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Book Chapter: Mohan, P.M., Dhivya, P., Subburaman, S. & Sachithanandam, V. (2012a). Status of the benthos and its environment in Jolly Buoy Island, Mahatma Gandhi Marine National Park, Andaman, India. pp. 23-48. In: Ecology of faunal communities on the Andaman and Nicobar Islands, (Eds.) Venkataraman, K., Raghunathan, C. and Sivaperuman, C., Springer, Heidelberg.

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- S. Dam Roy
President

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Effect of bio-intensive complimentary cropping systems on crop yield, productivity, profitability and resource use efficiencies

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Abstract

A field experiment was conducted at Project Directorate for Cropping Systems Research, Modipuram for three years on sandy loam soil and laid out in randomized block design involving 10 cropping systems in three replications. Among various cropping systems maize (*Zea mays*L.)(cob) + vegetable cowpea (*Vigna sinensis* L.) on broad beds (BB) + sesbania (*Sesbania sesban*) in furrows – lentil (*Lens esculenta* L.) on BB + mustard (*Brassica juncea* L.) in furrows -green gram (*Vigna radiata* L.) for grain + residue on beds produced the highest rice equivalent yield (24.67 t/.ha/year) with productivity of 67.60 kg grain/ha/day and profitability of Rs. 547 /ha/day. Water use productivity of 591.3 kg grain/ha cm of water and nutrient use productivity of 61.7 kg grain/kg nutrient was also found to be highest in this system. On the other hand the water use productivity (78.4 kg grain/ha cm of water) was found to be lowest in rice (*Oryza sativa* L.)- wheat (*Triticum aestivum* L.) and nutrient use productivity (22.6 kg grain/kg) with sorghum (*Sorghum bicolor* L.) (grain) + cowpea (*Vigna sinensis* L.) (V)-oat (*Avena sativa* L.) (f)-pearlmillet (*Pennisetum typhoides* L.) (f)- cluster bean (*Cyamopsis tetragonoloba* L.)(V) system. Bio-intensive system, was also found to be remarkably better which resulted rice equivalent yield (22.83 t/ha/year) with productivity (62.55 kg grain/ha/day) and profitability (Rs. 514 /ha/day). The input energy was found to be in the range of 45218 to 100231 MJ/ha with highest in maize (*Zea mays* L.) +cowpea (*Vigna sinensis* L.) (f) – maize (*Vigna sinensis* L.) + black gram (*Vigna mungo* L.)– wheat+methi (*Trigonellafoenum-graecum*)(6:1)-green gram (*Vigna radiata* L.). The energy ratio was found to be highest (18.5) with sorghum +cluster bean (*Cyamopsis tetragonoloba* L.) (f)-maize (*Zea mays* L.) (Cobs)+black gram (*Vigna mungo* L.)(1:1)– methi (*Trigonellafoenum-graecum*)–cowpea (*Vigna sinensis* L.) (V+R) and (17.30) followed by sorghum (*Sorghum bicolor* L.) (grain) +cowpea (*Vigna sinensis* L.) (V)-oat (f)-pearlmillet (*Pennisetum typhoides* L.) (f)+cluster bean (*Cyamopsis tetragonoloba* L.) (V).

Key words: *Complimentary Cropping systems, Energy consumption, Nutrient use productivity, Rice equivalent yield*

Introduction

Improvement in productivity with input use efficiencies, reduction in cost of cultivation and creating gainful employment are considered very crucial in present day scenario of Indian agriculture. A concept of complementary intensive intercropping system was conceived to deal such issues (Gangwar, 1983). Further, due to continued fragmentation of land holdings, the average holding size of marginal farms reduced to 0.38 ha (2010-11). Therefore, the strategy needed to produce more output from less resource, especially to ensure high income by small and marginal farmers. Using various land configurations offers scope for growing more than two crops in association at the same time in the same piece of land. Moreover, we have to consider the soil health and also changing climate scenarios and to think of climate smart systems with enhanced biological productivity aims for more biomass productions both above and below ground (*Rizosphere)* from root biomass. Keeping these issues in mind the concept of "Bio-intensive complimentary cropping systems" was conceived by the senior author during 2008. Latter further refined considering emerging scenarios' in agriculture in developing countries. The concept of "Bio-intensive complimentary cropping system" was defined as growing of morphologically and physiologically different two or more than two crops in association under different land configurations which complements each other and subsequent crops on one hand and saves the resources on the other. Under such systems, not only the higher productivity and total biomass yield both above & below ground along with enhanced microbial activity could be achieved but a lot of resources could also be saved. As understood, the microbes play a very important role in such systems for improving the yield of crops, by improving soil health, more judicious use of water, nutrients, radiant energy may result in resource saving too. To study all these aspects the present study was undertaken.

Materials and methods

A field study was conducted during 2010 to 2013 at Project Directorate for Farming Systems Research (now IIFSR), Modipuram, Meerut involving ten bio-intensive complementary cropping systems along with land configurations, in-situ green manuring, residue incorporation, zero/minimum tillage and inter cropping. The soil of the experimental plot was sandy loam containing initial level of 125.4 kg/ha available nitrogen, 24.5 kg/haP_2O_5 and 126.2 kg/haK_2O. The treatments were laid out in RBD replicated three times. In control treatment (T_0), the crop of rice (*Oryza sativa* L.)-(Saket4) and wheat (*Triticum aestivum* L.) (PBW 343) were grown using conventional package of practices. Under treatment T_1, after harvest of hybrid rice (*Oryz asativa* L.)(PRH10)-wheat (*Triticum aestivum* L.) was grown in furrows while lentil (*Lens esculenta* L.) (Pant lentil4) grown on ridges using FIRB system. In treatment $T_{2,}$ the broad bed and furrow system (BBF) was adopted. On broad beds (105 cm width), maize (*Zea mays* L.) hybrid (Ankur56) for cobs was sown at the spacing of 70x20 cm and a row of vegetable cowpea (*Vigna sinensis* L.) (Gomti) was grown in between two rows of maize while *sesbania* (*Sesbania sesban*) was grown in furrows (30 cm wide) and was incorporated after 32 days after sowing during *kharif*. Three pickings of vegetable cowpea (*Vigna sinensis* L.) were taken and foliage harvested alongwith maize green straw for feeding to cattle. In *rabi,* mustard (*Brassica juncea*L.) (Pusa bold) was grown in furrows, while three rows of lentil (*Lens esculenta* L.) (Pusa lentil 4) were grown at 30 cm in rows on beds using minimum tillage. In summer, 3 rows of green-gram (*Vigna radiata* L.) (SML 668) at 30x10 cm were sown on beds with zero till machine for grain + residue incorporation and the furrows were used for light irrigations. In sequence T_3, maize (*Zea mays* L.)Ankur 56 for (grain) + blackgram (*Vignamungo* L.)(Pant urad 35) for grain in *kharif* while in *rabi*, furrow irrigated raised beds were used for growing vegetable pea (*Pisum sativum* L.) (Arkel)-green gram (*Vigna radiata* L.)(SML 668) in summer for grain and green residue incorporation.

In T_4, between two rows of maize for cobs;one row of sesbania(*Sesbania sesban*) was grown in *kharif* and incorporated after 32 days after sowing. In *rabi,*toria (*Brassica napus*) (Type 9)was sown and gobhisarson(*Brassica napus*) hybrid(Hyola-401) was transplanted between the two rows of toria in the month of December. In summer, green gram (*Vigna radiata* L.) (SML 668) was sown for grain. After harvesting of pods, the residue was incorporated. In treatment $T_{5,}$ sorghum(*Sorghum bicolor* L.)(Kanpuri) + cluster bean (*Cyamopsis tetragonoloba* L.) (Gayatri 71) for fodder was grown in *kharif* and maize (cob) + black gram was sown in August. After its harvest in last week of November methi (*Trigonellafoenum-graecum*) (Kasuri) was sown first week of December. While in summer, vegetable cowpea (Gomti) was grown and foliage incorporated in the soil. In T_6, pigeonpea (*Cajanuscajan* L.) (UPAS 120) + blackgram (*Vigna mungo* L.) (Pant urd 35) was sown in June (*kharif*) followed by wheat (PBW 226) sown in last week of December and cowpea fodder using zero till approach in summer. In T_7, pigeonpea (Cajanus cajan L.) was sown in *kharif*, late sown wheat (*Triticumaestivum* L.) + methi (*Trigonellafoenum-graecum*)in *rabi* and cowpea fodder raised using zero till in summer.In treatment T_8,maize (*Zea mays* L.) + cowpea (*Vigna sinensis* L.) for fodder was grown in *kharif* and after its harvest, maize (cob) + black gram was sown in the month of August. In summer, vegetable cowpea was taken and foliage incorporated in the soil. In treatment T_9, sorghum (*Sorghum bicolor* L.)(CSH 16) + vegetable cowpea during *kharif*, oat (Kent) during *rabi* and pearl millet for fodder + vegetable cluster bean (Gayatri 71) were included in the study. The details of packages used in different systems are described in (Table.1)

The prevailing rates of different crops were used to calculate the rice equivalent yield (REY). The system productivity and profitability was calculated by dividing REY and net returns by 365. The irrigation system productivity was calculated by dividing the crop equivalent yield by the total amount of irrigation water was used to grow the crop(Katyal and Gangwar2011). Similarly, nutrient use productivity was calculated by dividing the rice equivalent yield by the total quantity of nutrients used in the cropping system. The energy production and specific energy under different cropping systems were calculated using the procedures as described by (Gopalan*et al*. 1978).

Results and Discussion

Equivalent yield, system productivity and profitability

Raising of maize for cobs + vegetable cowpea in 1:1 ratio on broad beds (BB) and sesbania in furrows during *kharif* and mustard in furrows and 3 rows of lentil on broad beds in *rabi* while 3 rows of green gram on beds in summer was found to be highest yielder of 24.67 t/ha/year as rice equivalent with productivity of 67.60 kg grain/ha/day and profitability of Rs. 547/ha/day (Table 1). Bio-intensive system of raising maize + cowpea (for fodder) during *kharif*- maize (cobs) + black gram as late (August) - wheat + methi in 6:1 ratio during *rabi* and green gram in summer was also found to be remarkably better which resulted in 22.83 t/ha/year rice equivalent yield with productivity of 62.55 kg grain/ha/day and profitability Rs. 514/ha/day (Table 2). This system provided to be second best in the order of merit. The complimentary effects in the system reflected due to broad bed and furrow (BBF) system of land configuration, the furrows served as drainage channels during heavy rains in *kharif* which were utilized for *in-situ* green manuring with 35 t/ha green foliage incorporated after 35 days of sowing and then mustard was timely sown in these furrows and a bonus yield of lentil intercropped with mustard could be harvested. Besides the yield advantage, around 40% of irrigation water could be saved as applied only in furrows. In summer, harvest of green gram pods for grain while incorporation of its green foliage of about 8 t/ha in the soil further helped the system favourably (Table 3).

Water use productivity and nutrient use productivity

Water use productivity591.3kg grain/ha cm of water and nutrient use productivity61.7 kg grain/kg) nutrient (Table 2) was found to be highestinmaize (C) +vegetable cowpea (BB)+Sesbania (F)-lentil(BB)+mustard(F)-green gram (G+R) system indicating efficient utilization both to applied nutrient and water. Water use productivity 78.4 kg grain/ha cm of water was found to be lowest in rice-wheat and nutrient use productivity 22.6 kg grain/kg was found to be lowest with sorghum (G) + cowpea (V) -oat (f)-pearl millet(f) + cluster bean (V) system (Table 4).

Energy consumption and output

The input energy required for production was found to be in the range of 45218 to 100231 MJ/ha with highest in maize+cowpea (f)-maize+blackgram–wheat+methi (6:1)-green gram (G+R) and lowest in maize (G) +black gram (1:1)-vegetable pea (FIRB) +mustard (F)-green gram (G+R). However, the specific energy 2.08 MJ/kg (i.e energy required to produce one kg of grain) was found to be lowest in maize(C)+vegetable cowpea (BB)+*Sesbania*-lentil(BB)+mustard(F)-greengram(G+R) and highest with sorghum (G) + cowpea (V) -oat (f)-pearl millet(f)+ cluster bean (V).The energy ratio was found to be highest(18.5)with sorghum+cluster bean (f)-maize(C)+black gram (1:1)-methi-cowpea (V+R) and 17.30 followed by sorghum(G)+cowpea (V)-oat (f)-pearl millet(f)+ cluster bean (V) (Table 4).

The present study conclusively revealed that under small and marginal farming situations the bio-intensive complementary cropping systems may result in highly significant increase in productivity and profitability on one hand and save the resources upto 50% on the other. However, deserves further investigations under both inorganic and organic situations at various locations.

Table1. Details of package of practices used for different crops

Tret.	Kharif	Pre rabi	Rabi	Summer
	Crop, Variety, Duration and Fertilizer dose (kg/ha) used			
T0	Rice, Saket 4, 115 (120:60:40:25)	-	Wheat, PBW 343, 150 (120:60:40)	-
T1	Hybrid rice,PRH 10, 115 (150:60:40:25)	-	Lentil, Pusa lentil 4, 135 Wheat, PBW 343, 150 (120:60:40)	Cowpea, Gomti, 75 (20:50)
T2	Maize (Cob) , Ankur-56, 100 (120:60:40) Vegetable cowpea, Gomti, 100 Sesbania, Local, 35	-	Lentil, Pusa lentil 4, 135 Mustard, Pusa bold, 135, (20:60:30)	Green gram, SML 668, 75 (20:50)
T3	Maize (Grain), Ankur-56, 120 (120:60:40) Black gram, Pant Urd 35, 75	-	Vegetable pea, Arkel, 70 Mustard, Pusa Bold, 135, (20:60:30)	Green gram, SML 668, 75 (20:50)
T4	Maize(Cob) , Ankur-56, 100 (120:60:40) Sesbania, Local, 35	Toria, T 9, 90, (60:60:40) GobhiSarson, Hyola-401(Hybrid), 140	-	Green gram, SML 668, 75 (20:50)
T5	Sorghum (f), Kanpuri, 60, (80:40) Cluster bean, local, 60	Maize(Cob), Ankur-56, 100 (120:60:40) Black gram, Pant Urd, 35, 75	Methi, Kasuri, 135, (25:25:50)	Cowpea, Gomti, 75 (20:50)
T6	Pigeonpea, UPAS 120, 120, (20:80:40) Black gram, Pant Urd 35, 75	-	Wheat, PBW 226, 135, (120:60:40) Mustard, Pusa Bold, 135	Cowpea (f), Local, 75, (20:50)
T7	Pigeonpea, UPAS 120, 120, (20:80:40)	-	Wheat, PBW 226, 135, (120:60:40) Methi, Kasuri, 135	Cowpea (f), Local, 75, (20:50)
T8	Maize (f), local, 65, (60:40) Cowpea (f), local, 65	Maize (Cob), Ankur-56, 100 (120:60:40) Black gram, Pant Urd 35, 75	Wheat, PBW 226, 135, (120:60:40) Methi, Kasuri, 135	Green gram, SML 668, 75 (20:50)
T9	Sorghum(Grain), CSH 16, (100:50:40) vegetable cowpea, Gomti, 100	-	Oat (f), Kent, 120, (90:40)	Pearl millet (f), local, 60, (100:40:30) vegetable cluster bean, Gayatri 71, 90 (60:40:30)

Table 2.Crops yield (t/ha.) as influenced by cropping systems grown in varying management configurations

Treatment/crops grown				Actual yield (t/ha)															Ave. of 3 years REY (t/ha)
				Ist Year(2010-11)				REY (t/ha)	IInd Year (2011-12)				REY (t/ha)	IIIrd Year (2012-13)				REY (t/ha)	
Kharif	Pre *rabi*	*Rabi*	Summer	*Kharif*	Pre *rabi*	*Rabi*	Summer		*Kharf*	Pre *rabi*	*Rabi*	Summer		*Kharf*	Pre *rabi*	*Ravi*	Summer		
T0-Rice	-	Wheat	-	5.11		4.16		9.96	5.00		6.28		13.26	5.11		5.17		11.26	11.49
T1-Hybrid rice	-	L (B)+W (FIRB)	Cowpea (V+R)	6.33		0.72+ 2.98	0.79	13.74	6.11		0.16+ 3.16	1.92	15.10	6.28		0.18+5.05	0.76	13.89	14.24
T2-Maize(C) +Veg. Cowpea (BB) +Ses. (F)	-	L(BB)+Mu (F)	Green gram (MT) (G+R)	8.61+ 0.60		1.35+ 1.84	1.59	21.86	10.22+0.92		1.47+ 2.02	1.25	24.60	10.94+1.08		1.33+2.00	1.66	27.56	24.67
T3-Ma (G)+Black gram (1:1)	-	Veg. pea (FIRB)+Mu (F)	Green gram (G+R)	2.72+ 0.37		1.03+ 1.86	1.43	21.57	2.50+0.51	-	0.58+2.05	1.11	15.37	2.33+ 0.45	-	0.83+0.94	1.60	15.11	17.35
T4-Ma (C) +Sesbenia.	Toria+Gobhisarson(TPT)		Green gram (ZT) (G+R)	8.72	1.17+ 1.05		1.63	16.62	10.44	0.80+ 0.67		1.08	16.12	11.67	1.39		1.54	20.30	17.68
T5-Sorgum+C. bean (f)	Maize(C) + B. gram (1:1)	Methi	Cowpea (V+R)	38.33	7.72 + 0.37	0.75	0.77	11.49	37.38	10.44+ 0.42	2.33	1.94	17.84	23.94	12.67+0.44	2.28	0.74	23.94	17.76
T6-P. pea+B. gram (1:1)	-	W+Mu (6:1) (ZT)	Cowpea (f) (ZT)	1.96+ 0.37		4.38+ 0.86	25.00	18.30	1.40+ 0.43		5.38+ 0.08	25.00	16.32	15.38		4.61+0.08	23.34	15.38	16.67
T7-Pigeonpea	-	W+Methi (6:1)(ZT)	Cowpea (f) (ZT)	1.78		4.21+ 0.42	28.00	15.76	1.79		5.11+ 0.06	21.94	15.49	1.80		4.53+0.07	26.27	14.84	15.36
T8-Ma+Cowpea (f)	Maize(C) + B. gram	W+Methi (6:1)	Green gram(G + R)	25.83	7.83 + 1.04	4.05+ 0.39	1.36	20.87	22.33	6.39+ 0.46	5.83+ 0.05	1.00	24.24	27.66	11.72+0.36	4.50+0.2	1.33	23.38	22.83
T9-So(G) + Veg. Cowpea CD (P=0.05)	-	Oat (f)	Pearl millet(f) + veg. C. bean	1.17 + 1.40		31.66	31.6+ 0. 25	6.55	2.35+ 0.88		51.67	46.38+ 0.33	11.15	2.50+ 2.17		52.78	47.40	15.47	11.06 5.13

L: lentil, V:vegetable, R: Residue, C: Cobs, Mu: Mustard, F:Furrow, BB: Broad Bad, Ma: Maize, G: Grain, Ses: Sesbania, ZT: Zero Till, So: Sorghum, C. bean: Cluster bean, W:Wheat, f: fodder

Table 3.Effect of bio-intensive complementary cropping systems on higher productivity and profitability under different systems as alternative to rice-wheat (pooled of 3 years)

Treatment	REY (t/ha)	Productivity (kg/ha/day)	Net returns (Rs./ha)	Profitability (Rs./ha/day)
Rice-wheat	11.49	31.49	84406	231
Hybrid rice-lentil (B)+wheat (FIRB)-cowpea (V+R)	14.24	39.01	109909	301
Maize(C)+vegetable cowpea(BB)+sesbania (F)-lentil(BB)+mustard(F)-green gram (MT) (G+R)	24.67	67.60	199482	547
Maize (G)+black gram (1:1)-vegetable pea (FIRB)+mustard (F)-green gram (G+R)	17.35	47.53	102054	280
Maize (C)+sesbania -toria+gobhisarson(TPT)- green gram (ZT) (G+R)	17.68	48.43	121978	334
Sorghum+cluster bean (f)-maize(C)+black gram (1:1)-methi-cowpea (V+R)	17.75	48.64	131020	359
Pigeonpea+black gram (1:1)-wheat+mustard (6:1)(ZT)-cowpea (f) (ZT)	16.67	45.66	138806	380
Pigeonpea-wheat+methi (6:1)(ZT)-cowpea (f) (ZT)	15.36	42.09	129455	355
Maize+cowpea (f)- maize(C)+black gram- wheat+methi (6:1)-green gram(G+R)	22.83	62.55	187695	514
Sorghum(G) + vegetable cowpea -oat (f)-pearl millet(f)+vegetable cluster bean	11.06	30.29	53828	147
CD (P=0.05)	5.13	14.06	55425	152

Note: MT (Minimum tillage), ZT (Zero tillage)
L: lentil, V:vegetable, R: Residue, C: Cobs, Mu: Mustard, F:Furrow, BB: Broad Bad, Ma: Maize, G: Grain, Ses: Sesbania, ZT: Zero Till, So: Sorghum, C. bean: Cluster bean, W:Wheat, f: fodder

Table4.Irrigation water use productivity, nutrient use productivity, energy consumption and output underdifferent bio-intensive cropping systems(pooled of 3 years)

Treatment	IWUP (kg grain/ha cm of water)	NUP (kg grain/ kg nutrient)	Input energy (MJ/ha)	Output energy (MJ/ha)	Energy ratio	Specific energy (MJ/kg)
Rice-wheat	78.42	24.72	77321	330110	4.27	6.82
Hybrid rice-lentil (B)+wheat (FIRB)-cowpea (V+R)	84.59	24.34	67796	666636	9.84	4.77
Maize(Cob)+vegetable cowpea(BB)+sesbania (F)-lentil(BB)+mustard(F)-green gram (MT) (G+R)	591.25	61.68	51105	591159	11.58	2.08
Maize (G)+black gram (1:1)-vegetable pea (FIRB)+mustard (F)-green gram (G+R)	477.70	38.55	45218	345505	7.64	2.68
Maize (C)+sesbania-toria+gobhisarson(TPT) green gram (ZT) (G+R)	323.03	39.28	82577	521204	6.40	4.69
Sorghum+cluster bean (f)-maize(Cob)+black gram (1:1)-methi-cowpea (V+R)	237.09	32.28	62260	1151793	18.50	3.84
Pigeonpea+black gram (1:1)-wheat+mustard (6:1) (ZT)-cowpea (f) (ZT)	370.37	38.76	58883	554381	9.42	3.54
Pigeonpea-wheat+methi (6:1)(ZT)-cowpea (f) (ZT)	341.41	35.73	57110	547385	9.59	3.72
Maize+cowpea (f)-maize(Cob)+black gram-wheat+methi (6:1)-green gram(G+R)	331.53	32.16	100231	872642	8.71	4.41
Sorghum(G)+vegetable cowpea-oat (f)-pearl millet(f)+vegetable cluster bean	197.43	22.56	79370	1373324	17.30	8.12

Note: IWUE- Irrigation Water use productivity, NUE- Nutrient use productivity, MT- Minimum tillage, ZT- Zero tillage and TPT- Transplanting technology
L: lentil, V:vegetable, R: Residue, C: Cobs, Mu: Mustard, F:Furrow, BB: Broad Bad, Ma: Maize, G: Grain, Ses: Sesbania, ZT: Zero Till, So: Sorghum, C. bean: Cluster bean, W:Wheat, f: fodder

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Integrated Farming System for enhancing farm income in rainfed lowlands of Andaman Islands

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Abstract

For crop + dairy based system, total farm production increased from 10 MT in 2013 to 26.8 MT in 2018 in an area of 0.75ha. The increased farm production is mainly by diversification and intensification of cropping system through the inclusion of crops like pulses, vegetables, sorghum, maize during dry season after harvesting of rice, land manipulation facilitated round the year vegetable cultivation in raised beds. The integration of dairy component in 2014 resulted in sudden spike in total production resulted in increased net returns from ₹.92355/- to ₹.217450 from an area of 0.75ha during the same period indicating that the diversification of crops and integration of different farm enterprises provides an opportunity for the farmers to increase yield and productivity per unit area thus doubling the farm income.

Keywords: *Alternative farming, coastal lowlands, crop diversification, IFS, tropical islands*

Introduction

The agriculture in Andaman Islands is characterized by mixed farming with predominance of crop and livestock components. The agriculture is predominantly rainfed and no permanent irrigation facilities are available. In coastal lowlands and valley plains rice is the only crop grown during wet season because of high rainfall and water stagnation due to poor drainage facilities. During dry period, the crop cultivation is limited by scarcity of water and in some places farmers are growing vegetables, pulses like green gram using limited water resources in fresh water streams. Because of poor management practices the crop productivity is very low in these areas. Among the livestock, dairy cattle and backyard poultry were the major contributors of farm income especially among the small and marginal farmers. The productivity of animals was comparatively low due to climatic stress, unavailability of quality fodder during dry season etc. The total farm income is only Rs 35 to 40000/- per ha/ year. In this regard, Integrated farming system (IFS) is only possible way out to increase the farmer's income and also fulfill the need for increasing food production to feed the growing population. In IFS, all agricultural enterprises including animal husbandry, fishery, bee keeping, goat rearing, cropping systems, fruits, vegetable and others are set up into a single unit of land and hence better recycling of resource or input occurs ultimately increasing the farmer's income (Choudhary *et al*.2019). The judicious mix of two or more components based on cardinal principles of minimum competition and maximum complementarity with advanced agronomic management practices which aimed at sustainable and environment friendly improvement of farm income, family nutrition and ecosystem services is defined as integrated farming system (IFS). The preservation of bio-diversity, diversification of cropping/farming system and maximizing recycling is the base for success of the farming systems approach (Singh and Ravisankar, 2015).

To achieve doubling farmer's income might require novel strategies and some change in the policy stance. The income enhancement of farmer can be achieved by increase in productivity of crops, increase in production of livestock, improvement in input use efficiency to reduce cost, increase in farm level cropping intensity, diversification towards high value commodities, better remunerative price realized by farmers, and shifting surplus labour (unproductive) from agriculture to nom-farm activities, all of which could only be possible through government initiatives, technology generation and dissemination besides policies and reforms in agriculture sector (Ponnusamy and Kousalya Devi 2017). Integrated farming system provides the scope for achieving many of the proposed strategies like increasing production, productivity, cropping intensity, crop diversification and efficient input use through resource recycling. Several studies were conducted in coastal lowlands for successful implementation of IFS strategies. In coastal lowlands, raised bunds are made around the rice fields to hold water for longer periods and to avoid over-flowing of flood water and a suitable fish refuge/trench system for successful rice-cum-fish farming (Velmurugan et al. 2015). In shallow lowlands, 500 to 700 kg/ha of fish or prawn and 5 to 6 t/ha of rice can be obtained under such mixed systems, while it is possible to increase the production of fish/ prawn to 2000 kg ha^{-1} in deepwater situations where water remains in the field for longer period. Vegetables and horticultural crops on raised bunds around the field with the soil excavated from the trenches further increase the land productivity to a great extent (Sinhababu and Venkateswarlu, 1998). The net income from tuber crop based farming system in tribal areas of Little Andaman in 0.2 ha, increased the net income to Rs 1, 32,820 from Rs.42,200 with the B: C ratio of 2.08 and employment generation up to 510 man days/ha as compared to 295 man days/ha in their traditional system (Domodaran et al.2015). By integrating livestock into a crop based farming increases the financial benefits and better use of farm resources such as manure and crop residues (Schiere *et al*., 2002 and Nedunchezhiyan, 2016). As there is greater scope for increasing the farm production and income, studies were conducted by crop diversification and its integration with other farm enterprises to enhance the farmer's income under rainfed lowland conditions.

Experimental set up

The study was conducted during 2010 to 2018 in an area of 0.75 ha at Field Crops Research Farm, Bloomsdale of ICAR- Central Island Agricultural Research Institute, Port Blair. The broad bed and furrow (BBF) system to grow vegetables on the beds and rice-fish in the sunken furrows was done in 0.30ha and in the remaining area of 0.35ha, different rice based cropping systems viz., rice (*Oryza sativa L.*) – maize (*Zea mays L.*), rice (*Oryza sativa L.*)- green gram (*Vigna radiata)*, rice (*Oryza sativa L.*) – sorghum (*Sorghum bicolor*) and rice (*Oryza sativa L.*) – vegetables (okra/brinjal/cowpea) were followed. The dairy component was integrated in 2014 by inclusion of 2 numbers of HF cross bred heifers. Fresh water cat fish such as singhi (*Heteropneustes fossilis*) and magur (*Clarias batrachus*) were introduced in the furrows and composting was done for residue recycling.

Economic evaluation

Economic evaluation was made based on observations on productivity in terms of rice–grain equivalent yield, net returns, cost of production, and employment generation from different farm enterprises and for the farming system as a whole.

Results and discussion

The inclusion of different components with diversified species of crops viz., rice, pulses, oilseeds, vegetables in the cropping system and integrating other farm enterprises like dairy and fishery in an area of 0.75 ha in coastal low lands not only increased the overall farm production but production of diversified food items resulted in achieving food and nutritional security of the household. The analysis revealed that the IFS model improved the total farm production and enhanced the livelihood security of marginal and small farmers. The total farm production during the same period increased from 10 MT in 2013 to 26.8 MT in 2018.This increase was mainly by integration of livestock component which contributed around 50% of total farm production followed by vegetable production in BBF system which enabled the crop diversification and increased cropping intensity. Wide variations were observed in performance of crops especially rice based cropping systems. During last two years the productivity of rice based cropping system was lowered due to more than 70% loss in rice caused by pests especially gundi bug *(Leptocorisa oratoria*) and birds during milky and grain filling stages. Eventhen, system stability was achieved by livestock component which alone contributed more than 50% of the total farm production after its integration.

Table 1.Physical production of different components of farming system model over the years

Cropping Systems/components	Total production (Rice Equivalent Yield kg)					
	2013	2014	2015	2016	2017	2018
Rice - Maize	866	575	749	939	985	606
Rice- sorghum	1033	637	933	1024	1309	873
Rice - Black gram	604	491	440	194	356	410
Rice - vegetable	1090	2895	3874	1229	1607	1627
Okra-radish-cucumber	1459	2046	1753	1496	1694	724
Amaranth- okra- brinjal	1312	905	1065	1349	925	1330
Okra-French beans-Bottle gourd	1853	2202	1411	1464	854	1044
Brinjal-brinjal-Bottle gourd	1419	687	1633	1642	495	1533
Fodder	0	1089	1786	1703	645	606
Furrows (rice)	438	311	345	256	290	286
Total (Crops)	10074	11837	13988	11296	9160	9031
Dairy	0	12187	13633	16348	16256	16388
Fisheries	0	240	0	194	240	171
Compost	0	1672	2370	1325	1226	1230
Total	10074	25937	29991	29162	26882	26829

This increase in farm production also led to rice in net farm income from Rs. 92355 /- in 2013 to Rs. 217450 /- in 2018. However, the major issue is increase in variable costs from Rs.57000/- to Rs.1.98 lakhs in 2018 during the same period(Fig 1). The total variable costs are inclusive of labour charges (44%) and recycled products (30%) within the system. Only 26% of the costs are accounted for inputs purchased from outside the system mainly of concentrated feed for the dairy animals, fertilizers, pesticides, seed costs and hiring charges of tractor and other farm machinery. So the actual expenditure will be Rs.51480/- for an income of around Rs.2 lakhs if family labour is engaged and wastes are efficiently recycled within the system.

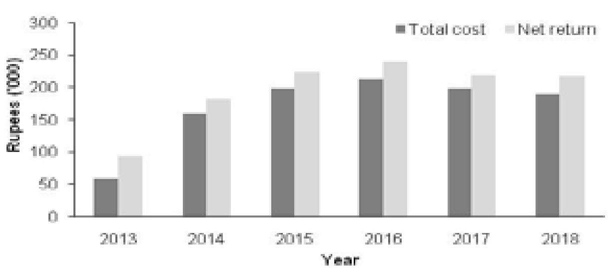

Fig. Total running cost and net income from 0.75 ha IFS model

The livestock components had contributed 60% of the total net income and 32.5% by crops. The system had generated total employment of 365 man days in a year with mean monthly employment generation of 30 man days. As expected highest share of employment or labour requirement is from dairy unit (56%) and it is spread throughout the year. It is followed by crops accounting 40.9% of labour requirement. Unlike, dairy component, the labour requirement is concentrated in few weeks of a season mainly for transplanting or sowing, weeding, harvest and threshing. Among, the crop component the vegetable cultivation in BBF is labour intensive unlike rice based cropping system where the work load is only seasonal.

Conclusions

The crop diversification and integration of livestock component in a mixed farming system model provides an opportunity for the marginal and small farmers to increase the farm production and total farm income from the same piece of land. The integration of livestock component proves to be more effective in increasing the farm income than crop diversification alone. Thus farmers can realize the doubling of their income within a contemplated period of five years by adopting mixed farming system. However, the heavy investment in the initial years and non-availability of labour were observed as the major constraints in adopting integrated farming system.

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Evaluation of *Morinda citrifolia (Noni)*, *Azolla pinnata* and *Andrographis panniculata (Kalmegh)* as herbal tonics in indigenous Nicobari fowl

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Abstract

A study was carried out to evaluate the efficacy of *Andrographis panniculata (Kalmegh), Morinda citrifolia* and *Azolla pinnata* on serum biochemical parameters in Nicobari fowl. Experiment I comprised of treatments with supplementation of Morinda juice in water @ 5 ml per bird per day, Azolla dry powder in feed @ 3 g per bird per day and Growiplex (Vitamin B complex tonic) in water in comparison with control birds. The SGOT (Serum glutamic oxaloacetic transaminase) level was significantly (P< 0.01) higher with supplementation of *Morinda* juice as water supplement @ 5 ml per bird per day. Significantly (P<0.01) higher level of total serum bilirubin was observed in Morinda juice, Azolla and Groviplex supplementation. All herbal supplementation groups had significantly (P<0.01) reduced the serum cholesterol level by 13% as compared to control group. Herbal supplementation did not have significant effect on the serum glucose. In the experiment II with Kalmegh, both water and feed supplement had significantly (P<0.01) lowest serum cholesterol (reduction of 23% and 26% respectively) on seventh day of supplementation as compared to control birds. The SGOT was significantly (P<0.01) reduced by 15% on third day supplementation of kalmegh in water. Serum glucose was significantly reduced on fifth day of supplementation of kalmegh as both feed and water supplement and it was sustained till seventh day of supplementation. The bilirubin level was significantly (P<0.01) reduced by 16% on fifth and seventh day of supplementation in both water and feed. Supplementation of *Andrographispanniculata*as water supplement in Nicobari fowl significantly increased the levels of haematinic mineral iron and immunity enhancing minerals.

Key words: *Nicobari fowl, Noni, Azolla, Kalmegh, Serum Biochemical profile, herbal tonics*

Introduction

The poultry industry is one of the most leading agribusiness trades in the world. Feed supplements in poultry production has significant role to improve the productivity of poultry among which antimicrobial compounds are commonly included in poultry diets for promoting growth and to control diseases. The ban for antibiotics as growth promoters by the European Union in 2006 and keeping in view of consumers' food safety and security, the research is now shifted towards the alternative feed supplements and organic additives/ plant-based compounds/extracts as herbal growth promoters. It has been well proven that the use of herbal supplements improves the growth, production, immunity and several other beneficial effects in poultry (Narimani-Rad *et al*., 2011;Sunder*et al.*, 2011) through action of many different bio-active ingredients such as alkaloids, bitters, flavonoids, glycosides, mucilage, saponins and tannins (Wang *et al*., 1999).Medicinal plants are basically involved in a cascade of physiological reactions, that in turn lead to the alteration of haematological and serum biochemical parameters (Ewuola and Egbunike, 2008). The level of stress poultry undergoes while taking herbal medicines must be evaluated in terms of lowering or elevating the haematological and biochemical values. Growth and production depends on metabolism that is best assessed by biochemical profile. Those values must be maintained within the r1eference ranges for chickens (Mitruka and Rawnsley, 1977).

Morinda citrifolia var. *citrifolia,* popularly known as Noni is a member in the diversified medicinal plants of A & N Islands. In Andaman & Nicobar Islands, the plant is mainly found in the Nicobar group of islands and is one of the most significant shrubs of traditional medicines among Nicobari tribes of these Islands (Sunder *et al*., 2007). All the components of this plant are utilised to prepare alternative and herbal medicines for human ailments (Solomon 1999). Due to its wide range of health benefits and therapeutic value, the studies on the effect of feeding of crude fruit extract to Nicobari fowl and broilers have been carried out(Sunder et al., 2007 and 2011). Nitrogen fixing aquatic fern, *Azolla*has improved the humoral and cellular immunity of the Nicobari fowl (Kannaiyan and Kumar, 2005, Sujatha*et al.,* 2013). Similarly, *Andrographi spanniculata* (AP), a shrub found throughout Southeast Asia is a well known medicinal plant as an immune system booster and for treating sore throat, flu and upper respiratory tract infections. However, the biological effect of *Morinda citrifolia*, *Azollapinnata* and *Andrographis panniculata* on biochemical characteristics in chicken is to be cleared even though already few works had been carried out in rats and other species (Mani Saminathan *et al.,* 2014). Hence, experiments were carried out to study the efficacy of *Morinda citrifolia*, *Azollapinnata* and *Andrographis panniculata* on serum biochemical parameters in the Nicobari fowl of A&N islands.

