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Research Article

Integrated Goat Fish Farming as Source of Low Cost Nutrition Security for Small Farmers

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Abstract

As per the 20th livestock census (2019), the population of goat in India is 148.88 million, which is 10.14% higher than the same in the 19th livestock Census, 2012 and around 27.8% of the total livestock population of the country. The increase in livestock population is always associated with the problem of waste disposal and its possible impact on the environment. Integration of fish farming with livestock husbandry is a viable option, where the livestock waste is recycled for production of fish. The present study encompasses integrated farming of goat and fish by recycling goat manure, a rich source of N (2.7%), P (1.7%) and K (2.9%) and protein (17.3%), for enhancing fish production in pond. The average range of production of goat dung was 106.2 gm - 176.4gm/goat/night for animal weighing 10.5 - 17.5 kg under open grazing system. It was found that application of goat dung @ 10,000 kg/Ha/year in split doses is the most viable proposition. Calculated per Ha production of fish @ 3879.4 kg (T2), 3430.8 kg (T3), 3358.9 kg (T1) and 2061.8 kg (C) indicated the comparative efficiency of goat dung application for small scale sustainable fish farming with low external input.

Keywords: Livestock Population; Waste Disposal; Integration; Goat Manure Recycling; Sustainable; Small Scale Fish Farming

Introduction

Livestock supports the livelihoods and food security of a large section of people of rural India. According to the recently concluded 20th Livestock Census of India, 2019, the total livestock population of the country is 535.78 million, which is 4.6% higher than the livestock population recorded during the 19th livestock Census, 2012. This enhancement in livestock population is primarily due to the increase in population of small animals like sheep and goat in the country (Figure 1). This indicated the increasing popularity of small animals among the farmers of the country as a means of livelihood and sustenance. According to recent Census Report (2019) the number of goats is 148.88million, which is around 27.80% of the total livestock population of the country, securing the position of second largest group of livestock in the country next to cattle in terms of population and 10.14% higher than the goat population recorded in previous livestock census, 2012 (135.17 million).

Among different livestock, farming of goat is very popular among the small and marginal farmers as an assured remunerative activity with low input and space. In the North East Region of the country, comprised of eight land locked states viz. Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Tripura and Sikkim, situated in the eastern Himalayan Region between longitude 21º57′ to 29º30′ N and latitude 84º46′ to 97º30′ E, with a

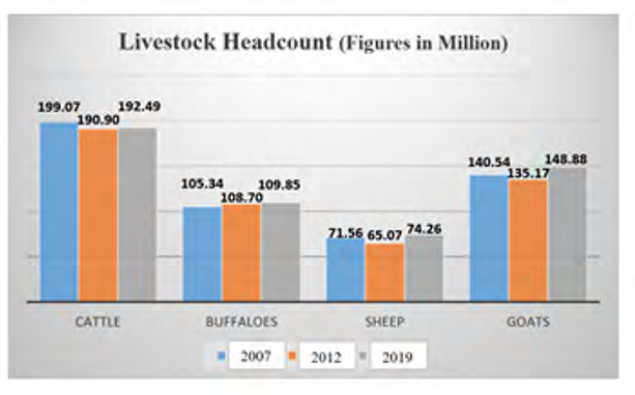

Figure 1: Trend of livestock population in India.

total population of 457,72,188 (around 4% of the country's total, Census 2011) comprising of around 220 ethnic communities with 90-100% non vegetarian food habit, goat raising is a popular activity for securing livelihood and family nutrition. Particularly in the state of Assam, the goat farming is a common economic activity as a part of the traditional homestead family farming system. The total goat population in the NE Region of India as a whole was recorded to be 54,08,245, out of which around 79.8% (43,15,173 nos) was recorded in the state of Assam. These statistics indicated the importance of goat keeping in the state's economy and depict its popularity as a means of livelihood and nutritional security particularly for the small and marginal farmers of the rural areas. Assam Hill goat, the local variety of goat is predominant among the small farmers of the state, along with some high yielding varieties like Beetal, Sirohi etc. and cross among them.

The increase in livestock population is always associated with the problem of waste disposal as well as its possible impact on the environment including green house gas emission [1]. This calls for systematic study on utilization of the livestock manure in production of other commodities in such a way so as to minimise the impact on environment while assuring maximum production of the desired commodities. Fish ponds may serve as a waste treatment system for the animal manure which otherwise cause pollution to the environment [2,3] and even contribute to carbon sequestration [4]. In India several technologies for integration of fish farming with different livestock (cattle, pig) and birds (poultry and duck) farming has been developed (where the manure from livestock and birds is recycled for production of fish) and advocated as a viable option for efficient utilization of available bio resources and production of food with low external input, that had been popularised with suitable location specific modifications, improvisations, and intensification in different states of the country [5-10]. Goat dung is considered to be good manure for agricultural crops and is known to be a rich source of N (2.7%), P (1.7%) and K (2.9%) and protein (17.3%), much higher than that of manure from cattle, pig, rabbit, poultry and duck [11,12]. However, its probable use in fish farming for enhancing pond productivity has not been studied in detail except for a few studies conducted in different parts of the world [13-15].

