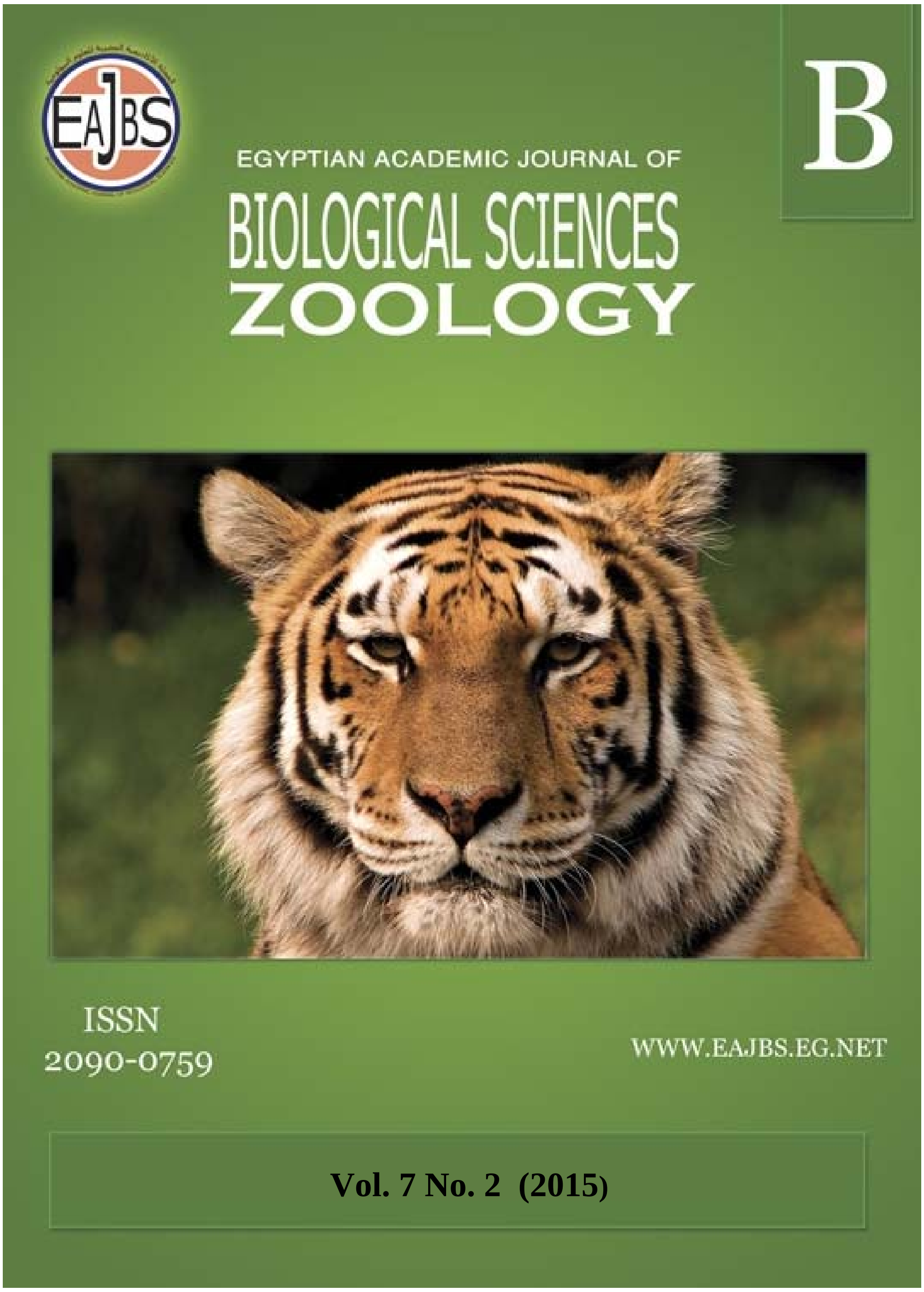


Egyptian Academic Journal of Biological Sciences is the official English language journal of the Egyptian Society of Biological Sciences, Department of Entomology , Faculty of Sciences Ain Shams University .

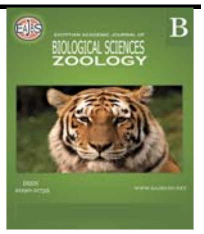
The Journal publishes original research papers and reviews from any zoological discipline or from directly allied fields in ecology, behavioral biology, physiology, biochemistry, development, genetics, systematics, morphology, evolution, and general zoology

www.eajbs.eg.net

Citation: *Egypt. Acad. J. Biolog. Sci. (B. Zoology) Vol. 7(2)pp21-31 (2015)*

Egypt. Acad. J. Biolog. Sci., 7(2): 21- 31 (2015)

Egyptian Academic Journal of Biological Sciences
B. Zoology
ISSN: 2090 – 0759
www.eajbs.eg.net



Temporary Aquatic Breeding Habitats: Its Importance in the Propagation of Anura (Amphibia) Species in Ajah, lagos State, Nigeria

A. B. Onadeko
Department of Zoology, University of Lagos, Akoka, Lagos, Nigeria.
aonaddeko@unilag.edu.ng / onadeko2002@yahoo.com

