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Evaluation of Intercrops in Arecanut Gardens of South Andaman Island

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Abstract

Intercropping experiments conducted in arecanut gardens in South Andaman, India revealed the scope of increasing profitablity by incorporating suitable crops. Arecanut is an important cash crop grown in Andaman groups of islands wherein, monocropping is a common practice in most of the areas resulting in underutilization of interspaces in land scarce islands. In order to optimally utilize the limited area available for cultivation in the islands and reduce dependance on supplies from mainland India, adoption of intercropping could be a viable option. Results with evaluation of three popular intercrops *viz*. elephant foot yam, banana andginger in arecanut gardens under island conditon suggested that adoption of intercropping could increasethe profitablity to the tune ofupto Rs. 17,94,000/- as gross returnswhen intercropping elephant foot yam in arecanut is followed as compared to Rs. 12,63,000/- in arecanut monocropping over a period of two years.Results also suggested that, considering the local demands and duration of crops, banana, ginger and elephant foot yam could be profitably incorporated in the existing arecanut gardens of Andaman islands.

Keywords: Island ecosytem, plantation crop, raifed cultivation, tropical

Introduction

Arecanut is the second most commonly grown plantation crop after coconut in the Andaman and Nicobar islands (ANI). Apart from the settler communities of these island, nuts are also chewed for mastication by native Great Andamanese tribe of these islands (Awasthi, 1991). Tropical conditions of ANI with prolonged rainy spells offer conducive growing environemnt for arecanut which is evidenced by its nut size. In recent past, cultivation of arecanut has gained popularity in Andaman groups of islands due tolimited input requirement for cultivation and remunerative market prices offered to the produce. Absence of major pests/ disesases such as red palm weevil, yellow leaf disease *etc*. in the islands also contribute to the increasing popularity of arecanut in the islands.

The crop is mainly cultivated in the hilly uplands of Andaman group of islands including Middle Andaman, North Andaman,South Andaman and Little Andaman islands. However, in most of the orchards, interspaces remain underutilized as intercropping is rarely adopted. Considering the limited area available for cultivation in the islands, use of interspaces in the perennial orchards is of prime importance to ensure regular supply of essential horticultural commodities to the island dwellers. In order to identify most suitable intercrops for cultivation in the exisiting areanut garden, experiments were carried out with most popular crops of these islands. The present report concerned evaluation of banana, ginger and elephant foot yam as intercrops under island conditions.

Materials and Methods

An experiment was conducted during 2016-17 and 2017-18 in11 years old garden of arecanut var. Samrudhi at Horticulture Research Farm, Sippighat located in South Andaman island under ICAR-Central Island Agricultural Research Institute. Terracing was done on hill slopes in arecanut which was planted at 2.7 m × 2.7 m. There were four treatments viz. arecanut aloneas monocrop(T_1), arecanut + banana (T_2), arecanut + ginger (T_3) and arecanut + elephant foot yam (T_4). The experiment was laid out in randomized block design with five replications under rainfed conditions. Banana var. Cheena (PisangAwak) was planted at 1.8 m × 1.8 m during 2016 in triangular

system to accommodate two rows in each terrace. Ginger was planted during 2016 and 2017 on raised beds of 10 m length and 0.6 m width at 25 cm × 25 cm spacing. Elephant foot yam was planted during 2016 and 2017 at 1 m × 1 m spacing to accommodate two rows in each terrace. The intercrops were grown using only organic manures (without any fertilizers) and yield data was recorded during both cropping years. Soil samples were collected before and after the experiment and analyzed using established procedures.

Results and Discussion

The soil and climatic conditions of Andaman and Nicobar islands are highly suitable for cultivation of banana, ginger and elephant foot yam. These crops are being cultivated under open condition in most parts of these islands. Considering the popularity of these crops, they were included in the experiment and results are presented in Table 1. During first year of evaluation, lowest yield of *chali*(1.11 t/ha) was obtained in arecanut sole cropping (T_1), which increased to 1.31 t/ha in arecanut + elephant foot yam, 1.49 t/ha in arecanut + banana combination and 1.65 t/ha in T_3 involving arecanut + ginger combination. Additionally, 0.95 t/ha ginger and 2.7 t/ha elephant foot yam was also obtained in treatments T_3 an T_4, respectively. Banana was in juvenile phase so no yield was obtained in first year.

Table. 1. Yield and gross income of Arecanut and different intercrops under island condition

Treatment	Crops	Year I		Year II		Cumulative gross income for two years (Rs.)
		Yield (t/ha)	Gross income (Rs.)	Yield (t/ ha)	Gross income (Rs.)	
T_1	Arecanut	1.11	3,33,000/-	3.1	9,30,000/-	**12,63,000/-**
T_2	Arecanut	1.49	4,47,000/-	3.1	9,30,000/-	
	Banana	-	-	12.2	3,66,000/-	
	Total T_2		**4,47,000/-**		**12,96,000/-**	**17,43,000/-**
T_3	Arecanut	1.65	4,95,000/-	3.6	10,80,000/-	
	Ginger	0.95	76,000/-	1.13	90,400/-	
	Total T_3		**5,71,000/-**		**11,70,400/-**	**17,41,400/-**
T_4	Arecanut	1.31	3,93,000/-	4.3	12,90,000/-	
	EFY	2.70	54,000/-	2.85	57,000/-	
	Total T_4		**4,47,000/-**		**13,47,000/-**	**17,94,000/-**

Selling prices: arecanut*chali*@Rs. 300 / kg;ginger @ Rs. 80/ kg; banana @ Rs. 30 /kg and EFY @Rs. 20/ kg

During second year, yields of arecanut and component crops were higher in all the treatments when compared with first year of trial. As the experimental garden was unmanaged before the trial, probably due to improved management practices, higher yields were noticed in second year of cropping.*Chali* yield was improved from 3.1 t/ha in areanut sole cropping to 4.3 t/ha in treatment involving arecanut + elephant foot yam combination. Banana came to harvesting during this year which gave additional yield of 12.2 t/ha. Additional estimated yields of 1.13 t/ha of ginger and 2.85 t/ha of elephant foot yam was also noticed in T_3 and T_4, respectively.

During both years of study, incorporation of intercrops were found to improve the *chali* yield and no adverse effects were noticed on arecanut, which suggested compatibility of the studied crops with arecanut. Improved *chali* yield due to use of suitable intercrops

have also been reported from Coastal Karnataka (Bhat *et al*., 1999) and Assam (Hussain *et al*., 2008) conditions. Further, improvement in yields of component crops over the period could be attributed to the creation of optimal microclimate as reported by previous researchers (Bhat *et al*., 1999; Hussain *et al*., 2008; Hussain *et al*., 2011).

During both the years, gross income was substantially higher in all the intercropping combinations than arecanut monocropping.In case of cumulative gross income from the cropping model over two years, highest gross returns were obtained from T_4 (Rs. 17,94,000/), followed by T_2 (Rs. 17,43,000/-) and T_3 (Rs. 17,41,400/-), which were substantially higher than arecanut alone. Banana with additional income of Rs. 3,66,000/-, was found to be most profit giving intercrop amongst the three crops studied over two years. However, considering the overall returns and maincrop-intercrop interactions, arecanut + elephant foot yam combination was found to be most remunerative under island conditions.Although the gross returns may vary according to the prevailing price of the produce and the location of production, the additional production and increased productivity are the advantages of the intercropping options. Ensuring inputs, timely harvesting, intercultural operations, marketing and quality of the produce are the other factors to be considered while going for intercropping.

Effect of intercropping on soil properties was also studied and data is presented in Table 2. Irrespective of the treatment, pH values of the soil increased after the experiment was over, which is in accordance with the earlier report from coastal Karnataka (Bhat and Sujatha, 2007). Although,addition of organic matter through residue tend to increase soil organic carbon content in the sytem, reduction in organic carbon content was noticed in the present study. This could be because of losses caused due land preparation activitiesas the area had remained undisturbed for longer times prior to experiment.Over the period, improvement could be expected as organic content is added during subsequent cropping cycles. Available nitrogen content increased after the cropping which indicates the positive effect of organic matter recycling on N content (Bhat and Sujatha, 2007). Available potassium content decreased after cropping, which could be due to the fact that organic recycling alone may not be sufficient to maintain the availablity of K in laterite soils to leaching losses and lesser K content in organic residues (Bhat and Sujatha, 2007).

Table. 2. Pre-experimental and post-experimental soil characteristics of Arecanut based cropping system models under island condition

Treatment	pH		EC (dS/m)		Organic Carbon (%)		Available N (kg/ ha)		Available K_2O (kg/ha)	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
T_1	4.64	5.75	0.7	0.06	2.1	0.6	292	489	226	115
T_2		5.80		0.13		0.9		533		186
T_3		5.95		0.10		0.9		383		96
T_4		5.58		0.07		0.8		527		136

In a nutshell, adoption of intercropping was found to be more remunerative than arecanut monocropping under South Andaman conditions and hence, could be recommended for the island farmers so as to improve their profits and reduce the dependance of islanders on external supplies for these commodities.

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References

Awasthi, A.K. (1991). Ethnobotanical studies of the Negritoislanders of Andaman islands, India- the Great Andamanese. *Economic Botany*45:274-280.

Bhat, R. & Sujatha, S. (2007). Soil fertility status as influenced by arecanut based cropping system and nutrient management. *Journal of Plantation Crops*35: 158-165.

Bhat R., Reddy, V.M. &Khader, K.B.A. (1999). Areca based high density multispecies cropping system in coastal Karnataka. *Journal of Plantation Crops*27: 22-26.

Hussain, M., Ray,A.K., Maheswarappa, H.P., Krishnakumar,V., Bhat,R., Subramanian, P.&Thomas,G.V. (2008). Recycling of organic biomass from arecanut based high density multi-species cropping system models under Assam condition. *Journal of Plantation Crops*36: 53-57.

Hussain,M., Ray,A.K., Maheswarappa,H.P., Subramanian,P., Bhat,R., Krishnakumar,V. &Acharya,G.C. (2011). Sustainable productivity and economics of arecanut based high density multi-species cropping system under Brahmaputra valley region of Assam. *Journal of Plantation Crops*39: 68-72.

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Diversification of rice based cropping systems for higher production and productivity in rainfed lowlands of Andaman Islands

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Abstract

Crop diversification is as an important tool for accelerating agricultural growth in smallholder farms for enhanced production, income and employment generation besides judicious use of natural resources and ecological management. However, in Andaman Islands the productivity of lowland system is very low due to the cultivation of photosensitive, long duration rice with lack of crop diversification. Hence, a field experiment was conducted with four rice based cropping systems viz., rice-maize, rice-green gram, rice-ground nut and rice-vegetable (okra) in completely randomized design with three replications to evaluate its performance under island condition. Use of photo insensitive rice varieties and advancement of transplanting date helped to accommodate dry season crop into the crop rotation. The results showed that rice - ground nut recorded highest production efficiency of 65.6 kg $ha^{-1}day^{-1}$ followed by rice-maize and rice-okra sequences. Among all the treatments rice- maize and rice-ground nut recorded highest net returns and B:C ratio while rice-groundnut recorded highest production efficiency.

Key words: Rice monocrop, Lowland, Cropping System, Production, Cost: benefit

Introduction

Balancing productivity, profitability, with ecological health is a key challenge for agricultural sustainability besides feeding the ever increasing population. As in many of the developing countries and in Southeast Asia, small holder farms constitute the bulk of agricultural production in India. As the smallholder farmers rely on seasonal yields for food and economic returns, achieving yield stability is paramount importance. The crop diversification is considered as an important tool for acceleration of agricultural growth in smallholder farms for enhanced production, income and employment generation besides judicious use of natural resources and ecological management.

Crop diversification involves growing more than one crop of the same or different species in a given area either in the form of crop rotations and or intercropping. The combination of various crops in smallholder farms allows more efficient utilization of agro ecological processes and improves household income, food and nutritional security (Mango *et al*.2018), provides resilience (Lin 2011) to small holder farms. The crop diversification also enhances farm level biodiversity (Swarnam *et al*.2016). It also increases cropping intensity and yield per unit area (Lal *et al*.2017) which is very much essential for maintaining stability in rainfed areas. The Islands have wet tropical climate with a total rainfall of 3100mm spread over 7 months from May to November. The mean annual temperature is 30.1° C, with a minimum of 18.6° C and a maximum of 33.0°C. The relative humidity varies from 63 to 90%. Agriculture in the Islands depends on rains which mostly occur during monsoon months (June-September). Due to heavy concentrated rainfall in a short span, flat topography, low infiltration rate and lack of proper drainage, most of the cultivated fields are deeply waterlogged limiting the cultivation of high yielding varieties (HYV) of rice, instead mono cropping of tall *indica* rice varieties are cultivated in wet season. During dry season, acute shortage of irrigation water along with increase in soil and water salinity in coastal lowlands/ plains due to presence of brackish water table at a shallow depth compelled the farmers to keep their land fallow resulting in lower productivity. Hence, this study was proposed to study different rice based cropping systems in increasing production and productivity of the rainfed lowlands of the island.

Materials and methods

Site description

Experiments were conducted during the wet and dry seasons of 2013 to 2014 at Field Crops Research Farm of Central Island Agricultural Research Institute, Port Blair. The two major cropping seasons of the Island includes a wet season from June to November and dry season from December to April. The soil at the experimental site was an Entisol with sandy clay loam texture with bulk density (1.42 Mg m^3). The soils are slightly acidic (pH 6.0), non saline (0.028 dS m^{-1}), and contained 8.2 g kg^{-1} of organic carbon, 310 kg ha^{-1} of available N, 13.3 kg ha^{-1} P and 176 kg ha^{-1} ammonium acetate K.

Experimental set up

Four rice based cropping systems viz., rice-maize, rice-green gram, rice-ground nut and rice-vegetable (okra) were carried out in completely randomized design with three replications in plots of 250 m^2 area. All the dry season crops of rice-based cropping sequences were chosen on the basis of their importance in ensuring food and nutritional security of samllholder farms in far isolated areas and economic returns as vegetable cultivation is gaining importance in these areas after harvest of rice. The urea, ammonium phosphate and muriate of potash were applied to all the crops in different crop sequences based on the recommended doses of fertilizer for specific crops and all other management practices were followed to raise the crops in different cropping sequences (Gangwar and Bandyopadyay 1996).

Economic analysis

Economic yields of component crops were converted into rice-equivalent yield (REY), taking into account the prevailing market prices of different crops in the cropping sequences. The above values were computed as per the following formula given by Verma nad Modgal (1983).

Rice-equivalent yield (REY) of a component crop (a) = (Yield of component crop x Market price of a component crop/ Price of rice)

Total REY = Yield f rice in the particular system + a

Production-efficiency values in terms of kg ha^{-1} day^{-1} were worked out for the total production by means of rice equivalent yield in a cropping system divided by total duration of that particular system. The values of production efficiency in terms of INR ha^{-1} day^{-1} were calculated by net monetary returns of the system divided by total duration of the crops in that system (Tomar and Tiwari, 1990).

Statistical analysis

Various treatments were compared under a randomized block design based on pooled average of yield for both the years. The critical difference (CD) was computed to determine statistically significant treatment differences.

Results and discussion

System productivity

The rice transplanting was advanced to June/ July months instead of August so as to clear the land for cultivation of dry season crops. Normally, the traditional long duration varieties are grown during August and harvested after second week of January. Because of lack of moisture and irrigation facilities, land could not be utilized for raising dry season crops. In our experiment new rice varieties like CSR 36 and CARI 5 are transplanted in second half of June or early July and harvest by end of October/ November months so that the land will be free for taking up second crop and sowing of these crops were completed by end of December or first week of January so that the crops won't affected by terminal drought in March.

Table 1 Yield and production efficiency of rice-based cropping systems

Cropping System	Crop Yield (q ha^{-1})				System Yield (q ha^{-1})			Mean system duration (days)	Production Efficiency (kg/ha/day)
	Wet season		Dry season*						
	2013	2014	2013	2014	2013	2014	Mean		
R-M	44	46	118	34	161	81	121^{a}	205	58.1^{b}
R- GG	43	43	16	12	59	55	57^{b}	173	32.8^{c}
R-GN	39	45	62	90	121	135	128^{a}	195	65.6^{a}
R-Ok	47	38	80	72	127	110	118^{a}	218	54.3^{b}
CD (p=0.05)	NS	NS	-	-	-	-	32	-	3.82

* in terms of REY, R-M rice-maize(cobs), R-GG rice-green gram, R-GN rice-ground nut(table purpose) and R-Ok rice-okra

The perusal of production data indicated that the rice grain yield during wet season in both the years (2013 and 2014) hadn't shown any significant difference with values ranged from 38 to 47 q ha^{-1}. However, significant differences were found in yield of dry season crops with highest REY in maize (118 q ha^{-1}) followed by okra (80 q ha^{-1}) during 2013. However, in 2014 the ground nut outperformed the relative yield of maize and okra in 2014. The maize yield in 2014 was drastically reduced due to heavy rainfall at the time of maturity leading to wilting of plants because of water stagnation. The lowest yield was observed in pulses (12 -16 q ha^{-1}) in both the years because of their inherent low productivity.

The analysis of mean system yield indicates that the rice-ground nut, rice-maize and rice-okra performed on par (118 to 128 q ha^{-1}) with rice- green gram recording the lowest mean system yield. This was reflected in production efficiency of the respective sequences as well where, the rice - ground nut recording highest production efficiency of 65.6 kg ha^{-1}day^{-1}followed by rice-maize (58.1 kg ha^{-1}day^{-1}) and rice-okra sequences (54.3 kg ha^{-1}day^{-1}). So it can be concluded that the inclusion of maize for green cobs, table purpose ground nut and okra after harvesting of rice in lowland areas will increase the productivity and total production.

Economic analysis

The cost analysis for different rice based sequences was summarized in Table 2. Among all the treatments rice- maize and rice-ground nut recorded highest net returns INR 93939/- and INR93201/- respectively and it was followed by rice-okra (INR 82683/-). The lowest net return was observed in rice-green gram sequence. This was reflected in production efficiency and B: C ratio as well. The production efficiency in terms of net return was highest in rice-ground nut (table purpose) with INR 478 ha^{-1} day^{-1} which was closely followed by rice-maize sequence. Similar to system production, productivity and net returns, the production efficiency and B: C ratio of the rice-green gram sequence was found to be lowest among all the sequences.

Table2. Economic analysis of rice based cropping systems (Mean of 2 years)

Cropping systems	Cost/return (Rs ha^{-1})			Production efficiency (INR ha^{-1} day^{-1})	B:C ratio
	Gross Return	Total cost	Net return		
Rice - Maize	166352	72413	93939	458.2	2.30
Rice - Green gram	78160	65876	12284	71.0	1.19
Rice - Ground nut	176774	83573	93201	478.0	2.12
Rice - Okra	163278	80595	82683	379.3	2.03

Conclusion

The production and productivity of small holder farms in rainfed lowlands of Andaman Islands can be increased by suitably adjusting the transplanting of wet season rice and growing photo insensitive high yielding rice varieties such as CSR36, CARI5 instead of long duration traditional photosensitive varieties like C-14-8. By advancing the transplanting date and completing the harvesting of rice in November will facilitate the sowing of second or dry season crops like maize, ground nut, vegetables and pulse utilizing residual moisture and with supplementary irrigation. Among various rice based cropping sequences, rice-maize, rice-ground nut performed better followed by rice-okra. While rice-green gram performed poorly but it can be used when there is a moisture stress condition.

References

Gangwar, B & Bandyopadyay, A.K. (1996). Agricultural production manual for Andaman and Nicobar Islands. Technical Bulletin No.2, Central Agricultural Research Institute, Port Blair.119 p.

Lal, B. Gautam, P., Panda, B.B., Raja, R., Singh, T., Tripathi, R., Shahid, M. & Nayak, A.K. (2017). Crop and varietal diversification of rainfed rice based cropping systems for higher productivity and profitability in Eastern India. *PLoS ONE* 12(4): e0175709. https://doi.org/10.1371/journal.pone.0175709

Lin, B.B. (2011). Resilience in agriculture through crop diversification: adaptive management for environmental change. *Bioscience* 61:183–193.

Mango, N., Makale, C., Mapemba, L. & Sopo, M. (2018). The role of crop diversification in improving household food security in central Malawi. *Agriculture & Food Security* 7:7

Swarnam, T.P., Velmurugan, A., Subramani, T., Kundu, M.S., Kirubasankar, R., Awnindra K. Singh, Jaisankar, I. & Dam Roy, S. (2016). Agrobiodiversity management in integrated farming system for food and nutritional security. *Vegetos* 29(special):9-13.

Tomar, S.S. & Tiwari, A.S. (1990). Production potential and economics of different crop sequences. *Indian Journal of Agronomy* 35(1&2): 30–35.

Verma, S.P. & Modgal, S.C. (1983). Production potential and economics of fertilizer application as resource constraints in maize-wheat crop sequences. *Himachal Journal of Agricultural Research* 9(2): 89–92.

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Mangosteen (*Garcinia mangostana* L.): A Potential Crop for Increasing Incomes of Island Farmers

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Abstract

Mangosteen is popularly known as the 'Queen of Tropical Fruits' owing to its delicious taste. Demand for fruits has increased in recent times and is being met by cultivation in non-traditional areas. An attempt was made to know cultivation suitability of mangosteen in the Andaman and Nicobar islands. Fruits grown in South Andaman and Little Andaman were evaluated for physicochemical parameters. Results revealed that fruit morphological characters varied with collection. Pulp content in island grown fruits varied from 27.3% to 35.7%, while total soluble solids content of pulp was in the range of 16.0 to 22.5 °B. This suggested comparable and even better pulp recovery and sweetness in island grown fruits than earlier reports from abroad. pH of pulp was in acidic range (3.8 to 4.4). Possible bottlenecks in cultivation and initiatives undertaken at authors' institute have been discussed. Further, roadmap for promotion of cultivation of mangosteen in the islands has also been given. Considering the findings, mangosteen could be a potential crop for backyard as well as commercial scale cultivation in the islands.

Keywords: fruiting; fruit quality; physico-chemical characters; total soluble solids; tropical fruit

Introduction

Mangosteen (*Garcinia mangostana* L.), a member of the botanical family Clusiaceae, is one of the most popular fruits in the South East Asia. It is commonly referred to as the 'finest fruit of the world' and the 'Queen of tropical fruits' (Fairchild 1915) owing to its superior taste and exotic appearance. It is found growing in the Tropical Asian countries including Thailand, the Philippines, Indonesia, Sri Lanka, Myanmar, Malaysia, Vietnam and parts of Australia (Sando*et al*. 2005). Considering the potential of this exotic fruit, the crop has been successfully introduced in some Indian states (Shree 2016) such as Karnataka, Tamil Nadu, Kerala, Goa and coastal Maharashtra.

Mangosteen is assumed to have evolved from natural cross between *G. hombroniana* and *G. malaccensis*(Ketsa and Paull 2011). Andaman and Nicobar Islands are home to a number of *Garcinia* species (Bohra *et al.* 2019) including *G. hombroniana* (*G. celebica*), which is distributed in both Andaman and Nicobar groups of islands. Further, mangosteen grows well in humid tropical conditions and is suitable as intercrop in coconut gardens (Shree 2016). Considering these points, there is ample scope for cultivation of mangosteen as backyard as well as commercial crop in the islands.

Farmers in a number of tropical countries are exporting their produce and getting multifold profits. For example, Indonesian farmers are getting 5-8 times higher prices in export markets than the domestic ones (Prabasari 2018). Mangosteen being a climacteric fruit with a shelf life of three weeks at 12-13 °C (Choehom*et al.* 2003), could be easily transported from the islands to other places including mainland India and abroad. In this report, few important observations on this crop under island conditions have been discussed to know its suitability for cultivation.

Materials and Methods

Field surveys were conducted in South Andaman and Little Andaman islands and locations with existing mangosteen trees were identified. Flowering and fruiting observations were recorded during 2015 to 2019. Based on availability, mature fruits were harvested from two trees in South Andaman and one tree grown in a farmer's

field in Little Andaman Island. Fruits were brought to authors' laboratory and various parameters were recorded as followed.

Fruit weight (g) was recorded using digital balance, while fruit length (cm) and diameter (cm) were recorded using a digital vernier caliper. Fruits were cut opened and rind thickness (cm) was measured using vernier caliper. Number of segments per fruit, seeds per fruit and seed weight (g) was determined. Pulp (%) was determined in all the collections. Observations were recorded with ten replications. Total soluble solids (TSS) and pH of pulp were determined in triplicate using hand held refractometer (Optics Technologies, India) and bench top pH meter (Hanna). Data was presented as mean± standard error of mean (SEm). Initiatives taken at authors' Institute and roadmap for development of mangosteen as a commercial crop in the islands have also been discussed.

Results and Discussion

During the surveys, four trees were observed in a temple premise in South Andaman, which are growing since a few decades. Of these trees, three were regular yielders while Tree No. 2 came into bearing for the first time during 2018. Being protected in the territory of a religious monument, trees are growing in natural condition without any external interference. One mature tree was observed in a farmers' field at Rabindra Nagar village of Little Andaman. This tree, being cultivated, was provided with irrigation during dry period, manuring and mulching with coconut husk. All the studied trees were under open conditions.

Observations were recorded during different stages of flower and fruit development. Flowering and harvesting was observed comparatively earlier in Tree No. 1. Fruits started ripening between May to July in Tree No. 1, while fruits came to harvesting during July to late August in Tree No. 3 and Little Andaman collection. Mangosteen fruit development takes place without pollination and fertilization (Ketsa and Paull 2011). During initial stages of development, fruit rind was light green in colour with purple stigmatic lobes. However, on attainment of full maturity, fruit colour changed with development of red spots which covered the complete fruit surface. Fully ripe fruits were attractive dark purple in colour with four attractive green calices (Fig. 1). Fruit development takes about sixteen weeks for attaining harvestable stage after flowering.

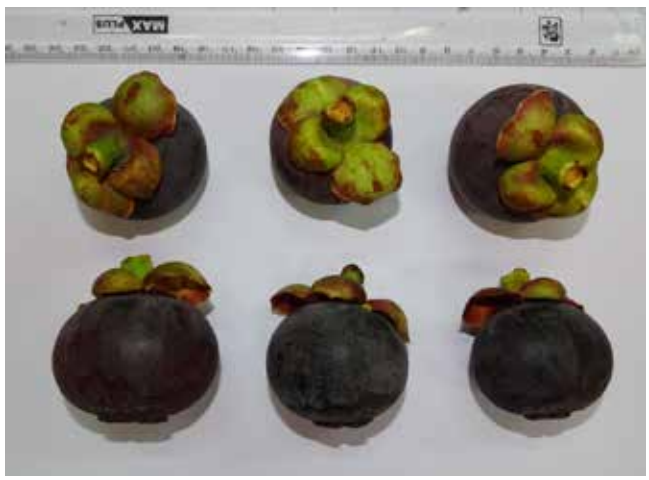

Fig. 1. Fully developed ripe fruits of mangosteen ready for consumption

Size of fruits varied amongst trees and each fruit weighed between 54.3 to 69.9 g (Table 1). In case of Tree No. 1, it varied between years of collection as fruit weight varied between 54.3 g (2016) and 62.4 g (2019). Being grown under natural conditions, such variations are expected. Fruits of Tree No. 3 weighed to 69.9 g, while those collected from Little Andaman weighed an average of 67.7 g. Fruit length and diameter were not influenced by year in Tree no. 1, while these values varied amongst the collections studied. Fruit length varied between 4.1 cm (Tree No. 1) to 4.8 cm (Little Andaman). Fruit diameter varied between 4.9 cm (Tree No. 1) to 5.3 cm (Tree No. 3).

Table 1. Fruit physicochemical parameters in mangosteen collections grown in ANI

Parameters	South Andaman			Little Andaman
	Tree No. 1		Tree No. 3	
	2016	2019	2018	2019
Harvesting period	May - July		July- August	July- August
Fruit weight (g)	54.3 ± 2.73	62.4 ± 3.98	69.9 ± 4.77	67.7 ± 2.43
Fruit length (cm)	4.1 ± 0.14	4.1 ± 0.09	4.5 ± 0.10	4.8 ± 0.09
Fruit width (cm)	4.9 ± 0.12	4.9 ± 0.13	5.3 ± 0.14	5.0 ± 0.06
No. of segments per fruit	6.1 ± 0.23	6.1 ± 0.18	6.1 ± 0.23	5.9 ± 0.23
No. of seeds/ fruit	0.9 ± 0.29	1.6 ± 0.18	1.3 ± 0.21	1.3 ± 0.21
Mean total seed weight (g)	0.4 ± 0.04	1.3 ± 0.24	0.6 ± 0.09	0.6 ±0.14
Rind thickness (cm)	0.7 ± 0.03	0.6 ± 0.02	0.9 ± 0.03	0.6 ± 0.02
Pulp (%)	32.6 ± 0.69	34.7 ± 0.8	27.3 ± 0.80	35.7 ± 1.71
TSS (°B)	21.3 ± 0.17	17.2 ± 0.6	22.5 ± 0.16	16.0 ± 0.32
pH	4.0 ± 0.04	4.4 ± 0.00	3.8 ± 0.06	4.0 ±0.09

Standards have been developed for trade of mangosteen by different countries and organizations e.g. CODEX (CODEX 2005), ASEAN (2008), Philippine National Standards, PNS (2005) etc. In all these standards, parameters such as fruit colour, fruit weight, fruit diameter, freedom from blemishes and pests/ pathogens are considered as important criteria. In all the studied locations, no pests/ diseases were reported. Considering sizes of fruits, fruits grown in the ANI were classified into Size Code 4 as per ASEAN standards, while they were categorized in Class B as per CODEX standards. As per Philippine National Standards, fruits were classified under Small category (51 to 75 g).

Number of stigmatic lobes present on the fruits was equal to number of edible segments present inside the fruits. It means even without cutting the fruit, number of segments could be made out. Further, thickness of each lobe was proportionate to plumpiness of segment. Number of segments in a fruit varied between 5.9 and 6.0 (Table 1). In general, seeds were present only in segments which were enlarged, while other segments were either seedless or had underdeveloped seeds. Number of seeds per fruit varied between 0.9 and 1.6 in Tree No. 1; while in other two collections it was 1.3. Rind thickness varied between 0.6 and 0.9 cm and thickest rind was observed in fruits of Tree No. 3. Presence of thick rind also makes the fruits amenable for long distance transportation with appropriate packaging and handling (Choehom*et al.* 2003). Earlier report suggested thickness of 0.82 to 0.94 cm in mangosteen grown in Philippines (Anabesa 1992).

Pulp is the economic part and in all the collections, it was found to be white with pleasant aroma. Recovery of pulp varied from 27.3% (Tree No. 3) to 35.7% (Little Andaman). This recovery is much higher than mangosteen cultivated in the Philippines, which was 17.75 to 24.85% (Anabesa 1992). Total soluble solids content was in the range of 16.0 to 22.5 °B, while pH of pulp was in acidic range (3.8 to 4.4). Earlier report suggested soluble solids content of 17.2 to 17.9% in fruits grown in Thailand (Palapol*et al.* 2009), while those grown in the Philippines had TSS content of 19.18-20.79 °B (Anabesa 1992). This suggested comparable and even better sweetness in fruits grown in ANI.

Without much management, mangosteen trees in the islands were able to produce good quality fruits. It has been reported that, major share of the mangosteen in the

world market comes from the backyard trees (Wieble*et al*. 1992) and forests in the Southeast Asian countries (Sobir*et al*. 2013). Hence, inclusion of a few trees in the backyard could fetch the farmers considerable income. Further, major area of island agriculture is under coconut plantations, most of which are under monocropping. Mangosteen could be successfully grown in such plantations on commercial scale. Andaman and Nicobar Islands being a popular tourist destination, marketing of this exotic fruit would not be difficult.

Various initiatives were taken up at authors' institute for promotion of its systematic cultivation in the islands. Improved variety *viz*. K-100 was introduced from Homegrown Nurseries, Kerala and a demonstration block was established. Various awareness programmes were conducted to popularize the crop among the island farmers. Seedlings are being produced in the Horticultural Plant Propagation Unit of the Institute for supply to the farmers. Translucent pulp and Gamboge disorder (exudation of yellow latex), which are major bottlenecks in mangosteen growing countries (Ketsa and Paull 2011), were observed to some extent in the ANI, which could be addressed by scientific management of crop especially by judicious watering. Further, rind hardening was observed as a result of impact injury to fruits while harvesting.

