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Parasitic Infection of Edible Terrestrial Gastropods in Benue and Plateau States, North-Central Nigeria

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Abstract:
An alternative to red meat due to cholesterol level has made large terrestrial snails a target. they could serve as a good replacement and source of protein but their mode of life especially feeding and locomotion makes them prone to parasitic infections. This study was aimed at investigating the parasitic infection of edible terrestrial snails in relation to specie in some parts of North-Central Nigeria. a total of 579 edible land snails were collected during the wet and dry seasons. Seven snail species belonging to three generals were identified. Out of the 579 collected snails, 447 (77.20%) were positive for parasitic infections. All infected snails showed multiple infections. Infection rates of 82.88%, 77.69%, 67.12% and 53.85% were recorded from Agila, Jos, Utonkon and Wadata respectively. However, no significant difference in snail infection in relation to location. (χ^2= , p > 0.05). Parasitic infection of snail species revealed that A. fulica was most infected (90.10%), this was followed by L. flammea (79.31%), A. marginata (77.42%), A. saturalis (75.58%). L. aurora (74.73%), A. achatina (72.09%) and A. ovum (65.39%). No significant difference was observed amongst snail species infection (p > 0.05). S. stercoralis recorded 100% infection rate in all snails, A. cantonensis 76.73%, while Entamoeba sp. recorded the least (1.70%). Different parasites were also recovered from in the tissues/organs of the snails observed. Public awareness on the public health implications of consuming terrestrial snails should be emphasized by public health workers especially when eaten raw or undercooked. Snail farms should be encouraged rather than consumption of snails gotten from the wild.

Keywords: *Edible, land snail, species, parasites, public health, Nigeria*

1. Introduction

With about one million species already identified, invertebrates are raised and used by man as pets and food, kept in institutions (Zachariah and Mitchell, 2009). Molluscs, one of the largest and most successful groups of the invertebrates. Snails are molluscs belonging to a group known as gastropoda. They are known to have soft body covered by a protective shell. Snails are found in most habitats but predominantly in fresh aquatic and wet terrestrial habitats. Land snails are predominant during wet season and both the fresh aquatic and land snails are known to serve as intermediate host to a variety of parasites known to infect man (Opisa et al., 2011; Caron et al., 2014; d'Ovidio et al., 2019). The fear for red meat due to its cholesterol level has resulted in a massive increase in the demand for alternative protein sources such as fish, poultry and now snail meat. This phobia has led to more value and demand placed on snail meat (Arvantoyannis and Vazakas, 2009) and the demand is still rising. Snail meat has been reported to be rich in protein, essential fatty acids and low in fat in addition to its Copper, Zinc and Iron content (Olgunoglu and Olgunoglu, 2009; Toader-Williams and Golubkina, 2009; Gocer and Olgunoglu, 2018). Terrestrial land snails live on land, scavenging for food and also for reproduction purposes, and these could expose them to infection by parasites. Eating infected snail meat can be a route to human infection. Not properly cooked or eaten of raw snail meat can lead to transmission of these parasites carried by snails to man (Yildirim et al., 2020; Igbonosa et al., 2016). In most cases snails are not properly heated owing to the fact that they are mostly served as continental dishes where low heat is required. In some places snails are cooked with their shells, mixed with vegetables and served after applying little heat (Yildirim et al., 2020). Snail consumption in the North-Central part of Nigeria is now very common. This may be due to high cost of other protein sources, explosion of snail farms and awareness of the health benefits associated with its consumption. Though the consumption of snail meat has greatly increased, the awareness of the disease transmission risk is still much unknown. Little or no work has been carried out in this region as regards the public health implication of consuming snail meat. This study therefore was aimed at investigating and evaluating the parasitic infections of wild terrestrial gastropods in Benue and Plateau States, North-Central Nigeria.

