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Captive breeding, developmental biology and commercial production of *Dravidia fasciata*- An indigenous ornamental fish of the Western Ghats of India

T.V. Anna Mercy*[1], Eapen Jacob[2] & K. Raju Thomas[3]

[1]*Kerala University of Fisheries and Ocean studies, Panangad, Cochin, 682506;*
[2]*Dept. Zoology, Govt. College, Kariyavattom, Trivandrum.;*
[3]*Dept. Zoology, Mar Thoma College, Thiruvalla, Kerala, 689103*

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Research article

ABSTRACT

Ornamental fishes of the Western Ghats of India have great demand in the export market. At present these fishes are collected from the wild and exported. Hence many times, the demand could not be met due to short supply. The only remedial measure for a sustainable supply is to produce the fish in captive conditions. Unfortunately, the breeding technology for the ornamental fishes of the Western Ghats of India has not been attempted seriously till date. The present paper is almost a pioneering attempt to develop captive breeding technology for 12 prioritized species of the indigenous ornamental fishes of the Western Ghats of India. *Dravidia fasciata* is one of them. It is popularly known as Melon barb. It is a beautiful barb, growing to a maximum size of 80 mm. In the present paper the methodology of captive breeding of this fish is provided with the economics of its production. Melon barbs were collected from the wild and brought to the hatchery of College of Fisheries in oxygen filled plastic bags and gradually acclimatized to the captive conditions. Its size at first maturity, sexual dimorphism, and developmental biology were studied and described with photographs. The total length (TL) at first maturity for males was 50 mm (50-55 mm) and 40 mm for females (40-45 mm). A sexually mature male developed beautiful pinkish red tinge all over the body. The black bands over the body also became deeper in colour during this time. The intensity of the colour reached its maximum during the courtship activities. Male also possessed nuptial tubercles on the operculum which could be identified only by keen observation. But a sexually mature female did not develop any colour change by the onset of sexual maturity. The results of the study clearly demonstrated that *D. fasciata* could be successfully produced in captivity through scientific management of brooders, eggs, larvae and hatchlings. The successful development of captive breeding technology is likely to pave way towards commercialization of the technology thus leading to the sustainable export of the species.

INTRODUCTION

Kerala has rich sources of water bodies such as rivers, lakes, reservoirs, canals and ponds. The rivers of Kerala possess rich diversity of ornamental fishes, with over 155 species of indigenous species (Mercy et al., 2007). Some of the potential ornamental fish of Kerala namely loachs, barbs, danios, catfishes, perches and cichlids are in great demand in export market. At present, these fishes are collected from the wild and exported. Even though Kerala

**corresponding author:*
Email: annamercy2002@yahoo.co.in

is a goldmine of indigenous ornamental fishes, the quantity of export is minimal. There are several reasons for the low export of fishes. The most important reason is that the exporters are not able to supply as per the demand. The demand usually, is for equal sized fishes in large quantities which cannot be supplied from wild collection alone. This can be achieved only through hatchery production. Hence, breeding in captivity is one of the desirable qualities of any ornamental fish. Unfortunately, the breeding technology for the ornamental fishes of the Western Ghats of India has not been attempted seriously till date, except for the work done by Mercy (2004) in which captive breeding technology was developed for 12 prioritized species of fishes. *D. fasciata* is one of them.

Dravidia fasciata is a beautiful indigenous ornamental fish found in the west flowing rivers of Goa, Karnataka, Kerala and up to Kanyakumari district in Tamil Nadu and also in the east flowing streams of River Cauvery basin in the foot of the Nallamala Hills (Jayaram, 1991). It is popularly known as melon barb. It is a small barb that grows to a maximum size of 8cm. It is omnivorous in diet and also is eaten by larger fish and crustaceans (Mercy et al., 2001). Captive studies on the behavior of the fish under aquarium conditions have shown that it occupies the mid water column in the tank.

Present paper describes the captive breeding technology of this beautiful ornamental fish. The development of captive breeding technology of this species clearly indicates that commercial production of *D. fasciata* is possible with this technology through scientific management of brooders, eggs, larvae and hatchlings. This success is likely to pave way towards commercial production of this species thus leading to its sustainable export.

MATERIALS AND METHODS

Specimens of *D. fasciata* were collected from River Pampa using cast net and small hand nets during the months of August-September (2002-05). They were brought to the hatchery of College of fisheries in oxygen filled plastic bags and gradually acclimatized to the captive conditions. Determination of size at first maturity and identification of male and female are two essential requirements for breeding a fish under captivity.

Size at first maturity

The length at which 50% of the fishes become mature is considered as the size at first maturity (Kagwade, 1975). Size at first maturity was computed with a total of 154 fishes of which 83 were females (ranging from 25 mm to 60 mm total length (TL)) and 71 were males (ranging from 30 mm to 65 mm TL). The total length of all the fishes collected was grouped according to different length groups. The percentage occurrences of mature fishes (early ripening, late ripening, ripe and partially spent) for both females and males were calculated. By plotting the percentage occurrence of mature fish (males and females) against respective length classes (5mm), the length at which 50% of the fishes become mature was demarcated.

Sexual Dimorphism

Different macroscopic and visual features were used for determining the sex of the individual. These includes 1) Overall body coloration (sexual dichromatism); 2) Bulginess of the stomach and 3) Behaviour in captive conditions

A total of 55 specimens were used for sex determination studies and they included fishes collected from their natural habitats and F1 and F2 generations of the hatchery reared fish. Different nuptial and breeding behavioral gestures like chasing; following, nubbing etc. also were used for distinguishing the sexes.

Development of brood stock

The brood stocks were raised on a mixed diet of artificial pelleted feed, live feeds like moina, mosquito larvae, blood worm and egg yolk. They were kept in glass tanks fitted with biological filter and in cement tanks devoid of biological filter. A daily water exchange at a rate of 1/3 was ensured in the cement tanks. They were continuously observed for their behavior in tanks. The maturity condition of the brooders was assessed based on the macroscopic characters such as body size, bulginess of belly and overall body colouration. Sometimes the behavioral patterns of the fishes were also considered. As the specimens became sexually mature they were separated sex-wise and kept in separate tanks of the same dimensions mentioned above.

Captive breeding

Breeding was conducted in small cement cisterns or round cement tanks as shown in the photographs (Plate). A breeding tank was set up providing the same water quality available in the natural habitat of the fish. The tank was cleaned properly and filled with water of desired quality up to three fourth of the tank. A separating net with small mesh mounted on a ring was kept 30cm above from bottom of the tank so that the eggs laid are fallen through the net to bottom of the tank This prevented the parents from devouring it. A pair of well-conditioned, fully mature melon barb (1:1 male: female) was introduced to the prepared breeding tank on an evening and were observed for their breeding. Next day morning eggs could be seen under the net trap in the tank. A total of 10 pair was used in each trial. The latency period was observed as the time duration between their introduction of conditioned pairs into the experimental tank and the start of spawning. Soon after the completion of laying eggs the fishes were removed from the breeding tank and the eggs were counted to find out the fecundity. The counting was conducted using the random sampling method.

Developmental biology

The fertilized eggs were collected soon after it was spawned. From each pair 5 to 10 eggs were collected and placed them in 2 liter capacity container. Developing eggs were observed with a trinocular microscope (Labomed) and photographs were taken with SLR camera (Nikon 90 X). The early developments up to hatching of the eggs were done in one hour interval. After hatching the developmental stages were photographed every 2 hours up to 24 hours and thereafter at every 24 hours up to the juvenile stage. All the measurements were taken under average room temperature of 26 to28 ˚C. The eggs were placed in cavity slides, immersed in water for observations and cavity blocks were used to observe larvae after hatching. The sampled eggs and larvae were fixed in 4% formalin for further observations.

In the present study, the developmental stages were divided into embryonic development, larval development and post larval development. The embryonic development started inside the

chorion and completed at hatching. The larval stage started from hatching and ended by the appearance of fin rays in all fins. After that, the larva was transformed into post larvae. The development of 25 individual embryos was documented right from fertilization. The water quality parameters were monitored weekly and daily exchange of 25% of water was done.

RESULTS AND DISCUSSION

Size at first maturity

The total length (TL) at first maturity was determined by analyzing the data relevant to all mature fishes (stage III and above examined). While the first mature male fishes appeared in 45-50 mm (TL) group (16.66 %), the first mature females appeared only in the group of 30-35 mm (16.66 %). All male fishes were matured on reaching a total length of 55 mm and all female fishes on reaching a length of 50 mm total length. The size at first maturity for males was 50 mm TL (50-55 mm) and for female it was 40 mm TL (40-45 mm) (Figure 1).

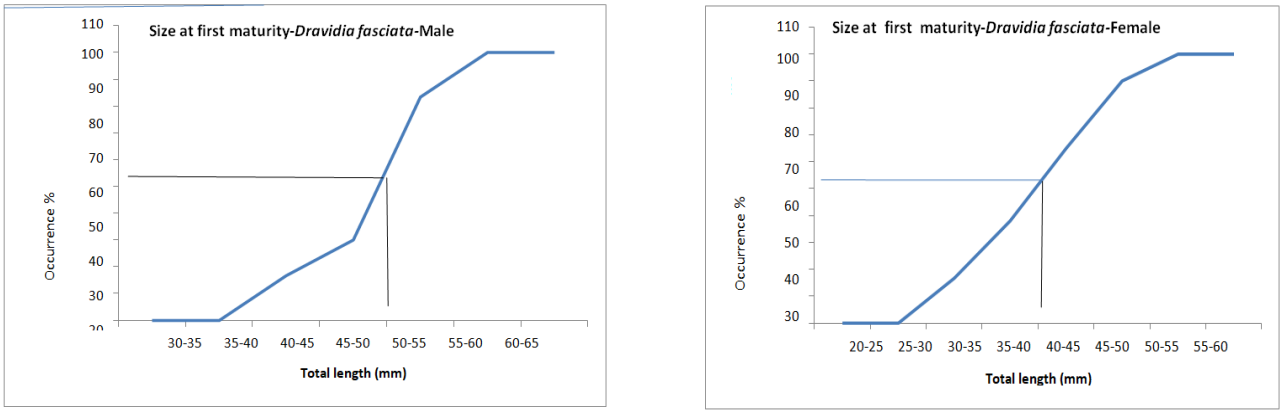

Figure 1. Size or total length of Dravidia fasciata at first maturity

The smallest mature male is within 40-45 mm length group. If the length at which 50% of the fishes are mature can be considered as the minimum length at first maturity (Kagwade, 1975), the specimens below 40 mm TL for males and 30 mm TL for females were not mature. The present study showed that the smallest mature male is bigger than that of the mature female in *D. fasciata*. Mercy et al. (2005) reported the size at first maturity of *Puntius melanostigma* as 50 mm for males and 55 mm for females. In the case of the African minnow, *Enteromius paludinosus,* sexual maturity was reached within a year at 50.0 mm TL (Cambray and Burton, 1985). In the case of European minnow, *Phoxinus phoxinus* the short lived populations of river Frome in England contained two spawning age groups and the largest fish caught was only 78.0 mm long. The size at first maturity ranged from 50-55 mm as two year olds (Mills, 1987). Six *Barbus* species studied in Sri Lanka had maximum total length of between 42.0 and 101.0 mm and a short life span (De Silva et al.,1985). In the freshwaters of South Africa out of the 52 *Barbus* species studied 43 attained maximum fork lengths of less than 150.0 mm (Cambray and Burton, 1985). The information on initial sexual maturity gives the ornamental fish producers the idea on the age at which the fish become mature

so that they could provide appropriate environment for the fish to spawn and obtain the maximum number of fry.

Sexual dimorphism

The male and female *Dravidia fasciata* showed clear differences in body coloration which could be termed as sexual dichromatism. The colour differences become prominent at the onset of sexual maturity. All the immature fish appeared in a dull grayish silvery colour. A sexually mature male developed beautiful pinkish red tinge all over the body (Figure 2). The black bands over the body also became deeper in colour during this time. The intensity of the colour reached its maximum during the courtship activities. But a sexually mature female did not develop any colour change by the onset of sexual maturity. It remained in the same colour pattern as that of a juvenile. Male also possessed nuptial tubercles on the operculum which could be identified only by keen observation. These types of nuptial tubercles are distinguishable in other cyprinids like gold fish, *Carassius auratus* and Indian major carps which have tubercles on pectoral fin rays also.

Another distinguishing character was the bulginess of stomach. A sexually mature female *Dravidia fasciata* exhibited a more swollen and deeper stomach than that of the males. The reproductive behavioural patterns exhibited during the onset of maturity were also used to distinguish sexes.

***Dravidia fasciata* male**	***Dravidia fasciata* female**
	

Figure 2. Sexual dichromatism of Dravidia fasciata

In cyprinids, sexual dimorphism in morphological characteristics other than colouration or presence of nuptial tubercles is uncommon (Scott and Crossman, 1973). Sexual dimorphism is a widespread phenomenon in fishes and may occur for a variety of reasons including, mate selection, male to male competition for mates, differences in sexual roles, predator avoidance, territoriality and ecological processes (Hubbs et al., 1974; Fernandes, 1998). Sexual dimorphism in body size, coloration, fin length, nuptial tubercles, and intromittent organs has been observed in many fish families (Scott and Crossman, 1973). Sex identification has practical applications in captive propagation processes.

Males and females usually differ not only in

reproductive organs, but also in external structures that are not directly related to reproduction. Information about sexual dimorphism is required for understanding the ecology, behavior and life history of a species. In addition, knowledge of sexual dimorphism and its appearance during ontogeny is indispensable when making morphological comparisons between populations. Although sexual differences in a variety of external structures have been noted in many species, studies on the sexual difference in fresh water fishes of India are less. A comprehensive study was done by Inasu (2008) in which sexual dimorphism of 26 species of Indian fishes was compiled. Mercy (2004) and Mercy et al. (2001, 2002, 2007, 2013) have described the sexual dimorphism of *Danio malabaricus, Pristolepis marginata*, *Puntius melanostigma*, *Garra mullya, Puntius pookodensis, Nemacheilus triangularis* and *Puntius denisonii*, which are important freshwater ornamental fishes of the Western Ghats of India.

Dravidia fasciata exhibited sexual dichromatism rather than sexual dimorphism. Breeding adults of male *D. fasciata* had marked sexual dichromatism. Males became pinkish when they became sexually mature. Reproductive females did not have pink colour. The colour became intense after the fish started breeding. It gradually faded after the courtship. This suggests that sexual dichromatism in the body is a secondary sexual character that may be regulated by reproductive hormones. Although sex in *D. fasciata* is genetically determined, it is currently unknown what genes or hormones might regulate secondary sexual dichromatism of body in this fish. Further analysis of the genetic and developmental mechanisms that underlie sexual dimorphism in *D. fasciata* will be possible by using the genomic tools established by Peichel et al. (2001) and Peichel (2005) and will provide a complement to ecological studies to discern the functional significance of sexual dichromtism in *D. fasciata.* Similar type of secondary sexual characters were also observedin *P. melanostigma* (Mercy et al., 2004) and *P. pookodensis* (Eapen, 2013).

Captive Breeding

The fully mature and well-conditioned male and female fishes were introduced in the prepared experimental tank (Plate) at a sex ratio of 1:1 (Female: Male). Soon after introduction, the fishes did not show any indication of breeding behavior. After half an hour, the fishes started its breeding behavioral signs like chasing, nubbing, following etc.

Breeding Behaviour

Parental care of the eggs and hatchlings either by male or by female parent was not observed in *D. fasciata.* It agrees with general behaviour of the cyprinid fishes. In the case of *D. fasciata,* it not only showed any signs of parental care but it also showed the tendency to deavour the eggs and hatchlings. So an appropriate breeding trap was needed in the captive breeding set up to protect them from the hungry parents. All cyprinids spawn using egg scattering methods and do not usually exercise parental care. But an exception is reported in fathead minnow *Pimephales promelas* (Sargent, 1989). The number of eggs spawned was at a range of 180 to 415 with a mean 264±86.6. The survival rate was at the range of 49 to 68%, with a mean 55.16±2.7.

Developmental biology

Embryonic development

Immediately after fertilization the eggs were swollen up considerably by absorbing water and within five minutes they attained a spherical, transparent and slightly adhesive structure. A streaming movement of the egg protoplasm took place, which resulted in the formation of blastodisc. The fertilized eggs of *D. fasciata* were amber coloured *en mass*, yolked, glossy, translucent and spherical with an average diameter of 0.85 mm (0.85 ± 0.02 mm). Like most other cyprinids the eggs of *D. fasciata* were free and demersal but not adhesive. The location of the micropylar region was distinct as a small depression in the animal pole, while it was absent in unfertilized eggs. The yolk which often had a yellowish tinge was coarsely granulated. The eggs were easily collected and transferred for incubation in hatching tanks with continuous oxygenation. The observations revealed that the hatching of eggs was accomplished 23 to 27 hrs in the ambient temperature of 26 ˚C (26 ± 2˚C). Neutral pH was maintained for the medium throughout the studies. After observations, some of the eggs were preserved in 5 % formalin for future studies. All measurements were made on fresh specimens using a calibrated ocular micrometer. Photographs of the developmental stages are provided in Plate (Annex).

The fertilized egg was telolecithal and cleavage was meroblastic. The blastoderm formed was restricted to animal pole at the point of entrance of sperm at the level of the micropyle, leaving large yolk mass at the vegetal pole. The first cleavage was meridional and incomplete. The second division was at perpendicular to the first and the third division resulted in the formation of 8 cells. The 4^{th} cleavage resulted in the formation of sixteen celled stage at 1.3 hrs and formation 32 celled stage occurred at about 1.45 hrs. A clear blastocoel began to appear at about 3.3 hrs and the blastula at this stage appeared as a cap of cells over the yolk. By 5 hrs it started to roll over the cytoplasm. After 5.5 hr, the blastoderm covered more than half of the yolk surface. At about 6.5 hours the early gastrula stage was reached and an embryonic shield was appeared. Gradually, epibolic germ layers were spread to the equator of the spherical yolk surface and at 6 hrs, the germ ring invaded $3/4^{th}$ of the yolk surface. At 7.5 hrs, the neural plate was formed and gradually almost $5/6^{th}$ of the yolk surfaces become invaded. As the blastopore got closed, yolk plug was projected and the head rudiment was seen lifted up. By 10 hrs, the optic rudiment appeared and gradually by 10.5hrs it became differentiated into a vesicle. At this stage, the head and tail got differentiated and the myotomes also became clearly visible. At 12 hrs the tail bud was formed and the embryo appeared very much elongated and was seen encircling over the yolk, reaching nearly $3/4^{th}$ of its circumference. At 15 hrs, caudal fin fold rudiment was drawn out from the yolk and the head region became more and more differentiated. Yolk sac got stretched and assumed a characteristic beaked appearance. Tail bud was projected out from the beak like yolk mass distally at around 16 hrs. Paired somites also became distinct at this point of time. At 18 hrs, optic vesicle became

conspicuous and the head region got separated; the caudal fin fold became very much elongated and the embryo appeared 'C' shaped encircling the yolk. At this period, the muscular somites were seen twitching at intervals. At 21 hrs the heart and optic capsule became conspicuous and embryonic movement became rapid. The heart began to pulsate at 21.5 h. At 22 hrs, tail got free and encircled almost 90 percent of the yolk mass. Gradually the heart pulsation became more rhythmic. The embryo began to roll within the egg case. As the development advanced, the embryo appeared more and more elongated and the tail overlapped the head. The myotomes and auditory vesicle became more prominent and the twitching of embryo started within the cytoplasm. As time passed the twitching movement of the embryo became faster.

Close to hatching, twitching and lashing of embryo inside the egg capsule became rapid. The egg shell was broken up and the tail emerged out first, followed by the head region. Hatching occurred at around 23.5 hrs. Egg hatching was protracted and the incubation period fluctuated between 23and 27 hrs post fertilization at the ambient temperature.