Materials and Methods

Preparation of herbs: Azolla was cultivated, harvested, dried under sun and dried. Morinda juice was prepared as per the protocol (Sunder *et al.,* 2011).

Experiment I

Forty eight Nicobari fowls of same hatch at 40 weeks of age were randomly subjected to each of four treatmentsviz., **T_1:** Supplementation of Morinda juice in water @ 5 ml per bird per day; **T_2:** Supplementation of Azolla powder in feed @ 3 g per bird per day; **T_3:**Supplementation of Growiplex in water; **T_4 (Control):** No supplementation. Each treatment comprised of twelve birds with three replicates of four birds per replicate. Birds were under treatment for 10 days under deep litter system.The common layer feed contained 2600 Kcal of ME kcal / kg of feed with dietary crude protein levels of 18 per cent. The ingredient and nutrient composition of layer feeds are presented in Table 1.



Table 1. Per cent composition of Basal layer ration (Feed)

Sl.No	Ingredients	Per cent
1	Yellow Maize	49.00
2	Broken rice	4.00
3	Cumbu/Bajra	5.00
4	De-oiled rice bran	4.50
5	Wheat bran	2.00
6	Sunflower oil cake	3.50
7	Soybean oil cake	19.50
10	Dry fish	5.20
11	Mineral mixture*	2.00
12	Di-calcium phosphate	0.29
13	Shell grit	5.20
	Total	**100**
	Per cent nutrient composition	
1	**Crude protein (%)***	17.85
2	**Calcium (%)***	3.12
3	**Total phophorus (%)***	0.58

Biochemical parameters: Two milliliters of blood was collected from all birds at the 10th day of experiment and serum was separated and kept at -20°C for biochemical studies. Serum total cholesterol, glucose, Bilirubin and SGOT was quantified using ERBA Automatic Biochemistry Analyzer by ERBA kit based on CHOD-PAP methodology (Allain*et al*., 1974) and GPO-PAP method (Bucolo and David, 1973).

Experiment 2:

Preparation of aqueous Kalmegh extract: Fifty gram of kalmegh powder was soaked in water (200 ml) whole night and was filtered.

Experimental design: Thirty breeders of Nicobari fowls were selected at 35 weeks of age. Fowls were assigned to each of dietary treatments namely, **T_1: Kalmegh feed supplement (**Kalmegh powder with feed @ 3g per bird per day; **T_2: Kalmegh water supplement (**Supplementation of Kalmegh aqeous extract in water for Oral administration) @ 10 ml per bird per day; **T_3(Control):** No Supplementation. All birds were fed *ad libitum* feed as per Bureau of Indian Standards (BIS, 2007) recommendation under deep litter system with 16 hours light of 3 lux intensity per sqft.

Biochemical profile: Blood was collected from all experimental birds on 0, 3rd, 5th, 8th and 12th day of experiment. Sera was separated and kept at -20 C for biochemical studies. Serum total cholesterol, glucose, Bilirubin and SGOT was quantified using Automatic Biochemistry Analyzer by ERBA kit based on CHOD-PAP methodology (Allain*et al*. 1974) and GPO-PAP method (Buccolo and David, 1973).

Micronutrient analysis of serum: The serum collected on third day of kalmegh supplementation in water was mixed with De-ionized water at 1:10 ratio. The samples were assayed for Iron and copper content using Atomic Absorption Spectro-photometry and were expressed as ppm.

Statistical analysis: Statistical analysis of data of experimental I and II was carried as per Snedecor and Cochran (1994) by using ANOVA. The significance of the difference among the groups was determined by Duncan's multiple range tests (Petrie and Watson, 1991).

Results and Discussion

Experiment I

Effect on serum biochemical profile of Nicobari fowl layers

The effect of herbal supplementation on biochemical profile is presented in table 2. The serum bilirubin, cholesterol and SGOT differed significantly among treatment groups. Supplementation of Noni juice @ 3ml per bird in the present study reduced SGOT ranging by 23% as compared to Azolla supplementation, commercial tonic and control groups. This per cent of reduction is agreed with the findings of Lovita *et al.* (2014) who found that supplementation of Noni juice @ 3% reduced SGOT by 25.94% from 234.67 U/L to 186.33, U/L. Pro-xeronine compound and the enzyme pro-xeronase present in noni juice might be attributing to protect liver cells so that the low level of SGOT was recorded in the study. Liver acts as the most important organ in the body's metabolism. Abnormalities of liver function can be diagnosed from the increased levels of SGOT. Hepatic cell damage can be caused by excessive processes such as reduction, oxidation, hydroxylation and conjugation in the metabolism of medicinal plants. Low level of SGOT in the present study is the indicators of normal functioning of liver cells. Herbs in general have the hepato protective effects as they decrease serum GOT levels (UmitPolat *et al.,* 2011; Soltan*et al.,* 2008; Abou-Elkhair, 2014). Azolla supplementation has decreased the SGOT at statistically comparable to commercial tonic and control. This significant reduction in serum GOT level with Azolla might be due to presence of antioxidants such as pigments.

The noni and Azolla supplementation reduced the secretion of bilirubin to a level that is statistically on par with the commercial tonic.Hossain*et al.* (2013) has recorded the ability of water plantain (*Alisma canaliculatum)* to lower serum bilirubin. Low level of serum GOT enzymes and bilirubin provides the research base for the hepato protective effect of Noni and Azolla. It is inferred that low levels of serum bilirubin and SGOT are attributed by bio active compounds present in many herbal and medicinal plants which in turn have not exertedtoxic effect on the liver which otherwise might have resulted in necrosis or changes in cell membrane permeability and there by these parameters would have increased(Hossain, et al., 2013).

Supplementation of noni and Azolla reduced serum cholesterol significantly by 17% as compared to control group and this reduction is statistically on par with commercial immune booster. These results are opined by previous reports by Sunder *et al*. (2011) and Lovita *et al*. (2014) who recorded the same per cent of reduction in serum cholesterol by supplementing noni @ 3%. Similarly, supplementation of sun-dried azolla at 4.5% in broiler diet reduced cholesterol in serum and meat (Balaji *et al.,* 2009). The reduction in serum cholesterol level is attributed to presence of beta-carotene and flavonoids in Noni and Azolla(Nuraini *et al.*, 2008). Beta-carotene can inhibit the action of HMG-CoA (3-hydroxy-3-methyl glutaryl Co-A) reductase, enzyme that plays a role in the formation of mevalonate in cholesterol biosynthesis. Both of these compounds will form cholesterol through a series of reactions. The findings of the present study is opined with number of medicinal plants in poultry feed such as Tulsi, Amla, Turmeric, Rosemary, Aloevera, Black pepper and Coriander (Lovita *et al.,* 2014; AbouElkhair *et al*., 2014 ; UmitPolat *et al*., 2011)

Noni and Azolla did not have hypoglycosemic effect since there was no significant reduction in serum glucose level though numerical decrease was recorded with herbal supplementation. However, the recorded mean serum glucose level (242mg/dl) is within the normal range reported as in previous reports.

Table 2: Effect of various herbal supplementations on serum biochemical profile of native Nicobari fowl

Treatment groups	SGOT*(U/dl)	Bilirubin(mg/dl)*	Cholesterol* (mg/dl)	Glucose (mg/dl)NS
T1:**Morinda juice @ 5ml per bird per day**	150.21 ± 8.46	0.045 ± 0.00	98.25 ± 4.17	233.8 ± 9.62
T2:**Azolla @ 5 gm per bird per day**	165.7 ± 10.5	0.044 ± 0.00	106.1 ± 3.48	246.27 ± 9.5
T3:**Growiplex (commercial tonic)**	195.1 ± 17.4	0.051 ± 0.01	101.9 ± 7.83	260.1 ± 16.5
T4:**Control (without supplementation)**	194.3 ± 9.10	0.073 ± 0.01	123.2 ± 4.23	252.1 ± 9.12

*Mean values in column having different superscripts vary significantly (P<0.05); NS-Non Significant

Experiment II

Biochemical profiles at various days of supplementation of Kalmegh *(Andrographis panniculata)*

Serum cholesterol

Serum cholesterol at various days as influenced by kalmegh supplementation is presented in Table 3. The cholesterol was significantly (P<0.01) reduced by 15% on third day supplementation of kalmegh in feed; while the similar trend of significantly (P<0.01) lowest serum cholesterol by 20% was observed with birds fed kalmegh feed supplement as compared to kalmegh water supplement and control groups. Kalmegh as both water and feed supplement had significantly (P<0.01) lowest serum cholesterol (reduction of 23% and 26% respectively) on seventh day of supplementation as compared to control birds. The early onset of hypo-cholesterolemic effect with kalmegh as feed supplement is due to presence of high fibre content in feed. This finding is in agreement with Mathialagan and Kalaiarasi (2007) who reported the decrease in serum cholesterol with supplementation of *A. panniculata*in broilers. However, the overall mean serum cholesterol of 125, 110 in kalmegh supplemented and control groups of present study was below the level reported in the previous reports which might be due to strain difference. The present study is confirming that kalmegh is having potent hypocholesterolemic effect like other medicinal plants viz., ginger, cinnamon, coriander, chicory and aniseed (Bashir *et al*., 2014; Issa and Omar, 2011; Rahimi *et al*., 2011; Soltan*et al.,* 2008;).

Table 3: Effect of Kalmegh supplementation on serum cholesterol (mg/dl) at various days of supplementation

Day of supplementation	Kalmegh water supplement	Kalmegh feed supplement	Control
1st NS	128.28 ± 6.02	127.42 ± 7.33	126.92 ± 4.79
3rd **	126.67 ± 7.32^{b}	105.42 ± 4.03^{a}	125.50 ± 8.59^{b}
5th **	128.58± 3.52^{b}	99.50 ± 7.94^{a}	133.58 ± 6.53^{b}
7th **	116.66± 10.08^{a}	110.92 ± 8.86^{a}	151.83± 8.74^{b}

**-Highly Significant; NS- Not Significant

Serum GOT

The effect of kalmegh supplementation on SGOT level at various days of feeding is presented in Table 4. Serum biochemistry can reflect the condition of an organism and the changes happening to it under the influence of internal and external factors. Liver enzymes GOT can be measured in serum as markers of hepatic damage. The SGOT was significantly (P<0.01) reduced by 15% on third day supplementation of kalmegh in water; while kalmegh supplementation through feed had statistically reduced to moderate level that was comparable with control group. Significantly (P<0.01) lowest SGOT was observed in birds fed with kalmegh through either feed or water on fifth (18% reduction) and seventh (25% reduction) day of feeding as compared to control groups. The serum GOT level was significantly lower in kalmegh fed groups compared to control groups which proved that the hepatoprotective activity of kalmegh due to presence of and rographolide (Handa and Sharma, 1990). The mean level of 180 U/dl in treatment groups is on par with the level reported in previous reports and this finding is in agreement with earlier works of Mathivanan and Kalaiarasi (2007) who reported the significant reduction of SGOT in broilers fed with *A. panniculata*.

Table 4: Effect of Kalmegh supplementation on serum SGOT (U/dl) at various days of supplementation

Day of supplementation	Kalmegh water supplement	Kalmegh feed supplement	Control
1st NS	209.90 ± 11.21	189.72 ± 17.58	203.37 ± 11.36
3rd **	173.24 ± 3.74^{a}	198.84 ± 13.18^{ab}	204.8 ± 13.84^{b}
5th **	182.34 ± 10.2^{a}	178.6 ± 8.16^{a}	221.32 ± 14.49^{b}
7th **	185.85 ± 7.88^{a}	177.42 ± 6.9^{a}	246.9 ± 27.7^{b}

**-Highly significant; NS-Not significant

Serum glucose level

The influence of kalmegh supplementation on serum glucose level at various days of feeding is given in Table 5. On third day of supplementation of kalmegh as water supplement, 9 per cent and 16 per cent reduction was observed as compared to kalmegh as feed supplement and control groups respectively and that was significantly (P<0.01) highest. Serum glucose was significantly reduced on fifth day of supplementation of kalmegh as both feed and water supplement and it was sustained till seventh day of supplementation. Mathivanan and Kalaiarasi could not find any significant reduction in serum glucose with feeding of *A. panniculata*in broilers.

However, herbal supplementations in poultry have proven their anti-hyperglycemic effect (Hosseinzadeh*et al.*, 2014; **Pandurang***et al.*, 2011; Soltan*et al.,* 2008). The serum glucose level (210 mg/dl) of the present treatment groups have been claimed to be normal in poultry (**Pandurang***et al.*, 2011). The antioxidant properties of aqueous leaf extract of the plant has been demonstrated in streptozotocin-induced diabetes. Oral administration of kalmegh plant extract led to significant reductions in blood glucose levels (Dandu and Inamdar, 2009). The plant reportedly showed insulin-releasing actions *in vitro*, when tested on pancreatic b-cells (Wibudi*et al.,* 2008). *In vitro* a-glucodidase and a-amylase inhibitory effects have been shown for extract of the plant and its component, andrographolide, which suggests that the plant can be a potential candidate for the management of type 2 diabetes mellitus (Subramanian *et al.,* 2008). Anti-hyperglycemicaction in streptozotocin-induced diabetic rats has been shown by an herbal preparation 'Ilogen- Excel', containing extract of the plant, among other constituents (Umamaheswari and Mainzen Prince, 2007). Significant reductions in blood glucose level have been observed when hyperglycemic rats were treated with aqueous extract of the plant grown in Malaysia (Husen*et al.,* 2004). Andrographolide, an active principle found in the leaves of the plant, reportedly demonstrated anti-hyperglycemic effects when administered to streptozotocin-induced diabetic rats (Yu *et al.,* 2003). Crude ethanol extract of the plant has been shown to possess anti-diabetic activity, which has been attributed to increased glucose metabolism. Ethanolic extract of the aerial parts of the plant reportedly showed antioxidant and anti-hyperglycemic properties in diabetic rats; notably, oxidative stress is considered an important factor in the development of diabetic complications (Zhang and Tan, 2000).

Table 5: Effect of Kalmegh supplementation on serum Glucose (mg/dl) at various days of supplementation

Day of supplementation	Kalmegh extract @ 50 gm per 200 ml water	In Feed @ 3g per bird per day	Control
1st NS	226.10 ± 5.45	234.48 ± 4.11	239.24 ± 5.04
3rd **	203.47 ± 7.50 [a]	225.32 ± 10.18 [b]	242.54 ± 6.10 [b]
5th NS	228.20 ± 9.92	239.05 ± 7.18	248.77 ± 6.92
7th NS	230.36 ± 9.41	235.88 ± 6.77	240.18 ± 6.68

**-Highly significant; NS-Not significant

Serum bilirubin

Serum bilirubin at various days as influenced by kalmegh supplementation is presented in Table 6. The bilirubin level was significantly (P<0.01) reduced by 16% on fifth and seventh day of supplementation in both water and feed as compared to control group. Though, relevant literatures could be untraceable, the ability of lowering serum bilirubin has been recorded by Kim et al. (2011) and Elias Hossain et al. (2012) with water plantain (*Alisma canaliculatum)*. Previous researchers also reported hepatoprotective effects in response to feeding different medicinal plants to broilers (Al-Jaff, 2011; Chand et al., 2011).

Table 6: Effect of Kalmegh supplementation on serum Bilirubin (mg/dl) at various days of supplementation

Day of supplementation	Kalmegh water supplement	Kalmegh feed supplement	Control
1st NS	0.066 ± 0.01	0.067 ± 0.00	0.062 ± 0.01
3rd NS	0.052 ± 0.01	0.051 ± 0.01	0.062 ± 0.01
5th **	0.054 ± 0.01 [a]	0.052 ± 0.00 [a]	0.069± 0.01 [b]
7th **	0.056 ± 0.01 [a]	0.054 ± 0.01 [a]	0.068 ± 0.01 [b]

**-Highly significant; NS- Not significant

Micronutrient profile of serum

The effect of kalmegh supplementation on serum micronutrient profile is presented in table 7. Supplementaion of Andrographis panniculata had significantly influenced total Serum iron, copper and zinc. The level of iron, copper and zinc was significantly (P< 0.01) higher of 0.27, 0.46 and 0.12 ppm with supplementation of *Andrographis panniculata* extract as compared to control. Supplementation of medicinal plant *Andrographis panniculata* as water supplement in Nicobari fowl significantly increased the levels of haematinic mineral iron and immunity enhancing minerals viz., copper and zinc in serum by 3.5, 1.2 and 2 times respectively. This improvement in the serum copper and zinc might be the contributing factors to facilitate the immune enhancing properties of andrographolide of *A .panniclata*.

Table 7: Effect of Kalmegh supplementation on micronutrient profile of serum

Micronutrients (ppm)	Kalmegh extract @ 50 gm per 200 ml water	Control
Iron	0.270 ± 0.03^{a}	0.076 ± 0.02^{b}
Copper	0.456 ± 0.01^{a}	0.367 ± 0.01^{b}
Zinc	0.12 ± 0.01^{a}	0.053 ± 0.00^{b}

Conclusion and Recommendations

Supplementation of noni as water supplement, Azolla as feed supplement, Kalmegh as both water and feed supplement reduced significantly serum GOT, cholesterol and bilirubin. Kalmegh supplments significantly reduced serum glucose levels. It is concluded that noni, Azolla and Kalmegh feed and water supplements have hepatoprotective, hypo-cholesterolemic and hypo-glycemic effect proving that these supplements do not exert metabolic toxicity in the function of liver cells. Further, serum iron, copper and zinc increased significantly with inclusion of kalmegh supplements facilitating the immunity of Nicobari fowls. Based on this study, noni as water supplement, Azolla as feed supplement and Kalmegh as water and feed supplements are recommended as herbal tonics in indigenous poultry. *Andrographis panniculata, Morindacitrifolia* and *Azolla*could be recommended as herbal water and feed supplements @ 3g per bird per day, @ 5 ml per bird per day and 3 g per bird per day respectively for the replacement of commercial tonics to enhance the liver function.

Authors' Contributions

All the authors contributed in various phases of this experiment viz., conduction of experiment, guidance to conduct the research, scientific discussion and preparation of manuscript.

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Effect of Seawater intrusion on soil and water quality parameter in vulnerable area of South Andaman Island, India

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Abstract

Sea level rise poses a serious threat to the natural resources of small islands. The effect is manifested as salinization of soil and water in the coastal areas which get aggravated by human activities. The present study attempted to analyze hydro-chemical property of coastal soil and groundwater samples collected from wells located in close proximity to sea. The vulnerability of the coastal aquifer to seawater intrusion and accumulation of Na_2CO_3 and $NaHCO_3$ salt in undrained area was studied. The study revealed that the condition favours sodic soil formation in the study area. The high clay content and presence of $CaCO_3$ concretions result in poor drainage and inundation of the area. The high sodium content resulted in high SAR, soil alkalinity and high pH which necessitate suitable amendment and land management practices to sustain the agricultural production.

Key words: Salinity, Seawater Intrusion, Water quality, Sea level rise, coastal aquifer

Introduction

Salinity is a major problem for agriculture in the coastal region where the soil and water is affected with sea water intrusion. Understanding and assessing of the coastal salinity is different from inland salinity as it comes under the strong influence of sea water. During the December 2004 Indian Ocean tsunami large tracts of agriculture area Andaman and Nicobar Islands was affected. The coastal paddy fields were converted into sea water inundated area which not only affected the standing crop but soil and water quality as well (Velmurugan et al., 2014). The primary process involved in transportation and deposition of salt (Pal et al., 2003; Dasberg et al., 1991) from the coastal creek and the low laying flats are the common topographic zones showing salt infestation along the coast (Manchanda, 1976). This affects the soil quality and results in waterlogging. In this context, water quality assessment is important because poor water quality can pose a health risk for people and the ecosystem. In addition, long-term use of poor quality water for irrigation will reduce soil fertility and crop production. Anthropogenic influences and natural processes (changes in precipitation, erosion, and weathering of crustal materials) degrade water resources and impair their use for drinking, industrial, agricultural, recreation or other purposes (Abrol et al., 1988).

The evaluation soil and water quality in most countries has become a critical issue especially due to concerns that freshwater will be a scarce resource in the future (Singh et al., 2004). Water quality monitoring is a helpful tool not only to evaluate the impacts of pollution sources but also to ensure an efficient management of water resources (Strobl and Robillard, 2008). Water is one of the most critical resource and constraint in an Island ecosystem where only rained agriculture is prevalent. The major ground water sources in Andaman and Nicobar islands are the porous formation consisting of beach sand with coral rags and shells, the thin cover of alluvial or colluvial deposits in the coastal or intermountain valleys and adjoining foothills besides fractured volcanic and igneous rocks (Central Ground water board, 2010). The salinization of this precious resource is a matter of great concern, therefore a study was conducted to assess the hydro-chemical properties of water and soil along the coastal areas of Ograbraj, South Andaman, India.

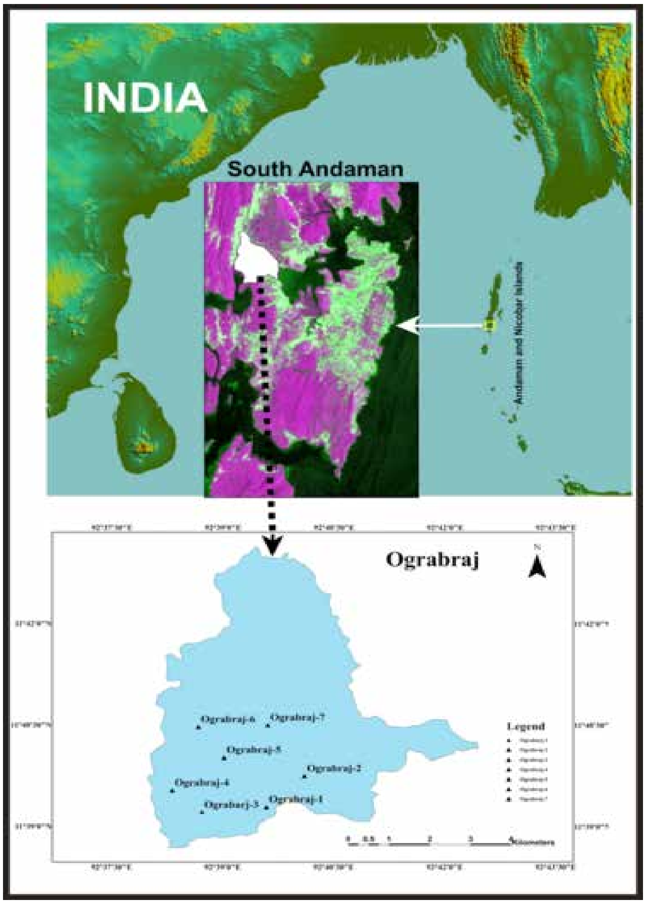

Fig 1. Location of the study area in South Andaman Districts

Material and methods

Assessment of salinization of soil and water along the coastal areas of Ograbraj, South Andaman, India was carried out by way of samples and field verification. The study area lies between *11º39'19.83"* N latitude and *92º39'33.86"* E longitude (Fig.1). A total of seven samples of sodic bulk soil samples were collected from the upper 0 to 90 cm soil depth at Ograbraj by following standard survey procedure. Further, ground water samples were also collected at Ograbraj along the coast during 2015-16 from seawater intruded waterlogged areas. The water sample collection area was close to sea and the soil sampling sites. The samples were collected during the summer month (Jan to May) in capped high-density PVC bottles, fortified with 1 ml of toluene to arrest the any biological activity for various anions and cations for water samples at Ograbraj. Soil was collected and processed according to standard procedure (Page et al., 1982).

Soil pH and EC were determined in saturation extract. The determination of carbonate and bicarbonate concentrations was carried out by titration using 0.01N sulfuric acid and in the presence of the indicators phenolphthalein for the first and methyl-orange for the second. Chloride content was determined with the standard silver nitrate (0.01 N) titration method and in the presence of 1mL of potassium chromate (5%) as an indicator. Calcium (Ca^{2+}) and magnesium (Mg^{2+}) contents were determined by complexation using EDTA (Ethylene diamineteracetate) with the ammonium purpurate as an indicator for the determination of Ca^{2+} content alone, and "Eriochrome Black T" for both Ca^{2+} and Mg^{2+}content (Richards, 1954). Sodium (Na+) and potassium (K+) ion concentrations were determined using a flame-photometer (JENWA PFP7).

Result and Discussion

During the survey of soil and water, samples were collected from the salt affected waterlogged area for physico-chemical characterization and quality appraisal. The data presented in table 1 & 2, indicated the strong relation between nature of salinity and the sea water. Soil morphological characteristic showed that soil were moderate to deep, pale brown to dark yellowish brown colour, sandy loam to sandy clay/ clay loam texture. This was in conformity with the soil characters of the study area earlier described by Mandal (2012). Change in texture or composition close to the sea and severely tsunami affected areas was noticed. It was sandy loam to sandy clay loam and sandy clay loam to clay at Ograbraj-1, Ograbraj-4, Ograbraj-5, Ograbraj-6 and Ograbraj-7 apparently due to clay illuviation. The silt and clay contents were higher than sand content in Ograbraj-2, Ograbraj-3 and Ograbraj-4 due to lower topography positions.

The pH values ranged from 9.1 to 10.7 showing slight to strong alkaline nature of the soil (Table 2). The ECe value showed strong indication for sea water intrusion and presence of soluble salts at the study areas. At Ograbraj -1 ECe varied from 4.6 to 7.4 dS m^{-1} , Ograbraj-5 4.6 to

7.4 dS m^{-1} , Ograbraj -6 4.5 to 5.3 dS $^{m-1}$ and Ogrbaraj-7 4.5 to 5.5 dS m^{-1} is higher than the Ograbraj-2 (1.2 to 6.2 dS m^{-1}), Ograbraj-3 (2.4 to 4.0 dS m^{-1}) and Ograbraj-4 (2.5 to 4.1 dS m^{-1}) due to its physiographic position and upward movement of salt from below. The pH increased with depth at all the sites due to accumulation of salts particularly sodium added from sea water. The higher alkalinity (pH 10.2) in Ograbraj-1, Ograbraj-5 (pH 10.1), Ograbraj –6 (pH 10.1) and Ograbraj-7(pH 10.1) at the sub-surface (40 cm) was due to the local condition and accumulation of salts which resulted in unfavorable soil physical properties and waterlogging at the surface. The higher pH in Ograbraj-1(9.6 to 10.2), Ograbraj-5 (pH 9.6 to 10.1), Ograbraj -6 (pH 9.3 to 10.1) and Ograbraj -7 (9.1 to 9.7) limited its use for arable cropping.

The ionic composition of soil showed the dominance of CO_3^{2-+} and HCO_3^- anion. It is high in Ograbaraj-1(17 to 28.5 me L^{-1}), Ograbraj -5 (18.0 to 30.0 me L^{-1}) , Ograbraj-6(18.0 to 29.0 me L^{-1}) and Ograbraj -7(20.0 to 28.0 me L^{-1}) while ionic composition was low in Ograbraj-2 (5.1 to 10 me L^{-1}), Ograbraj -3(5.0 to 10 me L^{-1}) and Ograbraj-4 (5.9 to 10.1 me L^{-1}). It was reported from several studies that high sodium in subsurface and surface soil causes dispersal of soil particles and waterlogging. In the study area, high Na^+ was recorded in Ograbraj 1,5,6 and 7 which varied from 70.4 to 98.7 me L^{-1} 70.4 to 83.9 me L^{-1} 70.1 to 74.7 me L^{-1} 99.5 to 70.9 me L^{-1}, respectively. This is present in the form of sodium carbonate and bicarbonate in coastal soils. At the same time, significant concentration of $CaCO_3$ at 12 - 58 cm depth in Ograbraj-2 (1.3 to 2.0%), at 12 - 99 cm depth in Ograbraj -3 (1.5 to 3.0%) and at 15 - 79 cm depth in Ograbraj-4 (1.3 to 5.3%) was observed.

The hydro-chemical properties of water samples collected from the coastal areas showed high pH (8.7 to 9.5) and SAR (8.14 to 23.90 me L^{-1}) indicating the sodic nature (Table 2). The salt composition showed dominance of CO_3^{2-} (1.5 to 3.0 me L^{-1}) HCO_3^- (2.5 to 13.4 me L^{-1}) and Na^+ (9.10 to 16.9 me L^{-1}) while Ca^{2+}+Mg^{2+} (1.0 to 2.5 me L^{-1}) and Cl^-(1.7 to 10.0 me L^{-1}) were also present. The samples with high RSC should be used after treatment with gypsum. The samples with moderate alkalinity can be used for growing salt resistant varieties.

Recommendation and use of Potential of slat affected soils

Sodic soil of Ograbraj in South Andaman Islands were rich in sodium carbonate and bicarbonate salt and showed strongly sodic soil (Ograbarj-1, Ograbraj- 5, Ograbraj-6 and Ograbraj-7) containing high Na_2CO_3 and $NaHCO_3$ salt. Coarse soil texture with sodic water need gypsum application so as to reduce the alkalinity followed by leaching of excess soluble salt. Moderately sodic soil of Ograbraj-1, Ograbraj-5 and Ograbraj -6 and Ograbraj -7 containing soluble Na_2CO_3 and $NaHCO_3$ salt and fine soil texture can be reclaimed by addition of gypsum and organic matter. Due to high clay content and presence of $CaCO_3$ concretion, Ograbraj -2, Ograbraj -3 and Ograbraj -4 (slightly sodic soil) showed drainage congestion and waterlogging. It may be used for growing deep water rice having tolerance to salt and waterlogging.

Conclusion

Salinization of coastal soil and water is a major concern for sustainable agriculture. In the study area presence of strong alkaline salts (Na_2CO_3 and $NaHCO_3$) lack of natural drainage and waterlogging conditions in sodic soil caused low productivity. The high soil pH, fine soil texture and presence of concretionary calcium carbonate layer at sub-surface depth are primary constraints for arable cropping. Suitable reclamation measures were suggested for strongly and moderately sodic soil using appropriate amendment such as gypsum and organic matter. Delineation of salt affected soil and seawater intruded area at Ograbraj, South Andaman Districts can help to identify the hot spot areas and treat them differently.

Table 2. Physico- chemical characteristics of water in Ograbraj

Location	pHs	EC ($dS\ m^{-1}$)	Na+ (me/L^{-1})	K^+ (me/L^{-1})	$Ca^{2+}+Mg^{2+}$ (me/L^{-1})	CO_3^- (me/L^{-1})	HCO_3^- (me/L^{-1})	Cl (me/L^{-1})	SAR ($(me/L^{-1})^{1/2}$)	RSC (me/L^{-1})
Ograbaraj-1	8.8	1.4	13.9	0.1	2.5	2.0	13.4	1.7	12.43	12.9
Ograbaraj-2	8.7	1.1	9.10	0.2	2.5	1.5	10.0	1.7	8.14	9
Ograbaraj-3	9.5	1.4	13.3	0.1	2.0	3.0	11.0	1.7	13.30	12
Ograbaraj-4	9.1	1.3	12.6	0.1	1.5	1.5	2.5	10.0	14.55	2.5
Ograbaraj-5	9.3	1.4	14.0	0.1	1.0	1.3	3.0	6.0	19.80	3.3
Ograbaraj-6	9.1	1.6	16.9	0.1	1.0	0.0	3.0	5.0	23.90	2
Ograbaraj-7	9.5	1.7	15.6	0.3	2.5	0.0	10.0	10.5	13.95	7.5

Table 1. Physico –chemical characteristic of soils in Ograbraj

Location	Depth (cm)	pH	ECe ($ds\ m^{-1}$)	Na^+ (me/L)	K^+ (me/L)	Ca^{2+} + Mg^{2+} (me/L)	Co_3- +HCO_3 (me/L)	Cl (me/L)	SAR (me/L)	$CaCO_3$
Ograbaraj-1	0-14	9.6	7.4	98.7	0.9	4.0	17.0	31.0	69.79	2.45
	14-40	10.0	5.5	80.0	0.2	4.0	21.0	18.0	56.57	2.45
	40-82	10.2	4.6	70.4	0.1	4.0	28.5	15.0	49.78	0.09
Ograbaraj-2	0-12	9.8	1.2	11.5	0.1	1.0	15.7	3.5	16.26	1.3
	12-28	10.7	5.3	54.0	0.1	1.5	30.3	12.5	62.35	1.0
	28-58	10.6	6.2	60.6	0.1	1.0	27.7	10.5	85.70	2.0
Ograbaraj-3	0-12	9.3	2.4	11.5	0.2	3.0	5.0	4.5	9.39	1.5
	12-28	9.7	2.6	54.0	0.1	2.0	40	14.5	54.00	2.5
	58-99	10.1	4.0	60.6	0.1	2.0	10	13.5	60.60	3.0
Ograbaraj-4	0-15	9.1	2.4	28.6	0.2	1.5	5.9	25.0	33.02	5.3
	15-39	9.6	2.6	33.0	0.1	1.0	45	20.0	46.67	1.7
	39-76	9.7	4.0	53.9	0.1	1.0	15	25.0	76.23	1.3
Ograbaraj-5	0-14	9.6	7.4	70.4	0.9	4.1	18.0	32.0	49.17	2.46
	14-40	10.0	5.5	83.9	0.2	4.1	25.0	20.0	58.60	2.46
	40-82	10.1	4.6	75.8	0.1	4.1	30.0	15.0	52.94	0.10
Ograbaraj-6	0-14	9.3	4.6	28.9	0.2	4.0	18.0	31.0	49.57	2.45
	14-40	9.7	5.3	34.0	0.2	4.0	28.0	19.0	56.71	2.46
	40-82	10.1	4.5	55.9	0.1	4.0	30.0	14.0	52.82	0.09
Ograbaraj-7	0-14	9.1	1.6	96.7	0.2	4.2	20.0	29.0	66.73	2.47
	14-40	9.6	1.7	99.5	0.2	4.2	22.0	18.0	68.66	2.48
	40-82	9.7	1.8	53.9	0.2	4.2	19.0	20.0	48.93	0.09

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Crop + Aquaculture practices for enhancing farm production in coastal degraded lands

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Abstract

In the coastal and humid tropical island region waterlogging and soil salinity are serious threat to the sustainability of rainfed agriculture due to sea water inundation and intensive monsoon rainfall. In addition there has been a perceptible change in surface temperature, rainfall, evaporation and extreme events linked to climate change affecting the tropical islands. Therefore an innovative management of waterlogged and saline soils of island ecosystem is imperative to provide livelihood to the local people. Land shaping measures combined with practicing different enterprises like crop + aquaculture, seaweed farming has great potential to address these challenges. Further, under island conditions rain water harvesting, storage and its efficient use should be an integral part of the strategy for sustainable agricultural production.

Keywords: *Island agriculture, salinity, waterlogging, land shaping, seaweed*

Introduction

The pressure of increasing global population, urbanization, and demand for diversified food / essential items from agricultural sector are eventually passed on to the land. At the same time land resources are also facing the consequences of global climate change. Together these two causes greatly impact the land resources particularly in the coastal areas. Soil salinity is wide spread and is one of the most important effects of land degradation. It is estimated to affect 10% of the world land surface (Szabolcs, 1989). Increased salinization of arable land is expected to have devastating global effects, resulting in 30% land losses within the next 25 years and upto 50% by the year 2050 in the absence of appropriate measures (FAO, 2004). Even though these changes are occurring at global level it poses serious threats to small islands and island nations. On the other hand in a quest to meet the food requirement, indiscriminate application of agricultural inputs has increased the risk of environmental degradation (Lal, 2004). The cause of such degradation is mainly regional, but the effects are globally manifested.

On the other hand, the climate regimes of small islands are dominantly influenced by maritime conditions, land form, physical extent, and geographical locations. Intensive monsoon rainfall, sea water intrusion, and high evaporation during dry season are primarily responsible for waterlogging and salinity, particularly in the coastal lowlands (Rasel *et al*., 2013) of Andaman and Nicobar Islands. Consequently in those areas agriculture will face the challenge of having to do with limited water at times with poorer quality and have to use saline or acid-saline soils. Under such situations it is highly desirable to use the land according to its production potential with required level of inputs and enhance the productivity and diversity by technological innovations. Different aquacultural practices suitable for the coastal regions and land shaping methods can help to improve the farm production, enhance its diversity and address land degradation as well (Velmurugan et al., 2014). Therefore some of the most prudent crop + aquaculture methods and technologies suitable for tropical island conditions to deal with waterlogging, salinity and climate change are discussed in this study.

The coastal concern

Physiography and soils

The topography of Andaman and Nicobar islands is rolling with low range hills to narrow valleys at the foothills forming undulating terrain ranging from steep slopes (>45°) to plains (<5°). The soils are formed by the dominant influence of climate and vegetation. Soils are medium to deep, red loamy including marine alluvium derived soils along the coast. They qualify for the Great Groups of **Hapludalfs, Dystropepts, Eutropepts** and **Sulfaquents** (along the coast). The soils have low to medium available water holding capacity, slightly to strongly acidic in nature and are moderate to low (40-70%) in base saturation. Seasonal salinity (4.0 – 5.9 dSm^{-1}) along with acidity (pH 4.8 – 5.4) is the major constraint for crop production (Singh and Mongia, 1985).

