Porcine Cysticercosis Seroprevalence and Potential Transmission Risk Factors in Iringa District Council, Tanzania

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Research Article

Keywords: Baseline, porcine cysticercosis, seroprevalence, digital health education, Tanzania, pig

Posted Date: June 7th, 2021

DOI: https://doi.org/10.21203/rs.3.rs-543414/v1

Abstract

Background

Porcine cysticercosis is endemic in Tanzania, especially in the southern, central part and northern highlands of the country. The disease reduces meat quality and affects pig industry. This study investigated porcine cysticercosis prevalence and possible risk factors for reference in preparation for sustainable control measures.

Methods

Current seroprevalence and potential risk factors were studied in selected ward/villages of Iringa district council, in the southern highland of Tanzania, prior to a digital health education intervention. A total of 346 pigs from 88 households of Izazi, Migoli and Mlowa wards were studied using an enzyme-linked immunosorbent assay (ELISA), which detects Taenia species antigens (Ag) in sera. Questionnaire used to dig information on pig management and sanitation and hygiene practices.

Results

The AgELISA detected 22.3% of the surveyed pigs as positive for porcine cysticercosis. The detected porcine cysticercosis seropositivity ranged between 21.3% and 25.7% per individual ward, with at least one seropositive pig in 53.4% of the surveyed households. Confining pigs was significantly related to low porcine cysticercosis seropositivity (OR = 2.426; 95% CI = 1.202–5.300; p = 0.026), whereas scavenging pigs had two times chance of being Ag-ELISA seropositive.

Conclusions

Pig confinement and feeding skills and community sensitization on hygiene and sanitation are recommended. Therefore, practical ways of delivering health education to rural communities such as the studied community should be investigated.

1. Introduction

The population of pigs in Tanzania is around 2 million, mostly kept under small scale production or as a farmyard activity (Michael et al., 2018). This population was estimated to be kept by 22.4% agricultural households (Kimbiet al., 2015) of both in rural and urban areas. Pig farming contributes to more than a quarter of rural livelihood and with a contribution to urban community livelihood. Globally, pig production has shown an increasing trend in developing countries, reaching 60% of the world pig production by 2020 (Zhang et al., 2012). Despite the on-going pig production efforts, the pig business encounters various constraints, including diseases (McGlone, 2013). Porcine cysticercosis is one of the diseases that hinder

production by reducing meat quality (Mkupasi et al., 2013). The disease is caused by a zoonotic parasite *Taenia solium* that also causes taeniosis and cysticercosis, worse neurocysticercosis in humans (Winkler, 2012). Cysticercosis causes up to 30% epilepsy cases in humans in endemic areas (WHO, 2020).

Porcine cysticercosis is common in developing countries with sub-standard pig rearing systems (Blocher and Auer, 2011). In Tanzania, the disease prevalence ranges between 1.5–33.3% based on different studies by antigen ELISA test conducted previously (Ngowi et al., 2019). The highest prevalence has been reported in Iringa, Mbeya, and Ruvuma regions in the southern highlands that contribute to about 54% of Tanzania pigs production (Kimbi et al., 2015). Some studies in Tanzania have associated porcine cysticercosis with free-range pig rearing systems, lacking household latrine, drinking water form rivers and ponds, feeding pigs peels from tuber foods and any possible environmental contamination with *Taenia solium* eggs (Ngowi et al., 2019).

Education on construction of modern pig housing with locally available resources, improved pig feeding and environmental sanitation and hygiene were recommended as important *Taenia solium* control strategies in Tanzania (Ertel et al., 2017; Lauridsen et al., 2019; Ngowi et al., 2008; Ngowi et al., 2019). Since infection persists in communities with free-roaming pigs, poor use of toilets, poor public hygiene and sanitation (Kavishe et al., 2017; Shonyela et al., 2017), community education might be a cornerstone in the control of the disease. Adherence to *Taenia solium* control measures varies in different societies that suggest for variations in levels of *Taenia solium* cysticercosis and taeniosis between regions and countries.

Community education through digital health education found to hasten knowledge transfer and effective diseases control worldwide (Ren et al., 2015). The Vicious Worm Educational Tool (VWET) was reported to be effective digital health education in *Taenia solium* zoonoses knowledge transfer among health and agricultural professionals in Mbeya region, Tanzania (Lauridsen et al., 2019). Efforts of digital health education based on cysticercosis control among smaholder pig-farmers in Iringa District Council (Holst et al., 2021), has created interest in investigating for the current porcine cysticercosis prevalence and possible risk factors to be references in the digital health education success.