Newly hatched larva

The newly hatched larva appeared to be sluggish and remained at the bottom. It was transparent without any pigmentation. A continuous fin fold was present starting from the start of the dorsal fin, surrounding the tail and ended in the insertion of the ventral fin. Oral and anal orifices were completely absent. The length of the hatchling at this stage was 2.3 mm. In 24 hours it attained a mean length of 16 mm. Melanophores started to appear on the opticrim and myotomes.

At 48 hours, the larva appeared slender and elongated. The yolk was very much reduced, though not completely exhausted. The hatchlings gradually began to swim up towards the water surface and sometimes found hung up from the water surface. Melanophores became conspicuous on the body surface. Fin rays were started to appear in the pelvic fin and stomach was visible through the transparent body. Above the stomach the gas bladder appeared as a glittering droplet. A small depression was started to appear on the fin fold at the portion of anus.

Juvenile Phase: One month old juvenile (average 25.80 ±1.39 mm TL) of *D. fasciata* (Originally *Puntius)* showed vertical body banding pattern. Many species of *Puntius* possessed black body markings at their juvenile phase which were quite different in size and shape. The juveniles of *D. fasciata* possessed three vertical black cross bands at nuchal, pre dorsal and caudal positions. Details of embryonic developmental stages are given in Table 1

Table 1- The embryonic developmental stages of *Dravidia fasciata*

Time after fertilization (Hours)	Developmental event
01.30	16 celled stage
01.45	32 celled stage
02.00	Early morula
03.30	Blastulation; Blastodisc formation
06.50	Gastrulation; early gastrula
07.00	Late gastrula
07.50	Neurula stage
08.00	Closure of blastopore/ Yolk plug
10.00	Optic rudiment appears
12.00	Formation of head and tail, Appearance of myotomes
16.00	Tail region detaches from the yolk
21.00	Twitching
22.30	Heart beat and blood flow starts
23.00 – 24.00	Hatching

The knowledge on different embryonic stages and its timings of developmental events has importance in developing hatchery techniques of a species. As far as *D. fasciata* is concerned, because of its importance in the ornamental fish trade, defining an effective hatchery technique is tremendously valued. In general, developmental biology of a species consisted of embryonic, larval and juvenile stages. The morphology of larval and juvenile *D. fasciata viz.,* overall appearance, fin ray formation, and pigmentation patterns were similar to that of many other cyprinids such as *Puntius pookodensis* (Jacob, 2013) and also as reported by Jones (1938); Balinisky **(**1948) and McClure (1999).

It is also to be noted that *D. fasciata, Puntius filamentosus and Puntius denisonii* co-exist and breed in the same habitat at the same season and the larvae of all the three species look alike with dark bands across the body. It is quite difficult to distinguish between the larvae unless experienced. In the case of *P. filamentosus* and *P. denisonii* the cross-bands are retained for about one month. They gradually fade to a single spot at the caudal peduncle in the case of *P. filamentosus* whereas they are completely vanished in *P.denisonii* (Mercy et al., 2013). Dry-season spawning of *D. fasciata* has already been observed and published by Harikumar et al. (1994). In the present study it has been observed that the peak period of breeding of *D. fasciata* is during the months from November to March/April. De Silva et al. (1985) have reported that among *Puntius* species in SriLanka seasonal and perennial breeders share the same macrohabitat.

Survival rate

Number of eggs produced at a time ranged from 30-40 eggs per gram bodyweight. Average weight of the female fish was 10-12gms. About

90 % of the eggs were fertilized and at the end of one month survival rate was 60-65%. On an average from a pair of brood 180-200 young ones can be obtained if properly maintained.

The economics of production: the cost of production is summarized in the following table.

Fixed cost	In US$
Cement Tanks: 12 x $ 30	$ 360
Net + Accessories	$ 15
Operational cost	
Brood fish, 20 pair :20x$ 2	$ 40
Feed+ accessories	$ 50
Packing and sale	$ 15
Total expenditure	$ 480
Income : From a single brood minimum number of 150 fishes can be obtained after three months. So from 20 pairs 3000 melon barbs can be obtained on an average	
Sale of fish 3000x$0.5/	$1500

Reproductive strategy

Studies on different aspects of captive breeding revealed that *D. fasciata* is an asynchronous spawner *i.e*., continuous development and release of gametes in the gonads are evident. The fish did not show any affinity towards aquatic plants or the presence of plants did not have any stimulating effect to start the spawning activities. In general, the reproductive strategies of *D. fasciata* showed that it is an iteroparous species, *i.e*., they spawn more than once during their lives and gonochoristic*, i.e.,* their sexes were separate and exhibited external fertilization without parental care. The fish possessed an asynchronous type ovary *i.e.,* oocytes of all stages of development are present without dominant populations. But the peak breeding time of the fish is during the period from November to March. *D. fasciata* can be bred continuously if proper conditions are provided, but the peak season is during the months of November–March/April. The species could be categorized as a batch spawner *i.e.,* eggs are recruited and ovulated from the population of yolked oocytes in several batches over a protracted period during spawning season. A summary of reproductive strategies shown by *D. fasciata* is shown in table 2.

Table- 2: Summary of Reproductive strategies based on different components of breeding systems in *Dravidia fasciata*

Sl. No.	Component of breeding system	Reproductive strategy
1	Number of breeding opportunities	Iteroparous (Multiple breeding)
2	Type of spawning	Batch spawner
3	Mating system	Promiscuous (both sexes with multiple partners during breeding season)
4	Gender system	Gonochoristic
5	Secondary sexual characteristics	Sexually dichromatic
6	Spawning site preparation	No preparation
7	Place of fertilization	External
8	Embryonic development	Oviparity
9	Parental care	No parental care
10	Ecological group	Pelagophils
11	Reproductive guild (Balon1975)	Ecological classification: Non-Guarders Ethological classification: Open substratum spawners Morphotype :Pelagophils

CONCLUSION

The results of the study clearly demonstrated that *D. fasciata* could be successfully produced in captivity through scientific management of brooders, eggs, larvae and hatchlings. The successful development of captive breeding technology is likely to pave way towards commercialization of the technology thus leading to the sustainable export of the species as well as its conservation.

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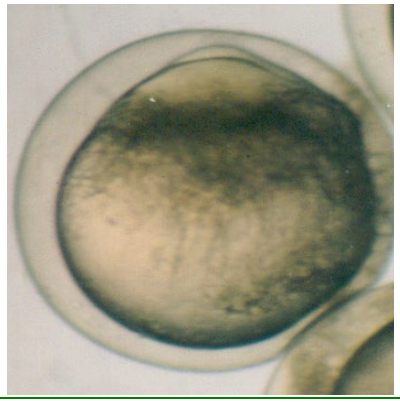
Plate: Developmental stages of *Dravidia fasciata*

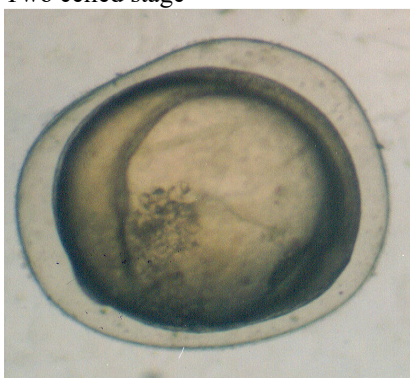
Single celled stage



Two celled stage

Four celled stage

Blastula stage



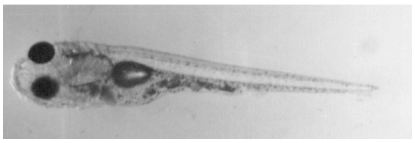
After four hours

After 10 hours

After 12 hours

Just hatched larva

24 hours after hatching



48 hours after hatching

Juveniles

Breeding tank

Breeding tank

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Study on clinically manifested reproductive health problems of dairy cows managed under intensive and semi-intensive production systems in Wondo Genet district, Southern Ethiopia

Amene Fekadu[1], Yifat Denbarga[1],Tesfaye Belay[2], Desie Sheferaw[1], Fufa Abunna[3], Kebede Amenu[3], Rahmeto Abebe[1], Mesele Abera[1], Berhanu Mekibib[1]*

[1]*Hawassa University, Faculty of Veterinary Medicine, P.O.Box 05, Hawassa, Ethiopia*
[2]*Hawassa University, College Forestry and Natural Resources, Wondo Genet, Ethiopia*
[3]*Addis Ababa University, College of Veterinary Medicine, P.O.Box 34, Bishoftu, Ethiopia*

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Dairy cows;

Production constraint;

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Wondo Genet

Research article

ABSTRACT

Reproductive disorders in cows are crucial as reproduction and fertility are the two key pillars of dairy production profitability. The study was conducted to identify and estimate the prevalence of clinically manifested postpartum reproductive disorders, to identify the associated risk factors and to estimate the sero-prevalence of brucellosis in dairy cows kept under intensive and semi-intensive dairy farms in Wondo Genet district from November 2019 to September 2020. Out of the total 205 cows examined, 90 cows (43.90%) had at least one of the reproductive problems identified by either questionnaire interview or regular follow up of individual cows. Out of 146 cows retrospectively and 59 cows prospectively assessed for the presence of any reproductive disorder, 62 (42.47%) and 28 (47.46%) cows had at least one reproductive disorders, respectively. Retained fetal membrane, abortion, uterine infections, anestrous and repeat breeding are the major reproductive disorders encountered followed by dystocia, milk fever and prolapses of the vagina and/or uterus. Among the considered host and management related risk factors, only presence of previous reproductive disorder had statistically significant association with the occurrence of reproductive disorder ($p<0.05$). This study also demonstrated that none of the serum samples collected from Wondo Genet and other towns (namely Hawassa, Wolaita Sodo and Arsi Negelle) and tested using Indirect Multi-species ELISA was positive for bovine brucellosis. Further studies, preferably laboratory based, should be conducted to identify the underlined causes of these problems in different parts of the country. Meanwhile, awareness should be created to farm owners/attendants to improve their farm management system.

INTRODUCTION

Dairying is one of the livestock productions practiced almost all over Ethiopia, involving a vast number of small, medium, or large-sized, subsistence or market-oriented farms (Abera, 2016). The dairy sector is dominated by traditional smallholder farmers who account for about 85% of the population and are responsible for 98% of the milk production (MoARD, 2007). Unfortunately, nearly 90% of the milk produced by the rural household is consumed

*Corresponding author:
Email: berhanumm2002@gmail.com, Phone +251- 91 024 8878

within the producer households with the proportion marketed being not more than 10% (CSA, 2020)

Owing to the rapidly increasing population size, low productivity of the local breeds (1.32 liter/cow per day), a growing urbanization and the concomitant growing demand for dairy products, the country is already in a very high demand-supply variance (Seifu and Doluschitz, 2014). To partly fill this gap, the country expends over 10 million USD annually for the import of dairy products from different countries (Tegegne *et al*., 2016). For a sustainable economic growth, however, both the public and private sectors are engaging in urban and peri-urban dairy development (Seifu and Doluschitz, 2014; Edao et al., 2018).

Despite the progressive growth in the commercial (market oriented) dairy farming in urban and peri-urban settings, the dairy industry is still underutilized and challenged by several factors. In general the development of the dairy sector is hindered by poor management system, shortage of proper nutrition, absence of well-developed market infrastructures and widespread infectious and parasitic diseases (MOA, 1998). Among health related issues, reproductive disorders in cows are crucial as reproduction and fertility are the two key pillars of dairy production profitability (LeBlanc, 2008). These problems, caused by infectious and non-infectious causes, are responsible to reduce milk yield and subsequent reproductive performance of dairy cows (Rajala and Gröhn, 1998; LeBlanc *et al*., 2002; LeBlanc, 2008) and ultimately cause premature and forced culling of high producing dairy cows (Esslemont and Peeler, 1993).

Bovine brucellosis, a bacterial zoonotic disease, is one of the infectious diseases assumed to hamper productivity of cattle in the country (Ibrahim et al., 2010; Edao et al., 2018). The disease in cattle is characterized clinically by abortion at third trimester of first gestation, retained fetal membrane (RFM), metritis, orchitis and epididymitis (Radostits et al., 2006). Bovine brucellosis has been reported from several parts of the country, particularly in cows kept in intensive and extensive management systems. However, recent reports particularly from central and southern Ethiopia are revealing a very low to zero prevalence (Alem and Solomon, 2002; Belihu, 2002; Asmare et al., 2013; Bashitu et al,.2015, Edao et al., 2018).

Although several studies have been conducted on the prevalence of bovine brucellosis (Asmare et al., 2013; Edao et al., 2018; Ataro e al., 2019; Dinknesh et al., 2019) and/or on the major reproductive disorders (Lobago et al., 2006; Hunduma, 2013; Wujira and Nibret, 2016; Yohannes and Alemu, 2019), majority are limited in the central highland, dairy farms of research centres and major towns/cities of the country. However, there is still paucity of information in some parts of the country including Wondo Genet district. Moreover, the scope of reproductive health in the dairy industry still demands more intensive investigation for better formulation of prevention strategies. Therefore, the present study is intended to identify and estimate the prevalence of the major clinically manifested postpartum reproductive disorders, to identify the associated risk factors and to estimate the sero-prevalence of brucellosis in dairy cows kept under intensive and semi-intensive dairy farms in Wondo Genet district.

MATERIALS AND METHODS

Study area

The study was conducted in Wondo Genet district, which is located 24km North East of Hawassa, the capital city of Sidama Regional state and 265.km to South of Addis Ababa, the capital of the country, Ethiopia. The district is classified administratively into 13 rural and 2 urban villages. It has temperature and altitude ranging from 7 to 26 °C and 1761 to 2695 m above sea level, respectively. The average rainfall is 1120 mm per annum and the main rainy season in the area is between July and early October (Bolka and Gebremedhin, 2019). In the area, animal husbandry is the main subsistent farming where cattle, sheep, goats and equines are the species of animals found (Jones et al., 2011). The town is known for its high potential in dairy production in Southern Ethiopia and major source of milk and other dairy products.

Study design

Study design and sample size

Both retrospective (questionnaire based) and prospective (follow-up and serological) studies were undertaken from November 2019 to September 2020 to estimate the prevalence of major reproductive problems in dairy cows. All female cattle with at least one calving history were purposively selected for the retrospective survey. For the prospective follow-up study, however, all pregnant cows and heifers (in their first pregnancy) which were at 4^{th} or more months of gestation were selected and registered according to their ear tag numbers /given name for follow-up.

The number of cattle required for serological survey was calculated based on the formula described by Thrusfield and Brown (2018), with 5% absolute precision with 95% confidence level. Moreover, a prevalence (2.7%) reported by Ataro et al. (2019) from Hawassa was used as expected prevalence as there is no previous report from Wondo Genet and its surroundings. As a result, the sample size computed was 40 for the study area. However, the sample size was increased by 5 fold and hence a total of 200 cows were randomly selected and examined. Moreover, equal numbers of animals were also sampled from the different farms found in Hawassa, Arsi Negelle and Wolaita Sodo for serological survey.

Study population and Study animals

The study population constituted all the dairy cows found in Wondo Genet district. The majority of dairy producers included in this study were market oriented small holder dairy farmers with average herd size of 10 cows. Although majority of the farms are small scale, there are also few governmental and private owned large (commercial) scale dairy farms with heard size of over 50. Most of these farms rear crossbred dairy cattle under semi-intensive management system. Hay and concentrate (wheat bran, molasses and oil and brewery by- products) were the common types of feed used in almost all farms. Majority of the management activities including heat detection (detection for the major oestrus sign of the cows) were done by the owners and attendants of the farm. Although both Artificial Insemination (AI) and natural method of breeding system were practiced in the study areas, most of the owners prefer natural mating because their cows repeat more than two times when inseminated by AI.

In all the farms, there was no regular vaccination and deworming practices for the common infectious and parasitic diseases, respectively.

Study Methodology

This research employed both retrospective and prospective (i.e. follow-up) studies to generate relevant data to attain the aforementioned specific objectives. Moreover, serological survey was also conducted to estimate the prevalence of Bovine Brucellosis.

Retrospective survey

Retrospective data was collected from the cow level record books kept by the farms (if any) and by using pretested semi-structured questionnaire (administered in the form of interview). Before the commencement of the interview, of course to get full co-operation of the dairy owners and hence obtain reliable data about their animals, thorough explanation was made to the respondent on the objectives of the study before the start of the interview and record exploration. During the interview, the actual questions on questionnaire were systematically and chronologically presented in Amharic (the national language). Accordingly, herd level information (housing, feeding, source of feed, herd size) and cow level information (parity, breed, service used, source of the cow, number of service per conception, and history of any reproductive disorder on the previous calving) were collected and recorded. All the cow level information was registered by their ear tag number and/ or given name for ease of identification. Moreover, the data collectors tried to make personal judgment and validation on the information given pertaining the management and husbandry. To avoid ambiguity, the major reproductive problems (Namely abortion, dystocia, retained fetal membrane (RFM), uterine infection, anoestrous, repeat breeder, vaginal prolapse and uterine prolapsed) were clearly defined according to the literature and explained to respondents.

Follow-up survey

During postpartum period, cows were regularly examined for the presence of retained fetal membrane, any systemic signs, and abnormal vaginal discharge. During each visit, rectal temperature of cows with rough hair coat, depression and reduced appetite was measured by digital veterinary thermometers (Microlife VT1831; Measurement accuracy of ± 0.1°C). Each postpartum cow was visually inspected for the presence of any discharge on the vulva, perineum or tail. Moreover, after cleaning the vulva, a clean and sterile vaginal speculum was slowly inserted into the vagina of the cows and then the cervix and vagina were thoroughly inspected with illumination from a penlight. The type and nature of the vaginal discharge was differentiated from cows with normal delivery. The nature of discharge was classified as clear mucus, predominantly clear mucus with flecks of pus, mucopurulent (approximately 50% pus and 50% mucus), purulent (>50% pus) but not foul-smelling, or purulent or red-brown and foul smelling according to LeBlanc et al. (2002). Retained fetal membrane was defined as failure to pass the fetal membrane within 24 h postpartum (Kelton et al., 1998). Abortion was defined as the expulsion of a dead fetus of recognizable size at any stage of gestation (Robert, 1986; Ball and Peters, 2004). Anoestrus was defined as the failure of the cow to show clinical heat signs for 90 days or more

after parturition (Arthur et al., 1992; Bekana et al., 1994). Moreover, cows or heifers that cycle normally and have on clinical abnormality but failed to conceive by three or more consecutive services were considered as repeat breeder (Robert, 1986; Bonneville-Hébert et al., 2011).

Serological survey

Blood and serum sample collection

Approximately 10ml of blood samples were collected from the jugular vein of the randomly selected cows (800 in total) using plain vacationer tubes. Each tube was properly labelled with codes and allowed to clot over overnight at room temperature by placing inclined on a table. On the next morning, the sera were separated undisturbed, aliquated in to 1.8 ml cryo vials, properly labelled, transported and stored at -20^{0}C in FVM-HU lab. The sera were shipped with a cold chain to the National Animal Health Diagnostic and Investigation Centre NAHDIC), Sebeta, for a better and safe storage and serological tests.

During sample collection, the town, farm name, herd size, Cow ID / name, parity, breed, history of previous abortion/reproductive disorder and current physiological state (viz lactating, dry, pregnant) were recorded for all sampled animals on a format prepared for the same.

Serological examination

In the lab, the sera were exposed for Brucellosis serological tests (ID Screen ® Brucellosis Serum Indirect Multi-species ELISA) as per the kits' instruction (ID.Vet Innovative Diagnostic, rue Louis Pasture- Grables, France). Briefly, before performing the test, the sera and all reagents taken out of the refrigerator and left at room temperature for half an hour and homogenized by inversion and flicking with finger. The serum and controls (positive and negative controls), at a dilution rate of 1/20 were added to microwells coated with *Brucella abortus* LPS. The plates were incubated at 37°C in a humid incubator for 60 min and washed 3x with washing buffer. Then, 100 µL of the conjugate was added to each well and incubated again at 37°C and wet for 60 min. Again, washes were repeated, and 100 µL of TBM (substrate solution) were added, the wells were shaken, covered, and incubated at 18-26°C for 15 min. Finally, the reaction was stopped by adding 100 µL of the "stop" solution to each well and the results were read using an automated ELISA reader with a wavelength of 450 nm. The test were valid if the mean OD value of positive and ratio of positive to negative controls were calculated as ODPC > 0.350 and ODPC/ODNC > 3, respectively. The result was interpreted by Sero-positivity percentage (S/P %) of ≥120% as positive and ≤ 110% as negative.