Land use

Forest covers nearly 86% of the total geographical area of 8249 km^2, agriculture and other land uses accounts for the remaining area. Agriculture is dominated by plantation crops in the hill slopes followed by rice in the valley and coastal plains wherein soil and climate play a major role in limiting rice productivity. Coconut and arecanut grown mostly in the side slopes of longitudinal hills alone accounts for 53% of cultivated area followed by oil palm and rubber grown in the undulating terrain. Pulses are mostly grown in North Andaman after the harvest of rice while vegetables are predominantly grown relatively in elevated lands in North and Middle Andaman Islands. After tsunami the coastal areas become waterlogged and rice could not be cultivated due to salinity which reduced the overall agricultural production (Velmurugan et al., 2014).

Climate change

The term climate change means "any significant in the statistical distribution of weather patterns over periods ranging from decades to millions of years". Climate change may be limited to a specific region or may occur across the whole Earth. If the weather parameters show year-to-year variations or cyclic trend, it is known as climate variability (IPCC, 2001). The most important factor affecting the coastal and island region is the sea level rise. Lowlying or areas within 1-2 m elevation from the mean sea level are highly vulnerable. The changes and its impact on tropical islands have emerged as an important issue in sustaining island agriculture.

The need for sustainable production technology

The emerging situation in population explosion in many of the small islands and island nations are posing major challenge in terms of demand for food and other products. In Andaman and Nicobar Islands the demands for cereals and vegetables is projected to increase by one third and that for pulses, milk and animal products by 60% within the next two decades. Presently $2/3^{rd}$ of rice comes from mainland India to meet the demand. The production statistics indicates that additional agricultural land is needed to meet the growing demand for food grains, vegetables, and fruits. In all likelihood, it is improbable in the near future primarily due to the government regulations and limited geographical extent of islands. The challenge can be partly addressed by increasing the productivity of agriculture while the remaining gap between demand and supply has to be met through supply from mainland India which may not be sustainable in long-run (Srivastava and Ambast, 2009).

There is also a perennial problem of waterlogging and salinity in the coastal areas which impose severe limitation on crop production though they peak at different seasons. The situation is no better in the hilly and uplands where leaching of soluble salts due to heavy rain leads to the development of soil acidity. In saline and water logged coastal areas, traditional long duration rice varieties are grown with limited management practices resulting in low productivity while lack of technological implementation hampers fruits and vegetable production. Meanwhile the demand for land to meet the developmental needs also growing which exerts pressure on agricultural land use. More particularly after 2004 Indian Ocean tsunami the pressure created by increasing population and tourism sector for safer sites is alarmingly rising.

One way of solving the food crisis in tropical islands require determined efforts to reduce the demand gap by evolving and practicing efficient and judicious methods from the existing land resources. But due to geographical limitations it is difficult to go for input intensive agriculture and the geographical location and extent don't allow the construction of large scale reservoirs. The other possibility lies in the reclamation of marginal and degraded lands to explore its suitability for annual crops in addition to phased conversion of existing plantation area into high density plantations (Table 1). Cropping intensity can be increased through appropriate intercropping and crop rotations with in the opportunity provided by the climatic window.

Presently the agro-ecosystem conditions of tropical islands are normally witnessed in the form of low cropping intensity and production besides monocropping of rice with poor agricultural diversification which is inadequate to ensure livelihood security. All such conditions and projection certainly demands innovative technologies to sustain the agriculture production in Andaman and Nicobar islands and elsewhere in the tropical islands.

Table 1. Area under agriculture and problem soils in some of the Indian Ocean Islands

Sl.No	Island / Island developing states	Land area (Km^2)	% area under agriculture	% of waterlogged / saline soils to agriculture area*
1	Sri Lanka	65610	43	3
2	Andaman & Nicobar Islands	8249	6	6
3	Mauritius	2030	43	6
4	Seychelles	460	6.5	11
5	Maldives	298	23	7
6	Lakshadweep	32	75	8

* Erosion not included (Data compiled from faostat.fao.org, www.worldbank.org & GOI reports)

Evaluation of technologies for coastal degraded land

Although salinity has adversely affected agriculture for thousands of years, the recognition that salt-affected land can be used for agriculture has slowly evolved along with the ecological problems associated with intensive cultivation. At the same time climate change and associated events have fast becoming a serious concern to cope with for the small islands. Consequently island conditions certainly demands specific methods and technologies to enhance and sustain the agricultural production. Development of aquaculture centric farming is an ideal option to utilize these areas for productive purpose. To be successful, this requires some special land manipulation techniques / land shaping methods to bring them under agro-aquacultural use. Some of the land shaping techniques suitable for Island and coastal lowlands are broad bed and furrow system, rice-cum-fish and farm ponds (Ambast *et al*., 2011).

Paddy cum fish system (P-F System)

In the coastal areas integrating aquaculture with agriculture by paddy cum fish system assures higher productivity and year round employment opportunities for farmers. Trenches of 3-4 m width and 1.5 m depth are dug around the rice field of suitable dimension. The excavated soil is used to raise the embankment all around the field to make the system (Fig. 1). The bunds built strong enough to make up the height to withstand high rainfall and runoff due to geographical and topographical conditions of the paddy field. During the rainy season the central land is used for paddy cultivation followed by vegetables during dry season. Bunds are used for year around vegetable cultivation due to the availability of fresh water. Fresh water fishes such as grass carp, catla, rogue, mirgal can be grown using the stored water in the trenches. The plots utilised for rice cum fish system is mainly based on organic fertilization with a varieties of animals excreta such as poultry dropping, pig excreta, cow dung and plants residues. Rice-fish systems enabled a higher cropping intensity (200%), increased fish production (1.5 t ha^{-1}), water productivity (42.2 Rs m^{-3}) and enhanced net return (Rs. 196500).

Farm pond with broader dykes

Farm ponds, as one of the suitable options of land shaping, form the centre of integrated farming system. It stores *in-situ* rainfall or harvest surface runoff from surrounding areas depending upon the available rainfall in a region. In high rainfall areas, like A&N Islands where average annual rainfall is about 3100 mm, even *in-situ* rainwater storage in farm pond serves the purpose (Fig. 2). Gupta et al., (2006) suggested that excess rainwater available during May to December should be stored *in situ* in the dugout farm ponds to provide supplemental irrigation during dry season. Apart from polyculture of IMC, fresh water prawn can also be grown. The fresh water prawn *Macrobrachium rosenbergii* is known for its fast growth, stress tolerance and high market values. But institutional support is very essential for breeding and seed production of fresh water prawns to sustain its production. The broader dykes and availability of fresh water favour year around cultivation of vegetables which increased the cropping intensity (190%).

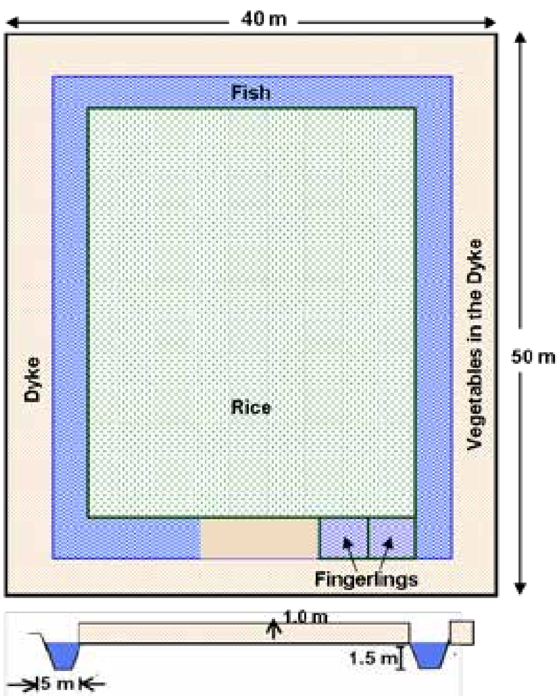

Fig. 1 Paddy-fish system

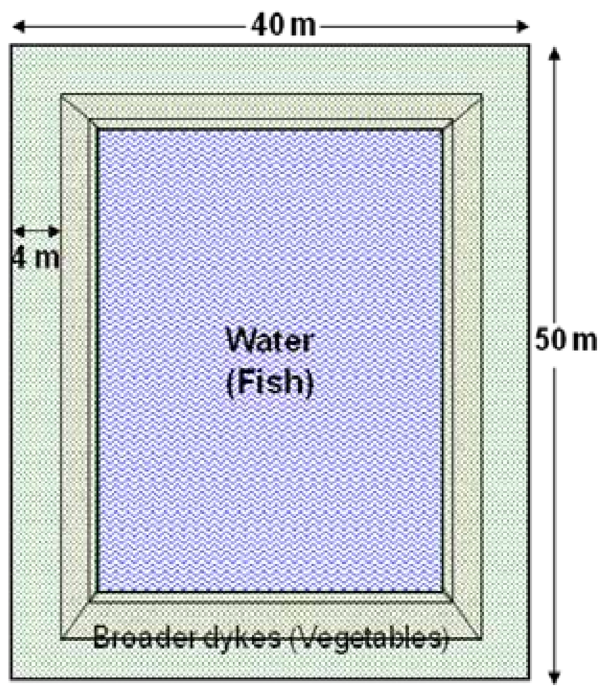

Fig. 2 Farm pond with broader dykes

Raised beds and furrow system

Construction of raised beds and furrow involved excavation of deep furrows alternated with raised beds by using the excavated soils in the same sequence as it existed in natural horizons. The raised beds system installed in the low lying waterlogged areas improved the drainage of the beds, harvested rain water (4476 m^3 ha^{-1}), prevented entry of tidal and runoff water into the furrow, and reduced the overall salinity (Table 2). Whereas the low lying areas were inundated during the monsoon season by 25 to 85 cm of water, soils under raised bed systems were adequately drained and had moisture content between field capacity and the saturation level. The depth of submergence (R^2 = 0.798) and soil salinity (R^2 = - 0.787) were correlated with the rainfall amount. Consequently, the BBF systems enabled a higher cropping intensity (218%), increased fish production (2.32 Mg ha^{-1}), water productivity (47.36 Rs m^{-3}) and enhanced employment generation (213 man days).

Table 2: Effect of crop + aquaculture intervention on productivity parameters

Interventions	Cropping intensity (%)	Fish productivity t/ha	Water productivity Rs/m³	Net Income Rs.
Raised bed system in saline water logged soil	220.0(5.66)[a]	1.3 (0.04)[b]	47.36	206600
Farm pond with broader dykes in Acid saline soil	190.0 (3.72)[c]	1.1(0.05)[c]	35.74	157800
Paddy fish cultivation	200.0 (2.50)[b]	1.5 (0.02)[a]	42.2	196500
Degraded land-Farmers practice	90.0(3.16)[d]	0.15(0.02)[d]	0.0	22000

Mean values, n=10; SE in parentheses; different letters within one column indicate a significant difference at $p<0.05$

Mud crab fattening

Another option available for using the coastal lowland is in the form of mud crab fattening in mangrove ecosystem as they are widely found in these Islands. Juvenile crabs can be collected from estuaries, lakes, back waters, creeks, mangroves and grown in grow out ponds constructed in tide fed estuaries, backwaters and creeks. The crab ponds can also be constructed by converting one portion of existing fish ponds and providing provision for brackish water inundation into that area. A pond of 0.1 ha area can be used for mud crab culture. With the stocking density of 500 numbers ha^{-1} of 50-60 g size crab for a period of six months production of about 780 kg/ ha can be achieved (Dam Roy *et al*., 2008).

Sea weed cultivation

Seaweed farming is the practice of cultivating and harvesting seaweed which is largely carried out as a diversification activity in mariculture. Many of the rocky beaches, mudflats, estuaries, coral reefs and lagoons of Andaman and Nicobar islands provide ideal habitats for the growth of seaweeds. Seaweeds refer to any large marine benthic algae that are multicellular, macrothallic, and thus differentiated from most algae that are of microscopic size (Smith, 1944). They form an important renewable resource in the marine environment as evidenced from its annual production of about 7.0 – 8.0 million tons of wet seaweed along the coastal regions of the world (McHugh, 2003).

Seaweeds belonging to different genera are mainly used for edible and industrial purposes all over the world. The edible seaweed are algae that can be eaten and used in the preparation of food that belong to one of several groups of multicellular algae viz., red algae, green algae, and brown algae. Alternatively seaweeds are also harvested or cultivated for the industrial extraction of alginate, agar and carrageenan substances collectively known as hydrocolloids or phycocolloids. Hydrocolloids have attained commercial significance, especially in food production as food additives. The food industry exploits the gelling, water-retention, emulsifying and other physical properties of these hydrocolloids. In India seaweeds are used as raw materials for the production of agar, aliginate and liquid seaweed fertilizers (NAAS, 2003). The sources of such materials are presented in table 3.

Attempts were made in the past to determine specifically, the alginophytes and agarophytes at their place of abundance, keeping in mind their economic importance (Thivy, 1960). Table 4 provides the summary of different types and standing stocks occurring in India. In all, 271 genera and 1153 species of marine algae, including forms and varieties have been enumerated till date from the Indian waters (Anonymous, 2005). But, India presently harvests only 2.5 % of macro-algae annually compared to a potential harvest of 870,000 tonnes, thus lot of scope for harnessing the unutilized seaweed potential. However, estimates presented here may not give a accurate picture of the standing crop available at present, since most of the surveys were conducted at different times by different methods during the past 20 years from 1971 to 1991 (Subba Rao and Mantri, 2006).

Table 3. Different types of marine algae cultivated in India and their use

Sl. No	Type of algae	Scientific name	Cultivation method	Use
1	Red algae	*Gracilaria edulis, G. crassa, G. foliifera and G. verrucosa*	Long-line ropes and nets by vegetative propagation	Agar manufacturing
		Gracilaria edulis	Single Rope Floating Raft Technique	hydrocolloids
		Gelidiella acerosa	Bottom-culture method using coral stone as a substratum	hydrocolloids
		Kappaphycus alvarezii,	net bag and raft method	Carrageenan and as food
2	Brown algae	*Sargassum spp., Turbinaria spp., and Cystoseira trinodis*	Collection and using nets	Production of alginates and liquid seaweed fertilizers

Table 4. Standing stalks of seaweed and species composition along the Indian coast and Islands

S. No.	Location	Standing stalk as fresh weight (tons)	Species composition			
			Green	Brown	Red	BG
1	South Andaman	19111 (40 km^2 area)	29	15	11	Nil
2	North & Middle Andaman	6817 (25 km^2 area)	11	11	5	Nil
3	Little Andaman	120	7	6	5	Nil
4	Nicobar	7315	18	15	18	Nil
5	Lakshadweep	4955 - 10077	33	10	39	Nil
6	All India	6,77,000 to 6,83,000	340	211	470	10

In Lakshadweep the estimated potential (fresh weight) ranged from 4955 to 10,077 tons with an average value of 7519 tons (Anonymous, 1979). The Andaman and Nicobar Islands have been partly surveyed by Central Marine Fisheries Research Institute, Cochin and the highest standing crop of 19,111 tons (fresh weight) was estimated for an area of 40 km^2 in South Andaman. The total potential of the islands stands at 33363 tons but the level of exploitation is negligible due to policy issues and infrastructural inadequacy (Gopinathan and Panigrahy, 1983). Among them Green algae followed by Red algae constitute the major species composition. Recently, natural incidence of *Kappaphycus alvarezii* has been reported from Andaman Islands. Ecological studies have been undertaken regarding the cultivation of the species and no adverse effects to the ecosystem by the species have been reported. Therefore, large-scale cultivation of *Kappaphycus alvarezii* can be undertaken in Andaman Islands.

The island offers suitable marine environment for the commercial cultivation of red algae but it is desirable to reduce the bulkiness by preprocessing before sending it to the mainland industries. It is also wise to promote integrated cultivation of shrimps and seaweeds in aquaculture as seaweeds act as scrubbers in reducing nutrient load and cleaning the environment. To utilize seaweed recourses in a sustainable manner, conservation as well as proper husbanding of these resources is a prerequisite. Planned promotion of diversified uses of seaweeds as feed, fodder, feed additives, fertilisers, biocides and antimicrobials will ensure sustained market for seaweeds and provide alternate livelihood to those living in waterlogged-saline areas in Andaman and Nicobar islands.

Conclusions

Waterlogging and salinity in the island eco-regions are recognized as major constraints to agricultural production. Climate change is inevitable and being experienced across the globe but, the vulnerability of different places varies based on different factors. The small islands and small island developing states are more vulnerable to the perceived climate change. Therefore, agriculture should move towards more water efficient, saline tolerant and climate resilient crops and measures in these islands. Crop + aquaculture practices along with land shaping are a viable option to restore the land productivity and enhance the net income in the coastal degraded lands. In other words, combining specific reclamation measures suitable to practice aquaculture with proper soil, water, and crop management practices should break the stagnant agricultural production barrier now experienced under island condition.

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Traditional agricultural knowledge among the Nicobarese of Nancowry group of Island

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Abstract

The practice of agriculture in any island bears the impression of traditional wisdom which is coming through generations. Sometimes it gets modified through external influence but larger characteristic feature of island farming remains. The *Nicobarese* of Nancowry group of islands are the inhabitant for centuries. The economic wellbeing and everyday life of *Nicobarese* is primarily depended on coconut, areca nut, banana, jackfruit, pandanus, and pig herding. The management of this primary activity is subjected to their age old traditional knowledge. At the same time this knowledge about agriculture is not only confined to their economic activities, but exhibited in various forms viz., material culture, customs and traditions, food habits, ethnic boundaries, geographical nomenclature, language etc., Now a days this traditional agricultural wisdom is being slowly replaced with modern technology and ideas which are perceived by the tribal and conservationist as exploitative in nature and have had adverse affects on the available natural resources. Despite of this fact, still the *Nicobarese* of these islands depend on this knowledge to a great extent in obtaining their livelihoods and their culture centered on it.

Introduction

Study of traditional knowledge assumes significance to understand how a group of people living in a place over a period of time have adapted to varied environments, derived their livelihood, survived natural disasters and understood the natural process around them. This also brings to light how the heritage of these communities had cultural linkage with the surrounding natural resources to live in harmony with nature. In other worlds these studies focused mainly on exploring how traditional knowledge and institutions could contribute to sustainable development. In this context it is very important to study the traditional knowledge of Nancowry group of island located South of Andaman Island between Bay of Bengal and Andaman Sea for optimum utilization and management of dwindling natural resources in these islands (Velmurugan et al. 2016).

The Nicobar island is a chain of twenty two Islands stretching from 9° 17′ 48″ North latitude and 92° 42′ 15″ East longitude of the Bay of Bengal are an integral part of Indian Union. The *Nicobarese* one of the major indigenous community inhabiting in the different group of islands followed by the Shompen tribe which is restricted to interior part of Great Nicobar Island. The entire Nicobar is divided into three geographical regions known as northern, central and southern group of islands for administrative convenience. Car Nicobar Island is the northernmost which is divided by Little Andaman with 10 degree channel. The central group consists of Chowra, Teressa, Bompuka, Katchal, Kamorta, Nancowry and Trinket islands. Whereas Pulo Milo, Little Nicobar, Kondul, and Great Nicobar are belongs to southern group of islands. The *Nicobarese* of all these islands are similar in physical appearance, food habits, and other material and non material cultural traits. But each island has its own identity in terms of origin folktales, language, material traits, and island specific rituals evolved over a period of time in isolation (Syamchaudhuri, 1977).

Therefore, the present study attempted to understand the traditional knowledge of management of natural resources (crop, soil, animal resources) to derive their livelihood by the *Nicobarese* of central group of islands. It was observed that the *Nicobarese* still maintain their traditional knowledge even after their conversion to Christianity and Islam in the post tsunami scenario.

Methodology

The present study was aimed at understanding the traditional knowledge of agricultural practices and management of land resources by the *Nicobarese* of Central group of islands particularly Nancowry Island (Fig. 1). In order to collect the data, qualitative and quantitative techniques were used by field visits and literature survey. These are mainly participant observation, case study, key informant interviews, group discussions, and non-formal interviews using a detailed checklist. Further detailed questionnaires on existing resource classification, categorization, and perception of climate, soil and water were used. Data from secondary sources such as books, articles, published reports, Census reports, and government documents have also been collected and compiled to source the relevant information.

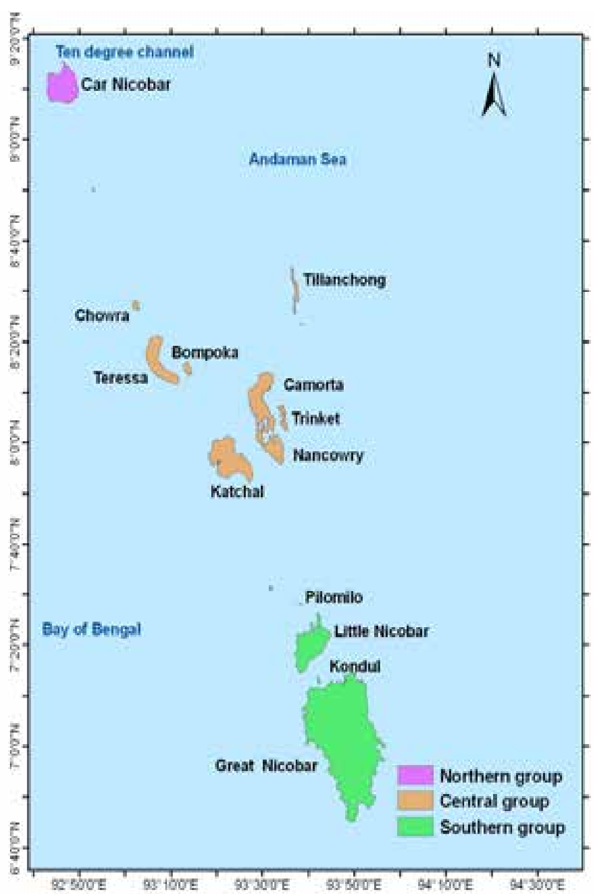


Fig. 1. Location of the study area

Results and discussion

Living environment

The Islands receive copious amount of rainfall from both the South west and North east monsoon and measures around 2750 to 3100 mm each year. The historical climatic data shows that the mean relative humidity is 79%, maximum temperature is 30.2°C, and minimum temperature is 23.0°C. Basically Nicobarese of Central group of islands are agriculturists and herders by tradition as they known to grow coconut and pig for centuries. Though they are educated and mingle with main stream of population, a vast majority of the *Nicobarese* still pursue their traditional occupation of coconut and areca nut plantation and rearing pigs. Some of them have also taken up rearing of goat and poultry. They have fair knowledge about the nature of resources under their possession and the ways to utilize them judiciously for their well being in the fragile island ecosystem. This knowledge might have been evolved in the tribal community by practice and has been passed on by generations.

Agricultural practices

The horticultural plantation is known as *pano-o*. Generally *Nicobarese* resort to shifting horticulture particularly mixed vegetable garden. During April-May, they start clearing the old vegetation in the previous garden or forest and began clearing the new plots. After axing down the big trees, they burn it along with dried twigs (Fig. 2). Initially planting of tubers and banana will take place in the cleared plot along with *tavok* (coconut saplings). Major varieties of tubers like *kupeng* or *takinhi*, *kunya*, *kani* or *nya*, *it-seaichtahangen*, and *malayalialu* are planted in June. In plantation, *kanoh* (coconut), *laeom* (pandanus), *ictusa* (indigenous cotton), *tisa-a* (areca nut), *chamam* (wild arecanut), *pubai* or *sampet* (papitha), banana (*tayuknog* or *hipu*), *kinreai* (Jackfruit) *suru* or *firung* (pine apple), *sealakaroch* (wild orange), *ronghami* (wild fruits), *payuoh* (wild fruits), *kumiyanta* (green chilli), *hiluli* (kind of small size green chilli), *siea-tahlava* (elongated banana), *kööfee* (wild clustered apple), *limong* (wild variety of lemon), *thak* (*katta* or wild tamarind), *chaf* (tamarind) are commonly found. The vegetables like *alithong* (brinjal), *panchalu* (bitter guard), *makka* or *miloh* (maize), ridge guard, okra, beans, bottle guard, drum stick, *kumda*, *kundru*, lemon, are also cultivated in their plantation.

Dense coconut plantation in Nancowry

Rubber plantation in Katchal

Fig. 2 Land use in Nicobar islands

Land Ownership and Distribution

It is very difficult to determine the size of holding as there are no land records and existence of different types of land ownership. The size of land holdings with proper records are available only for non-tribal settlements in revenue areas while there are no records available in case of both Nicobarese and Shompens. As discussed earlier certain lands are owned by tuhet head for common purposes and some other land collectively by the tribal society. Only usufructuary rights are given to other members of the tuhet. In other words the individual joint families in the concerned *tuhet* are allotted an area of land or plantation by its *ma-tuhet* (lineage head). Even the homestead and plantation area is identified with their lineage and clan names. In due course of time, the population increased and some new *tuhets* came into existence having links with original ones. In such cases, new plot to be cleared inside the forest (i.e., shifting horticulture) by all the *tuhet* members on cooperation basis and make ready for plantation. Till the harvest comes, they were allowed to consume the nuts of their parent *tuhet*. After harvest of new plantation nuts, it is their moral responsibility to contribute for *tuhet* as and when required. There is a tendency that the prospective bride or groom with less resources prefer to marry where their in-laws possess large plantation. If any new member increases in *tuhet*, it is their responsibility to clear more forest and expand their coconut plantation (Mann 2005). Thus the extension of coconut plantation had significant bearing on the rule of residence among the Nicobarese.

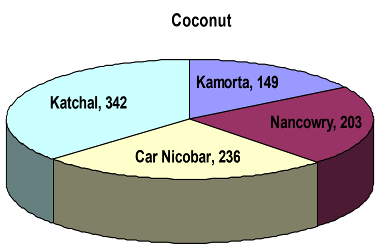
In the present study we collected information from household survey, interaction with village captains and from the number of coconut trees under each family. The number of recorded farm holdings of these Islands are 665 with a total land holding of 1643 ha (Table 1) where majority of the holdings are marginal (45.7%) with average holding of only 0.17ha, followed by medium (35.2%). The average land area of medium holdings is 4.86 ha and large holdings account for only 0.8% with average area of 34.45 ha which are government lands. Contrary to the popular belief, the Nicobari society also exhibited inequalities in terms of distribution of means of production and social status. Larger the size of holding higher is their influence on tribal affairs.

The experience shows that number of coconut trees owned by each household gives reliable information on size of land holding as coconut is an integral part of tribal society. Based on the number of coconut tress owned by individual farm family, size of land holding was inferred and the categorization was done accordingly. The data indicated a wide variation (10-1000 trees) in size of holding with an average of 235 coconut trees per household across the Islands. Majority of the tribal farmers come under marginal category (46%) followed by medium (35%) while only less than 1% are under large category who decides the tribal affairs. The increasing marginal category is mainly due to loss of coconut plantations in natural calamities and increase in population. Owing to this, some of the tribal families were shifted to Little Andaman some time ago.

Table 1. Details of Farm holding in Nicobar Islands

Size class (ha)	No. of holdings	Area of holding (ha)	Average holding (ha)	% to total holdings
Marginal (<1)	304	51	0.17	45.7
Small (1-2)	42	65.97	1.57	6.3
Semi medium (2-4)	80	218.02	2.73	12.0
Medium (4-10)	234	1136.2	4.86	35.2
Large (>10)	5	172.26	34.45	0.8
Total	665	1643.45	2.47	100.0

Analysis of ownership of coconut trees gives much clarity to the resource availability to each family as it is the major source of income for the Nicobarese. The average number of coconut trees held by a large farmer is 10 times higher than the marginal holders indicating a relatively high inequality in distribution of land in terms of ownership of coconut trees. However, only 5.5% of the households have more than 500 coconut trees which are normally influential in the tribal society, while 56.9% of them own less than the average of 235 trees. Significant differences were found in average number of coconut trees owned by individual households across the Islands. However, in Katchal mean holding of coconut trees exceeded the overall mean of 235 trees mainly because of loss of lives during tsunami in 2004 (Fig. 3).



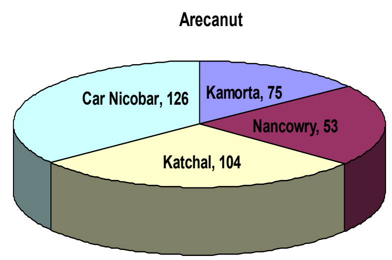


Fig. 3 Average holding of coconut and arecanut trees across the Islands

Hayaken (*Tuhet* Cooperation)

At the beginning of new plantation, the *Nicobarese* come together and assist in clearing trees in forest, cleaning and sowing works. In Katchal, *hayaken* unites the *Nicobarese* at lineage level irrespective of their present religious background especially during life cycle and annual festivals of that particular *tuhet*. During birth, marriage and death and seasonal festivals of each *tuhet,* the members of that particular *tuhet,* those who are living in other village and Islands are assembled at *gholghar* (beehive shaped community hut) and take part in different works as per the instruction of their headman along with their contribution in the form of pork, roots, tubers, banana, and so on. This lineage unity is instrumental in economic activities ranging from clearing of forest patches for new garden, fishing, hunting, etc.

It was observed that during which each family member of that particular lineage group has an obligation to participate in required economic activities ranging from plucking and collection of nuts for processing of coconuts, dehusking, extraction of copra from pucca nuts and oil extraction, etc. Initially the task involved is thoroughly discussed with the head of the lineage to request for necessary assistance to accomplish the task. To meet the manpower requirement of the proposed work, members assigned from the *tuhet* attended the works. This sort of mutual cooperation is also evident in dealing with seriously ill patients, relief in the aftermath of natural disasters, making of racing canoe, beehive community hut, making recreation ground for sports, etc (Prasad and Haider,2009).

Generally all the *Nicobarese* including men, women, children and aged participate in production activities. But in some economic activities, division of work is visible as it demands more physical power. In copra making, the activities ranging from collection and breaking of nuts, arranging in order, collection of fuel wood and burning, extraction of dry copra, storing in gunny bags and carrying them to collection centres are undertaken by both men and women except in peeling off nuts and carrying loads which is solely done by men. In copra making children and aged also participate in some minor works. But the scrapping of *malai*(endosperm or soft copra) for daily need is performed by women at household.

Uyau or *Taokoo* (Coconut)

Coconut occupies a prominent role in the socio-economic life of the *Nicobarese*. A glimpse of coconut cultivation and processing is seen in Fig. 4. They attribute that it has some versatile qualities that tender nuts are used for reducing thirst, pucca nuts are used for their own consumption as well as feed for their livestock and extraction of oil for domestic needs, toddy for self consumption, timber and thatch leaves for construction of hutments, use of spathe for decoration during ceremonial occasions, raw material for making brooms, etc. It is estimated that a coconut tree starts bearing nuts after eight years of its planting and had forty years of life span.

Due to its significance, *Nicobarese* never destroy them wherever it is located. In unavoidable circumstances, the palm tree is cut down only after its propitiation. Further certain taboos are associated in dealing with coconut tree in Katchal. It is prohibited to climb the coconut tree for tapping *thady* (toddy) or plucking the nuts by a person who is in a state of intoxication (after consuming liquor). Despite of this, if anyone mistakenly climbs the tree, the yield may be lesser when compared to other normal days. Hence, lot of care is taken before climbing the coconut tree.

Climbing coconut tree

The broken coconut is arranged on the stage and burned from below using coconut wastes

Traditional method of processing coconut

Pressing in *kintantavi-I* for milk and sun drying for extraction of virgin oil

Fig. 4 Traditional knowledge about coconut cultivation and processing

***Fanakö ta-òkohek fanakö in-uan* (Techniques of Climbing)**

There is a traditional way of climbing the coconut tree by making notches within a meter distance on the trunk of palm tree for extraction of toddy. By doing so they can easily climb the elongated coconut tree without any aid. Furthermore, these notches are useful in identifying the toddy extracting trees to nut bearing ones. The majority of toddy tapping trees appears with notches as they can easily sap its juice and come down along with toddy. In case tree is short one, they use *tahaho* (wooden ladder) for *thady* extraction. Use of *seanramat* (rope made from plant fiber) is also another technique used to climb palm tree. In this method, fiber rope is tied to both ankles in circular and climb by moving legs in systematic manner towards up and sliding down.

***Kavut*(Toddy) Tapping**

To understand or test the state of the fruits i.e., coconut in horticultural garden, *Nicobarese* gave a gentle blow with their pointing finger on either side of the fruit with their little finger. In case the resonance is low, it is considered as *kutcha* instead resonance is high they consider that the fruit was ripen. The fruits like jackfruit and pandanus are tested with the smell of the fruit. The traditional methods of toddy extraction are referred as *lavan* by the *Nicobarese*. They possess copious knowledge of identifying the suitable tree for *thady* extraction by seeing the inflorescence of different palm trees. Once the tree is selected, they cut the inflorescent regularly to channel its fluid out and tie a coconut shell or container. Every day morning and evening the filled containers are collected and again peel off its outer layer with knife for smooth flow of toddy. Otherwise it is dried in hot sun and block the channel.

Traditional Knowledge of Coconut Processing

Nicobarese are experts in processing coconut into different forms drying of nuts for copra, scrapping kutcha *malai* (copra) for extraction of oil, extraction of fiber for coir, use of shells as firewood as well as for craftwork, and scrapping copra for preparation of traditional *Nicobarese* dishes and puddings, etc. Recently they adopted coir extracting techniques through the training organized by the Industry Department of Andaman and Nicobar Administration. But it was not in use due to advent of earthquake and giant tsunami waves in 2004. Now they rely on native methods for utilization of coconut as it is mainstay for Nicobarese economy.

The works in horticulture plantation ranging from collection and pooling of fallen pucca nuts, dehusking, breaking of nuts, arranging on wooden stilt platform and exposing them to smoke from the below, and so on are carried out in traditional manner without using any technical aid. At present, the Nicobarese following three methods for extraction of oil from the coconut. *Nyanch Harat* is a popular traditional method of extracting coconut oil by using *chonkankintantavi-i* (carved wooden plate) and *chonkinykintan* (elongated log) with scrapped and fried kernel. The oil extracted through this method is considered as pure and used for medicinal and domestic purpose. *Hakuvan* is another method of extracting oil from scrapped *kutcha* kernel by boiling and cooling in the hot sun. In another method, the scrapped *malai* is mixed with water and crush it thoroughly with hands in a container. Later on the container is kept in hot sun for two to three days. In between they used to collect upper portion of the liquid by hand in separate container in regular intervals. Thus collected muddy loaded oil is filtered and again kept in hot sun. Later on it is stored in glass bottles.

Cultivation in Orchard

The tribes of Nicobar Islands practise natural farming and known to possess wealth of information which they pass on to the next generation. As far as Nicobarese are concerned, besides coconut plantation they have three types of gardens for growing fruits and vegetables. It helps to fulfill dietary, economic and social needs of different cultures in the islands (Gillespie *et al*., 1993) and provide them with supplementary food, fruit, fodder and fuel. The cultivation of yam and other horticultural crops in the plantation area is regulated by seasons and hence *Nicobarese* depend on their traditional calendar for undertaking cultivation and other economic activities. The seasons are broadly divided into *sikehagö* (summer season) *sung* or *yuuch* (rainy season) based on wind direction from the sea (Table 2). They rotate consumption of variety of foods in certain season due to non-availability of certain resources and hence alternative subsistence is procured based on their traditional economic calendar.

Table 2: *Hinruolo-kahe* (Seasonal Calendar) of the *Nicobarese*

SI.No.	*Chinget* (Native month)	English month	Economic Activity	Associated Rites
		***Sikehagö* (Summer season)**		
1.	*Ranch*	January	*Vini-i-panò-o* (Bush cleaning and firing)	*Kinaň ha-un* (pig sacrifice)
2.	*Inetö*	February	*Insolooaap* (weeding)	*Kalongpanò-o*
3.	*Linuiyo*	March	*Hachuhha-un* (fencing)	
4.	*Fineno*	April	*Hakon panô-o* (Dibbling plants)	*Nyòk chon, panò-o*
5.	*Tineuyö*	May	*Vito-an panò* (late gardening works)	*Ha-ing kak*
6.	*Tinfulö*	June	*Ha-ing kak*	
		***Sung* or *Yuuch* (Rainy season)**		
7.	*Sinatö*	July	*Yuch tamkak*	
8.	*Hinevhöre*	August	*Hatuilo potra*	
9.	*Minchuötore*	September	*Kuralkulufak*	
10.	*Sinömö*	October	*Saints Day*(Saints day)	*Church-ka-badadin*
11.	*Minchutore*	November	*Totmayak*(All Souls day)	*Tinòtmanak*
12.	*Mana-an*	December	*Kinioh*	

In *sikehago*, *Nicobarese* restrict consuming certain foods like *kanang* (crab), *thak* (*katta*), *laeom* (pandanus), lemon, sea fish, *pò* (sugarcane), and so on. In *yuuch*, they venture in sea for fishing with *tanam* or *miya* (spear) in out-rigger canoe collectively to mark the breach of prohibition of those restricted foods. As such major food collection is undertaken in rainy season. From *ranch* or *Sung* onwards *Nicobarese* harvest *kinreai* (jackfruit) from their garden as well as in the forest. Its seeds (*kulal)* are preserved for consumption in rainy season after thorough roasting.