Conclusions

Based on the above findings following points have been suggested for promoting cultivation of mangosteen in the ANI:

- Improved varieties with better fruit size and less juvenility should be promoted in the islands.
- Demonstration blocks of mangosteen as intercrop in coconut gardens should be established.
- Considering slow growth and absence of root growth in ANI, suitable rootstocks should be identified from native *Garcinia* species for commercial exploitation.
- Planting material should be produced on large scale, preferably in the islands, for distribution to island farmers.
- Packaging and storage facilities should be created for promotion of trade to mainland and export purposes.
- Community gardens should be established and provision for pooling of farm produce from different islands should be done.
- Cultivation practices such as shade provision (during vegetative phase), nutrient management, irrigation management etc. should be adopted.
- Development of harvester for safe harvesting of fruits to avoid impact injury while harvesting.

Considering the performance of crop in the islands and quality of fruits produced, it is evident that mangosteen could prove a profitable commercial crop for the island farmers.

References

Anabesa M.S. (1992). Maturity indices of mangosteen. *Philippine Journal of Crop Science* 17(3): 115-118.

ASEAN. (2008). ASEAN Standard for Mangosteen (ASEAN Stand 10:2008).

Bohra, P., Waman, A.A.& Mishra, S.(2019).Crop Wild Relatives of Selected Perennial Horticultural Crops in Andaman and Nicobar Islands, India. In: (Eds. P.E. Rajasekharan and V. RamanathaRao) Conservation and Utilization of Horticultural Genetic Resources. Springer-Nature. pp. 425-450.

Choehom, R., Ketsa, S. & van Doorn, W.G. (2003). Chilling injury in mangosteen fruit.*Journal of Horticultural Science and Biotechnology* 78: 559-562.

CODEX (2005). Standard for Mangosteens (CODEX STAN 204-1997).

Fairchild, D. (1915). The mangosteen.*Journal of Heredity*6(8):338-347.

Ketsa S. &Paull, R.E. (2011).Mangosteen (*Garcinia mangostana*L.). In: (Ed. Elhadi M. Yahia) Postharvest biology and technology of tropical and subtropical fruits Vol. 4 Mangosteen to White Sapote. Woodhead Publishing Limited, pp. 1-25.

Palapola Y., Ketsa, S., Stevenson, D., Cooney, J.M., Allan, A.C., Ferguson, I.B. (2009). Colour development and quality of mangosteen (*Garcinia mangostana* L.) fruit during ripening and after harvest. *Postharvest Biology and Technology* 51: 349–353.

PNS (2005).Philippine National Standards for fresh fruits – Mangosteen – Grading and classification (PNS/ BAFPS 31:2005), The Bureau of Agriculture and Fisheries Product Standards.

Prabasari, I. (2018). Comparison of Destructive and Non-Destructive Method in Maturity Index of *Garcinia mangostana*. *Planta Tropika: Jurnal Agrosains* (Journal of Agro Science) 6(2): 100-105.

Sandø, L., Peace, C, Ramage, C., Carroll, B.J. & Drew, R. (2005). Assessment of Genetic Diversity in Australian-grown Mangosteen (*Garcinia mangostana*L.) and its Wild Relatives.*ActaHorticulturae*692: 143-151.

Shree Padre. (2016). Mangosteen bonanza in Kerala village: farmer strikes it rich and others follow. *Civil Society* 14(1):18-21.

Sobir, Poerwanto, R., Santosa, E., Sinaga, S. and Mansyah, E.(2013).Genetic Variability of Mangosteen, an Apomictic *Garcinia*.*ActaHorticulturae*975: 155-164.

Wieble, J., Chacko, E.K. & Downton, W.J.S. (1992). Mangosteen (*Garcinia mangostana* L.) – A potential crop for tropical Northern Australia. *ActaHorticulturae*321:132-137.

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Mastitis-Metritis-Agalactia Syndrome in Andaman Local Pig-First Case Report

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Abstract

Mastitis-Metritis-Agalactia (MMA) syndrome causes huge economical losses in the swine industry. Andaman local sow aged 3 years with the history of farrowing 18 days ago and complaint of anorexia, restlessness and inattentive towards her piglets, agalactia and lameness was presented with the elevated rectal temperature, congested mucus membrane, swollen painful mammary glands with foul smelling muco-purulent vulval discharge. Based on the visible clinical signs, sow was tentatively diagnosed as suffered from mastitis-metritis-agalactia syndrome. The affected sow was treated with ice fomentation, cleaning with liquid soap, application of Lugol's iodine solution and antiseptic ointment on the udder, injection of gentamicin, streptopenicillin, non-steroidal anti-inflammatory drug, prostaglandin F2α, intrauterine infusion of normal saline followed by Lugol's iodine solution along with supportive therapy with multivitamin and hydrotherapy in water bath. The pig was fed with boiled chicken eggs for supports to her health. The piglets were fed with toned cow milk during the treatment regimen along with creep feed. On day 3rd post treatment, the sow was recovered and allowed the piglets to suckle. Thus the quick diagnosis and prompt treatment saved the pigs from the life threatening syndrome along with eliminating the pre-weaning piglet mortality. The MMA prevalence could be reduced through optimization of husbandry, feeding and managemental practices. This is first report of MMA syndrome in Andaman local pig in Andaman and Nicobar Islands that too affected after 18 days of farrowing.

Keywords: Andaman local pig, mastitis-metritis-agalactia syndrome, treatment and prevention, case report

Introduction

Pig rearing is an important component of animal husbandry in Andaman and Nicobar group of Islands (ANI). Among the indigenous livestock species, pig occupies 27.26% of the total livestock in Andaman and Nicobar Islands (Kundu *et al.,* 2017) and is associated with the socio-culture-economic-tradition of tribals. Being a prolific breeder, it is gaining popularity as a protein rich meat animal in ANI among the tribals and non-tribals. Several managemental and husbandry practices influence the incidence of diseases in pig farms, out of which, MMA syndrome is a wide spread disease complex of pig with multiple etiology. The disease lasts for a minimum of 3 days and then resolves spontaneously. By this time, the litter may have been lost due to severe piglet mortality through starvation and an increased susceptibility to other fatal diseases of the newborn. This inflicts considerable economic loss to pig farmers.

Infectious organisms like *E.coli*, *Streptococci* sp., *Staphylococci* sp *etc*. are involved in MMA syndrome (Gerjets and Kemper, 2009). Lack of exercise or close confinement, filth, chilling of sows at farrowing time or it is more severe in hot weather, imbalanced endocrine factors and toxic factors have contributory roles in the causation of the disease (Roberts, 1971). The typical disease occurs in very early stages of lactation, within 12-48 hours to several days after farrowing and is characterised by anorexia, restlessness, inattentive to her piglets, fever, agalactia, painful swelling of mammary glands (Radostits *et al.,* 2007). It was reported that 20-25% of pre-weaning piglet loss is due to this MMA syndrome (Kumaresan *et al.,* 2006).

Case History and Observations

A sow with the history of anorexia, restlessness, inattentive towards her piglets, fever, agalactia, painful swelling of mammary glands at day 18 of post farrowing was attended in pig unit, AICRP on Pig, ICAR-CIARI, Port Blair. The sow farrowed 9 piglets 18 days ago. The animal was very weak and was in sternal recumbency. Rectal temperature was recorded as 105.0°F. On examination,

visible mucus membranes were highly congested. There was swelling of the mammary glands with evidence of pain on palpation. Muco-purulent vaginal discharge was noticed with fetid smell. The case was tentatively diagnosed as MMA syndrome based on the clinical signs and examination carried out.

Treatment and Discussion

The treatment protocol is depicted in the figures 1-5. The treatment was started with Streptopenicillin 2.5 g IM daily in two divided doses and Phenylbutazone @10 mg per kg BW twice daily for three days. Prostaglandin F2α, cloprostenol@100mcg total dose, intramuscular was given on the 2nd day. Intrauterine infusion of normal saline followed by Lugol's iodine solution was done. Supportive therapy comprising multivitamin injection was continued for three days. Treatment of mastitis was carried out with ice fomentation, washing of the udder with liquid soap, application of povidone iodine solution and antiseptic ointment on udder daily for three days. Concentrate pig feed was supplied with six boiled eggs daily for 3 days. The sow was allowed to enter in the water dip. The piglets were separated and fed with cow milk. The sow recovered uneventfully and fed milk to the piglets.

Fig. 1. Cleaning of the infected udder with liquid soap

It has been reported that multiple infectious agents, imbalance of endocrine and nutritional factors are involved in causing MMA in pigs. Therefore, administration of antibiotics and anti-inflammatory agents might enhance the quick recovery whereas PGF2α causes contraction of the uterus and expulsion of pus (Kumaresan *et al.,* 2009). Thus, it may be indicated that administration of Streptopenicillin with phenylbutazone and PGF2α/ oxytocin is effective treatment regimen in the treatment of MMA in sows.

Fig. 2. Dressing of the infected udder with Povidone Iodine solution

Fig. 3. Washing the infected uterus with normal saline solution

Fig. 4. Intra-uterine treatment of the infected uterus with Lugol's iodine solution

Fig. 5. Hydrotherapy treatment for the infected inflamed mammary glands

MMA causes severe economical losses in the global swine industry. The disease complex can be present at farrowing time or it can appear within several days after parturition. The aetiology of syndrome includes endotoxins and generally the gram negative and some positive bacteria (*Colibacteroides*, ß-*Haemolytic Streptococci* G and L, Staphylococci, *Arcanobacterium pyogenes, Proteus, Bacteroides, Clostridium* and *Haemophilus)*. Moreover, several aetiological agents of functional hypoagalactia/ agalactia are factors associated with stress of sows and conditions that contribute in the proliferation of bacteria and consequently in the potential endotoxemia (cystitis, metritis, vaginitis, constipation and mastitis) seem to play a significant role. Risk factors are often suspected for MMA are health status of sows (fat sow syndrome, extended duration of parturition, post-partum pyrexia, teat malformation and injuries and hypoplasia of mammary glands), the housing and management conditions of the sow around its parturition (slippery floors, hygiene, temperature humidity index of rooms, reduced activity of the sows, watering system) and diet composition (concentration of fiber, proteins, vitamin E and selenium). The clinical signs are characterized mainly by disorders of lactation and health status of sows (anorexia, depressed attitude, pyrexia, rapid breathing, reluctance to move about or to allow nursing, constipation and abnormal postpartum vulval discharge) as well as from decreased litter performance (unsuccessful attempts for suckling, intense discomposure, diarrhoea, poor growth rates, unevenness of litters regarding to body weight of piglets, increase of pre-weaning mortality).

Mammary glands are more frequently involved in the MMA syndrome than any other body part in sow and amount of involvement differs from only one gland to the entire udder. The affected mammary glands are enlarged, more firm, warmer, and highly sensitive and often are discoloured when compared to other glands. Careful palpation of the mammary glands of each sow several times during the early postpartum period may reveal developing hypogalactia/agalactia and allow for early treatment in the syndrome. Primary hormones in mammogens such as estrogens, progesterone and prolactin along with different direct and indirect synergistic hormones are important in development and secretion of milk by mammary glands (Holtz *et al.,* 1983). Each of these hormones must be secrete at right time in right amount to initiate, stimulate and maintain the lactation. Any factors which altering the concentration of these hormones such as environmental stress (higher THI), lack of proper nutrition, bacterial infections or endotoxins or improper preventive injections can affect lactation. On the other hand, other body tissue alterations such as swelling, redness and haemorrhages in the tissues in and around the mammary glands, associated lymph glands/nodes, kidneys, synovial membranes, adrenal glands and pituitary gland can cause severe adverse effect on lactation. It is unknown that whether the genetics has played important roles to induce this disease, but stress-susceptible and stress-resistant lines have been identified and susceptible lines seem to have more agalactia problems than the stress-resistant.

Diagnosis of the disease complex usually is not much difficult. However, the finding the etiological factors in many of the cases is difficult. Differential diagnosis should be done with MMA syndrome from other diseases such as transmissible gastroenteritis or pseudorabies to conduct effective treatment and control measures (Sujatha *et al.,* 2003). Diagnosis is to be done with evaluation of history, observation of symptoms, palpation of sow mammary glands plus postmortem examination of one or several pigs usually will allow for a definitive diagnosis. Culturing of milk samples should be considered and if done, can reveal valuable information about a particular sow herd and this cultural examination need to be conducted periodically in the herd to find the prevalence of the infectious agents in the farm.

The prognosis for the life of the affected pig is good. The prognosis for the complete return or establishment of normal lactation is guarded; however, this will take some time. The affected sow usually recovers in two to five days with or without lactation function. Having the disease once does not mean that the sow will develop agalactia on subsequent farrowings. Unless sow lactation is rapidly re-established or supplemental feeding is successful, the chances for piglet survival are low. The effects of chilling, diarrhea and other baby pig diseases must be fully considered (Gooneratne *et al.,* 1982).

Treatment for affected sow must be directed towards the establishment of milk flow to help in sustaining life of the baby pig and prevention of secondary complications in both sow and piglets. Treatment with oxytocin is superior to any other treatment and which allow releasing the milk within the mammary glands that will be taken by the hungry piglets if the pig is strong enough to nurse. Corticosteroids can also be advisable to give to the affected sow for reducing the inflammation and minimizing the recovery period. Anti-bacterial agents should be used in treating the affected sow. Injectable mild, slow acting laxatives are indicated for the constipated sow. Use of vaginal or uterine infusions, douches or pessaries of antibiotics or Lugol's iodine to combat suspected uterine infections may stimulate a neuro-hormonal reflex action that could result in posterior pituitary release followed by increased contraction and expulsion of pus (Peter *et al.,* 2007).

Some MMA outbreaks are thought to have been human-induced by noise factors, schedule irregularities, etc. Gestational feeding of sows has significant influence on prevalence on agalactia. Apparently underfed sow cannot maintain sufficient blood glucose levels than the adequately fed sow; therefore, resistance may be lower in the underfed sows. Additives to reduce mammary gland edema might be considered in some herds. The mixture of 12 parts potassium nitrate, 4 parts methenamine and 1 part dicalcium phosphate by weight, given at the rate of 28 grams twice daily for one week prior to and one week following farrowing may be helpful to reduce the mammary edema.

Treatment must always include supplementary dietary support for the pigs because they have small energy storage capabilities; therefore, nourishment is critical for sustained life. Supplemental heat (29°-32°C) for piglets during the first few days is energy conserving to them and will aid in survival as a part of routine treatment or prevention. Prevention of this MMA syndrome is by proper maintenance of herd health and proper nutrition. Immunization is advisable and it must be done in advance of anticipated problems such as bacterial mastitis. Cultures from infected milk of sow can be used to prepare a bacterin. Those pig herds where bacterial mastitis occurs frequently may benefit from immunization if other management practices will not overcome the problem. Efforts should be taken to minimise the stress throughout gestation and during parturition and post parturient periods as the important preventive measures. However, further investigation is needed to assess the incidence of MMA syndrome in field condition and analysis the endocrinological and biochemical profiles in the affected indigenous Andaman local pigs and Nicobari pigs.

Conclusions

Mastitis-Metritis-Agalactia syndrome causes huge economical losses in the global swine industry. The condition can be treated with suitable antibiotics, anti-inflammatory agents, oxytocin and suitable intrauterine infusion along with supportive therapy. Therefore, quick diagnosis and prompt treatment are important to save the pigs from the life threatening syndrome along with eliminating the pre-weaning piglet mortality. Moreover, incidence of MMA syndrome could be reduced through optimization of husbandry, feeding and management.

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References

Gerjets, I. & Kemper, N. (2009). Coliform mastitis in sows: a review. Journal of Swine Health and Production. 17: 97–105.

Gooneratne, A. D., Hartmann, P.E. & Nottage, H.M. (1982). The initiation of lactation in sows and the mastitis-metritis-agalactia syndrome. Animal Reproduction Science. 5:135–140.

Holtz, W., Hartmann, J. F. & Welp, C. (1983). Induction of parturition in swine with prostaglandin analogs and oxytocin. Theriogenology. 19: 583-592.

Kumaresan, A., Bujarbaruah, K. M., Pathak, K. A., Chhetri, B. & Ahmed, S. K. (2009). Clinical management of metritis-mastitis-agalactia syndrome. Intas Polivet. 10(1):117-119.

Kumaresan, A., Pathak, K. A., Bujarbaruah, K. M. & Das, A. (2006). Swine production in Mizoram, Research Bulletin No 48. Published by ICAR Research Complex for NEH Region, Barapani, Meghalaya.

Kundu, M. S., Sunder, J., Kundu, A., De, A. K. & Sujatha, T. (2017). Reproductive and productive performances of crossbred Andaman local pigs under small holder production system at Bay Islands, India. Indian Journal of Animal Research. 51(2): 377-381.

Peter, G. G. J. & Peter, D. C. (2007). Handbook of Pig medicine. Sounders Elsevier Publication. pp. 164-165.

Radostits, O. M., Gay, C. C., Hinchcliff, K. W. & Constable, P. D. (2000). Veterinary Medicine, 10th Edn, Elsevier Publication, UK, pp. 754-759

Roberts, S. J. (1971). Veterinary obstetrics and Genital Diseases. 2nd Edn, CBS Publication, New Delhi, pp. 660.

Sujatha, K., Srilatha, C.H. & Nisar Ahmed, N. (2003). Metritis mastitis agalactia syndrome in sows. Indian Veterinary Journal. 80:379–380.

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Probiotics as Feed Additives in Pigs with Special Reference to Swine Health and Production

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Abstract

The importance of probiotics as alternatives to antibiotics in animals, especially in swine health and production is globally accepted and gaining more and more interest recently. Probiotics can provide a wide variety of health benefits to the host when administrated in adequate amounts. The most frequently used as probiotic agents are lactic acid bacteria (LAB). Former studies demonstrated that dietary supplementation of probiotics had growth promoting effects on pigs. In this review, we will give an overview on the current use of probiotics in swine industry.

Keywords: immune response, meat quality, growth response

Introduction

In early 20th century the Nobel laureate Elie Metchnikoff first introduced the concept of probiotics. He proposed that ingestion of beneficial live microorganisms have positive effect on the health of a being, by manipulating the gut environment. Several studies were carried out depending upon his doctrine both in humans as well as in animals. Probiotics can promote intestinal health along with its mucosal immune response by enhancing colonization of beneficial microbiota by limiting of colonization of pathogenic bacteria (W. C. Liu et al., 2018). A sound pig gastrointestinal tract is usually inhabited by wide variety of commensal microbiota. 1gm gut content of healthy pig colon has at around 1×10^{10} - 1×10^{11} bacteria (Fuller, 1989).

German scientist Werner Kollath in 1953 first use the term "probiotic" derived from the Latin 'pro' and the Greek 'bios' together meaning "for life", has a contrast with the term antibiotic which means "against life". Several definitions have been proposed to explain the term "probiotic" over the years (Sperti, 1971; Azizpour et al., 2009;) . FAO/WHO define probiotic as "live microorganisms which, when administered in adequate amounts, confer a good health benefit on the host" (FAO/WHO, 2002). A wide range of commensal microorganisms strains are being commercially promoted and marketed for animals as probiotics (Agazzi, 2015). Some of them can produce certain beneficial effect in the host while some of them not effective (Weichselbaum, 2009). However commercially selected stains are generally resistant to gastric acid as well as bile acid and they can potentially colonize in the intestine of host or can resist pathogenic microorganisms(Cho et al., 2011; Azizpour et al., 2009; Fuller,2009). A variety of LAB or lactic acid bacteria are commonly used as probiotics. This LAB group are generally gram-positive, acid-tolerant, mostly non-sporulating, non-respiring rod (bacillus) or spherical (coccus) shaped. LAB include variety of bacterial genera like, Lactobacillus, Bifidobacterium, Lactococcus, Lactosphaera, Leuconostoc, Melissococcus, Oenococcus, Pediococcus, Streptococcus, and Enterococcus (Yang et al., 2015). In this review we focus on the developments in probiotics and its health benefits to the host when administrated in adequate amounts.

Microbial succession in early life

The gut of new born piglet has long been thought to remain sterile prior birth and this germ free-state rapidly modified to highly dense microbial population shortly after birth, popularly known as microbial succession (Isaacson & Kim, 2012). Recent studies in mice and human brings out presence of some microbes into the meconium of newborns and amoniotic fluid of pregnant mice, which indicating in utero microbial colonization

(Ardissone et al., 2014) . In pig it is not proved yet. However, a fully grown microbial population is established in pig almost within a week following birth (Bauer et al., 2006; H. B. Kim & Isaacson, 2015; Tortuero et al., 1995). This population has a great diversity which forms a complex micro-ecosystem and makes a symbiotic relationship with the host (Fouhse et al., 2016).The diversity of microbial population is greatly affected by multiple factors like parturition time, mode of delivery, environment(Macpherson & Harris, 2004; Schmidt et al., 2011). Last few years ample of studies illustrated that kids born per-vaginally have microbial colonization resembles to the vaginal micobiota of mother. Likewise kids delivered by caesarean section (C-section) have identical microbial population of mother's skin (Bäckhed et al., 2015; Dominguez-Bello et al., 2010; Groer et al., 2014). Although till now C-section is not a usual way of action in swine industry. In future if C-section is follows in swine industry this query will be a important fact in health criteria of neonates (Hayashi et al., 2007).

Gut Microbial Diversity

A healthy swine gut is normally inhabited by dynamic microbial organism viz. bacteria, virus, fungi etc. Most of them are bacteria. Around 10^{12}-10^{14} bacteria resides in pig intestine which is 10 times more than their cells of body (Luckey, 1972). Bacteriodetes and Firmicutes are the two major phyla mostly occupying 90% of total bacterial population. Remaining part of the population covered by certain other phyla viz. Spirochaetes, Proteobacteria and Tenericutes (Pajarillo et al., 2014). Plenty of studies proved that gut microbial population modulates in different stage of life in response to changes in the feeding behavior, stress and illness (Konstantinov et al., 2006; Lallès et al., 2007). Before weaning Farmicutes are dominate in the gut which gradually subside after weaning and relative abundance of Bacteriodetes is increased by the time (Pajarillo et al., 2014). This is mainly because of their feeding pattern. Before weaning neonates take milk rich in lactose which can be utilized by Firmicutes. Likewise after weaning pigs mostly consume cellulose containing feed that is metabolized by Bacteriodetes (Hayashi et al., 2007; Lamendella et al., 2011). So probiotics should be selected according to the phase of life as microbial population of swine gut modulates in every phase.

Symbiosis and Dysbiosis

Trillions of bacteria take shelter, grow and colonized in the intestine. They set up a potent mutual relationship with the host where everyone gets benefit. This mutual relation is designated as symbiosis (Fouhse et al., 2016). Any changes in the resident bacterial colonization break that relationship with the host called dysbiosis (Petersen & Round, 2014). The consequences of dysbiosis are (1) qualitative and quantitative changes in the microbial population, (2) diminish the metabolic activities of commensal gut microbiota, (3) variation in the floral distribution and (4) expansion of pathogenic microbiota which leads to manifestation of several harmful events such as gas bloating, diarrhea, constipation and ulcer (Cho et al., 2011; Peterson et al., 2015).

Influence of Probiotics in swine production Modification and maintenance of gut microbiota

Suitable probiotic supplementation facilitates colonization of beneficial microorganism and check the growth of pathogens that ultimately results better health and performance of pigs, as this beneficial microorganism aids in the digestion, metabolism and better nutrient utilization of host (Kenny et al., 2011; Lescheid, 2014; Veizaj-Delia & Pirushi, 2012; Yirga, 2015). Several studies were done in past few years which appreciate the impact of probiotics on microbial population especially on weaned piglets (Table 1). Weaning is a very stressful condition for pigs, leading to remarkable changes in the gut microbiota. During this time piglets are heavily infected by pathogens such as enterotoxigenic strains of E. coli (Konstantinov et al., 2006).

Table 1: Effect of probiotics on population of pathogens

Reference	Bacterial stain used as Probiotic	Effect
(Le Bon et al., 2010)	Saccharomyces cerevisiae ssp. boulardii (CNCM I-1079) and Pediococcus acidilactici (CNCM MA 18/5 M)	Antagonized the growth of E. coli in weaned piglets
(Pospíšková et al., 2013)	Monoculture of E. faecium	Inhibit E. coli and C. perfringens in weaned piglets
(Bajagai et al., 2016)	Combined probiotic	Enhances the colonisation of LAB and limits Clostridium, E. coli, and Enterobacterium spp. in weanling pigs

Probiotics can modulates the gut microbiota mainly via two ways, they are,

Competition with the pathogenic microorganism

Once probiotic microorganism established and colonized in the gut, they started to compete with the harmful microbiota both for adhesion site and nutrition that reduces chances of infection (Cho et al., 2011). It is formulated pathogenic bacteria need to attached with the gut epithelium to express their harmful effect (Bajagai et al., 2016; Yirga, 2015). Probiotics inhibit adherence of pathogenic organism by blocking the receptor cites (Table 2). Certain species of probiotics can block the nutrient absorption sites of pathogens which results death of pathogenic bacteria (F. Yang et al., 2015).

Table 2: Studies related to the strategy of probiotics to inhibit harmful microbes via competition

Reference	Bacterial stain used as Probiotic	Effect
(Bhandari et al., 2010)	non-pathogenic Escherichia coli	Inhibit the attachment of E. coli K88 to the intestine of piglets
(Daudelin et al., 2011)	Pediococcus acidilactici and Saccharomyces cerevisiae boulardii	Limit the adherence of O149 enterotoxigenic Escherichia coli
(Daudelin et al., 2011; Konstantinov et al., 2006)	lactic acid bacteria including Pediococcus acidilactici	Stop enterotoxigenic E. coli to assemble with the intestinal mucosa
(Kiarie et al., 2011)	Saccharomyces cerevisiae fermentation products (YFP)	Spare the engagement of Escherichia coli K88+(ETEC) in the gut

Production of antimicrobial substances

Pollmann et al., (1980) reported that probiotics can generate antimicrobial substances which can suppress the growth of pathogenic bacteria. Cho et al., (2011) and Bajagai et al., (2016) proves those antimicrobial substances have broad spectrum antimicrobial property and they can sustain the gut microbial equilibrium. Certain probiotic bacteria such as LAB, E. coli generate some antimicrobial substances and creates acidic environment in small intestine which check the growth of pathogenic bacteria mentioned below in Table 3.

Table 3: Antimicrobial property of probiotics

Probictic strain	Antimicrobial substances	Effect	Reference
LAB	Short chain fatty acids like lactic acid, acetic acid, butyric acid	Decreases the luminal ph which is not suitable for the growth of pathogens	(Bajagai et al., 2016; Pollmann et al., 1980)
Probiotic E. coli	Microcin	Limit the growth of adherent-invasive E. coli and Salmonella	(Bhandari et al., 2010; Krause et al., 2010; Setia et al., 2009)(Lamendella et al., 2011)
LAB	Lactic acid	Destroy outer membrane of E. coli ATCC 35150 (O157:H7), Pseudomonas aeruginosa ATCC9027, and Salmonella enterica serovar Typhimurium SL696 (34)	(Alakomi et al., 2005)

LAB = Lactic acid bacteria

In addition probiotic bacteria also produce a variety of substances including antimicrobial peptides (defensins), bacteriocin, reuterins, microcin, hydrogen peroxide and antioxidants. These substances inhibit colonization, metabolism and toxin production of detrimental bacteria (Bajagai et al., 2016; Hou, Zeng, et al., 2015; Yirga, 2015).

Advancement of nutrient digestibility

Numerous previous studies on pigs documented that probiotics can enhance the apparent digestion and absorption of dry matter, crude protein, crude fiber, organic matter, energy and phosphorus (Ahmed et al., 2014; Cai et al., 2015; Giang et al., 2011). For example Meng et al. (2010) demonstrated that probiotic supplementation in weaned pigs can raise the apparent digestibility of crude protein and energy. The study related to the nutrient digestibility shortly narrated in Table 4.

Table 4: Study increases digestibility in pigs

Strain of probiotics	Dosage (CFU/ gm)	Effect	Reference
Complex lactobacilli preparation	2.4×10^5	Enhance apparent digestibility of crude protein and phosphorus in weaned pigs	(Huang et al., 2004)
Lactobacillus fermentum	$5.8 \times l0^7$	Maximized crude protein digestibility	(Yu et al., 2008)
L. reuteri and L. plantarum complex	1×10^6	Increases apparent total tract digestibility of nitrogen and energy	(Zhao & Kim, 2015)

Three different LAB complex Complex 1(Enterococcus faecium, Lactobacillus acidophilus, Pediococcus pentosaceus)	(3×10^8, 4×10^6, 3×10^6)		
Complex 2(Lactobacillus acidophilus, Lactobacillus plantarum, Enterococcus faecium)	(3×10^8, 4×10^6, 2×10^6)	Apparent total tract digestibility of crude protein and crude fiber increased in during the first 2 weeks	(Giang et al., 2010)
Complex 3(L. acidophilus L. plantarum 1K8, L. plantarum 3K2)	(4×10^6, 2×10^6, 7×10^6)		

In general, digestibility of nutrients proportionate with the enzymatic action of GI tract. Subsequent colonization some probiotic stain like lactobacilli potentiate the activity of useful enzymes such as β-galactosidase which could improves nutrient digestibility. A study was performed by Kim et al. (2007) to determine the effects of Lactobacillus sp. PSC101 on nutrient digestibility. The study disclosed that lactobacillus can produce active dietary enzymes, such as amylase, lipase, phytase, and protease in weaned pigs. In addition H.F. et al., (2008) also reported that lactobacilli yields lactic acid and proteolytic enzymes that can maximized the nutrient digestibility. Patarapreecha et al., 2018 conduct an experiment on pigs using Bacillus subtilis as a probiotics and appears that it favor better nutrient digestibility. Another study on Bacillus amyloliquefaciens claimed that they can generate several types of extracellular enzymes such as α-amylase, cellulase, proteases and metalloproteases, which elucidate probiotic supplementation can improve the nutrient digestibility (Bajagai et al., 2016).

Influence on growth performance

Growth is an important component of animal industry, as it determined the profit. Generally it is measured by following parameter such as average daily gain (ADG), average daily feed intake (ADFI), and feed con- version ratio (FCR). Several studies were done in past few decades to determine the effect of probitic supplementation on growth performance of pigs. Some of them proved effective some were not. In this review literature we summarized few representative studies which have significant impact on growth of pigs are shown in table 5.

Table 5: Positive effect of probitics on growth performance in pigs

List of studies performed on weaned pigs					
Strains of probiotics	**ADG**	**ADFI**	**FCR**	**Study period after weaning(days)**	**Reference**
Enterococcus faecium, Lactobacillus acidophilus, Lactobacillus plantarum	+	+	-	14	(Giang et al., 2010)
Saccharomyces cerevisiae subsp. boulardii	ns	ns	-	28	(Le Bon et al., 2010)
Bacillus subtilis, Bacillus licheniformis	+	+	-	28	(Ahmed et al., 2014)
Lactobacillus plantarum GF103, Bacillus subtilis B27	+	-	-	35	(Dong et al., 2014)

Lactobacillus reuteri, Lactobacillus plantarum	+	-	-	28	(Zhao & Kim, 2015)
Bacillus subtilis, Bacillus amyloliquefaciens	+	+	-	42	(Cai et al., 2015)
Lactobacillus acidophilus, Bacillus subtilis, Saccharomyces cerevisiae	+	+	-	28	(Choi et al., 2016)
Lactobacillus acidophilus, Bacillus subtilis, Saccharomyces cerevisiae	+	+	-	35	(Kim et al., 2017)
List of studies performed in growing and finishing pigs					
Lactobacillus acidophilus, Saccharomyces cerevisae, Bacillus subtilis	+	ns	ns	42	
Bacillus subtilis, Bacillus coagulans, Lactobacillus acidophilus	+	ns	ns		
Bacillus subtilis, Clostridium butyricum	+	ns	-	60	(Meng et al., 2010)
Bacillus licheniformis, Bacillus subtilis	+	ns	-	50	(Jørgensen et al., 2016)
Bacillus coagulance, Bacillus licheniformis, Bacillus subtilis	+	ns	-	112	(Balasubramanian et al., 2016)

ADG = average daily gain; FCR = feed conversion ratio; ADFI = average daily feed intake; + = significantly increase; - = significantly decrease; ns = no significant change

Whereas some study provided inconsistent result those are put together below (Table 6).

Table 6: List of inconsistent studies performed on pigs

Studies performed on weaned pigs					
Strains of probiotics	**ADG**	**ADFI**	**FCR**	**Period after weaning(days)**	**Reference**
Lactobacillus gasseri, Lactobacillus fermentum, Lactobacillus reuteri Lactobacillus acidophilus	ns	ns	ns	21	(Huang et al., 2004)
Enterococcus faecium, Lactobacillus salivarius, Lactobacillus reuteri, Bifidobacterium thermophilum	ns	ns	ns	28	(Mair et al., 2010)
Lactobacillus amylovorus, Lactobacillus mucosae, Lactobacillus salivarius, Lactobacillus reuteri, Lactobacillus johnsonii	ns	ns	ns	21	(Lähteinen et al., 2015)

Studies performed on grower and finisher pigs					
Bacillus subtilis, Bacillus licheniformis	Ns	+	ns		
Bacillus subtilis, Bacillus licheniformis	Ns	+	ns		(Y. Wang et al., 2009)
Bacillus subtilis, Saccharomyces cerevisiae	Ns	ns	ns	75	(Giang et al., 2011)

ADG = average daily gain; FCR = feed conversion ratio; ADFI = average daily feed intake; + = significantly increase; - = significantly decrease; ns = no significant change

From the previous findings it is very much clear that probiotic supplementation not always encourage the growth performance of pigs. Outcome of those studies altered may be due to the stains and doses of used probiotics, age of the animal, surrounding environment, strategies of probiotic supplementation (Giang et al., 2010; Jørgensen et al., 2016). However, according to the previous studies it appears that the beneficial effect of probiotics is more prominent in weaned piglets.