Data management and analysis

The data obtained from questionnaire and follow-up surveys were carefully entered into farm and cow-level database Excel files. The data were coded and analyzed using Stata 14.2 window version (StataCorp, College Station, TX USA). The association of different risk-factors such as breed, management system, and methods of breeding with over all prevalence of reproductive problems were analysed by using χ^2 (Chi- square) test and value of $p<0.05$ considered as significant.

RESULTS

In general, out of the total 205 cows examined, 90 cows (43.90%) were having at least one of the reproductive disorders identified by either questionnaire interview or regular follow up of individual cows. Out of 146 cows retrospectively and 59 cows prospectively assessed for the presence of any reproductive disorder, 62 (42.47%) and 28 (47.46%) cows had at least one reproductive disorders, respectively. Based on questionnaire surrey and longitudinal study (follow-up), Retained Fetal Membrane, Abortion, Uterine infection, Anestrus, Repeat breeding, Dystocia, Hypocalcemia, Uterine prolapsed and Vaginal prolapsed were the major reproductive problems in dairy cows of Wondo Genet district (Table 1). On questionnaire survey, Retained Fetal Membrane and Abortion (12.33% each), anestrus (8.22%), and dystocia (4.79%) were the leading reproductive problems in dairy farms. Whereas, uterine infection (23.73%), Retained Fetal Membrane (18.64%), and repeat breeding (15.25%) were the leading problems encountered during the follow-up period (Table 1).

Table-1: Table 1: Major reproductive disorders of cows encountered in the study area

Type of reproductive Disorder	Follow-up (n=59)	Retrospective (n=146)	Overall (n=205)
	No (%) affected	No (%) affected	No (%) affected
Retained Fetal Membrane	11 (18.64)	18 (12.33)	29 (14.15)
Dystocia	3 (5.08)	7 (4.79)	10 (4.88)
Uterine infection	14 (23.73)	6 (4.11)	20 (9.76)
Abortion	6 (10.17)	18 (12.33)	24 (11.71)
Hypocalcaemia	3 (5.08)	4 (2.74)	7 (3.41)
Anestrous	5 (8.47)	12 (8.22)	17 (8.29)
Uterine prolapsed	2 (1.37)	1 (1.69)	3 (1.46)
Repeat breeder	9 (15.25)	3 (2.05)	12 (5.85)
Vaginal Prolapse	1 (1.69)	2 (1.37)	3 (1.46)
Overall (at least one Reproductive Disorder)	28 (47.46)	62 (42.47)	90 (43.90)

Although reproductive disorder is multi-factorial in nature and influenced by several host and environment (management) related factors, only the most important and widely accepted factors are considered in this study. Among the considered host related risk factors, only the presence of previous reproductive disorder had statistically significant association with the occurrence of reproductive disorder ($p<0.05$) (Table 2).

Table- 2. Host Factors associated with the occurrence of major reproductive problems

Factors		No cows examined	Cows affected, No (%)	$\chi 2$	p value
Body Condition Score	Poor	6	5 (83.3)	3.455	0.175
	Medium	28	12 (42.86)		
	Good	25	11 (44)		
Previous rep. performance	Poor	21	15 (71.43)	7.514	0.006
	Good	38	13 (34.21)		
NSC	One	33	15 (45.45)	0.12	0.73
	≥Two	26	13 (50)		
Parity	First	6	3 (50)	2.752	0.432
	Second	14	4 (28.57)		
	Third	14	8 (57.14)		
	≥Fourth	25	13 (52)		
Breed/Blood level	50%HF*	21	10 (47.62)	0.850	0.654
	75%HF	14	8 (57.14)		
	87.5%HF	24	10 (41.67)		

NSC=number of service per conception, HF=Holstein Friesian

On the other hand, among the considered management related risk factors (*vis-a-viz* source of the animal, management type, service used, floor type, presence of calving pen and contact with dogs) none of them had statistically significant association with the occurrence of reproductive disorders (Table 3).

Table -3. Management Factors associated with the occurrence of major reproductive problems

Factors		No cows examined	Cows affected, No (%)	$\chi 2$	p value
Source of the animal	Raised in the farm	36	17 (47.2)	0.002	0.964
	Purchased	23	11 (47.83)		
Management	Semi- intensive	41	18 (43.9)	0.68	0.41
	Intensive	18	10 (55.6)		
Contact with dogs	Yes	38	17 (44.7)	0.317	0.573
	No	21	11 (52.4)		
Floor type	Soil	13	9 (69.2)	3.17	0.075
	Concrete	46	19 (41.3)		
Graze Outside	Yes	33	13 (39.4)	1.95	0.162
	No	26	15 (57.7)		
Calving pen	Yes	31	12 (38.7)	2.005	0.157
	No	28	16 (57.1)		
Service Used	Natural	40	9 (47.5)	0.0001	0.992
	AI	19	9 (47.37)		

Among the different reproductive disorders, abortion and retained fetal membrane showed statistically significant association ($p<0.05$) with uterine infection that was expressed either in the form of endometritis or metritis (Table 4).

Table-4. Association of uterine infection with the other reproductive disorders of cows as a predisposing factor

Predisposing factors	Number of cows	Cows with uterine infection	Cows without uterine infection	χ^2	p-value
RFM	11	7(63.6%)	4(36.4%)	11.9	0.001
Abortion	6	5(83.3%)	1(16.7%)	13.11	0.000
Dystocia	3	1(33.3%)	2(66.7%)	0.16	0.688
Hypocalcemia	3	1(33.3%)	2(66.7%)	0.16	0.688

RFM=Retained Fetal Membrane

The study further revealed that all the serum samples (800) collected from Wondo Genet, Hawassa, Wolaita Sodo and Arsi Negelle were negative for bovine brucellosis.

DISCUSSION

The prevalence of reproductive disorder recorded by the retrospective study (42.47%) is comparable with the studies of Dawit and Ahmed (2013) and Hadush et al (2013), who reported 40.3% and 44.3% from Kombolcha and central Ethiopia, respectively. Based on the existing published literatures, the prevalence of reproductive disorders in dairy cows, as reported by different researchers from different geographic locations in Ethiopia, range from 8.99% to 67.8% (Shiferaw et al., 2005; Abreham et al., 2010; Molalegne and Shiv, 2011; Ayele et al., 2013; Hunduma, 2013; Ambaw et al., 2017; Abunna et al., 2018; Abdeta and Hailu, 2020). However, the current report and of course most of the reports made earlier in the country, are quite higher than the reports made from abroad (Maruf et al., 2012; Elhassen et al., 2015; Khan et al., 2016). This variation in prevalence might be due to the difference in sample size, study methodology, farm management, environmental factors and breed of the animals kept in the different farms. However, variation in management system that is applied in different dairy farms including provision of veterinary service, proper feed and feeding, housing, hygiene, timely heat detection and insemination, implementation of farm biosecurity measures and record keeping.

Among the observed reproductive disorders, retained fetal membrane (RFM) was the leading problem accounted for a prevalence of 14.15%. Similar findings have been reported elsewhere by Abreham et al. (2010) from Addis Ababa milk shed, Ahmed and Naod (2019) from Jimma town and Ayele et al. (2013) from Wolaita Sodo town. Although RFM occurs more frequently in dairy farms of the developing countries, it is still an economically important disease of US dairy industry and affects approximately 7.8% (range: 1.3 to 39.2%) of the dairy cows (USDA, 2009; Qu et al., 2014). The presence of RFM greatly increases the risk of metritis and endometritis (LeBlanc, 2008) because of tissue decomposition, compromised immunity and

patent cervical canal with a concomitant ascending infection. In line with this, the current study also showed that cows with RFM developed uterine infection more significantly than those without RFM.

Abortion, the second most frequently encountered reproductive disorder in the current study (11.7%), was also reported as the second leading reproductive disorder in most parts of the country (Molalegne and Shiv, 2011; Abunna et al., 2018; Abdeta and Hailu, 2020). Based on the retrospective and/or follow-up studies conducted earlier, the prevalence of abortion in dairy cows in Ethiopia ranges from 0.63% in Wolaita Sodo (Ayele et al., 2013) to 28.9% in Adea Berga Dairy farm, West Shewa (Siyoum et al., 2016). Such variation in the prevalence of abortion among these studies could be partly explained by the difference in host and management related risk factors and the presence of different etiological factors for the occurrence of abortion. Regardless of the cause, most cases of abortions in cows are followed by uterine infection and hence connected with delayed uterine involution in the postpartum period (Getnet et al., 2018). The current study also showed that over 80% of the cows with abortion later developed uterine infection.

Studies suggest that although the causes of abortion are both infectious and non-infectious in origin, in most cases where a diagnosis is reached, the cause is infectious (Cabell, 2007). The attempt made in the current study to estimate the prevalence of bovine brucellosis in 4 selected towns including Wondo Genet revealed that brucellosis is not prevalent in the area and hence could not be blamed for abortion cases at least in the study areas. The current finding is concordant with the previous studies conducted by Belihu (2002) and Asmare et al (2013) who couldn't find positive reactors in dairy farms of the Addis Ababa area and from central Ethiopia (Adama) and northern Ethiopia (Mekele and Gondar), respectively. These findings strongly suggest the presence of infectious and/or noninfectious causes other than bovine brucellosis that should be considered the moment other similar serological surveys are planned in the future.

Uterine infection, in the form of clinical endometritis / metritis, was the third commonly encountered reproductive disorder in the area (9.76%). This problem is also reported by other researchers from different parts of the country with prevalence ranging from 1.2% in Bedelle (Esheti and Moges, 2014) to 16.9% in Ada'a district (Molalegne and Shiv, 2011). According to Lewis (1997), as large as 40% of the postpartum cows in some herds abroad may be diagnosed with, and treated for, uterine infections. Variation among studies in the prevalence of uterine infection could be emanated from the difference in the diagnostic methods used, the classification of the uterine infections, the postpartum period during which the infections were detected, the parity of the cows, the general characteristics of the cows, or the herd management practices at large. Although the risk factors for uterine infections are well established (LeBlanc et al., 2002), prevention of uterine infections is usually difficult because of the presence of nonspecific bacteria on the lower genitalia and all over the cow's environment (Lewis, 1997). However, most researchers argue that attention to sanitation and periparturent hygiene, particularly during calving, may be the best and wise attempt

Anoestrus (8.3%) and repeat breeding (5.85%) were the other reproductive disorders encountered in the study area quite frequently. Unlike the current findings, these reproductive disorders, particularly anoestrus, are the leading problem in most parts of the country including Borena zone (Benti and Zewdie, 2014), Desie and Kombolcha (Ambaw et al., 2017), Hosanna town (Adane et al., 2014), Nekemte town (Abdeta and Hailu, 2020), Ada'a district (Esheti and Moges, 2014) and Dawro zone (Bizuayehu and Wale, 2016). Some studies from abroad including Khan et al. (2016) from India, Elhassan et al. (2015) from Sudan and Maruf et al. (2012) from Bangladish also indicated that these problems are the leading among other reproductive disorders. Although the causes and pathogenesis of anoestrus and repeat breeding are multifactorial and beyond the scope of this research article to discuss, both problems can partly be the aftermath of other interrelated reproductive disorders mainly dystocia, abortion, retained fetal membrane and uterine infections. Most of the owners mentioned that anoestrus and repeat breeding are the major reason for the culling of cows followed by lack of space and feed. In line with this, Agarwal et al. (2005) and Hadley et al. (2006) also conclude that failure to resume to cyclicity and timely conceive are the major reasons for economic losses and why cows are culled in most dairy farms of the globe.

The effort made to assess the association of different host and management related risk factors with the occurrence of the reproductive disorders revealed that only previous history of reproductive performance showed statistically significant association ($p<0.05$). This clearly showed that cows with poor reproductive performance in their previous reproductive cycle are more likely to develop at least one of the reproductive disorders in their subsequent pregnancies. This could be partly explained by the likelihood of development of permanent changes (functional and/or mechanical damages like scaring and stenosis) on the uterus and ovaries following most reproductive disorders (Bonneville-Hébert et al., 2011). The absence of association with the other considered risk factors need to be proved further with a larger sample size preferably on a wider geographic area.

CONCLUSION

This study revealed the presence of a serious reproductive disorders in cows of the study areas, Retained Fetal Membrane, Abortion, Uterine infection and Anestrus were the leading reproductive disorders followed by others. Among the considered host and management related risk factors, only the presence of previous reproductive disorder had statistically significant association with the occurrence of the problem. The serological survey demonstrate that brucellosis was not a problem in area including Hawassa, Wolaita Sodo and Arsi Negelle towns.

Since the causes of reproductive disorders are multifactorial, laboratory based studies should be conducted to identify the underlined causes of these problems in different parts of the country. Meanwhile, awareness creation to farm owners/attendants to improve their farm management system through proper housing and feeding, accurate and timely heat detection and insemination, regular consultation with animal health and production professionals, selection of feasible breeding method, maintaining hygiene of the cow and its environment and strict farm

biosecurity can significantly minimize the occurrence of these problems and associated economic losses in the dairy farms of the area.

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Diet breadth of fish communities in Vamanapuram river, Kerala, South India

S. David Kingston[1], Koos Vijverber[2], P. Natarajan*[3] and Tigist Ashagre Amare[3]

[1]*Department of Aquatic Biology and Fisheries, University of Kerala, Trivandrum, India,*
2 Centre for Limnology, Netherlands Institute of Ecology, Niewersluis, Rijsstraatweg, The Netherlands
[3] *Department of Aquatic Sciences, Fisheries and Aquaculture, Hawassa University, Hawassa, Ethiopia*

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ABSTRACT

An understanding of the feeding habits of fish species in natural environment gives clues for selecting the species for aquaculture. It helps in formulating artificial feeds for culturing species under artificial conditions for small scale or large scale aquaculture. The main objective of the present study was to find the food preferences of fish species in different ecological niches such as low land streams, riverine and estuary. Stomachs were cut, food items removed and stored in 4% formalin. Diet breadth was calculated as per the standard methods widely recommended. The diet breadth calculated for the fish assemblages in Vamanapuram River showed that *Puntius amphibius* has the highest breadth of 6.64. The surface feeding fishes had low diet breadth which ranged from 1.13-1.83. Their main food has been observed to be terrestrial insects. The generalists like *Rasbora daniconius* and *Puntius filamentosus* have diet breadth of 3.27 and 4.15, respectively. Whereas fish species found in estuarine habitats showed diet breadth range from 1.00 to 2.82. The fishes present in the upper regions of the river habitat were observed to have low diet breadth than lowland streams. In general, high diet breadth values were observed during February to May. The breadth of *Barilius bakeri* showed minor variations among the three seasons (1.00 to 1.20). Based on the diet breadth, the majority of the fishes in Vamanapuram River generalists..

INTRODUCTION

The diet breadth of fish species in a community explains the spectrum or range of food items consumed by the fishes. The variations in diet breadth can be used to classify the fishes as specialist and generalist (Saswata Maitr et al., 2019). High breadth shows a generalistic mode of feeding and low values indicate more specialistic nature. In riverine ecosystems, because of the dynamic nature, and with varied habitats the fishes have adaptations to feed on variety of food items. Several studies pertaining to the diet breadth of fish species of different Indian rivers and streams have been carried out (Arunachalam et al., 1988; Arun, 1992; David kingston, 1992; David Kingston et al., 2011). The diet breadth of Srilankan streams, studied

**Corresponding author:*

Email: drpnatarajan123@gmail.com;Phone: +251-969-454307

by Moyle and Senanayake (1984) showed that most of the species had narrow diet breadths. Julio Cesar Sa- Oliveira et al. (2014) studied diet and niche breadth and overlap in fish communities within the area affected by an Amazonian Reservoir in Brazil. Heng et al. (2018) reported the diet breadth and dietary overlap between three commercially important food fishes of Cambodia. In the present study, the diet breadths of different fish species from the riverine stretches of Vamanapuram River, South Kerala, India have been studied in detail.

MATERIALS AND METHOD

Vamanapuram River is one of the major rivers in Kerala with a catchment area of 787 square kilometre located in Thiruvananthapuram and Kollam districts of Kerala state, India. It is found at latitude of 8˚35' 24'' N and 8˚49' 13'' N and longitude of 76˚44' 24'' E and 77˚12' 45'' E. The area is characterized by lateritic uplands with intermittent valleys. The altitude ranged from 40m to 300m. It originates from Ponmudi Hills (1074 m above sea level) flows onwards through Vamanpuram Town, and joins the Kadinamkulam backwater and then enters to the Arabian Sea at Mudalapallipozhi near Perumathura, 25 km north of Thiruvananthapuram city. The climate is typically sub-equatorial with three main seasons, the premonsoon (February- May), monsoon (June - September) and postmonsoon (October - January). The premonsoon and later part of the post-monsoon periods are usually dry (Pisharody, 1987).

Twelve sites were chosen for sampling throughout the Vamanapuram River from the lowlands to mouth of the river. The study sites were selected in different habitats like lowland streams (Habitat I), riverine (Habitat II) and estuary (Habitat III). Among the 12 study sites, seven were lowland streams three riverine and two estuarine stations. For trophic estimates, fishes were collected using monofilament gill nets. Depending on the habitats, depth of water column and availability of fishes, gill nets of varying mesh sizes were used. A uniform effort of 20 minutes was set for all the nets at all habitats during 10 am in the morning. Soon after the net is hauled, fishes were removed and anaesthetized in 50ppm Benzococaine to prevent the regurgitation of food particles. Then the fishes were transferred to 4% formalin for preservation. Large sized fishes were injected with formalin using a hypodermic syringe and then preserved in 4% formalin.

Thirty two (32) fish species representing 17 genera were collected during the study period. Dietary analysis was done on each individual fish. The fish were cut open and guts removed. The contents of the stomach or intestine up to the first bend and if no stomach was present the gut was pressed in a gridded glass slide and examined using dissection microscope. The minute and microscopic items were observed in high power microscopes. The diet breadth was calculated using the formula of Levins (1968):

$$B = 1 / P_{ij},$$

where P_{ij} is the proportion of the food in each category.

RESULTS AND DISCUSSION

Thirty two (32) fish species representing 17 genera were collected during the study period (Table 1). Among the 32 species available in the Vamanapuram river, *Puntius amphibious* (PA)

showed the highest diet breadth of 6.64 (Table 1). This species was observed to be a bottom feeder and it had affinity for a wide range of food items. Another bottom feeder, *Garra mullya* (GM) had a diet breadth of 2.21, whose main food items were small algae and filamentous algae. The morphological adaptation of this species especially mouth structure was more suited for the bottom feeding nature. Other bottom feeding fishes like *Etroplus maculatus* (EM), *Mystus montanus* (MM), *Puntius melanampyx* (PM), *Mystus armatus* (MA), *Puntius ticto* (PT) and *Puntius vittatus* (PV) had diet breadths ranged from 2.78 - 5.31. Of all the bottom feeding fishes *Garra mullya* (GM), *Puntius ticto* (PT) and *Puntius vittatus* (PV) came under category one in which their diet breadths was more or less in the same vicinity. The surface feeding fishes like *Danio aequipinnatus* (DA), *Barilius bakeri* (BB) and *Aplocheilus lineatus* (AL) had diet breadths of 1.83, 1.18 and 1.13 respectively, and they relied more on terrestrial insects as their main food. The generalists fish groups such as *Rasbora daniconius* (RD) and *Puntius filamentosus* (PF) had diet breadths of 3.27 and 4.15 respectively. The estuarine fishes had diet breadth values ranged from 1.00 - 2.82. Out of these, 42.5% had low diet breadth values (< 2.00).