It is seen from the table that cleaning of previous crop and wastage starts at the far end of February and it is continued till April end. Planting of yam, papaya, tubers and plantain of different varieties along with vegetables mentioned above are done in the month of May after rains. The method of *Nicobarese* cultivation is simple and no technology or major implements are involved. All the works in plantation are carried out on mutual cooperation without hiring any labour. It is being facilitated by their institutional framework known as *hayaken*. The *Nicobarese* do not have systematic pattern of plucking ripen coconuts and making copra. It is attributed to their easy way of living and widespread of plantation. Only fallen ripen nuts are gathered and used for feeding their stock regularly in their plantation. Whenever the need arise, then only they venture into plantation for making copra and oil preparation.

Kinlong Ha-un (Pig Slaughtering)

The major livestock in Nicobar Islands comprised of pig (76%) and goat (18.2%) which are reared in extensive open semi-feral system by the tribal community with no intension of business (Zacharia, 2012). Spatial differences in livestock population across the islands were observed with largest population of pig and goat found in Car Nicobar Island. It was observed that whenever the forest is cleared for new plantation, *Nicobarese* offer a grand feast by slaughtering pigs to garner the cooperation of the massive economic activity. Wherein the pigs already exist in homestead area were caught and slaughtered for the proposed feast. The remaining pigs are left in *tavat* (inner forest) for not causing destruction to the budding plantation. In general, every village and islanders observe *Kinlong haun* whenever the pig population exceeds the limit of Nicobarese population. It testifies the homeostasis mechanism of Tsumba Marringi.e., ritual killing of domestic pigs to maintain ecological (Rappaport. 1963).

Betal and Pan Leaves

Majority of the*Nicobarese* are found chewing *betal* nut along with tobacco, lime and pan leaf during leisure and working times. As such they procured some of the items from their natural surroundings and rest from the market. Of course the native or wild variety of nut and leaves are pungent when compared to those available in markets. The below mentioned two varieties are available locally and preferred during feasts.

Big Size*Pan* Leaf called *Roilong is a* wild creeper which are big and thick. It is used for chewing along with areca nut and lime and considered to be pungent in taste when compared to the leaves available in open market. *Similarly* Small Size*Pan* Leaf called *RoiHaei is a* wild *supari* creeper small in size and not thick unlike *roilong* it is also used for chewing purpose by the *Nicobarese* along with areca nut and lime.

Payuoh (Edible Wild Fruits)

It is a seasonal fruit and available in April-June every year. *Nicobarese* perform a ritual by sacrificing a hog or cock before plucking first fruits. The fruits are collected by those who are having these *payuoh* trees and distribute to their relative who are invited for this occasion.

Sabbalin (Lemon Grass)

It is an elongated grass available throughout Katchal. It is in ginger taste and used like spice in preparation of chicken, mutton, fish, vegetable, and in hot beverages. A bunch of tender grasses are added to tea decoction while boiling to enrich its taste. Sometimes, they used it for making non-vegetarian soups prepared with fish, pork and chicken.

Traditional Receptacles

Nicobarese use natural objects such as bark, coconut and arecanut spathe, dry coconut shell, bamboo stem, wild leaves with slight modification as receptacle for serving the food and drinks. With the contact with outsiders very few elites using the modern disposal plates and cups in Katchal. But by and large majority them still depend on traditional receptacles made from the natural objects are used as receptacles during feasting and ceremonial occasions. The following varieties of leaves are used as receptacles by the *Nicobarese* whenever they require.

The round and big size leaves collected from *rui* tree (***Roi Kinrul)*** are used as receptacle for serving food to guests and also for packing food items to carry distant places. Further, the kutcha leaves are used as wrappers for boiling pandanus, processed tubers, banana, etc., in a huge container.

The receptacle prepared with the help of half dried coconut spathe and *Rafoh* (arecanut spathe) is slightly cut into plate size and preferred for serving ceremonial food during ritual occasions (***Tö Siöp Roita-òkö***☺

Knowledge of Wild Tubers and Roots

Nicobarese have different terms for different varieties of tubers available in these islands. Some of the varieties are planted on their own and some are naturally grown in the forest. The tuber known as *kunya* is available throughout Nicobar followed by other varieties mentioned below. *Tahangin*is a widely available tuber in Katchal which is known as '*kunyaaalu'*. In case raw tuber eaten without processing, it causes itching on tongue and the body. *Sabudhan* is also a widely grown tuber in their plantation area. It is popularly known as '*malayaliaalu'*. *Kupeng* or *takinihi* is a black color tuber and used for consumption after processing. Other varieties of tubers found in the study area are mainly *lĕchlòng*, *vian* or *junglyaalu*, *ukov*, *tihaňlöo*, *kayun* or *walanj*, etc. *Taving* is a kind of root and its availability is limited to particular places in the forest.

In these islands the shelf life of tubers is very limited in hot humid conditions of Nicobar Islands, hence they should be stored in a cool dry place and should be free from dampness. The tribals use bamboo baskets/barns (Fig. 5) for storing the tubers of sweet potato or *Nicobari alu* for seed as well as consumption purposes at later time. The yam barn is very common in Nicobar to store the tubers. Basically it consists of ring walls of vertical pieces of bamboo, each 5-10 cm in diameter, one meter high and set about half meter diameter. The vertical wall is often made of split bamboo. It is the experience of Nicobarese that the structure reduces the risk of attack by termite. Inside the barn the tubers are kept individually and arranged vertically to allow maximum air circulation.

Fig. 5 Storage bins used by Nicobarese

To extract big size tubers, *Nicobarese* cut the branches of plant first till it reaches one feet height from its trunk. Then two to three persons hold it and shake thoroughly the plant towards its front and back. Whenever it uprooted, they cut roots from its trunk and collected into gunny bag. The same place is again ploughed with hand hatchet till the soil loosens thoroughly. There one piece of tuber is dibbled and fenced with one feet of the cut branches. This marking assist in prevent from stepping on it or sometimes as a protection from their livestock. After extraction, two persons carry the tubers either in baskets or gunny bag to plantation house. There they arrange these tubers systematically in the cane or bamboo bin erected on stilt inside the house. It is generally nearer to their kitchen, so that the problem of moisture is overcome with its smoke and air circulation from its bottom. Two or three tubers are placed on roof top as a symbol that the offering to their ancestors or spirits. The women engage in extraction of small tubers by digging the soil around the plant and plucking with hand. The extracted ones are pooled at one place and shifted to house.

Knowledge of Wild Vegetable Leaves

Nicobarese can recognize a wide variety of consumable wild leaves in the forest. Even the leaves grown on the banks of streams, estuaries, and their backyard are also consumed after processing. The *kutcha* coconut milk is used as additive in preparation of vegetable leaves. The below mentioned leafy vegetables are commonly identified by the *Nicobarese* in the study area.

*Roitakappu*is a kind of wild vegetable leaf found on a wine plant and found profusely in the forest. The leaves are plucked and eaten after thorough roasting on frying pan. It is used as vegetable mixed with fish along with coconut milk. Other wild leaves consumed by the *Nicobarese* are mainly *tilfung*, *vurong* (*kattabaaji* orleaves of *hibiscuscannabinus*) *roiturilö* or *tivilö*, *roikucho-ön*, *roinya-ön*, *sajnabaaji*, *naalibaaji*, *roitukapo*, *roi chon roikumda* and *turai*, *tukabu* or *linkong* (*meetabaaji* or sweet leaves), *roilimpop, roiparethi, kuvat, roi likol*.

Conclusion

In spite of outside contact and planned introduction of technologies, the *Nicobarese* still maintain the reminiscences of their traditional knowledge and it is reflected in both material as well as non-material cultural aspects like traditional stilt houses inside their plantation, outrigger canoes, worship of fetishes, maximal lineage groups, joint family, village and lineage Councils etc. The knowledge which is acquired from their fore fathers are still used in coping the disasters, food production, utilization of both terrestrial as well as aquatic resources. Simultaneously continuation of traditional economic activities in agricultural activities ranging from copra making, cultivation of different varieties of pandanus, banana, yam and tubers, collection of wild vegetable leaves, are possible with the application of their age old traditional knowledge which is passed from generations together to the *Nicobarese* of Central Nicobar Islands. Therefore, the skills of the local should be encouraged in the light of modern technological development, provide them solutions where ever they lack behind, and address to a specific problems.

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Soil and Water Conservation Measures for Andaman and Nicobar Islands

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Abstract

Soil erosion due to runoff water is a major land degradation problem in the sloppy and undulated terrains of Andaman and Nicobar Islands (ANI). Soil erosion resulted in fertility degradation and loss of top soil besides landslides due to high intensity storms and steep topography. However, the island suffers from soil moisture deficit during dry season due to high evapotranspiration. Therefore, planning suitable soil erosion control and water conservation measures in ANI is of utmost importance towards solving drinking water crises and optimizing agricultural production. Present study illustrates the different suitable soil and water conservation measures/interventions in ANI that are intended to reduce the erosive energy of water, soil erodibility by altering surface soil characteristics, and to reduce nutrient losses from agricultural fields. This paper also summarised different studies conducted in ANI with an aim to improve agricultural productivity and reduce land degradation.

Key words: *Soil erosion, model, land degradation, nutrient loss, water harvesting*

Introduction

Andaman and Nicobar Islands (ANI) are the tropical, humid and rain fed areas located between latitude 6°40 °N and 14°45 °N and longitude 92°8 °E and 94°1 °E with the total geographical area of 8249 km^2. The average annual rainfall of ANI is ≈3280 mm, which shows 26.40 billion m^3 of potential to store fresh rainwater with 69,185 m^3/capita/year water availability. The devastating Tsunami/earthquake took place on 26-12-2004 has changed the climate of these Islands drastically. It is evident that post Tsunami rainfall patterns are highly variable both in terms of total amount and distribution, which lead to drinking water problems and moisture stress during critical stages of crop production. Even though, about 90% rainfall from May to November is spread over about 117 rainy days, the existing water resources in ANI are not sufficient to meet the ever growing demands of native (380581 as per 2011 Census) and tourist population (515223 during 2018-19 as per Directorate of Economics and Statistics). This is due to the fact that nearly 70% of received rain water is lost as runoff immediately after rainfall due to its steep terrain and proximity to the Sea (Srivastava and Ambast, 2009). This high speed free runoff is associated with soil erosion, which has a scour potential to reduce the soil productivity by removing the most fertile topsoil and obstruct the agricultural operations.

The natural resources in ANI are profoundly afflicting from soil erosion as a result of intensive deforestation, overgrazing and subsistence agriculture due to population pressure, large-scale road construction and mining etc. along with anthropogenic activities. Soil being a non-renewable resource and the basis for 97% of all food production, strategies/measures to prevent soil depletion, land degradation, and erosion are critical for sustainable development. Quantifying the acceptable soil loss without affecting crop productivity is a major challenge for researchers, planners, conservationists, agriculturalists, environmentalists, etc.

Studies on soil erosion from different agricultural land uses in ANI are poorly documented due to various limitations of isolation from mainland, limited resources, undulated topography, huge capital requirement, administrative restrictions, ungauged locations, natural disasters, etc. Table 1 presents the summary of conducted various soil erosion and nutrient loss studies in Andaman and Nicobar Islands.

Table 1 Summary of soil erosion and nutrient loss studies in ANI

Sl. No.	Objective	Study Location/Land uses	Approach	Conclusion	Recommendations	Reference
1.	Soil, nitrogen and phosphorus loss	CIARI, Garacharma Farm	Three treatments: T1: Gliricidia + Maize + Tillage; T2: Gliricidia; T3: Maize	T3 treatment resulted less soil loss (t/ha/yr), less nitrogen & phosphorus losses (kg/ha) than T1 & T2.	Gliricidia hedgerows is good vegetative method for soil erosion control.	Pandey and Venkatesh (2002)
2.	Soil erosion based on selected incident rainfall events	Dhanikhari watershed of the South Andaman	Revised Morgan Morgan Finney (MMF) model, Remote Sensing (RS) and geographical Information System (GIS)	Average annual soil loss was 25.29 t/ha & total soil loss was 27142 tonnes.	Multiple rainfall events in whole year should be considered.	Velmurugan et al. (2008)
3.	Soil and nutrient loss	Five land uses: L1: vegetable fields; L2: contour plantation; L3: arecanut plantation; L4: home garden; L5: evergreen forest.	Runoff plots	Soil loss from the L1 under no till conditions, L2, L3, L4 and L5 was 3.8, 12.4, 10.6, 8.4 and 2.3 t/ha, respectively.	Gliricidia hedgerows for vegetable cultivation and cover crop for coconut plantation are good vegetative methods for soil erosion control.	Pandey and Chaudhary (2010)
4.	Soil loss	Andaman & Nicobar Islands	Runoff plots, Universal Soil Loss (USLE) model, RS & and GIS	In ANI, ≈ 609 km^2 area (7.4%) was under the very slight to slight erosion class and ≈ 90% of area exceeded the tolerance limit of 11.2 t/ha/yr	Planning suitable soil and water conservation measures at critiacal areas.	Sahoo et al. (2013)
5.	Drainage morphometry	Kalpong river, North Andaman	RS & GIS	Study area was susceptible to soil erosion and severe runoff.	Higher order stream or upward extension of tributaries for Kalpong watershed.	Shankar and Dharanirajan (2018)
6.	Soil loss	Agricultural lands of South Andaman	USLE	Annual soil loss of 184098.12 tons was recorded at the rate of 105.38 t/ha/yr.	Converting more mono crop area into double cropped land will reduce the average soil loss annually by 18.4%.	Nanda et al. (2019)

Soil Erosion Control and Water Conservation Measures

It is well known fact that one cannot control the climate and nullify the extreme events in any region. But its impacts can be mitigated by planning suitable conservation measures on long term. These measures include soil conservation, moisture retention, afforestation, improving groundwater recharge and building water harvesting structures. Soil erosion control and water conservation measures are divided into two main categories: 1) *in-situ* and 2) *ex-situ* measures. In-situ measures (Fig. 1) are made within agricultural fields like integrated farming, nutrient and pest management, crop diversification and intensification, contour trenches, bunding, terracing, broad bed and furrow, vegetative barriers, grass waterways, etc., whereas *ex-situ* measures (Fig. 2) include rain water harvesting structures, farm ponds, percolation tanks, earthen dams, check dams, gabions, and agroforestry.

In-situ Conservation Practices

Integrated Farming System (IFS)

In IFS, both the agriculture and non-agriculture activities like livestock production and dairy and fish farming are practiced for generating consistent source of income and to avoid crop failure risk to the farming community. In ANI, various small holder IFS systems have been evolved with the components of plantation crops, paddy cultivation, back yard poultry, fisheries, vermicompost, mushroom, apiary etc. Studies on rice based IFS (animal, poultry, and fish) have indicated 53% increase in employment at farm gate as compared to improved rice based cropping system and also net income by 23% at Port Blair (Ravishankar et al., 2006). Similarly, coconut based IFS integrated with vegetables at Nicobar Island resulted additional employment generation and balanced nutrition of tribals (Swarnam et al., 2014). Integrated Nutrient Management (INM) involves the integral use of organic manure, crop straw, and other plant and tree biomass material along with little application of chemical fertilizer (both macro and micro-nutrients). Similarly, Integrated Pest Management (IPM) involves use of different crop pest control practices like cultural, biological and chemical methods in a combined and compatible way to suppress pest infestations.

Crop Diversification & Intensification

Crop diversification refers to bringing about a desirable change in the existing cropping patterns towards a more balanced cropping system to reduce the risk of crop failure. Crop intensification is the increasing cropping intensity and production to meet the ever increasing demand for food in a given landscape by using advanced technologies, good variety of seeds, balanced fertilizer application and supplemental irrigation.

Contour Trenches, Bunding & Terraces

Contour trenches are made in non-agricultural areas for providing adequate moisture conditions in order to raise tree and grass species. Bunds are small earthen barriers provided in agricultural lands with slope ranging from 2-10%. They control the effective length of slope and thereby reduce the velocity of flowing water to avoid rill and gully formations. Bunds constructed along field boundaries are referred as peripheral bunds. Contour bunds are constructed along the contour in relatively low rainfall areas having annual rainfall less than 600 mm for controlling runoff and storage of water. Graded bunds are constructed in medium to high rainfall areas having annual rainfall of 700 mm and above for safe disposal of excess water. Terraces are usually constructed for cultivating sloppy areas by converting the land into series of platforms one above another. These measures are popular in hilly areas.

Broad Bed and Furrow System (BBF)

Function of BBF is to control erosion and to conserve soil moisture in the soil during rainy days. It acts as a drainage channel during heavy rainy days. It is suitable when the slope of the land is < 3%. In ANI, low lands of islands face the water logging problem during rainy season, which limits the crop choices to rice only and sometimes even this crop too fails. Most comman practice of BBF in ANI is that rice and fish are cultured in furrows and vegetable are grown on beds resulting higher and diversified production. In BBF, beds have also shown reduced salt built up problems (Ambast et al. 2010).

Vegetative Barriers & Grass Waterways

Vegetative barriers are closely spaced grass plantations usually a few rows of grasses or shrubs – grown along contours or with little grade for erosion control in agricultural lands.

Grass waterways are drainage channels either developed by shaping the existing drainage ways or constructed separately for effecting drainage of agricultural lands. They are aligned along the major slope to handle runoff discharge from contour/graded bunds, bench terraces, and contour trenches.

a) IFS

b) Contour trenches

c) Contour bund

d) Terrace

e) Grossed waterway

f) BBF

Fig. 1 In-situ soil and water conservation measures

Ex-situ Conservation Practices

Rainwater Harvesting (RWH)

A specific purpose of RWH is to catch and store monsoonal runoff, where it falls. RWH system can augment the transfer of 'blue' water (rivers and aquifers) to 'green' water (soil water and plant water use). The basic elements of RWH system are catchment area, conveyance, or conduit system, first flush, filter system, storage area, and recharge area. The RWH structures in islands should be planned at the local (individual structure) and watershed scale (community) with an aim to augment the irrigation and drinking needs. In ANI, where groundwater is saline and unusable for irrigation or drinking water, RWH can provide local increases in fresh water as the density of fresh water is less than for saline water. As a result, fresh water lenses that 'float' on top of the saline groundwater and can be harvested via wells. In urban areas, rainwater can be collected from the roof, paved and unpaved areas of a house, a block of flats, a colony, a park, a playground, parking areas, schools, and office complexes through roof top harvesting structures. Thumb rule: 10 mm of rainfall over 100 m^2 of roof area will fetch 1000 litres (volume = rainfall x area).

Farm Ponds & Percolation Tanks

Supplemental irrigation at times becomes essential for survival of horticultural and agricultural crops during dry season with undependable and erratic rainfall. In order to accomplish this, excess rain water has to be conserved in soil profiles through farm ponds. Farm ponds are bodies of water, made either by constructing embankment across a water course or by excavating a pit or the combination of both. Percolation tanks are structures constructed across Nallahs for checking velocity of runoff, increasing water percolation, improving soil moisture regime, and augmenting groundwater recharge.

Earthen Embankments and Check Dams

Earthen dam is a raised confining structure made from compacted soil of clay, sand and gravel. They are constructed across the streams/Nallahs for creating water reservoirs for providing one or two irrigations to the crops at critical periods. They are relatively smaller in height and broader at the base and are used for increasing infiltration, detention and retention facilities. A check dam is a small, temporary or permanent dam constructed across a channel to reduce the effective slope of the channel, thereby reducing the velocity of flowing water, allowing sediment to settle and reducing erosion. Temporary check dams can be made of brushwood, stone, woven wire and log, whereas permanent ones are of concrete and masonry.

Gabions

Gabions are partitioned, wire fabric or mesh containers filled with stone at the site of use to form flexible, permeable, monolithic structures for earth retention. They work as anti sea erosion bunds, revetments, sea walls and riprap.

Agro-forestry and Mangroves

Agro-forest measures increase rainfall and runoff, regulate flows, reduce erosion and floods, 'sterilize' water supplies and improve water quality. However, some negative effects are known from teak (*Tectona grandis*) trees and eucalyptus species, which may 'pump' excessive groundwater, since they cannot adjust their water intake to the temperature by opening or closing their stomata. Positive effects arise from planting nitrogen-fixing trees (legumes), often used in agro-forestry systems in order to regenerate depleted soils and to improve plant productivity.

Mangroves are an excellent control measures for coastal erosion. They reduce the height and energy of wind and swell waves passing through them, reducing their ability to erode sediments and to cause damage to structures such as dikes and sea walls. During rising tides, as the sea comes in, waves enter the mangrove forests. They lose energy as they pass through the tangled above-ground roots and branches and their height is rapidly diminished, by between 13 and 66% over 100 m of mangroves. As this happens, waves lose their ability to scour the sea bed and carry away sediments. Mangroves also reduce winds across the surface of the water and this prevents the propagation or re-formation of waves.

a) RWH

b) Farm Pond,

c) Earthen embankment

d) Check dam

e) Gabion

f) Agroforestry

g) Mangroves

Fig. 2 Ex-situ soil and water conservation measures

Conclusion

Agricultural activities in ANI exposes surface soils to the rainfall, which carry away a huge amount of top fine soil particles along with runoff to the Andaman Sea through low lying streams/nallahs. It is a matter of serious concern that due to huge loss of surface soil on account of soil erosion, associated soil macro, major and micro nutrients are lost recurrently to the mouth of Sea each year leading to nutrient depletion and poor soil fertility. The land mass of the Islands is precious not only from the soil fertility point of view, but also for the existence of the Islands as well. Therefore, suitable soil and water conservation measures are the needy of hour for solving water crises problem for both the drinking and agricultural uses in Andaman and Nicobar Islands. This paper reviewed the soil erosion control and water conservation measures suitable for Andaman and Nicobar Islands.

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Fishes of Andaman and Nicobar Islands: An Updated Checklist

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Abstract

Ichthyofauna of the Andaman and Nicobar Islands, situated in the Bay of Bengal is observed to be one of the most diverse in the world in part due to the confluence of Andaman Sea fishes with Western Pacific and the Indian Ocean. A total of 1601 valid species of fishes belonging to 585 genera and 165 families were reported from Andaman and Nicobar Islands based on underwater observation, landing centre visit and surveys conducted in different ecosystem. A total of 1111 reef fishes are reported inlcuding seventeen new species endemic to these Islands. Among these fishes, 50 species are threatened and 45 species are categoriezed as near threatened.

Keywords: Diversity, Fishes, Andaman and Nicobar Islands

Introduction

The Andaman and Nicobar Islands situated in the Bay of Bengal between 6°45′ -13 45′ N and 92°10′ – 94°15′E, are composed of 352 islands and 220 islets. These islands spread over a distance of almost 775 km along North-South direction, with a coastline of 1962 km and provide India an Exclusive Economic Zone (EEZ) of 600 thousand sq km. The shelf topography of these islands shows frequent rises supporting coral reefs, which are characterized as fringing reefs on the eastern side and barrier reefs off west coast. Besides coral reefs, the coastal region is composed of rocky and sandy areas and vast stretches of mangrove swamps. Geographically, Andaman group of islands are over the under-ocean continuation of the Arakan Yoma Range of Myanmar and the Nicobar group of islands form a part of Sunda Islands 'Hot Spot'. Being at the eastern edge of the 'Bay of Bengal Large Marine Ecosystem', these islands harbor a mixture of coastal fish elements of the Andaman Sea, Western Pacific and the Indian Ocean.

Although, Western Indian Ocean is known to harbor about 2000 species of fishes (Richmond 2001), the 8000 km long coast line of India is represented by 2443 species of marine and coastal fishes (Gopi and Mishra, 2014). Marine biodiversity of India is numbered at 21,663 species belonging to 35 groups of animals with a recent estimation of 2618 species of fishes (Chandra *et al*., 2016). The Andaman and Nicobar Islands contribute considerably to the total ichthyofaunal diversity of India and Indian Ocean as well. Blyth (1846) was first to provide a report on few fishes from Nicobar Islands. Day (1870) gave an account of 255 species from Andaman Islands. Herre (1941) made an extensive study of fishes around Andaman Islands and listed as many as 490 species. Subsequently, several new species and new records of fishes have been added to the list by many ichthyologists. This work paved way to further contributions to the knowledge of ichthyofaunal diversity of these islands. The check-list of all fishes (including freshwater forms) by Rajan *et al*. (2013) indicate that the Andaman and Nicobar Islands shows the highest degree of ichthyofaunal species diversity in the Indian Ocean region, reportedly with 1434 species.

Since publication of check-list in Rajan *et al*. (2013), additional information are also obtained through recent contributions from Rajan and Sreeraj (2013a & b; 2014a & b); Ray *et al.* (2013); Devi *et al.* (2014); Sachithanandam and Mohan (2014); Devi and Kumaralingam (2015); Bineesh *et al*. (2016, 2020); Kumar *et al*. (2016); Rajan *et al*. (2016, 2017, 2018); Rajeeshkumar *et al*. (2016a & b); Sumod *et al*. (2016), Vinu *et al*. (2016), Bineesh *et al*. (2018), Praveenraj *et al.* (2016, 2017, 2018) and Zoty *et al*. (2018). The author happened to dive at various locations and participated in game-fishing to collect further knowledge on fish faunal composition of these islands. The present work is carried out to assess the species diversity of fishes in Andaman and Nicobar Islands based on recent updates and direct observations by the author. The paper also discusses the endemic and threatened reef fishes of Andaman and Nicobar Islands and the management challenges in these islands.

Materials and methods

The paper is basically a review of literature compiled from the icthyofaunal works in the last 170 years from 1846 to 2016 including the knowledge gathered by traditional sampling through cast nets, beach seine, traps and hand line by the author during last four decades and fish catches in landing centers. Specimens were collected wherever possible and otherwise, live specimens were photographed during underwater roving surveys in the coral reef areas from 3 m to 30 m depth by the author. The specimens and photographs thus collected were identified using standard literatures, mostly through Allen and Erdman (2012). The scientific names of fishes used in the cited literature have been updated, following recent usage and hence junior synonyms were omitted. However, 41 names reported by different authors at different period are not included in the present list for obvious reasons cited in the table. The present paper is intended to prepare a checklist of fishes known from Andaman and Nicobar Islands, India by considering all the published taxonomic documents available till date and recent findings are also included.

Results and discussion

A total of 1601 species of fishes, including freshwater, mangrove, seagrass, pelagic and reef fishes, belonging to 585 genera and 165 families were recorded from Andaman and Nicobar Islands as updated till date, more than ten species of are introduced for fish culture. Of these, 1111 fishes are reef fish species. Reaching half of fishes (774) are represented in 15 families. The total percentage of species richness (calculated against the total number of species recorded) for these 15 families is 49.32% (Table-1). The remaining 86 families together compose 50.68% of the overall richness, while 18 families are represented by only a single species.

Table-1. Species richness of 15 major families of fishes from Andaman Nicobar Islands

Family	Genera	Species	% of species richness
Muraenidae	7	21	1.32
Lethrinidae	5	23	1.45
Nemipteridae	3	24	1.50
Syngnathidae	12	26	1.63
Acanthuridae	5	30	2.66
Scaridae	9	30	1.88
Chaetodontidae	6	43	2.70
Apogonidae	7	50	3.14
Carangidae	17	49	3.07
Lutjanidae	11	46	2.89
Bleniidae	21	62	3.89
Serranidae	10	64	4.01
Labridae	23	79	4.95
Pomacentridae	18	85	5.33
Gobiidae	28	143	8.90
Total: 15	**182**	**775**	**49.32**

Fauna from the family Gobiidae represent maximum number with 143 species, followed by Pomacentridae with 85 and Labridae with 79 (Table-2). Gobiidae is the largest group in Perciformes with approximately 2000 species (Nelson, 2006). These cryptic fish together with Blenniids have high abundance and diversity in benthic tropical reefs around the world (Nelson, 2006). Due to their cryptic and secretive nature, on an average, 34 new species are described each year (340 species in last ten year) (Eschmeyer and Fong, 2016), making them the family with the greatest number of newly described species. In the past three years, the author could have recorded 12 more species of Gobi, viz., *Acentrogobius janthinopterus, A. suluensis, Amblyeleotris diagonalis, A. fontanesii, A. downingi, Auloparia koumansi, Bryaninops amplus, B. earlei, B. loki, Eviota zebrina, Fusigobius duospilus* and *Lobulogobius morrigu* from Andaman and Nicobar Islands (Rajan and Sreeraj, 2014; Rajan *et al*., 2016). The family Pomacentridae is mostly reef associated small fish group having considerable morphological diversity and varied colour pattern in individuals, with many species complexes (Nelson, 2006). The family Labridae is the second largest family of marine fishes and one of the most diversified in all fish families in shape, size and colour. These are mostly small fishes and mainly reef associated and so, forms the second and third specious group in reefs of Andaman and Nicobar Islands. According to the currentupdate, so far a total of 1111 species of coral reef fishes have been recorded under 402 genera within 101 families and 20 orders. The number of reef fishes reported from Andaman & Nicobar Islands is the highest among the reefs of India, making up 75% of the fish recorded in these Islands. The name of the fishes is used as per the current status. Besides, a total of 41 species records which are questionable or unlikely to occur are included in Table 3.

Endemics: In marine fishes, the concept of endemism has received less attention than freshwater fishes and other taxonomic groups. The presence of endemic genera or species involves many complex issues such as geological age of the coastal area, its isolation and location, arrival of ancestral progenitors, competition, suitable habitat, and environmental stability over time (Eschmeyer *et al*., 2010). The zoogeographic analysis of East Indies reef fishes reveals that 279 species are having restricted range endemics. Indonesia has by far the largest number of endemics due to its extensive area. Mishra *et al.* (2013) have documented the endemic fishes of India, including 91 estuarine and marine fishes as endemic to Indian marine waters under 74 genera and 49 families. Allen and Erdman (2016) described 6 new species from these Islands (Plate. 1). Despite having high degree of diversity in fish faunal components in Andaman and Nicobar Islands, there are only seventeen endemic species *viz., Heteroconger obscurus, Halieutopsis nasuta, Ptereleotris caeruleomarginata, Pseudochromis tigrinus, Iniistius naevus, Alloblennius frondiculus, Amblyglyphidodon silolona, Helcogramma* species, *Priolepis* species, *Opistognathus albicaudatus, O. annulatus, Praealticus dayi, Eleotris andamanensis, Callogobius andamanica, C. trifasciatus, Oligolepis dasi* and *Scartelaos cantoris* (Plate 1). Recently a new freshwater snakehead, *Channa royi* Praveenraj *et al.*2018, a threadfin bream *Nemipterus andamanensis* Bineesh, Russell, & Chandra 2018 and a moray eel *Gymnothorax andamanensis* Mohapatra *et al.*2019 have been described.

Management Challenges: A preliminary checking of conservation status of reef fishes of Andaman and Nicobar Islands revealed that, as many as 50 species of fishes are threatened (IUCN, 2016), 6 of them Critically Endangered, 7 Endangered and 37 Vulnerable. Of these 50 threatened species, most of them (40) are elasmobranchs—sharks, skates and raysand the remaining 10 are bony fishes. In addition, 45 more species are Near-Threatened, being already on the path to vulnerability. The fore most obstacles in achieving fishery management plan for reef fish of these islands is lack of vital information. Fishery statistics were lacking or interrupted. Sharks and Groupers are usually live long and reach reproductive maturity later in life, that making them vulnerable to fishing before they mature. In addition, commercial fishing that targets reproductive gatherings of adults further hinders replenishment of unmanaged populations. Two species of coral trout grouper, *Plectropomus areolatus* (Ruppell) and *Plectropomus pessuliferus* (Fowler) which are the mainstays of the chilled fish markets face significant threat in Andaman Islands. At present, the fascinating communities of coral reef are increasingly at the risk from pressures of man's expanding developmental activities. Human intervention to the seabed can often cause changes in the direction of currents and patterns of sedimentation which can result in destruction of large areas of coral growth and reef fish habitat. Destructive fishing techniques are also followed here, mostly by foreign poachers. Besides, global warming is likely to cause coral bleaching with direct deleterious effects on the coral associates like many ornamental fishes.

Collection of corals and sea sand, removal of surface soil, mining of sandstones for construction purposes, cutting of natural vegetation from the shore, picking of shells and polluting the shore by oil and other substances, which are the common occurrences in Andamans, which should be prevented through proper management plans. Destructive fishing methods which damage the ecosystem should not be practiced in coral growing areas. Research on captive breeding and rearing of marine ornamental fishes may be promoted which can lead to the supply of hatchery produced marine ornamental fishes to the aquarium fish trade. This can reduce the indiscriminate exploitation of these fishes from the wild. There is enormous scope to develop ornamental fish industry in Andaman and Nicobar Islands. Ornamental fish collection, breeding, seed production and marketing as an industry can create employment opportunities, thus Andaman and Nicobar Islands can create a substantial additional employment in this sector. With the demand for high value export fishes, fishing is targeted at certain groups like groupers and snappers. In groupers, the target species are of genera *Plectropomus* (Coral trout, locally known as Dollar fish). Possible over-fishing of these fishes is eminent and that eventually depletes the stock. Importantly, size restrictions may be enforced and removal of groupers less than the average maturity size of 16 inches should be prohibited. There may also be gear restriction allowing operation of only hand lines for this fishing as it has proved that traps and nets break considerable amount of corals causing habitat destruction during their operation.

These islands, and particularly southern Nicobar Islands, which are considered as a part of Sunda Island 'Hot Spot', located just near to the Coral Triangle, serves as the richest area for marine life in the world. The fish diversity in these waters also receives special interest in terms of marine zoo-geography because of the confluence of Andaman Sea fishes with Western Pacific and the Eastern Indian Ocean. Two habitats, where most of the new marine taxa will likely be found are deep-reefs and deep-slopes, as these areas are poorly sampled and studied. Molecular genetic studies are proving valuable in phylogenetic and phylogeographic analyses as well as in species' population analyses, but these relatively new techniques should cover large numbers of new or cryptic taxa. The introduction of SCUBA in Andaman and Nicobar Islands in the field of research began in 1998 and use of ichthyocides is not still practiced, its use (SCIBA) has surely resulted in the discovery and description of many new marine species with team approach. Underwater photography has simplified the work of ichthyologists and helped in the discovery of new species. Long-term monitoring studies will allow a better understanding of connectivity patterns along the coast of Andaman and Nicobar Islands as well as the possible establishment of new populations of species.