This article reports the present porcine cysticercosis prevalence and potential transmission risk factors to set a baseline for determining the digital health education intervention effect.

2. Material And Methods

2.1 Study area

This study was conducted in Iringa Rural District in southern highlands of Tanzania. The district occupies 20,576 km^2 lying at 1600–2700 m above the main sea level and the estimated population was 254,032 (NBS, 2012). Average low temperature mostly is below 15°C and rainfall of up to 175 mm per year. The rain season is from November to May with a peak in January (World Weather Forecast, 2019). Pigs in this

area are predominantly kept on small scale farms. Iringa district was estimated to have 14.5% of the total pigs found in Iringa region that comprises five districts (NBS, 2012). The study was carried in nine villages that belong to three wards (Izazi, Migoli and Mlowa) (Fig. 1). The studied area was previously reported to have porcine cysticercosis prevalence of 7.5% by lingual palpation method (Yohana et al., 2013) and human taeniosis incidences in neighbouring regions (Mwanjali et al., 2013). Also the area was targeted for a community based digital health education intervention by providing the communities with free internet access and a digital health education platform, including porcine cysticercosis educational content (Holst et al., 2021). Izazi and Migoli wards were selected for the digital health education while Mlowa ward would serve as a control. The present study is a baseline assessment of porcine cysticercosis and potential risk .

2.2 Study design

The cross-sectional study was conducted between March and May, 2019, during the rainy season. Households were visited once during data collection period for interviews and pig blood samples.

2.3 Sample size and sampling

The number of pigs to be studied was estimated using the formula: $n = Z^2PQ/L^2$ where: n is the number of pigs to be examined and Z is a score for a confidence level. P is a known or estimated prevalence of the factor in the study area, Q is 1-P, a proportion free of the factor and L is an acceptable estimation error (Martin *et al.*, 1987). In this study Z was 1.96, calculated at 95% confidence level. P was estimated cysticercosis infected pigs in population (33% or 0.33) and Q was the proportion of pigs not infected with cysticercosis (1-0.33). L was the estimated error of the study (5% or 0.05). Thus a total of 339 pigs was required.

We aimed at sampling all eligible pigs in each selected household. Based on ward office records, one pig keeper had four pigs on average. Therefore, we included a random sample of 100 pig keeping households to achieve our sample size. The random sampling was done in Microsoft Excel worksheet with official list of 423 known pig keeping households. Out of the 100 selected households, 88 (88%) agreed to participate. These households had a total of 346 eligible pigs, hence more than the calculted sample size of 339 pigs, and enough to the required sample size. Reasons for non-participation of some households were; refusal by a spouse (n = 7) or unexplained no-show despite several attempts of phone calls and home visits (n = 5).

2.4 Pig blood sample collection

Prior to sampling, we used a checklist to obtain a brief animal history from the respondents, including the animal age and likelihood of pregnancy in females. Only animals above 2 months of age and for female pigs observed or informed not pregnant, were blood sampled. Piglets below 2 months and pregnant sows were excluded to avoid stressing that could lead to adverse effects. A pig was restrained using a pig snare and about 5 ml of blood was collected through external jugular vein puncture into a plain vacutainer tube (Swindle, 2010). The collected blood sample was immediately stored in a cool box in an

upright position. Then samples were transported to the mini-laboratory at Migoli ward dispensary for centrifugation and serum harvest. Harvested serum sample were kept in 2ml cryogenic tube per pig and temporarily stored at -20^{0}C in Migoli temporarily before they were transported to Sokoine University of Agriculture for further storage and analysis.

2.5 Questionnaire and observational data collection

A structured questionnaire was prepared in English and translated to Swahili. It was administered by face-to-face interview to respondents in the study households. For each study household a family head or adult representative was interviewed. The basic information collected included; duration and experience in pig rearing, reasons for an adopted pig rearing system and the purpose of keeping pigs. Upon permission from the household head or representative, a researcher examined the household latrines and pig pen through direct observations based on quality parameters described elsewhere (FAO 2009; FAO 2010). The latrine and pig pen quality were scored according to a scaled evaluation chart.