In general, the riverine habitat had low diet breadths than lowland stream habitats. PA showed highest breadth in Habitat-I (6.68) followed by *Mystus montanus* (MM) (5.31) and *Puntius melanampyx* (PM) (5.14). The surface feeders *Danio aequipinnatus* (DA), *Barilius bakeri* (BB) and *Aplocheilus lineatus* (AL) had diet breadths of 2.08, 1.20 and 1.13 respectively. While comparing the breadth values of Habitat-I and Habitat- II, with the exception of *Puntius ticto* (PT) (3.59) and *Labeo dero* (LD) (1.58), all other species in the riverine habitat had low breadth values than lowland stream habitat. In the estuarine habitat, diet breadth values were very low (1.00 - 2.42) indicating the dominance of specialists.

The fish assemblages of Vamanapuram River had wide temporal variations in diet breadth (Figure 1). In general, high breadth values were observed during premonsoon season. The breadth of *Puntius amphibious* (PA) during premonsoon was 6.28, whereas 4.17 during postmonsoon. The increased number of diet breadth was due to the concentration of food materials in place due to reduced water flow during premonsoon months. In species like DA, BB, PS and AL, the breadth values had an increase during monsoon and there was further a reduction during postmonsoon due to increased water flow during monsoon months and reduction of water flow during post monsoon months.

Table -1. Diet breadth of fish species in Vamanapuram River (mean count)

Species	Habitat I	Habitat II	Habitat III	Overall Diet breadth
Puntius amphibious (PA)	6.68	5.80		6.64
Puntius filamentosus (PF)	4.14	3.87		4.15
Danio aequipinnatus (DA)	2.08	1.28		1.83
Rasbora daniconius (RD)	3.33	2.06		3.27
Puntius ticto (PT)	3.52	3.59		3.41
Puntius vittatus (PV)	2.78			2.78
Puntius melanampyx (PM)	5.14			5.14
Garra mullya (GM)	2.44	2.00		2.21
Puntius sarana (PS)	2.54			2.54
Barilius bakeri (BB)	1.20	1.02		1.18
Etroplus maculatus (EM)	4.36	2.44	1.00	4.29
Mystus armatus (MA)	4.83			4.83
Mystus montanus (MM)	5.31			5.31
Amblypharyngodon microlepis (AP)	4.16			4.16
Labeo dero (LD)	1.45	1.58		1.53
Aplocheilus lineatus (AL)	1.13			1.13
Ambassis gymnocephalus (AG)	2.77		1.22	1.62
Gerres oblongus (GO)			1.51	1.51
Stolephorus commersoni (SC)			1.13	1.13
Carangoides malabaricus (CM)			2.42	2.42
Therapon jarbua (TJ)			1.00	1.00
Etroplus suratensis (ES)		2.82		2.82
Hemiramphus xanthopterus (HX)		1.00		1.00
Sillago sihama (SS)			1.00	1.00
Upeneus vittatus (UV)			1.00	1.00
Leiognathus equulus (LE)			1.34	1.34
Johnius aneus (JA)			1.00	1.00
Sphyraeno jello (SJ)			1.00	1.00
Liza tade (LT)			1.22	1.22
Xenentodon cancila (XC)			1.22	1.22
Glossogobius giurus (GG)			1.00	1.00
Channa gachua (CG)			1.00	1.00

Only very few species showed temporal consistency in diet breadth. In BB, the breadth was almost consistent with minor variations (1.00 - 1.31) among the three seasons. The diet breadth of *Gerres oblongus* (GO) varied between 1.00 during premonsoon and 1.47 during post monsoon. During the postmonsoon, when more number of estuarine fishes was caught and the

breadth of most of them was 1.00. Based on the diet breadth, the fishes in Vamanapuram can be classified as specialists (B < 3.00) and generalists (B > 3.00) and out of the 16 species occupying the freshwater region, 7 were specialists and 9, generalists. Out of the 7 specialists, 3 species were specialised to feed on the surface and 4 on bottom. Among the surface feeding specialists, DA was an important member of the community since it contributed to 13.55% of the total fish collected. According to Arunachalam et al. (1988), this species was a typical specialist feeding on the terrestrial insects. *Barilius bakeri* (BB), another specialist had a diet breadth of 1.18 and AL, 1.13.

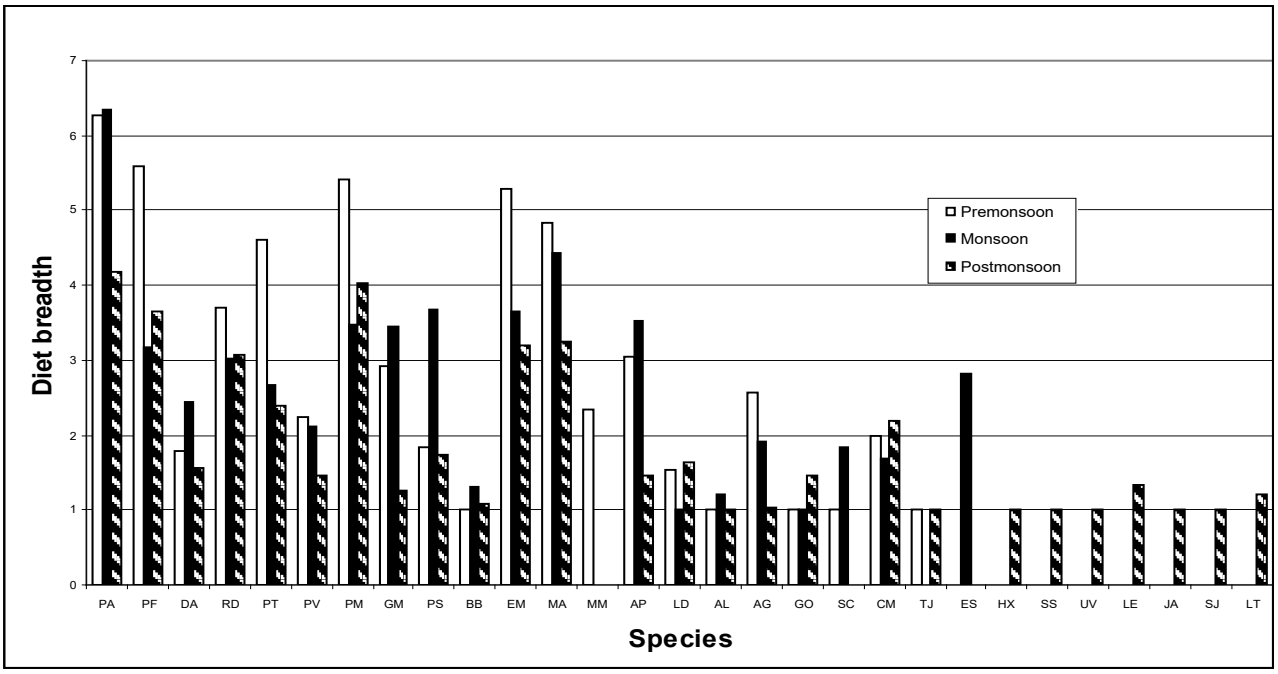

Fig. 1: Seasonal variations in diet breadth of fish species in Vamanapuram River

The bottom specialists were PV (2.78), GM (2.21), *Puntius sarana* (PS) (2.54) and LD (1.53). Among these, PV, GM and PS were herbivores feeding mainly on plant matter whereas LD was a carnivore feeding mainly on chironomid larvae. The important generalists were PA (6.64), PF (4.15), PM (5.14), PT (3.41) and *Amblypharyngodon microlepis* (AP) (4.16). Among these, PT and AP were herbivores. Most of the estuarine fishes were specialists feeding on fish. Temporal variations in diet breadth were noticed in almost all species and in general it was rather high during premonsoon season. According to Welcome (1979), differential prey availabilities, optimal foraging or interspecific competition could explain changes in diet breadth of a fish. The seasonal variations observed in the present study may be due to the differential food availabilities. Arunachalam et al. (1990) reported relatively low densities of invertebrates during the monsoon (wet) season in the stream pools of Kallar River. Various studies show that food availability was low during the dry season i.e. premonsoon in the present study (Zaret and Rand, 1971 and Power, 1983 in Panama; Matthes, 1964 in Zaire). The high diet breadth values observed during premonsoon may be due to the low food

availability of their choice and fishes switched over to other items of food. On the other hand, Moyle and Senanayake (1984) hypothesised that the relative consistency of the environment during dry season enabled the development of autochthonous food. This fact may also be true in the present study for the high diet breadth values noticed during dry season. The breadth of PA during premonsoon and monsoon were found to be 6.28 and 6.35, respectively. The breadth was 4.17 during post monsoon. During post monsoon the fish consumed a major percentage of small algae whereas in other seasons it consumed more of chironomid larvae. Similarly, PF had a diet breadth of 5.59 during premonsoon whereas during monsoon and postmonsoon, it was 3.18 and 3.65 respectively. Similarly, PT, PM and EM also showed relatively high values during premonsoon season.

Comparing the diet breadth values of fish species in different habitats, Habitat -I showed high values. The exceptions were PT and LD. The high segregation of bottom feeding fishes in riverine habitat observed in food overlap studies supports the high specialisations (low breadth values) noticed in this habitat. The interspecific competition may also be responsible for the high diet breadths observed in Habitat- I, since species richness is high in streams and more competition for the available food. *E. maculatus* (EM) had the maximum difference in diet breadth between the habitats (Habitat I - 4.36, Habitat- II - 2.44 and Habitat III – 1.00). It consumed more filamentous algae and littoral vegetation (58% and 23%, respectively) in riverine habitat. In the stream habitat, its food was mainly chironomid larvae (41%). Another fish which displayed much spatial difference in its food spectrum was RD (3.33 and 2.06 in Habitat I and Habitat II, respectively). The difference lies in the fact that the fish consumed a high percentage of terrestrial insects (67%) in the riverine habitat whereas it consumed a lower percentage (45%) of the same in the stream habitat. The streams which have comparatively more canopy cover are supposed to harbour more of terrestrial insects than the river habitat. Moreover, the trend is reverse with this fish in the present study. A similar reverse trend is observed in DA also. Thus the quantity of terrestrial insects available per fish is higher in rivers than in streams which in turn may be a factor for the high consumption of terrestrial insects in rivers.

Conclusion

Vamanapuram River, one of the major rivers of Kerala, is rich in fish species. The diet breadth study undertaken for different fish species of the river showed that the food preference greatly relied on habitat preference and feeding habits of the fish**.** Both specialists and generalists are found in the habitats. In general, the riverine habitat showed low diet breadths than lowland stream habitats. Estuarine fishes showed very low diet breadth indicating the dominance of specialists. *Puntius amphibious* showed the highest diet breadth followed by *Mystus montanus* and *Puntius melanampyx.*

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Groundwater quality evaluation and its suitability for domestic and irrigation use in the hard rock terrain of Olakkur block, Tamilnadu, India

Vinodh. D[1], Senthilkumar.S[2], Gowtham.B[1] , WegeneTalelign[3]and Jeevanandam M*[3]

[1]*Department of Geology, Presidency College(Autonomous),Chennai – 600 005, India*
[2]*Department of Earth Sciences, Pondicherry University, Puducherry, India*
3Department of Geology, College of Natural and Computational Sciences, Hawassa University, Hawassa, Ethiopia.

KEYWORDS:

Corrosion;
Hydrogeochemical;
Ollakur block;
Irrigation quality;
Groundwater quality

Research article

ABSTRACT

Ground water is the main source of water for agriculture and domestic use in the study area. This study was aimed to evaluate the groundwater quality for domestic and irrigational purposes. Groundwater samples were collected from twenty five locations in both pre-monsoon and post-monsoon months and examined for various physico-chemical parameters such as pH, total dissolved solids, total hardness, calcium, magnesium, sodium, potassium, bicarbonate, sulphate, Nitrate and chloride. To assess the domestic suitability of groundwater, all these parameters were compared with the standards of World Health Organization and Indian standards. Sodium Adsorption Ratio (SAR) and US salinity diagram were used to evaluate the groundwater for irrigation suitability. At some locations sodium and potassium values were higher than the prescribed limits. The SAR values were less than 10. Based on United States Salinity Laboratory Staff (USSL) diagram the dominant categories were C2-S1, C3-S1, C2-S1, C3-S1, C3-S2 in both pre and post-monsoon. Groundwater samples were classified as Na-HCO_3 and Na-Cl water type in pre-monsoon and Ca-Na-HCO_3 and Na-Cl types in post-monsoon. The geochemical analysis revealed that the groundwater samples were fit for domestic purpose. The irrigation quality assessment based on Sodium Adsorption ratio and US Salinity diagram suggested that, most of the groundwater samples were fit for irrigational activities except in certain locations where sodium and salinity values were high. Based on Piper water classification, mixing process and evaporation were the dominant geochemical process in the study area.

INTRODUCTION

In most parts of India ground water play a vital role and major source for drinking and agricultural purposes. The quality of groundwater is a function of physical and chemical parameters that are greatly influenced by anthropogenic activities and geological formations (Krishna Kumar et al., 2011). The chemistry of groundwater is not only related to lithology and rock water interaction but also reflects inputs from soil, atmosphere and pollutant sources such as saline intrusion, mining activities, industrial and domestic wastes (Babiker et al., 2007). Groundwater also gets polluted due to excessive irrigation practices (Sujatha and Reddy, 2003). Understanding

**Corresponding author:*
Email: jeevam24@hu.edu.et

geochemical evolution of groundwater in arid and semi-arid regions would be helpful for sustainable development, consumer protection from noxious substances/contaminants and proper management of water resources (Jalali, 2009; Furi et al., 2011). Geographic Information system (GIS) is an effective tool for assessing and mapping groundwater quality and its utilization for irrigation and drinking needs (Srinivasamoorthy et al., 2011; Ravikumar et al., 2013). The geological formations and anthropogenic activities are greatly influenced the groundwater quality in the study area. Agriculture practice is the major economic activity in the study area. Surface water resources are very scarce and groundwater resources represent water source for drinking and agricultural purposes for the people living in this area. It is widely accepted that the utilizations of groundwater resources are closely associated with their geochemical properties (Abderamane, 2013; Krishna Kumar et al., 2015). For effective and safe use of ground water for various agricultural and domestic uses, sufficient information should be available. However, there is no such study in the area. Therefore, the present study was attempted with the objective of assessing the groundwater quality and its suitability for drinking and irrigation purpose.

MATERIALS AND METHODS

Study area

The study area, Olakkur Block, is located between latitudes 12°10'00" and 12°25'00" N and longitudes 79°30'00" and 79°50'00" E, in Villupuram District (Figure 1) and covers an area of about 277.64 Sq.km. The study area falls in the following Survey of India topographic sheets 57P/11, 57P/12, 57P/15 and 57P/16. The area is bounded by the Kancheepuram district in the north Tiruvannamalai district in west, Marakanam block and Mailam block of Villupuram district in the east and south, respectively. Agriculture is the main activity where paddy is the principal crop, and crops such as sorghum, maize, ragi, pulses, chillies, groundnut, cotton and sugarcane are also cultivated.

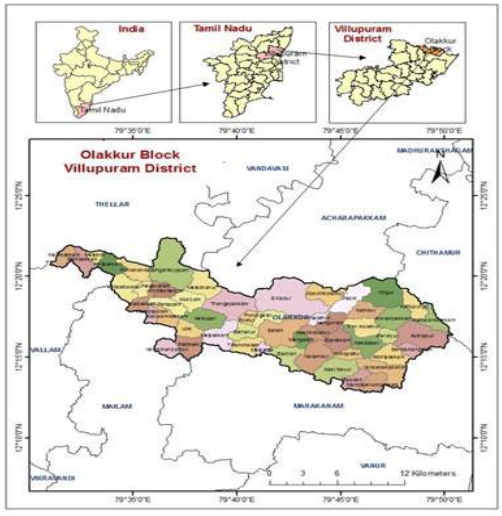

Figure 1Location map of the study area

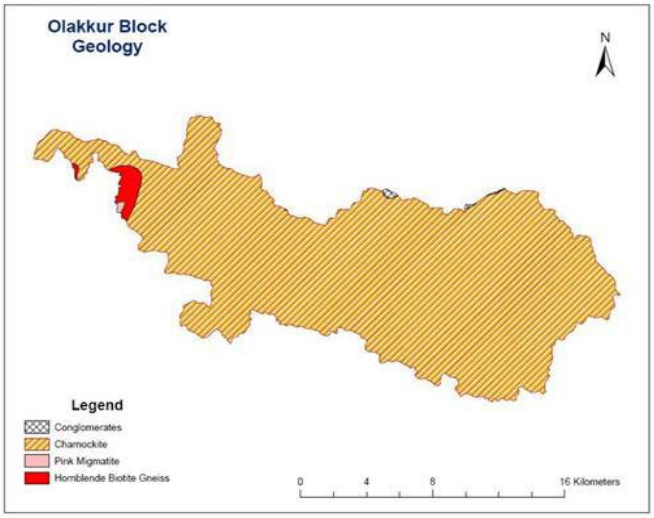

Figure 2 Geology map of the study area

Geology and Geomorphology

The Charnockite of Archaean age covers most part of the study area (Figure 2). Hornblende biotite gneiss and pink migmatite is seen along north western part of the study area. The rock shows typical granular texture with Quartzo-feldspathic composition. Conglomerate is exposed in north part near the Marakanam region. Thickness of weathering varies in different places and it depends on the mechanical and chemical action on the granitic rocks. Prominent vertical and oblique joints and fractures are observed from well inventories. The trend of the granitic gneiss is N60 °E and dipping towards S35°E which are noticed on the N-NE of Melmalayanur. The trend also varies from N35°E to N45°E on the northern and southern side of Gingee. This is due to the changes in tectonic disturbance, which also controls the movement of groundwater.

Charnockite is seen in North-West and South-East which extends up to Melmalayanur and NE till Gingee around Perumpugai village. It is composed of blue quartz, feldspar and hypersthene. In some part of the study area charnockiteacts as intrusive rock (Senthilkumar et al., 2014). The weathering thickness is moderate and the joints and fractures are limited. The Geo-morphological study area is based on the fact that the specific characteristics of each of the landform vary greatly in terms of shape, dimension, and thickness of the overburden material, permeability, porosity etc, depending on the underlying rock type, structural control, climate and vegetative cover. Geomorphology of the area dominantly consists of the deep buried pediment, shallow buried pediments and pediments.

Methodology

Base boundary map was prepared using Survey of India topo-sheets of the study area, and data such as rainfall, geomorphology, geology and land use were collected from central and state government agencies. During field study, groundwater samples were collected from 25 locations from both bore well and dug wells during pre-monsoon and post monsoon seasons in 2020. The samples were analysed for major ions by employing the standard water quality analysis procedures (APHA, 1995). Physical parameters such as pH and EC were measured using potable meters in the field. Major ions such as Ca, Mg were analyzed titrimetrically using Standard EDTA (0.2N) solution. Sodium (Na) and potassium (K) were estimated, using a Flame photometer (model CL354). Carbonate (CO_3) and bicarbonates (HCO_3) were analysed by standard HCl titration method and Sulphate (SO_4) was analyzed, using a spectrophotometer (model SL27). The Corrosivity ratio of water was calculated by using the formula of Ryznar (1944)

$$\text{Corrosivity Ratio (CR)} = \frac{\frac{Cl(mg/l)}{35.5} + \frac{2SO_4(mg/l)}{96}}{2\left(\frac{CO_3 + HCO_3(mg/l)}{100}\right)}$$

Total Hardness denotes the concentration of Calcium and Magnesium in water and is usually expressed as the equivalents of $CaCO_3$, calculated by the following formula

Total Hardness (TH) = 2.497 Ca+4.115 Mg (Karanth, 1991).