2. Materials and Methods

2.1. Study Areas

This study was carried out in parts of Benue and Plateau States, North Central Nigeria. Benue state occupies a land mass of about 34,059km^2 and has a population above 4.2million. The state borders Nasarawa state to the North, Taraba to the East, Kogi to the west and Ebonyi and Cross River to the South. Benue State lies within the Lower River Benue and its geographic coordinates are longitude 7^o 47` and 10$^o$ 0`E, and latitude 6^o 25` and 8$^o$ 8`N. It has an annual average rainfall of 100-200mm and temperature of 21-37^{o}C. Benue State is a rich agricultural region and popularly known as the Food Basket of The Nation with crop like oranges, rice, yam, maize and sorghum amongst other crop that are cultivated. Plateau state is located almost at the center of the country with a land mass of about 30,913km^2 and a population of over 3.7million. The state borders Bauchi State to the Northeast, Kaduna State to the Northwest, Nasarawa State to the Southwest and Taraba to the Southeast. The State is located between latitude 08^o 24`N and longitude 08$^o$32` and 010^{o}38`E. The State enjoys a near temperate climate with an annual average temperature of 13-22^{o}C and annual rainfall that varies between 113-141cm. the State is known as Home of Peace and Tourism. Plateau is well known for the production of vegetables such as cabbage, lettuce, carrot, cucumber, tomato, green beans and pepper amongst others.

2.2. Snail Collection

Large sizable snails were collected by handpicking in the wild from different places ranging from farmlands to trunks around homes from different communities in two specific Local Government Areas of Benue and Plateau States. Snail collection during the wet season was done between June and September 2020, and between November 2020 and January 2021 during the dry season where available.

2.3. Snail Identification

Snails were identified basically according to the shell size, shape, colour and patterns. Spire angle and the aperture were also considered as described by (Bequaert 1950; Raut and Barker 2002; PetSnails.co.uk 2018).

2.4. Snail Dissection/Digestion and Parasitological Investigation

The snails were individually anaesthetized with ethereal cotton placed in sterile plastic containers and separated from their shells using scissors, needle nose pliers and forceps. A standard procedure to separate organs/tissues of interest as described by Segun (1973) and Kerney and Cameron (1979) were used. The animal tissue was slowly removed from the shell using needle nose pliers and required organ/tissue was chopped into small pieces. This was then subjected to tissue digestion as described by Castillo and Paller (2018). The digested tissue was filtered using a strainer and the filtrate was placed in clean test tube. It was vortexed for 2 mins then centrifuged for 10 minutes at 300–400 rpm. Two methods; floatation technique (saturated salt solution) and concentration technique using formol-ether as described by Cheesbrough, (2006) were employed. Samples were viewed under the microscope and parasites seen were identified.

2.5. Data Analysis

Data were compiled in spreadsheet (Microsoft) and analysed using descriptive statistics. Statistical Package for Social Sciences (SPSS) version 25 (IBM Corp. New York) was used. Pearson Chi Square (χ^2) test was used to determine whether any differences exist between infected snails across location and between parasite infection and snail species. A p-value of < 0.05 at 95% confidence level was considered significant.

3. Results

A total of 579 edible snails of varying sizes were collected in both Benue and Plateau States during the wet and dry seasons, identified and examined for parasitic infections. Seven species namely Achatinaachatina, Achatinafulica, Achachatinamarginata, Achachatina ovum, Achachatinasuturalis, Limicolaria aurora and Limicolariaflemmea were identified. Limicolariaflemmea and Limicolaria aurora were collected from Jos and Agila only while Achatinaachatina, Achatinafulica, Achachatinamarginata, Achachatina ovum and Achachatinasuturalis were collected from Jos (Plateau), Agila, Utonkon and Wadata (Benue).

Out of the 579 land snails collected and examined for parasite infections, 447 (77.20%) were positive to at least one species of parasite infection and 22.80% were negative. In all infected snails, multiple infections was observed. Figure 1, revealed that a total of 121 land snails were collected from Jos, 333 from Agila, while 73 and 52 were collected from Utonkon and Wadata respectively.

Table 1 showed that infection rate was highest in snails collected from agila (82.88%), followed by Jos with 77.69%. Utonkon and Wadata both recorded 67.12% and 53.85% infection rate respectively.

Table 2 revealed parasite infection in snail species. *A. fulica*was most infected with a prevalence of 90.10%. This was followed by *L. flammea*(79.31%), *A. marginata*(77.42%), *A. saturalis*(75.58), *L. aurora* (74.73%). *A. achitina*(72.09%), *A. ovum* (65.39%) and an overall infection rate of 77.20% in edible terrestrial snail species in Benue and Plateau States was recorded.