2.6 Analysis for porcine cysticercosis seroconversion

Sample analysis was conducted at the CYSTINET-Africa laboratory in the College of Veterinary Medicine and Biomedical Sciences, Sokoine University of Agriculture, Morogoro Tanzania, approximately 407.1 km from the study area. Frozen serum samples were thawn at room temperature for 30 min, analysed for *Taenia solium* antigens using Enzyme-Linked Immunosorbent Assay (ELISA) and interpreted as per manufacturer's instructions (apDia, Belgium). Antigen index $\leq$ 0.8 was considered negative, antigen index $\geq$ 1.3 was considered positive readings, while values greater than 0.8 and less than 1.3 were judged as doubtful results and re-analysed.

2.7 Data analysis

Each completed questionnaire transcript was assigned an identification code and its data entered into a Microsoft Excel spreadsheet together with its pig data for analysis. The frequency and distribution of cysticercosis positive samples were generated in the same program. The association of the disease prevalence and household factors were analysed using regression analysis in the Statistical Package for Social Sciences (SPSS) version 20 of Armonk in New York.

3 Results

3.1 General results

The 88 surveyed households, the 346 studied animals and 75 pig pens presented in Table 1. A total of 13 households were practising totally free range pigs keeping, they had no pig pens.

Table 1
Presents households respondents, studied animals and pig pens particulars

Studied Particulars	Sample size (n)	Percentage (%)
Respondents: Male	60	68.5
Female	28	31.8
Respondents from: Izazi ward	15	17.0
Migoli ward	33	37.5
Mlowa ward	40	45.5
Household had pig pen? Yes	75	85.2
No	13	14.8
Studied animals: Male	121	35.0
Female	225	65.0
Animal raised: Indoor	298	86.1
Outdoor	48	13.9
Indoor raised animals: In good-pen	168	48.6
In poor-pen	178	51.4
Studied pig pens: Old appearance	63	84.0
New appearance	12	16.0
Old pig pen status: Good	27	42.9
Poor	36	57.1
New pig pen status: Good	8	66.7
Poor	4	33.3

Table 1: Pig-pen condition scores

Score	Condition	Elaboration
1-2	Very poor	Unsteady woody stick walls, Earth-soggy floors, no feeders, the pen in dirty condition with heaped manure inside, no doors
3-4	Poor	Unsteady woody stick walls, Earth-soggy floors, broken dirty feeders, the pen in a dirty condition, no doors
5-6	Fair	Wood sticks walls, Earth floors, dirty feeders, and the pen in a dirty condition. Have a lockable entrance
7-8	Good	Wood timber or brick walls, wood timber raised floors, clean feeders. Have lockable doors/entrances
9-10	Very good	Wood timber or brick walls, full protection from sun/rain, concrete or wood timber raised floors, clean steady feeders, floor and walls clean. Have lockable doors/entrances

Pig pens statuses in the three studied wards presented in Table 2. Of which Izazi ward had few number of pigs kept in pig-pen and farmers were having only old made pig-pen.

Table 2
Presents housed pigs and pens appearance in three studied wards

Ward	**Indoor pigs**		**Pigs kept in good pen**	**Pigs kept in poor pen**	**Pigs kept in new pen**	**Pigs kept in old pen**
	Yes (n)	**No (n)**	**(n)**	**(n)**	**(n)**	**(n)**
Izazi	49	21	25	45	0	70
Migoli	142	22	93	71	17	147
Mlowa	107	5	50	62	15	97
Total	**298**	**48**	**168**	**178**	**32**	**314**

Table 2: The latrine condition scores

Score	Condition	Elaboration
1-2	Very poor	No door (open doors), Earth-damp floors, Floor have see-through holes, Short walls (less than 1.5 m), Walls have see-through spaces, No roof
3-4	Poor	No lockable doors (have a cloth to protect view), Earth-damp floors, Short walls (less than 1.5 m), No roof
5-6	Fair	Have lockable doors, Earth but neat floors, high walls (more than 1.5 m), have a roof but cannot protect leakage from rainwater
7-8	Good	Have lockable door with a stopper, Earth but neat floors, high tight strong walls (more than 1.5 m), have a roof that protects rain
9-10	Very good	Have lockable doors with a stopper, concrete neat floors, high tight strong walls (more than 1.5 m), have a roof that protects rain, pit-hole have a cover, toilet in clean condition, have hand washing facilities

3.2 Seroprevalence of porcine cysticercosis

The overall porcine cysticercosis seroprevalence was 22.3% (positive = 77, n = 346), ranging from 21.3% (positive = 35, n = 164) to 25.7% (positive = 18, n = 70) among the three wards. Of the 88 assessed households, 47 (53.4%) had at least one infected pig; 11 (73%) from Izazi, 16 (48%) Migoli and 20 (50%) Mlowa (Table 3). The average percent of infected pigs per household was 47.2 % in Izazi, 42.0 % in Migoli and 46.6 % in Mlowa.