The spatial analysis of various physico-chemical parameters was carried out using the ArcGIS®9.1 software. An inverse distance weighed (IDW) algorithm was used to interpolate data spatially and estimate values between measurements. This interpolation technique calculates a value for each grid node by examining surrounding data points that lie within a user-defined search radius (Burrough and McDonnell, 1998). All of the data points are used in the interpolation process and the node value is calculated by averaging the weighted sum of all the points.

RESULTS AND DISCUSSION

Assessment of groundwater quality

The spatial distribution of total dissolved solids (TDS), total hardness (TH) and corrosivity ratio for pre and post-monsoon is shown in Figure 3.

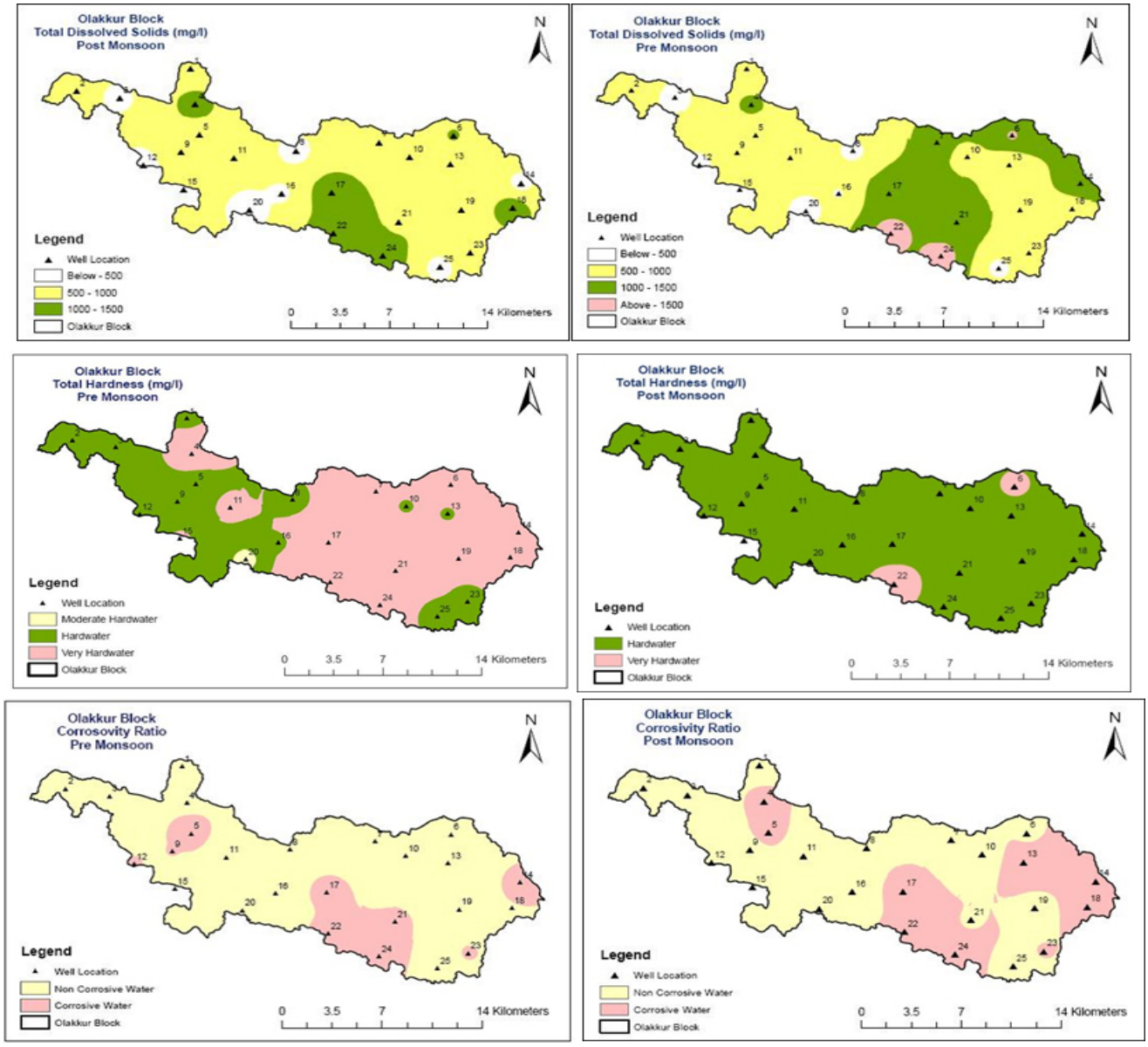

Figure 3: TDS, TH and Corrosivity ration for pre-monsoon and post-monsoon

The physico-chemical analysis of the groundwater samples for both seasons is presented in Table 1 & 2.

Table 1: Physico-chemical characteristics of groundwater in the study area Pre- monsoon

Sample locations	pH	TDS	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	SAR
1	7	756	31	18	153	18	393	126	27	1	6
2	7.2	399	29	5	48.6	5.4	207	22	10	3	2
3	7.2	1106	50	31	223.2	24.8	442	253	64	10	7
4	7.3	1533	77	55	217	25	613	250	81	9	5
5	6.8	1078	44	27	207	23	431	156	140	8	7
6	7.4	417	21	18	58	6	167	69	35	2	3
7	7.1	627	59	9	89	10	313	82	21	9	3
8	6.9	910	20	38	150	17	437	119	40	4	5
9	6.8	721	59	13	152	25	346	164	43	2	5
10	7.2	1155	71	40	225	30	462	336	43	4	6
11	7	483	48	8	60	10	242	46	42	2	2
12	7	1428	45	68	335	15	571	465	26	6	8
13	7.3	767	64	13	129	21	345	123	79	6	4
14	6.7	357	22	4	61	7	171	41	25	2	4
15	7.5	966	32	26	189	21	386	192	51	7	7
16	7.3	900	77	8	176	20	360	211	59	4	6
17	6.8	1229	99	33	224	24	491	260	148	5	6
18	6.9	1778	118	49	366	41	711	446	166	3	8
19	7.5	963	30	18	230	26	385	250	36	6	9
20	6.9	1736	107	27	462	51	694	577	103	10	12
21	7.4	350	25	6	67	7	140	76	27	5	3
22	7.2	956	58	11	260	29	382	307	67	6	9
23	7.3	595	44	13	87	10	238	100	35	6	3
24	6.6	403	27	8	59	7	161	69	18	4	3
25	6.9	606	48	10	183	20	297	58	53	7	4

pH: The pH value of groundwater samples ranging from 6.6-7.5 and 6.7-7.7 during pre and post-monsoon, respectively. WHO standards reveals that all the groundwater samples from the study area during both monsoons exceed the most desirable limit of 6.5 but under maximum allowable limit of 8.5. The pH values indicate slightly acidic nature in some locations which could be attributed to the weathering process of underlain geology.

Table 2: Physico-chemical characteristics of groundwater in the study area Post- monsoon

Sample locations	pH	TDS	Ca	Mg	Na	K	HCO_3	Cl	SO_4	NO_3	SAR
1	7.4	602	32	15	71	8	313	31	12	2	3
2	7.1	438	21	12	51	6	228	15	18	4	3
3	7	1302	92	8	331	37	521	442	11	3	10
4	7.1	1022	105	9	171	19	409	223	56	9	5
5	7.1	763	47	12	159	18	305	161	67	8	6
6	7.2	378	23	15	59	6	151	81	27	2	3
7	6.8	550	42	5	89	10	275	73	9	8	4
8	7.1	777	35	27	105	12	373	73	40	5	4
9	7.4	637	55	17	99	11	306	123	24	2	3
10	7.2	378	25	9	73	8	151	100	10	4	4
11	6.7	441	35	10	71	8	221	61	35	2	3
12	7.1	1358	50	22	377	42	543	461	31	5	12
13	6.9	693	57	13	113	13	312	131	28	6	4
14	6.7	315	25	7	39	4	151	38	12	3	2
15	7.5	945	36	24	182	20	378	188	50	8	6
16	6.7	1225	80	19	281	31	490	346	67	3	8
17	6.8	925	49	21	195	22	381	215	64	4	7
18	6.9	1372	119	36	286	32	549	413	103	3	7
19	7.7	900	30	19	211	23	360	242	21	6	8
20	7.4	1369	82	23	383	42	547	499	88	10	11
21	7.4	350	25	6	67	7	140	76	27	5	3
22	7.5	882	54	11	242	27	353	291	63	5	9
23	7.4	546	39	12	80	9	218	91	32	5	3
24	6.8	336	23	8	50	5	134	62	14	3	3
25	7	546	22	4	40	4	68	44	48	6	2

Total dissolved solids (TDS): Different geological regions influence the concentration of TDS due to differences in the solubility of minerals (WHO, 2004). As the residence time of groundwater in the geological formation increased, the TDS and major ion concentrations are also increased (Norris et al., 1992). Based on WHO standards, the highest desirable limit for TDS is 500mg/l and maximum permissible limit is 1500 mg/l. In the study area, during pre-monsoon the TDS values exceeds maximum permissible limit at locations 6, 22 and 24. The remaining locations fall under the category of highest desirable limit at Locations 3, 8, 12, 16, 20 and 25 and maximum permissible limit at Locations 1, 2, 4, 5, 7, 9, 10, 11, 13, 14, 15, 17 18, 19, 21 and 23. During post-monsoon the groundwater quality has been changed as evidenced by the locations 6, 22 and 24 which are changed in to maximum

permissible category from exceeding limit. The highest desirable limit category occurs at locations 3, 8, 12, 14, 16, 20 and 25 and maximum permissible limit category at 1, 2, 4, 5, 6 7, 9, 10, 11, 13, 15, 17 18, 19, 21, 22, 23 and 24. The classification of groundwater, according to Davis and De Wiest (1966), based on TDS is given in Table 3.

Table -3: Classification of groundwater based on TDS (Davis and De Wiest, 1966)

TDS (mg/l)	Water type	Samples (pre-monsoon)	Samples (post-monsoon)
<500	Desirable for drinking	3, 8, 12, 16, 20,25	3, 8, 12, 14,16, 20, 25
500-1000	Permissible for drinking	1, 2, 5, 9, 10, 11, 13, 15, 18, 19, 23	1, 2, 5, 7, 9, 10, 11, 13, 15, 19, 21, 23,
<3000	Useful for irrigation	4, 6, 7, 14, 17, 21, 22, 24	4, 6, 17, 18, 22, 24
>3000	Unfit for drinking and irrigation	------	------

Total Hardness (TH): The presence of carbonates and bicarbonates of calcium and magnesium, chlorides, nitrates and sulphates of calcium and magnesium cause total hardness in groundwater. According to Sawyer and McCarty (1967), based on TH, the groundwater is classified as soft (TH<75 mg/l), moderately hard (TH= 75-150 mg/l), hard (TH= 150-300 mg/l) and very hard (>300 mg/l). Spatial distribution of total hardness for pre and post-monsoon is shown in Figure 3. During pre-monsoon no soft water occurred in the study area but moderate hard water was found at location no. 20. Hard water mainly occurred in west and some eastern part of the study area at locations 1, 2, 3, 5, 8, 9, 10, 12, 13, 16, 23 and 25. Very hard water occurred at locations 4, 6, 7, 11, 14, 15, 17, 18, 19, 21, 22 and 24. In post-monsoon, the total hardness of the groundwater was remarkably changed. Except at locations 6 and 22, which showed very hard water, all other groundwater samples were observed as hard water. The drinking water quality was evaluated by comparing with the specifications of TH, TDS and other parameters set forth by the World Health Organization and Indian standards (Table 4).

Calcium and magnesium: Calcium and magnesium are abundantly occurred elements in natural waters in the form of bicarbonates, sulfate and chloride. Ca concentrations were varying from 21 to 118 mg/l in pre-monsoon and 21 to 119 mg/l in post-monsoon. The desirable limit of calcium concentration for drinking water as per the standards of WHO (2004) is 75 mg/l. During pre-monsoon and post-monsoon, 84% of the groundwater samples were under desirable limit. Only 16 % of the groundwater samples have crossed the desirable limit. The higher concentration of Ca could cause abdominal ailments in humans and encrustation and scaling in pipes. Magnesium content varied from 4 to 68 mg/l in pre-monsoon and 4 to 36 mg/l in post-monsoon. According to WHO standards, the desirable limit for Mg is 50 mg/l which shows that 92% and 100% groundwater samples from the study

area fell under the desirable category during pre-monsoon and post-monsoon respectively.

Table -4: Parameter range WHO (2004) and ISI (2009) standards for drinking purpose

S.No	Water quality parameters	WHO Standards (2004) Indian standard (ISI 10500,2009)				Pre-monsoon range in the study area	Post-monsoon range in the study area
		Most desirable limit	Max. allowable limit	Highest desirable	Max. permissible		
1	pH	6.5	8.5	6.5-8.5	No relaxation	6.6-7.5	6.7-7.7
2	TDS	500	1500	500	2000	350-1778	315-1372
3	TH (as $CaCO_3$)	100	500	200	600	71-495	71-445
4	Ca	75	200	75	200	21-118	21-119
5	Mg	50	150	30	No relaxation	4-68	4-36
6	Na	-	200	-	200	48-462	39-383
7	K	-	12	-	-	5-51	4-42
8	SO_4	200	400	200	400	18-166	9-103
9	Cl	200	600	250	1000	22-577	15-499
10	NO_3	40	50	45	No relaxation	1-10	2-10

Sodium and potassium (Na and K): The concentration of Na in the study area varied from 48 to 462 mg/l in pre-monsoon and 39 to 383 mg/l in post-monsoon. According to WHO standards (200 mg/l) 40% and 28 % of the groundwater samples exceeded the maximum allowable limit during pre and post-monsoon respectively. Water with high sodium content can be easily absorbed by soil which in turn determines the irrigation soil quality. High sodium concentration in the soils leads to development of an alkaline soil which results in alkaline hazard. The maximum allowable limit for K is 12 mg/l as per WHO standard but in pre-monsoon 68% of the groundwater samples exceeded the limit and during post-monsoon only 48 % of the samples exceeded the limit. The high concentration of K could be attributed to the dissolution of potash feldspar associated with charnockite in the study area.

Bicarbonate (HCO_3): The value of bicarbonate was observed from 140 to 711 mg/l and 68 to 549 mg/l during pre and post-monsoon respectively. Mineral dissolution plays the key role for higher concentration of HCO_3 in groundwater (Stumm and Morgan, 1996)

Sulphate (SO_4): The sources, residence time and different geochemical process influence the concentration of SO_4. Dissolution or weathering of gypsum and anhydrite minerals is the important geochemical process responsible for high concentration of SO_4 in groundwater. The SO_4 concentration in groundwater samples from the study area varied from 18 to 166 mg/l and 9 to 103 mg/l during pre and post-monsoon respectively. As per WHO standards, all groundwater samples were well within desirable limit of 200 mg/l in both the seasons.

Chloride (Cl): The chloride content in groundwater might be originated from different

sources such as intrusion of salt water, weathering, leaching of various rock types, domestic and industrial waste discharges (Karanth, 1987). In the study area, the concentration of chloride ranged between 22 and 577 mg/l and 15-499 mg/l in which 40% and 36% of total water samples exceeded the most desirable limit of 200 mg/l set by WHO during pre and post-monsoon respectively. The excess of chloride in the water is usually taken as an index of pollution and considered as tracer for groundwater contamination (Loizidou and Kapetanios,1993).

Nitrate (NO_3): According to WHO, nitrate concentration in groundwater samples from the study area was within the prescribed limit of 50 mg/l in both the seasons. The values vary from 1 to 10 mg/l and 2-10 mg/l during pre and post-monsoon respectively. Nitrate concentration in the study area could be attributed to discharges of sewage effluents and agriculture chemicals.

Corrosivity ratio: Corrosion is basically an electrolytic process, which severely attacks and corrodes the metal surfaces. The rate at which corrosion proceeds depends upon a variety of chemical equilibrium reactions as well as upon certain physical factors like the temperature, pressure and velocity of flow (Ayers and Westcot, 1985). If the corrosivity ratio is less than 1, then the metal pipes can be used for transporting water, whereas PVC pipes must be used in areas where corrosivity ratio is more than 1. Out of total water samplestested, only few locations at 5, 9, 12, 14, 17, 21, 22, 23 and 24 were exceeded the limit of 1 in pre-monsoon. During post-monsoon the corrosivity ratio of the groundwater samples was more than 1 at locations 4, 5, 13, 14, 17, 18, 22, 23 and 24.

Piper's Trilinear Plot: The major cations and anions are plotted on Piper diagram (Piper, 1944) to assess the geochemical evolution of groundwater. This diagram is used to study the differences and similarities in the composition of groundwater and for classification of water types. The hydrochemical facies for the groundwater samples from the study area is shown in Figure 4. During pre-monsoon two major facies types are present which are Ca-Na-HCO_3 water type and Na-Cl water type. These water types suggest that the groundwater chemistry was controlled by a mixing process and evaporation process. In post monsoon also the major water types are Ca-Na-HCO_3 and Na-Cl types. A few samples however were mixed Ca-Mg-Cl type suggesting that same geochemical process was controlling the groundwater chemistry.

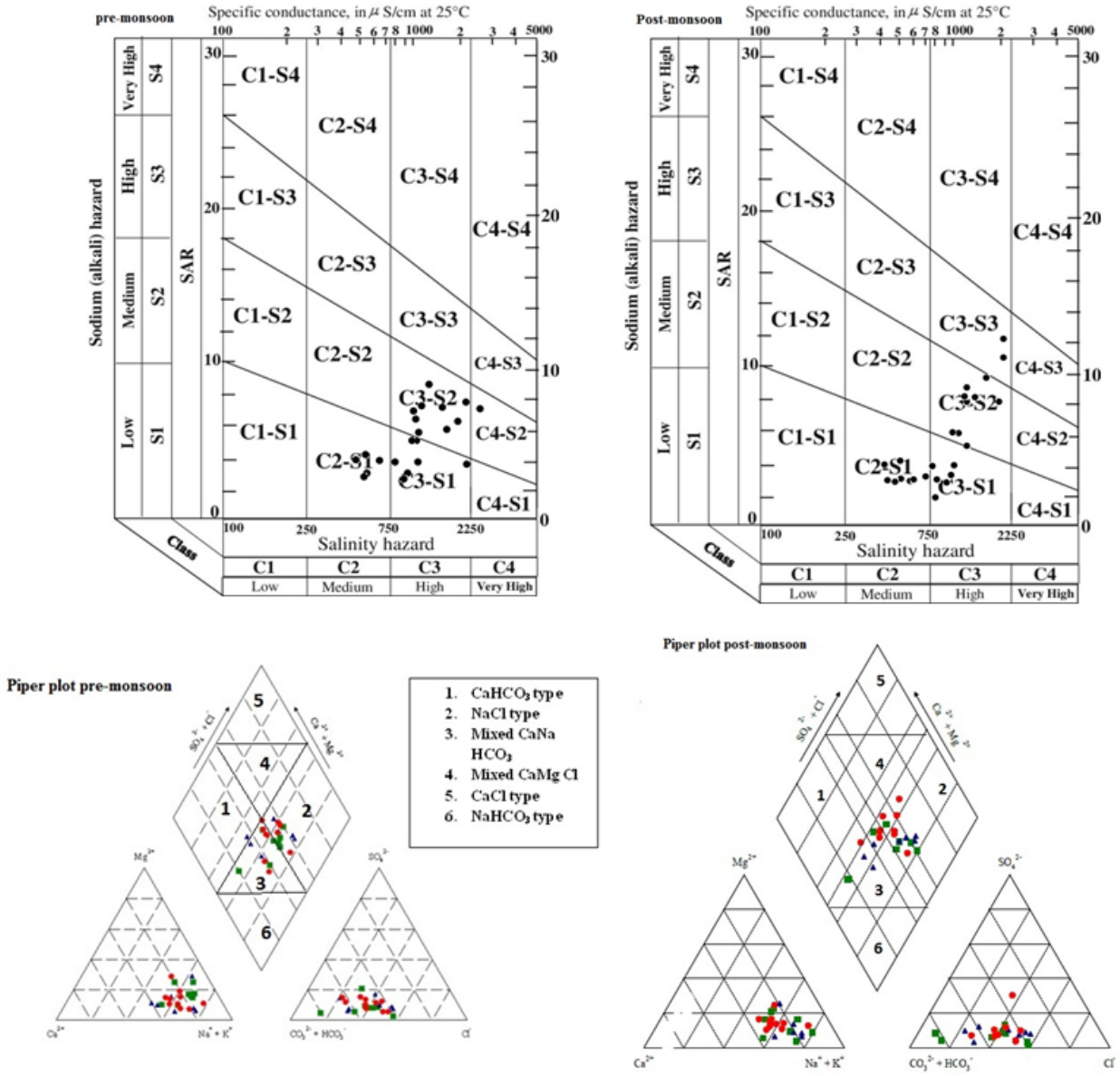

Figure- 4: US salinity and Piper plot for pre-monsoon and post-monsoon

Suitability of groundwater for irrigation

Sodium adsorption ratio (SAR): SAR ratio is a measure of alkali or sodium hazard to crops. More Na concentration in irrigation water can reduce permeability and free flow of air and water. This is due to exchange process by Na ions adsorbed by the clay particle replacing the Mg and Ca ions (Saleh et al., 1999; Yidana, 2010). The Sodium adsorption ratio is expressed as

$$SAR = \frac{Na^+}{\sqrt{\frac{Ca^{2+}+Mg^{2+}}{2}}},$$

where all ionic concentrations are expressed in meq/L.