Eight different parasite types were isolated from the infected snails. All eight (8) parasites species were isolated from *Limicolaria aurora*, seven (7) from *Achachatinamarginata* and *Achachatina ovum* six (6) from *Limicolariaflammea, Achatinafulica*and *Achachatina ovum,* five (5) from*Achatina folic* and three (3) from *Achachatinasuturalis*. Table 2 also showed that generally, *Strongyloidesstercoralis*infection was most prevalent (100.00%). This was followed by

Angiostrongyluscantonensis infection (76.73%) while the least parasite infection rates of 2.46% and 1.79 % were recorded in Fasciolagigantica and Entamoeba *sp.* respectively across all snail species. Five organs (digestive gland, rectum, mucus gland, intestine and ovotestes) were examined for parasitic infections. Three (3) parasite types were isolated from the digestive glands of all infected snail species except in *A. ovum* and *A. saturalis*where no parasites were found. Five (5) parasites from the rectum and Ovotestes, four (4) from the mucus gland and seven (7) from the intestine of all infected snails species.

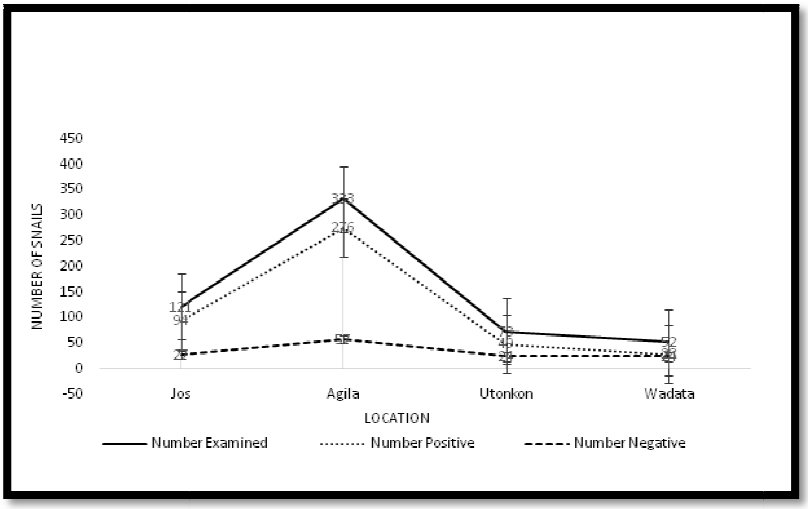

Figure 1: Prevalence of Snail Infections in Relation to Lacation

		PARASITES								
Location	**No. of Snails Examined**	**No. of Snails Infected (%)**	**StrongyloidesStercoralis (%)**	**Alaria sp .**	**Angiostrongylus cantonensis (%)**	**Drocoeliumdendriticum(%)**	**Fasciolagigantica(%)**	**Brachylaima sp. (%)**	**Philophthalmus sp. (%)**	**Entamoeba sp. (%)**
Jos	121	94 (77.69)	94 (100.00)	13 (13.83)	79 (84.04)	08 (8.51)	02 (2.13)	11 (11.70)	25 (26.59)	02 (2.13)
Agila	333	276 (82.88)	276 (100.00)	61 (22.10)	210 (76.09)	56 (20.29)	09 (3.26)	45 (16.30)	39 (14.13)	05 (1.81)
Utonkon	73	49 (67.12)	49 (100.00)	09 (18.37)	31 (63.27)	12 (24.49)	-	-	-	-
Wadata	52	28 (53.85)	28 (100.00)	03 (10.71)	23 (82.14)	-	-	-	02 (7.14)	01 (3.57)
Total	579	447 (77.20)	447 (100.00)	86 (19.24)	343 (76.73)	76 (17.00)	11 (2.46)	56 (12.53)	66 (14.77)	08 (1.79)

Table 1: Prevalence of Snail Parasites Infection in Relation to Location
χ^2= 6.00 , p = 0.199