Impact on meat quality and texture

Pork is the most frequently consumed meat in the world and its demand increasing day by day (Murphy et al., 2014). Probiotic supplementation may significantly improves the pork quality, produces more vivid color, enhances the water holding capacity and reduces drip loss and thiobarbituric acid reactive substances (TBARS) values of meat from finishing pigs (Giang et al., 2011; Jukna et al., 2005). Redness of meat mainly depends on the myoglobin concentration which alters with the oxidation of myoglobin (Livingston & Brown, 1981). Meat color is the most significant sensory trait of red meat which affecting consumer purchasing decisions as it indicates the freshness of meat (Morrissey et al., 1994). Drip loss and muscle WHC (water holding capacity) are the important qualitative character of meat. Lower drip loss and higher WHC indicates better quality meat. WHC not only affects the meat juiciness also concerned with other eating-related qualities, such as taste and aroma (Chen et al., 2009). TBARS value measure the lipid oxidation of meat. Low TBRAS value indicates less oxidation take place (Yang et al., 2006). In this regard Ko & Yang (2008) performed a study on finishing pigs and proved that green tea probiotics containing L. acidophilus 3.2×10^8 cfu/g, L. plantarum 2.2×10^8 cfu/g, B. subtilis 4.5×10^9 cfu/g and S. cerevisiae 5.2×10^8 cfu/g significantly reduced the TBARS value of loin meat. Beside this Kim et al. (2008) reported that 0.1% complex probiotics (S. cerevisiae 1.0×10^8 cfu/g, Phaffia rhodozyma 1.0×10^8 cfu/g L. crispatus 1.0×10^8 cfu/g, L. plantarum 1.0×10^8 cfu/g, Enterococcus faecium 1.0×10^8 cfu/g) supplementation in finishing pigs diets can minimize drip loss and enhance meat redness. Meng et al. (2010) also suggested that 0.2% complex probiotics (Clostridium butyricum 1.0×10^9 cfu/g and B. subtilis, 1.0×10^{10} cfu/g) supplementation increased the sensory color of pork. Another study was done by Balasubramanian et al., (2016) on growing-finishing pig using Bacillus-based probiotic mixture (B. coagulance 1×10^8 cfu/g, B. licheniformis 5×10^8 cfu/g, and B. subtilis 1×10^9 cfu/g). He observed that feeding Bacillus-based probiotic mixture could enhance the sensory color of pork and it can reduce the drip loss of right loin muscle. Few studies claim that the beneficial effects of complex probiotics on meat quality seen possibly due to the antioxidant properties of probiotics. Further studies required to establish the main reason behind this (W. C. Liu et al., 2018).

Impact on host immune response

Germ free animal can develop and rear in absence of any microbial colonization. But those animals have some major shortcoming in their certain bodily system, for instance the mucosal and systemic immune system, development of the gut associated lymphoid tissue (GALT) and susceptibility as well as immune response towards the pathogenic microorganisms (Lee & Mazmanian, 2010; Roselli et al., 2017). Intestinal epithelial cells

(IECs) act as a physical barrier between luminal contents and the immune system. IECs have some pathogen sensing and antigen presenting cells and molecules such as intraepithelial lymphocytes (IELs), Toll-like receptors (TLRs) and class II major histocompatibility complex (MHC II). It is observed that germ free mice have lower expression of TLRs and MHC II molecules (Lundin et al., 2008; Matsumoto et al., 1992). IELs also low in number in that animal (Imaoka et al., 1996). This gives an idea about the contribution of commensal gut micobiota to the development and function of host immune system.

Probiotic bacteria not only help in the colonization of commesal microorganism, also can modulate the immune system through adjusting the immune response directly or indirectly. They can directly enhance the production of pro-inflammatory as well as the anti-inflammatory substances, increase the production of immunoglobins, encourage the activity of macrophage or natural killer cells which modulates the host defense system. In addition they can enhance gut epithelial barrier through up-regulation of tight junctions (TJs) and alter the mucous secretion which comes under indirect pathway (La Fata et al., 2017). TJs ate the multi-protein complex consisting of trans-membrane and membrane-associated proteins which maintain the integrity of gut epithelium (Wang, 2019). It is proved that Immunoglobulins A (IgA) and G (IgG) are the most two immunoglobins whose production and circulation can be stimulated by probiotic supplementation (Bajaj et al., 2015; Vondruskova et al., 2010). Nevertheless it is clear that directly or indirectly probiotics can modulate both the innate and adaptive immune response of host (Oelschlaeger, 2010).

Role in the production of immunoglobulins

Serum immunoglobin (IgA, IgG and IgM) level determine the effectiveness of probiotic supplementation on humoral immunity, where influence on gut immunity measure by the secretory IgA content in luminal samples (T. Wang et al., 2019).

Effect on serum immunoglobulins

Numerous studies proved that probiotic bacteria are able to change in the immunoglobulin level of serum .For example, Dong et al., (2014) demonstrated that the serum IgA level improved after 2 weeks probiotic (L. plantarum and B. subtilis) supplementation. Ahmed et al., (2014) exert that serum IgG level was elevated by 0.04% Bacilli-based probiotic treatment in piglets challenged with Salmonella enterica serovar Typhimurium KCTC 2515 and Escherichia coli KCTC 2571. Naqid et al., (2015) claims that inclusion of Lactobacillus plantarum B2984 in the diet of piglets ($\sim 1\times10^{10}$ cfu/animal/day) enhanced serum IgM, IgG and IgA. Likewise Ayala et al., (2015) reported that there was an increase in the concentration of serum G immunoglobulins in the Bacillus subtilis C-34 treated sows. Lactobacillus based probiotic (Lactobacillus reuteri ZJ625, Lactobacillus reuteri VB4, Lactobacillus salivarius ZJ614, and Streptococcus salivarius NBRC13956) treatment on weaned piglet also show the same result on serum IgG (Dlamini et al., 2017). In addition Zhu et al., (2017) observed that piglets fed soybean meal fermented by L. plantarum, B. subtilis and S. cerevisieae had significantly higher serum IgA, IgG and IgM level. Moreover Shin et al., (2019) proved immunomodulatory effect of L. plantarum JDFM LP11 which elevated serum IgM level in weaned piglets.

Effect on mucosal immunoglobulins

It is well established that intestinal immunoglobulins play an important role in the clearance of pathogenic microorganism (Takahashi et al., 1998). Gut microbiota also take part in the production of mucosal immunoglobins. Gut microbiota and the secretory IgA together act as the first line of defense against pathogenic microorganism (MacDonald & Monteleone, 2005). Mach et al., (2015) find out secretory mucosal IgA concentrations are positively correlated with *Prevotella* abundance. It was reported that *B. cereus* var. toyoi feed supplementation led to an increased intestinal IgA secretion both in sows and piglets (Scharek et al., 2007). Zhang et al., (2008) indicated that LAB (Lactobacillus acidophilus and L. reuteri) supplementation in gnotobiotic (Gn) pig potentiate intestinal immunity by increasing IgM and IgG titer and total intestinal IgA secreting cell responses. Similarly number of IgA producing cell were significantly increased in the duodenum and ileum by dietary administration of the L. salivarius B1 or B. subtilis RJGP16, or co-

administration of the two probiotic in newborn piglets (Deng et al., 2013). Another study formulated by Kandasamy et al., (2015) using Lactobacillus rhamnosus strain GG and Bifidobacterium animalis lactis Bb12 against human rotavirus (HRV) infection in pig model. The study shows that LGG+Bb12 probiotics significantly enhanced small intestinal HRV IgA antibody and total IgA responses in post-challenge vaccinated piglets. It is assumed that this immunomodulatory effect of probiotics is observed may be due to the induction of dendritic cells and pattern recognition receptors of gut mucosa which significantly increases IgA responses and production.

In the mean time some studies claims that probiotic supplementation may reduce mucosal sIgA concentration due to improved barrier protection and reduced bacterial translocation. For example, Lessard et al., (2009) reported that Pediococcus acidilactici (PA) or PA+ Saccharomyces cerevisiae ssp. boulardii (SCB) supplementation reduce the sIgA concentration in ileal flushes. Beside this, Tejada-Simon et al., (1999) shows that mice treated with Lactobacillus bulgaricus and Streptococcus thermophilus decreased fecal sIgA titers against cholera toxin, while sIgA titers increased in those treated with Lactobacillus acidophilus and Bifidobacterium spp. This study indicates production of natural and specific sIgA in the gut are highly strain specific. Some induces sigA production whereas some reduces. Bos et al., (2001) also reported the same.

Beside this, time depended effect also reported. For instance, Perdigon et al., (1995) observed a significant increase in the sIgA-producing plasma cell number in mice treated with L. acidophilus in day 2 and 5, but decreased in day 7. Therefore, effect of probiotics on mucosal IgA production remains enigmatic and further study is needed.

Effect on cytokines production

Cytokines are important biological biomarkers which regulate the innate and adaptive immune response of body. Probiotics have been known to take part in the release of different biological biomarkers including interleukins (ILs), interferons (IFNs), tumor necrosis factors (TNFs), transforming growth factor (TGF), and chemokines (Foligné et al., 2010; Savan & Sakai, 2006). Cytokines are well characterized as pro-inflammatory and anti-inflammatory cytokines based on their influence on inflammation. Interleukin-1β (IL-1β), IL-6, IL-8, IL-12, IL-18, tumor necrosis factor (TNF), gamma-interferon (IFN-γ) are classified as pro-inflammatory cytokines whereas IL-4, IL-5, IL-10, IL-13, IFN-α and transforming growth factor-β (TGF-β) are marked as anti-inflammatory cytokines (Azad et al., 2018; Cavaillon, 2014)

Effect on intestinal cytokine expression

A number of studies proved the significant role of probiotic bacteria in production of pro- and anti-Inflammatory cytokines. For an example, mice treated with Lactobacillus rhamnosus was shown to reduce IL-6, TNF-α, IFN-γ gene expression of intestinal epithelial cell (Yan et al., 2011). Finamore et al., (2012) observed that orally Lactobacillus rhamnosus GG (LGG) or Bifidobacterium animalis supplementation in immunized rats increased IL-10 and TGF-β expression in mesenteric lymph nodes. Herfel et al., (2013) reported that ileal TNF and IL-10 expression tended to increase with Bifidobacterium longum supplementation in newborn piglets. In neonatal piglets, L. reuteri has been found to decrease the mRNA expression of IL-1β (pro-inflammatory) and IL-10 (anti-inflammatory) in the ileum after 14 days of treatment (H. Liu et al., 2014). In addition, Lähteinen et al., (2015) reported an up-regulation of IL-4 and IFN-α (anti-inflammatory) in the cecum, with down-regulation of IL-8 and TNF (pro-inflammatory) in the colon in the piglets fed with multispecies lactobacillus. The mRNA expression of TGF-β1 also diminished in the jejunum, ileum and colon of the treated animals. Moreover Hou et al., (2015) published that relative abundance of mRNA expression of TGF-β was increased while IFN-γ was decreased in the mesenteric lymph nodes of piglets treated with *L. reuteri*.

Effect on serum cytokine profile

Probiotic bacteria also have the capability to modulate the serum cytokine profile which can be proved by several studies. For instance, administration of Lactobacillus rhamnosus GG (LGG) before E. coli k88 infection

attenuated the elevation of serum IL-6 (associated with piglet diarrhea) induced by E. coli. Serum TNF-α (anti-inflammatory) was also increased in the treated piglets. This study showed that LGG was effective as preventive therapy for post-weaning diarrhea induced by E. coli k88 (Zhang et al., 2010). Previous study shows that probiotic Bifidobacterium can increase serum TGF-β levels (Ouwehand et al., 2008). Czyzewska-Dors et al., (2018) reported a higher concentration of IFN-α, IFN-γ, IL-12, and IL-10 were observed in pigs supplemented with probiotic bacteria. Another recent study found that L. plantarum PFM105 supplementation increase serum levels IL-10 and TGF-β in weaned piglets (Wang et al., 2019). Moreover, Laskowska et al., (2019) claims that use of multi-microbial probiotic formulation in sows during pregnancy was followed by an increase in the concentration of serum pro-inflammatory cytokines, i.e., IL-2, TNF-α, and IFN-γ, and anti-inflammatory, i.e., IL-4, IL-10 and TGF-β.

At the same time, some study shown that probiotic supplementation does not reflect the serum cytokine level. Baken et al., (2006) reported that Wistar WU rats orally administered with L. casei Shirota which did not alter serum cytokine level. Wang et al., (2009) demonstrated that L. fermentum I5007 supplementation in weaned piglets had no effect on serum cytokines level. This discrepancy may be attributed to the probiotic strain and the health status of introduced animals.

Effect on maturation and development of important immune cells and receptors

Beneficial effect on development and maturation of different regulatory T cells, including Th3, Tr1, CD4+CD25+ regulatory, CD8+ suppressor cells are established by several studies. These immune cells and their receptors sustain intestinal homeostasis and the equilibrium between tolerance and reactivity to ingested food antigens as well as to commensal microbiota (Thomas & Versalovic, 2010). Schierack et al., (2007) and demonstrated that intraepithelial CD8+ and CD25+ T cell population was enhanced in the piglets treated with Bacillus cereus var. toyoi. Likewise, Walsh et al., (2008) observed that Lactobacillus salivarius treated piglets have decreased CD25 induction on T cells and decreased CTLA-4 induction on CD4 T cells. Treated group also have increased CD4+ CD8+ T cells proportion within the peripheral T-cell population. CD25 and CTLA-4 are important T cell receptor which plays a key role in regulation of T cell activation (Inobe & Schwartz, 2004; Piriou et al., 2003). Decrease in the induction of these cell receptor proved the immunomodulatory effect of probiotics. Beside this, CD4+CD25+Foxp3+ T cell expansion in mesenteric lymph node was observed in Lactobacillus rhamnosus GG (LGG) fed rats (Finamore et al., 2012). Moreover, Laskowska et al., (2019) also proved that probiotic supplementation may increased regulatory T cell expression and polarized the immune response from Th1 to Th2.

However, some studies fail to show any beneficial effect on the immune cells (Galdeano & Perdigo, 2014; Gill et al., 2000; Wang et al., 2009)

Intestinal development

Villus height and crypt depth are the most two important measure which indicates the maturity and functional capability of enterocytes. Intensity of intestinal absorption is increases with the villi height as it provide more area for absorption (Hampson, 1986). Weaning is a very stressful condition which leads to villous atrophy and crypt hyperplasia with a consequent impairment of nutrient digestion and absorption (Boudry et al., 2004; Hampson, 1986). Probiotics have been proved to enhancing the gut health and development by minimize the weaning stress. Bontempo et al., (2006) reported that dietary supplementation of S. cerevisiae ssp. Boulardii increases villus height and crypt depth of weanling piglets. Gebert et al., (2011) observed that the ratio of villous height: crypt depth was greater in the ileum and duodenum of pigs fed with L. brevis 1E1 compared to control one. Application of B. subtilis-based multi-strain probiotics showed an increase villi length of duodenum and jejunum in weaning pigs (Cai et al., 2015). Similarly, Choi et al., (2016) found that L. acidophilus, B. subtilis and S. cerevisiae complex probiotic supplementation improved the villi length of duodenum, jejunum and ileum. Moreover, Zhu et al., (2017) observed that villus height

in the duodenum, jejunum, and ileum was significantly higher and the crypt depth was significantly lower in piglets fed soybean meal fermented by L. plantarum, B. subtilis and S. cerevisieae. Wang et al., (2019) concluded that L. plantarum PFM105 significantly increased the villus height in the jejunum and ileum of weaned piglets, which may be the main reason of improved growth performance. Shin et al., (2019) use another strain (JDFM LP11) of L. plantarum and found an increased villus height in segments of duodenum, jejunum, and ileum.

However, some study fails to show any positive effect on intestinal development. Walsh et al., (2008) and Choi et al., (2011) did not find any influence of complex probiotic on intestinal health and morphology. So, further studies needed to explore the underlying mechanism.

Antioxidant property and probiotics

Piglets are subjected to many stressors such as nutritional, psychological and environmental stressors during the post-weaning period which can increase diarrheal incidence, reduce growth performance, change gut microbial diversity, increase susceptibility to pathogenic microorganisms and even cause death in serious condition (Hampson, 1986). Not only in piglets, stress can hamper the growth and immune response of adult animal also (Duthie et al., 1989; Lauridsen et al., 1999). Stress induces the production of reactive oxygen (ROS) and nitrogen species (RNS) including superoxide anion, hydroxyl radical, hydrogen peroxide, singlet oxygen, nitric oxide and nitrogen dioxide (Devasagayam et al., 2004). A certain concentration of ROS is required for normal cellular function like energy production, phagocytosis and intercellular signaling regulation (Nordberg & Arnér, 2001; Poli et al., 2012). But when the concentration exceeds from normal cellular level, ROS can damage of its own cellular DNA, protein and lipid (Schieber & Chandel, 2014). This harmful effect of ROS neutralized by several anti-oxidant defense mechanisms, which including antioxidant enzymes such as superoxide dismutase (SOD), catalase, glutathione-peroxidase (GSH-Px) as well as non-enzymatic substances like glutathione (GSH), heat shock protein (HSP) and ascorbic acid (Birben et al., 2012; Shalini et al., 2015; Zininga et al., 2018). ROS produces their detrimental effect by stealing electrons from adjacent bimolecule. SOD is the first step cells use to stop this process. SOD converts superoxide radicals to the less toxic hydrogen peroxide which converted to non-toxic water by either catalase or GPx. Therefore, measurement of these enzymes can be used to assess the antioxidant status of an individual.

One of the major targets of ROS is the cell membrane where they induce lipid peroxidation resulting in the production of MDA which can react with biomolecules and exert cytotoxic and genotoxic effect (Ardestani & Yazdanparast, 2007). So, MDA is an important indicator of oxidative stress in an organism.

Hormones like cortisol and thyroid stimulation hormone (TSH) also related to the host stress response (Helmreich & Tylee, 2011; Stephens et al., 2014). Duthie et al., (1989) proved that stress-susceptible pigs have defective antioxidant defense mechanisms. Studies over the last few decades proved that consumption of probiotics alone or with food can improve antioxidant activity and reduce damage by ROS. For instance, Wang et al., (2009) suggested that the application of Lactobacillus fermentum in growing and finishing pigs improved the antioxidant status of pigs as exhibited by increased levels of antioxidant enzymes such as SOD and GSH-Px. Serum and muscle malondialdehyde (MDA) levels also decrease in the treated group. Additionally, Cai et al., (2014) observed that oral administration of L. fermentum I5007 to piglets early in life significantly increases glutathione concentration, the activity of GSH-Px, and the total antioxidant capacity in plasma of piglets. Likewise, Supplementation of *Lactobacilli sp.* increased serum concentration of SOD, GSH-Px and catalase, while decreased the concentration of MDA in mice (Tang et al., 2016) and weaning piglets (Wang et al., 2012). Beside this, Wang et al., (2017) reported that the serum total antioxidant capacity (T-AOC) and SOD activities and GSH levels were significantly enhanced in Bacillus amyloliquefaciens treated piglets.

Effects of Probiotics on Lipid Profiles

Cholesterol (CT) is a lipophilic molecule and an essential component of mammalian cell membranes.

Nearly 65-80% of total cellular cholesterol resides in the cell membrane (Soccio & Breslow, 2004). Cholesterol is essential both for humans and animals as it play important role in synthesis of cell membrane, steroid hormones, bile acids and in the process of bidirectional transference of adipose fat and blood glucose with the liver (Olson, 1998; White & Venkatesh, 2011). But higher level of cholesterol or hypercholesterolemia associated with serious diseases like atherosclerotic vascular disease both in humans and animals (Soccio & Breslow, 2004). Pathogenesis of atherosclerotic lesions is common in humans and pigs due to high anatomic and physiological similarities. Higher concentration of low density lipoprotein (LDL) cholesterol and triglycerides (TG) and lower concentration of functional high density lipoprotein (HDL) are strongly related with the atherosclerotic cardiovascular disease. Previous studies on human and pigs have documented the hypocholesterolemic effect of probiotics. For example Yu et al., (2004) reported that inclusion of probiotics (Lactobacillus acidophilus, Lactobacillus pentose and Bacillus subtilis) in piglets diet decreased serum concentration of TC and LDL, while increased HDL concentration. Likewise, Hung et al., (2008) demonstrated that feeding soybean meal fermented by probiotic bacteria decrease the serum concentration of TC, LDL and TG.

Conclusions

From the previous studies it is clear that the use of probiotics could improve the growth performance in weaning, growing and finishing pigs. However, the effect of probiotics application is not always consistent. The effects of probiotic could be affected by strain of probiotics, dosage of selected probiotics, feed form and their interaction with used probiotics, age of animals and surrounding environment of the animal. Therefore, more studies are required to standardize the supplementation protocol including dosages, treatment duration, and to evaluate the bioactivity of probiotics during feed processing. Different coating technique such as microencapsulation should be developed to maintain bacterial stability in the gut which will increase the beneficial effect of probiotics.

Reference

Agazzi, A. (2015). The Beneficial Role of Probiotics in Monogastric Animal Nutrition and Health. *Journal of Dairy, Veterinary & Animal Research*, *2*(4), 116–132. https://doi.org/10.15406/jdvar.2015.02.00041

Ahmed, S. T., Ji, H., Hong-Seok, M., & Chul-Ju, Y. (2014). Evaluation of Lactobacillus and Bacillus-based probiotics as alternatives to antibiotics in enteric microbial challenged weaned piglets. *African Journal of Microbiology Research*, *8*(1), 96–104. https://doi.org/10.5897/ajmr2013.6355

Alakomi, H., Skyttä, E., Saarela, M., & Helander, I. M. (2005). Lactic Acid Permeabilizes Gram-Negative Bacteria by Disrupting the Outer Membrane Lactic Acid Permeabilizes Gram-Negative Bacteria by Disrupting the Outer Membrane. *Applied and Environmental Microbiology*, *66*(5), 2000–2005. https://doi.org/10.1128/AEM.66.5.2001-2005.2000. Updated

Ardestani, A., & Yazdanparast, R. (2007). Antioxidant and free radical scavenging potential of Achillea santolina extracts. *Food Chemistry*, *104*(1), 21–29. https://doi.org/10.1016/j.foodchem.2006.10.066

Ardissone, A. N., De La Cruz, D. M., Davis-Richardson, A. G., Rechcigl, K. T., Li, N., Drew, J. C., Murgas-Torrazza, R., Sharma, R., Hudak, M. L., Triplett, E. W., & Neu, J. (2014). Meconium microbiome analysis identifies bacteria correlated with premature birth. *PLoS ONE*, *9*(3), e90784. https://doi.org/10.1371/journal.pone.0090784

Ayala, L., Bocourt, R., Castro, M., Martínez, M., & Herrera, M. (2015). Effect of the probiotic additive Bacillus subtilis and their endospores on milk production and immune response of lactating sows. *Cuban Journal of Agricultural Science*, *49*(1), 71–74.

Azad, M. A. K., Sarker, M., & Wan, D. (2018). Immunomodulatory Effects of Probiotics on Cytokine Profiles. In *BioMed Research International* (Vol. 2018). https://doi.org/10.1155/2018/8063647

Azizpour, K., Bahrambeygi, S., Mahmoodpour, S., & Azizpour, A. (2009). History and basic of probiotics.

In *Research Journal of Biological Sciences* (Vol. 4, Issue 4, pp. 409–426). https://doi.org/10.1016/j.vaccine.2009.06.094

Bäckhed, F., Roswall, J., Peng, Y., Feng, Q., Jia, H., Kovatcheva-Datchary, P., Li, Y., Xia, Y., Xie, H., Zhong, H., Khan, M. T., Zhang, J., Li, J., Xiao, L., Al-Aama, J., Zhang, D., Lee, Y. S., Kotowska, D., Colding, C., … Jun, W. (2015). Dynamics and stabilization of the human gut microbiome during the first year of life. *Cell Host and Microbe*, *17*(5), 690–703. https://doi.org/10.1016/j.chom.2015.04.004

Bajagai et al. (2016). Probiotics in animal nutrition - Production, impact and regulation. In *FAO Animal Production and Health Paper No. 179* (Vol. 24, Issue 1). https://doi.org/10.3920/BM2008.1002

Bajaj, B. K., Claes, I. J. J., & Lebeer, S. (2015). Functional mechanisms of probiotics. *Journal of Microbiology, Biotechnology and Food Sciences*, *04*(04), 321–327. https://doi.org/10.15414/jmbfs.2015.4.4.321-327

Baken, K. A., Ezendam, J., Gremmer, E. R., de Klerk, A., Pennings, J. L. A., Matthee, B., Peijnenburg, A. A. C. M., & van Loveren, H. (2006). Evaluation of immunomodulation by Lactobacillus casei Shirota: Immune function, autoimmunity and gene expression. *International Journal of Food Microbiology*, *112*(1), 8–18. https://doi.org/10.1016/j.ijfoodmicro.2006.06.009

Balasubramanian, B., Li, T., & Kim, I. H. (2016). Effects of supplementing growing-finishing pig diets with Bacillus spp. probiotic on growth performance and meat-carcass grade quality traits. *Revista Brasileira de Zootecnia*, *45*(3), 93–100. https://doi.org/10.1590/S1806-92902016000300002

Barszcz, M., Taciak, M., & Skomiał, J. (2016). The effects of inulin, dried Jerusalem artichoke tuber and a multispecies probiotic preparation on microbiota ecology and immune status of the large intestine in young pigs. *Archives of Animal Nutrition*, *70*(4), 278–292. https://doi.org/10.1080/1745039X.2016.1184368

Bauer, E., Williams, B. A., Smidt, H., Mosenthin, R., & Verstegen, M. W. A. (2006). Influence of dietary components on development of the microbiota in single-stomached species. *Nutrition Research Reviews*, *19*(1), 63–78. https://doi.org/10.1079/nrr2006123

Bhandari, S. K., Opapeju, F. O., Krause, D. O., & Nyachoti, C. M. (2010). Dietary protein level and probiotic supplementation effects on piglet response to Escherichia coli K88 challenge: Performance and gut microbial population. *Livestock Science*, *133*(1–3), 185–188. https://doi.org/10.1016/j.livsci.2010.06.060

Birben, E., Sahiner, U. M., Sackesen, C., Erzurum, S., & Kalayci, O. (2012). Oxidative stress and antioxidant defense. In *World Allergy Organization Journal* (Vol. 5, Issue 1, pp. 9–19). https://doi.org/10.1097/WOX.0b013e3182439613

Bontempo, V., Di Giancamillo, A., Savoini, G., Dell'Orto, V., & Domeneghini, C. (2006). Live yeast dietary supplementation acts upon intestinal morpho-functional aspects and growth in weanling piglets. *Animal Feed Science and Technology*, *129*(3–4), 224–236. https://doi.org/10.1016/j.anifeedsci.2005.12.015

Bos, N. A., Jiang, H. Q., & Cebra, J. J. (2001). T cell control of the gut IgA response against commensal bacteria. In *Gut* (Vol. 48, Issue 6, pp. 762–764). https://doi.org/10.1136/gut.48.6.762

Boudry, G., Péron, V., Le Huërou-Luron, I., Lallès, J. P., & Sève, B. (2004). Weaning Induces Both Transient and Long-Lasting Modifications of Absorptive, Secretory, and Barrier Properties of Piglet Intestine. *The Journal of Nutrition*, *134*(9), 2256–2262. https://doi.org/10.1093/jn/134.9.2256

Cai, L., Indrakumar, S., Kiarie, E., & Kim, I. H. (2015). Effects of a multi-strain Bacillus species–based direct-fed microbial on growth performance, nutrient digestibility, blood profile, and gut health in nursery pigs fed corn–soybean meal–based diets. *Journal of Animal Science*, *93*(9), 4336–4342. https://doi.org/10.2527/jas.2015-9056

Cavaillon, J. (2014). *Pro- versus anti-inflammatory cytokines : Myth or reality*. *July*.

Chen, P., Wang, A. Q., & Shan, A. S. (2009). Effects of Ligustrum lucidum fruits on growth performance, antioxidation and meat quality in arbor acres broilers. *Asian-Australasian Journal of Animal Sciences*, *22*(5), 700–705. https://doi.org/10.5713/ajas.2009.80537

Cho, J. H., Zhao, P. Y., & Kim, I. H. (2011). Probiotics as a dietary additive for pigs: A review. In *Journal of Animal and Veterinary Advances* (Vol. 10, Issue 16, pp. 2127–2134). https://doi.org/10.3923/javaa.2011.2127.2134

Choi, J. Y., Shinde, P. L., Ingale, S. L., Kim, J. S., Kim, Y. W., Kim, K. H., Kwon, I. K., & Chae, B. J. (2011). Evaluation of multi-microbe probiotics prepared by submerged liquid or solid substrate fermentation and antibiotics in weaning pigs. *Livestock Science*, *138*(1–3), 144–151. https://doi.org/10.1016/j.livsci.2010.12.015

Choi, Y., Goel, A., Hosseindoust, A., Lee, S., Kim, K., Jeon, S., Noh, H., Kwon, I. K., & Chae, B. (2016). Effects of dietary supplementation of Ecklonia cava with or without probiotics on the growth performance, nutrient digestibility, immunity and intestinal health in weanling pigs. In *Italian Journal of Animal Science* (Vol. 15, Issue 1, pp. 62–68). https://doi.org/10.1080/1828051X.2015.1128685

Czyzewska-Dors, E., Kwit, K., Stasiak, E., Rachubik, J., Slizewska, K., & Pomorska-Mól, M. (2018). Effects of newly developed synbiotic and commercial probiotic products on the haematological indices, serum cytokines, acute phase proteins concentration, and serum immunoglobulins amount in sows and growing pigs- A pilot study. *Journal of Veterinary Research (Poland)*, *62*(3), 317–328. https://doi.org/10.2478/jvetres-2018-0046

Daudelin, J. F., Lessard, M., Beaudoin, F., Nadeau, É., Bissonnette, N., Boutin, Y., Brousseau, J. P., Lauzon, K., & Fairbrother, J. (2011). Administration of probiotics influences F4 (K88)-positive enterotoxigenic Escherichia coli attachment and intestinal cytokine expression in weaned pigs. *Veterinary Research*, *42*(1), 1–11. https://doi.org/10.1186/1297-9716-42-69

Deng, J., Li, Y., Zhang, J., & Yang, Q. (2013). Research in Veterinary Science Co-administration of Bacillus subtilis RJGP16 and Lactobacillus salivarius B1 strongly enhances the intestinal mucosal immunity of piglets. *Research in Veterinary Science*, *94*(1), 62–68. https://doi.org/10.1016/j.rvsc.2012.07.025

Devasagayam, T. P. A., Tilak, J. C., Boloor, K. K., Sane, K. S., Ghaskadbi, S. S., & Lele, R. D. (2004). Free radicals and antioxidants in human health: Current status and future prospects. In *Journal of Association of Physicians of India* (Vol. 52, Issue OCT, pp. 794–804).

Dlamini, Z. C., Langa, R. L. S., Aiyegoro, O. A., & Okoh, A. I. (2017). Effects of probiotics on growth performance, blood parameters, and antibody stimulation in piglets. *South African Journal of Animal Sciences*, *47*(6), 766–775. https://doi.org/10.4314/sajas.v47i6.4

Dominguez-Bello, M. G., Costello, E. K., Contreras, M., Magris, M., Hidalgo, G., Fierer, N., & Knight, R. (2010). Delivery mode shapes the acquisition and structure of the initial microbiota across multiple body habitats in newborns. *Proceedings of the National Academy of Sciences of the United States of America*, *107*(26), 11971–11975. https://doi.org/10.1073/pnas.1002601107

Dong, X., Zhang, N., Zhou, M., Tu, Y., Deng, K., & Diao, Q. (2014). Effects of dietary probiotics on growth performance, faecal microbiota and serum profiles in weaned piglets. *Animal Production Science*, *54*(5), 616–621. https://doi.org/10.1071/AN12372

Duthie, G. G., Arthur, J. R., Nicol, F., & Walker, M. (1989). Increased indices of lipid peroxidation in stress-susceptible pigs and effects of vitamin E. *Research in Veterinary Science*, *46*(2), 226–230. https://doi.org/10.1016/s0034-5288(18)31149-4

Finamore, A., Roselli, M., Britti, M. S., Merendino, N., & Mengheri, E. (2012). Lactobacillus rhamnosus GG and Bifidobacterium animalis MB5 Induce Intestinal but Not Systemic Antigen-Specific Hyporesponsiveness in Ovalbumin-Immunized Rats.