Table 3
Shows households with cysticercosis infected pig(s) in the studied wards

Ward	Households surveyed	Average pigs per households	Households with infected pigs n(%)	Average percent of infected pig per household (%)
Izazi	15	5	11 (73.3)	47.2
Migoli	33	5	16 (48.5)	42.0
Mlowa	40	3	20 (50.0)	46.6
Overall	**88**	**4**	**47 (53.4)**	**45.1**

3.3 Risk factors associated with the prevalence of porcine cysticercosis

This study revealed risk factors that were associated with porcine cysticercosis seroprevalence Significantly higher seroprevalence was found in scavenging than confined pigs (OR = 2.426; 95 % CI =

1.202–5.300; *p* = 0.026) (Table 4). Also pigs raised in low-quality pens were at risk of being infected compared to those raised in good-quality pens (OR = 1.747; 95 % CI = 1.021–2.989; *p* = 0.042). The poor pigpens were characterised with weak walls, rough and wet muddy floor. These poor pigpens were lacking drinking water supply, shade and enough space to accommodate the existing number of pigs. The latrine quality factor had nothing significant to do with cysticercosis seroprevalence, and disease prevalence was not associated with irregular latrine use.

Table 4
Presents risk factors associated with positive Ag-ELISA test.

Risk factors	Status	Ag-ELISA		CysticercosisPrev. n (%)	Odds ratio (OR)	Chi-square p-value
		+ve	**-ve**			
Confined pigs	Yes	64	247	311 (20.6)	2.426	0.026*
	No	13	22	35 (37.1)	(1.202–5.300)	Ref
Pig house quality	Good	31	137	168 (18.5)	1.747	0.042*
	Poor	46	132	178 (25.8)	(1.021–2.989)	Ref
Pig farming experience	> 6 months	72	252	324 (22.2)	0.867	0.956
	< 6 months	5	17	22 (22.7)	(0.471–3.905)	Ref
Household latrine quality	Good	41	157	198 (20.7)	1.469	0.424
	Poor	36	112	148 (24.3)	(0.858–2.518)	Ref
Evident latrine use	Yes	73	256	329 (22.4)	1.238	0.645
	No	4	13	17 23.5)	(0.476–1.708)	Ref

+ve = Postive; **-ve** = Negative; Prev. **=** Prevalence; *significant difference between positive and negative risk factor status during a study to estimate porcine cysticercosis prevalence

4 Discussion

According to this study, porcine cysticercosis seroprevalence was within the range of the previously reported in the endemic regions of the southern highlands of Tanzania (Ngowi et al., 2019). The 22.3% seroprevalence was the evidence of endemicity that support the findings reported in neighbouring regions of Mbeya and Ruvuma in Tanzania (Braae et al., 2014; Shonyela et al., 2017). This finding indicates that *Taenia solium* life cycle has maintained and the environments of these endemic settings has contaminated with *Taenia solium* eggs (Chacha et al., 2013). Having contaminated environment with

Taenia species eggs, signifies open defecation is practised in community. Also it was revealed that community practices related to sociocultural settings and lifestyles was concerned with the *Taenia solium* epidermiology (Kajuna *et all.*, 2021). Therefore in this study, more than half of the studied households had at least one potentially infected pig. Indicating the common animal feed sources were prone to contamination, may be during the time of feeds collection by individual from different locations. Most studied free roaming pigs had no shelters, making them highly vulnerable to infection in contaminated environments. Lacking or having poor pig pen could be attributed with porvety and ignorance of using locally available resources for pig management. Possible unallocation of budgets for pig feeding, housing and veterinary services characterises the most traditional small scale pig production (Kavishe *et all.*, 2017) preferred by low income households (Thyset al., 2016). Poverty makes the little earnings save first human basic needs and less or nothing for animals.