Snails Species	PARASITES									
	No. of Snails Examined	No. of Snails Infected(%)	StrongyloidesStercoralis (%)	Alaria sp. (%)	Angiostrongylus cantonensis (%)	Drocoeliumdendriticum (%)	Fasciola gigantica (%)	Brachylaima sp. (%)	Philophthalmus sp. (%)	Entamoeba sp. (%)
L. aurora	91	68 (74.73)	68 (100.00)	14 (20.59)	41 (60.29)	16 (23.53)	03 (4.41)	17 (25.00)	27 (39.71)	02 (2.94)
L. flammea	87	69 (79.31)	69 (100.00)	25 (36.23)	69 (100.00)	-	01 (1.45)	09 (13.04)	-	03 (4.35)
A achatina	43	31 (72.09)	31 (100.00)	11 (35.48)	18 (58.07)	-	02 (6.45)	03 (9.68)	-	-
A. fulica	101	91 (90.10)	91 (100.00)	16 (17.58)	68 (74.73)	36 (39.56)	-	14 (15.39)	-	02 (2.20)
A. marginata	93	72 (77.42)	72 (100.00)	12 (16.67)	55 (76.39	17 (23.61)	05 (6.94)	08 (11.11)	16 (22.22)	-
A. ovum	78	51 (65.39)	51 (100.00)	08 (15.69)	39 (76.47)	07 (11.57)	-	05 (9.80)	09 (17.65)	01 (1.96)
A. suturalis	86	65 (75.58)	65 (100.00)	-	53 (81.54)	-	-	-	14 (21.54)	-
Total	579	447 (77.20)	447 (100.00)	86 (19.24)	343 (76.73)	76 (17.00)	11 (2.46)	56 (12.53)	66 (14.77)	08 (1.79)

Table 2: Prevalence of Parasites Infection in Snail Species
χ^2= 42.00, p = 0.227

Species/Organs	Digestive Gland	Rectum	Mucus Gland	Intestine	Ovotestes
L. aurora	S. stercoralis Alaria sp.	S. stercoralis A. cantonensis F. gigantica	S. stercoralis Alaria sp. A. cantonensis	S. stercoralis A. cantonensis Brachylaima sp.	S. stercoralis A. cantonensis D. dendriticum Philohthalmus sp.
L. flammea	S. stercoralis D. dendriticum Alaria sp.	S. stercoralis A. cantonensis Branchylaima sp.	A. cantonensi S. stercoralis Alaria sp.	S. stercoralis A. cantonensis Alaria sp. D. dendriticum Entamoeba sp.	S. stercoralis A. cantonensis D. dendriticum Philohthalmus sp.
A achatina	S. stercoralis D. dendriticum	S. stercoralis Philophthalmus sp.	S. stercoralis A. cantonensis	S. stercoralis A. cantonensis d. dendriticum	S. stercoralis A. cantonensis D. dentriticum

Species/Organs	Digestive Gland	Rectum	Mucus Gland	Intestine	Ovotestes
A. fulica	S. stercoralis	S. stercoralis	s. stercoralis	S. stercoralis A. cantonensis	S. stercoralis A. cantonensis D. dendriticum
A. maginata	S. stercoralis	S. stercoralis	Entamoeba sp. S. stercoralis A. cantonensis	S. stercoralis F. gigantica	S. stercoralis A. cantonensis
A. ovum	-	A. cantonensis Philophthalmus sp.	S. stercoralis A. cantonensis	S. stercoralis F. gigantica	S. stercoralis A. cantonensis F. gigantica D. dendriticum
A. suturalis	-	A. cantonensis F. gigantica	S. stercoralis A. cantonensis	S. stercoralis	S. stercoralis

Table 3: Parasite Isolation in Organs of Snails Species

4. Discussion

Parasitic foodborne diseases have become more widespread with intercontinental human interactions, increased human population and fast food habits (Yildirim 2020). Snail Borne Parasitic Diseases (SBPDs) are major public health issues worldwide, particularly in poor or developing countries and areas where snails are consumed as food (Lu et al 2018). Land snails are found in almost all terrestrial habitats. They are found in abundance in many parts of the world and have been implicated as intermediate host to a number of parasites (Urabe 2003; Saglam and Gokham 2006; Safer 2007; Liboria 2010; Sagade 2011; Barimah 2013). Several terrestrial gastropods have also been reported in different parts of Nigeria (Fashuyi and Adeoye, 1986; Gadzama, 2012; Chukwuka et al. 2014; Igbinosa et al. 2016; Onyishi et al. 2018).