The Journal of Nutrition, *142*(2), 375–381. https://doi.org/10.3945/jn.111.148924

Foligné, B., Dewulf, J., Breton, J., Claisse, O., Lonvaud-Funel, A., & Pot, B. (2010). Probiotic properties of non-conventional lactic acid bacteria: Immunomodulation by Oenococcus oeni. *International Journal of Food Microbiology*, *140*(2–3), 136–145. https://doi.org/10.1016/j.ijfoodmicro.2010.04.007

Fouhse, J. M., Zijlstra, R. T., & Willing, B. P. (2016). The role of gut microbiota in the health and disease of pigs. *Animal Frontiers*, *6*(3), 30–36. https://doi.org/10.2527/af.2016-0031

Fuller, R. (1989). Probiotics in man and animals. In *Journal of Applied Bacteriology* (Vol. 66, Issue 5, pp. 365–378). https://doi.org/10.1111/j.1365-2672.1989.tb05105.x

Galdeano, C. M., & Perdigo, G. (2014). The Probiotic Bacterium Lactobacillus casei Induces Activation of the Gut Mucosal Immune System through Innate Immunity The Probiotic Bacterium Lactobacillus casei Induces Activation of the Gut Mucosal Immune System through Innate Immunity. *Clinical and Vaccine Immunology, 13*(March 2006), 219–226. https://doi.org/10.1128/CVI.13.2.219

Gebert, S., Davis, E., Rehberger, T., & Maxwell, C. V. (2011). Lactobacillus brevis strain 1E1 administered to piglets through milk supplementation prior to weaning maintains intestinal integrity after the weaning event. *Beneficial Microbes*, *2*(1), 35–45. https://doi.org/10.3920/BM2010.0043

Giang, H. H., Viet, T. Q., Ogle, B., & Lindberg, J. E. (2010). Growth performance, digestibility, gut environment and health status in weaned piglets fed a diet supplemented with potentially probiotic complexes of lactic acid bacteria. *Livestock Science*, *129*(1–3), 95–103. https://doi.org/10.1016/j.livsci.2010.01.010

Giang, H. H., Viet, T. Q., Ogle, B., & Lindberg, J. E. (2011). Effects of supplementation of probiotics on the performance, nutrient digestibility and faecal microflora in growing-finishing pigs. *Asian-Australasian Journal of Animal Sciences*, *24*(5), 655–661. https://doi.org/10.5713/ajas.2011.10238

Gill, H. S., Rutherfurd, K. J., Prasad, J., & Gopal, P. K. (2000). Enhancement of natural and acquired immunity by Lactobacillus rhamnosus (HN001), Lactobacillus acidophilus (HN017) and Bifidobacterium lactis (HN019). *British Journal of Nutrition*, *83*(2), 167–176. https://doi.org/10.1017/s0007114500000210

Groer, M. W., Luciano, A. A., Dishaw, L. J., Ashmeade, T. L., Miller, E., & Gilbert, J. A. (2014). *<2049-2618-2-38.Pdf>*. 1–8.

Hampson, D. J. (1986). Alterations in piglet small intestinal structure at weaning. *Research in Veterinary Science*, *40*(1), 32–40. https://doi.org/10.1016/s0034-5288(18)30482-x

Hayashi, H., Shibata, K., Sakamoto, M., Tomita, S., & Benno, Y. (2007). Prevotella copri sp. nov. and Prevotella stercorea sp. nov., isolated from human faeces. *International Journal of Systematic and Evolutionary Microbiology*, *57*(5), 941–946. https://doi.org/10.1099/ijs.0.64778-0

Helmreich, D. L., & Tylee, D. (2011). Thyroid hormone regulation by stress and behavioral differences in adult male rats. *Hormones and Behavior*, *60*(3), 284–291. https://doi.org/10.1016/j.yhbeh.2011.06.003

Herfel, T. M., Jacobi, S. K., Lin, X., Jouni, Z. E., Chichlowski, M., Stahl, C. H., & Odle, J. (2013). Dietary supplementation of Bifidobacterium longum strain AH1206 increases its cecal abundance and elevates intestinal interleukin-10 expression in the neonatal piglet. *Food and Chemical Toxicology*, *60*, 116–122. https://doi.org/10.1016/j.fct.2013.07.020

Hou, C., Liu, H., Zhang, J., Zhang, S., Yang, F., Zeng, X., Thacke, P. A., Zhang, G., & Qiao, S. (2015). Intestinal microbiota succession and immunomodulatory consequences after introduction of lactobacillus reuteri I5007 in neonatal piglets. *PLoS ONE*, *10*(3), 1–17. https://doi.org/10.1371/journal.pone.0119505

Hou, C., Zeng, X., Yang, F., Liu, H., & Qiao, S. (2015). Study and use of the probiotic Lactobacillus reuteri in pigs: A review. In *Journal of Animal Science and Biotechnology* (Vol. 6, Issue 1, pp. 1–8). https://doi.org/10.1186/s40104-015-0014-3

Huang, C., Qiao, S., Li, D., Piao, X., & Ren, J. (2004). Effects of Lactobacilli on the performance, diarrhea incidence, VFA concentration and gastrointestinal microbial flora of weaning pigs. *Asian-Australasian Journal of Animal Sciences*, *17*(3), 401–409. https://doi.org/10.5713/ajas.2004.401

Hung, A. T. Y., Su, T. M., Liao, C. W., & Lu, J. J. (2008). Effect of probiotic combination fermented soybean meal on growth performance, lipid metabolism and immunological response of growing-finishing pigs. *Asian Journal of Animal and Veterinary Advances*, *3*(6), 431–436. https://doi.org/10.3923/ajava.2008.431.436

Imaoka, A., Matsumoto, S., Setoyama, H., Okada, Y., & Umesaki, Y. (1996). Proliferative recruitment of intestinal intraepithelial lymphocytes after microbial colonization of germ-free mice. *European Journal of Immunology*, *26*(4), 945–948. https://doi.org/10.1002/eji.1830260434

Inobe, M., & Schwartz, R. H. (2004). CTLA-4 Engagement Acts as a Brake on CD4 + T Cell Proliferation and Cytokine Production but Is Not Required for Tuning T Cell Reactivity in Adaptive Tolerance . *The Journal of Immunology*, *173*(12), 7239–7248. https://doi.org/10.4049/jimmunol.173.12.7239

Isaacson, R., & Kim, H. B. (2012). The intestinal microbiome of the pig. *Animal Health Research Reviews / Conference of Research Workers in Animal Diseases*, *13*(1), 100–109. https://doi.org/10.1017/S1466252312000084

J. S. Kim, Hosseindoust, A., Lee, S. H., Choi, Y. H., Kim, M. J., Lee, J. H., Kwon, I. K., & Chae, B. J. (2017). Bacteriophage cocktail and multi-strain probiotics in the feed for weanling pigs: Effects on intestine morphology and targeted intestinal coliforms and Clostridium. *Animal*, *11*(1), 45–53. https://doi.org/10.1017/S1751731116001166

Jørgensen, J. N., Laguna, J. S., Millán, C., Casabuena, O., & Gracia, M. I. (2016). Effects of a Bacillus-based probiotic and dietary energy content on the performance and nutrient digestibility of wean to finish pigs. *Animal Feed Science and Technology*, *221*, 54–61. https://doi.org/10.1016/j.anifeedsci.2016.08.008

Jukna, Č., Jukna, V., & Šimkus, A. (2005). the Effect of Probiotics and Phytobiotics on Meat Properties and Quality in Pigs. *Veterinarija Ir Zootechnika*, *29*(51), 80–84.

Kandasamy, S., Chattha, K. S., Vlasova, A. N., Rajashekara, G., & Saif, L. J. (2015). Lactobacilli and Bifidobacteria enhance mucosal B cell responses and differentially modulate systemic antibody responses to an oral human rotavirus vaccine in a neonatal gnotobiotic pig disease model. *Gut Microbes*, *5*(5), 639–651. https://doi.org/10.4161/19490976.2014.969972

Kenny, M., Smidt, H., Mengheri, E., & Miller, B. (2011). Probiotics-do they have a role in the pig industry? *Animal*, *5*(3), 462–470. https://doi.org/10.1017/S175173111000193X

Kiarie, E., Bhandari, S., Scott, M., Krause, D. O., & Nyachoti, C. M. (2011). Growth performance and gastrointestinal microbial ecology responses of piglets receiving Saccharomyces cerevisiae fermentation products after an oral challenge with Escherichia coli (K88). *Journal of Animal Science*, *89*(4), 1062–1078. https://doi.org/10.2527/jas.2010-3424

Kim, E. Y., Kim, Y. H., Rhee, M. H., Song, J. C., Lee, K. W., Kim, K. S., Lee, S. P., Lee, I. S., & Park, S. C. (2007). Selection of lactobacillus sp. PSC101 that produces active dietary enzymes such as amylase, lipase, phytase and protease in pigs. *Journal of General and Applied Microbiology*, *53*(2), 111–117. https://doi.org/10.2323/jgam.53.111

Kim, H. B., & Isaacson, R. E. (2015). The pig gut microbial diversity: Understanding the pig gut microbial ecology through the next generation high throughput sequencing. In *Veterinary Microbiology* (Vol. 177, Issues 3–4, pp. 242–251). Elsevier B.V. https://doi.org/10.1016/j.vetmic.2015.03.014

Ko, S. Y., & Yang, C. J. (2008). Effect of green tea probiotics on the growth performance, meat quality and immune response in finishing pigs. *Asian-*

Australasian Journal of Animal Sciences, *21*(9), 1339–1347. https://doi.org/10.5713/ajas.2008.70597

Konstantinov, S. R., Awati, A. A., Williams, B. A., Miller, B. G., Jones, P., Stokes, C. R., Akkermans, A. D. L., Smidt, H., & De Vos, W. M. (2006). Post-natal development of the porcine microbiota composition and activities. *Environmental Microbiology*, *8*(7), 1191–1199. https://doi.org/10.1111/j.1462-2920.2006.01009.x

Krause, D. O., Bhandari, S. K., House, J. D., & Nyachoti, C. M. (2010). Response of nursery pigs to a synbiotic preparation of starch and an anti-escherichia coli K88 probiotic. *Applied and Environmental Microbiology*, *76*(24), 8192–8200. https://doi.org/10.1128/AEM.01427-10

La Fata, G., Weber, P., & Mohajeri, M. H. (2017). Probiotics and the Gut Immune System: Indirect Regulation. In *Probiotics and Antimicrobial Proteins* (Vol. 10, Issue 1, pp. 11–21). Probiotics and Antimicrobial Proteins. https://doi.org/10.1007/s12602-017-9322-6

Lähteinen, T., Rinttilä, T., Koort, J. M. K., Kant, R., Levonen, K., Jakava-Viljanen, M., Björkroth, J., & Palva, A. (2015). Effect of a multispecies lactobacillus formulation as a feeding supplement on the performance and immune function of piglets. *Livestock Science*, *180*, 164–171. https://doi.org/10.1016/j.livsci.2015.07.016

Lallès, J. P., Bosi, P., Smidt, H., & Stokes, C. R. (2007). Nutritional management of gut health in pigs around weaning. In *Proceedings of the Nutrition Society* (Vol. 66, Issue 2, pp. 260–268). https://doi.org/10.1017/S0029665107005484

Lamendella, R., Santo Domingo, J. W., Ghosh, S., Martinson, J., & Oerther, D. B. (2011). Comparative fecal metagenomics unveils unique functional capacity of the swine gut. In *BMC Microbiology* (Vol. 11). https://doi.org/10.1186/1471-2180-11-103

Laskowska, E., Jarosz, Ł., & Grądzki, Z. (2019). Effect of Multi-Microbial Probiotic Formulation Bokashi on Pro- and Anti-Inflammatory Cytokines Profile in the Serum, Colostrum and Milk of Sows, and in a Culture of Polymorphonuclear Cells Isolated from Colostrum. *Probiotics and Antimicrobial Proteins*, *11*(1), 220–232. https://doi.org/10.1007/s12602-017-9380-9

Lauridsen, C., Højsgaard, S., & Sørensen, M. T. (1999). Influence of dietary rapeseed oil, vitamin E, and copper on the performance and the antioxidative and oxidative status of pigs. *Journal of Animal Science*, *77*(4), 906–916. https://doi.org/10.2527/1999.774906x

Le Bon, M., Davies, H. E., Glynn, C., Thompson, C., Madden, M., Wiseman, J., Dodd, C. E. R., Hurdidge, L., Payne, G., Le Treut, Y., Craigon, J., Tötemeyer, S., & Mellits, K. H. (2010). Influence of probiotics on gut health in the weaned pig. *Livestock Science*, *133*(1–3), 179–181. https://doi.org/10.1016/j.livsci.2010.06.058

Lee, Y. K., & Mazmanian, S. K. (2010). Has the microbiota played a critical role in the evolution of the adaptive immune system? In *Science* (Vol. 330, Issue 6012, pp. 1768–1773). https://doi.org/10.1126/science.1195568

Lescheid, D. W. (2014). Probiotics as regulators of inflammation: A review. *Functional Foods in Health and Disease*, *4*(7), 299. https://doi.org/10.31989/ffhd.v4i7.2

Lessard, M., Dupuis, M., Gagnon, N., Nadeau, É., Matte, J. J., Goulet, J., & Fairbrother, J. M. (2009). Administration of Pediococcus acidilactici or Saccharomyces cerevisiae boulardii modulates development of porcine mucosal immunity and reduces intestinal bacterial translocation after Escherichia coli challenge. *Journal of Animal Science*, *87*(3), 922–934. https://doi.org/10.2527/jas.2008-0919

Liu, H., Zhang, J., Zhang, S., Yang, F., Thacker, P. A., Zhang, G., Qiao, S., & Ma, X. (2014). Oral administration of lactobacillus fermentum I5007 favors intestinal development and alters the intestinal microbiota in formula-fed piglets. *Journal of Agricultural and Food Chemistry*, *62*(4), 860–866. https://doi.org/10.1021/jf403288r

Liu, W. C., Ye, M., Liao, J. H., Zhao, Z. H., Kim, I. H., & An, L. L. (2018). Application of Complex Probiotics

in Swine Nutrition - A Review. *Annals of Animal Science*, *18*(2), 335–350. https://doi.org/10.2478/aoas-2018-0005

Livingston, D. J., & Brown, W. D. (1981). The chemistry of myoglobin and its reactions Meat pigments, food quality indices. *Food Technology*, 238–252.

Luckey, T. D. (1972). Introduction to intestinal microecology. *American Journal of Clinical Nutrition*, *25*(12), 1292–1294. https://doi.org/10.1093/ajcn/25.12.1292

Lundin, A., Bok, C. M., Aronsson, L., Björkholm, B., Gustafsson, J. Å., Pott, S., Arulampalam, V., Hibberd, M., Rafter, J., & Pettersson, S. (2008). Gut flora, Toll-like receptors and nuclear receptors: A tripartite communication that tunes innate immunity in large intestine. *Cellular Microbiology*, *10*(5), 1093–1103. https://doi.org/10.1111/j.1462-5822.2007.01108.x

MacDonald, T. T., & Monteleone, G. (2005). Immunity, inflammation, and allergy in the gut. *Science*, *307*(5717), 1920–1925. https://doi.org/10.1126/science.1106442

Mach, N., Berri, M., Estellé, J., Levenez, F., Lemonnier, G., Denis, C., Leplat, J. J., Chevaleyre, C., Billon, Y., Doré, J., Rogel-Gaillard, C., & Lepage, P. (2015). Early-life establishment of the swine gut microbiome and impact on host phenotypes. *Environmental Microbiology Reports*, *7*(3), 554–569. https://doi.org/10.1111/1758-2229.12285

Macpherson, A. J., & Harris, N. L. (2004). Interactions between commensal intestinal bacteria and the immune system. *Nature Reviews Immunology*, *4*(6), 478–485. https://doi.org/10.1038/nri1373

Mair, C., Plitzner, C., Domig, K. J., Schedle, K., & Windisch, W. (2010). Impact of inulin and a multispecies probiotic formulation on performance, microbial ecology and concomitant fermentation patterns in newly weaned piglets. *Journal of Animal Physiology and Animal Nutrition*, *94*(5). https://doi.org/10.1111/j.1439-0396.2010.01000.x

Matsumoto, S., Setoyama, H., & Umesaki, Y. (1992). Differential induction of major histocompatibility complex molecules on mouse intestine by bacterial colonization. *Gastroenterology*, *103*(6), 1777–1782. https://doi.org/10.1016/0016-5085(92)91434-6

Meng, Q. W., Yan, L., Ao, X., Zhou, T. X., Wang, J. P., Lee, J. H., & Kim, I. H. (2010). Influence of probiotics in different energy and nutrient density diets on growth performance, nutrient digestibility, meat quality, and blood characteristics in growing-finishing pigs. *Journal of Animal Science*, *88*(10), 3320–3326. https://doi.org/10.2527/jas.2009-2308

Morrissey, P. A., Buckley, D. J., Sheehy, P. J. A., & Monahan, F. J. (1994). Vitamin E and meat quality. *Proceedings of the Nutrition Society*, *53*(2), 289–295. https://doi.org/10.1079/pns19940034

Murphy, K. J., Parker, B., Dyer, K. A., Davis, C. R., Coates, A. M., Buckley, J. D., & Howe, P. R. C. (2014). A comparison of regular consumption of fresh lean pork, beef and chicken on body composition: A randomized cross-over trial. *Nutrients*, *6*(2), 682–696. https://doi.org/10.3390/nu6020682

Naqid, I. A., Owen, J. P., Maddison, B. C., Gardner, D. S., Foster, N., Tchórzewska, M. A., La Ragione, R. M., & Gough, K. C. (2015). Prebiotic and probiotic agents enhance antibody-based immune responses to Salmonella Typhimurium infection in pigs. *Animal Feed Science and Technology*, *201*, 57–65. https://doi.org/10.1016/j.anifeedsci.2014.12.005

Nordberg, J., & Arnér, E. S. J. (2001). Reactive oxygen species, antioxidants, and the mammalian thioredoxin system. In *Free Radical Biology and Medicine* (Vol. 31, Issue 11, pp. 1287–1312). https://doi.org/10.1016/S0891-5849(01)00724-9

Oelschlaeger, T. A. (2010). Mechanisms of probiotic actions - A review. In *International Journal of Medical Microbiology* (Vol. 300, Issue 1, pp. 57–62). Elsevier. https://doi.org/10.1016/j.ijmm.2009.08.005

Olson, R. E. (1998). Symposium : Evolution of Ideas about the Nutritional Value of Dietary Fat Discovery of the Lipoproteins , Their Role in Fat Transport and Their Significance as Risk Factors 1. *Most*, *128*(April), 439–443. http://jn.nutrition.org/

Organization, W. H. (2002). *the Evaluation of Probiotics in Food. Report of a Joint FAO/WHO Working Group on Drafting Guidelines for the Evaluation of Probiotics in Food. FAO, WHO ….*

Ouwehand, A. C., Bergsma, N., Parhiala, R., Lahtinen, S., Gueimonde, M., Finne-Soveri, H., Strandberg, T., Pitkälä, K., & Salminen, S. (2008). Bifidobacterium microbiota and parameters of immune function in elderly subjects. *FEMS Immunology and Medical Microbiology*, *53*(1), 18–25. https://doi.org/10.1111/j.1574-695X.2008.00392.x

Pajarillo, E. A. B., Chae, J. P., Balolong, M. P., Kim, H. B., & Kang, D. K. (2014). Assessment of fecal bacterial diversity among healthy piglets during the weaning transition. *Journal of General and Applied Microbiology*, *60*(4), 140–146. https://doi.org/10.2323/jgam.60.140

Patarapreecha, P., Jaikan, W., Juangsaman, A., & Khajarern, J. (2018). Effects of dietary bacillus subtilis supplementation as probiotics on growth performance and nutrients digestibility in fattening pigs. *Pakistan Journal of Nutrition*, *17*(12), 634–640. https://doi.org/10.3923/pjn.2018.634.640

Perdigon, G., Alvarez, S., Rachid, M., Agüero, G., & Gobbato, N. (1995). Immune System Stimulation by Probiotics. *Journal of Dairy Science*, *78*(7), 1597–1606. https://doi.org/10.3168/jds.S0022-0302(95)76784-4

Petersen, C., & Round, J. L. (2014). Defining dysbiosis and its influence on host immunity and disease. In *Cellular Microbiology* (Vol. 16, Issue 7, pp. 1024–1033). https://doi.org/10.1111/cmi.12308

Peterson, C. T., Sharma, V., Elmén, L., & Peterson, S. N. (2015). Immune homeostasis, dysbiosis and therapeutic modulation of the gut microbiota. In *Clinical and Experimental Immunology* (Vol. 179, Issue 3, pp. 363–377). https://doi.org/10.1111/cei.12474

Piriou, L., Chevallier, S., Hutet, E., Charley, B., Le Potier, M.-F., & Emmanuel, A. (2003). *Humoral and cell-mediated immune responses of d/d histocompatible pigs against classical swine fever (CSF) virus Laurence*. 389–404. https://doi.org/10.1051/vetres

Poli, G., Leonarduzzi, G., Biasi, F., & Chiarpotto, E. (2012). Oxidative Stress and Cell Signalling. *Current Medicinal Chemistry*, *11*(9), 1163–1182. https://doi.org/10.2174/0929867043365323

Pollmann, D. S., Danielson, D. M., & Peo, E. R. (1980). Effects of Microbial Feed Additives on Performance of Starter and Growing-finishing Pigs. *Journal of Animal Science*, *51*(3), 577–581. https://doi.org/10.2527/jas1980.513577x

Pospíšková, P., Zorníková, G., Kolářová, M., Sládek, Z., Komprda, T., & Geršiová, J. (2013). Effect of probiotics in the pig nutrition on the pathogenic bacteria counts in the gut. *Acta Universitatis Agriculturae et Silviculturae Mendelianae Brunensis*, *61*(6), 1839–1843. https://doi.org/10.11118/actaun201361061839

Roselli, M., Pieper, R., Rogel-Gaillard, C., de Vries, H., Bailey, M., Smidt, H., & Lauridsen, C. (2017). Immunomodulating effects of probiotics for microbiota modulation, gut health and disease resistance in pigs. *Animal Feed Science and Technology*, *233*(June), 104–119. https://doi.org/10.1016/j.anifeedsci.2017.07.011

Savan, R., & Sakai, M. (2006). Genomics of fish cytokines. In *Comparative Biochemistry and Physiology - Part D: Genomics and Proteomics* (Vol. 1, Issue 1 SPEC. ISS., pp. 89–101). https://doi.org/10.1016/j.cbd.2005.08.005

Scharek, L., Guth, J., Filter, M., & Schmidt, M. F. G. (2007). Impact of the probiotic bacteria Enterococcus faecium NCIMB 10415 (SF68) and Bacillus cereus var. toyoi NCIMB 40112 on the development of serum IgG and faecal IgA of sows and their piglets. *Archives of Animal Nutrition*, *61*(4), 223–234. https://doi.org/10.1080/17450390701431540

Schieber, M., & Chandel, N. S. (2014). ROS function in redox signaling and oxidative stress. In *Current Biology* (Vol. 24, Issue 10, pp. R453–R462). Elsevier. https://doi.org/10.1016/j.cub.2014.03.034

Schierack, P., Wieler, L. H., Taras, D., Herwig, V., Tachu, B., Hlinak, A., Schmidt, M. F. G., & Scharek, L. (2007). Bacillus cereus var. toyoi enhanced systemic immune response in piglets. *Veterinary Immunology and Immunopathology*, *118*(1–2), 1–11. https://doi.org/10.1016/j.vetimm.2007.03.006

Schmidt, B., Mulder, I. E., Musk, C. C., Aminov, R. I., Lewis, M., Stokes, C. R., Bailey, M., Prosser, J. I., Gill, B. P., Pluske, J. R., & Kelly, D. (2011). Establishment of normal gut microbiota is compromised under excessive hygiene conditions. *PLoS ONE*, *6*(12). https://doi.org/10.1371/journal.pone.0028284

Setia, A., Bhandari, S. K., House, J. D., Nyachoti, C. M., & Krause, D. O. (2009). Development and in vitro evaluation of an Escherichia coli probiotic able to inhibit the growth of pathogenic Escherichia coli K88. *Journal of Animal Science*, *87*(6), 2005–2012. https://doi.org/10.2527/jas.2008-1400

Shalini, S., Dorstyn, L., Dawar, S., & Kumar, S. (2015). Old, new and emerging functions of caspases. In *Cell Death and Differentiation* (Vol. 22, Issue 4, pp. 526–539). Nature Publishing Group. https://doi.org/10.1038/cdd.2014.216

Shin, D., Chang, S. Y., Bogere, P., Won, K. H., Choi, J. Y., Choi, Y. J., Lee, H. K., Hur, J., Park, B. Y., Kim, Y., & Heo, J. (2019). Beneficial roles of probiotics on the modulation of gut microbiota and immune response in pigs. *PLoS ONE*, *14*(8), 1–23. https://doi.org/10.1371/journal.pone.0220843

Soccio, R. E., & Breslow, J. L. (2004). Intracellular cholesterol transport. In *Arteriosclerosis, Thrombosis, and Vascular Biology* (Vol. 24, Issue 7, pp. 1150–1160). https://doi.org/10.1161/01.ATV.0000131264.66417.d5

Sperti, G. (1971). *Probiotics*.

Stephens, M. A. C., McCaul, M. E., & Wand, G. S. (2014). The Potential Role of Glucocorticoids and the HPA Axis in Alcohol Dependence. In *Neurobiology of Alcohol Dependence* (pp. 429–450). https://doi.org/10.1016/B978-0-12-405941-2.00021-3

Takahashi, T., Nakagawa, E., Nara, T., Yajima, T., & Kuwata, T. (1998). Effects of orally ingested bifidobacterium longum on the mucosal iga response of mice to dietary antigens. *Bioscience, Biotechnology and Biochemistry*, *62*(1), 10–15. https://doi.org/10.1271/bbb.62.10

Tang, W., Xing, Z., Hu, W., Li, C., Wang, J., & Wang, Y. (2016). Antioxidative effects in vivo and colonization of Lactobacillus plantarum MA2 in the murine intestinal tract. *Applied Microbiology and Biotechnology*, *100*(16), 7193–7202. https://doi.org/10.1007/s00253-016-7581-x

Tejada-Simon, M. V., Lee, J. H., Ustunol, Z., & Pestka, J. J. (1999). Ingestion of yogurt containing Lactobacillus acidophilus and Bifidobacterium to potentiate immunoglobulin A responses to cholera toxin in mice. *Journal of Dairy Science*, *82*(4), 649–660. https://doi.org/10.3168/jds.S0022-0302(99)75281-1

Thomas, C. M., & Versalovic, J. (2010). Probiotic-host communication: Modulation of Host Signaling Pathways. *Gut Microbes*, *13*(3), 148–163. www.landesbioscience.com/journals/gutmicrobes/article/11712

Tortuero, F., Rioperez, J., Fernandez, E., & Rodriguez, M. L. (1995). Response of Piglets to oral administration of lactic acid bacteria. *Journal of Food Protection*, *58*(12), 1369–1374. https://doi.org/10.4315/0362-028X-58.12.1369

Veizaj-Delia, E., & Pirushi, R. (2012). The utilization of probiotics as a way to improve human and animal gut health. *Macedonian Journal of Animal Science*, *2*(2), 175–181.

Vondruskova, H., Slamova, R., Trckova, M., Zraly, Z., & Pavlik, I. (2010). Alternatives to antibiotic growth promoters in prevention of diarrhoea in weaned piglets: A review. *Veterinarni Medicina*, *55*(5), 199–224. https://doi.org/10.17221/2998-VETMED

Walsh, M. C., Gardiner, G. E., Hart, O. M., Lawlor, P. G., Daly, M., Lynch, B., Richert, B. T., Radcliffe, S., Giblin, L., Hill, C., Fitzgerald, G. F., Stanton, C.,

& Ross, P. (2008). Predominance of a bacteriocin-producing Lactobacillus salivarius component of a five-strain probiotic in the porcine ileum and effects on host immune phenotype. *FEMS Microbiology Ecology*, *64*(2), 317–327. https://doi.org/10.1111/j.1574-6941.2008.00454.x

Wang. (2019). Tight Junction Proteins in the Weaned Piglet Intestine: Roles and Regulation. *Current Protein & Peptide Science*, *20*(7), 652–660. https://doi.org/10.2174/1389203720666190125095122

Wang, A. N., Yi, X. W., Yu, H. F., Dong, B., & Qiao, S. Y. (2009). Free radical scavenging activity of Lactobacillus fermentum in vitro and its antioxidative effect on growing-finishing pigs. *Journal of Applied Microbiology*, *107*(4), 1140–1148. https://doi.org/10.1111/j.1365-2672.2009.04294.x

Wang, A., Yu, H., Gao, X., Li, X., & Qiao, S. (2009). Influence of Lactobacillus fermentum I5007 on the intestinal and systemic immune responses of healthy and E. coli challenged piglets. *Antonie van Leeuwenhoek, International Journal of General and Molecular Microbiology*, *96*(1), 89–98. https://doi.org/10.1007/s10482-009-9339-2

Wang, J., Ji, H. F., Wang, S. X., Zhang, D. Y., Liu, H., Shan, D. C., & Wang, Y. M. (2012). Lactobacillus plantarum ZLP001: In vitro assessment of antioxidant capacity and effect on growth performance and antioxidant status in weaning piglets. *Asian-Australasian Journal of Animal Sciences*, *25*(8), 1153–1158. https://doi.org/10.5713/ajas.2012.12079

Wang, T., Teng, K., Liu, Y., Shi, W., Zhang, J., Dong, E., Zhang, X., Tao, Y., & Zhong, J. (2019). Lactobacillus plantarum PFM 105 promotes intestinal development through modulation of gut microbiota in weaning piglets. *Frontiers in Microbiology*, *10*(FEB), 1–16. https://doi.org/10.3389/fmicb.2019.00090

Wang, Y., Cho, J. H., Chen, Y. J., Yoo, J. S., Huang, Y., Kim, H. J., & Kim, I. H. (2009). The effect of probiotic BioPlus 2B® on growth performance, dry matter and nitrogen digestibility and slurry noxious gas emission in growing pigs. *Livestock Science*, *120*(1–2), 35–42. https://doi.org/10.1016/j.livsci.2008.04.018

Wang, Yang, Wu, Y., Wang, B., Cao, X., Fu, A., Li, Y., & Li, W. (2017). Effects of probiotic Bacillus as a substitute for antibiotics on antioxidant capacity and intestinal autophagy of piglets. *AMB Express*, *7*(1), 222–227. https://doi.org/10.1186/s13568-017-0353-x

Weichselbaum, E. (2009). Probiotics and health: A review of the evidence. *Nutrition Bulletin*, *34*(4), 340–373. https://doi.org/10.1111/j.1467-3010.2009.01782.x

White, H., & Venkatesh, B. (2011). Clinical review: Ketones and brain injury. *Critical Care*, *15*(2), 1–10. https://doi.org/10.1186/cc10020

Yan, F., Cao, H., Cover, T. L., Washington, M. K., Shi, Y., Liu, L. S., Chaturvedi, R., Peek, R. M., Wilson, K. T., & Polk, D. B. (2011). Colon-specific delivery of a probiotic-derived soluble protein ameliorates intestinal inflammation in mice through an EGFR-dependent mechanism. *Journal of Clinical Investigation*, *121*(6), 2242–2253. https://doi.org/10.1172/JCI44031

Yang, F., Hou, C., Zeng, X., & Qiao, S. (2015). The use of lactic acid bacteria as a probiotic in swine diets. *Pathogens*, *4*(1), 34–45. https://doi.org/10.3390/pathogens4010034

Yang, Y. X., Kim, Y. J., Jin, Z., Lohakare, J. D., Kim, C. H., Ohh, S. H., Lee, S. H., Choi, J. Y., & Chae, B. J. (2006). Effects of dietary supplementation of astaxanthin on production performance, egg quality in layers and meat quality in finishing pigs. *Asian-Australasian Journal of Animal Sciences*, *19*(7), 1019–1025. https://doi.org/10.5713/ajas.2006.1019

Yirga, H. (2015). The Use of Probiotics in Animal Nutrition. *Journal of Probiotics & Health*, *03*(02), 1–10. https://doi.org/10.4172/2329-8901.1000132

Yu et al. (2008). Effect of viable Lactobacillus fermentum on the growth performance, nutrient digestibility and immunity of weaned pigs. *Journal of Animal and Feed Sciences*, *17*(1), 61–69.