ARTICLE INFO

Article History
Received: 10/7/2015
Accepted: 1/9/2015

Key words:
Temporary, aquatic, metamorphosis, anuran and propagation

ABSTRACT

This study reveals the importance of temporary aquatic habitats as crucial breeding sites for local anuran species that are gradually declining due to the continuous sand-filling of wetlands in Ajah, Nigeria. Out of the 22 pools at the study site, all of these were used for reproduction (amplexus and oviposition), 19 (86%) of these pools had metamorphoses while 3 (14%) had none observed. A total of six anuran species were observed at the site namely; *Hoplobatrachus occipitalis, Ptychadena pumilio, P. bibroni, Phrynobatrachus latifrons, Xenopus muelleri* and *Amietophrynus regularis.* The larvae of *H. occipitalis, P. pumilio, Phrynobatrachus latifrons* and *A. regularis* metamorphosed every year with *A. regularis* metamorphosing in the largest number of pools compared to other species. There were no significant ($F_{0.05,\ 2,\ 15} = 0.012$) difference observed between the years (2008, 2009 and 2010) of surveys ($P > 0.05$). But however, there was a significant ($F_{0.01,\ 5,\ 12} = 59.754$) difference between the number of species observed breeding ($P < 0.01$). The types of pools had a significant effect ($F_{0.05,\ 2,\ 15} = 3.921$) on the number of anuran species breeding in them at $P < 0.05$. While all species bred in the small and medium sized pools, *X. muelleri* did not use the small sized pools and only *H. occipitalis* and *A. regularis* made use of the large sized pools. The abiotic factors and the biotic factors did not have significant ($P > 0.05$) effect on the number of species and all had a positive ($r > 0$) association. These habitats are of crucial importance for anuran propagation. To prevent the extinction of local species, urgent planning is needed to conserve these systems of temporary pools.

INTRODUCTION

Temporary aquatic systems are those in which the entire habitat for aquatic organisms shifts from being available to being unavailable for a duration and/or frequently sufficient to substantially affect the entire biota (Schwartz and Jenkins, 2000). They provide a rich environment for aquatic organisms that inhabit them and make a significant contribution to the increase of biodiversity both on a local and regional level (Williams, 1987; Semlitsch, 2000; Hartel *et al.*, 2005). However temporary water bodies are vulnerable because they are sensitive both to human impacts and climatic variations. Pond-breeding anurans are often dependent on temporary water bodies for their reproduction and hence are sensitive to loss of temporary ponds (Hartet *et al.*, 2011).

Temporary waters exist in different geographical regions (arid and semi-arid regions, forests, wetlands, degraded lands) and in different forms and sizes (small depressions, potholes, pools, ponds, riparian wetlands etc.). These habitats are transient for aquatic organisms, being habitable for a duration of time to being inhabitable and then back to being habitable. The availability of water is often lacking in temporal habitats for duration of period during the year especially during the dry season. Aquatic organisms living in such habitats have two alternatives; must either become dormant until conditions permit activity (Olivieri and Gouyon, 1997) or disperse to other permanent habitats (Ims and Yoccoz, 1997). The interval that liquid is present (hydroperiod) and the variance in hydroperiod is critical for aquatic organisms and comprises intense natural selection for them to cope (Schwartz and Jenkins, 2000). Some aquatic organisms like the anurans have a terrestrial phase in their life cycle that enables them to recolonize these habitats during their hydroperiods (Van Buskirk, 2005).

Rainfall is a major factor influencing the inter-annual differences in pool hydroperiod affecting breeding cycle of anurans (Gomez- Rodriguez *et al.,* 2009). It leads to the creation of ephemeral/transient pools usually small and only holds water for a few days. These habitats unlike larger temporary ones must rely on subsequent rains to hold water for several weeks at a time. Insufficient rainfall, even for just a few critical days may allow shallow pools to evaporate completely, leading to the death of all the tadpoles (Channing *et al.,* 2012). Unfortunately these ponds can sometime dry before the tadpoles are ready to metamorphose.

In this light, amplectant (parent pair) anuran species should choose a suitable environment for oviposition and lay eggs that will metamorphose fully. Oviposition site choice is therefore an extremely important decision for parents and selection should act strongly in favour for the successful survival of the species (Worley, 2009). Laying eggs in a suboptimal habitat has strong survival cost to offspring and parents should be able to correctly discriminate potential risk to their offsprings. Several other anuran species preferably avoid laying eggs in ponds containing competitors or pathogens (Resatraits and Wilbur, 1989; Kiesecker and Skelly, 2000). Numerous studies have documented a variety of induced responses by prey to risk of predation to their offspring (Dicke and Grostel, 2001; Skelly, 2001). Such decision as these can increase the likeliness of offspring survival. Blaustein *et al.,* (2004) also observed that natural selections favours females that avoid ovipositing where risk of predation is high for their progeny.