Table 2 : updated list and taxonmical order of fishes of Andaman and Nicobar Islands

CLASS: CHONDRICHTHYES

Sub Class: Elasmobranchii

Order: ORECTOLOBIFORMES

Family: HEMISCYLLIDAE

1. ***Chiloscyllium griseum* Muller & Henle, 1838**
2. ***Chiloscyllium hasseltii*** Bleeker, 1852
3. ***Chiloscyllium indicum* (Gmelin, 1789)**
4. ***Chiloscyllium punctatum* Muller & Henle, 1837**

Family: **Stegostomatidae**

5. ***Stegostoma fasciatum* (Hermann, 1783)**

Family Odontaspididae

6. ***Carcharias taurus*** Rafinesque, 1810

Order: LAMNIFORMES

Family: Alopidae

7. ***Alopias pelagicus* Nakamura, 1935**
8. ***Alopias superciliosus* (Lowe, 1840)**
9. ***Alopias vulpinus* (Bonaterre, 1788)**

Family: Laminidae

10. ***Isurus oxyrinchus* Rafineque, 1810**

Order: CARCHARHINIFORMES

Family: Pentanchidae(catsharks)

11. ***Apristurus investigatoris* (Misra, 1962)**
12. ***Bythaelurus hispidus* (Alcock, 1891)**

Family: Proscylliidae

13. ***Eridacnis radcliffei* Smith, 1913**

Family: Hemigaleidae

14. ***Chaenogaleus macrostoma* (Bleeker, 1852)**
15. ***Hemigaleus microstoma* (Bleeker, 1852)NEW**

Family: Carcharhinidae

16. ***Carcharhinus albimarginatus* (Ruppell, 1837)**

17. ***Carcharhinus amblyrhynchos* (Bleeker, 1856)**
18. ***Carcharhinus altimus*** (Springer, 1950)
19. ***Carcharhinus amboinensis*** (Müller & Henle, 1839)
20. ***Carcharhinus brevipinna* (Muller & Henle,1839)**
21. ***Carcharhinus dussumieri* (Muller & Henle, 1839)**
22. ***Carcharhinus hemiodon* (Valenciennes, 1939)**
23. Carcharhinus leucas (Müller & Henle, 1839)
24. ***Carcharhinus limbatus* (Muller & Henle, 1839)**
25. ***Carcharhinus longimanus* (Poey, 1861)**
26. ***Carcharhinus macloti* (Muller & Henle, 1839)**
27. ***Carcharhinus melanopterus* (Quoy & Gaimard, 1824)**
28. ***Carcharhinus plumbeus* (Nardo 1827) (New)**
29. ***Carcharhinus sealei* (Pietschmann, 1913)**
30. ***Carcharhinus sorrah* (Valenciennes, 1839)**
31. ***Cephaloscyllium silasi***(Talwar, 1974)
32. ***Centrophorus granulosus***(Bloch & Schneider, 1801)
33. ***Centrophorus atromarginatus***Garman, 1913
34. ***Centrophorus moluccensis***Bleeker, 1860
35. ***Galeocerdo cuvier* (Peron & Le Sueur, 1822)**
36. *Pseudocarcharias kamoharai*(Matsubara, 1936)

Family: HEMIGALEIDAE

37. ***Hemipristis elongata*** (Klunzinger, 1871)
38. ***Paragaleus randalli*** Compagno, Krupp & Carpenter, 1996

Family Triakidae

39. ***Hemitriakis indroyonoi*** W.T. White, Compagno & Dharmadi, 2009
40. ***Mustelus mosis***Hemprich & Ehrenberg, 1899
41. **Loxodon macrorhinus Muller & Henle, 1839**
42. Nebrius ferrugineus(Lesson, 1831)
43. ***Negaprion acutidens* (Ruppell, 1837)**
44. ***Prionace glauca* (Linnaeus, 1758)**
45. ***Rhizoprionodon acutus* (Ruppell, 1837)**
46. ***Rhizoprinodon oligolinx* Springer, 1964**
47. ***Scoliodon laticaudus* (Muller & Henle, 1838)**
48. ***Triaenodon obesus* (Ruppell, 1837)**

Family: Sphyrnidae (Hammerhead Sharks)

49. ***Eusphyra blochii* (Cuvier, 1817)**
50. ***Sphyrna lewini* (Griffith & Smith, 1834)**
51. ***Sphyrna mokarran* (Ruppell, 1837)**
52. ***Sphyrna zygaena* (Linnaeus, 1758)**

Order: SQUALIFORMES

Family: Squalidae

53. Squalus hemipinnisWhite, Last & Yearsley, 2007
54. ***Squalus megalops* (Macleay, 1881)**

Family: Centrophoridae

55. ***Centrophorus acus* Garman, 1906**
56. ***Centrophorus atromarginatus*** Garman,1913

Order HEXANCHIFORMES

Family HEXANCHIDAE

57. ***Heptranchias perlo***(Bonnaterre, 1788)

Family HEXANCHIDAE

58. ***Hexanchus griseus***(Bonnaterre, 1788)

Family ECHINORHINIDAE

59. ***Echinorhinus brucus***(Bonnaterre, 1788)

Order CHIMAERIFORMES

Family RHINOCHIMAERIDAE

60. ***Neoharriotta pinnata***(Schnakenbeck, 1931)

Order: PRISTIFORMES

Family: Pristidae

61. ***Anoxypristis cuspidata* (Latham 1794)**
62. ***Pristis pristis* (Linnaeus 1758)**
63. ***Pristis zijsron* Bleeker, 1851**

Order: RAJIFORMES

Family: Rhyncobatidae

64. ***Glaucostegus granulatus* (Cuvier 1829)**
65. ***Rhina ancylostoma* Schneider, 1801**
66. ***Rhinobatos thouiniana*** (Shaw 1804)
67. ***Rhynchobatus laevis* (Bloch & Schneider, 1801)**

Family: Rajidae (Skates)

68. *Cruriraja andamanica (Lloyd,1909)*

Order: MYLIOBATIFORMES

Family: Dasyatidae

69. ***Dasyatis thetidis*** **Ogilby, 1899**
70. ***Dasyatis zugei*** **Muller & Henle, 1841)**
71. ***Himantura gerrardi*** **(Gray, 1851)**
72. ***Himantura imbricata*** **(Bloch & Schneider, 1801)**
73. ***Himantura jenkinsii*** **(Annandale 1909)New**
74. ***Himantura uarnak*** **(Forsskal, 1775)**
75. ***Himantura undulata*** **(Bleeker, 1852) New**
76. ***Neotrygon kuhlii*** **(Muller & Henle, 1841)**
77. ***Pastinachus sephen*** **(Forsskal, 1775)**
78. ***Taeniura lymma*** **(Forsskal, 1775)**
79. ***Taeniura meyeni*** **Muller & Henle, 1814**
80. ***Urogymnus asperrimus***(Bloch & Schneider, 1801) New

Family: Gymnuridae

81. ***Gymnura poecilura*** **(Shaw, 1804)**

Family: Myliobatidae (Eaglerays and Devilrays)

82. ***Aetobatus ocellatus*** **(Kuhl,1823)**
83. ***Aetomylaeus nichofii*** **(Bloch & Schneider, 1801)**
84. ***Manta birostris*** **(Walbaum, 1792)**
85. ***Rhinoptera javanica*** **Muller & Henle, 1841**

CLASS: ACTINOPTERYGII

Order: ELOPIFORMES

Family: Elopidae (Ladyfsihes)

86. ***Elops machnata*** **(Forsskal,1775)**

Family: Megalopidae

87. ***Megalops cyprinoides*** **(Broussonet, 1782)**

Order: ALBULIFORMES

Family: Albulidae

88. ***Albula vulpes*** **(Linnaeus, 1758)**

Order: NOTACANTHIFORMES

Family: Halosauridae (Halosaurs)

89. ***Halosaurus carinicauda*** **(Alcock, 1889)**

Order: ANGUILLIFORMES

Family: Anguillidae

90. ***Anguilla bengalensis*** **(Gray, 1831)**
91. ***Anguilla bicolor*** **McClelland, 1844**
92. ***Anguilla marmorata*** **(Bennett,1844)**

Family: Moringuidae (Spaghetti eels)

93. ***Moringua bicolor*** **Kaup,1856**

Family: Muraenidae

94. ***Echidna nebulosa*** **Ahl, 1789**
95. ***Echidna rhodochilus*** **Bleeker 1863**
96. *Gymnothorax andamanensis* Mohapatra, Praveenraj and Mohanty,2019
97. ***Gymnomuraena zebra*** **(Shaw, 1797)**
98. ***Gymnothorax favagineus*** **Bloch & Schneider, 1801**
99. ***Gymnothorax fimbriatus*** **(Bannett, 1831)**
100. ***Gymnothorax flavimarginatus*** **(Ruppell, 1830)**
101. ***Gymnothorax javanicus*** **(Bleeker, 1859)**
102. ***Gymnothorax pictus*** **(Ahl 1789)**
103. ***Gymnothorax richardsonii*** **(Bleeker, 1852)**
104. ***Gymnothorax rueppelliae*** **(McClelland, 1845)**
105. ***Gymnothorax thyrsoideus*** **(Richardson, 1845)**
106. ***Gymnothorax tile*** **(Hamilton, 1822)**
107. ***Gymnothorax undulatus*** **(Lacepede, 1803)**
108. ***Gymnothorax zonipectis*** Seale, 1906
109. ***Rhinomuraena quaesita*** **Garman,1888**
110. ***Scuticaria tigrina*** **(Lesson, 1828)**
111. ***Strophidon sathete*** **(Bleeker,1854)**
112. ***Uropterygius concolor*** **Ruppell, 1838**
113. ***Uropterygius marmoratus*** **(Lacepede, 1803)**
114. ***Uropterygius macrocephalus*** **(Bleeker 1864)**
115. ***Uropterygius micropterus*** **(Bleeker, 1852)**

Family: Ophichthidae (Snake Eels)

116. ***Callechelys catastomus*** **(Schneider, 1801)**
117. ***Cirrhimuraena playfairii*** **(Gunther, 1870)**
118. ***Leiuranus semicinctus*** **(Lay & Bennett, 1839)**
119. ***Muraenichthys schulzei*** **Bleeker, 1857**
120. ***Myrichthys colubrinus*** **(Boddaert, 1781)**
121. ***Myrichthys maculosus*** **(Cuvier, 1816)**
122. ***Ophichthys altipennis*** (Kaup, 1856)**New**

123. ***Pisodonophis cancrivorus*** **(Richardson,1848)**
124. ***Scolecenchelys macropterus*** **(Bleekr, 1857)**
125. ***Yirrkala maculata*** **(Klausewitz 1964)**
126. ***Xestochilus nebulosus*** **(Smith 1962)**
127. ***Coloconger raniceps*** **Alcock,1889**

Family: Muraensocidae

128. ***Congresox talabon*** **(Cuvier 1829)**
129. ***Congresox talabonoides*** **(Bleeker, 1853)**
130. ***Gavialiceps taeniola*** **Alcock, 1889**
131. ***Nemichthys scolopaceus*** **Richardson, 1848**

Family: Congridae (Conger Eels)

132. ***Ariosoma anago*** **(Temminck & Schlegel, 1846)**
133. ***Ariosoma mauritianum*** **(Pappenheim, 1914)**
134. ***Bathycongrus macrocercus*** **(Alcock, 1889)**
135. ***Conger cinereus*** **Ruppell, 1830**
136. ***Gorgasia maculata*** **Klausewitz & Eibl-eibesfeldt, 1959**
137. ***Gorgasia klausewitzi*** **Quéro & Saldanha 1995**
138. ***Heteroconger hassi*** **(Klausewitz & Eibl-Eibesfeldt, 1959)**
139. ***Heteroconger obscurus*** **(Klausewitz & Eibl-Eibesfeldt, 1959)**
140. ***Heteroconger perissodon*** **Böhlke & Randall 1981**

Family: Serrivomeridae

141. ***Serrivomer microps*** **(Alcock, 1889)**

Order: CLUPEIFORMES

Family: Dussumieridae

142. ***Dussumieria acuta*** **Valenciennes, 1847**
143. ***Dussumieria elopsoides*** **Bleeker, 1849**

Family: Clupeidae

144. ***Amblygaster clupeoides*** **(Bleeker,1849)**
145. ***Amblygaster leiogaster*** **(Valenciennes,1847)**
146. ***Amblygaster sirm*** **(Walbaum, 1742)**
147. ***Anodontostoma chacunda*** **(Hamilton, 1822)**
148. ***Anodontostoma selangkat*** **(Bleeker, 1852)**
149. ***Anodontostoma thailandiae*** **Wongratana, 1983**
150. ***Escualosa thoracata*** **Valenciennes 1847**
151. ***Gonialosa manmina*** **(Hamilton 1822)**
152. ***Herklotsichthys quadrimaculatus*** **(Ruppell, 1837)**
153. ***Hilsa kelee*** **(Cuvier, 1829)**
154. ***Nematalosa nasus*** **(Bloch, 1795)**
155. ***Sardinella albella*** **(Valenciennes, 1847)**
156. ***Sardinella brachysoma*** **Bleeker, 1852**
157. ***Sardinella fimbriata*** **(Valenciennes, 1847)**
158. ***Sardinella gibbosa*** **(Bleeker, 1849)**
159. ***Sardinella longiceps*** **Valenciennes 1847 ?**
160. ***Sardinella melanura*** **(Cuvier, 1829)**
161. ***Spratelloides delicatulus*** **(Bennett, 1831)**
162. ***Tenualosa toli*** **(Valenciennes, 1847)**

Family: Pristigasteridae

163. ***Ilisha filigera*** **(Valenciennes, 1847)**
164. ***Ilisha megaloptera*** **(Swainson, 1839)**
165. ***Ilisha melastoma*** **(Schneider, 1801)**
166. ***Opisthopterus tardoore*** **(Cuvier, 1829)**
167. ***Pellona dayi*** **Wongratana, 1983**
168. ***Pellona ditchela*** **Valenciennes, 1847**

Family: Engraulidae

169. ***Coilia ramcarati*** **(Hamilton, 1822)**
170. ***Encrasicholina heteroloba*** **(Rüppell, 1837)**
171. *Setipinna phasa* (Hamilton, 1822)
172. ***Setipinna tenuifilis*** **(Valenciennes, 1848)**
173. ***Stolephorus andhraensis*** Babu Rao 1966
174. ***Stolephorus commersonii*** Lacepede, 1803
175. ***Stolephorus indicus*** **(van Hasselt, 1823)**
176. ***Stolephorus waitei*** **Jordan & Seale, 1926**
177. ***Thryssa baelama*** **(Forsskal, 1775)**
178. ***Thryssa encrassicholoides*** **(Bleeker, 1852)**
179. *Thryssa malabarica* (Bloch, 1795)
180. ***Thryssa mystax*** **(Schneider, 1801)**
181. ***Thryssa setirostris*** **(Broussonet, 1782)**

Family: Chirocentridae

182. ***Chirocentrus dorab*** **(Forsskal, 1775)**
183. ***Chirocentrus nudus*** **Swainson, 1839**

Order: GONORHYNCHIFORMES

Family: Chanidae

184. ***Chanos chanos*** **(Forsskal, 1775)**

Order: CYPRINFORMES

Family: Cyprinidae

185. ***Cirrhinus cirrhosus*** **(Bloch 1795)**
186. ***Cirrhinus mrigala*** **(Hamilton, 1822)**
187. ***Ctenopharyngodon idella*** **(Valenciennes, 1844)**
188. ***Cyprinus carpio*** **Linnaeus, 1758**
189. ***Cyprinus danrica***, Hamilton 1822
190. ***Gibelion catla*** **(Hamilton, 1822)**
191. ***Hypophthalmichthys molitrix*** **(Valenciennes, 1844)**
192. ***Labeo calabasu*** **(Hamilton, 1822)**
193. ***Labeo rohita*** **(Hamilton, 1822)**
194. ***Rasbora daniconius*** **(Hamilton, 1822)**
195. ***Rasbora hobelmani*** **Kottelat, 1984**

Order: CHARACIFORMES

Family: Serrasalmidae

196. ***Piaractus brachypomus*****(Cuvier 1818)**

Order: SILURIFORMS

Family: Plotosidae

197. ***Plotosus canius*** **Hamilton, 1822**
198. ***Plotosus lineatus*** **(Thunberg, 1787)**

Family: Clariidae

199. ***Clarias magur*** **(Hamilton 1822)**

Family: Heteropneustidae

200. ***Heteropneustes fossilis*** **(Bloch, 1794)**

Family: Ariidae (Sea catfishes)

201. ***Arius subrostratus*** **Valenciennes, 1840**
202. ***Arius sumatranus*** **(Anonymus[Bennett], 1830)** Arius venosus**Valenciennes 1840 *Ketengus typus* Bleeker, 1847**
203. ***Nemapteryx macronotacantha*** **(Bleeker, 1846)**
204. ***Netuma bilineata*** **(Valenciennes, 1840)**
205. ***Netuma thalassina*** **(Ruppell, 1837)**
206. ***Plicofollis dussumieri*** **(Valenciennes, 1840)**

Family: Pangasiidae (Shark catfishes)

207. ***Pangasianodon hypophthalmus*** **(Sauvage 1878)**

Order: OSMERIFORMES

Family: Alepocephalidae (Slickheads)

208. ***Alepocephalus longiceps*** **Lloyd, 1909**
209. ***Bathytroctes macrolepis*** **Günther, 1887**
210. ***Rouleina squamilatera*** **(Alcock 1898)**

Order: STOMIIFORMES

Family: Gonostomatidae (Bristlemouths)

211. ***Cyclothone microdon*** **(Gunther, 1878)**
212. ***Diplophos taenia*** Gunther, 1873

Family: Sternoptychidae (Hatchetfishes)

213. ***Polyipnus spinosus*** **Günther, 1887**

Family: Phosichthyidae (Lightfishes)

214. ***Polymetme corythaeola*** **(Alcock, 1898)**

Family: Stomiidae

215. ***Chauliodus sloani*** **Bloch & Schneider, 1801**
216. ***Malacosteus niger*** **Ayres, 1848**
217. ***Photostomias atrox*** (Alcock 1890)
218. ***Stomias affinis*** **Günther, 1887**
219. ***Stomias nebulosus*** **Alcock, 1889**

Order: ATELEOPODIFORMES

Family: Ateleopodidae (Jellynose fishes)

220. ***Ateleopus indicus*** **Alcock, 1891**

Order: AULOPIFORMES

Family: Synodontidae

221. ***Saurida gracilis*** **(Quoy & Gaimard, 1824)**
222. ***Saurida micropectoralis*** **Shindo & Yamada, 1972**
223. ***Saurida nebulosa*** **Valenciennes, 1850**
224. ***Saurida tumbil*** **(Bloch, 1795)**
225. ***Saurida undosquamis*** **(Richardson, 1848)**
226. ***Synodus dermatogenys*** Fowler, 1912 New
227. ***Synodus hoshinonis*** **Tanaka, 1917**
228. ***Synodus indicus*** **(Day, 1873)**
229. ***Synodus oculeus*** **Cressey, 1981**
230. ***Synodus variegatus*** **Lacepede, 1803**
231. ***Trachinocephalus myops*** **(Forster, 1801)**

Family: Ipnopidae (Deepsea tripodfishes)

232. ***Bathypterois guentheri*** **Alcock, 1889**

233. ***Ipnops agassizii*** **Garman, 1899**

Family: *Evermannellidae* *(Saber-toothed fishes)*

234. ***Coccorella atrata*** **(Alcock, 1894)**

Order: MYCTOPHIFORMES

Family: Neoscopelidae

235. ***Neoscopelus macrolepidotus*** **Johnson, 1863**

Family: Myctophidae (Lanternfishes)

236. ***Benthosema pterotum*** **(Alcock, 1890)**

237. ***Diaphus coeruleus*** **(Klunzinger, 1871)**

238. ***Diaphus diademophilus*** **Nafpaktitis, 1978**

239. ***Diaphus malayanus*** **Weber, 1913**

240. ***Diaphus nielseni*** **Nafpaktitis, 1978**

241. ***Diaphus regani*** Taning, 1932

242. ***Diaphus suborbitalis Weber*****, 1913**

ORDER: POLYMIXIIFORMES

Family: POLYMIXIIDAE

243. ***Polymixia brendti*** **Gilbert 1905**

Order: GADIFORMES

Family: Bregmacerotidae

244. ***Bregmaceros mcclellandi*** **Thompson, 1840**

Family: Macrouridae

245. ***Bathygadus furvescens*** **Alcock, 1894**

246. ***Caelorinchus parallelus*** **(Gunther, 1877)**

247. ***Coelorinchus quadricristatus (Alcock, 1891)***

248. *Coryphaenoides macrolophus* (Alcock, 1889)

249. ***Gadomus multifilis*** (Günther 1887)

250. ***Hymenocephalus heterolepis*** (Alcock 1889)

251. ***Malacocephalus laevis*** **(Lowe, 1843)**

252. ***Nezumia brevirostris*** **(Alcock, 1889)**

253. ***Nezumia investigatoris*** **(Alcock, 1889)**

254. ***Nezumia semiquincunciata (Alcock, 1889)***

255. ***Ventrifossa petersonii*** **(Alcock,1891)**

Family: Moridae

256. ***Physiculus roseus*** **Alcock, 1891**

Order: OPHIDIIFORMES

Family: Carapidae

257. ***Encheliophis homei*** **(Richardson, 1844)**

258. ***Onuxodon margaritiferae*** **(Rendahl, 1921)**

Family: Ophidiidae

259. ***Brotula multibarbata*** **Temminck & Schlegal, 1846**

260. ***Dicrolene multifilis*** **(Alcock, 1889)**

261. ***Dicrolene nigricaudis*** **(Alcock, 1891)**

262. ***Glyptophidium argenteum*** **Alcock, 1889**

263. *Lamprogrammus niger* Alcock, 1891

264. ***Monomitopus nigripinnis*** **(Alcock, 1889)**

265. ***Neobythites macrops*** **Günther, 1887**

266. ***Spottobrotula mahodadi*** **Cohen & Nielsen, 1978**

Family: Bythitidae

267. ***Alionematichthys piger*** **(Alcock, 1890)**

268. ***Dinematichthys iluocoeteoides*** **Bleeker, 1855**

269. ***Diplacanthopoma raniceps*** **Alcock, 1898**

270. ***Eusurculus andamanensis*** Schwarzhans & Møller 2007

271. ***Hephthocara simum*** **Alcock, 1892**

Family: Aphyonidae

272. ***Barathronus diaphanus*** **Brauer, 1906**

Order: LOPHIIFORMES

Family: Lophiidae

273. ***Lophiodes mutilus*** **(Alcock, 1894)**

274. ***Lophiomus setigerus*** **(Vahl, 1797)**

Family: Antennariidae Anglerfishes

275. ***Antennatus coccineus*** **(Lesson, 1831)**

276. ***Antennarius commerson*** **(Latreille, 1804)**

277. ***Antennarius pictus*** **(Shaw, 1794)**

278. ***Histrio histrio*** **(Linnaeus, 1758)**

Family: Ogcocephalidae (Batfishes)

279. ***Coelophrys micropa (Alcock 1891)***

280. ***Halieutaea coccinea Alcock, 1889***

281. ***Halieutaea nigra Alcock, 1891***

282. ***Halicmetus ruber*** **Alcock, 1891**

283. ***Halieutopsis stellifera*** **(Smith & Radcliffe, 1912)**
284. ***Malthopsis lutea*** **Alcock, 1891**
285. ***Malthopsis mitrigera*** **Gilbert & Cramer, 1897**
286. ***Halieutopsis nasuta*** **(Alcock 1891)**

Order: MUGILIFORMES

Family: Mugilidae

287. ***Crenimugil crenilabis*** **(Forsskal, 1775)**
288. ***Ellochelon vaigiensis*** **(Quoy & Gaimard, 1825)**
289. ***Liza carinata*** **(Valenciennes, 1836)**
290. ***Liza macrolepis*** **(Smith, 1846)**
291. ***Chelon melinopterus*****(Valencienes, 1836)**
292. ***Liza parmatus*** **(Cantor, 1849)**
293. ***Liza parsia*** **(Hamilton, 1822)**
294. ***Liza subviridis*** **(Valenciennes, 1836)**
295. ***Planiliza tade***Forsskål 1775
296. ***Crenimugil buchanani*** (Bleeker 1853).
297. ***Osteomugil cunnesius*** (Valenciennes 1836)
298. ***Crenimugil seheli*** (Forsskål 1775).
299. ***Mugil cephalus*** **Linnaeus, 1758**
300. ***Oedalechilus labiosus*** **(Valenciennes, 1836)**

Order: ATHERINIFORMES

Family: Isonidae (Notocheiridae)

301. ***Iso natalensis*** **Regan, 1919**

Family: Atherinidae

302. ***Atherinomorus duodecimalis*** **(Valenciennes, 1835)**
303. ***Atherinomorus endrachtensis*** **(Quoy & Gaimard, 1825)**
304. ***Atherinomorus lacunosus*** **(Forster, 1801)**
305. ***Hypoatherina temminckii*** **(Bleeker, 1854)**

Order: BELONIFORMES

Family: Adrianichthyidae

306. ***Oryzias carnaticus*** **(Jerdon 1849)**

Family: Exocoetidae

307. ***Cheilopogon furcatus*** **(Mitchill, 1815)**
308. ***Cheilopogon spilopterus*****(Valenciennes, 1847)**
309. ***Cypselurus naresii*** **(Gunther 1889)**
310. ***Cypselurus oligolepis*** **(Bleeker, 1866)**
311. ***Cypselurus poecilopterus*** **(Valenciennes, 1846)**
312. ***Exocoetus volitans*** **Linnaeus, 1758**
313. ***Parexocoetus brachypterus*** **(Richardson, 1846)**

Family: Hemiramphidae

314. ***Hemiramphus far*** **(Forsskal, 1775)**
315. ***Hemiramphus lutkei*** **Valenciennes, 1847**
316. ***Hyporhamphus dussumieri*** **(Valenciennes, 1846)**
317. ***Hyporhamphus limbatus*** **(Valenciennes, 1847)**
318. ***Hyporhamphus quoyi*** **(Valenciennes, 1847)**
319. ***Hyporhamphus xanthopterus*** **(Valenciennes, 1847)**
320. ***Rhynchorhamphus georgii*** **(Valenciennes 1847)**
321. ***Rhynchorhamphus malabaricus*** **Collette 1976**

Family: Zenarchopteridae

322. ***Zenarchopterus buffonis*** **(Valenciennes, 1846)**
323. ***Zenarchopterus dispar*** **(Valenciennes, 1847)**
324. ***Zenarchopterus dunckeri*** **Mohr 1926**
325. ***Zenarchopterus gilli*** **Smith, 1945**
326. ***Zenarchopterus pappenheimi*** **Mohr, 1926**

Family: Belonidae

327. ***Ablennes hians*** **(Valenciennes, 1846)**
328. ***Strongylura leiura*** **(Bleeker,1851)**
329. ***Strongylura strongylura*** **(Van Hasselt, 1823)**
330. ***Tylosurus acus melanotus*** **(Bleeker 1850)**
331. ***Tylosurus crocodilus*** **(Peron & Le Sueur, 1821)**

Order: CYPRINODONTIFORMES

Family: Aplocheilidae

332. ***Aplocheilus panchax*** **(Hamilton, 1822)**
333. ***Aplocheilus andamanicus*** **(Köhler, 1906)**

Family: Poeciliidae

334. ***Gambusia affinis*** **(Baird & Girard 1853)**

Order: BERYCIFORMES

Family: Diretmidae

335. ***Diretmoides veriginae*** **Kotlyar 1987**

Family: Monocentridae Pinonone Fishes

336. ***Monocentris japonica*** **(Houttuyn, 1782)**

Family: Holocentridae

337. ***Myripristis adusta*** **(Bleeker, 1853)**
338. ***Myripristis berndti*** **Jordan and Evermann, 1903**
339. ***Myripristis hexagona*** **(Lacepede, 1802)**
340. ***Myripristis murdjan*** **(Forsskal, 1775)**
341. ***Myripristis violacea*** **Bleeker,1851**
342. ***Neoniphon aurolineatus*** **(Lienard,1839)**
343. ***Neoniphon samara*** **(Forsskal, 1775)**
344. ***Ostichthys japonicus*** **(Cuvier, 1829)**
345. ***Sargocentron caudimaculatum*** **(Ruppell, 1838)**
346. ***Sargocentron diadema*** **(Lacepede, 1802)**
347. ***Sargocentron ittodai*** **(Jordan & Fowler, 1903)**
348. ***Sargocentron melanospilos*** **(Bleeker, 1858)**
349. ***Sargocentron praslin*** **(Lacepede, 1802)**
350. ***Sargocentron punctatissimum*** **(Cuvier, 1829)**
351. ***Sargocentron rubrum*** **(Forsskal, 1775)**
352. ***Sargocentron spiniferum*** **(Forsskal, 1775)**

Order: GASTEROSTEIFORMES

Family: Pegasidae

353. ***Eurypegasus draconis*** **(Linnaeus, 1766)**
354. ***Pegasus volitans*** **Linnaeus, 1758**

Order: SYNGNATHIFORMES

Family: Aulostomidae (Trumpetfishes)

355. ***Aulostomus chinensis*** **(Linnaeus, 1766)**

Family: Fistulariidae

356. ***Fistularia commersonii*** **Ruppell, 1838**
357. ***Fistularia petimba*** **Lacepede, 1803**

Family: Centriscidae

358. ***Aeoliscus strigatus*** **(Gunther, 1861)**
359. ***Centriscus scutatus*** **Linnaeus, 1783**

Family: Solenostomidae

360. ***Solenostomus cyanopterus*** **Bleeker, 1854**
361. ***Solenostomus paradoxus*** **(Pallas, 1870)**

Family: Syngnathidae (Pipefishes and Seahorses)

362. ***Acentronura gracilissima*** **(Temminck & Schlegel, 1850)**
363. ***Bhanotia fasciolata*** **(Duméril, 1870)**
364. ***Corythoichthys amplexus*** **Dawson and Randall, 1975**
365. ***Corythoichthys benedetto*** **Allen and Erdmann, 2008**
366. ***Corythoichthys haematopterus*** **(Bleeker, 1851)**
367. ***Corythoichthys intestinalis*** **(Ramsay, 1881)**
368. ***Corythoichthys ocellatus*** **Herald, 1953**
369. ***Choeroichthys sculptus*** **(Gunther. 1870)**
370. ***Corythoichthys schultzi*** **Harald, 1953**
371. ***Doryichthys martensi*** **(Peters, 1869)**
372. ***Doryramphus dactyliophorus*** **(Bleeker, 1853)**
373. ***Doryramphus excisus excisus*** **Kaup, 1856**
374. ***Halicampus grayi*** **Kaup 1856**
375. ***Halicampus macrorhynchus*** **Bamber, 1915**
376. ***Halicampus mataafae*** **(Jordan & Seale, 1906)**
377. ***Hippichthys cyanospilos*** **(Bleeker, 1854)**
378. ***Hippichthys heptagonus*** **Bleeker, 1849**
379. ***Hippichhys spicifer*** **(Ruppell, 1838)**
380. ***Hippocampus histrix*** **Kaup, 1856**
381. ***Hippocampus kuda*** **Bleeker, 1852**
382. ***Hippocampus trimaculatus*** **Leach, 1814**
383. ***Ichthyocampus carce*** **(Hamilton 1822)**
384. ***Microphis brachyurus*** **(Bleeker,1853)**
385. ***Oostethus insularis*** **(Hora 1925)**
386. ***Phoxocampus tetrophthalmus*** **(Bleeker, 1858)**
387. ***Syngnathoides biaculeatus*** **(Bloch, 1785)**

Order: SCORPAENIFORMES

Family: Dactylopteridae

388. ***Dactyloptena orientalis*** **(Cuvier, 1829)**
389. ***Dactyloptena peterseni*** **(Nystrom 1887)** (Need better reference)

Family: Scorpaenidae

390. ***Caracanthus unipinna*** **(Gray, 1831)**
391. ***Dendrochirus biocellatus*** **(Fowler, 1938)**
392. ***Dendrochirus brachypterus*** **(Cuvier, 1829)**
393. ***Dendrochirus zebra*** **(Cuvier, 1829)**
394. ***Parascorpaena bleekeri*** **(Day, 1878)**
395. ***Parascorpaena picta*** **(Cuvier 1829)**
396. ***Pontinus rhodochrous*** **(Gunther 1872)**
397. ***Pterois antennata*** **(Bloch, 1787)**
398. ***Pterois miles*** **(Bennett, 1828)**
399. ***Pterois radiata*** **Cuvier, 1829**

400. ***Pterois russelli*** **Bennett, 1831**
401. ***Scorpaena neglecta*** **Temminck & Schlegel, 1843**
402. ***Scorpaenodes guamensis*** **(Cuvier & Gaimard, 1824)**
403. ***Scorpaenodes smithi*** **Eschmeyer & Rama-Rao, 1972 ?**
404. ***Scorpaenopsis cirrosa*** **(Thunberg, 1793)**
405. ***Scorpaenopsis diabolus*** (Cuvier, 1829)
406. ***Scorpaenopsis gibbosa*** **Bloch & Schneider, 1801**
407. ***Scorpaenopsis oxycephalus*** **(Bleeker, 1849)**
408. ***Scorpaenopsis possi*** **Randall & Eschmeyer, 2001 New**
409. ***Scorpaenopsis venosa*** **(Cuvier, 1829)**
410. ***Sebastapistes strongia*** **(Cuvier, 1829)**
411. ***Taenianotus triacanthus*** **Lacepede, 1802**

Family: Setarchidae

412. ***Setarches guentheri*** **Johnson, 1862**
413. ***Setarches longimanus*** **(Alcock, 1894)**

Family: Synanceiidae

414. ***Inimicus caledonicus*** **(Sauvage, 1878)**
415. ***Inimicus didactylus*** **(Pallas, 1769)**
416. ***Synanceia alula*** **Eschmeyer & Rama-Rao, 1973**
417. ***Synanceia horrida*** **(Linnaeus, 1766)**
418. ***Synanceia verrucosa*** **Bloch & Schneider, 1801**
419. ***Trachicephalus uranoscopus*** **(Bloch & Schneider, 1801)**

Family: Tetrarogidae

420. ***Ablabys macracanthus*** **(Bleeker, 1852)**
421. ***Ablabys taenianotus*** **(Cuvier, 1829)**
422. ***Tetraroge barbata*** **(Cuvier, 1829)**
423. ***Tetratoge nigra*** **(Cuvier, 1829)**
424. ***Neovespicula depressifrons*** **(Richardson, 1848)**
425. ***Vespicula trachinoides*** **(Cuvier, 1829)**

Family: Aploactinidae

426. ***Acanthosphex leurynnis*** **(Jordan & Seale 1905)**
427. ***Cocotropus echinatus*** **(Cantor, 1849)**
428. *Cocotropus steinitzi* Eschmeyer & Dor, 1978
429. *Xenaploactis cautes* Poss & Eschmeyer, 1980

Family: Triglidae

430. ***Lepidotrigla longipinnis*** **Alcock, 1890**

Family: Peristediidae (Armored Searobins)

431. ***Scalicus investigatoris*** **(Alcock 1898)**
432. ***Scalicus serrulatus*** **(Alcock 1898)**
433. ***Paraheminodus murrayi*** **(Gunther, 1880)**

Family: Platycephalidae

434. ***Cociella crocodila*** **(Tilesius, 1812)**
435. ***Cymbacephalus beauforti*** **(Knapp, 1973) New**
436. ***Sunagocia carbunculus*** **(Valenciennes, 1833)**
437. ***Grammoplites scaber*** **(Linnaeus, 1758)**
438. ***Inegocia japonica*** **(Cuvier, 1829)**
439. ***Kumococius rodericensis*** **(Cuvier 1829)**
440. ***Onigocia oligolepis*** **(Regan, 1908)**
441. ***Platycephalus indicus*** **(Linnaeus, 1758)**
442. ***Rogadius pristiger*** **(Cuvier 1830)**
443. ***Sorsogona tuberculata*** **(Cuvier, 1829)**
444. ***Thysanophrys celebica*** **(Bleeker, 1855)**
445. ***Thysanophrys chiltonae*** **Schultz, 1966**

Order: PERCIFORMES

Family: Ambassidae

446. ***Ambassis ambassis*** **(Lacepède, 1802) ?**
447. ***Ambassis buruensis*** **Bleeker, 1856**
448. ***Ambassis buton*** **Popta, 1918**
449. ***Ambassis dussumieri*** **Cuvier, 1828**
450. ***Ambassis gymnocephalus*** **(Lacepède, 1802)**
451. ***Ambassis interruptus*** **Bleeker, 1852**
452. ***Ambassis kopsii*** **Bleeker, 1856**
453. ***Ambassis nalua*** **(Hamilton, 1822)**
454. ***Ambassis urotaenia*** **Bleeker, 1852**
455. ***Parambassis dayi*** **(Bleeker,1874)**

Family: Latidae (Lates)

456. ***Lates calcarifer*** **(Bloch, 1790)**
457. ***Psammoperca waigiensis*** **(Cuvier,1828)**

Family: Serranidae (Anthias and Groupers)

458. ***Aethaloperca rogaa*** **(Forsskal, 1775)**
459. ***Anyperodon leucogrammicus*** **(Valenciennes, 1828)**
460. ***Aulacocephalus temmincki*** **Bleeker, 1854**
461. ***Cephalopholis argus*** **Schneider, 1801**
462. ***Cephalopholis boenak*** **(Bloch, 1790)**

463. ***Cephalopholis cyanostigma*** **(Valenciennes, 1828)**
464. ***Cephalopholis formosa*** **(Shaw & Nodder, 1812)**
465. ***Cephalopholis leopardus*** **(Lacepede, 1802)**
466. ***Cephalopholis microprion*** **(Bleeker, 1852)**
467. ***Cephalopholis miniata*** **(Forsskal, 1775)**
468. ***Cephalopholis nigripinnis*** **(Valenciennes, 1828) New**
469. ***Cephalopholis polyspila*** **Randall & Satapoomin, 2000**
470. ***Cephalopholis sexmaculata*** **(Ruppell,1830)**
471. ***Cephalopholis sonnerati*** **(Valenciennes, 1828)**
472. ***Cephalopholis urodeta*** **(Forster, 1801)**
473. ***Chromileptes altivelis*** **(Valenciennes, 1829)**
474. ***Diploprion bifasciatum*** **Cuvier, 1828**
475. *Epinephelus amblycephalus* (Bleeker, 1857),
476. ***Epinephelus areolatus*** **(Forsskal, 1775)**
477. ***Epinephelus bleekeri*** **(Vaillant 1878)**
478. ***Epinephelus coeruleopunctatus*** **(Bloch, 1790)**
479. ***Epinephelus chlorostigma*** **(Valenciennes, 1828)**
480. ***Epinephelus coioides*** **(Hamilton, 1822)**
481. ***Epinephelus corallicola*** **(Valenciennes, 1828)**
482. ***Epinephelus epistictus***(Temminck and Schlegel, 1842) (in Book, New?)
483. ***Epinephelus erythrurus*** **(Valenciennes, 1828)**
484. ***Epinephelus fasciatus*** **(Forsskal, 1775)**
485. ***Epinephelus faveatus*** **(Valenciennes, 1828)**
486. ***Epinephelus flavocaeruleus*** **(Lacepede, 1801)**
487. ***Epinephelus fuscoguttatus*** **(Forsskal, 1775)**
488. ***Epinephelus hexagonatus*** **(Forster, 1801)**
489. ***Epinephelus lanceolatus*** **(Bloch, 1790)**
490. ***Epinephelus longispinis*** **(Kner, 1864)**
491. ***Epinephelus macrospilos*** **(Bleeker, 1855)**
492. ***Epinephelus malabaricus*** **(Bloch & Schneider, 1801)**
493. ***Epinephelus melanostigma*** **Schultz, 1953**
494. ***Epinephelus merra*** **Bloch, 1793**
495. ***Epinephelus miliaris*** **(Valenciennes, 1830)**
496. ***Epinephelus morrhua*** **(Valenciennes 1833)?**
497. ***Epinephelus ongus*** **(Bloch, 1790)**
498. ***Epinephelus polyphekadion*** **(Bleeker,1849)**
499. ***Epinephelus polystigma*** **(Bleker,1853)**
500. ***Epinephelus quoyanus*** **(Valenciennes. 1830)**
501. ***Epinephelus radiatus*** **(Day,1868)**
502. ***Epinephelus retouti*** Bleeker, 1868
503. ***Epinephelus sexfasciatus*** **(Valenciennes, 1828)**
504. ***Epinephelus spilotoceps*** **Schultz, 1953**
505. ***Epinephelus tauvina*** **(Forsskal, 1775)**
506. ***Epinephelus undulosus*** **(Quoy & Gaimard, 1824)**
507. ***Gracila albimarginata*** **(Lowe, 1834)**
508. ***Grammistes sexlineatus*** **(Thunberg, 1792)**
509. ***Hyporthodus octofasciatus*** **(Griffen, 1926)**
510. ***Plectranthias winniensis*** **(Tyler, 1966)**
511. ***Plectropomus areolatus*** **(Ruppell, 1830)**
512. ***Plectropomus laevis*** **(Lacepede, 1802)**
513. ***Plectropomus maculatus*** **(Bloch,1790)**
514. ***Plectropomus pessuliferus*** **(Fowler, 1904)**
515. ***Pogonoperca ocellata*** **Gunther, 1859**
516. ***Pseudanthias bimaculatus*** **(Smith, 1955)**
517. ***Pseudanthias cooperi*** **(Regan, 1902)**
518. ***Pseudanthias hypselosoma*** **Bleeker, 1878**
519. ***Pseudanthias ignitus*** **(Randall and Lubbock, 1981)**
520. ***Pseudanthias pulcherrimus*** **(Heemstra & Randall 1986)**
521. ***Pseudanthias squamipinnis*** **Peters, 1855**
522. ***Variola albimarginata*** **Baissac, 1952**
523. ***Variola louti*** **(Forsskal, 1775)**