In view of the above, the present study was undertaken on possible utilization of goat dung in fish culture in Assam with a hypothesis that goat dung as an easily available input with high NPK content will be a suitable option for small farmers in enhancing fish production in the state of Assam with low external input. The work was carried out as a part of a research project under the Non-Project Faculty Research Component of Assam Agricultural University during 2013-2019 at Fisheries Research Centre, AAU, Jorhat, Assam, India (Figure 2).

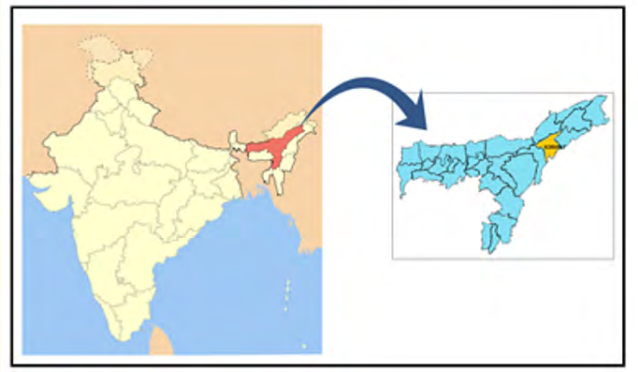

Figure 2: Map of India showing the location of study.

Materials and Methods

The experiments were conducted in three phases as detailed below:

- Preliminary study on time/days required for decomposition of fresh goat dung in water was carried out by using 5 plastic tubs (capacity 20 liters) filled with pond water and putting fresh sample of goat dung @1kg to each tub. Weekly observation on decomposition of goat dung was carried out till 45 days. For comparison of decomposition process another set of treatments was conducted by using same quantity of goat dung, air dried and macerated and put in water by using similar plastic tubs. Sampling was done as per standard procedure [16].
- Quantification of goat manure produced per animal (under open grazing system) per night was done by keeping the animals separately (live weight of each goat recorded) over night, collecting and taking weight of the dung in the morning to assess the quantity produced per kg live weight of the goat as per standard method of total fecal output collection [17] and calculate the number of animals required for fertilizing unit water area. The study was done continuously for 10 consecutive days with goats (Beetal x Assam Hill goat) of different size groups.
- Study on impact of application of different doses of goat dung on water quality parameters was conducted by using 5 nos. of cement cisterns with uniform size (Length 3.0m, breadth 2.0m and height 0.75m). Four treatments with goat manure with 3 replications of each treatment were conducted with split up application doses as shown in the Table- 1. One control was kept without manure for comparison. Initial and periodic water quality parameters assessment was done at 15 days interval [18].
- Growth and production of different carps in earthen ponds treated with different doses of goat manure was studied by using 4 nos earthen ponds with area 500 sqm/pond (Table 2), prepared and stocked by following six species composite carp culture technology (Annon, 1997) @ Rohu (*Labeo rohita*)-15%, Catla (*Catla catla*)-15%, Mrigal (*Chirrhinus mrigala*)-20%, Silver carp (*Hypohthalmichthys molitrix*)-20%, Grass carp (*Ctenopharyngodon idella*)- 10%, and Common carp (*Cyprinus carpio*)-20% @ 8,800 nos./ha.

Initial and periodic water quality parameters assessment was done at 15 days interval (as per APHA 1989). No supplementary feeding was done in any of the treatments. Harvesting was done on 11th month of rearing by complete dewatering and growth of different fish species was recorded in different treatments and compared. Final yield of fish was calculated (kg/ha) and compared to find out the best treatment.

Treatments	Rate of Goat manure Kg/ha/ year	quantity of goat manure applied Kg/cistern/ year	Dose applied/ cistern (kg)	
			Initial dose (1/3rd)	Monthly installment (10)
T_1	5,000	3.0	1.0	0.200
T_2	7,500	4.5	1.5	0.300
T_3	10,000	6.0	2.0	0.400
T_4	15,000	9.0	3.0	0.600
Control	No manure	0	0	0

Table 1: Treatment with goat manure in cement cisterns (volume 3.0m X 2.0m X 0.75m).

Treatments	Rate of application Kg/ha/year	Rate of application Kg/500sqm/ year	Dose of application (kg/500sqm)	
			Initial ($1/3^{rd}$)	Monthly (10 installments)
T_1	7,500.0	375.0	125.0	25.0
T_2	10,000.0	500.0	167.0	33.3
T_3	15,000.0	750.0	250.0	50.0
Control	No manure	-	-	-

Table 2: Treatment in earthen ponds (500sqm) with goat manure.