There is no doubt that temporary ponds are habitats of critical importance for many anuran species. These species have suffered a recent global decline; and especially due to habitat reduction the native species are facing potential mass extinction (Wake and Vredenburg, 2008). This is the case of Ajah (a fast growing suburb) in Lagos where vast areas of land are being sand-filled for infrastructural development. This has led to the loss of large areas of temporary breeding habitats of anuran species. The aim of this study is to survey temporary aquatic habitats of areas that have not been sand-filled with the sole focus of determining; 1) some anuran species breeding occupancy and reproductive success and 2) the morphometry (width, depth), some physicochemical properties, floral and faunal elements of these temporary habitats. Conservation efforts focused on the protection of these sites could be employed from the results thereof.

MATERIAL AND METHODS

Study Area and Inventory of Temporary Water Bodies

The study took place at Ajah ($06^{o}\ 30^{'}$ 064'' N $03^{o}\ 36^{'}$ 276'' E) in Eti-Osa Local Government area about 20km from Lagos city centre in Lagos State, Nigeria. Lagos State falls within the marine, brackish and freshwater ecological zones (Udo, 1970). Ajah is characterized mostly by wetlands and marshes that are being constantly sand-filled for infrastructural development. An area of 30,000m^2 that have not been sand-filled was used as the study site. Temporary pools (Plate 1) were observed in this location which was classified based on their area (m^2), maximum depth (cm), and the presence or absence of aquatic floral and faunal organisms. The physicochemical parameters evaluated were; p^H, conductivity and turbidity. Also these temporary pools were categorized based on their hydroperiods; Small pool (those that dry up within in few days [1-2 weeks]), Medium pool (those that dry up 2-3 times during the rainy season) and Large pool (those that dry up only during the dry season). See Table 1.

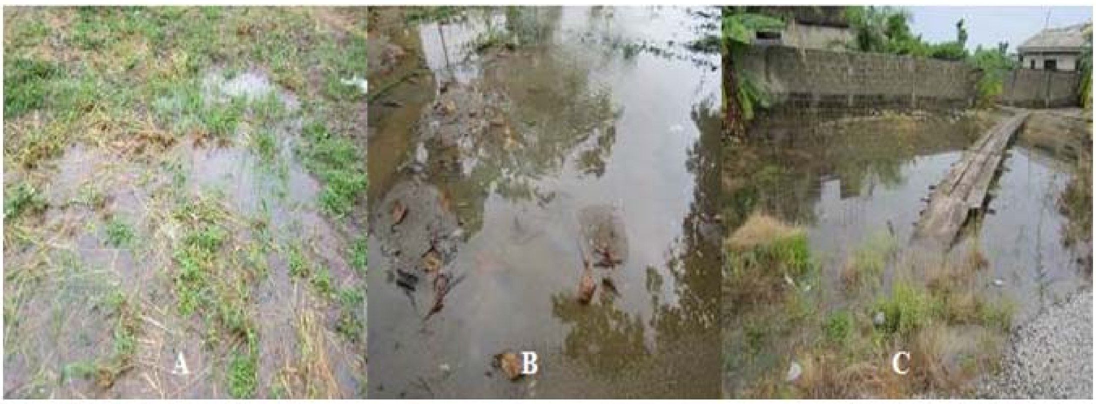


Plate 1: Types of temporary pools. A) Small B) Medium and C) Large pools.

Table 1. Categorization of temporary aquatic habitats.

Pool type	Number	Area (m^2)	Maximum depth (cm)
Small	7	12 – 50	6 – 11
Medium	11	56 – 98	12 – 28
Large	4	224 - 483	36 - 54

Sampling and Anuran Inventory

The present work was performed during three consecutive years from 2008 to 2010. Sampling took place during the rainy season when hydroperiods were created due to more frequent and heavier rainfalls between the months of April and October (see Fig. 1). Within the three hydroperiods (April 2008-October 2010), eggs and metamorphic anurans were sampled with a minimum of three consecutive days per month using dip-netting techniques (Heyer *et al.*, 1994). All macrofaunal organisms were captured by sweeping the dip-net (300 µm mesh; 25 cm in diameter) in all the microhabitats within the pools. Anuran larvae were sorted and identified using literature of Channing *et al.*, (2012). When necessary, the tadpoles were collected and reared to adults in the laboratory for identification. Pools that dried up were noted and dead tadpoles recorded. Reproductive success was estimated based on the number of pools where metamorphosed juveniles were observed.

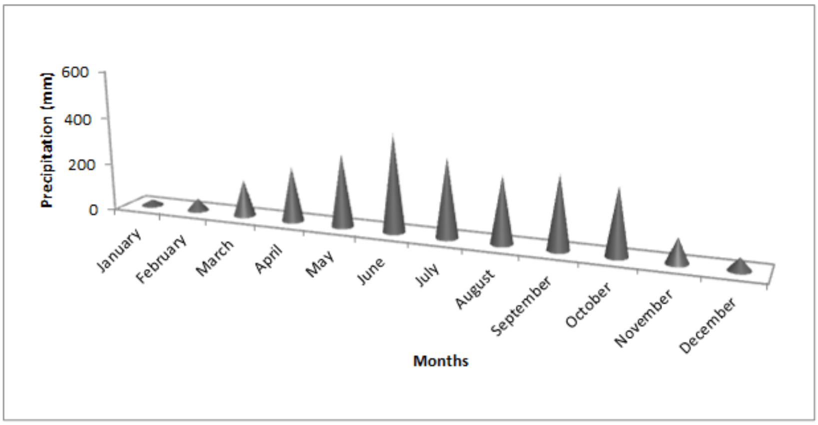


Fig. 1: Average monthly rainfall of 2008-2010. Source: (Nigerian Meterological Station, Oshodi, Lagos)