Studies on snail helminth parasite in Nigeria have over the years focused largely on Schistosoma species intermediate hosts. The occurrence of aquatic snails have been reported in different parts of Nigeria (Okafor and Ngang, 2004; Ayanda, 2009). The report on parasitic helminthes of terrestrial land snails in Nigeria is lacking, although this has been reported in some parts of Africa (Kishinioto and Asato, 1974; Rashed, 2008; CDC, 2013; McLaughlin, 2016). Consumption of snail meat can lead to human infection when such meat are undercooked or eaten raw (Caron et al 2014; Igbinosa et al 2016). Therefore, determination of snail parasitic infections has become something of great concern. The findings of this study revealed a high infection rate in the collected and examined edible land snails from the North-Central parts of Nigeria. Transmission and infection of snails with soil transmitted helminthes is common in areas with warm and moist climatic conditions and especially where hygiene and sanitary conditions are very poor. Snail abundance and distribution are influenced by several factors with availability of food, predation weather and human consumption and diseases playing significant roles (Onyishi et al, 2018). Favourable weather condition, especially rainy season play a key role in snail abundance because this associated with high humidity promotes snail proliferation (Sukikowska-Drozd, 2005; Nunes and Santos, 2012) and availability of food. The high number of Achatina and Achachatina snails (143 and 257 respectively) collected during this study may be due to their high proliferation rates such that within a short period they can displace other snail species on one hand, and in the other impose colossal loss to farmers when they act as pest (Raut and Barker, 2002; Ugwu et al., 2011; Nelson, 2012; Nyameasem and Borketey-La, 2014). S. stercoralis is a soil transmitted parasite. In this study, a 100% prevalence rate of S. stercoralis was recorded in infected snail. Our findings agree with Igbinosa et al. (2016) who also recorded a similar result in land snails from Edo State. This is not surprising due to its abundance in the soil, coupled with its ability to easily locate its host from the urocanic acid that its host may possibly exude (Safer et al. 2007) that serves as an attractant. The parasite could also easily penetrate any exposed body part and infect the snail due to its morphological and parasitic features. S. stercoralis occurrence in all infected snails further highlights its ubiquitous nature. Alaria parasites were isolated from six out of seven snail species (except Achachatinasuturalis). This is in contradiction with the findings reported by Igbinosa et al (2016) where they isolated Alaria parasites in Lamicolaria and Limicoriopsis but not in Achatina and Achachatina species. These differences may be as a result of location and a coalition of sanitary and hygienic conditions. Although the definitive and intermediate host of this parasite are not land snails, there presence in most land snails examined is alarming. The need to investigate further the role of these snails either in the disease transmission cycle or as unidentified intermediate host is called into question. A. cantonensis (Rat Lungworm) is a zoonotic parasitic nematode inhabiting the pulmonary arteries of rats. The definitive host is rat and several species of snails serve as intermediate hosts (Tunholi-Alves et al., 2012; Stockdale-Walden, et al 2015). A. cantonensis may cause oesinophilis meningitis and central nervous system angiostrongyliasis in humans if accidentally ingested (Cawas, et al, 2020) and has been reported in giant African snails (Kim et al., 2014; Iwanowicz et al., 2015). Cawas et al., (2020) recorded 18.27% prevalence rate. This figure is low when compared with the 76.73% recorded in this study. This we attributed to differences in types of snail species examined, geographical location and level of environmental hygiene between the study areas. Freshwater snails are known to be intermediate host to several parasites and the family Lymnaeidae are well documented for their active roles in the life cycle of F. gigantica. An increasing number of other molluscan intermediate hosts of F. gigantica have been reported (Soliman, 2008). In this study L. aurora haboured the widest range of parasites among collected snails, in which is F. gigantica was not an exception. These parasites were only found amongst all three genera of the collected snails. However, only four out of the seven species examined were positive for F. gigantica, an indication that the parasite may be species specific. D. dendriticum is known to have two intermediate hosts (Igbinosa et al.,2018) and the parasite isolated only in Limicolariaflammea. Our findings however showed otherwise. D. dendriticum was isolated from Limicolariaflammea, Limicolaria aurora,

Achatinaachatina, Achatinafulica and Achachatina ovum. This an indication that if their preferred snail hosts are not readily available, the available snail host may serve as the preferred.