Pig roaming has been reported as an important risk factor for porcine cysticercosis in other studies in Tanzania (Komba et al., 2013; Shonyela et al., 2017) and in neighbouring countries of Kenya (Eshitera et al., 2012) and Mozambique (Pondja et al., 2010). The current study, revealed significantly higher prevalence in pigs reared under free range systems than confined ones. Given freedom pigs normally roam to supplement from farm leftovers (Thys et al., 2016) and whatever edible they meet on open ground including human dung. Pig producers in studied cites were missing information concerning health and wealth side effects associated with free ranged pigs. Traditional pig farming usually accompanied with home animal slaughters and less or no meat inspection (Fasina et al., 2020). This situation make the control of porcine cysticercosis a challenge, as pork can be consumed uninspected and thus enhance further transmission of the parasite (Kombaet al., 2013). Training related to improved pig management and pork control for optimum production and consumer safety would be necessary for these rural communities (Kimbi et al., 2015).

Improvement of environmental hygiene and sanitary practices has been presumed to encourage a *Taenia solium* free environment (Gabriël et al., 2016; Kavishe et al., 2017). Other studies in Tanzania (Maganira et al., 2019; Ngowi et al., 2004; Shonyela et al., 2017) and in Kenya (Eshitera et al., 2012;), have reported significantly high prevalence of porcine cysticercosis in areas lacking latrines. Pigs become exposed to *Taenia solium* eggs either by feeding on contaminated feeds or faeces from infested human. In the current study, household latrines were common, but latrine quality varied greatly. Surprisingly, latrine quality was not significantly associated with porcine cysticercosis disease prevalence. In the present study, community latrines were fixed with empty locally made handwashing facilities that were claimed to be for showing to public health inspectors when they visited households for inspection. Not washing hands after using the toilet predisposes community to cysticercosis, since *Taenia solium* carrier may spread worm eggs through contaminated hands (Winkler, 2012). A number of latrines had indications of not being used. Such abandoned latrines suggested open defecation, further encouraging transmission of *Taenia solium* infections as reported elsewhere (Okulloet al., 2017). The observed poor latrines and lack of use of the existing latrines may explain the reason for lacking statistical association of this factor with the prevelance of porcine cysticercosis.

Heath education improved the smallholder pig farmers' knowledge and attitudes towards *Taenia solium* control based on a previous study in Tanzania (Ngowi et al., 2011). Therefore community training and sensitization on safety latrine may promote latrine ownership and regular use in the community. The present study acknowledge community needs of sustainable health education on pig management, sanitation, hygiene and safety pork consumption for control of *Taenia solium* infection and other hygiene and meat borned diseases. Digital health education is presumed to enhance dissemination of knowledge that persist in community (Lauridsen et al., 2019) since it facilitates learning by unlimited training time and easy access to learning material (Gilman et al., 2012). With internet access, more people can access online digital health education.

5. Conclusion And Recommendation

Iringa District Council in Tanzania was still endemic for porcine cysticercosis after some years of no further studies on the subject matter. Pigs were traditionally produced; commonly in free range system making them prone to porcine cysticercosis infection. Farmers' training on proper and practical pig management is of importance, taking advantage of available local resources. It is important to design and evaluate effective and sustainable ways to train the local communities on *Taenia solium*.

Study limitations

Ag-ELISA test for porcine cysticercosis is only 82.7 % sensitive and 86.3% specific (Kabululu et al., 2020). Thus a few false positive or false negative results should be expected. In pigs, the assay test may cross-react with *Taenia hydatigena* and *Taenia asiatica* if the pig is infected with these *Taenia species*. Fortunately, *Taenia asiatica* has not been found in Tanzania to date. Thus the major concern at the moment is *Taenia hydatigena* and *Taenia solium.* In Tanzania, *Taenia hydatigena* is most common in sheep and goats. However, a study by Braae et al., (2015) reported prevalence of 6.6% in pigs, in goats and sheep reported prevalence of 45.7% and 51.9% respectively in Mbeya Tanzania. In addition, exclusion of pigs that were seemingly pregnant, lactating or piglets below two months might have underestimate or overestimate seroprevalence of porcine cysticercosis in the study area.

6. List Of Abbreviations

ELISA; enzyme-linked immunosorbent assay, Ag; antigens, DigI; Digital Inclusion, SUA; Sokoine University of Agriculture and NIMR; National Institute for Medical Research

7. Declarations

Research ethical clearance and consent to participate

This research was approved by the Sokoine University of Agriculture (Ref. No. SUA/ADM/R.1/8/316) and the Tanzania National Institute for Medical Research (Ref. No. NIMR/HQ/R.8a/Vol. IX/2947). Participants

were consented for participation. An identity number was assigned to each household instead of names, for confidentiality and data protection. Permission to carry out the study was also provided by the district, ward and village authorities of Iringa District Council (Ref. No. FA.255/265/01/PART ‘C;/72).