Statistical Analyses

The means and standard deviations of the various data were analyzed. The analysis of variance (ANOVA) and multiple comparison analysis will be applied to substantiate if significant difference exists between the pool types and number of species breeding in them. The linear regression will be applied to ascertain if biotic or abiotic factors have a significant effect on the number of anuran species reproducing in temporary pools.

RESULTS

Inventory of Temporary Water Bodies

A total of 22 temporary water bodies were observed at the site. All of these were used for reproduction (amplexus and oviposition), 19 (86%) of these pools had metamorphoses while 3 (14%) had none observed (Figs. 2 and 3). Based on water permanence, 7 (32%) were classified as small pools; 11 (50%) as median and 4 (18%) as large pools.

Anuran Use of Temporary Habitats

A total of six anuran species were observed at the site namely; *Hoplobatrachus occipitalis, Ptychadena pumilio, P. bibroni, Phrynobatrachus latifrons, Xenopus muelleri* and *Amietophrynus regularis* (Fig. 2). The larvae of *H. occipitalis*, *P. pumilio, Phrynobatrachus latifrons* and *A. regularis* metamorphosed every year with *A. regularis* metamorphosing in the largest number of pools compared to other species (Fig. 3). *P. bibroni* and *Xenopus muelleri* were not present every year at the site, but had their larvae metamorphosed (two pools each) in 2010 and 2009 respectively. Though *P. bibroni* was present in 2008, its larvae could not metamorphose due to short hydroperiod. Pools (45%) use for reproduction by three anuran species were the most common followed by those (36%) used by two species. Only one (4.5%) was used by four species.

There were no significant ($F_{0.05, 2, 15} = 0.012$) difference observed between the years (2008, 2009 and 2010) of surveys ($P > 0.05$). But however, there was a significant ($F_{0.01, 5, 12} = 59.754$) difference between the number of species observed breeding in the different pools ($P < 0.01$) (Fig 2). See Appendix for multiple comparison analysis of the means of each anuran species.

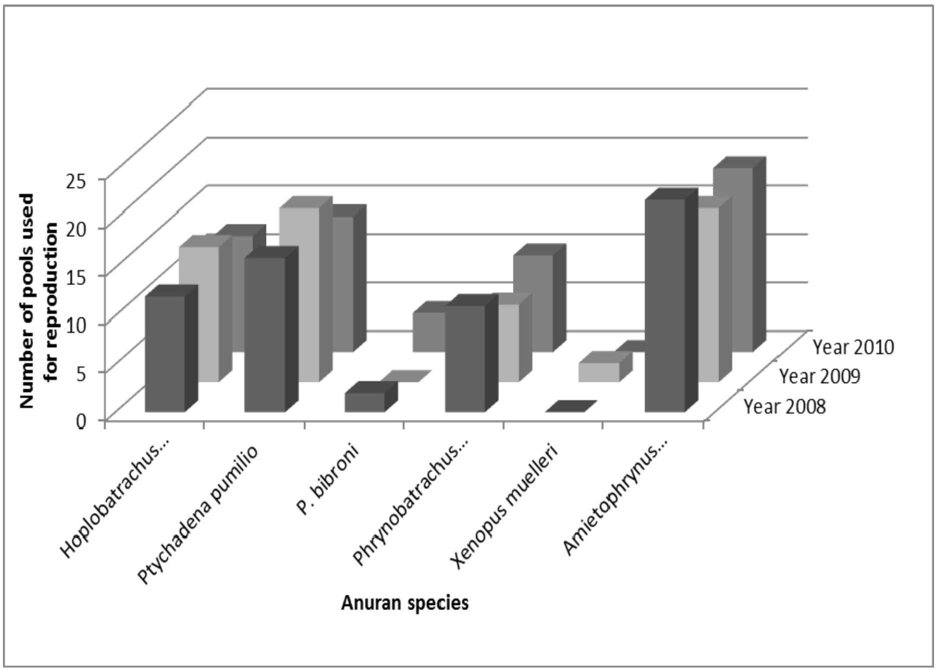


Fig. 2: Number of temporary pools used for anuran breeding between 2008-2010.