Family: Centrogeneyidae

524. ***Centrogenys vaigiensis*** **(Quoy & Gaimard 1824)**

Family: Pseudochromidae Dottybacks

525. ***Congrogadus subducens*** **(Richardson, 1843)**
526. ***Pseudochromis andamanensis*** Lubbock 1980
527. ***Pseudochromis coccinicauda*** (Tickell 1888)
528. ***Pseudochromis dutoiti*** Smith, 1955 New
529. ***Pseudochromis fuscus*** **Muller & Troschel, 1849**
530. ***Pseudochromis tigrinus*** **Allen & Erdmann 2012**
531. ***Pseudochromis xanthochir*** **Bleeker, 1855**

Family: Plesiopidae

532. ***Plesiops auritus*** **Mooi, 1995**
533. ***Plesiops coeruleolineatus*** **Ruppell, 1835**
534. ***Plesiops corallicola*** **Bleeker, 1853**
535. ***Plesiops oxycephalus*** **Bleeker, 1855**

Family: Opistognathidae

536. ***Opistognathus annulata*** **(Eibl-Eibesfeldt & Klausewitz, 1961)**

537. ***Opistognathus albicaudatus*** **Smith Vaniz, 2011**

538. ***Opistognathus cyanospilotus*** **Smith-Vaniz 2009**

539. ***Opistognathus nigromarginatus*** **Ruppell 1828**

540. ***Opistognathus rosenbergii*** **Bleeker, 1857**

Family: Priacanthidae (Bigeyes)

541. ***Heteropriacanthus cruentatus*** **(Lacepede,1801)**

542. ***Priacanthus blochii*** **Bleeker, 1853**

543. ***Priacanthus hamrur*** **(Forsskal, 1775)**

544. ***Priacanthus tayenus*** **Richardson, 1846**

545. ***Pristigenys niphonia*** **(Cuvier, 1829)**

Family : APOGONIDAE

546. ***Apogonichthyoides melas*** **(Bleeker 1848)**

547. ***Apogonichthyoides nigripinnis*** **(Cuvier 1828)**

548. ***Apogonichthyoides taeniatus*** **(Cuvier 1828) ?**

549. ***Apogonichthys ocellatus*** **(Weber, 1913)**

550. ***Apogonichthys perdix*** **Bleeker, 1854**

551. ***Archamia bleekeri*** **(Gunther, 1859)New**

552. ***Cheilodipterus arabicus*** **Gmelin, 1789**

553. ***Cheilodipterus artus*** **Smith, 1961**

554. ***Cheilodipterus intermedius*** **Gon, 1993**

555. ***Cheilodipterus isostigmus*** **(Schultz, 1940)**

556. ***Cheilodipterus macrodon*** **(Lacepede, 1802)**

557. ***Cheilodipterus quinquelineatus*** **Cuvier, 1828**

558. ***Fibramia lateralis*** **(Valenciennes 1832)**

559. ***Fibramia thermalis*** **(Cuvier 1829)**

560. ***Fowleria aurita*** **(Valenciennes, 1831)**

561. ***Fowleria variegata*** (Valenciennes, 1832) **New**

562. ***Jaydia poeciloptera*** **(Cuvier 1828)**

563. ***Jaydia truncata*** **(Bleeker 1854)**

564. ***Lepidamia multitaeniatus*** **(Cuvier 1828)**

565. ***Nectamia fusca*** **(Quoy & Gaimard 1825)**

566. ***Nectamia savayensis*** **(Günther 1872)**

567. ***Ostorhinchus angustatus*** **(Smith & Radcliffe, 1911)**

568. ***Ostorhinchus aureus*** **(Lacepede, 1802)**

569. ***Ostorhinchus chrysotaenia*** **(Bleeker,1851)**

570. ***Ostorhinchus compressus*** **(Smith & Radcliffe, 1911)**

571. ***Ostorhinchus cookii*** **(Macleay, 1881)**

572. ***Ostorhinchus cyanosoma*** **(Bleeker, 1853)**

573. ***Ostorhinchus endekataenia*** **Bleeker, 1852**

574. ***Ostorhinchus fasciatus*** **(White, 1790)**

575. ***Ostorhinchus fleurieu*** **(Lacepede,1802)**

576. ***Ostorhinchus moluccensis*** **Valenciennes, 1832**

577. ***Ostorhinchus nanus*** (Allen, Kuiter & Randall, 1994) **NEW**

578. ***Ostorhinchus neotes*** **(Allen, Kuiter & Randall 1994)**

579. ***Ostorhinchus nigricans*** **(Day 1875)**

580. ***Ostorhinchus nigrofasciatus*** (Lachner, 1953)

581. ***Ostorhinchus novemfasciatus*** **Cuvier, 1828**

582. ***Ostorhinchus properuptus*** **(Whitley, 1964)**

583. ***Ostorhinchus septemstriatus*** **Günther, 1880**

584. ***Ostorhinchus wassinki*** **(Bleeker, 1861)**

585. ***Pristicon trimaculatus*** **(Cuvier 1828)**

586. ***Pristiapogon fraenatus*** **(Valenciennes, 1832)**

587. ***Pristiapogon kallopterus*** **(Bleeker, 1856)**

588. ***Rhabdamia gracilis*** **(Bleeker, 1856)**

589. ***Siphamia tubifer*** **Weber, 1909**

590. ***Sphaeramia orbicularis*** **(Kuhl & Van Hasselt, 1828)**

591. ***Taeniamia fucata*** **(Cantor, 1850)**

592. ***Taeniamia macroptera*** **(Cuvier,1828)**

593. ***Yarica hyalosoma*** **(Bleeker 1852)**

594. ***Zoramia fragilis*** **(Smith 1961)**

595. ***Zoramia leptacanthus*** **(Bleeker,1857)**

Family: Sillaginidae

596. ***Sillaginopodys chondropus*** **(Bleeker 1849)**

597. ***Sillago aeolus*** **Jordan & Evermann, 1902**

598. ***Sillago sihama*** **(Forsskal, 1775)**

Family: Malacanthidae

599. ***Hoplolatilus fronticinctus*** **(Gunther, 1887)**

600. ***Hoplolatilus luteus*** **Allen & Kuiter 1989**

601. ***Malacanthus brevirostris*** **Guichenot, 1848**

602. ***Malacanthus latovittatus*** **(Lacepede, 1801)**

Family: Lactariidae

603. ***Lactarius lactarius*** **(Schneider, 1801)**

Family: Coryphaenidae

604. ***Coryphaena hippurus*** **Linnaeus, 1758**

Family: Rachycentridae

605. ***Rachycentron canadus*** **(Linnaeus, 1766)**

Family: Echeneidae

606. ***Echeneis naucrates*** **Linnaeus, 1758**

607. ***Remora remora*** **(Linnaeus, 1758)**

Family: Carangidae

608. ***Alectis ciliaris*** **(Bloch, 1788)**

609. ***Alectis indicus*** **(Ruppell, 1830)**

610. ***Alepes djedaba*** **(Forsskal, 1775)**

611. ***Alepes kleinni*** **(Bloch, 1793)**

612. ***Alepes melanoptera*** **Swainson,1839**

613. ***Alepes vari*** **(Cuvier 1833)**

614. ***Atropus atropos*** **(Bloch and Schneider 1833)**

615. ***Atule mate*** **(Cuvier, 1833)**

616. ***Carangoides armatus*** **(Ruppell, 1830)**

617. ***Carangoides bajad*** **(Forsskal, 1775) (New)**

618. ***Carangoides coeruleopinnatus*** **(Ruppell, 1830)**

619. ***Carangoides chrysophrys*** **(Cuvier, 1833)**

620. ***Carangoides dinema*** **Bleeker, 1851**

621. ***Carangoides ferdau*** **(Forsskal, 1775)**

622. ***Carangoides fulvoguttatus*** **(Forsskal, 1775)**

623. ***Carangoides gymnostethus*** **(Cuvier, 1833)**

624. ***Carangoides hedlandensis*** **(Whitely, 1934)**

625. ***Carangoides humerosus*** **(Mc Culloch,1915)**

626. ***Carangoides malabaricus*** **(Bloch & Schneider, 1801)**

627. ***Carangoides oblongus*** **(Cuvier, 1833)**

628. ***Carangoides plagiotaenia*** **Bleeker, 1857**

629. ***Carangoides talamparoides*** **Bleeker, 1852**

630. ***Carangoides uii*** **Wakiya, 1852**

631. ***Caranx ignobilis*** **(Forsskal, 1775)**

632. ***Caranx malabaricus*** **(Bloch & Schneider, 1801)**

633. ***Caranx melampygus*** **Cuvier, 1801**

634. ***Caranx sexfasciatus*** **Quoy & Gaimard, 1824**

635. ***Caranx tille*** **Cuvier,1833**

636. ***Decapterus kurroides*** **Bleeker,1851**

637. ***Decapterus macrosoma*** **Bleeker,1851**

638. ***Decapterus maruadsi*** **(Temminck and Schlegel,1843)**

639. ***Decapterus russelli*** **(Rüppell, 1830)**

640. ***Elegatis bipinnulata*** **(Quoy & Gaimard, 1824)**

641. ***Gnathanodon speciosus*** **(Forsskal, 1775)**

642. ***Megalaspis cordyla*** **(Linnaeus, 1758)**

643. ***Parastromateus niger*** **(Bloch,1795)**

644. ***Scomberoides commersonnianus*** **Lacepede, 1802**

645. ***Scomberoides lysan*** **(Frosskal, 1775)**

646. ***Scomberoides tala*** **(Cuvier, 1831)**

647. ***Scomberoides tol*** **(Cuvier, 1832)**

648. ***Selar boops*** **(Cuvier, 1833)**

649. ***Selar crumenophthalmus*** **(Bloch, 1739)**

650. ***Selaroides leptolepis*** **(Cuvier, 1833)**

651. ***Seriola lalandi*** **Valenciennes 1833 (New)**

652. ***Seriola rivoliana*** **Valenciennes, 1833**

653. ***Seriolina nigrofasciatus*** **(Ruppell, 1828)**

654. ***Trachinotus baillonii*** **Lacepede, 1801**

655. ***Trachinotus blochii*** **(Lacepede, 1801)**

656. ***Ulua mentalis*** **(Cuvier 1833)**

Family: Menidae

657. ***Mene maculata*** **(Bloch & Schneider, 1801)**

Family: Leiognathidae (Ponyfishes)

658. ***Aurigequula fasciata*** **(Lacepede, 1803)**

659. ***Aurigequula longispina*****(Valenciennes, 1835)**

660. ***Deveximentum insidiator*** **(Bloch,1787)**

661. ***Deveximentumruconicus*** **(Hamilton,1822)**

662. ***Equulites leuciscus*** **(Gunther, 1860)**

663. ***Equulites lineolatus*****(Valenciennes, 1835)**

664. ***Eubleekeria jonesi*** **(James 1971)**

665. ***Eubleekeria splendens*** **(Cuvier, 1829)**

666. ***Eubleekeria rapsoni*** **(Munro 1964)**

667. ***Gazza achlamys*** **Jordan and Starks, 1917**

668. ***Gazza minuta*** **(Bloch, 1797)**

669. ***Karalla daura*** **(Cuvier, 1829)**

670. ***Karalla dussumieri*** **(Valenciennes, 1835)**

671. ***Leiognathus berbis*** **(Valenciennes, 1835)**

672. ***Leiognathus equula*** **(Forsskal, 1775)**

673. ***Nuchequula blochii*** **(Valenciennes, 1835)**

674. ***Nuchequula gerreoides*** **(Bleeker 1851)**

675. ***Photopectoralis bindus*** **(Valenciennes, 1835)**

Family: Bramidae

676. ***Taractes rubescens*** **(Jordan & Evermann 1887)**

677. ***Taractichthys steindachneri*** **(Döderlein 1883)**

Family: LutjanidaeSnappers

678. ***Aphareus furca*** **(Lacepede, 1801)**
679. ***Aphareus rutilans*** **(Cuvier, 1830)**
680. ***Aprion virescens*** **Valenciennes, 1830**
681. ***Etelis carbunculus*** **Cuvier 1828**
682. ***Etelis coruscans*** **Valenciennes 1862**
683. ***Etelis radiosus*** **Anderson, 1981**
684. ***Lipocheilus carnolabrum*** **(Chan ,1970)**
685. ***Lutjanus argentimaculatus*** **(Forsskal, 1775)**
686. ***Lutjanus bengalensis*** **(Bloch, 1790)**
687. ***Lutjanus biguttatus*** **(Valenciennes, 1830)**
688. ***Lutjanus bohar*** **(Forrskal, 1775)**
689. ***Lutjanus boutton*** **(Lacepede, 1802)**
690. ***Lutjanus carponotatus*** **(Richardson 1842)**
691. ***Lutjanus decussatus*** **(Cuvier, 1828)**
692. ***Lutjanus ehrenbergii*** **Peters, 1869**
693. ***Lutjanus erythropterus*** **Bloch, 1790**
694. ***Lutjanus fluviflamma*** **(Forsskal, 1775)**
695. ***Lutjanus fulvus*** **(Schneider, 1801)**
696. ***Lutjanus gibbus*** **(Forsskal, 1775)**
697. ***Lutjanus guilcheri*** **Fourmanoir, 1959**
698. ***Lutjanus indicus*** **Allen, White & Erdmann 2013**
699. ***Lutjanus johnii*** **(Bloch, 1792)**
700. ***Lutjanus kasmira*** **(Forsskal, 1775)**
701. ***Lutjanus lemniscatus*** **(Valenciennes, 1828)**
702. ***Lutjanus lunulatus*** **(Park, 1797)**
703. ***Lutjanus lutjanus*** **Bloch, 1790**
704. ***Lutjanus madras*** **(Valenciennes, 1831)**
705. ***Lutjanus malabaricus*** **(Schneider, 1801)**
706. ***Lutjanus monostigma*** **(Cuvier, 1828)**
707. ***Lutjanus quinquelineatus*** **(Bloch, 1790)**
708. ***Lutjanus rivulatus*** **(Cuvier, 1828)**
709. *Lutjanus rufolineatus* (Valenciennes, 1830),
710. ***Lutjanus sanguineus*** **(Cuvier)**
711. ***Lutjanus sebae*** **(Cuvier, 1816)**
712. ***Lutjanus vitta*** **(Quoy & Gaimard, 1824)**
713. ***Macolor niger*** **(Forsskal, 1775)**
714. ***Paracaesio sordida*** **Abe & Shinohare, 1962**
715. ***Paracaesio xanthura*** **(Bleeker, 1869)**
716. ***Pinjalo lewisi*** **Randall,Allen & Anderson, 1987**
717. ***Pinjalo pinjalo*** **(Bleeker, 1850)**
718. ***Pristipomoides filamentosus*** **(Valenciennes)**
719. ***Pristipomoides multidens*** **(Day, 1871)**
720. ***Pristipomoides sieboldii*** **(Bleeker, 1855)**
721. ***Pristipomoides typus*** **Bleeker, 1852**
722. ***Pristipomoides zonatus*** **(Valenciennes, 1830)**
723. ***Symphorus nematophorus*** **(Bleeker, 1860)**

Family: Caesionidae (Fusilisers)

724. ***Caesio caerulaurea*** **Lacepede, 1801**
725. ***Caesio cuning*** **(Bloch, 1791)**
726. ***Caesio lunaris*** **Cuvier, 1830**
727. ***Caesio teres*** **Seale, 1906**
728. ***Caesio varilineata*** **Carpenter, 1987**
729. ***Caesio xanthonota*** **(Bleeker, 1845)**
730. ***Dipterygonotus balteatus*** **(Valenciennes, 1830)**
731. ***Gymnocaesio gymnoptera*** **(Bleeker, 1856)**
732. ***Pterocaesio chrysozona*** **(Cuvier, 1830)**
733. ***Pterocaesio marri*** **Schultz, 1953**
734. ***Pterocaesio pisang*** **(Bleeker, 1853)**
735. ***Pterocaesio tessellata*** **Carpenter, 1987**
736. ***Pterocaesio tile*** **(Cuvier, 1830)**
737. ***Pterocaesio trilineata*** **Carpenter, 1987**

Family: Lobotidae

738. ***Lobotes surinamensis*** **(Bloch,1790)**

Family: Gerreidae

739. ***Gerres erythrourus*** **(Bloch, 1791)**
740. ***Gerres filamentosus*** **Cuvier, 1829**
741. ***Gerres limbatus*** **Cuvier 1830**
742. ***Gerres longirostris*** **(Cuvier,1829)**
743. ***Gerres oblongus*** **Cuvier, 1830**
744. ***Gerres oyena*** **(Forsskal, 1775)**
745. ***Gerres phaiya*** **Iwatsuki & Heemstra, 2001**
746. ***Gerres setifer*** **(Hamilton, 1822)**
747. ***Pentaprion longimanus*** **(Cantor,1849)**

Family: Haemulidae (Sweetlips)

748. ***Diagramma picta*** **(Thunberg, 1792)**
749. ***Plectorhinchus albovittatus*** **(Rüppell, 1838)**
750. ***Plectorhinchus ceylonensis*** **(Smith 1956)**
751. ***Plectorhinchus chaetodonoides*** **Lacepede, 1800**
752. ***Plectorhinchus diagrammus*** **(Linnaeus, 1758)**
753. ***Plectorhinchus flavomaculatus*** **(Cuvier, 1830)**
754. ***Plectorhinchus gibbosus*** **(Lacepede, 1802)**

755. ***Plectorhinchus macrospilus*** **Satapoomin & Randall, 2000**

756. ***Plectorhinchus rayi*** **(Menon and Talwar, 1973)**

757. ***Plectorhinchus schotaf*** **(Forsskal, 1775)**

758. *Plectorhinchus sordidus* (Klunzinger, 1870)

759. *Plectorhinchus vittatus* (Linnaeus 1758)

760. *Pomadasys andamanensis* McKay & Satapoomin, 1994,

761. ***Pomadasys argenteus*** **(Forsskål, 1775)**

762. ***Pomadasys argyreus*** **(Valenciennes, 1833)**

763. ***Pomadasys furcatus*** **(Bloch & Schneider, 1801)**

764. *Pomadasys guoraca* (Cuvier, 1829)

765. ***Pomadasys kaakan*** **(Cuvier, 1830)**

766. ***Pomadasys maculatus*** **(Bloch, 1793)**

Family: Nemipteridae

767. ***Nemipterus bipunctatus*** **(Valencienneus, 1830)**

768. *Nemipterus andamanensis* Bineesh, Russell, & Chandra 2018.

769. ***Nemipterus furcosus*** **(Valenciennes, 1830)**

770. ***Nemipterus hexodon*** **(Quoy & Gaimard, 1824)**

771. ***Nemipterus japonicus*** **(Bloch, 1791)**

772. ***Nemipterus mesoprion*****(Bleeker, 1853)**

773. ***Nemipterus nemurus*** **(Bleeker, 1857)**

774. ***Nemipterus peronii*** **(Valenciennes, 1830)**

775. ***Nemipterus randalli*** **Russell, 1986**

776. ***Nemipterus zysron*** **(Bleeker, 1853)**

777. ***Parascolopsis eriomma*** **(Jordan & Richardson, 1909)**

778. *Parascolopsis inermis* (Temminck & Schlegel, 1843)

779. ***Scolopsis affinis*** **Peters 1877 (New)**

780. ***Scolopsis aurata*** **(Park,1797)**

781. ***Scolopsis bilineata*** **(Bloch, 1793)**

782. ***Scolopsis ciliata*** **(Lacepede, 1802)**

783. ***Scolopsis frenata*** **(Cuvier, 1830)**

784. ***Scolopsis ghanam*** **(Forsskal, 1775)**

785. ***Scolopsis lineata*** **Quoy & Gaimard, 1824**

786. ***Scolopsis margaritifera*** **(Valenciennes, 1830)**

787. ***Scolopsis monogramma*** **(Cuvier, 1830)**

788. ***Scolopsis taenioptera*** **(Cuvier, 1830)**

789. ***Scolopsis vosmeri*** **Bloch,1792**

790. ***Scolopsis xenochrous*** **Gunther, 1872**

Family: Lethrinidae

791. ***Gnathodentex aureolineatus*** **(Lacepede, 1802)**

792. ***Gymnocranius elongatus*** **Senta, 1973**

793. ***Gymnocranius grandoculis*** **(Vaclenciennes, 1830)**

794. ***Gymnocranius griseus*** **(Temminck & Schlegel, 1843)**

795. ***Lethrinus amboinensis*** **Bleeker, 1854**

796. ***Lethrinus conchyliatus*** **(Smith, 1959)**

797. ***Lethrinus erythracanthus*** **Valenciennes, 1830**

798. ***Lethrinus erythropterus*** **Valenciennes, 1830**

799. ***Lethrinus harak*** **(Forsskal, 1775)**

800. ***Lethrinus lentjan*** **(Lacepede, 1802)**

801. ***Lethrinus mahsena*** **(Forsskal, 1775)**

802. ***Lethrinus microdon*** **Valenciennes, 1830**

803. ***Lethrinus nebulosus*** **(Forsskal, 1775)**

804. ***Lethrinus obsoletus*** **(Forsskal, 1775)**

805. ***Lethrinus olivaceus*** **Valenciennes, 1830**

806. ***Lethrinus ornatus*** **Valenciennes, 1830**

807. ***Lethrinus rubrioperculatus*** **Sato, 1978**

808. ***Lethrinus semicinctus*** Valenciennes, 1830 (in book, New?)

809. ***Lethrinus variegatus*** **Valenciennes, 1830**

810. ***Lethrinus xanthochilus*** **Klunzinger, 1870**

811. ***Monotaxis grandoculis*** **(Forsskal, 1775)**

812. ***Monotaxis heterodon*** **(Bleeker 1854)**

813. ***Wattasia mossambica*** **(Smith, 1957)**

Family: Sparidae

814. ***Acanthopagrus berda*** **(Forsskal, 1775)**

815. ***Argyrops spinifer*** **(Forsskål, 1775)**

Family: Polynemidae

816. ***Eleutheronema tetradactylum*** **(Shaw, 1804)**

817. ***Filimanus perplexa*** **Feltis 1991**

818. ***Filimanus similis*** **Feltis 1991**

819. ***Leptomelanosoma indicum*** **(Shaw, 1804)**

820. ***Polydactylus microstoma*** **(Bleeker, 1851)**

821. ***Polydactylus plebeius*** **(Broussonet, 1782)**

822. ***Polydactylus sexfilis*** **(Valenciennes, 1831)**

823. ***Polydactylus sextarius*** **Bloch & Schneider, 1801**

Family: Sciaenidae

824. ***Dendrophysa russelli*** **(Cuvier, 1830)**

825. ***Johnius amblycephalus*** **(Bleeker, 1855)**
826. ***Johnius belangerii*** **(Cuvier,1830)**
827. ***Johnius carouna*** **(Cuvier, 1830)**
828. ***Johnius carutta*** **Bloch, 1793**
829. ***Johnius dussumieri*** **(Cuvier, 1830)**
830. ***Johnius macropterus*** **(Bleeker, 1853)**
831. ***Otolithes ruber*** **(Schneider, 1801)**
832. ***Nibea soldado*** **(Lacepède, 1802)**
833. ***Pennahia anea*** **(Bloch, 1793)**

Family: Mullidae

834. ***Mulloidichthys ayliffe*** **Uiblein, 2011**
835. ***Mulloidichthys flavolineatus*** **(Lacepede, 1801)**
836. ***Mulloidichthys vanicolensis*** **(Valenciennes, 1831)**
837. ***Parupeneus barberinus*** **(Lacepede, 1801)**
838. ***Parupeneus cyclostomus*** **(Lacepede, 1801)**
839. ***Parupeneus heptacanthus*** **(Lacepède 1802)**
840. ***Parupeneus indicus*** **(Shaw, 1803)**
841. ***Parupeneus macronema*** **(Lacepede, 1801)**
842. ***Parupeneus pleurostigma*** **(Bennett, 1831)**
843. ***Parupeneus rubescens*** **(Lacepède, 1801)**
844. ***Parupeneus spilurus*** **(Bleeker, 1854)**
845. ***Parupeneus trifasciatus*** **(Lacepede, 1801)**
846. ***Upeneus guttatus*** **(Day, 1868)**
847. ***Upeneus luzonius*** **Jordan & Seale 1907**
848. ***Upeneus moluccensis*** **(Bleeker, 1855)**
849. ***Upeneus sulphureus*** **Cuvier, 1829**
850. ***Upeneus taeniopterus*** **(Cuvier 1829)**
851. ***Upeneus tragula*** **Richardson, 1846**
852. ***Upeneus vittatus*** **(Forsskal, 1775)**

Family: Pempherididae

853. ***Parapriacanthus ransonneti*** **Steindachner, 1870**
854. ***Pempheris flavicycla*** **Randall, Bogorodsky & Alpermann 2013**
855. ***Pempheris malabarica*** **Cuvier 1831**
856. ***Pempheris mangula*** **Cuvier 1829**
857. ***Pempheris schwenkii*** **Bleeker 1855**

Family: Bathyclupeidae

858. ***Bathyclupea hoskynii*** **Alcock, 1891**

Family: Monodactylidae (Moonfishes)

859. ***Monodactylus argenteus*** **(Linnaeus, 1758)**

Family: Toxotidae

860. ***Toxotes chatareus*** **(Hamilton, 1822)**
861. ***Toxotes jaculatrix*** **(Pallas 1767)**

Family: Kyphosidae (Seachubs)

862. ***Kyphosus bigibbus*** **Lacepède, 1801**
863. ***Kyphosus cinerascens*** **(Forsskal, 1775)**
864. ***Kyphosus vaigiensis*** **(Quoy & Gaimard, 1825)**

Family: Drepanidae

865. ***Drepane longimana*** **(Bloch & Scneider, 1801)**
866. ***Drepane punctata*** **(Linnaeus, 1758)**

Family: Chaetodontidae Butterfly Fishes

867. ***Chaetodon andamanensis*** **Kuiter and Debelius, 1999**
868. ***Chaetodon aruiga*** **Forsskal, 1775**
869. ***Chaetodon bennetti*** **Cuvier, 1831**
870. ***Chaetodon citrinellus*** **Cuvier, 1831**
871. ***Chaetodon collare*** **Bloch, 1787**
872. ***Chaetodon decussatus*** **Cuvier, 1829**
873. ***Chaetodon ephippium*** **Cuvier, 1831**
874. ***Chaetodon falcula*** **Bloch, 1793**
875. ***Chaetodon gardineri*** **Norman, 1939**
876. ***Chaetodon guttatissimus*** **Bennett, 1832**
877. ***Chaetodon interruptus*** **Ahl, 1923**
878. ***Chaetodon kleinii*** **Bloch, 1790**
879. ***Chaetodon lineolatus*** **Cuvier, 1831**
880. ***Chaetodon lunula*** **(Lacepede, 1803)**
881. ***Chaetodon madagaskariensis*** **Ahl, 1923**
882. ***Chaetodon melannotus*** **Bloch & Schneider, 1801**
883. ***Chaetodon meyeri*** **(Bloch & Schn., 1801)**
884. ***Chaetodon mitratus*** **Gunther, 1860**
885. ***Chaetodon octofasciatus*** **Bloch, 1787**
886. ***Chaetodon ornatissimus*** **Cuvier, 1831**
887. ***Chaetodon oxycephalus*** **Bleeker, 1853**
888. ***Chaetodon plebeius*** **Cuvier, 1831**
889. ***Chaetodon punctatofasciatus*** **Cuvier, 1831**
890. ***Chaetodon rafflesii*** **Bennett, 1830**
891. ***Chaetodon semeion*** **Bleeker, 1855**
892. ***Chaetodon triangulum*** **Cuvier, 1831**

893. *Chaetodon trifascialis* Quoy & Gaimard, 1825
894. *Chaetodon trifasciatus* Mungo Park, 1797
895. *Chaetodon unimaculatus* Bloch, 1787
896. *Chaetodon vagabundus* Linnaeus, 1758
897. *Chaetodon xanthocephalus* Bennett,1833
898. *Chaetodon xanthurus* Ahl, 1923
899. *Chelmon rostratus* (Linnaeus, 1758)
900. *Coradion altivelis* (McCulloch, 1916)
901. *Forcipiger flavissimus* Jordan & McGregor, 1898
902. *Forcipiger longirostris* (Broyssonet, 1782)
903. *Hemitaurichthys polylepis* (Bleeker, 1857)
904. *Hemitaurichthys zoster* (Bennet, 1831)
905. *Heniochus acuminatus* (Linnaeus, 1758)
906. *Heniochus diphreutes* Jordan, 1903
907. *Heniochus monoceros* Cuvier 1831
908. *Heniochus pleurotaenia* Ahl, 1923
909. *Heniochus singularius* Smith & Redcliffe, 1911

Family: Pomacanthidae (Anglefishes)

910. *Apolemichthys trimaculatus* (Cuvier, 1831)
911. *Apolemichthys xanthurus* (Bennett, 1833)
912. *Centropyge bicolor* (Bloch, 1787)
913. *Centropyge bispinosus* (Gunther, 1860)
914. *Centropyge eibli* Klausewitz, 1963
915. *Centropyge flavipectoralis* Randall & Klausewitz, 1977
916. *Centropyge flavissima* (Cuvier, 1831)
917. *Centropyge multispinis* (Playfair, 1867)
918. *Chaetodontoplus melanosoma* (Bleeker, 1853)
919. *Chaetodontoplus mesoleucus* (Bloch, 1787)
920. *Genicanthus lamarck* (Lacepede, 1802)
921. *Pomacanthus annularis* (Bloch, 1787)
922. *Pomacanthus imperator* (Bloch, 1787)
923. *Pomacanthus semicirculatus* (Cuvier, 1831)
924. *Pomacanthus sexstriatus* (Cuvier, 1831)
925. *Pomacanthus xanthometapon* (Bleker, 1853)
926. *Pygoplites diacanthus* (Boddaert, 1772)

Family: Terapontidae (Tigerperches)

927. *Pelates quadrilineatus* (Bloch, 1790)
928. *Terapon jarbua* (Forsskal, 1775)
929. *Terapon puta* Cuvier, 1829
930. *Terapon theraps* (Cuvier, 1829)

Family: Kuhliidae (Flagtails)

931. *Kuhlia marginata* (Cuvier, 1829)
932. *Kuhlia mugil* (Forster, 1801)
933. *Kuhlia rupestris* (Lacepede, 1802)

Family: Cirrhitidae (Hawkfishes)

934. *Cirrhitichthys aprinus* (Cuvier, 1829)
935. *Cirrhitichthys falco* Randall, 1963
936. *Cirrhitichthys oxycephalus* (Bleeker, 1855)
937. *Cirrhitus pinnulatus* (Schneider, 1801)
938. *Oxycirrhites typus* Bleeker, 1857
939. *Paracirrhites forsteri* (Schneider, 1801)

Family: Cichlidae (Cichlids)

940. *Orechromis mossambica* (Peters, 1852)

Family: Pomacentridae (Damselfishes)

941. *Abudefduf bengalensis* (Blcoh, 1787)
942. *Abudefduf notatus* (Day, 1870)
943. *Abudefduf septemfasciatus* (Cuvier, 1830)
944. *Abudefduf sexfasciatus* (Lacepede, 1801)
945. *Abudefduf sordidus* (Forsskal, 1775)
946. *Abudefduf vaigiensis* (Quoy & Gaimard, 1825)
947. *Amblyglyphidodon aureus* (Cuvier, 1830)
948. *Amblyglyphidodon indicus* Allen & Randall, 2002
949. *Amblyglyphidodon leucogaster* (Bleeker, 1847)
950. *Amblyglyphidodon silolona* Allen, Erdmann & Drew, 2012
951. *Amblyglyphidodon ternatensis* (Bleeker, 1853)
952. *Amblypomacentrus breviceps* (Schlegal & Muller, 1840)
953. *Amphiprion akallopisos* Bleeker, 1853
954. *Amphiprion clarkii* (Bennett, 1830)
955. *Amphiprion ephippium* (Bloch, 1790)
956. *Amphiprion frenatus* Brevoort, 1856
957. *Amphiprion ocellaris* Cuvier, 1830
958. *Amphiprion perideraion* Bleeker, 1855
959. *Amphiprion polymnus* (Linnaeus, 1758)
960. *Amphiprion sebae* Bleeker, 1853
961. *Cheiloprion labiatus* (Day, 1877)
962. *Chromis atripectoralis* Welander & Schultz, 1951
963. *Chromis delta* Randall 1988

964. *Chromis leucura* **Gilbert, 1905**
965. *Chromis margaritifer* **Fowler, 1946**
966. *Chromis nigrura* **Smith 1960 ?**
967. *Chromis opercularis* **Gunther, 1867**
968. *Chromis ternatensis* **(Bleeker, 1856)**
969. *Chromis viridis* **(Cuvier, 1830)**
970. *Chromis weberi* **Fowler & Bean, 1928**
971. *Chromis xanthochira* **(Bleeker, 1851)**
972. *Chrysiptera biocellata* **Quoy & Gaimard, 1824**
973. *Chrysiptera browniriggi* **(Bennett, 1828)**
974. *Chrysiptera caeruleolineatus* **(Allen, 1973)**
975. *Chrysiptera cyanea* **(Quoy & Gaimard, 1825)**
976. *Chrysiptera glauca* **(Cuvier, 1830)**
977. *Chrysiptera rollandi* **(Whitley, 1961)**
978. *Chrysiptera talboti* **(Allen, 1975)**
979. *Chrysiptera unimaculata* **(Cuvier, 1830)**
980. *Dascyllus aruanus* **(Linnaeus, 1758)**
981. *Dascyllus carneus* **Fischer, 1885**
982. *Dascyllus melanurus* **Bleeker, 1854**
983. *Dascyllus trimaculatus* **(Ruppell, 1829)**
984. *Dischistodus perspicillatus* **(Cuvier, 1830)**
985. *Dischistodus prosopotaenia* **(Bleeker, 1852)**
986. *Hemiglyphidodon plagiometopon* **(Bleeker, 1852)**
987. *Lepidozygus tapeinosoma* (Bleeker 1856) (New)
988. *Neoglyphidodon bonang* **(Bleeker, 1852)**
989. *Neoglyphidodon melas* **(Cuvier, 1830)**
990. *Neoglyphidodon nigroris* **(Cuvier, 1830)**
991. *Neoglyphidodon oxyodon* **(Bleeker, 1858)**
992. *Neoglyphidodon thoracotaeniatus* (Fowler & Bean, 1928) (New)
993. *Neopomacentrus anabatoides* **(Bleeker, 1847)**
994. *Neopomacentrus azysron* **(Bleeker, 1877)**
995. *Neopomacentrus cyanomus* (Bleeker 1856) (New)
996. *Neopomacentrus sororius* Randall & Allen, 2005 (New)
997. *Neopomacentrus taeniurus* **(Bleeker, 1856)**
998. *Neopomacentrus violascens* **(Bleeker, 1848)**
999. *Plectroglyphidodon dickii* **(Lienard, 1839)**
1000. *Plectroglyphidodon johnstonianus* **Fowler & Ball, 1924**
1001. *Plectroglyphidodon lacrymatus* **(Quoy & Gaimard, 1825)**
1002. *Pomacentrus adelus* **Allen, 1991**
1003. *Pomacentrus alleni* **Burgess, 1981**
1004. *Pomacentrus amboinensis* **Bleeker, 1868**
1005. *Pomacentrus azuremaculatus* **Allen, 1991**
1006. *Pomacentrus bankanensis* **Bleeker, 1854**
1007. *Pomacentrus chrysurus* **Cuvier, 1830**
1008. *Pomacentrus indicus* **Allen 1991**
1009. *Pomacentrus lepidogenys* **Fowler and Ball, 1928**
1010. *Pomacentrus littoralis* **Cuvier, 1830**
1011. *Pomacentrus moluccensis* **Bleeker, 1853**
1012. *Pomacentrus nagasakiensis* **Tanaka, 1917**
1013. *Pomacentrus pavo* **(Bloch 1787)**
1014. *Pomacentrus philippinus* **Evermann and Seale, 1907**
1015. *Pomacentrus polyspinus* **Allen 1991**
1016. *Pomacentrus proteus* **Allen 1991**
1017. *Pomacentrus similis* **Allen, 1991**
1018. *Pomacentrus trilineatus* **Cuvier, 1830**
1019. *Pomacentrus tripunctatus* **Cuvier, 1830**
1020. *Pomacentrus xanthosternus* **Allen, 1991 NEW**
1021. *Premnas biaculeatus* **(Bloch, 1790)**
1022. *Stegastes albifasciatus* **(Schlegel & Muller, 1839)**
1023. *Stegastes insularis* **Allen & Emery 1985**
1024. *Stegastes nigricans* **(Lacepede, 1802)**
1025. *Stegastes punctatus* **(Quoy & Gaimard 1825)**

