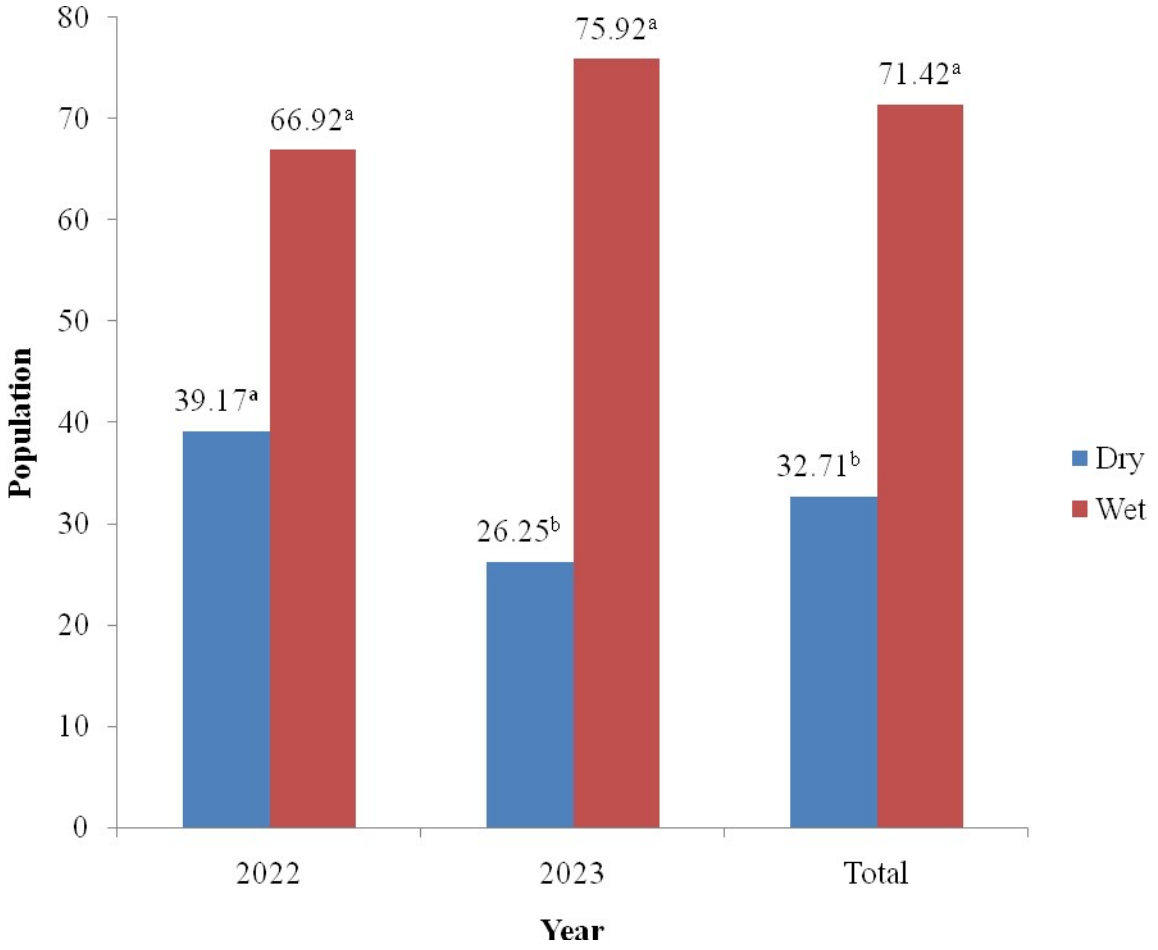

Fig. 2: Seasonal Population Variations of Testudine species (*Means with same alphabet are not significantly different at p≤0.05*)