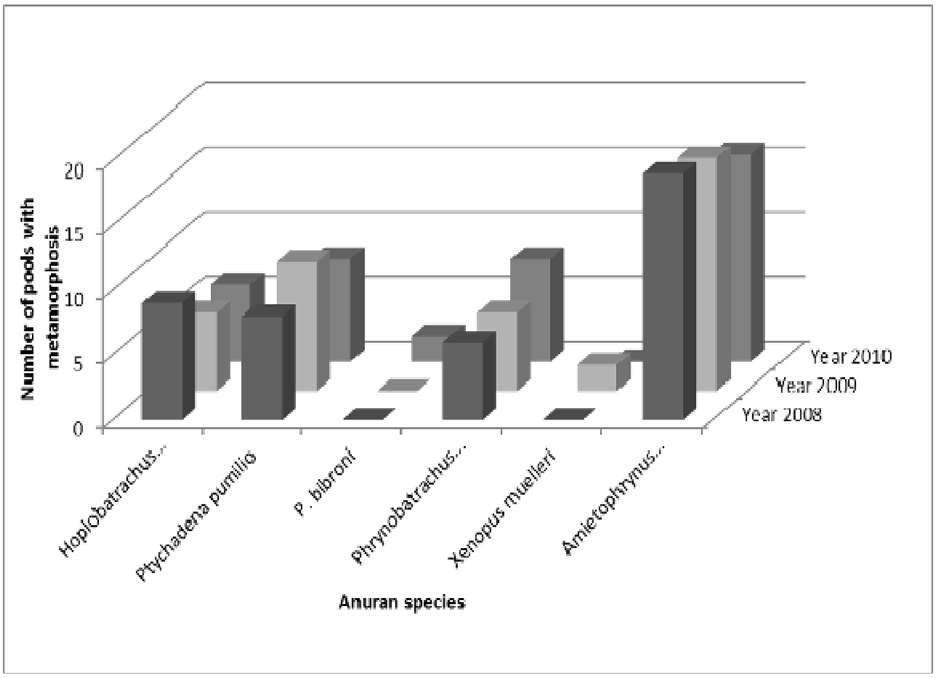


Fig. 3: Number of temporary pools in which anuran metamorphoses occurred between 2008-2010.

Anuran species were observed to breed in all the types (small, medium and large) of pools. All species bred in the small and medium sized pool while only *X. muelleri* did not use the small sized pools (Table 2). Only two species (*H. occipitalis* and *A. regularis*) made use the large sized pools. The types of pools had a significant effect ($F_{0.05,2,15} = 0.043$) on the number of anuran species at $P < 0.05$. See Appendix for multiple comparison analysis of the means of pool types.

Table 2: Descriptive statistics of variables affecting the temporary pools at Ajah site inhibited by six anuran species.

	Total pools	Hoplobatrachus occipitalis	Ptychadena pumilio	P. bibroni	Phrynobatrachus latifrons	Xenopus muelleri	Amietophrynus regularis
Area	112.6±129.1	112±110.3	57.4±29.5	46.1±21.9	50.3±28.6	69±18.3	84.1±80.5
	*(12-483)	(22-360)	(12-92)	(30-61)	(12-92)	(56-82)	(12-360)
Max depth	20.1±14.7	21.3±14.9	14.6±5.4	12.5±3.5	12.5±5.2	13±1.4	17.6±11.1
	*(7-54)	(7-52)	(8-21)	(10-15)	(7-23)	(12-14)	(8-52)
Ph	6.8±0.3	6.8±0.36	6.9±0.25	7.2±0.1	6.9±0.24	6.8±0.14	6.9±0.28
	(6.4-7.4)	(6.4-7.4)	(6.6-7.4)	(7.1-7.2)	(6.6-7.4)	(6.7-6.9)	(6.4-7.4)
Turbidity	4.5±0.8	4.3±0.76	4.8±0.95	5.6±1.06	4.7±0.8	3.9±0.14	4.5±0.77
	(3.4-6.3)	(3.4-6.1)	(3.4-6.3)	(4.8-6.3)	(3.8-6.1)	(3.8-4)	(3.4-6.3)
Conductivity	166.2±23.8	164.9±25.9	178.3±22.7	154.3±36.7	164.8±24.5	177±4.9	168.3±25.1
	(128-204)	(125-201)	(160-204)	(128-180)	(130-204)	(173-180)	(130-204)
Mean species richness	2.27±0.5	4.33±1.2	4.9±1.1	3±1.4	3.13±1.6	2.5±0.7	3.74±1.6
	(0-6)	(2-6)	(3-6)	(2-4)	(1-5)	(2-3)	(1-6)
Predators (no. of pools)	13	7	7	1	4	0	11
Vegetation (no. of pools)	15	5	8	2	4	1	13
Small pool	7	3	4	1	4	0	6
+Medium pool	11	4	6	1	4	2	11
Large pool	4	2	0	0	0	0	2

*No anuran metamorphoses were observed in the largest and deepest pools.
+Some medium sized pools were created by human excavations made by filling up foundations of houses.

The abiotic factors (e.g. pH, turbidity, area) and the biotic factors (predators and vegetation) did not have significant ($P > 0.05$) effect on the number of species and all had a positive ($r > 0$) association (Table 3).

Table 3: Regression analysis between variables and number of species.