The SAR value varied from 2 to 12 (Table 1 and 2) in both pre-monsoon and post-monsoon. Table 5a and 5b illustrates SAR classification of groundwater samples from the study area for both the season. During pre-monsoon 96% of groundwater samples were suitable for all types of crops and soil except for those crops sensitive to sodium. The remaining 4% of the ground water sample was suitable for coarse textured or organic soil with permeability. During post-monsoon 92% of the groundwater samples were suitable for all types of crops and soils except for those crops which were sensitive to sodium, and 8 % were suitable for coarse textured or organic soil with permeability.

Table- 5a: Suitability of water for irrigation with different value of SAR-Pre- monsoon

SAR	Suitability of Irrigation	Samples
1-10	Suitable for all types of crops and soil except for those crops sensitive to sodium	96%
10-18	Suitable for coarsed textured or organic soil with permeability	4%
18-26	Harmful for almost all soil	--
>26	Unsuitable for irrigation	--

Table- 5b: Suitability of water for irrigation with different value of SAR-Post- monsoon

SAR	Suitability of Irrigation	Samples
1-10	Suitable for all types of crops and soil except for those crops sensitive to sodium	92%
10-18	Suitable for coarse textured or organic soil with permeability	8%
18-26	Harmful for almost all soil	--
>26	Unsuitable for irrigation	--

US Salinity Diagram (1995): The analytical data was interpreted using USSL diagram to assess the groundwater quality for irrigation purpose. Figure 4 shows 60% samples were in C2-S1 and C3-S1 categories suggesting that the water can be used for irrigation activity in pre-monsoon. The remaining 40 % were in C3-S2 and C4-S2 indicating that groundwater is suitable for irrigational use with limited risk due to exchangeable sodium. In post-monsoon 56% of the samples belonged to C2-S1 and C3-S1 categories and 36 % samples were in C3-S2 category suggesting that the water can be used for irrigational purpose. The remaining 8% samples fell in C3-S3 category which shows high salinity and sodium hazard suggesting that water is not suitable for irrigation purpose.

CONCLUSIONS

The geology and geomorphology of the study area comprises of Charnockite of Archaean age and buried pediments respectively. In the present study, interpretation of geochemical analysis of groundwater samples revealed that, TH and TDS values were found to be suitable for drinking purposes. Based on TH values very hard water occurred at locations 4, 6, 7, 11, 14, 15, 17, 18, 19, 21, 22 and 24. Total dissolved solids in groundwater were less than 2000 mg/l in both the seasons. In some locations the sodium and potassium concentrations were

higher than the prescribed limit Corrosivity ratio of the groundwater samples was more than 1 at some sampling points suggesting that PVC pipe must be used in those areas. Except for a very few locations SAR valuewas less than 10 signifying the suitability of groundwater for irrigation purpose. Based on USSL diagram, the dominant categories were C2-S1, C3-S1, C2-S1, C3-S1, C3-S2 in both pre and post-monsoon, suggesting that the groundwater is suitable for irrigational activities excepting a few locations which fall under the C3-S3 category indicating high sodium hazard. According to Piper diagram most of the samples were classified as Na-HCO_3 water type and Na-Cl water type in pre-monsoon and Ca-Na-HCO_3 and Na-Cl types in post-monsoon. The interpretation of these water types suggests that, mixing and evaporation processes are the two dominant geochemical processes in the study area.

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Ethno-veterinary medicinal plants and modes of their traditional application to cure animal ailments in Adaa'Liben district, Ethiopia

Ijigu Asefa[1], Asefa Asmare[2], Fikru Regassa[3], Amene Fekadu[2*]

[1] *Wolaita Sodo University, P. O. Box 138,Wolaita, Ethiopia*
[2] *Hawassa University Faculty of Veterinary Medicine, P. O. Box 05, Hawassa, Ethiopia*
[3] *College of Agriculture and Veterinary Medicine, P. O. Box, Bishoftu, Ethiopia*

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ABSTRACT

Cross-sectional survey of ethno-veterinary medicinal plants was carried out from November 2016 to April 2017 in Ada'a-Liben district, Ethiopia. The purposes of the study were to identify and document medicinal plants, animal ailments treated by the medicinal plants, and modes of preparation of the medicinal plants for the treatment of animals in the study area. Rapid appraisal methods were used to gather relevant information to select study kebeles and identify the 31 informants including traditional healers. Information about the medicinal plants and their usage to cure various animal ailments were gathered through a semi-structured questionnaire, field observation, group discussion and market survey. Thirty one ethnoveterinary medicinal plant species belonging to 23 families were used to treat 24 livestock ailments in the study area. Among the medicinal plants, *Zingibera officinale, Solanium incanum, Withania somnitera*, and *Allium sativum* were used to treat blackleg and respiratory diseases whereas *Cypresnivies, Cordia africana, Celtisa africana,* and *Vernonia amygdalina* serve for deworming animals. Fresh moist medicinal plants (51.6 %, n = 16/31) were the most frequently used in preparing remedies comparing to dry plants (48.4 %, n = 15/31). The widely used plant part was leaf (51.6 %) followed by fruit, seed and root (each 9.7 %) and leaf/fruit/root mixed, seed/pods, leaf/seed/stem, leaf/root, stem and bulb (each 3.2 %). The modes of preparation of medicinal plant remedies were found to be chopping (35.5 %), grinding (25.8 %), crushing (19.4 %) , decoction and using medicinal plants without processing (6.5 % each), and socking and crushing/shopping (3.2 % each). The most widely used route of administration of these remedies was oral (77.4 %) followed by topical (19.4 %) and nasal (3.2 %). Eighteen species of the medicinal plants were used to traditionally treat more than one animal ailment while the remaining 13 were used to cure only one ailment each. Agricultural expansion was the highest threat for the ethnoveterinary medicinal plants (51.6 %, n = 16/31) followed by drought (19.4 %, n = 6/31), soil erosion and deforestation (9.7 %, n = 3/31 each). In conclusion medicinal plants and remedies derived from them are still important and readily available source of livestock health-care to rural people in the study area. Awareness creation work for traditional healers and further research on formal *in-vivo* and *in-vitro* experimental trails are suggested for a sustainable and efficient utilization of these medicinal plants.

**Corresponding author:*
Email: amenefe@gmail.com, +251- 91 1300314

INTRODUCTION

The use of plants as medicine goes back to early man. Evidences of this early association have been found in the grave of a Neanderthal man buried 60,000 years ago. Pollen analysis indicated that the numerous plants buried with the corpse were all of medicinal value. The earliest known medical document is a 4000-year-old Sumerian clay tab let that recorded plant remedies for various illnesses (Kong et al., 2003). The recorded uses of plants as medicine are also found in Babylon around 1770 BC in the Code of Hammurabi and in ancient Egypt approximately 1550 BC. Among the remedies prescribed were mandrake for pain relief and garlic for the treatment of heart and circulatory disorder. In fact, ancient Egyptians believed medicinal plants to have uses even in the afterlife of their pharaohs. In 77 AD, the Greek surgeon Dioscorides published "*De material medica*", a catalog of about 600 plants in the Mediterranean. It also included information on how the Greeks used the plants, especially for medical purposes (Acharya and Anshu, 2008).

The various climatic and topographic conditions of Ethiopia contribute to a rich biological diversity. Ethiopia is believed to be home for about more than 6,500 species of higher medicinal plants with approximately 12 % endemism (Vivero et al., 2006). Although modern veterinary medicine usage is gradually growing in rural Ethiopia, many people are still using ethnoveterinary medicinal plants to treat their livestock ailments. This is attributed to the insufficient number of veterinarians, inadequate health facilities, and the high cost of most of the available drugs which is out of the reach of the farmers and pastoralists (Giday et al., 2003). Absence of response to some antimicrobial and parasitic treatment coupled with lack of adequate awareness to the usefulness of modern pharmacotherapy also compel livestock keepers particularly in rural areas to frequently visit traditional healers for getting solutions for their ill-health animals. Similar to all other parts of the country, majority of the community in the study area use traditional medicines for generations to treat human and livestock ailments. Still now the dependence on the traditional medicine is continuing because of its acceptability, accessibility and availability at little or no cost to the farmer. It is also believed that it is safe for it has been practiced for centuries.

The use of traditional healing systems has evolved over a long period of time and the knowledge of selection of plant species for their medicinal value is not obtained over night but after many trial and error practices. Those knowledgeable people don't easily transfer their knowledge on medicinal plants usage to community where they live. Instead, they want their knowledge to remain as secret and the knowledge of plant remedies remained in their hands (Giday et al., 2003). When the knowledge of healing by traditional medicinal plants is passed from generation to generation, the original and valuable information passed in an incomplete fashion (Elujoba et al., 2005). In addition, the knowledge is very often passed only verbally and most of this knowledge has not been comprehensively documented yet it is rapidly diminishing due to changing cultures (Kedir et al., 2012). Therefore, scientific research on medicinal plants enables to document the verbally passed knowledge and provides additional evidence to the present knowledge of medicinal plants which has been

handed down from generation to generation (WHO, 1998). In addition, research results provide scientific based evidences on the efficacy and safety of traditional medicinal plants before using them for therapeutic purposes. This is what the modern health professionals and some of the consumers ask for.

Thus, unraveling the information and documentation of ethno-veterinary medicinal plants, recording the indigenous ethno-veterinary medicinal knowledge, and associated skills, practices and beliefs pertaining to animal health care builds up a strong platform for further researches aimed at developing easily accessible and affordable medicines for animal ailments. However, such information is missing in some parts of the country. To the best of our knowledge, this study is the first of its kind in the study area. Therefore, the objectives of this study were to identify and document ethno-veterinary medicinal plants, the way medicinal plants are prepared and route of administration, and animal ailments treated by the medicinal plants in Ada'a-Liben district, Ethiopia.

MATERIALS AND METHODS

Description of Ada'a Liben district

Ada'a Liben district is one of the 12 districts in East Shoa zone and is located about 45 kms south-east of the capital Addis Ababa and is very close to the other major urban centers. The district covers an area of 1750 km2 , stretching east of the Bole International Air Port to the North West of the Koka dam. It is located at 38° 58′E to 39° 22′E longitude, 08° 22′N to 8° 56′ N latitude and at an altitude ranging from 1500 to over 2000 meter above sea level. Sedentary farming dominated by extensive type of management system is a feature of the highlands and midlands of the districts. The human population in Addis Ababa, Adama and Bishoftu create a large market for most agricultural commodities produced in the district. About 78 % of the household population who are over 10 years of age are engaged in full agricultural activities, 19.5 % in partial and 2.6 % in non-agricultural activities (Gebremedhin et al., 2013).

Study design and methodology

A cross-sectional study was carried out from November 2016 to April 2017 to identify and document the ethno-veterinary medicinal plants and the threats currently affecting medicinal plants in the study area. Rapid rural appraisal (Beebe, 1995) was made by conducting meetings with traditional leaders, elders, and the kebele administrators, and the state veterinary service officers at the beginning of the study to explain the purpose of the research and to gather relevant information that helps to select study kebeles (the smallest administrative unit of the country) and indentify the knowledgeable traditional healers in the study area. Thus, the study sites were selected based on the availability of traditional medicinal practice as per the recommendations of the elders and local authorities in the study area. In addition, the agro-climatic zones were taken into consideration to select the study sites (kebeles). Accordingly, six (Qaaxilla, Hiddi, Qaaliti, Gandagorba, Calalaqa, Caffee) out of 27 kebeles of the Ada'a Liben district were selected for ethnobotanical data collection. All the traditional healers in the selected kebeles were

included in the study. Ethno-botanical data were collected using semi-structured interviews, field observations, market observations, and group discussion.

Ethno-veterinary medicinal plant data collection

The semi-structure questionnaire was prepared and the interview was carried out according to the method of Cotton (1996). Field observation on the study kebeles including the market survey was done with the help of local guide and interpreter. At the time of observation, important points including culture of the community, market value and cultivation practices of the medicinal plants were recorded. Group discussions were made with 31 purposefully selected traditional healers and knowledgeable elders. The discussions were made at each study kebele in order to correct, harmonize and share the information among the respondents. Those smallholder farmers, traditional healers, and knowledgeable elders who were individually interviewed were members of the group discussion. Each group had five to seven members. The group discussion focused on the application of ethno-veterinary medicinal plants to cure animal ailments, parts of the plants that have medicinal values, methods of medicament preparation, routes of administration, and animal ailments treated by the medicinal plants. During the guided field walk, the traditional healers came together with the researchers to the place where the medicinal plants are found. They indicated local names and shared their ethno-medicinal knowledge, practice and beliefs on the medicinal plants. In addition, market survey and interview for herbal drug distributors and sellers was also made to distinguish the type of herbal drugs sold in the market and for which disease(s) they are indicated.

Moreover, semi-structured questionnaires were used to document knowledge and skills of traditional healers and knowledgeable elders about the plants used for treatment of livestock diseases. An interview was also held with a professional veterinarian to confirm diseases referred to by the farmers and traditional healers. Then, the medicinal plants were collected after recording all the important information obtained from the traditional healers and farmers.

In order to confirm the reliability of the information, each informant was contacted at least twice and if the responses that were given at different times contradict to each other, the information was considered to be unreliable and was rejected. In addition, reliability of the information was assessed and confirmed when information given by different informants on the same issue was similar.

Plant specimen collection and identification

Medicinal plant species were collected under the guidance of the traditional healers from the wild and home gardens. Pictures of the plants were taken with a digital camera. One specimen of each plant species was collected and pressed according to the methods of Fish (1999). The collected plants and the necessary recorded information were taken to the National Herbarium of Biology Department in Addis Ababa University, Ethiopia (Annex 1 & 2). After the specimens were taken to the Department, plant species were identified using taxonomic keys following protocol mentioned on The Flora of Ethiopia and Eritrea (Edwards

et al., 2000; Hedberg et al., 2006) and by making a comparison with the already identified specimens that were deposited at the Biology Department National Herbarium.

Data analysis

Descriptive statistical methods (Proportions or percentiles) were used to summarize the collected ethno-veterinary medicinal plants data. Microsoft Excel and SPSS (Statistical Package for Social Science) Version 20 software were used for the data analysis.

RESULTS

Informants and their characters

Out of the 31 informants, 27 (87.1 %) were male, whereas 4 (12.9 %) were females. Twelve (38.7 %) were traditional healers and 18 (58.1 %) were farmers (Table 1).

Table- 1: General characteristic of the informants at the study area

Variable	Character	Count/response	Percentage (%)
Sex	Male	27	87.1 %
	Female	4	12.9 %
Age	Young	3	9.7 %
	Adult	28	90.3 %
Educational status	Illiterate	21	67.7 %
	Literate	10	32.3 %
Marital status	Married	24	77.4 %
	Single	7	22.6 %
Occupation	Traditional Healers	12	38.7 %
	Farmers	18	58.1 %
	Others	1	3.2 %

Sources, type, and seasonal availability of medicinal plants

The data collected from the study sites showed that most of the ethnoveterinary medicinal plants were collected from the wild (n = 16/31; 51.6 %) and others were from home gardens (n = 15/31; 48.4 %). In addition, regarding the type of the plants, 13 (49.9 %) were herbs and 10 (32.3 %) were trees. Ethno-veterinary medicinal plants found in the study area were affected by season; many of the plants were available in every season (81.3 %, n = 28/31) while some are available seasonally (12.5 %, n = 2/31), and the rest are difficult to find at any season (6.3 %, n = 1/31).

Medicinal plant parts used as a medicament, mode of preparation, and route of administration

The study showed that the widely used plant part for the preparation of the remedies in the study area was leaves (51.6 %) and followed by other parts of the plant (fruit, seed and root) or a combination of these parts (Table 3). The study

revealed that the highest mode of preparation of medicinal plants for animal treatment was in the form of chopping (35.5 %); followed by grinding (25.8 %), crushing (19.4 %), and other methods (Table 2).

Table- 2: Modes of preparation of the ethnoveterinary medicinal plants for animal treatment

No;	Scientific name	Family name	Local name	Preparations
1	*Cypresnivies*	Cypraceae	Quunii	Grinding
2	*Euphorbia ampliphyllapex*	Euphorbiceae	Adaamii	Grinding
3	*Cordia africana*	Boraginaceae	Wadeessa	Chopping
4	*Achyranthes bidentata*	Amaranthaceae	Maxxaanee	Chopping
5	*Azadiracta indica*	Meliaceae	Mimii	Grinding
6	*Calpurnia aurea*	Fabaceae	Ziigixaa	socking
7	*Allium sativum*	Alliaceae	Qullubiiadii	Grinding
8	*Brassica carinata*	Brassicaceae	Gomeenzera	Chopping
9	*Ocimum lamifolium*	Lamifoliumceae	Masoobila	Decoction
10	*Celtis africana*	Ulmaceae	Ceekkata	Chopping
11	*Withania somnitera*	Solanaceae	Mimmiixa	Grinding
12	*Carrissa spinarum*	Apocynaceae	Hagamsaa	Crushing
13	*Coffea arabica*	Rubiaceae	Buna	Grinding
14	*Croton macrostachyus*	Euphorbiaceae	Makaniisaa	Grinding
15	*Dracaena steudneri*	Draceanaceae	Afarfattuu	Chopping
16	*Rhammus prinoides*	Rhamnaceae	Geeshe	Chopping
17	*Justicia schimperiana*	Acanthaceae	Dhumugaa	Chopping
18	*Nicotiana tabacum*	Solanaceae	Taamboo	Chopping
19	*Aloe vera*	Asphodeiaceae	Harmagusaa	Crushing/chopping
20	*Phragmanthera macrosolen*	Loranthaceae	Dheertuu	Chopping
21	*Ricinus communis*	Euphorbiaceae	Qobboo	Crushing
22	*Solanium incanum*	Solanaceae	Hiiddii	Grinding
23	*Achyranthes aspera*	Amarantaceae	Daarguu	Chopping
24	*Vernonia amygdalina*	Asteraceae	Eebicha	As it is
25	*Ocinum lamifolium*	Lamifoliumceae	Damakase	Crushing
26	*Carica papaya*	Caricaceae	Papaya	Crushing
27	*Sorghum bicolar*	Poaceae	Mishingaa	As it is without
28	*Citrus aurantifolia*	Rutaceae	Loomii	Crushing
29	*Vernonia auriculifera*	Asteraceae	Giraawa	Chopping
30	*Clausena anisata*	Rutaceae	Uluma'ii	Decoction
31	*Zingibera officinale*	Zingebiraceae	Jinjiibila	Crushing

Fresh moist medicinal plants (82.5 %) were the most frequently used to prepare remedies comparing to dry medicinal plants (17.5 %). The most widely used route of administration was oral, which accounted for 77.4 % followed by topical (19.4 %) and other routes (3.2 %) (Table 3).