Family: Labridae (Wrasses)

1026. *Anampses caeruleopunctatus* **Ruppell, 1829**
1027. *Anampses meleagrides* **Valenciennes, 1840**
1028. *Bodianus axillaris* **(Bennett, 1832)**
1029. *Bodianus diana* **(Lacepede, 1801)**
1030. *Bodianus leucosticticus* **(Bennett, 1832)**
1031. *Bodianus mesothorax* **(Bloch & Schneider, 1801)**
1032. *Bodianus neilli* **(Day, 1867)**
1033. *Cheilinus chlorurus* **(Bloch, 1791)**
1034. *Cheilinus diagrammus* (Lacepede, 1801)
1035. *Cheilinus fasciatus* **(Bloch, 1791)**
1036. *Cheilinus trilobatus* **Lacepede, 1801**
1037. *Cheilinus undulatus* **Ruppell, 1835**
1038. *Cheilio inermis* **(Forsskal, 1775)**
1039. *Choerodon anchorago* **(Bloch, 1791)**
1040. *Choerodon robustus* **(Gunther, 1862)**
1041. *Choerodon zamboangae* **(Seale & Bean 1907)**
1042. *Cirrhilabrus beauperryi* Allen, Drew & Barber, 2008 (New)
1043. *Cirrhilabrus joanallenae* **Allen 2000**

1044. ***Coris aygula*** **Lacepede, 1801**
1045. ***Coris aurilineata*** **Randall & Kuiter, 1982**
1046. ***Coris batuensis*** **(Bleeker, 1857)**
1047. ***Coris cuvieri*** **(Bennett, 1831)**
1048. ***Cymolutes praetextatus*** **(Quoy & Gaimard, 1834)**
1049. ***Cymolutes torquatus*** **(Valenciennes, 1840)**
1050. ***Diproctacanthus xanthurus*** **(Bleeker, 1856)**
1051. ***Epibulus insidiator*** **(Pallas, 1770)**
1052. ***Gomphosus caeruleus*** **Lacepede, 1801**
1053. ***Gomphosus varius*** **Lacepède 1801**
1054. ***Halichoeres argus*** **(Schneider, 1801)**
1055. ***Halichoeres bicolor*** **(Bloch & Schneider, 1801)**
1056. ***Halichoeres chloropterus*** **(Bloch, 1791)**
1057. ***Halichoeres chrysotaenia*** (Bleeker, 1855)
1058. ***Halichoeres chrysus*** **Randall, 1980**
1059. ***Halichoeres cosmetus*** **Randall & Smith, 1982**
1060. ***Halichoeres hortulanus*** **(Lacepede, 1801)**
1061. ***Halichoeres leucurus*** **Walbaum,1792**
1062. ***Halichoeres leucoxanthus*** **Randall and Smith, 1982**
1063. ***Halichoeres margaritaceus*** **(Valienciennes, 1839)**
1064. ***Halichoeres marginatus*** **Ruppell, 1835**
1065. ***Halichoeres melanurus*** **(Bleeker, 1851)**
1066. ***Halichoeres nebulosus*** **(Valenciens, 1839)**
1067. ***Halichoeres nigrescens*** **Bloch & Sch. 1801**
1068. ***Halichoeres richmondi*** Bean & Fowler, 1928
1069. ***Halichoeres scapularis*** **(Bennett, 1831)**
1070. ***Halichoeres timorensis*** **(Bleeker, 1852)**
1071. ***Halichoeres trispilus*** **Randall & Smith, 1982**
1072. ***Hemigymnus fasciatus*** **(Bloch, 1792)**
1073. ***Hemigymnus melapterus*** **(Bloch 1791)**
1074. ***Hologymnosus annulatus*** **(Lacepede, 1801)**
1075. ***Iniistius griffithsi*** **Randall, 2007**
1076. ***Iniistius naevus*** **Allen & Erdmann 2012**
1077. ***Iniistius pavo*** **(Valenciennes,1840)**
1078. ***Iniistius pentadactylus*** **(Linnaeus, 1758)**
1079. ***Iniistius twistii*** **(Bleeker 1856)**
1080. ***Labrichthys unilineatus*** **(Guichenot, 1847)**
1081. ***Labroides bicolor*** **Fowler & Bean, 1928**
1082. ***Labroides dimidiatus*** **(Valenciennes, 1839)**
1083. ***Leptojulis chrysotaenia*** **Randall & Ferraris, 1981**
1084. ***Leptojulis cyanopleura*** (Bleeker, 1853)
1085. ***Macropharyngodon meleagris*** **(Valenciennes, 1839)**
1086. ***Macropharyngodon negrosensis*** **Herre, 1932**
1087. ***Macropharyngodon ornatus*** **Randall, 1978**
1088. ***Novaculichthys taeniourus*** **(Lacepede, 1801)**
1089. ***Oxychelinius diagramma*** **(Lacepede, 1801)**
1090. ***Pseudocheilinus hexataenia*** **(Bleeker, 1857)**
1091. ***Pseudocoris petila*** **Allen & Erdmann 2012**
1092. ***Pseudodax moluccanus*** **(Valenciennes, 1840)**
1093. ***Pteragogus cryptus*** **Randall 1981**
1094. ***Stethojulis interrupta*** **(Bleeker, 1851)**
1095. ***Stethojulis strigiventer*** **(Bennett, 1832)**
1096. ***Stethojulis trilineata*** **(Bloch & Sch., 1801)**
1097. ***Thalassoma amblycephalum*** **(Bleeker, 1856)**
1098. ***Thalassoma hardwicke*** **(Bennett,1830)**
1099. ***Thalassoma hebraicum*** **(Lacepède, 1801)**
1100. ***Thalassoma jansenii*** **(Bleeker, 1856)**
1101. ***Thalassoma lunare*** **(Linnaeus, 1758)**
1102. ***Thalassoma lutescens*** **(Lay & Bennett, 1839)**
1103. ***Thalassoma purpureum*** **(Forsskal, 1775)**
1104. ***Thalassoma quinquevittatum*** **(Lay & Bennett, 1839)**

Family: Scaridae (Parrotfishes)

1105. ***Bolbometopon muricatum*** **(Valenciennes,1840)**
1106. ***Calotomus carolinus*** **(Valenciennes,1840)**
1107. ***Calotomus spinidens*** **(Quoy & Gaimard, 1824)**
1108. ***Cetoscarus ocellatus*** (Valenciennes, 1829)
1109. ***Chlorurus bleekeri*** **(de Beaufort,1940)**
1110. ***Chlorurus capistratoides*** (Bleeker, 1847)
1111. ***Chlorurus enneacanthus*** **(Lacepede, 1802)**
1112. ***Chlorurus japanensis*** **Bloch,1789**
1113. ***Chlorurus sordidus*** **(Forsskal, 1775)**
1114. ***Chlorurus strongycephalus*** **(Bleeker, 1854)**
1115. ***Chlorurus troschelii*** **(Bleeker 1853)**
1116. ***Hipposcarus harid*** **(Forsskal,1775)**
1117. ***Leptoscarus vaigiensis*** **(Quoy & Gaimard, 1824)**
1118. ***Scarus caudofasciatus*** **(Günther 1862)**
1119. ***Scarus dimidiatus*** **Bleeker, 1859**
1120. ***Scarus festivus*** **Valenciennes,1840**
1121. ***Scarus flavipectoralis*** **Schultz, 1958**
1122. ***Scarus frenatus*** **Lacepede, 1802**
1123. ***Scarus ghobban*** **Forsskal, 1775**
1124. ***Scarus globiceps*** **Valenciennes, 1840**

1125. ***Scarus maculipinna*** **Westneat, Satapoomin & Randall 2007**
1126. ***Scarus niger*** **Forsskal, 1775**
1127. ***Scarus prasiognathos*** **Valenciennes, 1840**
1128. ***Scarus psittacus*** **Forsskal, 1775**
1129. ***Scarus quoyi*** **Valenciennes 1840**
1130. ***Scarus rivulatus*** **Valenciennes, 1840**
1131. ***Scarus rubroviolaceous*** **Bleeker, 1847**
1132. ***Scarus russelii*** **Valenciennes, 1840**
1133. ***Scarus scaber*** **Valenciennes, 1840**
1134. ***Scarus viridifucatus*** **Smith, 1956**

Family: Chiasmodontidae (Swallowers)

1135. ***Dysalotus alcocki*** **MacGilchrist, 1905**

Family: Champsodontidae(Gapers)

1136. ***Champsodon capensis*** **Regan, 1908**

Family: Trichonotidae

1137. ***Trichonotus setiger*** **Bloch & Schneider, 1801**

Family: Pinguipedidae

1138. ***Parapercis bimacula*** **Allen & Erdmann 2012**
1139. ***Parapercis clathrata*** **Ogilby, 1911**
1140. ***Parapercis cylindrica*** **(Bloch, 1792)**
1141. ***Parapercis hexophthalma*** **(Ehrenberg, 1829)**
1142. ***Parapercis lineopunctata*** **Randall, 2003**
1143. ***Parapercis maculata*** **(Bloch & Schneider, 1801)**
1144. ***Parapercis millepunctata*** **(Gunther, 1860)**
1145. ***Parapercis schauinslandi*** **(Steindachner, 1900)**
1146. ***Parapercis snyderi*** **Jordan and Starks, 1905**
1147. ***Parapercis tetracantha*** **(Lacepede, 1801)**
1148. ***Parapercis xanthozona*** **(Bleeker, 1849)**

Family: Percophidae (Duckbills)

1149. ***Bembrops caudimacula*** **Steindachner, 1876**
1150. ***Bembrops platyrhynchus*** **(Alcock, 1894)**

Family: Pholidichthyidae (Convict blenny)

1151. ***Pholidichthys leucotaenia*** **Bleeker, 1856**

Family: Tripterygiidae

1152. ***Enneapterygius fasciatus*** **(Weber, 1909)**
1153. ***Helcogramma gymnauchen*** **(Weber, 1909)**
1154. ***Helcogramma striata*** **Hansen, 1986**
1155. ***Helcogramma trigloides*** **(Bleeker, 1858)**
1156. ***Ucla xenogrammus*** **Holleman, 1993**

Family: Blenniidae (Blennies)

1157. ***Alloblennius frondiculus*** **Smith-Vaniz & Allen 2012**
1158. ***Alticus andersonii*** **(Day 1876)**
1159. ***Alticus kirkii*** **(Gunther, 1868)**
1160. ***Andamia expansa*** **Blyth 1858**
1161. ***Andamia reyi*** **(Sauvage, 1880)**
1162. ***Aspidontus taeniatus*** **Quoy & Gaimard, 1834**
1163. ***Aspidontus tractus*** **Fowler, 1903**
1164. ***Atrosalarias fuscus*** **(Ruppell, 1835)**
1165. ***Blenniella bilitonensis*** **(Bleeker, 1858)**
1166. ***Blenniella chrysospilos*** **(Bleeker, 1857)**
1167. ***Blenniella cyanostigma*** **(Bleeker, 1849)**
1168. ***Blenniella interrupta*** **(Bleeker, 1857)**
1169. ***Blenniella leopardus*** **(Fowler, 1904)**
1170. ***Blenniella periophthalmus*** **(Valenciennes, 1836)**
1171. ***Cirripectes auritus*** Carlson, 1981 New
1172. ***Cirripectes perustus*** **Smith, 1959**
1173. ***Cirripectes polyzona*** **(Bleeker, 1868)**
1174. ***Cirripectes quagga*** **(Fowler & Ball, 1924)**
1175. ***Cirripectes stigmaticus*** **Strasburg & Schultz, 1953**
1176. ***Cirrisalarias bunares*** **Springer, 1976**
1177. ***Ecsenius bicolor*** **(Day, 1888)**
1178. ***Ecsenius lineatus*** **Klausewitz, 1962**
1179. ***Ecsenius lubbocki*** **Springer, 1988**
1180. ***Ecsenius midas*** **Starck, 1969**
1181. ***Ecsenius paroculus*** **Springer,1988**
1182. ***Ecsenius polystictus*** **Springer & Randall, 1999**
1183. ***Ecsenius trilineatus*** **Springer, 1972**
1184. ***Ecsenius stictus*** **Springer, 1988**
1185. ***Enchelyurus flavipes*** **Peters 1868**
1186. ***Enchelyurus kraussi*** **(Klunzinger, 1871)**
1187. ***Entomacrodus caudofasciatus*** **(Regan 1909)**
1188. ***Entomacrodus epalzeocheilos*** **(Bleeker, 1859)**
1189. ***Entomacrodus striatus*** **(Quoy & Gaimard, 1836)**
1190. ***Entomacrodus vermiculatus*** **(Valenciennes, 1836)**
1191. ***Exallias brevis*** **(Kner, 1868)**
1192. ***Istiblennius bellus*** **(Gunther, 1861)**
1193. ***Istiblennius dussumieri*** **(Valenciennes, 1836)**

1194. ***Istiblennius edentulus*** **(Schneider, 1801)**
1195. ***Istiblennius lineatus*** **(Valenciennes, 1836)**
1196. ***Meiacanthus grammistes*** **(Valenciennes, 1836)**
1197. ***Meiacanthus smithi*** **Klausewitz, 1962**
1198. ***Mimoblennius rusi*** **Springer & Spreitzer, 1978**
1199. ***Nannosalarias nativitatis*** **(Regan 1909)**
1200. ***Omobranchus elongatus*** **(Peters, 1855)**
1201. ***Omobranchus punctatus*** **(Valenciennes, 1836)**
1202. ***Omobranchus obliquus*** **(Garman, 1903)**
1203. ***Omobranchus zebra*** **(Bleeker, 1868)**
1204. ***Parenchelyurus hepburni*** **(Synder, 1908)**
1205. ***Petroscirtes breviceps*** **(Valenciennes, 1836)**
1206. ***Petroscirtes mitratus*** **Ruppell, 1830**
1207. ***Petroscirtes variabilis*** **Cantor, 1849**
1208. ***Plagiotremus phenax*** **Smith-Vaniz, 1976**
1209. ***Plagiotremus rhinorhychos*** **(Bleeker, 1852)**
1210. ***Plagiotremus tapeinosoma*** **(Bleeker, 1857)**
1211. ***Praealticus dayi*** **(Whitelay, 1929)**
1212. ***Praealticus oortii (Bleeker, 1851)***
1213. ***Praealticus triangulus*** **(Chapman, 1951)**
1214. ***Salarias alboguttatus*** **Kner, 1867**
1215. ***Salarias fasciatus*** **(Bloch, 1786)**
1216. ***Salarias guttatus*** **Valenciennes, 1836**
1217. ***Xiphasia matsubarai*** **Okada & Suzuki 1952**
1218. ***Xiphasia setifer*** **Swainson, 1839**

Family: Callionymidae

1219. ***Callionymus enneactis*** **Bleeker, 1879**
1220. ***Callionymus filamentosus*** **Valenciennes, 1837**
1221. ***Calliurichthys japonicus*** **Houttuyn, 1782**
1222. ***Callionymus melanotopterus*** **Bleeker 1850**
1223. ***Eleutherochir opercularis*** **(Valenciennes, 1837)**
1224. ***Dactylopus kuiteri*** **Fricke 1992**
1225. ***Repomucenus octostigmatus*** **(Fricke 1981)**
1226. ***Synchiropus ocellatus*** **(Pallas 1770)**
1227. ***Synchiropus splendidus*** **(Herre, 1927)**
1228. ***Synchiropus stellatus*** **Smith, 1963**

Family: Eleotridae (Sleepers)

1229. ***Belobranchus belobranchus*** **(Valenciennes, 1837)**
1230. ***Belobranchus segura*** **Keith, Hadiaty and Lord, 2012**
1231. ***Bostrychus sinensis*** **Lacepède 1801**
1232. ***Bunaka gyrinoides*** **(Bleeker, 1853)**
1233. ***Butis amboinensis*** **(Bleeker, 1853)**
1234. ***Butis butis*** **(Hamilton, 1822)**
1235. ***Butis gymnopomus*** **(Bleeker, 1853)**
1236. ***Butis humeralis*** **(Valenciennes 1837)**
1237. ***Butis koilomatodon*** **(Bleeker, 1849)**
1238. ***Eleotris andamensis*** **Herre, 1939**
1239. ***Eleotris fusca*** **(Schneider, 1801)**
1240. ***Eleotris lutea*** **Day, 1876**
1241. ***Giuris margaritaceus*** **(Valenciennes 1837)**
1242. ***Hypseleotris guentheri*** **(Bleeker, 1875)**
1243. ***Ophiocara ophicephalus*** **(Valenciennes 1837)**
1244. ***Ophiocara porocephala*** **(Valenciennes, 1837)**

Family: Gobiidae

1245. ***Acentrogobius caninus*** **(Valenciennes, 1837)**
1246. ***Acentrogobius janthinopterus*** **(Bleeker, 1853)**
1247. ***Acentrogobius madraspatensis*** **(Day, 1868)**
1248. ***Acentrogobius suluensis*** (Herre, 1927)NEW
1249. ***Acentrogobius viridipunctatus*** **(Valenciennes, 1837)**
1250. ***Amblyeleotris aurora*** **(Polunin & Lubbock, 1977)**
1251. ***Amblyeleotris downingi*** **Randall, 1994**
1252. ***Amblyeleotris fontanesii*** (Bleeker, 1853)
1253. ***Amblyeleotris latifasciata*** **Polunin & Lubbock, 1979**
1254. ***Amblyeleotris steinitzi*** **(Klausewitz, 1974)**
1255. ***Amblygobius albimaculatus*** **(Ruppell, 1828)**
1256. ***Amblygobius bynoensis*** **(Richardson, 1844)**
1257. ***Amblygobius decussatus*** **(Bleeker, 1855)**
1258. ***Amblygobius nocturnus*** **(Herre, 1945)**
1259. ***Amblygobius semicinctus*** **(Bennett, 1833)**
1260. ***Arcygobius baliurus*** **(Valenciennes, 1837)**
1261. ***Asterropteryx atripes*** **Shibukawa & Suzuki 2002**
1262. ***Asterropteryx bipunctata*** **Allen & Munday 1995**
1263. ***Asterropteryx ensifera*** **(Bleeker, 1874)**
1264. ***Asterropteryx semipunctatus*** **Ruppell, 1830**
1265. ***Aulopareia koumansi*** **(Herre 1937)**
1266. ***Awaous grammepomus*** **(Bleeker, 1849)**
1267. ***Awaous guamensis*** **(Valenciennes, 1837)**
1268. ***Awaous melanocephalus*** **(Bleeker, 1849)**
1269. *Awaous ocellaris* (Broussonet, 1782)
1270. *Bathygobius coalitus* (Bennett 1832)

1271. ***Bathygobius fuscus* (Ruppell, 1830)**
1272. ***Boleophthalmus boddarti* (Pallas, 1770)**
1273. ***Bryaninops tigris* Larson, 1985**
1274. ***Bryaninops yongei* (Davis & Cohen, 1969)**
1275. ***Callogobius andamanensis* Menon & Chatterjee, 1974**
1276. ***Callogobius hasselti* (Bleeker, 1851)**
1277. ***Callogobius mannarensis* Rangarajan 1970**
1278. ***Callogobius trifasciatus* Menon & Chatterjee, 1976**
1279. ***Caragobius urolepis* (Bleeker, 1852)**
1280. ***Cryptocentrus cinctus* (Herre, 1936)**
1281. ***Cryptocentrus fasciatus* (Playfair & Gunther, 1867)**
1282. ***Cryptocentrus octofasciatus* Regan, 1908**
1283. ***Cryptocentrus pavoninoides* (Bleeker, 1849)**
1284. ***Cryptocentrus sericus*** Herre, 1932 (in Book, New?)
1285. ***Cryptocentrus strigilliceps* (Jordan & Seale, 1906)**
1286. ***Ctenogobiops maculosus* (Fourmanoir, 1955)**
1287. ***Ctenogobiops pomastictus* Lubbock & Polunin, 1977**
1288. ***Drombus triangularis* (Weber, 1909)**
1289. ***Eviota cometa* Jewett and Lachner 1983**
1290. ***Eviota distigma* Jordan & Seale, 1906**
1291. ***Eviota guttata* Lachner & Karnella, 1978**
1292. ***Eviota prasina* (Klunzinger, 1871)**
1293. ***Eviota parasites* Jordan & Seale, 1906**
1294. ***Eviota queenslandica* Whitley, 1932**
1295. ***Eviota sebreei* Jordan and Seale, 1906**
1296. ***Eviota sigillata* Jewett & Lachner 1983**
1297. ***Eviota storthyx* (Rofen, 1959)**
1298. ***Eviota zebrina*** Lachner & Karnella, 1978 (in book, New?)
1299. ***Eviota zonura* Jordan & Seale, 1906**
1300. ***Exyrias puntang* (Bleeker, 1851)**
1301. ***Favonigobius reichei* (Bleeker, 1854)**
1302. ***Fusigobius duospilus*** Hoese & Reader 1985 (in book, New?)
1303. ***Fusiogobius inframaculatus* (Randall, 1994)**
1304. ***Fusigobius neophytus* (Gunther, 1877)**
1305. ***Fusigobius signipinnis* (Hoese & Obika, 1988)**
1306. ***Glossogobius bicirrhosus* (Weber, 1894)**
1307. ***Glossogobius celebius* (Valenciennes, 1837)**
1308. ***Glossogobius giuris* (Hamilton, 1822)**
1309. ***Gnatholepis cauerensis* (Bleeker, 1853)**
1310. ***Gobiodon citrinus* (Ruppell, 1830)**
1311. ***Gobiodon erythrospilus* Bleeker 1875**
1312. ***Gobiodon histrio* (Valenciennes, 1837)**
1313. ***Gobiodon rivulatus* (Rüppell, 1830)**
1314. ***Gobiopsis arenaria* (Snyder, 1908)**
1315. ***Gobiopsis quinquecincta* (Smith, 1931)**
1316. ***Gobiopsis woodsi* Lachner & Mc. Kinney, 1978**
1317. ***Hemigobius hoevenii* (Bleeker, 1851)**
1318. ***Istigobius decoratus* (Herre, 1927)**
1319. ***Istigobius diadema* (Steindachner, 1876)**
1320. ***Istigobius goldmanni* Bleeker, 1852**
1321. ***Istigobius ornatus* (Ruppell, 1830)**
1322. ***Koumansetta hectori* (Smith, 1957)**
1323. ***Lentipes andamanicus* (Mukerji 1935)**
1324. ***Mahidolia mystacina* (Valenciennes, 1837)**
1325. *Mugilogobius tigrinus*, Larson 2001
1326. ***Odontamblyopus rubicundus* (Hamilton, 1822)**
1327. ***Oligolepis acutipennis* (Valenciennes, 1837)**
1328. ***Oligolepis dasi* (Talwar, Chatterjee & Dev Roy, 1982)**
1329. ***Oplopomus caninoides* (Bleeker, 1852)**
1330. ***Oplopomus oplopomus* (Valenciennes, 1837)**
1331. ***Oxuderces dentatus* Eydoux & Souleyet, 185**0
1332. ***Oxyurichthys microlepis* (Bleeker, 1849)**
1333. ***Oxyurichthys ophthalmonema* (Bleeker 1856)**
1334. ***Oxyurichthys papuensis* (Valenciennes, 1837)**
1335. ***Oxyurichthys tentacularis* (Valenciennes, 1837)**
1336. ***Parachaeturichthys polynema* (Bleeker, 1853)**
1337. ***Paragobiodon echinocephalus* (Ruppell, 1830)**
1338. ***Parapocryptes serperaster* (Richardson 1846)**
1339. ***Paratrypauchen microcephalus* (Bleeker, 1860)**
1340. ***Periophthalmodon schlosseri* (Pallas, 1770)**
1341. ***Periophthalmodon septemradiatus* (Hamilton, 1822)**
1342. ***Periophthalmus argentilineatus* Valenciennes, 1837**
1343. ***Periophthalmus kalolo* Lesson, 1830**
1344. ***Periophthalmus kallopterus* Bleeker 1854**
1345. ***Periophthalmus malaccensis* Eggert, 1935**
1346. ***Periophthalmus minutus* Eggert 1935**
1347. ***Periophthalmus novemradiatus* (Hamilton, 1822)**

1348. ***Periophthalmus variabilis*** **Eggert, 1935**
1349. ***Phyllogobius platycephalops*** **(Smith, 1964)**
1350. ***Pleurosicya bilobata*** **(Koumans, 1941)**
1351. ***Pleurosicya boldinghi*** **Weber, 1913**
1352. ***Priolepis cincta*** **(Regan 1908)**
1353. ***Priolepis compita*** **Winterbottom, 1985**
1354. ***Priolepis profunda*** **(Weber 1909)**
1355. ***Priolepis semidoliatus*** **(Valenciennes, 1837)**
1356. ***Psammogobius biocellatus*** **(Valenciennes, 1837)**
1357. ***Pseudapocryptes elongatus (Cuvier 1816)***
1358. ***Pseudogobius javanicus (Bleeker 1856)***
1359. ***Pseudogobiopsis oligactis (Bleeker 1875)***
1360. ***Redigobius balteatus*** **(Herre, 1935)**
1361. ***Redigobius bikolanus*** **(Herre, 1927)**
1362. *Redigobius oyensi* (De Beaufort, 1913)
1363. ***Redigobius tambujon*** **(Bleeker, 1854)**
1364. ***Scartelaos cantoris*** **(Day, 1871)**
1365. ***Sicyopterus microcephalus*** **(Bleeker, 1854)**
1366. ***Stenogobius gymnopomus*** **(Bleeker, 1853)**
1367. ***Stigmatogobius sadanundio*** **(Hamilton, 1822)**
1368. ***Stonogobiops nematodes*** Hoese& Randall, 1982 (in Book, New?)
1369. ***Sueviota lachneri Winterbottom & Hoese, 1988***
1370. ***Taenioides anguillaris*** **(Linnaeus, 1758)**
1371. ***Taenioides cirratus*** **(Blyth, 1860)**
1372. ***Tomiyamichthys oni*** (Tomiyama, 1936) (New?)
1373. ***Tomiyamichthys russus*** **Smith, 1956**
1374. ***Trimma griffithsi*** **Winterbottom, 1984**
1375. ***Trimma naudei*** **Smith, 1957**
1376. ***Trimma sanguinellus*** **Winterbottom and Southcott, 2007**
1377. ***Trimma striatum*** **(Herre, 1945)**
1378. ***Trypauchen vagina*** **(Bloch & Schneider, 1801)**
1379. ***Valenciennea decora*** **Hoese and Larson, 1994**
1380. ***Valenciennea limicola*** **Hoese and Larson, 1994**
1381. ***Valenciennea puellaris*** **(Tomiyana, 1956)**
1382. ***Valenciennea sexguttata*** **(Valenciennes, 1837)**
1383. ***Valenciennea strigata*** **(Broussonet, 1782)**
1384. ***Valenciennea wardii*** **(Playfair, 1867)**
1385. ***Vanderhorsita ambanoro*** (Fourmanoir, 1957) (NEW)
1386. ***Vanderhorstia dorsomacula*** Randall, 2007 (in book, New?)
1387. ***Vanderhorstia phaeosticta*** (Randall, Shao & Chen, 2007) (in Book, New?)
1388. ***Yongeichthys nebulosus*** **(Forsskal, 1775)**

Family: Microdesmidae (Dartfishes)

1389. ***Gunnellichthys viridescens*** **Dawson, 1968**
1390. ***Nemateleotris decora*** **Randall & Allen, 1973**
1391. ***Nemateleotris magnifica*** **Fowler, 1938**
1392. ***Parioglossus rainfordi*** McCulloch, 1921 (New?)
1393. ***Parioglossus raoi*** **(Herre, 1939)**
1394. ***Ptereleotris evides*** **(Jordan & Hubbs, 1925)**
1395. ***Ptereleotris hanae*** **(Jordan & Snyder, 1901)**
1396. ***Ptereleotris heteroptera*** **(Bleeker, 1855)**
1397. ***Ptereleotris microlepis*** **Bleeker, 1856**

Family: Ephippidae (Batfishes)

1398. ***Ephippus orbis*** **(Bloch, 1787)**
1399. ***Platax orbicularis*** **(Forsskal, 1775)**
1400. ***Platax pinnatus*** **(Linnaeus, 1758)**
1401. ***Platax teira*** **(Forsskal, 1775)**

Family: Scatophagidae

1402. ***Scatophagus argus*** **Linnaeus, 1766**

Family: Siganidae (Rabbitfishes)

1403. ***Siganus argenteus*** **(Quoy & Gaimard, 1825)**
1404. ***Siganus canaliculatus*** **(Park, 1797)**
1405. ***Siganus corallinus*** **(Valenciennes, 1835)**
1406. ***Siganus fuscescens*** **(Houttuyn, 1782)**
1407. ***Siganus guttatus*** **(Bloch, 1787)**
1408. ***Siganus javus*** **(Linnaeus, 1766)**
1409. ***Siganus labyrinthodes*** **(Bleeker, 1853)**
1410. ***Siganus lineatus*** **(Valenciennes 1835)**
1411. ***Siganus magnificus*** **(Burgess, 1977)**
1412. ***Siganus margaritiferus*** **(Valenciennes, 1835)**
1413. ***Siganus puelloides*** **Woodland & Randall, 1979**
1414. ***Siganus spinus*** **(Linnaeus, 1758)**
1415. ***Siganus stellatus*** **(Forsskal, 1775)**
1416. ***Siganus vermiculatus*** **(Valenciennes, 1835)**
1417. ***Siganus virgatus*** **(Valenciennes, 1838)**
1418. ***Siganus vulpinus*** **(Schlegel & Müller, 1845)**

Family: Zanclidae (Moorish Idol)

1419. ***Zanclus cornutus*** **(Linnaeus, 1758)**

Family: Acanthuridae (Surgeon Fishes)

1420. Acanthurus auranticavus **Randall 1956 (New)**
1421. Acanthurus bariene **Lesson, 1830**
1422. Acanthurus blochii **Valenciennes 1835**
1423. Acanthurus dussumieri **Valenciennes, 1835**
1424. Acanthurus japonicus **(Schmidt, 1931) ?**
1425. Acanthurus leucocheilus Herre, 1927 (New)
1426. Acanthurus lineatus **(Linnaeus, 1758)**
1427. Acanthurus mata **Cuvier, 1829**
1428. Acanthurus nigricauda **Dunker & Mohr, 1939**
1429. Acanthurus nigrofuscus **(Forsskål, 1775)**
1430. Acanthurus tennentii **Gunther, 1861**
1431. Acanthurus thompsoni **(Fowler, 1923)**
1432. Acanthurus triostegus **(Linnaeus, 1758)**
1433. Acanthurus tristis **Randall, 1993**
1434. Acanthurus xanthopterus **Valenciennes, 1835**
1435. Ctenochaetus cyanocheilus **Randall & Clements, 2001**
1436. Ctenochaetus striatus **(Quoy & Gaimard, 1825)**
1437. Ctenochaetus truncatus **Randall & Clements, 2001**
1438. Naso annulatus **(Quoy & Gaimard, 1825)**
1439. Naso brachycentron **(Valenciennes, 1835)**
1440. Naso brevirostris **(Valenciennes, 1835)**
1441. Naso elegans **(Rüppell, 1829)**
1442. Naso hexacanthus **(Bleeker, 1855)**
1443. Naso tuberosus **Lacepede, 1802**
1444. Naso unicornis **(Forsskal, 1775)**
1445. Naso vlamingii **(Valenciennes, 1835)**
1446. Paracanthurus hepatus **(Linnaeus, 1766)**
1447. Zebrasoma desjardinii **(Bennett, 1836)**
1448. Zebrasoma scopas **(Cuvier, 1829)**
1449. Zebrasoma velifer **(Bloch, 1797)**

Family: Sphyraenidae

1450. Sphyraena acutipinnis **Day, 1876**
1451. Sphyraena barracuda **(Walbum, 1792)**
1452. Sphyraena chrysotaenia **Klunzinger, 1884**
1453. Sphyraena flavicauda **Ruppell, 1838**
1454. Sphryaena forsteri **Cuvier 1829**
1455. Sphyraena jello **Cuvier, 1829**
1456. Sphyraena obtusata **Cuvier, 1829**
1457. Sphyraena putnamae **Jordan & Seale 1905**
1458. Sphyraena qenie **Klunzinger, 1870**

Family GEMPHYLIDAE

*1459. Diplospinus multistriatus*Maul, 1948 (New)
*1460. Ruvettus pretiosus*Cocco, 1829

Family: Trichiuridae

1461. Lepturacanthus savala **(Cuvier, 1829)**
1462. Tentoriceps cristatus **(Klunzinger, 1884)?**
1463. Trichiurus lepturus **Linnaeus, 1758**

Family: Scombridae

1464. Acanthocybium solandri **(Cuvier, 1832)**
1465. Auxis rochei **(Rasso, 1810)**
1466. Auxis thazard **(Lacepede, 1802)**
1467. Euthynnus affinis **(Cantor, 1849)**
1468. Grammatorcynus bilineatus **(Ruppell, 1836)**
1469. Gymnosarda unicolor **(Ruppell, 1836)**
1470. Katsuwonus pelamis **(Linnaeus, 1758)**
1471. Rastrelliger brachysoma **(Bleeker, 1851)**
1472. Rastrelliger faughni **(Matsuai, 1967)**
1473. Rastrelliger kanagurta **(Cuvier, 1817)**
1474. Sarda orientalis **(Temminck & Schlegel, 1844)**
1475. Scomberomorus commerson **(Lacepede, 1800)**
1476. Scomberomorus guttatus **(Bloch & Scneider, 1801)**
1477. Thunnus alalunga **(Bonnaterre, 1788)**
1478. Thunnus albacares **(Bonnaterre, 1788)**
1479. Thunnus obesus **(Lowe, 1839)**
1480. Thunnus tonggol **(Bleeker, 1851)**

Family: Xiphiidae

1481. Xiphias gladius **Linnaeus, 1758**

Family: Istiophoridae

1482. Istiompax indica **(Cuvier 1832)**
1483. Istiophorus platypterus **(Shaw & Nodder, 1791)**
1484. Kajikia audax **(Philippi, 1887)**
1485. Makaira nigricans **Lacepède 1802**

Family: Centrolophidae

1486. Psenopsis obscura **Haedrich, 1967**

Family: Ariommatidae

1487. Ariomma indicum **(Day, 1871)**

Family: Nomeidae

1488. Psenes maculatus **Lutken, 1880**
1489. Cubiceps whiteleggi **(Waite, 1894)**

Family: Stromateidae (Butterfishes)

1490. Pampus argenteus **(Euphrasen, 1788)**
1491. Pampus chinensis **(Euphrasen, 1788)**

Family: Anabantidae (Climbing perch)

1492. Anabas testudineus **(Bloch, 1795)**

Family: Channidae

1493. Channa gachua **(Hamilton, 1822)**
1494. Channa punctatus **(Bloch, 1793)**
1495. *Channa royi* Praveenraj & Raymond 2018
1496. Channa stewartii **(Playfair, 1867)**
1497. Channa striatus **(Bloch, 1793)**

Order: PLEURONONTIFORMES

Family: Psettodidae

1498. Psettodes erumei **(Bloch & Sch., 1801)**

Family: Citharidae

1499. Brachypleura novaezeelandiae **Günther 1862**

Family: Bothidae

1500. Arnoglossus tapeinosoma **(Bleeker, 1865)**
1501. Bothus mancus **(Broussonet, 1782)**
1502. Bothus myriaster **(Temminck & Schlegel, 1846)**
1503. Bothus pantherinus **(Ruppell, 1830)**
1504. Engyprosopon grandisquamis **(Temminck & Schlegel,1846)**

Family: Paralichthyidae

1505. Pseudorhombus arsius **(Hamilton, 1822)**
1506. Pseudorhombus dupliciocellatus **Regan,1905**
1507. Pseudorhombus elevatus **(Ogilby, 1912)**
1508. Pseudorhombus triocellatus **(Scneider 1801)**

Family: PLEURONEDIDAE

1509. Poecilopsetta colorata **Gunther, 1880**
1510. Poecilopsetta praelonga **Alcock, 1894**

Family: Samaridae

1511. Samaris cristatus **Gray, 1831**

Family: Soleidae (Soles)

1512. Aesopia cornuta **Kaup, 1858**
1513. Brachirus orientalis **(Bloch & Schneider, 1801)**
1514. Heteromycteris oculus **(Alcock, 1889)**
1515. Pardachirus marmoratus **(Lacepede, 1802)**
1516. Pardachirus pavoninus **(Lacepede, 1802)**
1517. Soleichthys heterorhinos **(Bleeker, 1856)**
1518. Zebrias quagga **(Kaup, 1958)**

Family: Cynoglossidae

1519. Cynoglossus arel **(Bloch & Schneider, 1801)**
1520. Cynoglossus cynoglossus **(Hamilton,1822)**
1521. Cynoglossus lida **(Bleeker, 1851)**
1522. Cynoglossus lingua **Hamilton, 1822**
1523. Cynoglossus macrolepidotus **(Bleeker 1851)**
1524. Cynoglossus kopsii **(Bleeker, 1851)**
1525. Paraplagusia bilineata **(Bloch, 1787)**
1526. Symphurus septemstriatus **(Alcock, 1891)**
1527. Symphurus woodmasoni **(Alcock, 1889)**

Order: TETRAODONTIFORMES

Family: Triacanthodidae (Spikefishes)

1528. Halimochirurgus centriscoides **Alcock 1899**
1529. ***Macrorhamphosodes platycheilus*** **Fowler, 1934**
1530. ***Mephisto fraserbrunneri*** **Tyler, 1966**
1531. ***Tydemania navigatoris*** **Weber 1913**

Family: Triacanthidae

1532. Pseudotriacanthus strigilifer **(Cantor, 1850)**
1533. Triacanthus biaculeatus **(Bloch, 1786)**
1534. Triacanthus nieuhofii Bleeker, 1852.