Consent for publication

Not applicable

Availability of data and materials

The analysed data are available from the corresponding author on reasonable request. These are the data from questionnaire, observation checklist and antigen ELISA test results from pig blood samples, were coded and entered into a Microsoft Excel spreadsheet window 10.

Competing interests

The authors declare that they have no competing interests.

Funding

Publication will be funded by the institute that supervised this research activities. (The Sokoine University of Agriculture in Morogoro, Tanzania).

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Acknowledgements

This study was funded by the Non-discriminating Access for Digital Inclusion (DigI) project co-financed by the Research Council of Norway. Grateful to the institute of Sokoine University of Agriculture (SUA) and National Institute for Medical Research in Tanzania (NIMR) for their support in pursuing the study. I acknowledge Ms Asha Makweta and Mr Albert Manyesela for their assistance in data collection. The ward executive officers, extension officers and livestock field officers of Izazi, Migoli and Mlowa wards. I am grateful to Mr Godson Kinyala for driving the team during the research works.

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Figures

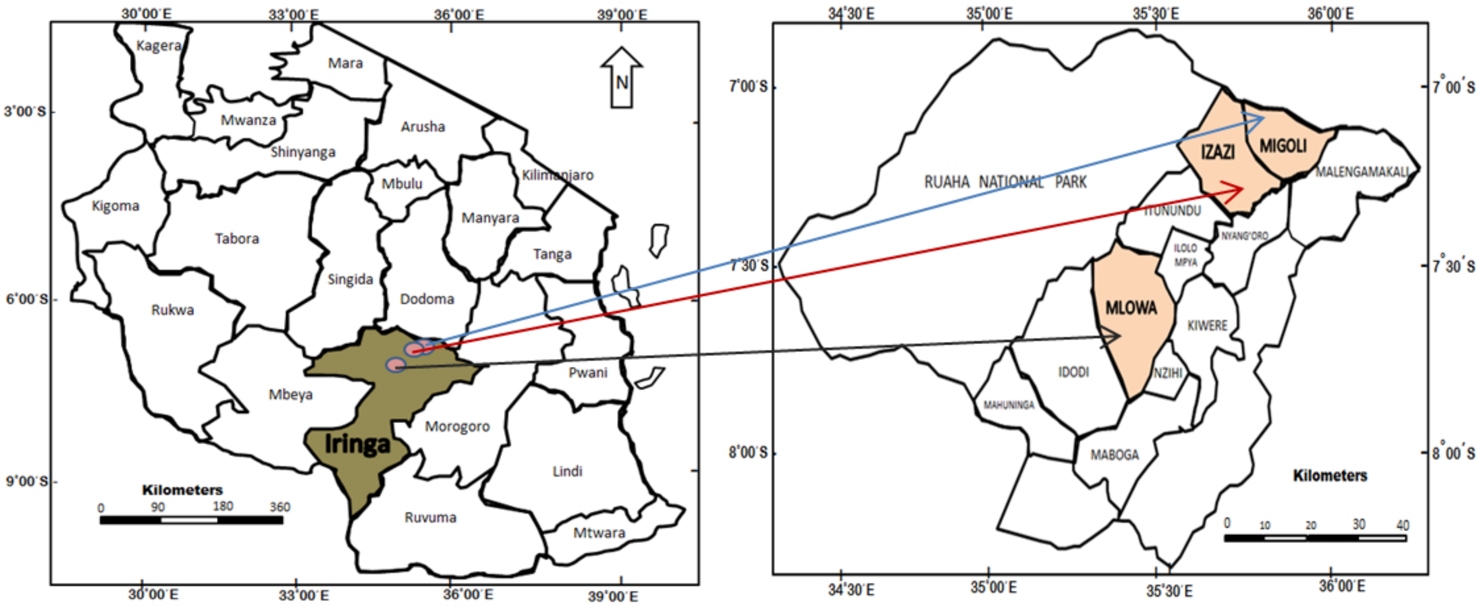

Figure 1

A sketch map of Tanzania, indicating the studied area in Iringa District Council. Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

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