Yu, I. T., Ju, C. C., Lin, J., Wu, H. L., & Yen, H. T. (2004). Effects of probiotics and selenium combination on the immune and blood cholesterol concentration of pigs. *Journal of Animal and Feed Sciences*, *13*(4), 625–634. https://doi.org/10.22358/jafs/67630/2004

Zhang, L., Xu, Y. Q., Liu, H. Y., Lai, T., Ma, J. L., Wang, J. F., & Zhu, Y. H. (2010). Evaluation of Lactobacillus rhamnosus GG using an Escherichia coli K88 model of piglet diarrhoea: Effects on diarrhoea incidence, faecal microflora and immune responses. *Veterinary Microbiology*, *141*(1–2), 142–148. https://doi.org/10.1016/j.vetmic.2009.09.003

Zhang, W., Azevedo, M. S. P., Gonzalez, A. M., Saif, L. J., Van Nguyen, T., Wen, K., Yousef, A. E., & Yuan, L. (2008). Influence of probiotic Lactobacilli colonization on neonatal B cell responses in a gnotobiotic pig model of human rotavirus infection and disease. *Veterinary Immunology and Immunopathology*, *122*(1–2), 175–181. https://doi.org/10.1016/j.vetimm.2007.10.003

Zhao, P. Y., & Kim, I. H. (2015). Effect of direct-fed microbial on growth performance, nutrient digestibility, fecal noxious gas emission, fecal microbial flora and diarrhea score in weanling pigs. *Animal Feed Science and Technology*, *200*(1), 86–92. https://doi.org/10.1016/j.anifeedsci.2014.12.010

Zhu, J., Gao, M., Zhang, R., Sun, Z., Wang, C., Yang, F., Huang, T., Qu, S., Zhao, L., Li, Y., & Hao, Z. (2017). Effects of soybean meal fermented by L. plantarum, B. subtilis and S. cerevisieae on growth, immune function and intestinal morphology in weaned piglets. *Microbial Cell Factories*, *16*(1), 1–10. https://doi.org/10.1186/s12934-017-0809-3

Zininga, T., Ramatsui, L., & Shonhai, A. (2018). Heat shock proteins as immunomodulants. *Molecules*, *23*(11). https://doi.org/10.3390/molecules23112846

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Estrus Induction and Fixed Time Artificial Insemination of Crossbred Anestrus Cattle Under Semi Intensive Rearing in Tropical Island Ecosystem

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Abstract

A study was conducted in cross bred anestrus cattle at ICAR-CIARI, Port Blair, Andaman and Nicobar Islands with aim to observe efficacy of controlled intra vaginal drug release (CIDR) device and Ovsynch protocol as combination for estrus induction besides conception rate at fixed time artificial insemination (FTAI) in induced estrus thereafter. The cattle were maintained under semi intensive rearing which is a prevalent practice of cattle rearing in these islands. A total of eight dairy cows and heifers were selected based on history of anestrus and reproductive examination of ovary at 10 days interval to confirm inactive ovaries including non pregnancy status. All experimental animals were first given oral dose of dewormer (day0) and supplement of mineral mixture for a month from day3 onward. On day19 (8:00 AM), CIDR device was inserted followed by first GnRH injection at same time. CIDR implants were removed on day26 (8:00 AM) followed by prostaglandin injection at same time. The second injection of GnRH was injected on day28 (4:00 PM) followed by two frozen semen inseminations at fixed time, first on day29 (afternoon) and second 12 hours later (day30). Pregnancy diagnosis was performed using ultrasonography and by per rectal examination. Present study has shown that all the animals (100%) responded to estrus induction using combination of CIDR device and Ovsynch protocol. Out of eight cattle, five becomes pregnant (62.5%) using FTAI. It may be concluded that estrus can be induced in anestrus cattle using combination of CIDR device and Ovsynch protocol and fertility of anestrus cattle can be enhanced with use of fixed time AI during induced estrus.

Keywords: Andaman, Anoestrus cattle, CIDR, Conception, Estrus Induction, Fixe Time AI

Introduction

Andaman and Nicobar Islands (ANI) have a tropical hot and humid climate where the experimental station is located (11.68°N 92.77°E). Cattle populations in these islands account 53488 as per 19th Livestock census (2012) and thereafter 45617 in number (Sunder, 2014). Semi intensive rearing is prevalent practice of cattle rearing in ANI. The majorities of the cattle in these islands are affected with anoestrus and repeat breeding problem where some pockets of these South Andaman district have almost 52.63% of cattle with cases of infertility (Sunder, 2014). In a survey of Andaman districts (Kundu *et al.,* 2010), a total of 31.62% of cattle suffered infertility out of which 48.6% have encountered anestrus problem followed by 33.8% cases of repeat breeding, infectious cause of reproductive problem such as Brucellosis and IBR (6%) and other causes viz. underdeveloped genitalia, failure of insemination (2%) etc. Anoestrus and repeat breeding are major reproductive diseases of economic importance which account for loss of production, cost of treatment, and feed, fodder labour charges during unproductive period. Anoestrus may arise from various reasons including negative energy balance after parturition, underfeeding, environmental stress, uterine pathology and improper management practices. True anoestrus is characterized by quiescent ovaries without signs of cyclicity (Zulu *et al.,* 2002). Use of Ovsynch protocol, controlled internal drug release (CIDR) device and Norgestomet ear implant were suggested for estrus induction and estrus synchronization to improve conception rate in anestrus dairy bovines (Kutty and Ramchandran, 2003; Nak *et al.,* 2011; Chaudhari *et al.,* 2012). Estrus synchronization and fixed time artificial insemination (FTAI) become one of the popular reproductive management tools to enhance pregnancy rate in cyclic cattle. Estrus synchronization

technique allows manipulating the estrous cycle or inducing estrus within a short and predetermined time in a group of females (Odde, 1990). The advantage of estrus synchronization protocols is that estrus detection is not mandatory especially in large herds. FTAI can be performed at prescheduled time which improves the fertility of animals. Thus, these tools minimize the human error and reduce the cost on detection of heat in animals. Parturition of animals can also be scheduled at the favorable season and during availability of food for better survival.

Short term exposure to progestogens along with a luteolytic agent in (pre pubertal or post partum anoestrus cattle benefitted them to begin estrous cycle (Islam, 2011). Thus, some of the anestrous females are induced to show signs of estrus and ovulate using estrus synchronization treatment. CIDR insert along with prostaglandin F2α (PG2α) treatment increased the synchronization rate by approximately 30% and pregnancy rate by 20%, in both the anestrous and cyclic females (Lucy *et al.,* 2001). Cyclicity in postpartum anestrous cows can also be induced with combination of GnRH and PG2α (Pursley *et al.,*1995). The Ovsynch protocol can be applied at any stage of the estrous cycle in the cow. It include administration of first dose of GnRH, followed by PGF2α on day7, and a second dose of GnRH 2 days after PGF2α, and subsequent FTAI done 12 to 24 hour later. Other modifications of this protocol include an intra vaginal insert containing progesterone which is placed for 7 days between the first dose of GnRH and the administration of PGF2α in the Ovsynch protocol (El-Zarkouny et al., 2004; Ambrose et al., 2005; Stevenson et al., 2006). The effectiveness of such protocol is yet to be used in anoestrus cattle for estrus induction under the tropical Island ecosystem of ANI. Therefore, present study was conducted to induce estrus in anoestrus cross bred cattle and to study conception rate in them during induced estrus using combination of Ovsynch and CIDR insert.

Methodology

Present study was conducted at Cattle Farm, ICAR-Central Island Agricultural Research Institute, Port Blair during August to September of year 2019. For this study, a total of eight anoestrus cross bred cattle aged 3 to 9 years (Parity 0 to 5) and weighing more than 250 kg were included based on animal's history of not showing signs of estrus. Reproductive tract examination was conducted using ultrasonography to confirm lack of uterine pathology and non pregnancy status of animal. Anoestrus cattle were confirmed by presence of small and smooth ovary palpated at 10 days interval. A month long schedule was initiated first with deworming (Day0) of all the experimental animals cows with Albendazole Oral Suspension (ALbomar, Virbac India) @60 ml per animal total dose. From Day 3 onwards, mineral mixture (Agrimin Forte, Virbac India) @40 gm daily per animal was given with concentrate feed to animals and continued for one month. First injection of synthetic GnRH, (Receptal, Intervet India Pvt. Ltd., Thane) @0.021 mg Buserelin-Acetate, IM along with insertion of CIDR ((1.38 g of progesterone in the silastic coil, Pfizer Animal Health, Mumbai) device was placed intra vaginally on Day19 (7:00 AM). On Day26 (7:00 AM), CIDR devices were removed and all experimental cows were injected intramuscularly with synthetic Prostaglandin, Cloprotenol (Pregova, Virbac Animal Health India Pvt. Ltd, Mumbai) @250mcg IM, total dose per animal. Second injection of GnRH@@0.021 mg Buserelin-Acetate, IM was given on Day28 (3:00 AM). On Day29 forenoon, all cows were inseminated with frozen semen and repeated after 12 hours of first insemination. To note number of conceived animals, pregnancy diagnosis was performed 35 days post insemination using ultrasonography and reconfirmed by rectal examination at 60 days post insemination. Data analysis was done as per standard procedure.

Results and Discussion

This study presents the results of using controlled internal drug release (CIDR) in cows (Fig. 1). We found that CIDR insert was retained in all the experimental cows (100%) for 7 days. Again, signs of estrus were exhibited by all the experimental cows (100%) within 48-72 hrs of PGF2α treatment with no difference as in the normal cyclic cow. Findings of present study is supported by study of Dhami *et al.* (2015) where all the anestrus cows (n=10) under three groups treated with either CIDR insert, Ovsynch protocol or Norgestomet ear implant exhibited

induced estrus within 42-72 hrs of PGF2α treatment in all three protocols where estrus signs were similar to normal cyclic cows. In our study, a total of 5 out of 8 (62.5%) cows conceived following estrus induction treatment and timed artificial insemination with frozen semen. Pregnancy was confirmed at day 35 with ultrasonography post insemination and reconfirmed by rectal examination. Dhami *et al.* (2015), conducted study in crossbred anestrus cows using CIDR, Ovsynch and Norgestomet ear implant were conception rate of 60, 50 and 50%, respectively were obtained during induced estrus which supports findings of this study. In similar study, anoestrus cows treated with combination of Ovsynch and CIDR have shown 64% conception compared to 27% with Ovsynch alone (El-Zarkouny *et al.,* 2004). They reported however, that cycling cows receiving Ovsynch plus CIDR had a pregnancy rate similar to that of cycling cows receiving Ovsynch alone. Stevenson *et al.* (2003) reported that pregnancy outcomes showed larger increases when cows were treated with Ovsynch plus CIDR than with Ovsynch alone because more anestrus cows conceived. In another study, cows that did not show signs of estrus following treatment with two PGF injections at 14 days intervals started on 47 days postpartum stage were given Ovsynch treatment with or without progesterone insert (containing 1.9 g of progesterone) are compared for pregnancy rate. It was observed that group of cows given Ovsynch treatment with progesterone insert had a greater pregnancy rate (31.2% compared to control (22.7%) group (Melendez *et al.,* 2006). Following removal of implant or vaginal insert allow resumption of follicular development and their maturation due to the flux of the gonadotropin from the pituitary gland. Behavioral estrus is direct effect of the high endogenous estradiol on the hypothalamus (Cavalieri and Fitzpatrickm 1995). Use of hormonal protocols like Ovsynch, controlled internal drug release (CIDR) insert and Norgestomet ear implant can be helpful to induce and synchronize the estrus which can achieve better conception rate in anoestrus dairy cattle with lesser number of services per conception and making acyclic cow to cycle normally, thereby achieving ideal inter-calving interval of 12-13 months (Nak *et al.,* 2011; Chaudhari *et al.,* 2012).

Materials used for estrus induction | Intra vaginal insertion of CIDR device | Cow with induced estrus

Fig. 1 Use of controlled internal drug release

Conclusions

It may be concluded that estrus induction using Ovsynch and CIDR protocol together is effective in anestrus cows to bring them into estrus and fixed time insemination thereafter during induced estrus enhance conception rate of anestrus cows which can be implemented successfully to improve fertility in anestrus cows.

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References

Ambrose, J.D., Kastelic, J.P., Rajamahendran, R., Aali, M., & Dinn, N., (2005). Progesterone (CIDR)-based timed AI protocols using GnRH, porcine LH or estradiol cypionate for dairy heifers: Ovarian and endocrine responses and pregnancy rates. Theriogenology 64:1457–1474.

Cavalieri, J. & Fitzpatrick, L.A., (1995). Oestrus detection techniques and insemination strategies in Bos indicus heifers synchronized with norgestomet-estradiol. Australian Veterinar Journal 72(5): 177-182.

Chaudhari, C.F., Suthar, B.N., Sharma, V.K., Dabas, V.S., Chaudhari, N.F. & Panchasara, H.H., (2012). Estrus induction and fertility response in delayed pubertal Kankrej heifers treated with Norgestomet ear implant. Veterinary World 5: 453-458.

Dhami, A.J., Nakrani, B.B., Hadiya, K.K., Patel, J.A., Shah, R.G., (2015). Comparative efficacy of different estrus synchronization protocols on estrus induction response, fertility and plasma progesterone and biochemical profile in crossbred anestrus cows. Veterinary World 8(11): 1310-1316.

EL-Zarkouny, S.Z., Cartmill, J.A., Hensley, B.A. & Stevenson, J.S., (2004). Pregnancy in dairy cows after synchronized ovulation regimens with or without pre-synchronization and progesterone. Journal of Dairy Science 87: 1024-1037.

Islam, R., (2011). Synchronization of Estrus in Cattle: A Review. Veterinary World Vol.4(3):136-141.

Kundu, A., Sunder, J., Jeyakumar, S., Verma, S.K. & Srivastava, R.C., (2010). Livestock and poultry production policy for Andaman and Nicobar Islands: a scientific perspective. Published by CARI, Port Blair.

Kutty, C.I. & Ramachandran, K., (2003) Bovine infertility - A field oriented categorization based on investigation among crossbred cattle in a district of Kerala. Indian Journal of Animal Science 73(2): 35-37.

Lucy, M. C., Billings, H. J., Butler, W. R., Ehnis, L. R., Fields, M. J., Kesler, D. J., Kinder, J. E., Mattos, R. C., Short, R. E., Thatcher, W. W., Wettemann, R. P., Yelich, J. V. & Hafs, H. D., (2001). Efficacy of an intravaginal progesterone insert and an injection of PGF2α for synchronizing estrus and shortening the interval to pregnancy in postpartum beef cows, peripubertal beef heifers, and dairy heifers. Journal of Animal Science 79:982-995.

Melendez, P., Gonzalez, G., Aguilar, E., Loera, O., Risco, C. & Archbald, L. F., (2006). Comparison of Two Estrus-Synchronization Protocols and Timed Artificial Insemination in Dairy Cattle. Journal of Dairy Science 89:4567–4572.

Nak, Y., Tuna, B., Nak, D., Karakas, E. & Simsek, G., (2011) The effects of Ovsynch, Ovsynch with progestin and progestin plus double TAI on pregnancy rates in unobserved oestrus dairy cows and heifers. Kafkas Üniversitesi Veteriner Fakültesi Dergisi 17(6): 917-922.

Odde, K. G., (1990). A review of synchronization of estrus in postpartum cattle. Journal of Animal Science 68:817-830.

Pursley, J.R., Mee, M.O., & Wiltbank, M.C., (1995). Synchronization of ovulation in dairy cows using PGF2α and GnRH. Theriogenology 44:915-923.

Stevenson, J.S., Lamb, G.C., Johnson, S.K., MedinaBritos, M.A., Grieger, D.M., Harmoney, K.R., Cartmill, J.A., El-Zarkunoy, S.Z., Dahlen, C.R. & Marple, T.J., (2003). Supplemental norgestomet, progesterone, or melengestrol acetate increases pregnancy rates in suckled beef cows after timed inseminations. Journal of Animal Science 81: 571-586.

Stevenson, J. S., Pursley, J. R., Garverick, H. A., Fricke, P. M., Kesler, D. J., Ottobre, J. S., & Wiltbank, M. C., (2006). Treatment of cycling and noncycling lactating dairy cows with progesterone during Ovsynch. Journal of Dairy Science 89:2567–2578.

Sunder, J. (2014). Status of livestock and poultry diseases in A & N Islands: strategies to make island disease free. Advances in Animal and Veterinary Sciences 2 (4S): 42 – 47.

Zulu, V.C., Nakao, T., & Sawamukai, Y., (2002). Insulin-like growth factor-I as a possible hormonal mediator of nutritional regulation of reproduction in cattle. Journal of Veterinary Medical Science, 64: 657-665.

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Livestock Production Challenges in The Bay Islands and Their Mitigation

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Abstract

The Andaman and Nicobar islands with an area of 8249 sq.km are the largest archipelago system in the Bay of Bengal. According to the last census, these islands have 3.81 human population and total livestock population of 154750 including crossbred animals. The total milk production was 25 lakh liters in year 2012 and per capita availability of milk at these Islands was 185 ml/day and per capita meat/eggs availability was about one kg/ annum and 168 eggs. The total poultry population was 1165363 in the year 2003. At present the population of the islands is hovering near 9 lakhs and an extra 6 lakhs tourists visits the islands on yearly basis, which pushes these resource poor islands to huge shortage of animal products to support this population. At present per capita availability of milk is 113g, with an import of 16.2 lakh litres and total production of 16 lakh liters per annum. It is obvious the productivity of the birds and animals are very low, which is mainly due to severe scarcity of feed and fodders in the islands. There is 99% shortage of green fodder, 52% shortage of dry fodder and 97% concentrates/grain mixture shortage in the islands. Thus, meeting the demand for feeds and fodder and preserving potential germplasm are the big challenges. To bridge these challenges line departments along with ICAR-CIARI and extension agencies need to exert multi-dimensional combined efforts.

Key words: *animal rearing, health problems, improved practices, production*

Introduction

The Livestock provide not only food and income security but also provide social status, insurance and cultural values, employment especially of women which are still highly regarded by farming communities in most part of our country. In the islands, livestock rearing is done mostly by small and marginal farmers with holding size of 1-2 cattle/ buffalo and 2-3 dozens of backyard poultry birds per household in rural Andaman. There are few large herds of cattle in the in south Andaman for supply of milk to the consumers of Port Blair town. Poultry are reared by (women) farmers in small numbers to meet their own requirement of eggs and meat; surplus is sold in local markets. The total milk production was 16 lakh liters in year 2012 and per capita availability of milk at these Islands was 185 ml/day and per capita meat/ eggs availability was about one kg/ annum and 168 eggs. Due to immigration of different classes of workers and other investors from mail land India in different sectors (mainly tourism), at present the population of the islands is hovering near 9 lakhs and an extra 6 lakhs tourists visits the islands on yearly basis, which pushes these resource poor islands to huge shortage of animal products to support this population. At present per capita availability of milk is 113g, with an import of 16.2 lakh liters and local total production of 16 lakh liters per annum. The rural household women farmer prefers poultry to cater the need of meat, egg and instant cash money. It is obvious the productivity of the birds and animals are very low, which is mainly due to severe scarcity of feed and fodders in the islands and the climatic condition of the islands (farmers are unaware). According to the recent data available, there is 99% shortage of green fodder, 52% shortage of dry fodder and 97% concentrates/grain mixture shortage in the islands. Generally, India follows the western countries and US after decades for the rearing system to practice livestock rearing and the islands follows mainland India, then. The ecology and climatic condition of the islands are totally different from the mainland India, thus to give both agriculture and livestock rearing a sustainable approach we need to understand the ecological (and climate), socio-economic and cultural limitations to design a suitable system. To bridge these challenges line departments along with ICAR-CIARI and extension agencies need to exert multi-dimensional combined efforts.

Further, we should be proactive to support anticipated future development of the islands. After opening of international airport, there would be increase in the number of tourists visiting the islands. At present the pollution in the islands is negligible, even though we should be cautious enough not to disturb the carbon sink and the agriculture and animal rearing system we would opt in future should be of less emissive in nature or supported by proper mitigating strategy/plan.

Livestock sector plays a crucial role in rural economy and livelihood of the islanders. The overall growth rate in this sector is steady and is around 6%. Ownership of the livestock is evenly distributed with poor and marginal farmers, and organized livestock farming is very rare. It is well known fact that livestock farming along with agriculture imparts more balanced and sustainable development of the rural economy. Currently per capita availability of animal products is less than the ICMR norms. Improvement in this sector will provide nutritional security, income and employment. Nowadays, due to awareness creation by ICAR-CIARI and extension departments the un-employed youths are embracing livestock and poultry rearing as their vocation. But, their nightmare is the availability of feed, which incurs more than 70% rearing cost of any bird or animal production. Thus, here focus is how we can address the low productivity of the livestock sector and possible interventions required from the resourceful players in the sector.

Methodology

This study was conducted based on secondary information pertaining to Andaman and Nicobar Islands. The islands had total population of 3.8 lakh (Census, 2011) and more than 82%literacy rate. The Union Territory of Andaman and Nicobar Islands is divided into three districts namely South Andaman, North and Middle Andaman and Nicobar and further subdivided into four subdivisions with 11 Tehsils and 204 revenue villages (Census villages 547). But, the present population is hovering near 9 lakhs, with a huge influx of blue and pink (daily wage labourers) collar job seekers to the islands. According to the inhabitants of the islands, the real pace in development of the islands started after 1995 and it saw a new sunshine after the devastating Tsunami, when the islands were implicated with huge loss in every arena and came into limelight of media and people of mainland India and other philanthropic countries. The immigration was neither encouraged nor discouraged, but there were huge shortage of different types of workers in the islands. The secondary sources were also used to generate comprehensive database for the study. The data was collected from Governmental data books, Directorate of economics survey and data from Central Island Agricultural Research Institute and field data.

Results and discussion

Prevailing animal rearing practices and related problems

Andaman and Nicobar group of islands have total geographical area of 8, 249 sq.km with a coast line of 1,962 km. The 90 percent of land area of the Andaman is reserved or protected forest of which 36 percent is tribal reserve. The total area of Andaman covers 6340 sq.km and Nicobar group covers 1841 sq.km. The land distribution was not uniform in the islands. The early rehabilitation system allowed each settler with 4.4 ha of land consisting of 2 ha of paddy land, 2 ha of hilly land and 0.4 ha land for the homestead. But, latter got only 2.5-5 acre of land with agricultural inputs or land for commercial purpose with inputs. In the last four decades, there has been a spurt of immigration from mainland India, mainly from West Bengal, Tamil Nadu and Kerala. Similarly, after the Tsunami there was huge influx of workers of different class from mainland India to support the flourishing tourism and vast construction industry. Mono cropping of paddy, haphazard planting of coconut, areca-nut, and few fruit trees in the backyard were the usual practices in the agricultural sector. However, great loss due to tsunami had disturbed the agriculture and allied sectors of these islands in the year 2004, when several hectares (about 6000 ha.) of cultivable land turned salty due to Tsunami and become unsuitable for agriculture.

Amongst the field crops rice is the major crop, occupying about 7685.47 ha (2011-12), with productivity

of about 2.20 t/ha, cropping intensity as revealed by dismally low at 105 percent. However, the cropping area was 317.3 ha in the year 2013-14. Rice cultivation was practiced in Little Andaman, remaining south Andaman, Middle and North Andaman, but due to uprising of areca-nut and coconut plantation the area under rice cultivation and banana plantation has decreased drastically during the years. Now, rice is cultivated sporadically in north and middle Andaman only, where both coconut and areca-nut plantation cannot be practiced due to water logging condition or any other reason. Before Tsunami, banana was cultivated in Little Andaman and Havelock islands in a very vast area, but now those areas are engulfed by the nuts plantation. Similarly, vegetables in the Port Blair used to come from Little Andaman, Havelock, Neil and North and middle Andaman, but now the scenario is changed. Vegetables are grown at south Andaman and some comes from North Andaman, very little from Neil and Little Andaman. Little Andaman caters the Nicobar Islands need over the Nicobar's local production. Vegetables are really scare commodity in the islands, which fetch very high price at the local market due to very high demand. As said earlier, the resourceful farmers are indifferent to agriculture, so with vegetable growing. Several areas of South Andaman (Hamfrigunj, Manglutan, Wandoor, R.K. Pur, V.K. Pur, etc.) who used to supply the main chunk of vegetables to the Port Blair market is now supplied by the landless farmers of mainland India, who cultivates vegetable in the leased land of settlers. The farmers are also indifferent to agriculture due to lack of supply of pesticides and fertilizers (the islands are declared organic).

The livestock farming depends on the success of agriculture and its thrives in tandem with agriculture, here in this region it has suffered mostly due to low intensity of crop production and several other location specific problems viz. poor germplasm, unavailability of good quality forage, higher cost of commercial feed, unfavorable environment, animal health problems and transportation of goods and marketing difficulties. However, recently livestock and poultry farming in these islands has gained a significant improvement and emerged as one of the major source of self-employment and subsidiary income.

During rehabilitation the settlers were distributed with descriptive breeds of animals in the islands. Though the life was very tough then due to unavailability of proper transport and communication facility, the people were getting quite good amount of animal's product. Till date Andaman and Nicobar islands do not have any breeding policy and in due course of time indiscriminate breeding made the animals un-descriptive in nature. At present livestock populations in the islands consist of nondescript cattle, buffaloes, pigs, and goats. As per the 1997 census, total livestock population on the islands was 188311 including 5400 crossbred animals. The total milk production was 25 lakh litres in the year 2012, with per day average milk yield was about 1.5 liters for cows and 1.5- 2.0 liters for buffaloes.

The livestock supports the agriculture in the form of draft power. Majority of farmers are following the concept of integrated farming in these islands for optimum use of land. The total poultry population was 800950 in year 1997 and it further increased to 1165363 in the year 2003. Common practice of households in Islands is to have some poultry birds in the back yard. Animal Husbandry sector provides large self-employment opportunities to the farm women. Livestock Sector not only provides essential protein and nutritious human diet through milk, eggs, meat etc but also plays an important role in utilization of non-edible agricultural by-products. Livestock also provides raw material/by products such as hides and skins, blood, bone, fat etc. At present the population of the islands is hovering near 9 lakhs and an extra 6 lakhs tourists visits the islands on yearly basis, which pushes these resource poor islands to huge shortage of animal products to support this population. At present per capita availability of milk is 113g, with an import of 16.2 lakh litres and total local production of 16 lakh liters per annum. It is obvious the productivity of the birds and animals are very low, which is mainly due to severe scarcity of feed and fodders in the islands. Thus, meeting the demand for feeds and fodder and preserving potential germplasm are the big challenges.

Constraints and problems in livestock production system

These Islands are far away from mainland and the input supplies are mainly dependent on mainland, which is most often uncertain and costly affair. Several studies have been conducted by ICAR-CIARI, to register the major constraints in livestock rearing. The most important one expressed by the respondents have reflected that shortage of fodder especially during dry season followed by shortage of fodder during rainy season. After Tsunami most of the valley lands used for grazing inundated by sea and hence, farmers are facing severe deficiency of fodder. Similarly, during dry spell of summer farmer face acute deficiency of fodder.

Settler's indifferent attitude towards animal (cattle and buffalo) rearing

Yes, the islanders are indifferent to rear animals by their own. The animals are mainly reared by the poor and marginal farmers. If not fully organised, semi-organised farms are very rare in the islands, one is at Indira Nagar (Wandoor). The resourceful farmers have different thought for his vast land holding. They prefer hassle free cash crops like areca-nut and coconut, where no regular inputs are necessary and sometimes the well-doing resourceful farmer would giveaway this plantation in lease for 2-5 year duration. If the plantation is not on lease, he would allow the nut collector to milk the plantation on contract basis. These practices make the farmers live a hassle free life in the islands.

Whereas, a livestock farmer is bound to face the following problems while rearing their animals

a. Feed shortage
b. Poor breed of animals
c. High price of commercial feed
d. Lack of proper scientific rearing knowledge
e. Less availability of grazing land
f. Hear the music of neighbour, if the animal gets free of its tag
g. Shortage of fodder during rainy and non-rainy seasons (Mid October to May)
h. Lack of money
i. Poor health cover for the birds and animals
j. Poor marketing facility
k. Lack of Governmental support for marketing milk
l. Lack of labour

Above all these problems, the farmers are also distracted by the flourishing tourism and construction work all over the islands.

Problems in poultry farming in the islands

Backyard poultry rearing is just like a culture of the rural Bengali farmers in the islands. The farmers are apathetic towards awareness and rarely follow scientific knowledge of rearing. The farmers are unaware of importance of vaccination, medication, feed additives and supplements. They approach the local vet only when the chickens are in moribund condition or half of their flock is wiped off, and seldom follow any control measure for any disease. There is no systemic or organized production and marketing of the poultry. Rural farmers are reluctant to transport their birds to the weekly fair the "Sunday market" where they can fetch handsome cost for their birds. They are happy if they can sale the birds at their doorstep. Here the shopkeepers, who sale the dressed birds fetch the birds with great profit from the farmers and thus creating a monopoly in the market. Moreover, the farmers have no part in deciding the market price of their product. To add on this, to the dismay the islands do not have any cold storage facility neither for eggs nor for meat. The farmers prefer non-descriptive country birds, which are poor layers and so their growth rate. The nondescript birds found in these islands seems to be the crosses of the following breeds like Australorp, Sussex, Rhod Island Red, New Hampshire, Plymouth Rock, White Leghorn, Aseel, Naked Neck, Nicobari, Frizzle and many other non-descript desi birds.

Problems in pig rearing in the islands

The pigs are reared in both groups of islands, the Andaman and Nicobar. In Nicobar, the tribes there rear pigs in small village units and have amicable and very good bonding with their pigs. But, they fail in case of breeding the animals. They prefer the best one to sacrifice for the special occasion in calendar, which make them to lose the best to breed for the future sounder. The extensive system of rearing causes productive energy to lose, which could be used for faster growth of the animals. Moreover, there is no proper diet or ration followed by the Nicobarese. Feeding coconut (high fat nut) to the growing animals may cause inefficient digestion of fibre in diet, in turn decreasing the feed conversion efficiency of the pigs. In Andamans, pig rearing is taboo in Muslim community and in certain Hindus also have a notion that rearing pigs may affect their social status or pigs are reared by people of lower social stratum. Generally, animal rearing is seldom allowed in municipal areas openly or one cannot free range the animals in such areas. The farmers who rear pigs outskirt the city seldom use pukka floor, thus the pigs are untidy, dirty, rolling in muddy areas and production is unhygienic. Here too, the farmers seldom follow scientific feeding and management. This sector too is unorganised and in spite of huge demand of pork in the market, there is no systematic supply at the market.

Problems in goat rearing in the islands

The goats are reared in the islands only for meat purpose, as the goat milk is neither relished by the farmers nor sold at market. As chevon is devoid of any social taboo, are sacrificed by both Hindu and Muslims for their ceremonial worship. Andaman breed of goat (cross of Black Bengal) is the predominant breed in the islands. Farmers are not having good stock to breed and rear. Islanders do not rear goats intensively and lack of grazing land and rearing space, small land of the farmer makes goat rearing a challenge. Several times the goats sneak into the neighbour's garden or field, culminating into violent quarrel among the neighbours. Moreover, vegetables and horticulture trees are tonsured by the goats, which discourage the farmers to opt goatery. Due to huge shortage of feed and fodders in the islands, the farmers dare not rear goats. Times come when unstoppable rain showers for weeks in the islands making the goats to be confined into their pen and in such condition the farmer is helpless in the absence of storage feed. The farmers who rear goats are indifferent to the growth rate of the goats, as the sale happens on the basis of piece (head basis) rather on the body weight of the animal. Now, the efforts are exerted by Animal Science Division of ICAR-CIARI for creating awareness on the scientific rearing, feed formulation, breeding strategy, feed conversion ratio, etc.

Strategies to mitigate the challenges of livestock and poultry production in Andaman

The technological model cannot be copied as such from the productive mainland or else areas (western countries or US) to these islands due to variation in socio-economic and climatic conditions. Therefore, to improve the productivity, suitable policy, environment and supporting infrastructure have to be provided. In view of the ecological and socio economic constraints to livestock production system, proper strategies need to be devised.

1. Planning and initial course of work

As the saying "good planning is the halfway to success" a plan is imperative and the following interventions need to be done urgently. We need to estimate the potential of not only fallow land but also road side land, waste land and potential hilly terrains which can be used for fodder production. Generally, every Panchayat has certain land area which is not used, so we should tap the chances of possibility of leasing those lands. Most importantly, we should urge the administration to get released grazing land from the encroachers, where grassland development can be done including an aim of establishing a "Grass Reserves". Thus, we can develop a Block/village Grazing cum-Fodder and Pasture Management system. Along with this we need to impart Awareness and training on improved management to the livestock farmers.