Family: Balistidae

1535. Abalistes stellaris **(Bloch & Schneider, 1801)**
1536. Abalistes stellatus **(Lacepede, 1798)**
1537. Balistapus undulatus **(Mungo Park, 1797)**
1538. Balistoides conspicillum **(Bloch & Schneider, 1801)**
1539. Balistoides viridescens **(Bloch & Sch., 1801)**
1540. Canthidermis maculatus **(Bloch, 1786)**
1541. Melichthys indicus **Randall & Klausewitz, 1973**
1542. Melichthys niger **(Bloch, 1786)**
1543. Melichthys vidua **(Richardson, 1845)**
1544. Odonus niger **(Ruppell, 1836)**

1545. ***Pseudobalistes flavimarginatus*** **(Ruppell, 1829)**

1546. ***Pseudobalistes fuscus*** **(Bloch & Schneider, 1801)**

1547. ***Rhinecanthus aculeatus*** **(Linnaeus, 1758)**

1548. ***Rhinecanthus rectangulus*** **(Bloch & Schneider, 1801)**

1549. ***Rhinecanthus verrucosus*** **(Linnaeus, 1758)**

1550. ***Suffamen bursa*** **(Bloch & Schneider, 1801)**

1551. ***Sufflamen chrysopterus*** **(Bloch & Schneider, 1801)**

1552. ***Sufflamen fraenatus*** **(Latreille, 1804)**

Family: Monacanthidae

1553. ***Acreichthys tomentosus*** (Linnaeus, 1778)(in Book, New?)

1554. ***Aluterus monoceros*** **(Linnaeus, 1758)**

1555. ***Aluterus scriptus*** **(Osbeck, 1765)**

1556. ***Amanses scopas*** **(Cuvier, 1829)**

1557. ***Anacanthus barbatus*** **(Gray, 1830)**

1558. ***Cantherhines pardalis*** **(Ruppell, 1837)**

1559. ***Cantherhines verecundus*** **Jordan, 1925**

1560. ***Monacanthus chinensis*** **(Osbeck, 1765)**

1561. ***Oxymonacanthus longirostris*** **(Bloch & Schneider 1801)**

1562. ***Paramonacanthus choirocephalus*** **Bleeker, 1852**

1563. ***Paramonacanthus curtorhynchus*** **(Bleeker, 1855)**

1564. ***Paramonacanthus japonicas*** **(Tilesius, 1865)**

1565. ***Paramonacanthus pusillus*** **(Ruppell, 1829)**

1566. ***Pervagor melanocephalus*** **(Bleeker, 1853)**

1567. ***Rudarius excelus*** Hutchins, 1977 (New)

Family: Ostraciidae (Boxfishes)

1568. ***Lactoria cornuta*** **(Linnaeus, 1758)**

1569. ***Ostracion cubicus*** **Linnaeus, 1758**

1570. ***Ostracion meleagris*** **Shaw, 1796**

1571. ***Rhynchostracion nasus*** **(Bloch, 1785)**

1572. ***Tetrosomus gibbosus*** **(Linnaeus, 1758)**

Family: Tetraodontidae (Puffers)

1573. ***Arothron hispidus*** **(Linnaeus, 1758)**

1574. ***Arothron immaculatus*** **(Bloch & Sch., 1801)**

1575. ***Arothron mappa*** **(Lesson, 1827)**

1576. ***Arothron nigropunctatus*** **(Bloch & Sch., 1801)**

1577. ***Arothron reticularis*** **(Bloch & Sch., 1785)**

1578. ***Arothron stellatus*** **(Bloch & Sch. 1801)**

1579. ***Canthigaster bennetti*** **(Bleeker, 1854)**

1580. ***Canthigaster cyanospilota*** **Randall, Williams & Rocha, 2008**

1581. ***Canthigaster investigatoris*** **(Annandale & Jenkins, 1914)**

1582. ***Canthigaster papua*** **(Bleeker, 1848)**

1583. ***Canthigaster petersii*** **(Bianconi, 1854)**

1584. ***Canthigaster smithae*** **Allen & Randall, 1977**

1585. ***Canthigaster solandri*** **(Richardson, 1844)**

1586. ***Canthigaster valentine*** **(Bleeker, 1853)**

1587. ***Chelonodontops patoca*** **(Hamilton, 1822)**

1588. ***Dichotomyctere fluviatalis*** **(Hamilton 1822)**

1589. ***Dichotomyctere nigroviridis*** **(Marion de Proce, 1822)**

1590. ***Lagocephalus guentheri*** **Ribeiro, 1915**

1591. ***Lagocephalus inermis*** **(Temminck & Schlegel, 1850)**

1592. ***Lagocephalus lunaris*** **(Bloch & Schneider, 1801)**

1593. ***Lagocephalus scleratus*** **(Forster, 1788)**

1594. ***Pao palembangensis*** **(Bleeker 1851)**

1595. ***Torquigener hypselogeneion*** **(Bleeker, 1852)**

Family: Diodontidae

1596. ***Diodon holocanthus*** **Linnaeus, 1758**

1597. ***Diodon hystrix*** **Linnaeus, 1758**

1598. ***Diodon liturosus*** **Shaw, 1804**

Family: Molidae (Sunfish)

1599. ***Mola mola*** **(Linnaeus 1758)**

Table. 3 Species records questionable or unlikely to occur

1. **Glyphis gangeticus (Muller & Henle 1839)**

   Glyphis gangeticus:Rao 2009: 335 (checklist); Ramakrishna *et al.* 2010: 46 (checklist); Rajan *et al.* 2012: 120 (A & N Islands);

2. ***Apsilus fuscus*** **Valenciennes 1830** Distribution: Eastern Atlantic

   Apsilus fuscus:Rao 2009: 342 (checklist); Ramakrishna *et al.* 2010: 67 (checklist);

3. ***Tripterodon orbis*** **Playfair 1867: unlikely to occur**

   Tripterodon orbis: Kamla Devi 1991: 102 (checklist); Rao 2009: 343 (checklist);

4. ***Peltorhamphus novaezeelandiae*** **Günther 1862**Distribution: Western South Pacific.

Peltorhamphus novaezeelandiae: Rao 2009: 350 (checklist);

5. ***Arothron diadematus* (Rüppell 1829). Distribution:** Red Sea endemic:

Arothron diadematus: Rao 2009: 351 (checklist);

6. ***Leptophrys trigonus* (Linnaeus 1758)** Western Atlantic.

Ostracion trigonus: Day 1871: 689 (Andaman Islands);

Note:However Day has not mentioned this species in his subsequent works.

7. ***Carangoides ruber* (Bloch 1793) ??known from** Western Atlantic and Ascension Island.

Caranx blochii Cuvier: Day 1871: 689 (Andaman Islands); Herre 1941: 351 (Andaman);

Note: Herre (1941) questioned the nomenclature used by Day, since *C. ruber* is an Atlantic species.

8. ***Mobula diabola* (Shaw 1804) [confused identity]**

Mobula diabola:Rao 2009: 336 (checklist); Ramakrishna *et al.* 2010: 48 (checklist); Rajan *et al.* 2012: 121 (A & N Islands);

Following Day (1889) and Allen & Erdmann (2012) Andaman specimens, if available, may well **be treated as *M. eregoodootenkee* Bleeker**.

9. ***Dicrolene introniger* Goode & Bean 1883: An Atlantic species**

Dicrolene intronigra: Talwar 1990: 74 (checklist); Ramakrishna *et al.* 2010: 56 (checklist);

Remarks: Possibilities are more for it being *Dicrolene vaillanti* (Alcock 1890). Need confirmation.

10. *Diplacanthopoma brachysoma* Gunther, 1887:

Talwar 1990: 74 (checklist); Rao 2009: 339 (checklist); Ramakrishna *et al.* 2010: 56 (checklist); Rajan *et al.* 2013: 54 (checklist);

Remarks: *D. brachysoma* is a Western Atlantic species. The specimen reported as *D. brachysoma* by Alcock (1889: 385) is apparently lost. The suggested name for this species, *D. alcockii* Goode & Bean, 1896: 528, isa *nomen nudum* as there was no description in Alcock (Cohen & Nielsen, 2002:15).

11. *Coryphaenoides nasutus* Günther, 1877:Known to have restricted to Northwest Pacific: northern Japan to East China Sea. Andaman specimen misidentified.

Coryphaenoides nasutus:Rao 2009: 339 (checklist); Ramakrishna *et al.* 2010: 57 (checklist); Rajan *et al.* 2013: 53 (checklist);

12. ***Cypselurus starksi* Abe 1953 - possibly a misidentification**

Cypselurus starksi:Kyushin *et al*. 1977: 40 (Andaman Sea); Talwar 1990: 75 (checklist); Rao 2009: 339 (checklist); Ramakrishna *et al.* 2010: 58 (checklist);

13. *Parupeneus forsskali* (Fourmanoir & Gueze, 1976) (known from Red Sea, northwestern Indian Ocean, its report from Andamans is a misidentification)

Parupeneus forsskali:Ramakrishna *et al.* 2010: 71 (checklist); Rajan *et al.* 2013: 63 (checklist);

14. ***Eleotris feliceps* Blyth 1860 Status uncertain, Type lost**

Eleotris feliceps: Blyth 1860: 146 (Port Blair, Andaman Islands); Day 1870: 516 (Andamans);Day 1876: 310, 312 (Andamans);Day 1889(II): 292 (Andamans);Rao 2009: 349 (checklist); Ramakrishna *et al.* 2010: 90 (checklist); Rajan *et al.* 2013: 69 (checklist);

Ophiocara feliceps (Blyth): Rao 2009: 349 (checklist); Ramakrishna *et al.* 2010: 90 (checklist);

15. *Solea bleekeri* Boulenger, 1898 = Synonym of *Pegusa nasuta* (Pallas 1814) Northern Mediterranean Sea, Black Sea, Sea of Azov.

Solea bleekeri:Rao *et al.* 2000: 333 (Port Blair, South Andaman); Rao 2003: 480 (A & N Islands); Rao 2009: 350 (checklist); Ramakrishna *et al.* 2010: 95 (checklist); Rajan *et al.* 2013: 73 (checklist);

16. ***Hippocampus capensis* Boulenger 1900 - misidentification**

Hippocampus capensis:Rao 2009: 340 (checklist); Ramakrishna *et al.* 2010: 59 (checklist);

17. ***Chaetodon reticulatus* Cuvier 1831 – occurrence doubtful**

Ramakrishna *et al.* 2010: 75 (checklist);

18. ***Heniochus chrysostomus* Cuvier 1831 (occurrence doubtful)**

Heniochus chrysostomus:Rajan 2010: 47 (A & N Islands); Rajan 2010: 339 (Mahatma Gandhi Marine National Park, Cinque Is.);

19. ***Chromis dimidiata* (Klunzinger, 1871) =** restricted to the Red Sea

Chromis dimidiata:Rao 2009: 345 (checklist); Ramakrishna *et al.* 2010: 78 (checklist); Rajan *et al.* 2013: 66 (checklist); Ray *et al*. 2013: 24 (North Bay Reef);

20. ***Naso lopezi* Herre, 1927** known from Similam Islands in Andaman Sea; no record from A & N Islands

Naso lopezi:Rao 2009: 349 (checklist); Ramakrishna *et al.* 2010: 91 (checklist); Rajan *et al.* 2013: 72 (checklist);

21. ***Centropyge nox* (Bleeker, 1853)**?

Centropyge nox: Rao 2009: 344 (checklist); Ramakrishna *et al.* 2010: 74 (checklist); Rajan *et al.* 2013: 65 (checklist);

22. ***Centropyge tibicen* (Cuvier, 1831) ?**

Centropyge tibicen: Rao 2009: 344 (checklist); Ramakrishna *et al.* 2010: 74 (checklist); Rajan *et al.* 2013: 65 (checklist);

23. ***Centropyge vrolikii* (Bleeker, 1835) ?**

Centropyge vrolikii:Rao 2003: 272 (A & N Islands); Rao 2009: 344 (checklist); Ramakrishna *et al.* 2010: 74 (checklist); Rajan *et al.* 2013: 65 (checklist);

It has been observed by Allen & Erdmann (2012) that these three species of the genus *Centropyge* (*C. nox, C. tibicens* and *C. vrolikii*) are known to occurr in East Indian region **except Andaman Sea**. Unless having better references these three species cannot be included.

24. ***Anguilla australis* Richardson, 1841 – unlikely to occur**

Anguilla australis:Rao 2009: 336 (checklist); Ramakrishna *et al.* 2010: 48 (checklist); Rajan *et al.* 2013: 50 (checklist);

25. ***Pseudochromis dutoiti* Smith, 1955**??? (known from Western Indian Ocean. Unlikely to occur)

Pseudochromis dutoiti:Rao 2003: 176 (A & N Islands); Rao 2009: 341 (checklist); Ramakrishna *et al.* 2010: 65 (checklist); Rajan *et al.* 2013: 58 (checklist);

26. ***Apogon coccineus* Ruppell, 1838** (Questionable, may be referable to *Apogon crassiceps* Garman) Red Sea, western Indian Ocean: Gulf of Oman, Persian Gulf.

Apogon coccineus:Rao *et al.* 2000: 148 (Rutland Is., South Andaman); Rao 2003: 186 (A & N Islands); Rao 2009: 341 (checklist); Ramakrishna *et al.* 2010: 65 (checklist);

Ostorhinchus coccineus (Ruppell): Rajan *et al.* 2013: 59 (checklist);

27. *Blennius semifasciatus*Ruppell, 1835 =*Parablennius cyclops* (Rüppell 1830) Red Sea endemic.

Blennius semifasciatus: Mukerji 1935: 273 (Ross Is., Andamans); Herre 1939: 329, 353 (Andaman Islands); Rao 2009: 347 (checklist); Ramakrishna *et al.* 2010: 85 (checklist); Rajan *et al.* 2013: 68 (checklist);

Parablennius cyclops (Ruppell): Rao 2009: 347 (checklist); Ramakrishna *et al.* 2010: 86 (checklist);

Blennius cyclops: Talwar 1990: 81 (checklist);

28. ***Entomacrodus marmoratus* (Bennett 1828) :**known from Hawaii only

Salarias marmoratus: Herre 1939: 329, 370 (Murdakhari Bay, Port Blair; Brookesabad, South Andaman; Long Island, Middle Andaman);

Entomacrodus marmoratus:Rao 2009: 347 (checklist); Ramakrishna *et al.* 2010: 85 (checklist);

29. ***Priolepis eugenius* (Jordan & Evermann 1903)** Unlikely to occur- endemic to Hawaii

Quisquilius eugenius: Menon & Talwar 1973: 58 (Shampen village, Dogma river, Great Nicobar);

Priolepis eugenius: Rao 2009: 348 (checklist); Ramakrishna *et al.* 2010: 89 (checklist);

30. ***Paramonacanthus nematophorus* (Gunther, 1870) (erroneous)**

Monacanthus nematophorus (Gunther): Rao *et al.* 2000: 336 (Hut Bay, Little Andaman); Devi & Rao 2003: 48 (Andaman Islands);

Paramonacanthus nematophorus:Rao 2003: 499 (A & N Islands); Rao 2009: 350 (checklist); Ramakrishna *et al.* 2010: 96 (checklist); Rajan *et al.* 2013: 74 (checklist);

31. ***Acanthurus coeruleus* Bloch & Schneider 1801 – Atlantic species**

Acanthurus coeruleus: Rao 2009: 349 (checklist); Ramakrishna *et al.* 2010: 90 (checklist);

32. ***Halichoeres ornatissimus*** (Garrett 1863) **(needs confirmation)**

Halichoeres ornatissimus:Ray *et al.* 2013: 22 (North Bay Reef);

33. ***Engyprosopon natalensis* Regan, 1920 questionable**

Engyprosopon natalensis:Rao 2009: 350 (checklist); Ramakrishna *et al.* 2010: 94 (checklist); Rajan *et al.* 2013: 73 (checklist);

34. ***Gymnothorax hepaticus* (Ruppell 1830)** (Distn: Red Sea & western Indian Ocean; probably refer to *G. monochorus*)

Gymnothorax hepatica (Ruppell): Herre 1939: 328, 330 (South Corbyn Cove, Port Blair); Herre 1941: 338 (checklist);

Gymnothorax hepaticus:Talwar 1990: 72 (checklist); Rao 2009: 336 (checklist); Ramakrishna *et al.* 2010: 49 (checklist);

35. ***Epinephelus itajara*** **(Lichtenstein 1822)** (Western Atlantic: Florida, USA to southern Brazil,)

    Epinephelus itajara: Ray *et al*. 2013: 22 (North Bay Reef);

36. ***Pomacanthus navarchus*** **(Cuvier, 1831) (erroneous inclusion)**

    Pomacanthus navarchus:Rao 2009: 344 (checklist); Ramakrishna *et al.* 2010: 74 (checklist); Rajan *et al.* 2013: 65 (checklist);

Allen & Erdmann (2012) clearly stated that this species does not occur in Andaman Sea and there is no original description of the species from Andamans available.

37. *Rhabdoblennius snowi* (Fowler, 1928) =possibly misidentification; Pacific Ocean: the Solomons to American Samoa.

    Rhabdoblennius snowi:Kamla Devi 1991: 102 (checklist); Rao *et al.* 2000: 287 (Indira Point, Great Nicobar); Rao 2003: 419 (A & N Islands); Rao 2009: 347 (checklist); Ramakrishna *et al.* 2010: 86 (checklist); Rajan *et al.* 2013: 69 (checklist);

38. ***Fowleria isostigma*** **(Jordan & Seale, 1906)**

    Fowleria isostigma:Rajan & Dam Roy, 2004: 127 (A & N Islands);

39. ***Kramericus smithi*** **Menon & Talwar 1972 (Status uncertain)**

    Kramericus smithi:Menon & Talwar 1973: 55 (Shompen village, Dogma River, Great Nicobar Island); Talwar 1990: 82 (checklist); Devi & Rao, 2007: 128 (A & N Islands); Rao 2009: 349 (checklist); Ramakrishna *et al.* 2010: 90 (checklist); Rajan *et al.* 2013: 69 (checklist);

40. ***Muraena nigra***, Day 1871

    Muraena nigra, Day 1871: 702 (Port Blair, Andaman Islands)

The name ispreoccupied by *Muraena nigra* Risso 1810, hence objectively invalid andnot available.

41. ***Atherina melanostigma*** **Day 1876 (status uncertain)**

    Atherina melastigma:Herre 1941: 346 (Port Blair, Andamans);

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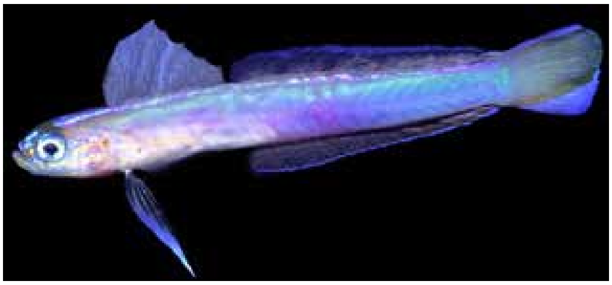
Plate 1. New species of fishes from Andaman and Nicobar Islands



Ptereleotris caeruleomarginata

Pseuodchromis tigrinus

Iniistius naevus

Alloblennius frondiculus

Amblyglyphidodon silolona

Opistognathus albicaudata

Helcogramma species

Priolepis species

Eleotris andamensis Herre, 1939

Oostethus insularis (Hora 1925)

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Analysis of land transformation and land degradation using Remote Sensing and GIS

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Abstract

Land-use and land-cover change is a general term for the human modification of Earth's terrestrial surface. The present study aims at interpretation, identification, mapping and analytical studies of land characteristics to integrate all these attributes for better understanding of land use/land cover change and various land degradation types of Dehradun district for the last two decades using remote sensing and geographical information system (GIS). The results indicated that in the last two decades, three distinct features have characterized the study area that are increasing population growth rate, migration to the urban areas and rapid rise in population; continued dependence of a very large proportion of the population on the land resources; and increasing degradation and depletion of land resources with a consequent declines in the productive capacity of the land. If the present trend continues it will lead to severe degradation of natural resources and hence, it calls for proper land use policy. Remote sensing and GIS can be an effective tool for natural resource assessment, monitoring and management.

Key words: remote sensing and GIS, land use change, degradation and demographic factors

Introduction

One of the clearest manifestations of human activity within the biosphere has been the conversion of natural landscapes to highly managed ecosystem, such as croplands, pastures, forest plantations, and urban area (Ramankutty et al., 2002). Though humans have been modifying land to obtain food and other essentials for thousands of years, current rates, extents and intensities of land use and land cover change (LU/LC) are far greater than ever in history, driving unprecedented changes in ecosystems and environmental processes at local, regional and global scales (DeFries et al. 2004). These changes encompass the greatest environmental concerns of human populations today, including climate change, biodiversity loss and the pollution of water, soils and air. Monitoring and mediating the negative consequences of LU/LC change while sustaining the production of essential resources has therefore become a major priority of researchers and policymakers around the world (Global Land Project, 2005).

Biodiversity is often reduced dramatically by LU/LC change. When land is transformed from a primary forest to a farm, the loss of forest species within deforested areas is immediate and complete. Even when unaccompanied by apparent changes in land cover, similar effects are observed whenever relatively undisturbed lands are transformed to more intensive uses, including livestock grazing, selective tree harvest and even fire prevention (Meyer and Turner, 1994). Research also demonstrates that species invasions by non-native plants, animals and diseases may occur more readily in areas exposed by LU/LC change, especially in proximity to human settlements. Vegetation removal leaves soils vulnerable to massive increases in soil erosion by wind and water, especially on steep terrain, and when accompanied by fire, also releases pollutants to the atmosphere. Other environmental impacts include the destruction of stratospheric ozone by nitrous oxide release from agricultural land and altered regional and local hydrology (Turner et al. 1990 and Ruddiman, 2003).

While land cover may be observed directly in the field or by remote sensing, observations of land use and its changes generally require the integration of natural and social scientific methods (expert knowledge, interviews with land managers) to determine which human activities are occurring in different parts of the landscape, even when land cover appears to be the same. High rates of population growth, poverty and resource degradation, in many instances, have been mutually reinforcing processes. A major issue in sustainable development in Uttarakhand has therefore been the growth in population and its attendant causes and consequences. In the present study assessment of land transformation and land degradation of Dehradun district was carried out along with the analysis of the demographic features.

Study area

The district Dehradun is situated in the north-west corner of the Uttarakhand state (Fig. 1) and lies between 29º 58' to 31º 2' north latitudes and 77º 34' to 78º 18' east longitudes. Doon valley is a intermontane valley surrounded by lesser Himalayas in the North and Siwalik ranges in the south. Physiographically Dehradun can be divided into five units namely mountains, hills, piedmont plains, river terraces and flood plins. Geologically the study area is is comprised of phyllites and shales and alluvium. Old and recent flood plains have been formed by the deposition of the river at the lower side.

Materials and methods

The methods of land-change science include remote sensing and geospatial analysis and modeling together with the interdisciplinary assortment of natural and social scientific methods needed to investigate the causes and consequences of LULCC across a range of spatial and temporal scales. Remote sensing is an essential tool of land-change science because it facilitates observations across larger extents of Earth's surface than is possible by ground-based observations.

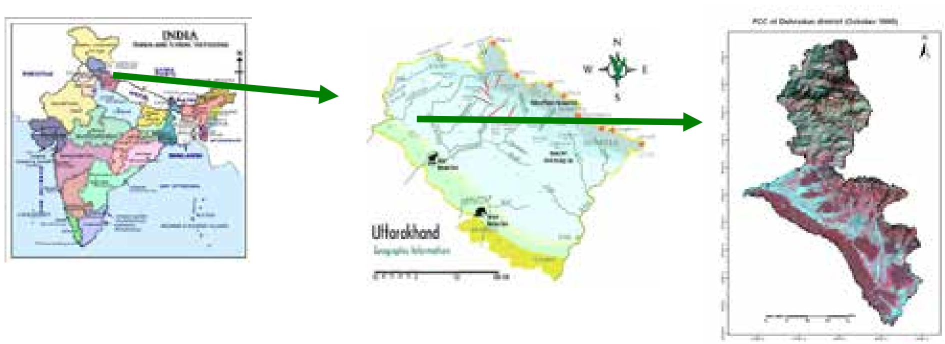

Fig. 1: Location of the study area

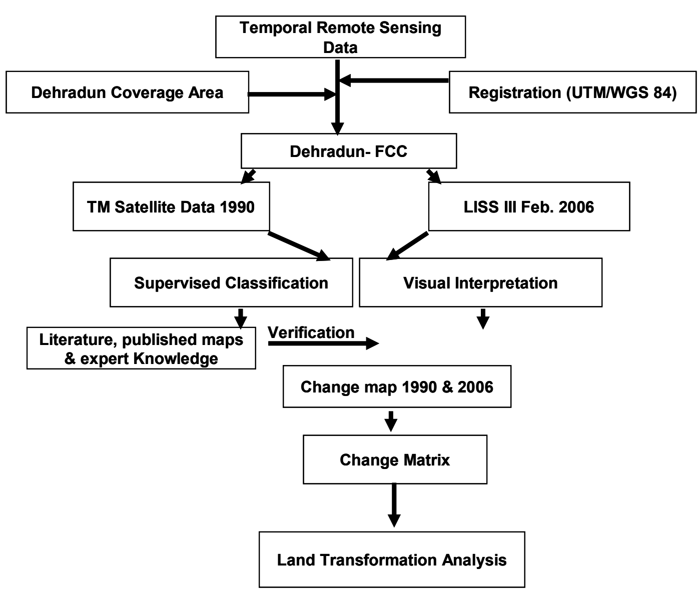

Fig. 2. Flow chart showing the methodology

The present study aims at interpretation, identification, mapping and analytical studies of land characteristics to integrate all these attributes for better understanding of land use/land cover change of Dehradun district for the last two decades. Various land degradation types were also visually interpreted using visual interpretation keys, so as to estimate the degraded areas. We have used IRS LISS III FCC of November 2005 and February 2006, TM satellite data of October 1990, Survey of India topographic map No. 53 F/15, 53 J/4 and 53 J/3 in the scale of 1:50,000. IRS LISS-III FCC imagery of February 2006 and TM data of 1990 were interpreted individually making use of the interpretation keys. Verification was carried out using ground truth and published information. Change matrix was prepared to analyse the land transformation. The detailed methodology is given in figure 2. Further, land use/land cover, and characteristics of various physiographic units were recorded so as interpret the land degradation types and severity. Census of India data of various time periods were used to study the demographic characters of Dehradun and to understand its impact on the land degradation.

Results and discussion

Remote sensing technology can be effectively utilized for change detection and monitoring activities. Ideally, the change detection procedures involve remotely sensed data acquired by the same sensor, having same spatial resolution viewing geometry, spectral bands and time of the day. It is observed that in 1990 the major land cover category was forest (40%) followed by scrub land (36%) and agriculture (11%). The spatial extent of forest area was spread over both in valley and mountain (Fig 3 & 4). Scrub land was mostly in the mountain slopes and majority of the agriculture land was observed in the valley. However, in 2006 (Fig. 5 & 6) mixed land use has under gone tremendous decrease in area which occupies only 2% of the geographical area followed by slight decrease in forested area (39%). The agricultural activity has gone up and it covers nearly 13% of the area with no change in scrub land status (36%). One of the most conspicuous change was noticed in settlement which has gone up from 3% to 6% of the study area, indicating the land conversion and pressure on natural resources of the region.

The results of land use/land cover change matrix indicated that forest cover has undergone both conversion and density reduction. It is estimated that 933, 974 and 160 ha of forest area has been converted into settlement, agriculture and mixed land use (agriculture & settlement), respectively during 1990-2006 (table 1). Owing to the demand for settlement 9,658 ha mixed land use and 22 ha of agricultural land have been converted into settlement. A significant finding of the study is that scrub area in the mountain region has been transformed into agriculture (303 ha) and the area under agriculture has witnessed intensification. As a result of these changes area under forest has declined by 1.7 %, scrub land by 0.3 per cent. On the other hand, a remarkable increase in the settlement area (122 per cent) was noticed followed by agriculture (17.5%) in the study area during 1990-2006 (Fig. 7).

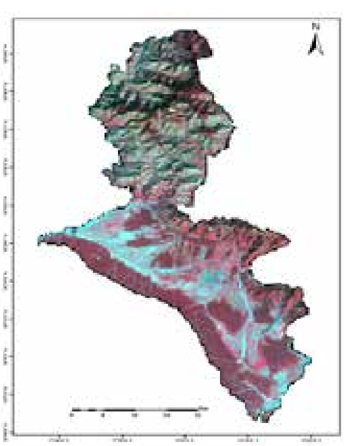

Fig. 3: FCC of Dehradun District (October 1990)

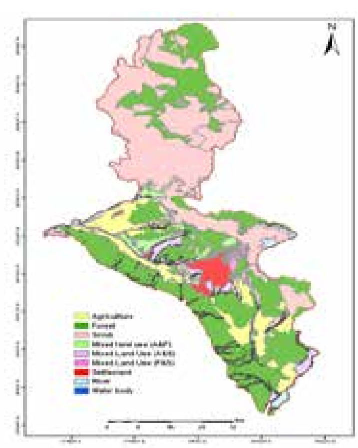

Fig. 4: Land use/land cover map of Dehradun District (1990)

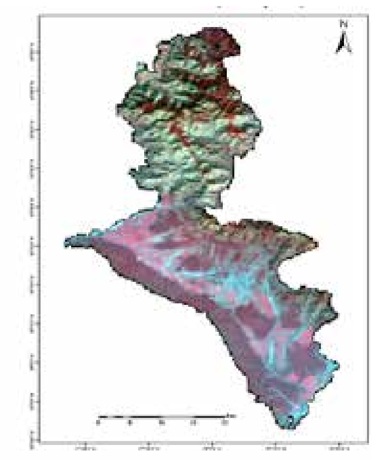

Fig. 5: FCC of Dehradun District (February2006)

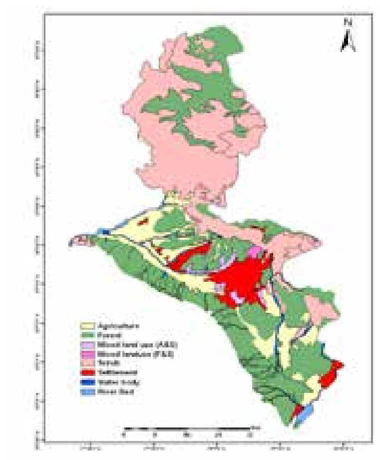

Figure 6: Land Use/Land Cover map of Dehradun District (2006)

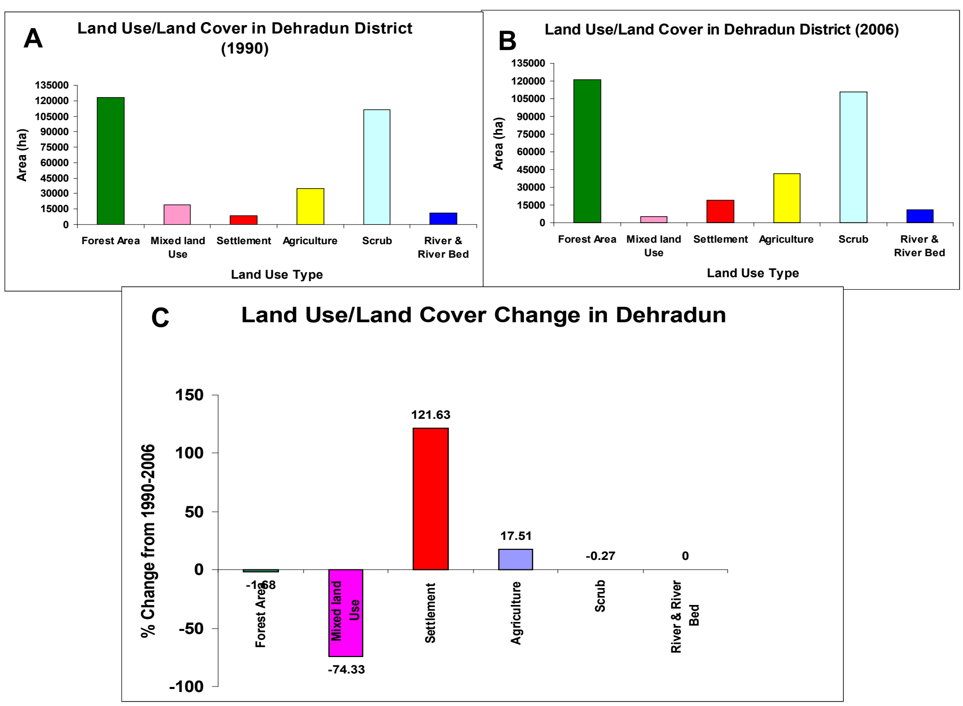

Fig. 7: Land Use/Land Cover Change (%) in Dehradun from 1990 to 2006

Further land degradation assessment using remote sensing data indicated that majority of the land cover area is under some form of degradation especially moderate to severe degradation in the Himalayan mountain. The change analysis of degradation types indicated that the degraded land in Dehradun has increased by 2063 ha in 2006 which was estimated to be 179198 ha in 1996. This means, during the period under study nearly 0.67% of new area has been brought under degraded land category. It is observed that gully erosion is the dominant form of degradation. It is a serious concern that in 2006 nearly 58.85 % of the area is subject to some form of degradation and only 41.15% of the area is free from degradation.

The analysis also indicated that majority of the degraded areas are located in the forested and mixed land use category. Gully erosion has increased as a result of forest density reduction and disturbance of scrub land for various activities in the mountain areas. Rills become prominent in the sloppy areas where intensive agriculture is practiced.

The demographic analysis of the Uttarakhand and Dehradun using census of India statistics indicated that during the seventies and eighties, dramatic declines were seen in mortality rates while fertility rates remain more or less stable at high levels. The result has been a rapid rise in population and growth rates that has historically never been experienced over such a short period of time. Environmental deterioration, poverty, and migration have been the obvious consequences.

In Dehradun urbanization as a process is relatively a recent phenomenon mostly due to immigration. The un-sustainability of mountain agriculture has contributed to out migration into more productive areas in the plains, to urban areas where there are seemingly more opportunities. Urbanization is generally regarded as an indicator of opportunities for employment in non-agricultural sectors and much of the service sector employment in Dehradun is generated in urban areas in the plains. As a consequence of this rapid change in land use is observed and Dehradun district is being converted into the dense settlement. With the increase in demographic pressure on agriculture land, marginal land (scrub land) has been brought into agriculture with intensification of already existing agricultural land. Similarly, the dense forest of the Doon valley is also going to be converted either into the settlement or agricultural land in the future (Sati and Kumar, 2004).

Conclusion

Thus, it can be concluded that the land use/ land cover of Dehradun district has undergone conspicuous change during 1990-2006 as a result of demand for settlements and food production. The study suggested that the forest should be protected in order to maintain the ecological balance. The settlement area should not be allowed to increase at the cost of productive land. However, nothing can be achieved unless and until we check the population growth. Economic transformation appears therefore as the key to effectively slow down population growth. The basis for economic transformation essentially is searched within the context of mountain specificities. If the present trend continues it may lead to severe degradation of several natural resources of the Doon valley and in this context remote sensing can play a vital role in aiding land use policy options and conservation efforts.

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