Source	R	df	F	Sig.
Area	0.07	1	0.015	0.91
Max depth	0.5	1	1.02	0.38
pH	0.07	1	0.016	0.91
Turbidity	0.19	1	0.119	0.75
Conductivity	0.37	1	0.5	0.53
Predators	0.69	1	2.78	0.19
Vegetation	0.66	1	2.41	0.21
				P > 0.05

During metamorphosis, it was observed that every anuran species had mortalities due to dried up pools except *X. muelleri* (Fig. 4). *P. bibroni* experienced 100% mortality loss in 2008 when the only two pools it was metamorphosing in dried up. The pools in which *X. muelleri* was metamorphosing never dried up. However these deaths were insignificant because the dried up pools get filled again during the year and similar or other anuran species metamorphose in it to adulthood.

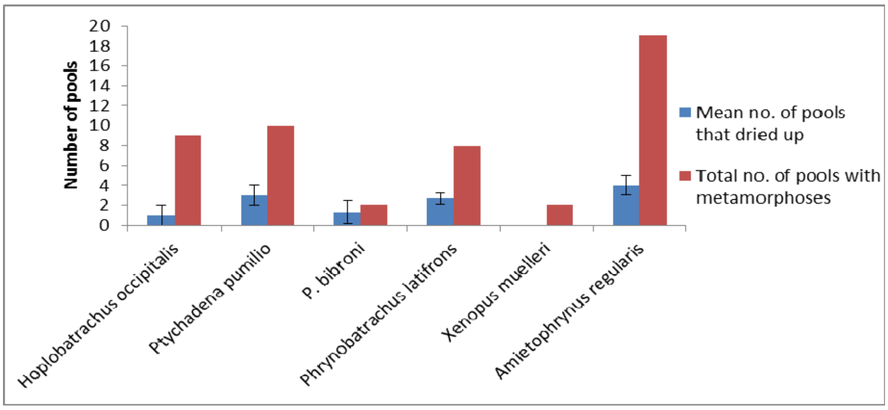


Fig. 4. Number of dried up pools with anuran mortalities.

DISCUSSION

This study shows the importance of temporary pools for anuran reproductive processes, physiology and its existence in totality. This network of pool presents a remarkable variability in the environment in time and space, and yet they serve as highly suitable breeding habitat for anurans. From the survey, all (100%) of the temporal habitats had breeding activities and 86% had metamorphoses which further proves its importance regarding anuran propagation. At the site, the breeding activities of anurans correlate with the formation of temporary pools which is seasonal (rainy season). This correlates positively to the rainfall pattern that is high during the rainy season (April-October). As observed by many authors (Aichinger, 1987; Donnelly and Guyer, 1994; Bertoluci and Rodrigues, 2002; Prado *et al.*, 2005), the breeding activity of anurans that inhibits seasonal environment is generally correlated with periods of rains, mainly in the tropics. Hartel *et al.*, (2005) also revealed that reproductive success of anurans in temporary aquatic habitats is influenced principally by the hydroperiods, which depends in turn on precipitation. These observations support the result of the study which shows that the formation of temporary pools was seasonal and their formation supported the breeding activity of the anurans.

There was no significant difference between the years of surveys. This may be due to the fact that rainfall patterns were not different and/or the species inhibiting the environment were basically the same surveyed each year. There may not have been emigration of other species into the study site, rather the native species maintained their territory. However there was a significant difference between the different numbers of anuran species inhabiting the pools. *A. regularis* was the most dominant followed by *P. pumilio* and *H. occipitalis.* By selecting different breeding sites at different seasons, *H. occipitalis* and *A. regularis* take advantage of any available resource (Rodel, 2000). This is the reason why *A. regularis* was observed in almost all the pools. As soon as the rainy season begins, the behavior of these toads changes completely, leaving the river banks to form new breeding choruses in the savanna where temporary pools are formed. *X. muelleri* and *P. bibroni* were the least dominant of the species observed breeding at the temporary pool habitats. *X. muelleri* was quite difficult find and they were only seen in one year (2009) of the survey. According to Rodel (2000), the reproduction of this species apparently takes place exclusively in a rather restricted number of pools. He suggested that they may be comparatively common in large pools, but occur occasionally in puddles containing less than 200 litres of water or residuary ponds. *P. bibroni* may have had a low abundance of individuals at the study site, hence its low numbers. Another reason for its low dominance is that the tadpoles swim mainly near the bottom of pools and also in deep water where the larvae of other *Ptychadena* species are far less common (Rodel, 2000).

Anuran tadpole can colonize almost all water bodies for its survival (Rodel, 2000; Channing, 2012). To maximize their reproductive success, anurans must choose breeding pools in such a way that the growth and development of the larvae can be assured before the end of metamorphosis (Hartel *et al.*, 2005). Every species follow its own reproductive strategy to ensure many offspring as much as possible, with maximum survival rates until adulthood. In this study, anuran species were observed to breed in all the three types of pool identified which had a significant difference on the number of species. The large pools had very few (only *H. occipitalis* and *A. regularis*) or no metamorphosis occurring in them. This confirms the observations of Rodel (2000) that tadpoles of *H. occipitalis* and *A. regularis* are observed in almost all pools. These tadpoles may have developed survival techniques not possessed by other tadpoles for surviving in larger pools with invertebrates and vertebrates predators. The small and medium pools had greater metamorphoses and were not significantly different from each other (see Appendix), but unlike the large pools, they had to contend with the problem of drying up leading to the infrequent desiccations of tadpoles. Thumm and Mahony (1999, 2005) reported on the embryonic and larval mortality of the red-crowned toadlet (*Pseudophryne australis*) due to dessication, with survival to metamorphosis measured at 0.8%. However at the site, desiccation did not affect the reproductive success of the anurans because sites that dried up gained water during the year and several metamorphoses occurred within it. Also through evolutionary development, anurans have adapted to rapid larval development to prevent desiccation in rapid drying pools (Newman, 1989) which is clearly an advantage for temporary pond breeders (Greenberg and Tenner, 2004).