Results and Discussion

The trials on decomposition of fresh goat dung pellet under submerged condition in water revealed that the decomposition process of goat dung was very slow. There was very minimum change in the texture, shape and size of the goat dung pellets up to 35-40 days. After 30-38 days, the water became turbid and blackish color indicating slow diffusion of nutrients from the pellets into the water. Complete decomposition of the pellets could not be achieved up to

45 days of observation. Similar findings were recorded by Grimsby., *et al.* [19] who observed that goat manure having high Total Solid content (50%) maintained their shape and floated in water till 50 days during anaerobic stirred reactor trial. Ugwuoke., *et al.* [19], reported slow anaerobic digestion of goat dung due to inadequate lignocelluloses breakdown and slow activities of anaerobic bacteria during initial days when used for biogas production. Higher percentage of Total Solid (50%) and Lignin (21%) in goat dung in comparison to some other livestock manure like cow dung and pig droppings might be the reason for slow decomposition [19]. In contrast, the air dried and grinded goat manure was mixed with water readily and the decomposed after 7-8 days of application. This was in agreement of Grimsby., *et al.* [19], who stated that maceration of goat droppings was needed to reduce the particle size and enhance anaerobic digestion. These observations indicated that goat dung in macerated form is more suitable for application in fish culture ponds in comparison to the fresh pellet form, for obtaining prompt desired impact on water quality and productivity.

The study on quantification of goat dung produced by the animals (Beetal x Assam Hill goat) of known weight revealed substantial variation without any distinct trend (Table 3). The wide fluctuation in weight of goat dung produced per night by the same animal may be due to the feeding rate/frequency and type of feed taken during grazing by the day. Similar kind of variation in goat dung produced per animal was also reported by Grimsby., *et al.* [19]. The average range of production of goat dung was recorded at 106.2 gm - 176.4gm/goat/night for animal weighing from 10.5 kg - 17.5 kg. Earlier Grimsby., *et al.* [19], recorded 166 gm TS/goat/day to 378 gm TS/goat/day for different age group of Red Sokota goats in Nigeria grazed under different situations. This indicated that manure produced by goat may vary depending on species, age, size and feed, feeding intensity and feeding pattern.

The study of the impact of goat dung application on water quality parameter in cement cisterns indicated highest turbidity and pH in T_4 indicating the impact of goat dung at higher dose on water quality. Significant enhancement in growth of plankton population in the treated cisterns was recorded in comparison to the untreated one which was in agreement with Megerssa., *et al.* [20], who found abundant growth of plankton in goat manure treated pond in comparison to other livestock manure. The plankton population was recorded to be in the most desirable range [21] in treatment T_3 indicating the efficacy of the dose @ 10,000 kg goat dung/hectare/year in enhancing primary productivity (Table 4). This was supported by the optimum BOD and COD range [21] as well as other water quality parameters recorded in the trial as shown in the table 4. Earlier, Megerssa., *et al.* [20] reported higher plankton production in goat manure treated ponds that had positive impact on growth of filter feeder fish species like Tilapia and Carps without any supplementary feeding.

The growth performance and total yield of fish in earthen ponds with different dose of goat manure without any supplementary feeding (Table 5) indicated that significantly higher production could be achieved with goat manure treated ponds in comparison to the control. This finding was in agreement with earlier study by Megerssa., *et al.* 2016. Highest production was achieved in pond with goat dung application @ 10,000 kg/ha/year (T2) (significant at 0.05 level), followed by 15,000 kg/ha (T3), 7,500 kg/ha (T1) and

Goat manure produced (gm/animal/night)											
Wt. of goat (kg)	**Day 1**	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Day 6**	**Day 7**	**Day 8**	**Day 9**	**Day 10**	**Average**
12.0	145	90	96	84	176	144	96	90	125	95	114.1
17.0	160	130	166	110	274	197	166	130	145	286	176.4
15.0	168	141	160	145	140	163	210	94	138	121	148.0
11.0	98	110	65	125	130	154	110	90	210	151	124.3
10.5	75	85	31	86	90	130	163	95	167	140	106.2
12.0	148	151	90	198	150	105	200	176	96	145	145.9
17.5	178	168	110	248	286	87	143	160	130	159	166.9

Table 3: Quantification of Goat (Beetal XAssam Hill goat.) manure.