2. Improved breed and health management programme

The selection of breed adaptable to the existing agro climatic conditions that can thrive on unconventional feed

and fodder resources should be given priority in livestock management programme. There is need to encourage the farmers to breed local non-descript animal with improved breeds through Artificial Insemination (AI) and adopt pregnancy diagnosis (PD) as a tool to avoid the losses. Moreover, A & N administration is on the way to procure good germplasm of dairy animals from the mainland India by Embryo transfer technology, which will surely improve the productive potential of island animals.

3. Improved feeding practices

Balanced feeding of animals is very important to address global warming, eutrophication from animal excreta, improved or better growth and production of animals and high revenue generation. The efforts from the extension agencies should be made to make aware the farmers, of importance and functions of concentrate feeding, viatmins and supplements, and minerals in animal diets. The dissemination of simple and cost effective technologies like chaffing of fodder, urea or ammonization of straw and supplementation of mineral salt could enhance the productive and reproductive efficiency of the livestock and poultry.

4. Curbing the stray cattle menace in the islands

As per my memory, stray cattle in islands are there long back in 1980s and so their menace. We need to ponder as these animals are threat to the agriculture farms, causing blockade of the only arterial road (ATR road) and sometime causing accidents and attacks. The Goushalas can manage these animals are use for productive purpose. Two such Goshala volunteers are there, one at Mithakhari (South Andaman) and second at Diglipur (North Andaman), would certainly do the needful if get some support in terms of technologies and construction plan.

5. Production and enhancement of fodder availability in the islands

The scheme incorporates the following components/ technology interventions:

a) Status of fodder production

Feed alone accounts for 70% or more of the rearing cost of the animals or birds. It was learned that green fodder was about 99% deficit followed by concentrates (97%) and dry fodder was deficit by 52 percent in the islands. The non availability of feeds and fodder is the major challenge to sustain the livestock. Due to heavy rains for about 8-9 months, green fodder cultivation is difficult and further processing of these fodders to dry (hay) and silage making. Similarly, cereals, which can be used as feed ingredients also not cultivated due to different attitude and invasion of cash crops.

b) Fodder for the animals

It is very true that we can rear medium yielding dairy animals (cattle and buffalo) and goats (mainly meat purpose) only with fodder of high to medium quality. The cattle and buffalo which produce milk up to 5-6 liters can very well be supported by only fodder diet. The islanders rear goats mainly for meat purpose and seldom use milk for consumption, which again can be well supported by only fodder diet (also tree fodder). Similarly, pigs can also thrive well with fodder as main chunk of the feed along with supplemental mixture of root/tubers (or grain mixture). Backyard poultry graze on grasses and devour insects present around the houses. A high quality legume fodder (Azolla/Cowpea) can be a good primary feed for the backyard poultry with supplemental kitchen waste (left over human food, vegetable or fruit waste, etc).

c) Inter-cropping fodders and use of fallow land

As the government allotted grazing lands to the islanders are encroached by the landless immigrants and the settlers too, the only option remain with the islanders is grazing at road side and fallow land, cultivation of fodder in waste land and hilly terrains. The shortage of fodder can be tackled by utilization of traditional/ local feeds/ fodder crops with proper intercropping system between the coconut and areca-nut plantation. The annual and perennial fodder crop/ trees can be incorporated in the crop calendar. Fodders like Napier Bajra hybrid and Guinea grass are good option and have been successfully intercropped with coconut/areca nut plantation in south India. Maize and Sudan grass are very good intercrop option for both coconut/areca nut plantations in India. But, fodder like maize grows strong taproot deep into

the soil and will improve the soil condition physically by breaking plow sole and require lot of nitrogen in the soil, thus crop rotation is always advisable. The suitable storage mechanism for the fodder and feeds may be adopted with proper technology backup.

d) Use of unconventional fodder resources (multipurpose crop plants and trees)

In most cases multipurpose trees and plants have a primary role such as being part of a living fence, a windbreak, or used in an ally cropping system by the farmer. In addition to this they will have one or more secondary roles, most often serving to supply a family with food, firewood, and forage (most common is *GlIyricidia*). Unconventional fodder resources, like tree fodders and utilization of forest resources as source of fodder with participatory management has high scope. As the islands are declared "Organic" the tree species like Acacia, Prosopis, Leucaena, Gliricidia, Guazuma, Inga, Albizia, Cassia, *Pithecellobium* and *Alnus spp*., can be used for increasing the soil fertility and increasing the tree fodder production for the animals in fallow land. Unconventional feeds generally have anti-nutritional factors thus can be fed to the ruminants with little processing and precaution, while these feeds are not advisable for the monogastrics such as pigs and poultry. The tree fodders can be grown in fallow/waste land, as barrier/wind shields for the houses or farms, fence (*Glyricidia* is extensively used in the islands) and both side of the bunds.

e) Encourage farmers to take up fodder production as business

Watching the severe scarcity of feed to support the livestock, farmers can be encouraged to take up fodder production as business. This can be well accepted by the large farmers, having large land holding. They can also preserve and sale the fodders in off seasons to earn good profit out of this.

f) Use of alternate feed resources

Exploring alternate feeds and supplements such as fish meal and coconut meal, which are abundant in the islands can be a good step towards making the islands self sustainable in term of feed resources of the islands. The islands are blessed with abundant mangrove plants, thus there is need to tap the possibility if these plants can be used as fodders for the island's livestock. The islands are also bestowed with huge quantity of sea weeds at the shore area, if not directly fed to the animals silage is a possible intervention. Silage is known to reduce the anti-nutritional factors in the final product, which are possible unwanted factors in the sea weeds.

g) Hydroponics as Green Fodder

Growing fodder plants without use of soil just in mineral nutrient solutions in water. Like greenhouses, hydroponic can have total control over the climate - temperature, humidity, light intensification, the composition of the air. Thus, season is not at all a concern and fodder can be grown all year round. Maize, pulses, wheat, and horse gram seeds are preferred hydroponic fodder but do not use pearl millet and sorghum seeds because these sprouted leaves contain poison that can harm your livestock. Hydroponics is also good in the sense, it has better growth rate in plants, less labour intensive, gives a better efficiency of nutrient use, uses 10% water compared to field grown fodders and it require less space.

h) Complete feed blocks

Complete feed block (CFB) can help the farmers to practice feeding balanced ration to his animals in turn increase the production. CFB is made from forage, concentrate and other supplementary nutrients in desired proportion capable to fulfill nutrient requirements of animals (ruminants). CBF is not only an economic viable technique but also has multiple advantages like easy transportation, easy storage, correcting nutritional deficiencies, easy handling and reduces feeding cost. CFB can be prepared out of forest tree leaves (which are non toxic in nature), with incorporation of urea and molasses (jaggery solution, as molasses not available here) to increase protein and energy, respectively. Establishment of Fodder Block Making Units will help the animals to meet out their feed need during the lean period of the year. Moreover, this unit may serve as the supply during

the disaster strike to the islands (Tsunami, earth quake, draught of any type, etc).

i) Fodder Seed Production and Distribution

ICAR-CIARI is having the fodders like Hybrid napier, CO-3, CO-4, Guinea grass and DHN-6, which are grown in the fodder fields of the campus and time to time the cutting of the fodder stalks are distributed to the needy farmers as inputs to propagate fodder to the farmer's fields to satiate their livestock. A plan is also in pipe line to establish a fodder garden at the ICAR-CIARI campus to supply the fodder stalks to farmers as regular inputs with collaboration with ICAR-IGFRI, Jhansi, MP.

j) Dissemination of package of practices

A wholesome package of practices for profitable livestock farming in the inlands has to be prepared and provided to the farmers. ICAR-CIARI is working on this issue and will come with a suitable PoP very soon. Along with this the following practices are also recommended

i. Introduction of Chaff cutters

A chaff cutter mechanically cuts straw, hay or large grasses (fodders) into small pieces before being fed to cattle, buffalo or goats. It increases the surface area of the fodder for better action of ruminal microbes and gut enzymes for better digestion. Cutting the fodder into small pieces also reduces the rejection as well as minimises the wastage by the animals. There is hand operated and Hand Cum Power Operated Chaff-Cutter in the market. Thus, a farmer having small to large number of animals can choose his cutter based on his need and efficiency he is intended.

ii. Area Specific Mineral Mixture (ASMM)

Minerals are required by the animals for their maintenance of metabolic functions, growth, milk production, reproduction, immunity and health status. Animals cannot synthesize minerals inside their body and generally feed and water do not provide all the minerals in the required quantity to the animals. Therefore, animal should be supplemented with adequate amount of good quality mineral mixture in their feed.

The supplemental mineral requirement by the animals depends on the mineral content in feed and fodder they eat, which in turn rely on the area where they are grown and varies from region to region. So, it is necessary to prepare region/area specific mineral mixture. Balanced mineral feeding to the animals is known to have several benefits like boosting immunity and better resistance against diseases, provides better feed conversion ratio, improves growth rate in young animals and early puberty, reduced inter calving period, increased milk SNF and production and increased reproductive efficiency and life in both sexes of the animals.

iii. Feed Pelleting

Basically, the purpose of pelleting is to make larger particles from finely ground dusty, sometimes unpalatable and difficult-to-handle feed materials by using heat, moisture and pressure. Pelleting make the feedstuffs more digestible by breaking down the starches by heat and moisture and increases palatability. Pellet feeding causes less wastage of feed and increases feed conversion ratio.

k) Establishment of silage making units

Silage making can be a very good step to address the fodder scarcity during the lean period (Jan-April) in the islands. Silage can be prepared from grasses (natural pasture and hybrids), tree leaves and vegetable market wastes. The fodders having high soluble carbohydrates like maize, ordinary grasses, sorghum, oats, pearl millet, and hybrid napier make very good silage. Silage can also prepared from legumes after mixing with cereal fodders as mixed silage. Certain island abundant plants/shrubs like sea weeds and touch me not (*Mimosa Pudica*) can also be used to utilize this technology.

l) **Arecanut:** The fallen areca sheath is available throughout the year in the islands. Areca sheath, as an alternate resource, has been evaluated for use as a fodder by several governmental and private agencies. To prepare 2 kg cattle feed take 1.5 kg shredded areca sheath (2cm X 1-2 cm) soaked in warm water for 1-2 h or cooked for 30 min and

mixed with 500g grain (wheat, rice or any cereal) can be fed after cooling.

m) **Azolla cultivation and production units**

Azolla (*Azolla* sp.) is an aquatic (duckweed) fern consisting of a short, branched, floating stem, bearing roots which hang down in the water. An area of 4-4.5 m² and 10-15 cm deep can produce about 2 kg/d of fresh azolla, enough to supplement 2 dairy cows. Azolla has crude protein (CP) of approx. 21% on dry matter basis and dry matter of 6-7%. Azolla can be supplementary feed not a primary feed for the animals, as 1 kg fresh Azolla will have CP of 12.6-14.7g. It needs humidity more than 60% and shady area.

n) **Establishment of Silvi-Pasture System**

Silvopasture is the practice of integrating trees, forage, and the grazing of domesticated animals in a mutually beneficial way in same land with principles of managed grazing. Properly-managed silvi-pasture can increase overall productivity and long-term income due to the simultaneous production of tree crops, forage, and livestock, and can provide environmental benefits such as carbon sequestration. Silvi-pasture is one of the oldest known forms of agriculture, and has been practiced in many parts of the world for centuries. Livestock production component in silvi-pasture system creates a stable source of cash flow prior to timber harvest and diversifies the forestry enterprise. Nitrogen-fixing forage species, pasture fertilization and animal manure all component help improve the soil and tree nutrition. Grazing controls competing brushy species and competition between trees is less at the wider spacing employed with silvi-pasture, resulting in greater timber yield. Trees create a sheltered microclimate to protect animals from heat and cold. Shelter also improves forage quality and lengthens its growing season. The prunings/cuttings of some trees can also be used as fodder to support better livestock growth.

o) **Selective rearing of livestock**

The topography of the bay islands can be better described as long range of hills in the sea stretched from north to south. These islands are commonly hilly and rippling and the flat islands are relatively less in number, making them suitable for plantation crops and livestock rearing. The shortage of grazing land and fodders indirectly compels to rear small animals like goats, pigs, rabbits, chickens (broilers and layers) and Japanese quail, which are very good venture for these islands.

Goat, poor man's cow supports economy and nutrition of poor and marginal rural farmers and act as source of additional income and insurance against disaster. Goats are hardy animals and can thrive on shrubs and trees in adverse harsh environment in low fertile lands where no other crops can be grown. The additional advantages of goat farming are like, require low initial investment and less management, best suited animals for feed scarce areas, highly prolific (triplets and quadruplets kidding), fast sexual maturity (12 m) and more importantly has no religious taboo.

Pig meat (pork) and poultry meat have huge demand in the islands. To meet out the pork demand semi-intensive and intensive piggery is a good option. The pig has highest feed conversion efficiency and thus best converter of grains, forages, damaged feeds and garbage into nutritious meat. Piggery is very beneficial as pig can utilize wide variety of feed stuffs, prolific with shorter generation interval (12, average litter size and sow can be bred at 8-9m age), requires less initial investment (building and equipments'), high dressing percentage (65-80%), manure can be utilized as bio-fertilizer and pigs are

always instant money (piglets or pigs can be sold any time).

Backyard poultry is like culture in the rural Andaman households but, commercial poultry need a boost to meet-out the market demand. More suppliers of broilers chicks are needed and more awareness about the poultry farming necessitate for the islands. Quails are very hardy birds (after 2 weeks of age) and several diseases resistant. Quail require less space ($1/6^{th}$ of chicken) and less expensive to start with. Quails can be sold after 30 days and starts laying at 7 week for 280 eggs in a year. Moreover, quail meat is more acceptable (opines to have nutraceutical properties) in the islands and are more tasty than chicken.

Rabbit farming can be very good venture for the interested farmers. Rabbits are very fast growing animal. Consume forages of diverse origins and food converting rate is very good. One female rabbit can produce 2 to 8 bunny (young one) per birth. Production costs are less, and require very less space. Main problem in Rabbit farming in the islands is marketing and islanders are not familiar with the meat, thus advertisement and awareness creation is obligation.

p) **Integrated Farming System (IFS)**

IFS practice meant for all-round development of agriculture with animal husbandry and other components related to core agricultural practices. The islanders posses land holdings, a suitable IFS model can enhance sustainability and decrease the input cost and increase the profit of the farmer. In the IFS, the products or the by-products of one component act as input for other, thus require very less outside input for the system. Rice-goat-vegetable-chicken/duck-fish IFS model can do wonder in the island. In rice cultivating areas, straw can act as the feed for the cattle or buffaloes. Goat droppings can be used as bio-fertilizer or vermi-compost can be prepared. The poultry dropping can be used as livestock feed (dropping and feather meal), fish feed or vermin-compost. Fish can be sold in market or fish meal can be of good protein source for the goats. The vegetables can be used by household, surplus sold at market and the waste can be fed to poultry/fishes. The land can be fertilized by the compost or vermi-compost prepared out of droppings of poultry and goats.

Conclusion

The islanders have many problems in animal rearing, which can be curbed by a combined effort of ICAR-CIARI, KVKs and the line departments (Agriculture and Animal Husbandry Depts.) of the island administration. The islanders are indifferent and unaware of many aspects of scientific animal rearing, thus there is need to impart awareness campaign, training, practical field demonstration on technical knowledge and knowhow of the animal production and modern rearing system. Our islands need a breeding policy, fodder policy, island special package of practices for all the animals and birds, fodder banks, implementation of neo-fodder production and preservation technologies (viz.Azolla, Hydroponics) and old practices (but, new to the islands, viz., urea/ ammoniation of the straw, CFB, etc.) to be implemented, where Scientist/experts of Animal Nutrition, Breeder and Production & management can play a pivotal role. It is required to apply new feeding practices, mineral and balanced ration feeding, precise nutrition (the best animal feeding strategy), special feeding (young, pregnant and lactating animals) pellet feeding and integrated farming system (best farming system for islands) and silvi-pasture system.

There is dire need of fodders for animals and birds; moreover the islands are declared organic which emphasizes more requirements of fodders. Thus, fodder production can be increased in the islands by introducing island friendly high yielding varieties, increase use of fallow land, intercropping, using unconventional fodders (areca-sheath, tree leaves, abundant edible weeds and

leafy veggies), silvi-pasture system and encouraging large land-holder farmer to opt fodder production as business. Moreover, the governmental agencies like ICAR-CIARI, KVKs and the line departments (Agriculture and Animal Husbandry Depts. and Disaster Management Agency) of the island administration can take up preparation of Fodder reserves and Complete Feed Blocks for instant or future use. Finally some efforts are also invited from the farmers in terms of better rearing practices, such as feeding chaffed fodder, feeding balanced ration, feeding mineral mixture, de-worming and if possible feeding the bird or the animal according to the need (precise nutrition). Thus, livestock production can only be sustained and can be a profitable venture if these challenges are curbed.

References

Agriculture Contingency Plan for District: South Andaman (2014-15). Andaman & Nicobar Islands Administration.

Ganesh Kumar B. (2006). Livestock Farming as an Alternative Economically Viable Enterprise for Farmers of Andaman. Livestock-based Livelihoods. An action programme for the Andaman and Nicobar Islands. Pp-47-48.

Government of India (2005). Annual Report 2004–05. Department of Animal Husbandry, Dairying and Fisheries.

India Livestock Production: Milk: Andaman and Nicobar Islands (1998-2018). Department of Animal Husbandry, Dairying and Fisheries. file:///E:/Paper%20NRM/India%20% 20%20Livestock%20 Production%20%20Milk%20%20Andaman%20 and%20 Nicobar % 20Islands%20%20%20 Economic%20Indicators.htm.

Livestock Census (2012) All India Report. Ministry of Agriculture Department of Animal Husbandry, Dairying and Fisheries. Krishi Bhawan, New Delhi.

Statista (2020). Volume of meat, milk and fish production across Andaman & Nicobar islands in India in FY 2017 (in 1,000 metric tons). file:///E:/Paper% 20NRM /%E2%80%A2%20India%20-%20livestock%20 products% 20volume%20in% 20Andaman%20 &%20Nicobar%20islands%20by%20type%20 2017%20%20%20Statista.htm

Subhash Chand, Naresh Kumar & S. Dam Roy (2013). Livestock production challenges and strategies for tropical agro-ecosystem, Andaman and Nicobar Islands, India. Basic Research Journal of Agricultural Science and Review. 2: 195-201.

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Study on High Dense Feed in Commercial Layers to Alleviate Physiological Stress During Transitional Phase

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Abstract

A study was carried out to review Bureau of Indian Standards recommendations (BIS) for layer pullet feed and study its efficacy of pre-lay feeds on haematology and serum protein. Commercial layer chicks were fed from 0 to 14 weeks of age as per BIS. At 15 weeks, pullets were randomly assigned to each of five pre-lay diets namely, T1 (BIS control), T2–16/2700, T3–18/2700 (%CP / kcal ME/kg); T4–Same as T2+lysine and methionine by 10% higher than BIS and T5 – same as T4 with 2 per cent oil. Significantly higher values of Packed Cell Volume, Haemoglobin, Red Blood Cell count and Heterophil/Lymphocyte ratio obtained in the present study from pullets fed with high dense pre-lay diet indicated that pullets were healthy with a normal metabolic rate. Significantly higher H/L ratio of the control group indicated that birds seemed to be under stress due to nutritional deficiency during the critical pre-lay periods, also haemoglobin level was lower in this group although it was within normal metabolic range. Total serum protein was high in pullets fed with higher pre-lay protein level of 18 per cent. Hence, it is concluded that pullets nearing lay are under metabolic stress and pre-lay diet containing 2700 kcal/kg of dietary energy and 18 per cent CP is advisable for pullets before sexual maturity as against the BIS recommendation of 2500/16 dietary energy and protein level to lower the stress and to make pullets entering into layer house with sufficient nutrient reserves.

Key Words: Transitional phase, physiological stress, high dense feed, commercial pullets, haematology, serum biochemistry

Introduction

There has been considerable interest in recent years in the use of pre-lay diets, which are often used as a way of introducing a transition phase in terms of calcium metabolism and to manipulate body size (Leeson & Summers, 1997). Pre-layer diet has been based on the assumption that the bird's nutrient requirements changes during this critical period of its life when the pullet increases body weight (200-300 g) quite dramatically, which is at about 2-3 weeks before sexual maturity. There are major changes that occur in the bird's metabolism, which relate to ovary and oviduct development, thus making this time the basis for a specialised diet. Haematology and biochemistry assay of livestock suggests the physiological disposition of the animals to their nutrition. Haematological constituents reflect the physiological responsiveness of the animal to its internal and external environments which include feeds and feeding. Hence, concept of pre-lay feed was introduced in the existing traditional feeding system of Bureau of Indian Standard for layers and an experiment was designed and conducted to study the effect of pre-lay feed in the BIS recommendations for layer during transition period (15 weeks to sexual maturity) on haematology and serum protein was studied.

Materials and Methods

An experiment was conducted at the University Research Farm, Madhavaram Chennai-51. 165 day old commercial layer chicks (Bovans') belonging to a single hatch were purchased and they were placed in deep litter in a brooder cum grower house up to 13 weeks of age. On the 14th week, 150 pullets were shifted to cages and randomly divided into five groups of 30 birds per treatment, each with five replicates of six birds per replicate. All 165 birds were provided with a starter diet containing metabolizable energy level of 2600 kcal/kg and protein of 20 per cent from 0 to 8 weeks of age and a grower diet having metabolizable energy level of 2500 kcal/kg and protein of 16 per cent from 9 to 14 weeks of

age as per BIS recommendations. At the age of 15th week, pre-lay pullets were randomly allotted to five dietary treatments, viz., T1 (BIS control): Diet formulated with crude protein of 16 per cent and metabolizable energy of 2500 kcal/kg; T2 (High energy diet): Dietary treatment with crude protein of 16 per cent and metabolizable energy of 2700 kcal/kg; T3 (High energy + high protein diet): Dietary treatment with crude protein of 18 per cent and metabolizable energy of 2700 kcal/kg; T4 (High energy with 10% extra methionine and lysine): Dietary treatment with crude protein of 16 per cent supplemented with synthetic lysine and DL-methionine by 10 per cent higher than BIS recommendations and metabolizable energy of 2700 kcal/kg; T5 (High energy , 10% extra methionine and lysine with 2% oil): Dietary treatment with crude protein of 16 per cent supplemented with synthetic lysine and DL-methionine by 10 per cent higher than BIS recommendations and metabolizable energy of 2700 kcal/kg with two per cent addition of rice bran oil to meet this energy level. Experimental feed ingredient and nutrient composition is presented in Table 1.

Table 1. ingredient and chemical composition (%) of experimental rations

Ingredient composition	Pre-layer Feed (15 weeks - 5% Egg production)				
	T1 (BIS control)	T2	T3	T4	T5
Yellow Maize	24.00	38.97	38.50	37.00	28.00
Broken rice	13.00	10.00	10.75	10.00	12.00
Cumbu/Bajra	22.00	17.00	12.75	20.00	20.25
Deoiled rice bran	12.50	10.00	10.75	8.87	13.00
Wheat bran	8.00	2.00	1.00	2.00	3.50
Sunflower oil cake	4.80	4.00	1.00	4.00	2.50
Soybean oil cake	9.50	11.00	18.25	11.00	11.50
Dry fish	4.00	5.00	5.00	5.00	5.00
Rice bran oil	-	-	-	-	2.00
Mineral mixture*	1.55	1.55	1.55	1.55	1.55
Dicalcium phosphate	0.52	0.48	0.45	0.45	0.44
Lysine	-	-	-	0.05	0.02
DL-Methionine	0.05	0.05	-	0.08	0.09
Salt	0.08	-	-	-	-
Total	100	100	100	100	100
Chemical composition					
CP	15.94	16.06	18.33	15.93	16.23
ME (kcal / kg)*	2543	2715	2705	2716	2729
Calcium	1.23	1.05	1.33	1.11	1.08
Total phophorus (%)*	0.60	0.59	0.57	0.60	0.59
Lysine*	0.71	0.73	0.87	0.77	0.77

Methionine*	0.35	0.35	0.37	0.39	0.39
Crude fibre	7.41	6.15	5.93	5.99	6.55
Salt*	0.48	0.48	0.47	0.48	0.48

Composition of feed supplements: 100 g Ultra Vite-M contains Vit A-3,20,000 IU,Vit B2-0.1g, Vit D3- 69,000 IU, Vit B12- 0.6mg, Vit E -30 IU, Vit K-0.04g, Niacinamide-0.4g, Calcium pantothenate-0.1 g,Choline chloride-12 g, Calcium-30.4 g, Copper-0.08g, Iodine-0.08g Iron-0.8g, Manganese-2.2 g, Zinc-2.08 g and Cobalt-4 mg; **100 g Ultra Sil-TCF** contains Sodium Alumino Silicate-95.25 %, predigested protein -20 ppm, Cobalt and Organic acid-2 ppm; **100 g Ultra Phos –D3** contains Calcium-21.6 g, Phosphorus-15.6 g, Vit D3- 12,000 IU, Vit B12-80 Mcg, Manganese-1080 mg and Zinc-1040 mg; **100 g Ultra- B12-FS** contains Vit B12-10 mg, Elemental Cobalt -10 mg, Elemental Calcium -22.5 % and Protein Hydrolysate- 5 ppm

***Mineral mixture(TANUVAS) Composition** : Calcium- 23%, Phosphours-12%, Magnesium-6.5 %,Iron -0.5 %, Iodine -0.026 % ,Copper- 0.077 %, Manganese- 0.12 % , Cobalt -0.012 % ,Zinc -0.38 % , Sulphur-0.5%,Fluorine-0.07 (max) and Selenium- 0.3 ppm:

*Calculated values

Blood samples were collected randomly from eight birds from each group at five percent egg production. About 0.5 ml of blood was later used to estimate haemoglobin (Hb) concentration as per the method of Sahli's Acid hematin (Sahli, 1909), packed cell volume (PCV) using Wintrobe's microhaematocrit method (Mcinroy,1953), total erythrocytes count (TLC) and total leucocytes count (TLC) by using Nambiar's diluting fluid(Bancroft and Marilyn Gamble, 2008), differential count (DC) by using modified Leishman-Giemsa stain as per the method described by Bancroft and Marilyn Gamble (2008). Serum samples collected from experimental birds were subjected to estimation of total protein in A 15 Biosystem auto analyser by using commercial available AGAPPE kit based on Direct Biuret method (Gornall, *et al*., 1949). The experimental data was analysed statistically (Snedecor and Cochran, 1994) by using the SPSS 10.0 program package (SPSS, 2001). The significance of the difference among the treatment groups was determined by Duncan's multiple range tests (Petrie and Watson, 1991).

Results and Discussion

Influence of pre-lay dietary treatments on total serum protein and haematological parameters such as, haemoglobin, packed cell volume, red blood cell count, white blood cell count and differential count in pullets is presented in Table 2. The haematological parameters of pullets fed with high energy pre-lay diets varied significantly. The highest Hb, PCV RBC and per cent lymphocytes values of 11.83±0.21, 38.3±0.71, 3.33±0.27 and 70.33±0.33 respectively were recorded in 2700 kcal energy with 18 per cent protein pre-lay treatment group. The control (BIS) feed of 2500 kcal energy with 16 per cent protein recorded significantly ($P<0.05$) lowest respective values. However, the Hb, PCV and RBC values of BIS control group were comparable with 2700/16 and 2700/16+lysine and methionine groups. White blood cells count did not differ significantly between pre-lay dietary treatments; whereas H/L ratio was significantly ($P<0.05$) highest for control (BIS) group and it was significantly ($P<0.05$) lowest in 2700/18 group but was comparable with groups fed with two per cent oil and 2700/16 group. All other pre-lay treatment group had significantly ($P<0.05$) lower H/L ratio when compared to the control (BIS) group. Blood represents an important index of nutritional status of the organism (Awotwi, 1990 and Oladapo *et al.,* 2007). Any nutritional inadequacy causes metabolic stress to an animal which is reflected in blood composition. Pullets fed with a high dense pre-lay diet of 2700 kcal energy and 18 per cent had significantly ($P<0.05$) higher haemoglobin, packed cell volume, Red blood cell count and lower heterophil / lymphocyte ratio. Higher protein and energy might have influenced improved haematological parameters. On the other hand, pullets fed with BIS feed during pre-lay period had the lowest respective values and higher heterophil / lymphocyte ratio. However, all the values of haemoglobin, PCV and RBC counts obtained in the present study were within the normal range of established values (Mitruka and Ransley, 1977; Nworgu *et al.,* 2007, Ridddell, 2011) for healthy chicken. White blood cell count did not significantly

vary among treatments. A high nutrient dense diet had not influenced the bird's ability to fight disease invasion and phagocytosis. These results agreed with findings of Oke *et al.* (2003), Oladapo *et al.* (2007) and Afolabi *et al.* (2011). The H/L ratio was comparable among 2700 kcal energy groups with 18 and 16 per cent protein and oil in feed. H/L ratio of blood is an indicator of stress in birds. Pullets nearing lay are under metabolic stress and a good nutrition tends to lower the stress, but pullets on a lower nutritional plane were under stress and this caused an elevated H/L ratio.

Table 2. Effect of various pre-lay energy and protein diets on total serum protein (g/dl), Haemoglobin (Hb) (g/dl), Packed cell volume (PCV) (per cent), Total erythrocyte count (TEC) ($\times 10^6/mm^3$), total leucocyte count (TLC) ($\times 10^3/mm^3$) and Differential count (DC) (per cent) of pullets at 5 per cent egg production

Pre-lay treatments	T1*	T2*	T3*	T4*	T5*
Parameters	----------Standard layer feed----------				
Total serum protein*	$5.02^{b} \pm 0.44$	$5.99^{b} \pm 0.62$	$7.15^{a} \pm 0.30$	$5.66^{b} \pm 0.41$	$5.16^{b} \pm 0.10$
Hb*	$9.17^{c} \pm 0.42$	$10.42^{bc} \pm 0.37$	$11.83^{a} \pm 0.21$	$10.17^{bc} \pm 0.47$	$11.17^{ab} \pm 0.47$
PCV*	$28.3^{c} \pm 1.17$	$31.7^{bc} \pm 0.66$	$38.3^{a} \pm 0.71$	$31.5^{bc} \pm 1.47$	$34.8^{b} \pm 1.95$
RBC*	$2.03^{c} \pm 0.10$	$2.70^{bc} \pm 0.11$	$3.33^{a} \pm 0.27$	$2.50^{bc} \pm 0.26$	$2.98^{ab} \pm 0.25$
WBC^{NS}	25.75±0.57	23.66 ± 0.98	19.16± 0.66	23.91 ± 0.72	22.83 ± 0.38
Heterophil *	$38.83^{c} \pm 0.60$	$29.83^{b} \pm 0.47$	$28.00^{a} \pm 0.36$	$29.66^{b} \pm 0.66$	$28.33^{a} \pm 0.33$
Lymphocyte*	$58.00^{c} \pm 1.26$	$68.33^{b} \pm 0.61$	$70.33^{a} \pm 0.33$	$67.83^{b} \pm 0.60$	$70.16^{a} \pm 0.40$
Eosinophil^{NS}	1.83 ± 0.60	1.50 ± 0.42	0.83 ± 0.30	1.16 ± 0.40	0.83 ± 0.30
Monocytes^{NS}	1.33 ± 0.33	1.00 ± 0.25	1.00 ± 0.25	1.00 ± 0.44	0.50 ± 0.22
H/L Ratio*	$0.67^{c} \pm 0.20$	$0.43^{ab} \pm 0.37$	$0.39^{a} \pm 0.24$	$0.44^{b} \pm 0.26$	$0.40^{a} \pm 0.34$

* Significant (P<0.05), NS-Not Significant, Mean values sharing any one common superscript in a row or column do not differ significantly.

Total serum protein was significantly (P<0.05) higher at sexual maturity in high dense pre-lay diet of 2700 kcal energy and 18 per cent protein. Significantly (P<0.05) lower total serum protein was observed in pullets fed BIS feed. No literature could be traced on total serum protein in chicken as influenced by pre-lay energy and protein levels. The present study agreed with findings of Oke *et al.* (2003) who observed higher plasma protein levels in guinea fowl as influenced by dietary protein and energy levels during pre-lay period (20-28 weeks). This may be correlated to dietary effect.

Based on the blood profile study, it is suggested for an effective pre-lay diet in the existing traditional method of feeding layer pullets (Bureau of Indian Standards). Under a humid tropical climate, both the dietary energy and crude protein levels need to be increased at-least three to four weeks before sexual maturity (transition period) so as to make her body fit to enter into productive laying life.