The abiotic and biotic factors had no significant effect and were positively correlated with the number of species. Some of the common plants were *Ipomoea asarifolia, I. aquatic, Azolla africana, Pistia stratiotes* and *Nymphaea lotus.* The larvae of *H. occipitalis* and juveniles of catfish were the major predators seen. Spiders, larvae of aquatic beetles (Dytiscidae) and water scorpions (*Nepella pauliani*) were other predators seen. Reproduction was successful in the pools despite the abiotic variables and the type of faunal and floral elements present. Similar observations were made by Hartel *et al.,* (2005) while studying the use of temporary ponds by amphibian in a wooded pasture in Romania. However contrasting report of Neckel-Oliveira and Wachlevski (2004) showed that staphilynid beetles and phorid flies were the main cause of clutch loss, followed by mammals and unidentified predators in three species of *Phyllomedusa tomopterna.* Some habitats such as tropical forest are very rich in species including those that prey on anuran eggs (Channing, 2012). Among the predators are snakes (Roberts, 1994), other frogs (Drewes and Altig, 1996), frogflies (Vonesh, 2000), birds (Lamotte and Lescure, 1977) and monkeys (Rodel *et al.*, 2002).

CONCLUSION

Most anurans have a free-living tadpole stage that develops in water. The development in aquatic habitats cushions them from environmental fluctuations preventing them from desiccation. Adults anurans have device ways and means (strategies) of attaining successful reproduction and these vary according to time (season), places (eg. temporary pools) and modes of reproductive behaviour. Unfortunately humans are the greatest threat to tadpoles especially through anthropogenic factors such as habitat loss and degradation. In Ajah, Lagos, the low wetlands that favour the thriving conditions of the anurans are fast disappearing due to massive sand-filling for infrastructural development. Urgent planning is needed which is highly important to conserve these systems of temporary pools that will ensure a long term existence of these species.

ACKNOWLEDGEMENT

Many thanks go to the land owners (Mr Adebayo, Mr Izuka, Mr Peter and Mr Fatima) of the study area for granting access to their land. Also I am highly indebted to the field assistants who tirelessly helped with the monitoring of the study site. Also thanks to my wife who supported financially.

REFERENCES

Aichinger, M. (1987). Annual activity patterns of anurans in the seasonal Neotropical environment. *Oecologia* 71: 583-592.

Bertoluci, J. and Rodrigues, M.T. (2002). Seasonal patterns of breeding activity of Atlantic rainforest anurans at Boracéia, Southeastern Brazil. *Amphibia-Reptilia* 23: 161-167.

Blaustein, L., Kiflawi, M., Eitam, A., Mangel, M. and Cohen, J.E. (2004). Oviposition habitat selection in response to risk of predation in temporary pools: mode of detection and consistency across experimental venue. *Oecologia*. 138: 300–305

Channing, A., Rodel, M.O. and Channing, J. (2012). Tadpoles of Africa: The biology and identification of all known tadpoles in sub-Saharan Africa. Edition Chimaira, Frankfurt am Main.

Dicke, M. and Grostal, P. (2001). Chemical detection of natural enemies by arthropods: an ecological perspective. *Annu Rev Ecol Syst* 32:1–23.

Donnelly M.A., Guyer C., Juterbock J.E. and Alford R., (1994). Techniques for marking amphibians. In: Heyer W.R., Donnelly M.A., McDiarmid R.W., Hayek L.-A.C. and Foster M.S. (eds.), Measuring and Monitoring Biological Diversity. Standard Methods for Amphibians, Smithsonian Institution Press, Washington, DC, 277–284.

Drewes, R.C. and Altig, R. (1996). Anuran egg predation and heterocannibalism in a breeding community of African frogs. *Tropical Zoology*. 9: 333-347.

Greenberg, C.H. and Tenner, G.W. (2004). Breeding pond selection and movement patterns by Eastern Spadefoot Toads (*Scaphiopus holbrookii*) in relation to weather and edaphic conditions. *Journal of Hepetology*. 38 (4): 569-577.

Gomez-Rodriguez, C., Diaz-Paniagua, C., Serrano, L., Florencio, M and Portheault, A. (2009). Mediterranean temporary ponds as amphibian breeding habitats: the importance of preserving pond networks. *Aquatic Ecol.* 43: 1179-1191.

Hartel, T., Moga, C.I. and Nemes, S. (2005). Use of temporary ponds by amphibians in a wooded pasture, Romania. *Biota* 6(1-2): 21-28.

Hartel, T., Bancila, R. and Cogalniceanu, D. (2011).Spatial and temporal variability of aquatic habitat use by amphibians in a hydrologically modified landscape. *Freshwater Biology*. 56 (11): 2288-2298.