5. Conclusion

The results obtained from this study indicated that large wild terrestrial snails within the study area are heavily infected, carry different types of parasites and his poses a public health threat. Multiple infections were recorded in most of the infected snails and most predominant is Strongyloidesstercoralis and Entamoeba sp. recording the least.

We therefore strongly recommend a public awareness amongst residents of the study area by public health officials to help spread the knowledge about zoonotic parasites and the danger of consuming wild terrestrial snails. Emphasis should be placed on proper cooking and avoiding raw snail meat consumption if wild terrestrial snail is to be picked at all for consumption. In addition, rearing of large edible snails at home or farm are strongly recommended.

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7. References

i. Arvanitoyannis, I.S. and Varzakas, T.H. (2009). Application of Çfailure mode and effect analysis (FMEA) and causes and effectanalysis in conjunction with ISO 22000 to a snail (Helix aspersa) processing plant: A case study. Critical Reviews in Food Science40(7):607-625.
ii. Ayanda O.I. (2009). Prevalence of snail vectors of schistosomiasis and their infection rates in two localities within Ahmadubello University (ABU) capus, Zaria, Kaduna State, Nigeria. Journal of cell and Animal Biology. 3(4):58-61.
iii. Barimah, M.N.Y. (2013). Microbiological Quality of Edible Land Snails from Selected Markets in Ghana (Doctoral dissertation,University of Ghana).
iv. Bequaert, J.C. (1950). Studies in the Achatininae, a group of African land snails. Bulletin of the Museum of Comparative Zoology, 105(1):1-216.
v. Caron, Y., Martens, K., Lempereur, L., Saegerman, C. and Losson, B. (2014). New insight in lymnaeid snails (Mollusca,
vi. Gastropoda) as intermediate host of Fasciola hepatica (Trematode, Digenea) in Belgium and Luxembourg. Parasites and Vectors
vii. 7:66. Doi: 10.1186/1756-3305-7-66.
viii. Cawas, J.R., Quisao, C.J.T., Castillo, D.S.C., Pornobi, K.O. (2020). Prevalence of Angiostrongyluscantonensis among different
ix. species of snails in the village of BagongSikat Munoz, Nueva Ecija, Philippines and its associated risk factors foe zoonotic transmission. Journal of Parasitic Diseases, 44(2):388-394. doi: 10.1007/s12639-020-01200-0.
x. Center for Disease Control and Prevention (CDC)(2013). Dicrocoeliasis (Dicrocoeliumdendriticulum)www.cdc.gov/dpdx/docrocoeliasis/index/html. (Accessed February 2016).
xi. Chukwuka, C.O., Ejere, V.C., Asogwa, C.N., Nnamonu, E.I., Okeke, O.C., Odii, E.I., Igwu, G.C., Okanya, L.C. and Levi, C.A.
xii. (2014). Eco-physiological adaptation of the land snail Achatinaachatina (Gastropoda: pulmonata) in tropical agro-ecosystem
xiii. Journal of Basic and Applied Zoology 67:48-57. https://doi.org/10.1016/j.joba.2014.06.001.
xiv. d'Ovidio, D., Nermut, J., Adami,C. and santiro, M. (2019). Occurrence of Rhabditid Nematodes in the Pet giant African Land Snail
xv. (Achatinafulica). Frontier in Veterinary Science 6(88):1-5.
xvi. Fashuyi, S.A. and Adeoye, G.O. (1986). The possible snail intermediate host of Dicrocoelium hopes in Nigeria. Acta Veterinaria
xvii. Brno. 551:85-88. https://doi.org/10.2754/avb198655010085.
xviii. Gadzama, I.M.K. (2012). Distribution and taxonomy of molluscs (Mollusca) in some parts of Northern Nigeria. PhD. Desertation,
xix. Department of Biological Sciences, Ahmadu Bello University, Zaria, Nigeria.
xx. Göçer, M., Olgunoğlu, İ.A. (2018). Comparison of Fatty Acid Profile of Edible Tissues of Wild Terrestrial Snail (Helix lucorum
xxi. L.1758) Collected in Two Province (Adana and Sinop). Turkish Journal of Agriculture - Food Science and Technology, 6(7), 877-880
xxii. Igbinosa I.B., Isaac C, Adamu H. O. and Adeleke G. (2016). Parasites of edible land snails in Edo State, Nigeria.Helminthologia.53:331–5. Doi: 10.1515/helmin-2016-0031.
xxiii. Iwanowicz, D.D., Sanders, L. R., Schill, B.W., Xayavong, M.V., Da Silva JA, Qvarnstrom, Y. Smith, T. (2015). Spread of the Rat
xxiv. Lungworm (Angiostrongyluscantonensis) in Giant African Land Snails (Lissachatinafulica) in Florida, USA. J. Wildl. Dis.,51(3):749 – 753. doi: 10.7589/2014-06-160.
xxv. Kerney, M.P., Cameron, R.A.D. (1979). A field guide to the land snails of Britain and North-West Europe, Collins, London. Pp228.