References

Afolabi, K.D., Akinsoyinu, A.O., Abdulla, A.R.O., Olajide, R. and Akinleye, S.B. 2011. Haematological parameters of the Nigerian local grower chickens fed varying dietary levels of palm kernel cake. *Poljoprivreda.* **17**:74-77.

Awotwi, E.K. 1990. A study of base line haematological value of domestic and commercial chicken in Ghana. *Bulletin Animal Production Africa.***38**: 453 -455.

Bancroft, J. D. and Marilyn, G. 2008. Theory and practice of histological techniques. (Sixth edition).

Gornall, A. G., Bardawill, C J. and David, M. M. 1949. Determination of serum proteins by means of the biuret reaction. *Journal of Biological Chemistry*. **177**: 751-753.

Mcinroy, R. A. 1953. A micro-haematocrit for determining the packed cell volume and haemoglobin concentration on capillary blood. *Journal Clinical Pathology.* **7**: 32-34.

Mitruka, B.M. and Rawnsley H.M. 1977. Clinical biochemical and haematological references values in normal experimental animals. Masson Publishing. USA.

Nworgu, F.C., Ogungbenro, S.A. and Solesi, K.S. 2007. Performance and some blood chemistry indices of broiler chicken served fluted pumpkin (*Telfaria Occidentalis*) leaves extract supplement American-Eurasian. *American-Eurasian Journal Agriculture and Environment Science.* **2**: 90-92.

Oke, U.K., Herbert, U. and Akinmutimi, A. H. 2003. Early Lay Characteristics and Haematology of Pearl Guinea Fowls as Influenced by Dietary Protein and Energy Levels. *International Journal of Poultry Science.* **2:** 128-130.

Oladapo, A., Alalade, E., Iyayi, A. and Alalade, T.O. 2007. The nutritive value of Azolla *(Azolla pinnata)* meal in diets for growing pullets and subsequent effects on laying performance. *Journal of Poultry Science.* **44**: 273-275.

Ridell, C. 2011. Comparative anatomy, histology and physiology of the chicken. Dept.of Pathology, Western college of Veterinary Medicine, University of Saskatchewan,Saskatoon, Canada S7N0W0. pg.37.

Sahli, H. Lehrbuch d. klin. Untersuchungen Methode, 5th ed., 1909, pg. 846.

Snedecor,G.W. and Cochran, W.G. 1994. Statistical Methods,8th edn; Oxford and IBH Publishing Company, New Delhi, India.

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Exploring the Status, Constraints and Prospects of Processing, Value Addition and Waste Utilization of Marine Fishes in Andaman and Nicobar Islands

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Abstract

Andaman and Nicobar group of Islands is a tropical archipelago well known for its pristine waters, marine ecosystems with rich icthyofaunal diversity. Fisheries sector plays a significant role in providing livelihood and employment to the Island population and the aboriginal tribes. Among fishing sector, marine fishery sector plays a major role in providing fish supplies with a estimated landings of 39,284 tonnes in 2017-18. Majority of the catches landed are consumed in fresh form from domestic markets whereas fishes in chilled, frozen and dried forms are exported to mainland, India. Fish processing activities are very limited and confined associated with constraints such as limited fish supplies, lack of adequate infrastructure, demand- supply tradeoff and lack of technical knowledge among the stakeholders. This paper provides a brief outlook on the marine fishing sector, landings and the possible ways to promote processing and value addition in fishes. As marine fish catches are landed with various bycatches, such underutilized and low value fishery resources can be utilized for product development and value addition, and the waste generated from fishery sector can be utilized for byproduct development. The existing infrastructure and fish utilization pattern can be restructured and strengthened for post harvest management of fishery resources. Fish processing sector has immense scope to provide additional income, livelihood and employment to the Islanders especially in empowering fisherwomen.

Keywords: Fishery resources, product development, value addition, byproducts

Introduction

Andaman and Nicobar Islands (ANI) is one of the union territories of India, located in the South East of Bay of Bengal as a linear strip of emerald Islands in close proximity to South East Asian countries. The ANI archipelago consists of 572 Islands and Islets, having an aggregate coastline of 1912 km which accounts for one fourth of India's coastline and the Islands are also known as Bay Islands (ANDFISH (2005); Roy et al. (2006)). The Islands are spread over 8200 Sq.km of geographical area and encompasses 0.6 million km^2 of Exclusive Economic Zone (EEZ), which accounts for 30% of India's total EEZ. The continental shelf forms nearly 6.60% of the total Indian Continental shelf that is about 34965 Sq.km.

Marine fishery resources

The presence of diverse marine ecosystems and habitats like mangroves, creeks, lagoons, estuaries, muddy shores and coral reefs are the major reasons for enormous diversity of finfish and shellfish resources. Around 1434 fish species were reported from the Island water bodies including marine and freshwater habitats (Rajan et al. (2013)), among which, 400 species are of commercial importance as food fishes (Rajan et al. (2013)). Currently capture fisheries is the major contributor to marine fish production as mariculture activities are yet to take off on commercial scale to achieve fish production in the Islands. The estimated marine fisheries potential of the Island is 1.48 lakh tonnes (Anonymous (2018), Andaman and Nicobar Islands Fisheries Policy) (Table 1). In spite of the huge potential, the fish harvest stands at 39,284 tonnes during 2017-18 (Fig. 1). The reasons for lower harvests are mainly attributed to the lack of efficient fishing fleet, lack of offshore fishing crafts, infrastructure facilities and skilled manpower. Some of the resources available along with the potential and catches are given in Table 1.

Table 1. The major catches of pelagic, demersal and oceanic resources and its potential

Resources	Potential	Major catches
Pelagic	0.56 lakh tonnes	Seer fishes, coastal tunas, barracudas, anchovies, sardines, wolf herring, mackerel, carangids, ribbon fishes, etc.
Demersal	0.32 lakh tonnes	Silver bellies, elasmobranchs, perches, pomfrets, thread fins, croakers, gerrids, goat fishes, silver grunt, drift fishes, lizard fishes, flat fishes, bulls eye, cephalopods, shrimps, crabs, lobsters, etc.
Oceanic	0.60 lakh tonnes	Tunas (yellow fin tuna, skipjack tuna, big eye tuna), bill fishes (marlins, sailfishes, swordfish), wahoo, dolphin fish, flying fish, oceanic squids, etc.

(Source: Anonymous (2018), Andaman and Nicobar Islands Fisheries Policy; Kundu and Kiruba Sankar (2019)).

Diverse fishery resources are available in the Island waters but majority of these resources are not properly exploited, especially the oceanic resources which has not been harnessed to its potential. The major fishing gears operated in the Island are ring seine, gill net, hand-line, long-line and trawl net. During 2017-18, out of 39284 tonnes of total marine fish production 29130 tonnes was from South Andaman, 9749 tonnes was from North and Middle Andaman and 405 tonnes from Nicobar district. Pelagic resources constitute 19478 tonnes, followed by demersal 16731 tonnes, and oceanic 3075 tonnes.

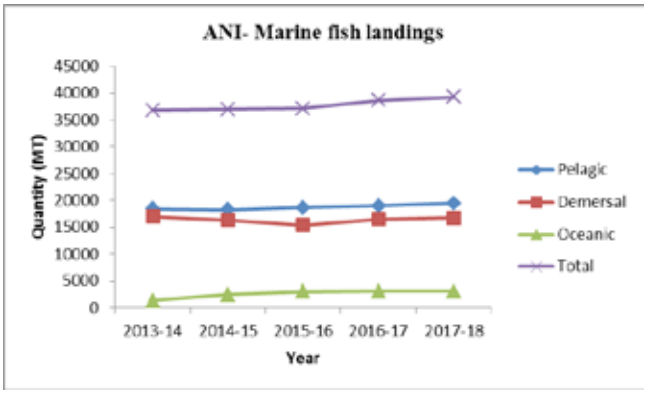

Fig.1. Marine fish landings of ANI (Source: Unpublished data from Department of Fisheries (2017-18), Andaman and Nicobar Administration).

Fish processing sector

Fish processing involves stepwise processes associated with fish and fish based products from the time of harvest till it reaches the consumers. Quality loss usually happens in fish as it is a perishable commodity. Processing activities explores ways of fish preservation by lowering the temperature or by using high temperature or by reducing water activity, etc. Before the development of advanced fish processing techniques people used to preserve fish by traditional fish preservation techniques such as curing methods which involves sun drying, salting, smoking, marination and fermentation.

Inspite of enormous potential and payoffs, fish processing activities are still confined to sun drying, salting, chilling and freezing of available fish catch. Fisher folk use to dry the excess and low valued fishes for sale in local market. Among the fishery products, fish and prawn pickles, fish cutlets, fish finger, canned fish, etc. are available in supermarkets and retail shops. Few Self Help Groups (SHG's) were actively involved in preparing and selling pickles in small scale manner. Traditional methods like sun drying, salting, smoking, marination, etc. are very popular among tribal population in Nicobar Islands. There is a greater demand for fish based products in these Islands which are mainly imported from mainland. Fishes in chilled, frozen and dried forms are exported from the Islands to mainland, India. At present, no proper utilization and recycling of fish wastes is happening in the Islands. The waste generated from fish markets are directly thrown into the waste baskets without any further treatment.

Current state of catch utilization

Most of the available catch is sold as fresh in the local markets. Nearly 15 % of the catch is processed in the form of salted or sundried with some defects identified as poor salting, high sand content and rancidity (Mustafa, (1983)). Out of 36980 tonnes, during the year 2014-15 the marine fishes marketed as fresh (24037 tonnes), frozen (5547 tonnes) and salt dried (7396 tonnes) (Shirke et al. (2018)). The disposition data of marine fish catches and the details of fish and fishery products exported from the Island are given in fig.2 and table 2 respectively.

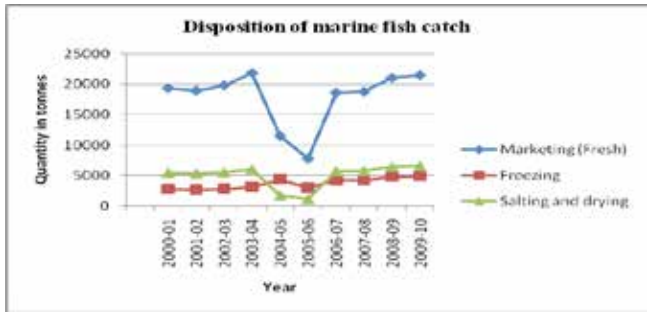

Fig.2. Disposition of marine fish catch (Source: Unpublished data from Department of Fisheries, (2017-18). Andaman and Nicobar Administration).

Table 2. Fish and fish products exported from the Island for last five years (Quantity in Kg)

Item	2012-2013	2013-2014	2014-2015	2015-16	2016-17	2017-18
Crab	52585	41022	58895	89906	121477	135541
Lobster	12511	3994	2107	7147	6016	7766
Prawn	74	0	15	0	0	0
Fish	1399669	1589066	1627280	1525999	2037458	2183885
Tuna	0	10000	0	0	117262	157780
Shark fin	4,277	631	230	482	766.5	601
Shark flesh	331584	147928	103489	141946	214066	154150
Dry fish	31,958	47303	4314	19074	51578	6290
Total	**1,832,658**	**1,839,944**	**1,796,330**	**1,784,554**	**2,548,624**	**2,646,013**

(Source: Unpublished data from Department of Fisheries, (2017-18). Andaman and Nicobar Administration).

Marketing of fish and fishery products

Andaman and Nicobar Islands are included in the list of highest fish consuming states/UT in India. A study showed that majority of Andaman's population consumes fish 3 to 4 days in a week (Suresh, (2012)). Average yearly fish consumption of an individual in the Island is 53.57 Kg (Unpublished data from Department of Fisheries, Andaman and Nicobar Administration, 2017-18). The mode of fish marketing is categorized into five ways such as door to door selling, export agent, street vendors, auction and market (Suresh, (2012)). Majority of sellers prefers to be street vendors as it gives good profit in less time. Door to door selling of fish is also a common practice to sell fishes. The other mode of fish sale is by involving the export agents. The fishermen sell highly priced, good quality fresh fishes to them directly to earn good profit. The agents come and collect the fishes directly from them in the landing centres. These agents provide inputs for fishing like baits, ice and fuel to the fishermen. They export the fishes to mainland in chilled or frozen condition. This mode is to maintain the demand of Island fishes in export market as well as local markets. The other mode of sale is through auction, which involves high risk of losing money, at the same time this is the easiest way to earn huge profit. The fishermen sell fish to exporters or vendors or other business owners who offers the highest price. Purchase of fish from market is the most common business mode through which customers are buying fish from different market from the vendors. The study in Port Blair, South Andaman reported that fish markets are the major platform for the domestic fish sale but fish marketing is highly unorganized and unregulated

(Shirke et al. (2018)). An earlier study found that fish varieties such as perches (snappers, groupers & emperors) were found to be more preferred by the Islanders followed by mackerel, sardine, anchovies & carangids and prawns (Shirke et al. 2016)).

Infrastructure

The available infrastructure for post harvest management of marine landings includes fish landing centres, fish markets, cold stores, ice plants and fish processing plants. Other than landing centres, fish landed at 46 landing points also in different locations in Andaman and Nicobar Islands. Out of 8 landing centres, 3 landing centre is at South Andaman, 4 is at North and Middle Andaman and 1 is at Nicobar district. Construction of 9 landing centre and 2 fish market is going on in different locations. Till now 2 modern fish markets are there in the Island in which one is functional at Junglighat, South Andaman and the other one is not yet functional which is constructed at Mohanpura, South Andaman. The total number of cold storage available is 08 with a capacity of 290 tonnes/day and ice plant is 15 with a capacity of 223 tonnes/day. The available infrastructures for Island fisheries are listed below (Table 3).

Table 3. Infrastructure available in the fisheries sector

Infrastructure	Number of units	Remarks
Fish landing centres	**08**	Construction of 09 more landing centres is going on and work of 02 landing centres is yet to commence.
Fish markets	**17**	02 Fish markets are under construction in North and Middle Andaman
Fish processing plant	**03**	Total capacity 130 tonnes/day
	01 (Public undertaking)	100 tonnes/day
	02 (Private units)	30 tonnes/day
Ice plants	**15**	Total capacity 223 tonnes/day
	03 (Govt.)	30 tonnes/day)
	09 (Private units)	Total capacity is 178 tonnes/day
	03 (Public undertaking)	15 tonnes/day
Cold storages	**08**	Total capacity of all cold storages is 290 tonnes/day
	03 (Govt.)	45 tonnes/day
	02 (Private units)	Total capacity of 125 tonnes/day
	03 (Public undertaking)	120 tonnes/day

(Source: Unpublished data from Department of Fisheries, (2017-18). Andaman and Nicobar Administration)

Constraints

- Lack of diverse fishing methods which lead to low catches followed by shortage of raw materials for fish processing activities
- Limited infrastructure facility for proper post harvest handling of fishes
- Lack of technical knowledge among the Islanders regarding the fish processing techniques and its potential in employment

- Limitation in transportation and trade between the Islands and to mainland, India, due to remoteness of the Island; Nonexistence of air connectivity to foreign markets; poor information and communication linkages etc. also hinders the developmental activities.
- Intense competition from mainland for processed fish products such as pickle, canned foods etc. Quality demand will be on par with that of mainland products.

Product development and value addition

The diverse fishery resources can be well utilized for developing products that could be marketed within the Island for local consumption as well as outside the Island. Utilization and consumption of low valued fishes that have less demand and fewer prices in the market can be promoted through value addition of these resources. According to the preference and requirement of the market, the resources can be converted into different forms or products with different nature which can earn more profit at the time of sale. Value added products from fish can be of different type such as mince based, surimi based and battered and breaded products. Convenience products such as ready to eat, ready to serve, ready to cook products have greater demand in global market as it gives ease to the consumers in the preparation of their meal. Specialty products such as sausages, skewered shrimp, wafers and analog products also have high demand in the international markets. The fishery resources of these Islands can be utilized to develop such high value products for earning more profit (Table 4).

The fish catches landed are sufficient enough to cater local consumption. Any unutilized fish landings and low value fishes can be utilized for processing and value addition. Marketing of fish in fresh form in the mainland may not be economically viable as transport and holding cost will be added on the product cost, it won't be able to challenge local market condition. So marketing of fish in processed form will be a sustainable option (ANDFISH, 2005).

Table 4. Popular fish based products

Products	Suitable fishes	Technology Advantage
Chilled & Frozen products	High value fishes like grouper, pomfret, shrimps, tuna, etc.	Preservation of fish at low temperature closest to fresh state, high potential in domestic and export market
Salted and dried products	Small sized, low value fishes are mostly preferred. Examples: Anchovies, small shrimps, lesser sardines, etc.	Shelf life extension of fish by reducing the water activity without much financial input and sophisticated equipments. Storage of products at ambient temperature is possible
Canned products	Tuna, mackerel, sardine, crab, shrimps, etc.	Preservation of fish with the application of high temperature for commercial sterility and longer shelf life. Products are stable at room temperature without any cold chain requirement
Pickle	Both finfish and shellfish are preferred. Example: Tuna, shrimp, clam, etc.	Easy & one of the safest preservation technique and it is a highly demanded value added product with market potential in domestic and export market.
Fish kheema/ fish mince and mince based products (Example: Fish ball, fish cakes etc.)	Low value & white fleshed fishes are mostly used. Example: Threadfin bream	Better utilization of low value fishes. Highly acceptable product by consumers.

Coated products/ battered & breaded or enrobed products (Fish cutlet, fish finger etc.)	Low value fishes, fishes with less pin bones are mostly preferred eg. Nemipterus, ribbon fish, tuna. Coated shrimps & cephalopods products are also popular.	Better utilization of low value fishes through value addition. Highly acceptable product by consumers.
Surimi and surimi based products like sausages	Lean, white fleshed fishes like thread fin bream, bigeye snapper, croaker etc. Mackerel & sardine can also be used.	Better utilization of low value fishes through value addition. High demand in export markets.
Convenience products (Fish curry, fish burger, fish samosa, fish wafer, soup powder etc.)	Any fish can be used. For fish curry, high priced fishes like pomfret, seer fish etc. are mostly preferred. Lean white fleshed fishes like threadfin bream, big eye snapper, etc. can be used for burger, samosa, etc. Low cost, lean white fleshed fishes are mostly preferred.	Better utilization of low value fishes through value addition. Increasing demand for ready to eat, ready to cook products.

(Source: Datta, (2015))

The low value fishery resources of the Islands such as sardines, mackerel, threadfin bream and ribbon fish, etc. can be targeted for its better utilization. One of the potential resources for processing, and value addition is the oceanic tuna resources which are quite underutilized in comparison to coastal tunas. Development of a cold chain by connecting the existing ice plants and cold stores in the entire island is essential to maintain the quality of fish catches. Adoption of sanitary handling practices is an utmost necessity to manage the catches suitable for processing and to avoid any possible contamination with pathogens of public health significance.

Fish waste utilization and byproduct development

Another potential area under fish processing is byproduct development from fish wastes. Fishes are mostly consumed as fresh in the Island, even though some portion are still utilized after some kind of preservation and processing. Wastage can happen during handling and processing of fish along with the wastes from fish markets by the dressing and cleaning activities of fish for customers. Similarly, bycatch, discarded fishes due to quality loss/spoilage or less demand and wastes from fish processing units will also contribute to the wastes generated in the fisheries sector. Fish is known for its rich nutrient reserves and the waste materials generated from fish are also a good source of high quality protein, minerals, fat etc. which are having potential for recycling. Different byproducts such as fish meal, fish silage, fish oil, chitin, etc. can be developed from these waste materials (Table 5). Post harvest losses can be reduced if we could utilize these wastes effectively converting them to products. This technology could be well suited for the Island as there is no demand for sophisticated equipments or a big industry set up to process the products.

Table 5. Popular byproducts from fish wastes

Products	Product application	Type of wastes material/ Waste part utilized (whole fish, head, skin, bone, etc.)
Fish meal	Livestock feed supplement	Wastes from high fat fishes like anchovies, sardines etc., small bycatch fishes & wastes from fish processing units
Gelatin	Food industry: as a gelling, emulsifying, dispersing or thickening agent & other industrial application: in photoengraving and chemical etching of metal parts; in optical industry in the formulation of coating for light sensitive materials like blue print papers	From skin and bones of fish
Fish Calcium	Food industry; used to combat calcium deficiency in the diet, particularly for children	Bone of fishes especially tuna
Fish silage	Used in animal feeding	Whole fish wastes or parts of fish
Fish glue	Industrial application; used in furniture, box making etc.	Fish head & skin
Fertilizer from fish waste	Agricultural application	Fish offal & low value fishes
Fish oil	Industrial application; as drying oils in paint and varnishes, manufacture of detergents, soaps, lubricants etc. & food industry; cooking oil and medium in fish canning	Fatty fishes or wastes with high oil content
Chitin & chitosan	Industrial application; purification of drinking water, treatment of waste water, In Food industry; as clarification agent in fruit juices, thickening and stabilizing agent, animal feeding, In cosmetics as moisturizer, and in pharmaceutical industry; slow releaser of drugs etc.	Exoskeleton of crustaceans
Isinglass/ fish maws	Used for production of gelatin or glue, clarifying agent for beer, cider, wine, vinegar etc., adhesive base, ingredient in Indian ink and as a sizing agent in textiles	Air bladder of fish
Pearl essence	For making artificial pearls, as spray or dip for several items to impart iridescent sheen. Used on diverse articles such as shoe, pencil, fishing rod, ash tray, vanity bag, book cover etc.	Fish scale

(Source: Balachandran, 2001)

Fisher folk are aware of waste utilization; however they lack technical knowledge regarding the technology of byproduct development. Further, capacity building programmes such as trainings should be conducted for the stakeholders to popularize the products. This could be a promising sector for their livelihood and development of self employment. At present, the bay islands are encouraged towards conversion of organic agriculture

and hence the products like fish silage, fish compost/ fertilizer, etc. can be used effectively for the agriculture sector. There is high demand for feed for livestock as there is no much availability of them in the Island, so the production and supply of products like fish meal can be a good option for earning profit. Diverse products can be developed from these wastes which have industrial applications too; these products can be marketed well in the Island and can be exported.

Marketing chain - recommendations and proposal

The demand for fish is high in the Islands as majority of the Island population are fish consumers considering the abundant fishery resources in the Islands. Diverse products can be developed and marketed in the Islands according to the demand and preference of the population. Market surveys are essential for a comprehensive study to know the taste preference of the fish consuming population. Smart marketing tools can be used effectively to market fish and fishery products and Women Self Help Groups should be promoted to engage them in production, packaging and marketing of fishery products. Marketing of products can be strengthened by exploring the new marketing strategies such as targeting the ever growing tourist population and by expanding the market outlets at various prominent places including popular tourist destinations. The products can be sold through retail markets, supermarkets, self help group units and department units. The fish markets should be converted into modern fish markets with proper hygiene and facilities for waste disposal, storage facilities, etc. This will create a space for hygienic marketing of fish as well as demand of products can be increased by attracting the customers with the supply of safe-quality produce. The marketing system should be more regulated and organized with involvement of limited intermediaries and with proper logistical support.

Marketing of the Island fishes and fish products can be possible with an eco-label, 'Andaman brand' etc. which will fetch more price than a regular product in the market. Packaging of fish and fishery products is another important area. Packaging material need to be selected with utmost care for local market and export by avoiding the use of single use plastic for packing the fish products. Products can be marketed after proper quality check with adequate label carrying full information about the product inside. The export is possible after getting the export clearance from the competent authority.

The marketing channel for fish marketing involves many intermediaries such as auctioneer, wholesaler, retailers, processing agents and fish vendors etc. In the marketing chain of fish, the number of intermediaries can be limited as much as possible to increase the profit share of fishermen community. This can be achieved by strengthening of fishermen cooperative and by increasing the role of fishermen not only in production and harvest but also in processing, packaging and marketing.

Future prospects of fish processing sector

Productive areas for development of processing, value addition and waste utilization sector is shown in Fig 3. Production of high end products such as convenience products in retort pouches, canned tuna and specialty products like analog products, sashimi grade tuna, etc. should be targeted which have high demand in the international markets. Infrastructure facilities for proper handling, preservation, processing, storage and transportation of fishery resources can be strengthened with establishing most modern export friendly set up and sophisticated equipments including hygienic waste disposal systems. Facilities for preserving fish onboard should also be improved for getting better quality raw material for processing. A well managed cold chain between the Islands including cold store, reefer containers, ice plants etc. should be established. Supply of good quality inputs like ice, potable water should be assured for production of quality fish. Data collection on post harvest loss and quantification of wastes generated from the fisheries sector should be carried out. The wastes generated should be collected and used judiciously for developing products with diverse applications. Facilities for production of diversified value added products and byproducts should be developed in the Island. Export of fishery products via sea and air should be strengthened, the strategic location of A&N Islands with its proximity to the world tuna markets located at Singapore and Bangkok

can be utilized for earning foreign money through export of sashimi grade tuna.

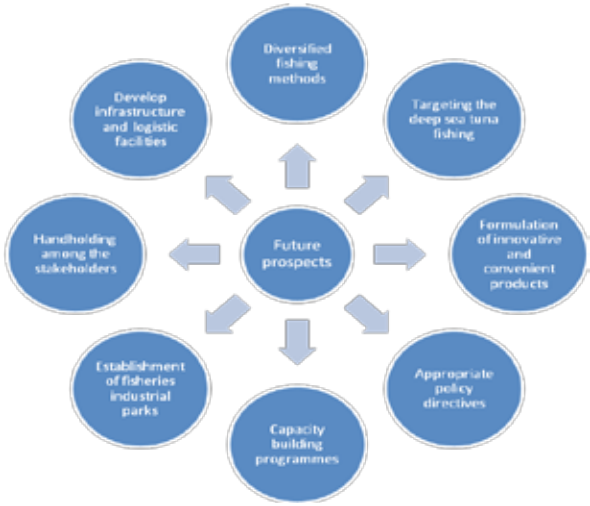

Fig. 3.Future prospects for the development of fish processing in ANI

Sustainable and judicious use of marine fishery resources is essential to promote livelihood and employment activities in the Islands. Fisheries sector plays a huge role in the livelihood of Island population including the tribal population. More than subsistence fishing, fisheries and its allied sectors should be seen as a business activity to reap the benefits in fishery sector. Fish processing sector should be promoted and could be well adapted in Island conditions with a quality brand. The development of new innovative and diverse value added products and byproducts from the fishery resources can meet the existing demand of local market. Further, these products can be exported to mainland, India and nearest South East Asian countries. Scientific data in the area of fish processing should be strengthened to add more information to the existing database. The sector is if engaged proactively could play a significant role in promoting trade, securing food and nutritional requirement of the population along with improvement in livelihood and employment opportunity of the Islanders.

References

ANDFISH, (2005). Roadmap for the Development of Fisheries in Andaman and Nicobar Islands. CMFRI, CIFT, CIBA, CARI and Fisheries Science Division, Indian Council of Agricultural Research, New Delhi. Pp.90.

Anonymous, (2018). Andaman and Nicobar Islands Fisheries Policy. Department of Fisheries, Andaman and Nicobar Administration, Port Blair. Pp.17.

Balachandran, K. K. (2001). Post-harvest Technology of Fish and Fish Products. Daya Books. 433 p.

Datta, S. (2015). Prospects of value added products and it's future in Indian market.

Kundu, A. & Kiruba Sankar, R. (2019). Exploring the potential, Challenges and looming Issues in Andaman and Nicobar Islands with Reference to Coastal Aquaculture and Fisheries. Souvenir, BRAQCON, 2019. Pp 37-47.

Mustafa, A.M. (1983), Fisheries of the Andaman and Nicobar Islands. ICLARM Newsletter, 6 (4): 7-9.

Rajan, P. T., Sreeraj, C.R. & Immanuel, T.I.T.U.S. (2013). Fishes of Andaman Andaman and Nicobar Islands: a checklist. *Journal of Andaman Science Association* 18(1): 47-87.

Roy, S. D, Rajan, P. T. & Soundarajan, R. (2006). Marine food fishes of Andaman and Nicobar Islands. Fishing Chimes. 25: 108-110.

Shirke, S. S., Pradeep, H.D & Sukham, M. D. (2016). Fish consumption behavior and Socio-economic status of different income group strata of Port Blair city, Andaman and Nicobar Islands, *Journal of fisheries economics and development* 17 & 18: 11-20.

Shirke, S.S., Sukham, M.D., Nashad, M., Pradeep, H.D. & Rahman, M.R. (2018). An overview of adoption of hygienic practices by fish marketing personnel in selected fish markets of Port Blair city, Andaman and Nicobar Islands. *Indian Journal of Economics and Development 6*: 1-6.

Suresh, M. (2012). Export Potential of Marine products and its impact on eradication of poverty in Andaman Islands-A Study with Special Reference to Tuna Fish Variety. PhD thesis (Pondicherry University, Andaman and Nicobar Islands, India).

Unpublished data from Department of Fisheries (2017-18), Andaman and Nicobar Administration.

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Fishery, Growth and Stock Status of Little Tuna, *Euthynnus Affinis* (Cantor, 1849) from Andaman Waters

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Abstract

Euthynnus affinis, also known as little tuna or kawakawa, is one of the important coastal tuna species contributing significantly to the tuna fisheries in Andaman and Nicobar Islands. In this study; fishery, growth parameters and the stock status of *E. affinis* from Andaman waters was investigated. The major gears exploiting this resource were drift gill net followed by hook and lines. The fishes in the length class of 33-48 cm contributed more than 50% to the little tuna fishery. This species predominantly feeds on fishes followed by crustaceans and molluscs. The length-weight relation was found as $W=0.196\ L^{2.913}$. The von Bertalanffy growth parameters estimated were $L\infty=74.03$ cm, K=0.41/ year and t_0=-0.025 years. Mortality parameters estimated were M=0.77, Z=1.09 and F=0.32 with the exploitation ratio E=0.294 and exploitation rate U=0.195. The M/K ratio was 1.87. The estimated maximum sustainable yield was 3535 tons which is higher than the average annual catch indicating the stocks of *E. affinis* are not fully exploited.

Key words: Andaman, *Euthynnus affinis*, little tuna, fishery, growth parameters, stock status

Introduction

The archipelago of Andaman & Nicobar Islands (ANI) is a group of 572 islands, islets and rocks, lying in the South Eastern part of the Bay of Bengal. The aggregate coastline of ANI is 1912 km. The continental shelf area is very limited with an estimated area of 16000 km^2 and the sea is very deep within a few kilometers from the shore. The Exclusive Economic Zone (EEZ) around the Islands encompasses around 0.6 million km^2, which is about 30% of the Indian EEZ (Pillai and Abdussamad, 2009). Marine fishery resources of ANI are vast and abundant with estimated fishery potential of 1.48 lakh tons (John *et al.*, 2005). Andaman & Nicobar waters are known to harbour rich tuna resources to the tune of 64500 tons (Anrose *et al.*, 2009). Of the total tuna potential, oceanic tunas (skipjack, yellowfin and bigeye tuna) forms 46500 tons and the remaining 18000 tons is of the neretic tunas. Out of 6 genera of tuna, 3 genera are reported from oceanic region of ANI viz *Thunnus albacores* (yellowfin tuna), *T. obsesus* (big eye tuna), *Katsuwonus pelamis* (skipjack tuna) and *Gymnosarda unicolor* (dogtooth tuna). The other four genera represented by the coastal tunas include *Euthynnus affinis* (little tuna), *Thunnus tonggol* (longtail tuna), *Sarda orientalis* (oriental bonito), *Auxis thazard* (frigate tuna) and *Auxis rochei*(Bullet tuna) (Anrose *et al.*, 2009).

Euthynnus affinis, also known as little tuna or kawakawa, is one of the coastal tuna species which has a wide distribution in tropical and sub tropical waters of Indo-pacific region. This species is reported from Cape St. Francis, South Africa along the coasts of east Africa, Arabian Peninsula, Indian sub continent, Islands of Indian Ocean including Andaman and Nicobar Islands, Malaysian peninsula to southern china, off southern Japan up to Australia and is dominant in narrow shelves such as Sri Lanka and Philippines (Mitsuo, 1989). Genetic studies on the stocks of *E.affinis* in South-East Asia have revealed that it is a pan-mixing stock (Mudjekeewis *et al.*, 2010) and in Indian waters (including both islands) it is a single stock (Girish *et al.*, 2012). *E. affinis,* being a coastal species, is widely exploited all along the Indian coast to the tune of 35,446 tons forming about 40% of the

total tuna landings of India in 2016 (CMFRI, 2017). The combined landing of tuna species in ANI during the year 2016-17 was 2208 tons (Unpublished data, 2018). Coastal tunas contributed 2008 tons (99%) to the total tuna production whereas the contribution of oceanic tunas was 200 tons only. *Euthynnus affinis* contributed significantly to the tuna production in ANI.