Table -3: The use of ethnoveterinary plants for the treatment of animal ailments

i. Herbs

Scientific name	Local name	Part	Routes	Indications
Cypresnivies	*Quunii*	*Root*	*Oral*	*Deworming of equidae*
Euphorbia ampliphyllapex	*Adaamii*	*Stem*	*Topical*	*Blackleg*
Achyranthes bidentata	*Maxxannee*	*Fruit*	*oral*	*Blackleg, Mastitis and Bleeding*
Allium sativum	*Qullubbiiadii*	*Bulb*	*oral*	*Abdominal pain, Blackleg, Leech, Respiratory disease and Bloat*
Brassica carinata	*Gomeenzeraa*	*Seed*	*Oral*	*Bloat*
Ocimum lamifolium	*Masobiilaa*	*Leaf*	*Oral*	*Appetizer and Spice*
Withania somnifera	*Miimmiixaa*	*seed/pods*	*Oral*	*Abdominal pain, Bloat, Black leg, Respiratory disease, Leech infestation*
Rhammus prinoides	*Geeshee*	*Leaf*	*Oral*	*Leech and Tick infestation*
Aloe vera	*Harmaguusaa*	*Leaf*	*Topical*	*Weaning of calf*
Solanium incanum	*Hiiddii*	*leaf/root and fruit*	*Oral*	*Black leg, Respiratory disease and Dermatophilosis*
Ocimum lamifolium	*Damakaase*	*Leaf*	*Oral*	*Blackleg and 'Dingetegna'*
Sorghum bicolar	*Miishingaa*	*Seed*	*Oral*	*Retained placenta*
Zingibera officinale	*Jinjibiilaa*	*Root*	*oral*	*Blackleg, Respiratory disease, Abdominal pain and Leech*

ii. Trees, shrubs and climbers

Scientific name	Local name	Part	Routes	Indications
Cordia africana	*Wadeessa*	Leaf	oral	Deworming of equidae
Azadiracta indica	*Miimii*	Leaf	Oral	Blackleg, Trypanosomosis and Abortion
Calpurnia aurea	*Ziigixaa*	Seed	Topical	Lice infestation
Celtis Africana	*Ceekkataa*	Leaf	Oral/topical/nose	Lice infestation, Leech, Diarrhea and GIT parasite
Carrissa spinarum	*Hagamsa*	Root	Oral	Ring worm, Wound
Coffea arabica	*Buna*	Fruit	topical	Wound
Croton macrostachyus	*Makkanniisa*	Leaf	oral/topical	Ring worm, Bloat, Wound
Dracaena steudneri	*Afarfattuu*	Leaf	Oral	Rabies
Justicia schimperiana	*Dhummuugaa*	root/leaf	Oral	Black leg, Rabies
Nicotiana tabacum	*Taamboo*	Leaf	Oral	Leech infestation and Bloat
Phragmanthera macrosolen	*Dheertuu*	Leaf	Oral	Bloat, Blackleg
Ricinus communis	*Qobboo*	Friut	Oral	Retained fetal membrane, Rabies, Headache(human)
Achyrentes aspera	*Daarguu*	Leaf	Oral	Abdominal discomfort & Febrile disease
Vernonia amygdalina	*Eebiichaa*	Leaf	Oral	Increase milk production
Carica papaya	*Papayaa*	Leaf	Topical	Wound treatment
Citrus aurantifolia	*Loomii*	Fruit	Topical	Tick infestation and Wound
Vernonia auriculifera	*Giiraawa*	Leaf	Oral	Anti parasite and Abdominal pain
Clausena anisata	*Uluma'ii*	Leaf	Oral	Poultry Coccidiosis

Livestock diseases treated and plant families frequently used for the treatment

According to our findings, there are a total of 23 known livestock ailments/diseases in the study area, which are treated by traditional healers. Of the diseases, blackleg was treated by 32.3 % of the medicinal plants (n = 10), leech by 19.4 % (n = 6), bloat by 19.4 % (n = 6), wound by 16.1 % (n = 5), abdominal pain or colic by 16.1 % (n = 5), respiratory disease by 12.9 % (n = 4), GIT helminthes by 12.9 % (n = 4), ectoparasites by 12.9 % (n = 4) (Table 4).

Table -4: Livestock ailments and number of ethnoveterinary plants used to treat them

Diseases treated	Local name of the disease	No of ethnoveterinary plant used
Deworming of GIT helminthes	*Ciniintobeylada*	*2*
Wound	*Madaa*	*5*
Blackleg	*Abba gorba*	*10*
Ring worm	*Roobbii*	*2*
Abdominal Pain	*Garaaciinina*	*2*
Bleeding	*Lola'udhiiga*	*1*
Respiratory diseases	*Gororsaa*	*4*
Trypanosomosis	*Gaandii*	*1*
Mastitis	*Dhiita'uu guru*	*1*
Leech	*Ulaandhula*	*6*
Bloating	*Bokoksaa*	*5*
Dermatophilosis	*Gogaaharcaas*	*1*
Rabies	*Sareemaraatu*	*3*
Lice infestation	*Hinjiran*	*2*
Coccidiosis	*Mugsiisalukku*	*1*
GIT parasites	*Maxxantoota*	*1*
Diarrhea	*Garaakaasa*	*1*
Tick infestation	*Silmiihorii*	*2*
Fuminant ailment	*Dhukkubatasa*	*1*
Febrile disease	*Ho'iinsaqaama*	*1*
Delayed weaning of calves	*Harmaadhabsiisu*	*1*
To increase milk production	*Anaandabaluf*	*1*
Abortion	*Gatachiisa*	*1*

In this ethnoveterinary medicinal plant survey, thirty one medicinal plants species belonging to twenty three families were recorded in the study area. Of the plants Solanaceae and Euphorbiaceae families constituted the highest proportion (10.9 % n = 3/23 each) and followed by Rutaceae, Amaranthaceae, Asteraceae and Lamifoliumceae with the same proportion (7.3 %, 2/23 each), all the rest seventeen families constituted a proportion of 3.7% (n = 1/23 each) (Table 5).

Table- 5:Medicinal plant families frequently used by traditional healers

Family name	No of ethno-veterinary plant species used	Proportion (%)
Cypraceae	1	3.7 %
Boraginaceae	1	3.7 %
Apocynaceae	1	3.7 %
Euphorbiaceae	3	10.9 %
Amaranthaceae	2	7.3 %
Rubiaceae	1	3.7 %
Lamifoliumceae	2	7.3 %
Acanthaceae	1	3.7 %
Asteraceae	2	7.3 %
Poaceae	1	3.7 %
Caricaceae	1	3.7 %
Loranthaceae	1	3.7 %
Draceanaceae	1	3.7 %
Asphodeiaceae	1	3.7 %
Rhamnaceae	1	3.7 %
Ulmaceae	1	3.7 %
Meliaceae	1	3.7 %
Fabaceae	1	3.7 %
Rutaceae	2	7.3 %
Brassicaceae	1	3.7 %
Alliaceae	1	3.7 %
Zingebiraceae	1	3.7 %
Solanaceae	3	10.9 %

Threats to ethnoveterinary plants and necessity of their conservation

In the group discussion, it was revealed that agricultural expansion is the highest threat for the ethnoveterinary medicinal plants (51.6 %, n = 16/31) followed by drought (19.4 %, n = 6/31), soil erosion and deforestation (9.7 %, n = 3/31 each). Over grazing (3.2 %, n = 1/31) was the least threat for ethno-veterinary medicinal plants in the study area (Table 6). The study indicated that many of the informants who have knowledge on traditional medicine usage give priority to the immediate use of the medicinal plants than to its sustainable future uses, as a result their harvesting style is destructive. However, some medicinal plants have been protected because they are multipurpose. In addition to ethno-veterinary remedies, they also serve as spices, cash crop, food, live fence, or other purposes.

Table -6:Priority ranking of factors perceived as threat to Ethno-veterinary plants

Factors	Frequency	Percentage (%)	Rank
Agricultural expansion	16	51.6 %	1
Drought	6	19.4 %	2
Soil erosion	3	9.7 %	3
Deforestation	3	9.7 %	3
Low cultivation	2	6.5 %	4
Over grazing	1	3.2 %	5
Total	31	100 %	

Transfer of knowledge about the ethno-veterinary medicinal plants and practices

In the group discussion, the highest number of attendants/respondents agreed that the transfer of knowledge of traditional medicine is to trusted eldest son (36%, n = 11/31) followed by trusted sons (25.5%, n = 8/31), all members of the family (18.5%, n = 6/31), relatives (12%, n = 4/31), and friends (8%, n = 2/31). During the group discussion, it was evidenced that as people become older and older their knowledge of traditional medicine becomes better and better. It was also observed that there was no much trading on medicinal plants in the study area though very few practitioners and women sell some medicinal plants in the market and at their homes for medical purposes with a very low price. Some of the medicinal plants that are grown at home gardens and often sold as ethnoveterinary remedies, spices and other purposes are *Allium sativum*, *Nicotiana tabacum*, *Zingiber officinale*, *Capsicum annum*, *Coffea arabica*. The group discussion also revealed that there is no standardized known unit of measurements of the plant remedies. This means that the same types of ethno-veterinary medicinal remedies for the same types of ailments were given with different measurements in the same or different kebeles of the study area. But, higher dosage was given for severe diseases.

DISCUSSION

Medicinal plants belonging to 23 families and 31 species were being used extensively for curing 24 animal ailments commonly found in the study area. These ethnoveterinary medicinal plants were documented with their scientific, local, and family names. Their type, traditional preparation methods, and route of administration for treating animal ailments were also recorded. Medicinal plant species belonging to Solanaceae and Euphorbiaceae families were relatively abundant in the study area followed by Rutaceae, Asteraceae, Lamifoliumceae and Amaranthaceae. Plants under the families Solanaceae, Euphoraceae, Rutaceae, Asteraceae were also used as ethnoveterinary remedies in Zimbabwe (Nyahangare et al., 2015), whereas Solanaceae and Euphorbiaceae in South Africa (Luseba and Van Der Merwe, 2006), and Solanaceae, Asteraceae, Zingiberaceae, and Rutaceae in India (Phondani et al., 2010). Acording to Yigezu et al. (2014), Asteraceae, Cucurbitaceae and Solanaceae make up larger proportion of medicinal plants used in Jimma zone, Ethiopia.

The study revealed that medicinal plants are still important, readily available, and cheap source of animal health-care remedies to livestock raisers in the study area. The high cost of pharmaceutical products and limited access to veterinary services probably were among the reasons for farmers to use the traditional ethnoveterinary medicinal plants as means of keeping their animals healthy and productive. The same species of medicinal plants found in the study area were also used to cure animal ailments elsewhere in the world. Farmers in the study area used *Nicotiana tabaccum* for the treatment of leech infestation and bloat whereas, in Zimbabwe, Kenya, and Appalachia of Rural North America, it was used as acaricide to treat ectoparasites mainly ticks, lices, and bots (Gakuubi and Wanzala, 2012; Nyahangare et al., 2015; Terrel, 2015, respectively). In Jimma zone, south west Ethiopia, *Nicotiana tabaccum* is widely used by farmers for the treatment of snake bite, blackleg and for fattening purpose (Yigezu et al., 2014). *Zingibera officinale* was remedies for abdominal pain or colic in the study area. It was also used in India (Singh et al., 2012) and Appalachia of USA (Terrel, 2015) for the same purpose;. Herbalists in the study area and India (Singh et al., 2012) applied *Allium sativum* for the treatment of colic and bloat among others while in Ghana, Mali, Niger, and Nigeria it was used for the cure of fever (Adedeji et al., 2013). There was similar usage of *Solanum incanum* as a remedy for blackleg in the study area, Ghana, Nigeria, Niger, and Mali (Adedejiet al., 2013), and skin disease in the study area and Kenya (Gakuubi and Wanzala, 2012). Another ethnoveterinary medicinal plant, *Azadiracta indica* was used for curing blackleg in the study area and India (Sajal et al., 2016). On the other hand, the same medicinal plant was used in Kenya (Gakuubi and Wanzala, 2012) and Senegal (Adedeji et al., 2013) to deworm animals. *Aloe verae* was used for deworming animals in Zimbabwe (Matekaire and Bwakura, 2004) and for treating diarrhea in Somalia (Adedeji et al., 2013), and for delayed weaning of calves in the study area. Diarrhea and delayed weaning of calves may mostly be connected with helminthiasis because most of the calves in the rural areas of the said countries totally depend on grazing as source of their feed where they can easily acquire parasites.

Most of the medicinal plants in the study area were available always, while some were found seasonally mainly during the rainy season. About 6% of the medicinal plants were at the verge of extinction probably due to expansion of agriculture in which most of the bushes and forests were destroyed to grow crops and the remaining land was overgrazed. Traditional healers in the study area gather medicinal plants of different plant group (41.9 % herbs and 32.3 % tree) from the wild and/or home gardens. Increased number of medicinal plants was collected from the wild comparing to the home garden. Similar finding was recorded by Tamene (2000), Giday (2003), and Awas and Demissew (2009). This may indicate the necessity of conserving medicinal plants because those plants in the wild are at the risk of extinction. According to Demisse (2001), the biodiversity of Ethiopia is eroding by natural and anthropogenic pressures, the later being predominant in urban and peri-urban areas.

Most medicinal plants were collected when needed but some were dried, ground and stored in the form of powder. In general, fresh moist medicinal plants were the most frequently used in preparing remedies comparing to dried plants.

This is in agreement with the finding of Balemie et al. (2004). This might be because fresh moist medicinal plants were more effective remedy than dried ones and drying probably decreased active ingredients and hence the efficacy of remedies extracted from medicinal plants. Leaves, roots, seeds and fruit from the documented medicinal plants were used to prepare remedies. Leaves were the most frequently used parts in the study area particularly for 18 medicinal plants used, followed by roots for five, and seeds for four and fruits for other four medicinal plants. This finding is in agreement with the finding of Giday et al. (2003), Mesfin (2007), Yigezu et al. (2014) and Abera and Mulate (2019) . Leaves of most medicinal plants were used to process remedies probably because they are collected without affecting sustainability of the medicinal plants and further they may contain more medicinally valuable ingredients that make them more effective than the other plant parts. Moreover, the use of leaves compared to their roots is advantageous to protect the plants from extinction. The end products of the traditional medicinal remedies were prepared by grinding, crushing decoctions, chopping, roasting, and pounded forms. Then, most of the plant remedies were administered orally (77.4%) followed by topical (19.4%) and intra nasal (3.2%). Similar route of administration of medicinal plant remedies was registered by Abebe and Ayehu (1993), Teklehaymanot and Giday (2007), Teshale et al. (2004), Yigezu et al. (2014). The group discussion revealed that there was no standardized known unit of measurements of the plant remedies. This means that the same types of ethno-veterinary medicinal remedies may be given for the same types of ailments perhaps with different measurements in the same or different kebeles of the study area. However, respondents of the current study and reports on previous studies argued that higher dosage was given for severe diseases.

Most of the traditional ethnoveterinary knowledge is not yet documented particularly in the study area and the country at large. It is passed on orally from generation to generation. The healers pass the knowledge to the family member only when they are unable to prepare the remedies by their own particularly when they get very old or critically sick. This might be the reason why elders are important source of the ethno-veterinary knowledge in this study.

CONCLUSION

Thirty one medicinal plants species belonging to 23 families were used to traditionally treat 24 livestock ailments including blackleg, wounds, leeches and rabies among others. Most of the medicinal plants, majorly their leaves, were gathered by traditional healers from the wild and about 6% of the medicinal plants are at the verge of extinction. Crushed leaves of fresh moist medicinal plants mixed with water were primarily administered through oral route as a preferred ethno-veterinary remedies. However, there was no standardized known unit of measurements (dose) of the plant remedies for the treatment of animal diseases in the study area. Although, medicinal plants are still important, readily available, and cheap source of animal health-care remedies to livestock raisers, they have not yet received good attention by the researchers. Their efficacy has not been tested through formal *in-vivo* and *in-vitro* experimental trails on which more work is required. For efficient and sustainable use of these plants,

particularly those endangered, awareness creation is required for traditional healers.

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Annex 1: Different medicinal plants commonly used by traditional healers in Adaa'Liben District

(A) Euphorbia ampliphyllapex L; (B) *Dracaena steudneri* L; (C)*Coffe arabica* L; (D)*Celtisa africana* L; (E) *Achayrentes bidentata* L; (F) *Ocinum lamifolium* L; (G) *Phragmanthera macrosolen* L; (H) *Justicia schimperina* L; (I) *Vernoni amygdalina* L; (J) *Rhammus pirnoides* L; (K) *Vernoni amygdalina* L; (L) *Brassica carinata* L; (M) *Carrisas pinarum* L; (N) *Aloe vera* L; (O) *Solanium incanum* (L); (P)*Azadiracta indica*

Annex 2: Different medicinal plants commonly used by traditional healers in Adaa'Liben District

(Q)*Zingibera officinale* L; (R) *Citrus aurantifolia* L; (S)*Ocimum lamifolium* L; (T) *Achyranthes bidentata* L; (U) *Croton macrostachyus* L; (V) *Clausena anisata* L; (W) *Withania somnitera* L; (X) *Sorghum bicolor* L; (Y) *Carica papaya* L; (Z) *Ricinus communis* L; (A1) *Allium sativum* L; (A2) *Cypresnivies* L; (A3) *Nicotiana tabacum*L; (A4) *Cordia africana*L; (A5)*Calpurnia aurea* L.

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Challenging students' performance through Practical Skills Assessment in Elective Football coaching in Hawassa University: An action research study

Dagne Getachew[1], Samuel Assefa[2], Mekoya Mengesha[3]

[1] *Department of Sport science, Hawassa University, P. O. Box 05, Hawassa, Ethiopia*
2 School of Teachers Education, Hawassa University, P. O. Box 05, Hawassa, Ethiopia
3 Sport Science Academy, Jimma University, P. O. Box 378, Jimma, Ethiopia

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ABSTRACT

Complaints from the university students enrolled in sport science fields or their hiring employers have been heard to practical assessment in sports science. On top of that, long years ofexperience in teaching taught us the problem of practical skills assessment has existed in sports science. This problem emanates primarily from the activities of gross motor parts of the organism while doing sport; leading to a highly subjective assessment. Furthermore, the absences of safe and secured facilities for practice, large class sizes, as well as the absence of video materials, to track students' progress, are among the other factors. This study used the process of action research: identify-plan-act-reflect, in order to improve 3rd year, sports science students' practical assessment skills in Elective football coaching at Hawassa University. The study participants included 25 randomly selected students from a population of 50 students. Football's basic skill first was taught theoretically and practically for the betterment of easy to conduct assessment skills. To do so, the researcher allotted three sessions in consecutive days; after conducting the pre-test assessment. The study has shown that there was a statistically significant increase of difficulty dribbling and trapping the ball from pre-test (M= 1.24, SD= .43) to post-test (M=1.64, SD=.49), t(24)= -4, P<0.005). The eta squared statistics (.4) indicated a large effect size. There was statistically significance increase of control ball with both feet from pre-test (M=2.44, SD= .5) to post-test (M=3.72, SD= .45), t(24)= -8.6, P<0.005). The eta squared statistics (.75) indicated a large effect size. There was statistically significance increase of ability to dribble either direction with token pressure from pre-test (M=2.56, SD= .5) to post-test (M=4.76, SD= .43), t(24)= -17, P<0.005). The eta squared statistics (.92) indicated a large effect size. Therefore, from the five parameters of football skill practical assessments, all skill parameters are significant to apply in assessing the psychomotor domain of football in the Elective coaching course at Hawassa University. The findings revealed that, participation of students in educational assessments are resulted an alteration of training performance in academics.