xxvi. Kim, J.R., Hayes, K.A., Yeung, N.W., Cowie, R.H. (2014): Diverse gastropod hosts of Angiostrongyluscantonensis, the rat lungworm, globally and with a focus on the Hawaiian Islands. PLoS One, 9(5): e94969. doi: 10.1371/journal.pone.0094969.

xxvii. Kishinioto, T. and Asato, R. (1974). A survey of Angiostrongylus cantonensis on Okinawa: Incidence in rats and Achatinafulica. Public health 8:97-107.

xxviii. Liboria, M., Morales, G., Carmen, S., Isbelia, S., Luz, A. (2010). First finding in Venezuela of Schistosomamansoni eggs and other helminths of interest in public health found in faeces and mucous secretion of the molluscAchatinafulica (Bowdich, 1822).

xxix. Zootecnia Tropical, 28(3), 383-394

xxx. Lu, X.T., Gu, Q.Y., Limpanont, Y., Song, L.G., Wu, Z.D., Okanurak, K., Lv, Z.Y. (2018). Snail-borne parasitic diseases: anupdate on global epidemiological distribution, transmission interruption and control methods. Infectious Diseases of Poverty, 7(1), 28

xxxi. McLaughlin, J. (2016). The giant African snail: What you need to know about the rat lungworm, mollusks and human disease. www.miamidade.ifas.ufl.edu/pdfs/urban_hort/The%20giant%20African%20land%20snail%20and20lungworm.pdf (Accessed 1 September, 2020).

xxxii. Nelson, S. (2012). The giant African Snail. Hanai'Ai/the food provider. Hawaii.

xxxiii. Nunes, G.K.M. and Santos, S.B.(2012). Environmental factors affecting the distribution of land snails in the atlantic rainforest ofIlha Grande, Angra dos Reis, R.J. Brazil. Brazil Journal of Biology 72:79-86.

xxxiv. Nyameasem, J.K. and Borketey-La, E.B. (2014). Pest incidence, mortality, aestivation, feed intake and growth in West Africangiant snail (Achatinaachatina) reared under different housing systems. Int. J. Sci. Technol., 3: 314–319.

xxxv. Nyameasem, J.K. and Burketey-La, E.B. (2014). Pest incidence, mortality, aestivation, feed intake and growth in West Africagiant snail (Achatinaachatina) reared under different housing systems. International journal of Science and Technolohy 3:314-319.

xxxvi. Okafor, F.C. and Ngang, I. (2004). Freshwater snails of Niger-Cem. Nkalagu Eastern Nigeria: Observations on somedemographic aspects of the schistosome-transmitting Bulinids. Animal Research International 1:120-124.

xxxvii. Olgunoglu, I.A. and Olgunoglu, M.P. (2009). Preparation of frozen buttered snail (Helix lucorum Linnaeus, 1758) meat andanalyses of food labels. Research journal of Biological Science 2(1):35-39.

xxxviii. Onyishi, G.C., Aguzie, I.O., Okoro, J.O., Nwani, C.D. Ezenwayi, N., Oluah, N.S. and Okafor, F.C. (2018). Terrestrial snail

xxxix. fauna and associated helminth parasites in a tropical semi-urban zone, Enugu state, Nigeria. Pakistan Journal of Zoology 50(3):1079-1085.

xl. Opisa, S., Odiere, M.R., Jura, W.G.Z.O., Karanja, M.S.D. and MWinzi, M.N.P. (2011). Malacological survey and geographicdistribution of vector snail for schistosomiasis within informal settlement of Kisumu City, Western Kenya. Parasites andVectors 4:226. Doi: 10.1186/1756-3305-4-226.