Studies on distribution, abundance and various aspects of biology had been conducted from different regions of the world. Biology of Indo-Pacific tunas was studied in detail and compiled as synopsis (Mitsuo, 1989). From Sri Lankan waters biology of exploited stocks (Sivasubramaniam, 1970) and stock assessment (Pauline *et al.*, 1991) of *E. affinis* was studied. Distribution of *E. affinis* in western Thailand was studied (Chamchang and Chayakul, 1988). Stock assessment of *E.affinis* for entire Indian Ocean was done (Rishi *et al.*, 2012). Length frequency distribution and population parameters for little tuna of northwestern Sumatran waters were studied (Ririk *et al.*, 2014) while biological studies were also conducted for tuna and tuna like species from Malaysian waters and Gulf of Thailand (Chiampreecha, 1978). From Indian waters, stock assessment studies of various tuna species including *E. affinis* was done (Silas *et al.*, 1985). Various authors have studied the fishery, biology and stock assessment of tunas (James et al., 1993; Pillai and Gopakumar, 2013). Distribution, abundance, exploitation and biology of tunas from Andaman and Nicobar waters were studied earlier by Madhu *et al.*, (2002), Pandian et al., (2007) Pradeep et al., (2017). But these studies are mostly for oceanic tunas such as *Thunnus albacores* and *Katsuwonus pelamis*. There is no information on the biology and stock status of *E.affinis* from Andaman waters. Studies on the fishery, biology and growth of *E. affinis* in different parts of globe including India are limited (Prathiba *et al.*, 2012). In this context, an effort was taken to study the fishery, growth parameters and stock status of *E. affinis* from Andaman waters.

Materials and Methods

Euthynnus affinis were sampled to record fork length (cm) and weight (gm) from April 2015 to March 2017 at commercial landing centers around Port Blair and at the fish processing plants in Port Blair who receive fish from other parts of Andaman Islands. Fish samples were collected randomly and brought to laboratory for conducting biological studies. The length weight relation was calculated using the formula ($W=aL^b$). Stomachs were analyzed for fullness by visual method and prey was identified up to genus level wherever possible. ELEFAN I module of FiSAT II software was used to estimate the von Bertalanffy's growth parameters ($L\infty$ and K). 't_0'was estimated using the formula $Log_{10}\text{-}t_0$=-0.3922-0.2752*$Log_{10}L_\infty$-1.038 $\log_{10}$ K. The growth performance index was estimated using the formula $\log_{10}(K) + 2Log_{10}(L_\infty)$. Longevity was estimated from $t_{max}=3/K + t_0$. Natural mortality (M) was estimated using Paulys empirical formula. Length converted catch curve method in FiSAT II software was used to estimate total mortality (Z). Fishing mortality (F) was calculated by F=Z-M. Exploitation ratio (E) was estimated using the formula E=F/Z, where F is fishing mortality rate and Z is total mortality rate. To calculate Exploitation rate (U) formula $U=F/Z*(1-e^{-z})$ was used. Length based Virtual Population Analysis (VPA) was performed in the FiSAT II software to obtain length class wise fishing mortalities. Total stock (P) was estimated by the ratio of Y/U, where Y is the annual average yield. Biomass or standing stock (B) was estimated from the ratio Y/F. Maximum sustainable yield (MSY) was calculated by the equation $MSY=Z\times0.5\times B$ for exploited fish stocks.

The data on fish catch and effort was obtained from the Department of Fisheries, A&N Administration. The Department of Fisheries, A&N Administration collects catch data of tunas in two categories; one is oceanic tuna and the other is coastal tuna. Under the category of oceanic tuna, catch data of three species (*Thunnus albacores, T. obsesus* and *Katsuwonus pelamis*) is collected separately whereas under the category of coastal tunas, species wise catch data is not collected. Therefore, on the basis of our observations in fish landing centers and fish markets, interactions with the staff of Department of Fisheries, A&N Administration and fishermen, it was assumed that 70-90%of the coastal tuna catch is comprised of *E. affinis.* Hence, an average of 80% (1608 tons) of average coastal tuna catch of last five years (2010 tons) was used for the estimation of total stock (P), standing stock (B) and MSY.

Results

Euthynnus affinis formed the dominant species in landing among the coastal tuna. Drift gill net was the single major gear exploiting the *E.affinis* by using plank built boat with inboard engines locally known as '*bongadongi*' and fibre reinforced plastc (FRP) boats of varying size. Other gears harvesting tunas were hook and line, troll lines and ring seine.Gill nets with mesh size 100-120 mm were mostly used. For trolling fish hooks of size 1-6 were used. Annual landings of coastal tuna from 2012-13 to 2016-17 is shown in figure 1. The annual landings varied from 1972 tons in 2015-16 to 2200 tons in 2014-15.The average catch of coastal tuna during the last 5 years was 2010 tons forming about 11% of the estimated coastal tuna potential of ANI. Though the fish is caught round the year, the peak fishing season is from December to April. Most of the tuna catch is exported to mainland India due to low demand in the local market.

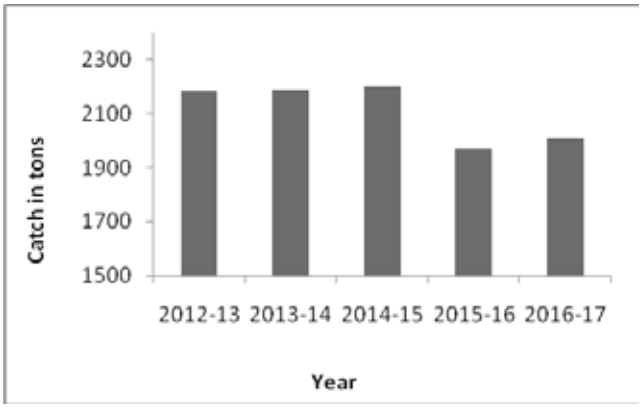

Fig. 1 Annual landings of coastal tuna during 2012-13 and 2016-17 in ANI.

The length-weight data was collected from a total of 1935 fish samples. The fork length of the observed fishwas in the range of 15 to 72cm. The figure 2 shows the length frequency distribution of little tuna in Andaman waters. More than 53% of the little tuna catch was contributed by fishes falling in the length range of 33 to 48cm making it the modal class. The stomachs of the little tuna were analyzed to study feeding intensity and feeding habits. 52% of the fishes had half full stomachs. Stomachs with one forth fullness constituted about 30% and little with empty stomachs constituted 18% (figure 3). None of the fishes had full stomach. The prey of little tuna included fishes, molluscs and crustaceans. Fish formed the dominant group (>90%) of diet such as horse mackerel, lesser sardines, white baits, threadfin breams etc.

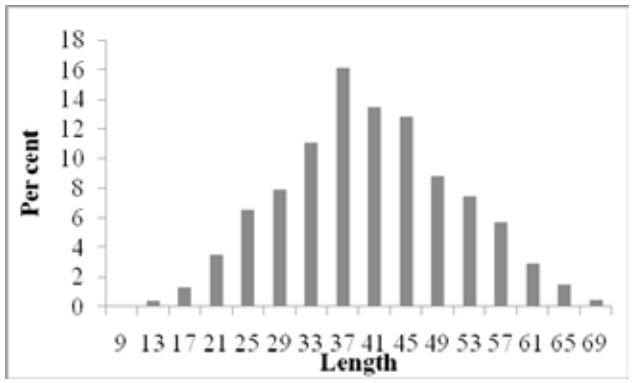

Fig. 2 Length frequency distribution of little tuna from Andaman waters.

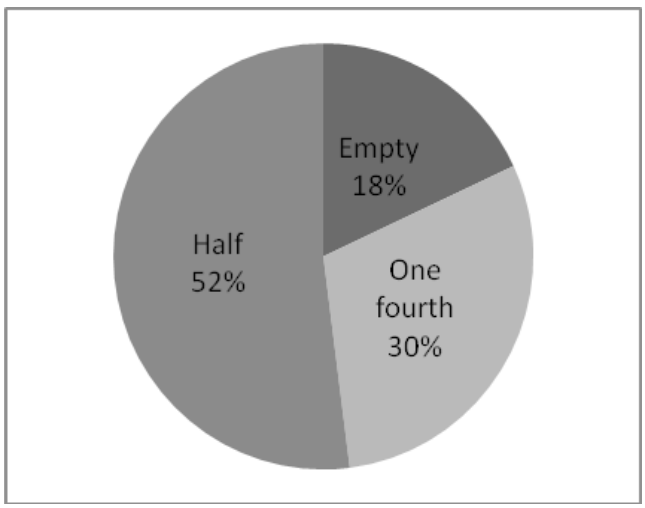

Fig. 3 Stomach condition of little tuna during the study period

Length weight relationship of little tuna was W=0.196 $L^{2.913}$ where W is the weight of the fish in grams and L is the fork length of the fish in centimeters. The growth parameters in von Bertalanffy's growth equation $Lt=L_{\infty}[1-(e^{-K(t-t0)})]$estimated were $Lt=74.03[1-(e^{-0.410(t+0.025)})]$.The growth performance index (Ø) was 3.351. The estimated longevity of the *E.affinis* was 7.10 years and the length attained after 1st, 2nd and 3rd year was 25, 41 and 52 cm respectively. The M/K ratio estimated was 1.87 which is within thenormal range of 1 to 2.5. The natural mortality rate (N), fishing mortality rate (F) and total mortality rate (Z) estimated were0.77, 0.32 and 1.09 respectively. Exploitation ratio (E) and exploitation rate (U) estimated was0.294 and 0.195 respectively. Virtual Population

Analysis (VPA) indicated that major loss in the little tuna stock upto 30.5 cm was due to natural reasons (figure 4). Mortality due to fishing increased after this point but the fishing mortality remained more or less low. The estimated total stock (P) was 8662 tons and standing stock (B) was 5275 tons. The estimated value of maximum sustainable yield (MSY) corresponded to 2639 tons which is higher than the annual average yield indicating that little tuna stocks are underexploited.

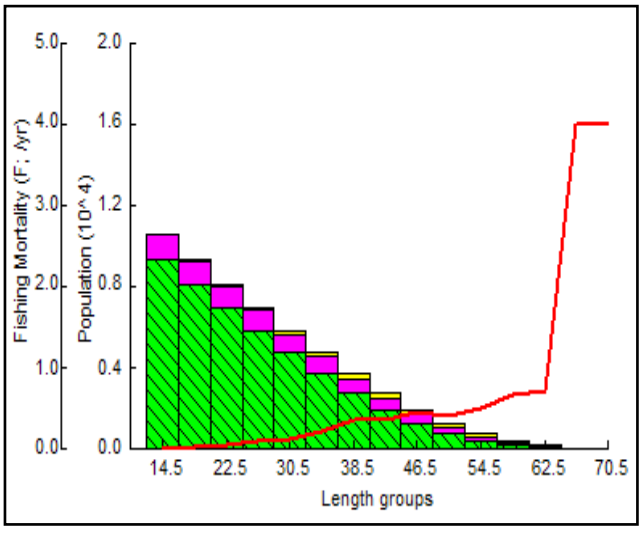

Fig. 4 Virtual Population Analysis of *Euthynnusaffinis.*

Discussion

Andaman Nicobar waters have a fishery potential of 1.48 lakh tons and are known as one of the best fishing grounds for tunas with a potential of 64500 tons/year against their harvest of only 2208 tons during 2016-17. Out of 64500 tons of potentially harvestable tuna, 46500 tons is constituted by oceanic tunas whereas the annual harvest was 200 tons in 2016-17. The remaining 18000 tons in the potential catch is constituted by coastal tunas which are harvested to the tune of around 2000 tons. This indicates that though the potential of oceanic tunas is more, the fishing pressure is more on the coastal tunas. This may be due to the status of present fishing fleet who fish mostly within 200m depth zone (Pillai and Abdussamad, 2009), limited tradition of tuna fishery, low market price of tuna in relation to other pelagic resources such as barracudas and seer fishes making tuna fisheries less attractive etc. There is no species specific catch data for the coastal tunas from Andaman waters but we observed that *E. affinis* is the major contributor to the catch of coastal tunas. Also, studies on the fishery and biology of this species were not undertaken earlier. Understanding the biological characteristics of fished stocks and their assessment is imperative for the management of fishery. Growth characteristics of fishes are important part of population dynamics and essential parameters to take serious decision on the management issues of any fishery (DeVries and Frie, 1996).

Various authors have reported the length range of *E. affinis* such as 10-78cm (Pillai *et al.*, 2002) and 14-80cm (Prathibha *et al.*, 2012) for Indian waters. Little tuna fishery in the northwestern Sumatran waters was supported by fishes in the length range of 23.5 – 61.5 cm (Ririk *et al.*, 2014). The length range recorded in this study (15-72cm) is within the range of values of earlier studies. This study recorded 33-48cm as modal length class supporting fishery which was close to the observations (34-58 cm) made for Indian waters (Prathibha *et al.*, 2012). *Euthynnus affinis* is a highly opportunistic predator and feeds on small fishes, squids, crustaceans and zooplankton indiscriminately (Collette, 2001). Studies from Indian waters also observed that the major component of *E.affinis* diet is fish followed by crustaceans and mollusks. In this study, we recorded small carangids, clupeoids and stolephorus (whitebaits) as major component among the fish followed by crustaceans and mollusks. The length-weight relationship ($W=a\ L^b$) explains the exponent 'b' in the parabolic equation. The value of 'b' usuallylies between 2.5 and 4.0, and for an ideal fish which maintains constant shape, b=3. The 'b' values from various region of Indian waters [16-20,22&40-42] and from Indian Ocean[43-45] were reported where the value of 'b' ranges from 2.5 (Silas et al., 1985) to 3.2 (Siraimeetan, 1985). The estimated 'b' value in this study was 2.91 which isalmost closer to 3 indicating the isometric growth.

Growth parameters L_∞, K and $t_0$were estimated by various workers. The value of L_∞ ranges from 72.5 in the Saurashtra coast (Shubhadeep *et al.*, 2010) to 87.5 in the east coast (Kasim and Abdussamad, 2003). The value of K showed wider range from 0.365/year (Silas *et al.,* 1985) to 1.5/year (Kasim and Abdussamad, 2003). The values obtained in this study were within the range

of earlier studies indicating *E. affinis* as a fast growing fish with longevity of 7.10 years. The exploitation ratio (E) is an index used to assess if a stock is overfished, on the assumption that optimal value of E is equal to 0.50. The 'E' of 0.83 is reported along east coast (Kasim and Abdussamad, 2003) indicating over exploitation of *E. affinis* stocks whereas the reports from Veravel coast (Shubhadeep *et al.*, 2010) and Indian waters (Prathibha *et al.*, 2012) indicates that the *E. affinis* stocks are under exploited with value of 'E' being around 0.36. In the present study the value of 'E' estimated was 0.294 which is less than 0.5 indicating that the *E.affinis* stocks in Andaman waters are underexploited. A similar value of 'E' was reported from Sri Lankan waters (Pauline and Janaka, 1970) who inferred that the *E affinis* stocks were not fully exploited. In the present study fishing mortality (0.32) is lesser than the natural mortality (0.77) which indicates the stocks of *E.affinis* are not under the pressure of biological overfishing. The estimated MSY for *E. affinis* was 2639 tons which is higher than the average annual landings of 1608 tons (80% of the average annual production), indicating that the stocks are within the safe limits. The stock assessment studies of *E affinis* for Indian Ocean shows that the stocks are approaching overfishing levels (Rishi *et al.*, 2012) though the author cautions about the reliability of the results due to lack of quality input data. Of the 600 fish stocks monitored by FAO globally, 52% are fully exploited, 17% are overexploited 7% are depleted and 1% are recovering from depletion (FAO, 2011) and in contrast, fish stocks in the EEZ of ANI are underexploited. In ANI the present harvest is only 25% of the potential. The results of this study indicate that the MSY of *E. affinis* is higher than the present harvest indicating that stocks are within safer limits. Any attempt of increasing the production of this species should be done judiciously due to the nature of multi gear multi species fishery. Another important aspect is that the average annual landing of oceanic tunas is about 200 tons, which is less than 0.5% of its potential. The fishery managers may consider focusing on exploiting the oceanic tuna resources to reduce the fishing pressure on coastal tuna stocks.

Conclusion

Tuna is the most dominant and internationally demanded resource. Since the Andaman Nicobar waters are blessed with rich tuna resources, any development of fisheries program in the islands should be centered on it. The reliability of output of any study greatly relies on the quality of input data and is applicable for this study also. One shortcoming in this study was the unavailability of species specific catch and effort data which we have tried address by certain assumption based on regular observations and interactions with fishermen. Scattered landing centers in the remote and distant islands, unsure landing times and unavailability of tunas in the catch all the days as it is not a prime target for fishermen are some other issues in performing stock assessment studies in the bay islands. This study indicates that the present exploitation level of little tuna stock is below MSY and scope is available to increase the fishing pressure. Collection of species specific fish catch and effort data employing standard statistical methods and conducting similar studies on the other species of coastal and oceanic tunas will help in better understanding of the dynamics and stock status of tunas in Andaman and Nicobar waters. The information generated in this study will help the fishery managers in the islands to plan the future course of actions for the development of island fisheries in a sustainable way.

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References

Anrose, A. Sinha, M. K. & Kar, A. B. (2009). Oceanic Tuna Resources Potential in Andaman & Nicobar Waters. *In*: *Proceedings of Brainstorming session on Development of Island Fisheries,* edited by Dam Roy S, Krishnan P, Kamal Sharma & Grinson George, Central Agricultural Research Institute. 5-22.

Chamchang, C. & Chayakul, R. (1988). Distribution of longtail (*Thunnustonggol*, Bleeker), kawakawa (*Euthynnusaffinis*, Cantor) and frigate tuna (*Auxisthazard*, Lacepede) in the western coast of the Gulf of Thailand. *Indo - Pac. Tuna Dev. Mgt. Programme,*IPTP/87/GEN/13. 80–88.

Chiampreecha, B. (1978). Biological studies on tuna and tuna-like fishes in the west of the Gulf of Thailand and off east coast of Peninsular Malaysia. *Pelagic Fish. Rep.,* (Marine Fisheries Division, Department of Fisheries, Bangkok). 25.

CMFRI. (2017). Annual Report 2016-17. Central Marine Fisheries Research Institute, 292.

Collette, B. B. (2001). Scombridae. Tunas (also, albacore, bonitos, mackerels, seerfishes, and wahoo), *In*: *FAO species identification guide for fishery purposes. The living marine resources of the Western Central Pacific*, edited by Carpenter, K. E. & Niem, V. (Vol. 6. Bony fishes part 4 (Labridae to Latimeriidae), estuarine crocodiles. FAO, Rome) 3721-3756.

De Vries, D. R. & Frie, R. V. (1996). Determination of age and growth. *In*: Fisheries techniques (2nd edition), edited by Murphy, B. R. & Willis, D. W. (American Fisheries Society, Bethesda, Maryland) 483-512.

FAO. (2011). Review of the state of world marine fishery resources, FAO Fisheries and Aquaculture Technical Paper No. 569 (FAO, Rome) 334.

Girish,K., Kunal, S. P. & Menezes, M. R. (2012). Low genetic variation suggest single stock of kawakawa, *Euthynnusaffinis*(Cantor, 1849) along the Indian Coast. *Turk. J. Fish. Aquat. Sc*., 12: 371-380.

James, P. S. B. R., Pillai, P. P., Jayaprakash, A. A., Pillai, N. G. K., Gopakumar, G., Kasim, H. M., Sivadas, M. & Said Koya, K. P. (1993) Fishery, biology and stock assessment of small tunas, *In*: *Tuna research in India*, edited by Sudarsan, D. & John, M. E. (Fishery Survey of India, Bombay, India) 123-148.

John, M. E., Bhargava, A. K., Varghese, S., Gulathi, D. K., Ashok, S. K. & Dwivedi, S. K. (2005) Fishery Resources of the Indian EEZ around Andaman and Nicobar Islands, *Bull. Fish. Surv. India.,*28.

Kasim, H. M. & Abdussamad, E. M. (2003) Stock assessment of coastal tunas along the east coast of India, *In*: *Proc. Tuna Meet,* edited by Somvanshi, V. S., Varghese, S. & Bhargava, A. K. 42-53.

Madhu, K., Rema, M., Ahlawat, S. P. S., Raveendran, E. K. & Dam Roy S. (2002). Status of exploitation of tuna, mackerel and seerfish in Andaman and Nicobar Islands. *In*: *Management of scombroid fisheries,* edited by Pillai, N. G. K., Menon, N. G., Pillai, P.P. & Ganga, U. (CMFRI, Kochi, India) 49-55.

Mitsuo,Y. (1989) Synopsis of biological data on kawakawa, *Euthynnus affinis. Indo-Pac.Tuna Dev. Mgt.Programme,* (IPTP/89/WP/19) 55.

Mudjekeewis, D. S., Grace, V. L. & Noel, C. B.(2010). A Pilot Study on the Genetic Variation of Eastern Little Tuna (*Euthynnus affinis)* in Southeast Asia. *Philipp J Sci.,* 139: 43-50.

Paul Pandian, P., Kar, A. B., Sinha, M. K., & Pattnayak, S. K. (2007). Observation on the distribution and abundance of tuna resources in the exclusive economic Zone (EEZ) of Andaman &Nicobar Islands. *In*: *National Symposium on Conservation and Valuation of Marine Biodiversity,*edited by the Director (Zoological Survey of India, Kolkata) 287-299.

Pauline, D. & Janaka, D. S. (1991). An assessment of Kawakawa (*Euthynnus affinis*) stock on the west coast of Sri Lanka. *Asian Fish. Sci.,*4: 219-226.

Pillai, N. G. K. & Abdussamad, E. M. (2009). Development of Tuna Fisheries in Andaman and Nicobar Islands. *In*:*Proceedings of Brainstorming session on Development of Island Fisheries,* edited by Dam Roy, S., Krishnan, P., Sharma, K. & George, G. Central Agricultural Research Institute, 23-34.

Pillai, P. P. & Gopakumar, G. (2003). Tunas. *In*: *Status of exploited marine fishery resources of India,* edited by Mohan, J. M. & Jayaprakash, A. A. (CMFRI, Kochi, India), 51-59.

Pillai, P. P., Pillai, N. G. K., Muthiah, C., Yohannan, T., Kasim, H. M., Gopakumar, G., Koya, K. P. S., Manojkumar, B., Sivadas, M., Nasser, A. K. V.,

Ganga, U., Dhokia, H. K., Kemparaju,S., Bhaskaran, M. M., Elayathu, M. N. K., Balasubramanian, T. S., Manimaran, C., Kunhikoya, V. A. & Ajith Kumar, T. T. (2002). Status of exploitation of coastal tunas in the Indian seas. *In*: *Management of Scombroid fisheries,* edited by Pillai, N. G. K., Menon, N. G., Pillai, P. P. & Ganga, U. (CMFRI, Kochi) 56-61.

Pradeep, H. D., Swapnil, S. S. & Kar, A. B. (2017) Estimates of length-based population parameters of the skipjack tuna, *Katsuwonus pelamis* (Linnaeus, 1758) in the Andaman waters. *Journal of Fisheries*. 5: 477–482.

Prathibha, R., Anulekshmi, C., Abdusssamad, E. M., Joshi, K. K., Said Koya, P., Sivadas, M., Shubhadeep, G., Margaret, M. R. A., Kemparaju, S., Dhokia, H. K., Prakasan, D. & Beni. N. Fishery and bionomics of the little tuna, *Euthynnus affinis* (cantor, 1849) exploited from Indian Waters. *Indian J. Fish.* 59: 33-42.

Ririk, K. S., Irwan, J. & Arief, W. (2014). Length Frequency Distribution and Population Parameters of Kawakawa (*Euthynnus affinis*) (Cantor, 1849) Caught by Purse Seine in the Indian Ocean (a Case Study in Northwest Sumatera IFMA 572). *IOTC* 04-20.

Rishi, S., Miguel, H. & Julien, M. (2012). Indian Ocean Neritic Tuna Stock Assessments (Kawakawa and Longtail): Using Surplus Production Models with Effort: An Observation Error Based Approach. *Second Working Party on Neritic Tunas, Penang, Malaysia, IOTC* 1-16.

Shubhadeep, G., Pillai, N. G. K. & Dhokia, H. K. (2010). Fishery, population characteristics and yield estimates of coastal tunas at Veraval. *Indian J. Fish*., 57: 7-13.

Silas, E.G. (1985). *Tuna fisheries of the exclusive economic zone of India: biology and stock assessment*. (CMFRI Bull., 36).

Siraimeetan, P. (1985). Fishery and Bionomics of tunas at Tuticorin. *In*: *Tuna fisheries of the exclusive economic zone of India:biology and stock assessment*, edited by Silas, E. G., (CMFRI Bulltin 36) 86-103.

Sivasubramaniam, K. (1970). Biology of the exploited stock of mackerel tuna *E. affinis* (Cantor) off the south-west region of Ceylon. *Bull. Fish. Res. Stn. Ceylon*, 21: 7-16.

Unpublished data. Directorate of Fisheries, A&N Administration, 2018.

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Novel Technique of Therapeutic Bloodletting used by a Folk Healer of South Andaman: A Short Communication

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Abstract

In Ayurveda, *Agni Karma* (thermal micro-cautery), *Kshara Karma* (caustic therapy), and *Raktamokshana* (bloodletting) are mentioned as para-surgical procedures. Among them, *Raktamokshana* (bloodletting) is an important procedure used to mitigate various ailments associated with vitiated blood (*Rakta-dushti*). Tools like a hollow horn (*Shringa*), dried hollow pumpkin fruit (*Alabu*), Cupping glass (*GhatiYantra*) and *Jalauka* (leech) have been reported for this procedure since ancient times. But, in the present era, *Ayurvedic* physicians mostly rely on leech therapy and venesection (*Sira-vedha*). Here, we are going to narrate a bloodletting procedure practiced by the folk healer of South Andaman using tools like glass Vial and *Bamboo*.

Key words: Bloodletting, Vial, *Vansha*, folk healer.

Introduction

In Ayurveda, bloodletting (*Raktamokshana*) has been mentioned under five bio-purificatory methods called as *Panchakarma (*Vaibhav et al., 2016). This ancient para-surgical procedure basically used in the diseases originated due to the vitiation of blood (*Rakta-dushti*). When the blood gets vitiated by an imbalance of *Tridosha* (three regulatory functional factors of the body*)*, bloodletting has been advocated in prescribed quantity by using tools like a horn (*Shringa*), leech (*Jaluka*) and hollow dried pumpkin (*Alabu*) respectively (Sushruta). Nowadays, though leech application is the commonest modality used for bloodletting followed by the venesection (*Sira-vedha*) with needles, syringe and scalp veins are also frequently practiced by *Ayurvedic* physicians. On the other hand, some tools that emerged from traditional practices of an individual always remain unexplored and limited to that specific indigenous community only. Even though, they are utilized to the restoration of health, diagnosis, and the treatment of physical and mental illness (WHO 2017). However, worldwide many organizations of different sectors are now working on the validation and documentation of such kinds of traditional healthcare practices.

Thus, it is a report on distinct tools utilized for the bloodletting by a folk healer whose forefather's belonged to Pegu district of Western Myanmar and were brought to Andaman by the Britisher's for forest timber operations during the year 1924-25 (Sharif et al., 2005). After Independence, they have been settled in nine villages of Mayabunder Block of Andaman and Nicobar Territory. We conducted a systemic interview of the folk healer with his prior consent. The requisite information was obtained by the observation of the actual bloodletting procedure. Undoubtedly, the procedure practiced by him shown remarkable resemblance with the classical Ayurvedic method of bloodletting but, the tools used in this procedure need special attention.

Material and Method

The team visited the Webi village of Mayabunder to conduct Health survey and provide health coverage to the populace organized by the AYUSH Wing, Directorate of Health Services, A and N Administration in 2015; and conducted a group interview and discussion with a well-known folk healer of this region.

Observations

The folk healer demonstrated the procedure of bloodletting on a 45-year male, suffering from swelling over the dorsum of the right foot and he had a history of an insect bite at the previous night (Fig.1). Initially, he did hot fomentation (like *pariseka* in Ayurveda) at the affected part by keeping the affected leg over the decoction pot for 15-20 minutes. And at the same time, he also put a glass vial (bottle) in the decoction pot for its disinfection (Fig.2). Then he took a single superficial linear incision (4-5 mm length) with a new blade (Topaz shaving double-sided blade) at the above site. Immediately after the incision he put the mouth of hot vial over it and covered it with a cloth soaked in cold water. It created a firm grip of vial on the skin and blood oozed out and collected inside the vial. Similarly, he also took another incision with the sharpened bamboo, and this time hallow Bamboo (*Vansha*) was used for the bloodletting procedure (Fig.3). At the end, he applied the pulp of *Aloe vera* (*Kumari*) over the incision sitefollowed byhot fomentation.

Discussion

The blood (*Raktadhatu*) and other bodily fluids are believed as 'humors' in *Ayurveda* and their state of equilibrium is essential for healthy individual.However, bloodletting is a para-surgical procedure conducted for withdrawal of blood in the unhealthy person to achieve the cure; and in a healthy person to prevent illness. It was the most common medical practice performed by physicians from antiquity till the late 19th Century (Bodley 2011).. In this procedure use of leeches (*Jalokacharan*) is quite common and its clinical efficacy has been reported in the eczema (Raval and Thak 2012) and arthritis (Rai et al., 2011) and also considered as unique therapy in other numerous diseases. Although, use of tools like horn (*Shringa*), hallow pumpkin (*Alabu*), and cupping glass (*Ghatiyantra*), etc. has been mentioned inancient classics but in present area *Ayurveda* physicians mostly rely upon the leech, and venous bloodletting. In most of the traditional procedure conducted by using a hallow object a negative pressure is created (by putting ignited wick anointed with oil inside the tool) which interns leads to vasodilatation and bleeding. This same principle of creating a vacuum and generating a negative pressure with fire cupping (Mukhopadhyay and Biswas 2015) is being utilized in various bloodletting procedures by different tribes (Anonymous 2018) across the globe. The particular procedure reported here is also based on the same principle, where the vacuum and negative pressure is generated by applying a cold cloth over hot Vial/Bamboo.

Conclusion

This report provides insight for the further research for utilization of said tools in a therapeutic bloodletting procedure. Also, systematic documentation of many other unexplored surgical and para-surgical procedures prevalent among folk healers is essential for their timely preservation, validation, and revitalization.

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Fig. 1. Site of the swelling

Fig. 2. Tools used for bloodletting

Fig. 3. Bloodletting

References

Ananoymus (2018). Tribal Healing practices. http://epgp.inflibnet.ac.in/epgpdata/ uploads/epgp_content/S000825CR/P001532/M018431/ET/1483519747Text.pdf. (accessed 20 May 2018).

Bodley, J.H. (2011). Cultural Anthropology: Tribes, states and the globes system .Lanham, MD, USA: Rowman& Littlefield Publishers; April 2011. https://rowman.com/ISBN/ 9780759118652/Cultural-Anthropology-Tribes-States-and-the-Global-System-5th-Edition# (accessed 30 December 2017).

Mukhopadhyay, R. & Biswas, M. (2015). The Science of Cupping Therapy- A Review. Indian Journal of Ethnophyto pharmaceuticals, 1(1): 12-15.

Rai, P.K., Singh, A.K., Singh, O.P., Rai, N.P. & Dwivedi, A.K. (2011). Efficacy of leech therapy in the management of osteoarthritis. 32(2): 213-217.

Raval, H.N & Thak, A.B. (2012). Role of Raktamokshana by Jalaukavacharana and Siravedhana in the management of Vicharchika (Eczema). 33(1): 68-72.

Sharif, M.U., Senthil Kumar, P.G. Diwakar & TVRS Sharma (2005). Traditional Phototherapy among Karens of Middle Andaman. Indian Journal of Traditional Knowledge, 4(4): 429-43.

Sushruta. Sushruta Samhita, Dallhan Nibandhasangrah Teeka. Varanasi: Chaukambha Orientalia; 5005.

Vaibhav, A., Antiwal, M., Singh, J.P. & Singh, O.P. (2016). Leech Therapy (Jalaukavacharana) in Ayurveda: A Scientific Review. International Journal of Pharmacy and Pharmaceutical Research Human, 6(4): 503-517.

WHO (2017). General Guidelines for Methodologies on Research and Evaluation of Traditional Medicine. http://apps.who.int/iris/bitstream/handle/10665/66783/WHO_EDM_TRM_2000.1.pdf; jsessionid = 48371 C69616 A35617D6 D67BBBD68C0D8 ?sequence=1(accessed 25 May 2017).

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Journal: Menon, A.G.K. & Talwar, P.K. (1972). Fishes of the Great Nicobar Expedition, 1966, with a description of a new gobioid fish of the family Kraemeriidae. *Records of Zoological Survey of India* 66(1-4): 35-61.

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