Parameters	T_1	T_2	T_3	T_4	Control
DO (ppm)	5.00-7.35	5.75-8.10	5.35-8.25	3.25-6.90	5.25-8.65
Temperature (°C)	14ºC-31ºC	15ºC-31ºC	15ºC-32ºC	16ºC-32.5ºC	15ºC-31ºC
Turbidity (ppm)	17.5-19.0	18.3-19.2	18.5-23.3	23.0-27.5	12.0-13.0
pH	7.8-8.45	7.7-8.55	7.4-8.18	8.1-8.8	6.6-7.2
Conductivity (mS/cm)	54- 154	68- 175	98-237	122-278	45-68
CO_2 (ppm)	5.0-7.0	5.5-7.3	5.3-7.5	6.7-8.3	4.8-6.3
COD (mg/L)	16-24	18-27	22-28	34-38	14-25
BOD (mg /l)	3.9-4.0	4.3-5.1	4.7-5.4	5.3-6.0	2.9-3.3
Plankton population (nos/l)	2100-3645	2540-3510	3745-4350	4525-5380	1937-2870
Alkalinity (ppm)	53.6-61.3	69.3-76.0	77.0-85.5	89.0-94.5	27.5-43.3

Table 4: Water quality parameters under different treatments.

control(C) in the descending order. Calculated per hectare production was 3879.4 kg (T2), 3430.8 kg (T3), 3358.9 kg (T1) and 2061.8 kg (C) respectively (Figure 3), which depicted the comparative efficiency of different doses of goat dung application. The inherent ecological bottleneck in the form of low range of ambient temperature (<18ºC) prevailed in the state during winter months (November- February) had a negative impact on the growth of fish during that period [22]. Similar findings were recorded in earlier studies on semi intensive composite culture in the state [23,24]. Species wise production data revealed that the highest production could be achieved in Silver carp, which might be due to abundance of phytoplankton growth, the major natural food for the species, due to goat manure application.

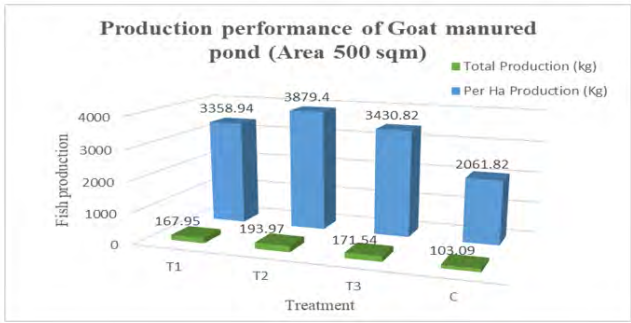

Figure 3: Production performance of Goat Manured Pond (Area 500sqm).

The number of animals required for fertilizing a 1,000 sqm pond (as a small unit pond) and for 1 ha area was also calculated out to be 25-30 nos. and 250-300 nos. respectively on the basis of average amount of goat dung produced per animal of varying sizes. Earlier, Libunao (1990) reported that integration of 300 goats per ha is the most efficient proposition for production of Tilapia (*O. niloticus*) exhibiting highest yield. Although it was reported that growth performance of some fish species is better when fed with formulated feed than grown with goat dung only [14], yet application of goat manure in proper dose in fish pond may be an efficient proposition for resource poor farmers who have a herd of goats and small pond in their homestead as an efficient option for securing nutrition and livelihood with low external input cost in an environment friendly way.

The result of the study opens a new avenue for integrating goat farming with fish farming as an efficient farming system model for small and marginal fish farmers. Although further study on performance of different fish species combination and stocking density, fortification and application schedule are required, the results of the present study can be taken as a basis for formulating an efficient package of practice in due course.

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Species and nos.** Stocked/pond	Initial av. weight (gm)				Final av. weight (gm)				Production (gm)/pond				Nos. recovered and % of recovery*			
	T_1	T_2	T_3	C	T_1	T_2	T_3	C	T_1	T_2	T_3	C	T_1	T_2	T_3	C
Silver carp (88)	35	36	35	35	630	685	667	360	42210	46580	40687	19800	67 (76.1)	68 (77.3)	61 (69.3)	55 (62.5)
Rohu (66)	25	20	23	22	440	530	511	400	20680	26500	23506	17600	47 (71.2)	50 (75.8)	46 (69.7)	44 (66.7)
Catla (66)	40	45	45	40	620	640	605	367	31620	33280	30250	16515	51 (77.3)	52 (78.8)	50 (75.7)	45 (68.2)
Mrigal (88)	20	18	18	22	430	465	433	320	27950	31620	28578	20800	65 (73.9)	68 (77.3)	66 (75.0)	65 (73.9)
Common Carp (88)	45	40	40	45	445	520	480	326	28925	34840	29760	18256	65 (73.9)	67 (76.1)	62 (70.5)	56 (63.6)
Grass carp (44)	35	38	35	35	637	705	670	440	16562	21150	18760	10120	26 (59.1)	30 (68.2)	28 (63.6)	23 (52.3)

Table 5: Growth of fish in goat manure treated pond (Area 500sqm/pond, stocking @ 8,800 nos./ha)

Culture period: 10 months.

*Figures in parentheses indicate % of recovery.

**Figures in parentheses indicate number stocked for each species.

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