xli. Petsnails.co.uk Retrieved 03/05/2018

xlii. Rashed, A.A. (2008). A new parasitic metacercaria from the land snail Minachaobstuta Pfeiffer 1842 with critical review onrelevant metacercariae belonging to the genus BrachylaimaDujardin 1843. Journal of Egypt Society of Parasitology 38:484-500.

xliii. Raut, S.K. and Baker, G.M. (2002). AchatinafulicaBowdich and other Achatinidae as pests in tropical agriculture.

xliv. Wallingford: CAB International, United Kingdom. p. 55–114 https://doi.org/10.1079/9780851993201.0055.

xlv. Safer, D., Brenes, M., Dunipace, S. and Schad, G. (2007). Urocanic acid is a major chemoattractant for the skin penetratingparasitic nematode Strongyloidesstercoralis. Procedings of the National Academy of Sciences U.S.A. 104:1627-1630.Doi.10.1073/pnas.0610193104.

xlvi. Sağlam, N., Gökhan, H.B. (2006). Elazıg, KebanYöresindeYaşayanSalyangoz (Helix lucorum Linnaeus, 1758)'daEndohelmintlerinAraştırılması. Journal Su ÜrünleriDergisi, 23(2).

xlvii. Segade, P., Crespo, C., Garcia, N., Garcia-Estévez, J.M., Arias, C., Iglesias, R. (2011). Brachylaimaaspersae n. sp. (Digenea:

xlviii. Brachylaimidae) infecting farmed snails in NW Spain: Morphology, life cycle, pathology, and implications for heliciculture. Veterinary Parasitology 175(3-4), 273-286.

xlix. Segun, A.O. (1973). Land Snail (Dissection guides of common tropical animals. Ethiope Publications.

l. Soliman, M.F.M. (2008). Epidemiological review of human and animal fascioliasis in Egypt. Journal of Infection inDeveloping Countries, 2(3): 182–189. doi: 10.3855/jidc.260

li. Stockdale-Walden H, Slapcinsky J, Qvarnstrom Y, McIntosh A, Bishop H, Rosseland B (2015). Angiostrongyluscantonensisin introduced gastropods in Southern Florida. Journal of Parasitology, 101(2):156–159.

lii. Sulikowska-Drozd, A. (2005). Habitat choice in the Carpathian land snails Macrogastratumida (Rossmässler, 1836) and

liii. Vestiaturgida (Rossmässler, 1836) (Gastropoda: Clausiliidae). Journal of Mulluscan Studies 71:105-112. https://doi.org/10.1093/mollus/eyi013.

liv. Toader-Williams, A., Golubkina, N. (2009). Investigation upon the edible snail's potential as source of selenium for humanhealth and nutrition observing its food chemical contaminant risk factor with heavy metals. Bulletin of University ofAgricultural Sciences and Veterinary Medicine Cluj-Napoca, 66(2), 495-499.

lv. Tunholi-Alves V, Tunholi V, Pinheiro J, Thiengo S (2012) Effects of infection by larvae of Angiostrongyluscantonensis(Nematoda, Metastongylidae) on the metabolism of the experimental intermediate host Biomphalariaglabrata. Experimental\Parasitology 131:143–147.
lvi. Ugwu, S.O.C., Ogbu, C.C. and Ikechiuno, I.K. (2011). Reproduction characterization of three species of giant African landsnails (GALS) in captivity. African Journal of Biotechnology 10:10315-10319. https://doi.org/10.5897/AJB11.875.
lvii. Urabe, M. (2003). Trematode fauna of prosobranch snails of the genus Semisulcospira in Lake Biwa and the connecteddrainage system. Parasitology International, 52(1), 21-34.
lviii. Yildirim, F.Y., Ulosoy, B.H., Erdogmus, S.Z. and Hecer, C. (2020). A survey study on parasite presence of edible wild terrestrial snails (Helix pomata L.)in Northern Ccyprus. International Journal of Scientific and technological Research 6(9):11-16.
lix. Zachariah, T. and Mitchell, M. (2009). Invertebrates In: Mitchell M.A., Tully, T. editors. Manual of exotic pet practice. St.Louis, MO: Saunders Elsevier p.11-38.