Ims, R.A. and Yoccoz, N.G. (1997). Chap. 11 – Studying transfer processes in metapopulations: emigration, migration, and colonization. In: Hanski, I.A. and Gilpin, M.E. (eds.), Metapopulation Biology: Ecology, Genetics and Evolution. Academic Press, New York, pp. 247-266.

Kiesecker, J.M. and Skelly, D.K. (2000). Choice of oviposition site by gray treefrogs: The role of potential parasitic infection. *Ecology* 81(10):2939-2943.

Lamotte, M. and Lescure, J. (1977). Tendances adaptives a l'affranchissement du milieu aquatique chez les amphibiens anoures. *La Terre et la Vie.* 31: 225-311.

Newman, R.A. (1989). Developmental plasticity of *Scaphiopus couchii* tadpoles in an unpredictable environment. *Ecology.*70: 1775-1787.

Neckel-Oliveira, S. and Wachlevski, M. (2004). Predation on the arboreal eggs of three species of *Phyllomedusa* in Central Amazonia. *Journal of Herpetology.* 38 (2): 244-248.

Olivieri, I. and Gouyon, P.H. (1997). Evolution of migration rate and other traits: the metapopulation effect. In: Hanski, I.A. and Gilpin, M.E. (eds.), Metapopulation Biology: Ecology, Genetics and Evolution. Academic Press, New York, pp. 293-324.

Prado, C.P., Uetanabaro, M. and Haddad, C.F. (2005). Breeding activity patterns, reproductive modes, and habitat use by anurans (Amphibia) in a seasonal environment in the Pantanal, Brazil. *Amphibia-Reptilia.* 26: 211-221.

Resatarits, W.J. and Wilbur, H.M. (1989). Choice of oviposition site by *Hyla chrysoscelis*: Role of predators and competitors. *Ecology* 70(1):220-228.

Rodel, M.O. (2000). Herpetofauna of West Africa. Vol. 1. Amphibians of West African Savanna. Frankfurt/M. (Edition Chimaira).

Rodel, M.O., Range, F., Seppanen, J. and Noe, R. (2002). Caviar in the rainforest: monkeys as frog spawn predators in Tai National Park, Ivory Coast. *Journal of Tropical Ecology.* 18: 289-294.

Schwartz, S.S and Jenkins, D.G. (2000). Temporary aquatic habitats: constraints and opportunities. *Aquatic Ecology.* 34: 3-8.

Semlitsch, R.D. (2000). Principles for management of aquatic – breeding Amphibians. *J. Wildl. Management* 64: 615-631.

Skelly, D.K. (2001). Distribution of pond-breeding anurans: an overview of mechanisms. *Isr J Zool.* 47:313–332.

Thumm, K. and Mahony, M. (1999). Loss and degradation of red-crowned toadlet habitat in the Sydney region. Pp. 99-108. In Campbell (Ed.), Declines and Disappearances of Australian Frogs. Environment Australia, Canberra, Australia.

Thumm, K and Mahony, M. (2005). Is variable egg size the proximate cause of diversified bet-hedging in the hatching dynamics of the red-crowned toadlet (*Pseudophryne australis*) (Anura: Myobatrachidae)? *Herpetologica.* 61 (1): 9-19.

Van Buskirk, J. (2005). Local and landscape influence on amphibian occurrence and abundance. *Ecology*. 86, 1936–1947.

Vonesh, J.R. (2000). Dipteran predation on the arboreal eggs of four *Hyperolius* frog species in western Uganda. *Copeia.* 2000: 560-566.

Wake, D.B. and Vredenburg, V.T. (2008). Are we in the midst of the sixth mass extinction? A view from the world of amphibians. *Proc. Natl. Acad. Sci*. 105: 11466–11473.

Williams, D.D. (1987). The ecology of the temporary waters. Timber Press, Croom Helm, London, 205pp.

Worley, J. (2009). Oviposition site choice in a Neotropical treefrog, *Dendropsophus ebraccatus*. *Portland State University McNair Scholars Online Journal*. 3 (1): 226-239.

Appendix 1

Multiple Comparisons Between Means Of Anuran Species

ANOVA

Number

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	863.111	5	172.622	59.754	.000
Within Groups	34.667	12	2.889		
Total	897.778	17			

P<0.01 There is significant difference between the anuran species.

A= Hoplobatrachus occipitalis B= Ptychadena pumilio C= Ptychadena bibroni
D= Phrynobatrachus latifrons E= Xenopus muelleri F= Amietophrynus regularis

A	B	C	D	E	F
12.67^{b}	16.00^{c}	2.00^{a}	9.67^{a}	0.67^{a}	19.67^{d}

Multiple Comparisons between Pool Types

ANOVA

Species

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	48.444	2	24.222	3.921	.043
Within Groups	92.667	15	6.178		
Total	141.111	17			

(P<0.05) There is significant difference between the anuran species found in the different pool types.

A= Small pool B= Medium pool C= Large pool

A	B	C
3.00^{ab}	4.67^{b}	0.67^{a}