INTRODUCTION

Professional skills in sport can be developed through a variety of ways, initiation, qualification, training, specialization, and re-training (Gloriaa et al., 2015).This can be realized with suitable assessment among others;

**Corresponding author:*
Email: dagnegetachew@hu.edu.et +251- 913282529

Popa et al. (2009) figure out that, formative assessment is powerful effect on stimulate learning and boost up instructional-educational processes. Unlike the theoretical assessment in sport science, practical skillassessment should be presented via explaining the skills prior to the formal assessment and even correcting the errors of the performer. Because football skills preferred gross motor action, involvement of major large muscle groups: quadriceps femoris and calf muscles. Unlike fine motor skills, the involvement of small muscle groups, which enable us to write on the paper and typing a computer. The actions offered by our feet are not accurate. Based on Popa et al. (2009) observation, they claimed that formative comparatively from others is very powerful and effective in educational-instructional processes. Since assessment is perceived as manipulation of instructional-processes, within the scheme professional values are structured, shaping the assessment ability is a necessity to check the work of training and for future teachers, to be stacked with the archive.

Based on Gloriaa et al. (2015) discussed that students are expected to learn verbal and communication skills while they are learning, simultaneously they should be brought with the ability of assessment empirically, and it can empower them to use in their career profession. Allowing permanent involvement of the student’s, in the ability of formative assessment skill, bring improvement in their educational objective of the pre-determined outlines. As per the educational formative objective and the instruction, content constitutes the training of assessment skills on the teacher's course description.

In Ethiopia, Dessalegn (2012) tried to bring the experience of teachers in practical assessment skills studied in Awi Zone, though the designed questionnaire is very vague and difficult to accept by the readers. The same author found out from Awi Zone's physical education teachers, 43.75% of sport science teachers do not incorporate practical assessment into their lessons, while 56.25% of teachers bring practical assessment every day. The data is not consistent within the study; still, the paradox is going on because of the experience of higher institution sport science teachers. Enormous studies have been conducted in theoretical assessment of sport science skills, but limitations of studies are shown in the area of practical assessment skills.

The instructional-educational process, as Gloriaa et al. (2015)notedin higher education, various competences are developed. Among others, Praxeological competences are offered in the sport skill pedagogy, training of assessment competence and capacity for the evaluation of practical skills. Furthermore, students are permanently considering in the execution of assessment, detecting errors of fellow students and also grading performance. The ideology brought more freedom for the learner, being active in the decision process also.

The current research is embedded theoretically to critical action research; problem is identified in the teachers’ work area. Action research should be conducted to solve the problem identified via presenting an action plan as remedy. Further this thought of action research justified that, philosophically the teachers believe that the normal research is doing on the teacherrather for them (Mills, 2014). For instance, students’ are challenged with time

consuming problem solving methods in mathematics, to overcome this problem the mathematics teacher can present a new problem solving strategy. So that, the teacher researcher can writes up the influence of the new intervention. Therefore, the purpose of this action research was to improve the subjective nature of practical assessment to make objective in Hawassa University 3rd year sports science student's practical assessment skills in Elective football coaching.

Initial reflection

Based on Gamachis et al. (2021) justified that, teachers are working in a more controlled manner, promising to the country's educational system. The educational policy approach is rigid and inflexible to induce implementation of authentic pedagogical texts. In their study, they have objectively concluded that, practitioner inquiry or action research can present an opportunity to present an immediate solution concerning the problem of teaching learning process. Teachers in the school curriculum are mechanized into traditional teaching strategy, incubating a dictatorial socio-educational system in the country. However, instructors in Ethiopian public higher institution are working in a more free will environment; they can construct and implement authentic pedagogical texts. From the experience, instructors in sport science have limited their action to conduct an action research to provide a solution for the subjective nature of the courses. They are accustomed with the old saying, assessing the psychomotor domain of sport skills are subjective, traditionally customized themselves. Even a blurred vision exists, to differentiate the normal research from the action research. The essence of normal research is simply conducting, administering a questionnaire on the teacher on the other side, the action research bring a solution for the teacher. It is true that, the magnitude and strength of the problemis known by the researcher; prior to conduct the action plan for implementation.

In teaching sport science, teachers are overwhelmed by practical skill assessments, because of the subjective nature of the course. As well as the type of serial skills, in which the students are expected to execute different connected skills, this needs the involvement of gross motor skill, at a particular period. Movements demanding the involvement of large muscle groups are not accurate; it needs more repetition to perceptualize. Thus, the skill should make a vicious circle until it becomes internalize and it may demand the intelligence of the students while the skill is conducted randomly.

However, it does not mean that there is no problem in the theoretical class but the practice which is done in the field is more exaggerated, rate of skill assessment. The current sport science courses are classified into indoor and outdoor course delivery. In the first case, the students who are taught indoor or in the gymnasium may not be affected by weather conditions like sun, rain, and windy environment. But outdoor sports activities like football are not conducting in the above environment. So that the level of judgments will be affected because of giving a test at one shot as well as tiredness of both teachers and students, which leads the assessment too much subjective. In this regard, practical skill assessment should be taught first as well as the practicing the assessment should be given

before the actual assessment is started for the improvement of student's performance.

The objective of incorporating "Elective sport" into undergraduate sport science curriculum by 2012 is to differentiate the existing sport based on student's area of interest and alleviating the scarcity of coaches in the country. Giving the above fact, majority of graduates in the area of football coaching are complaint on their performance and within a decade action research has not conducted to maximize the objectivity in football assessment.

In the light of the above fact, the current researcher tried to induce intervention from the traditional teaching way, because action research in nature oblige the classroom teacher to practice out of the usual locus of control. Thus, beyond the usual custom of student's skill assessment, this research work presented to challenge their performance other than the traditional approach of footballskill assessment.

The study was conducted with the objective of minimizing the bias of practical skill assessment after they have been thought by the instructor. More specifically, to reduce the subjectivity of assessment in Hawassa University 3rd year sports science student's practical assessment skills in Elective football coaching and also enhance the quality of practical skills assessment for the student concerning the mechanics of each technique in football.

MATERIALS AND METHODS

The instrument is developed from with the assumption that, 80% of the goal score is scored from three consecutive passes in football matches (Reilly and Williams, 2003*;* Reep and Benjamin, 1968). The empirical evidence of the previous match analysis conducted by the above authors are agreed and presented for football coaching specialization graduating class of 2019 in Hawassa University. In this regard, the current teacher researcher is sliced the football skills into five independent skills in a stations where the student coaches are going to be assessed. They are namely, (1) has difficulty dribbling and trapping ball (2) Possesses some ball skills but they are very limited (3) Can control ball with dominant foot only (4) Can control ball with both feet (5) Has ability to dribble either direction with token pressure (6). For instance, the first football skill is "has difficulty dribbling and trapping ball", while the teacher researcher is administering the skill performed by student coaches. Every skills has got measured onto three levels, accurate, partial and inaccurate, it can simplify the rating process at time of football skill assessment. The study preferred a cross-sectional research design, teaching and demonstrating five football skills, they are utilized for a formal assessment.

The study was conducted at Hawassa University. The study participants included 3rd-year sport science students; from the problem which has been detected on practical skill assessment in Elective football coaching. The study participants include 25 (twenty-five) randomly selected student participants from a total of 50 (fifty) students. The study used: pre-test and post-test measures, adopting from football skill assessment for individual skills.

The study followed four consecutive stages to detect the problem and improving stages namely: (a) initial reflection phase- based on the subject teacher and head department, the problem was identified in practical skill

assessment from the experience of teaching-learning, (b) Intervention action plan phase- based on the reflection upon the practical skill assessment from the subject teacher with the head department, and also pre-test will be administered on the respondents, (c) Implementation and data collection phase- conducted by higher diploma program **(**HDP**)** candidate and followed by post-test were administered (d) analysis of data and reflection phase- includes discussion and comparison of the pre and post-test findings and reflections on the recommended action. The pre-test has 6 components.

RESULTS

The results of individual assessment for team play is summed in table 1. The skill is provided and prepared with seven variables (explaining football). The weights are allotted based on the difficulty level of the skill assessment. They are divided by five and it can better explain student's assessment from the point of Accurate, partial accuracy, and inaccuracy; 6 & 19, 16 & 9; respectively. This explains, according to the result of pre-test results, they are less accurate while they are executing on difficulty dribbling and trapping the ball. At the time of the post-test, the result is reverted and shown improvement in their football skill delivery to conduct the assessment (Table 1).

Table 1: Summary of the results of students' measures on pre-and post-tests

Components of Individual football skills	Parameters of assessment	Pre - measurement	Post measurement
Difficulty dribbling and trapping the ball	Accurate. (2)	6	16
	Partial (1)	19	6
	Inaccurate	-	-
Possesses some ball skills but they are very limited	Accurate (3)	-	-
	Partial (2)	8	18
	Inaccurate(1)	17	7
Control ball with the dominant foot only	Accurate (4)	-	-
	Partial	19	19
	Inaccurate (2)	6	6
Control ball with both feet	Accurate (5)	-	-
	Partial (3)	11	18
	Min. (2)	14	7
Ability to dribble either direction with token pressure	Accurate (6)	-	-
	Partial (3)	14	19
	Inaccurate (2)	11	6

NB: The numbers in brackets (2, 3, 4, 5 & 6) are allotted to accurate skill executions based on the difficulty skill levels presented in each football components. For the partial and inaccurate measurement less number was given.

The test consists of 5 football skills, which gathers information about the basics of football. Namely: difficulty dribbling and trapping the ball, possesses limited ball skills, can control the ball with the dominantfoot only, Can control the ball with both feet and can dribble either direction with token pressure, the weight of each skill are, 2, 3, 4, 5 & 6; consecutively applied on the students. The assessment of football basic skill items was analyzed by dividing the items out of 5 (five).

As summarized on table 1, individual football skills on difficulty dribbling and trapping the ball before (pre) and after (post)-test/measurement were 6 & 19, 16 & 9; respectively. This means that the value shown a change in numerical value. Similarly, possesses some ball skills but they are very limited, were measured to be 8 & 17, and 18 & 7; at pre and post-test respectively. Control ball with the dominant foot only was measured on pre and post-test, from the point of Accurate, partial accuracy, and inaccuracy; 19 & 6, 19 & 6, respectively. Control ball with both feet was measured on pre and post-test, from the point of Accurate, partial accuracy, and inaccuracy; 11 & 14, 18 & 7, respectively. ability to dribble either direction with token pressure were measured on pre and post-test, from the point of Accurate, partial accuracy and inaccuracy; 14 & 11, 19 & 6, respectively.

Action and implementation plan

Based on the initial reflection phase, HDP candidate designed an intervention to teach a soccer skill for individual assessment, before the assessment they were coached concerning the implementation of the test.

For the betterment of the practical assessment, first, they have introduced the concept of peculiar football skills to be examined in the classroom. Then they were thought the five soccer skills of the assessment and they will be informed for the practical assessment.

In elective football coaching mainly instructors are using to evaluate the capacity of students in the following type of practical skills: (a) difficulty in dribbling and trapping ball, (b) possesses on some ball skills but they are very limited, (c) can control the ball with the dominant foot only, (d) can control the ball with both feet and (e) ability to dribble either direction with token pressure.

The first practical skill which is: difficulty dribbling and trapping ball, before the execution of the given skill, will be told how to execute. Because in sport there are mechanics on how to manipulate the skill; when they are displaying the skill their heads need to be down and the distance between the feet and the ball, not more than 15 inches. The second football skill is: the ball should be retained via his position and he should protect the ball from the opponents. The third football skill should be: do the students are controlling the ball with the dominant foot only. Fourthly, do the students use both feet while he is applying the technique. Lastly, students can dribble the ball in either direction with token pressure.

Findings

In this section, the comparison of students' test scores is presented based on the participants' pre and post results. Figure 1 shows the comparison of pre and post-test for each parametermeasured. Either the intervention brought a change also has been assessed, only three a consecutive day of practical training was given for the third-year elective football coaching students.

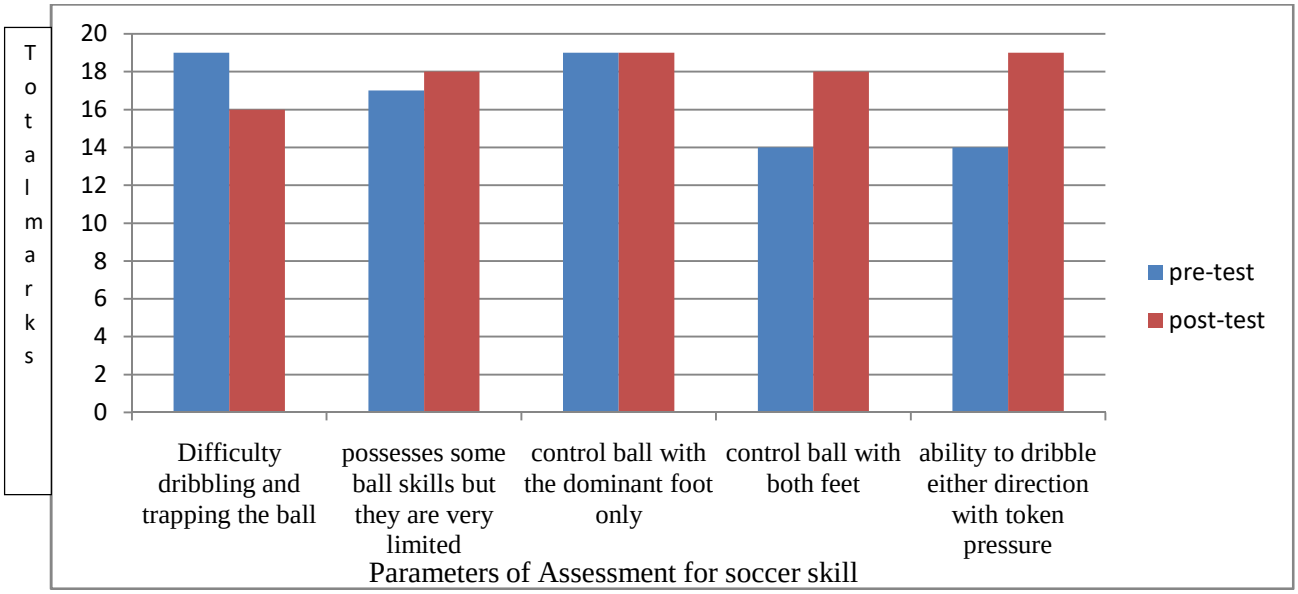

Figure 1: Comparison of pre & post test scores

As per the subjectivity of practical assessment, it is the big deal in the academic institutions, however the time for intervention unveil some alteration concerning the psychomotor domains of the subjects. In the process of assessment, students were given five independent but interrelated pieces of soccer skills without demonstration of model or instructors. The subjects were faced challenges to execute and emanate towards the external stimuli, but with the assistance of their classmates they have invariably responded to the test. Apparently discussing, scores were taken that is the highest peak among the comparators of accurate, partial accurate and inaccurate. This is because of other factors like the length of engagement in practicing the skill of soccer, method of teaching and limitation of materials. In the time of pre-test, students have known the way of execution but unable to associate with the specific type of soccer skills randomly. One of the parameter to assess students were difficulty dribbling and trapping the ball, the pre-test score is maximum, it explicit that the intervention does not show change from the result of post-test. In the soccer skill, dribbling can help us to overcome our opponents even with the maximum number of players are aggregated in the specific area.

However, with the three independent assessors (like, possesses some ball skills but they are limited, control ball with both feet, and ability to dribble either direction with token pressure), the intervention has able to embark some amount of changes in the soccer assessment skills.

In the final event that is happened in a steady state is the control ball with the dominant ball only, result is not ubiquitous unlike to the three changed skill of soccer.

Table 2: Summary results of the paired sample t-tests across the 5 measures

	Components of Individual football skills		**Mean**	**N**	SD	**GM**	**t test**	**P value**
Pair 1	Difficulty dribbling and trapping the ball	Pre	1.24	25	0.436	-0.4	-4*	0.001
		Post	1.64	25	0.490			
Pair 2	possesses some ball skills but they are very limited	Pre	1.32	25	0.476	-0.4	-2.8*	0.009
		Post	1.72	25	0.458			
Pair 3	control ball with the dominant foot only	Pre	2.36	25	0.490	-0.4	-3*	0.005
		Post	2.76	25	0.436			
Pair 4	control ball with both feet	Pre	2.44	25	0.507	-1.28		
		Post	3.72	25	0.458		-8.6*	0.000
Pair 5	ability to dribble either direction with token pressure	Pre	2.56	25	0.507	-2.2	-17*	0.000
		Post	4.76	25	0.436			

* significant ($p<0.05$), GM= grand mean, SD= standard deviation

In general the intervention has resulted change in the academic assessment of students concerning soccer skill assessment. To realize and grasp change, there must be a demonstration before execution of the skill. Teachers found in Ethiopian public higher institutions, of sport science department can devote ample time for practice and active demonstration can be executed by the instructor for the betterment of assessment.

A paired samples t-test was conducted to evaluate the impact of assessment on student's score in football skill assessment. There was statistically significance increase of difficulty dribbling and trapping the ball from pre-test to post test ($p<0.005$). The eta squared statistics (0.4) indicated a large effect size.

There was statistically significance increase of possesses some ball skills but they are very limited from pre-test to post test ($p<0.009$). There was statistically significance increase of control ball with the dominant foot only from pre-test to post test ($p<0.005$).

There were also statistically significance difference in the other components of individual football skills. There was an increase of control ball with both feet from pre-test to post test

($p<0.005$). The eta squared statistics (0.75) indicated a large effect size. There was also statistically significance increase of ability to dribble either direction with token pressure from pre-test to post test ($p<0.005$). The eta squared statistics (0.92) indicated a large effect size.

DISCUSSION AND CONCLUSION

According to Mills (2014), a written account concerning the classroom life experience is important; it can be a record for professional and personal use. In this regard, the researcher has not found resemble literatures which can be used as a stepping board to show the agreement and disagreement of the action research.

The finding of the study is supported by Fitts' Stage Theory of Motor Learning, developed by different authors (Schmidt and Lee, 2005, Abernethy, 2001; Anderson, 1982). As noted by Fitts' model, there are three stages learners can go through, cognitive, associative stage and autonomous stage. In the cognitive stage, elective students should be taught about the rules and verbal instructions of the selected football skills. The session can provide an opportunity to the learners or they are free will to practice with different errors. In the second stage, candidates can easily associate with every pattern of skill and be consistent. Finally, more practice is presented for the learner can maximize their performance and execute with minimal error.

One of the main challenges in sports science coaching practice is how to evaluate the practical performance of students, owing to the absence of standard parameter used for assigning grades. Football instructors are using different approach and rating system to measure the performance of football coaches.

In this regard, this action research identified a problem in elective football coaching course, designed an intervention of teaching on the given assessment contents in practical sessions; they have provided with how the content measured and also the pattern of each skill practiced. Students had open discussion opportunities to deal with the psychomotor domain of the subject; practiced prior to the main assessment sessions.

A few elite footballers' has the capability to play in both feet, but in executing an assessment there must be teaching the technique of football and students should be informed. The experience is different in assessing the theoretical domain of football amid fear of mark inflation. Thus, in practical assessment, the pattern of test should be provided to the student's. In this way, the subjectivity of objectivity can be decreased and customer's satisfaction can be achieved.

In general, the study revealed that there is a significance difference in all variables of football skill practical assessment. In football learning, dribbling is difficult to catch easily from the coaches or trainers even at the time of assessment. But if dribbling with trapping the ball may be taught prior to the actual assessment, the performance of elective students can be escalated. During the attachment phase, they have shown progress in their individual football skills practice in addition to the direct measurement of their performance. Based on the findings, the researcher concludes that, students' need to be learned the contents and assessments both theoretically and practically.

Study Limitations

The study has limitation pertaining the limited number of variables, area coverage and sample size (number of participant, representativeness, year of graduates). Moreover, instead of approaching the most fragmented skill individual assessment, an integrated assessment developed by team of professionals may need further investigation.

Acknowledgement

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