

Snow trout fisheries in Arunachal Pradesh of the Eastern Himalayas

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Left, right: A haul of *S. plagiostomus* at Dirang River

The natural aquatic resources of Arunachal Pradesh, lying in the eastern part of Indian Himalayan Region (IHR), is comprised of five major river drainages and numerous upland lakes, supporting a rich diversity of valuable cold water fishes, some of which are indigenous to the region and provides subsistence fisheries to the people inhabiting the area. Among the recorded indigenous species, snow trout are known for their economic importance and are recognised as potential species for food and recreation in the region. Very little information is available on their taxonomy, distribution, biology, habitat and food value. Considering these facts, an attempt has been made by the authors in this present communication to highlight the status of snow trout fisheries thriving in the snow fed streams, rivers and upland lakes of Arunachal Pradesh.

Snow trout are carps belonging to the subfamily Schizothracinae and are classified as vulnerable in India by the IUCN (2012). The demand for this group of fish has increased drastically with increasing fishing pressure due to lack of sustained aquaculture alternatives in this hill locked part of the world. The coming decades are expected to pose newer

challenges to the coldwater fisheries sector both in the development of aquaculture practices as well as conservation perspectives in the hill regions of the country with the concern for the indigenous fishes as candidate aquaculture species.

At present, the snow trout fishery in Arunachal Pradesh is mostly confined to the capture fisheries from the three major drainages viz., Kameng, Subansiri and Siang, the north bank tributaries of the river Brahmaputra. The other two drainages are Lohit and Tirap rivers, the south bank tributaries of river Brahmaputra having a comparatively tropical climate. Aquaculture of this group of fishes is at a lower level in Arunachal Pradesh and India more broadly, due to their inherent slow growth rate and lack of seed availability.

Seven snow-fed tributaries of Arunachal Pradesh have been explored by a team of scientists of ICAR-DCFR, Bhimtal, since 2016 with one fishing site on each tributary assessed to collect samples of snow trout for biological studies and record data on their habitat, abiotic and biotic environment, the catch composition and the fishing methods. Fishermen, local



Snow trout at the Sangti River.



Morphometric counts of snow trout from the Tenga River.



*A haul of *S. richardsonii* from the Choskorong Kho River.*



Snow trout from the Kiile River.



Catch of *S. progastus* from the Shei River.

residents and Fishery Officers were also interviewed to collect information on the abundance and catch details of snow trout. The tributaries assessed were:

- Dirang River (92°16'23"E, 27°22'30"N).
- Sangti River (92°37'22.4"E, 27°18'29.1"N).
- Tenga River (92°45'58"E, 27°18'15.7"N).
- Choskorong Kho River (92°27'32.8"E, 27°26'51.5"N) of Kameng drainage in West Kameng District.
- Kiile River (93°49'53"E, 27°33'18.2"N) of Subansiri drainage in Lower Subansiri District.
- Shei River (94°71'90"E, 27°99'08"N).
- Yargyap River (94°09'49.3"E, 28°34'32.4"N) of Siang drainage in West Siang District and Shi Yomi District respectively of Arunachal Pradesh in the Eastern Himalayas.

Snow trout composition

Snow trout are known as nga in local dialect and account for a major and important part of the capture fishery in the region. The dominant species of snow trout in most of the selected sampling sites of Kameng drainage were that of *Schizothorax plagiostrum* followed with *S. richardsonii*. Choskorong Kho River was observed to be dominated by *S. richardsonii* whereas *S. richardsonii* and *S. progastus* (McClelland 1839) were recorded in Shei River. Scanty information is available on snow trout from the Kiile River and Yargyap River in Lower Subansiri and Shi Yomi districts respectively due to remoteness of fishing sites and lack of transport facilities.

The average length of *S. richardsonii* was recorded as 14.64 ± 2.36 cm with an average catch size of 49.33 ± 21.52 kg in weight during the investigation in the different sampling sites of Arunachal Pradesh. *S. richardsonii* is distinguished by an



Snow trout, brown trout and other fishes from Yargyap River.

inferior and slightly arched mouth, hard cartilaginous covering below lower jaw extending between corners of mouth followed by a flesh and flat lower lip. The dorsal spine is strong and serrated behind.

In case of *S. plagiostrum*, the recorded average length was 17.32 ± 4.89 cm with an average catch size of 54.36 ± 33.92 kg in weight. The fish has a projected snout, mouth distinctly



A maximum size snow trout from the Kameng drainage.

Fig. 1: Average length (cm) of snow trout from different sampling stations.

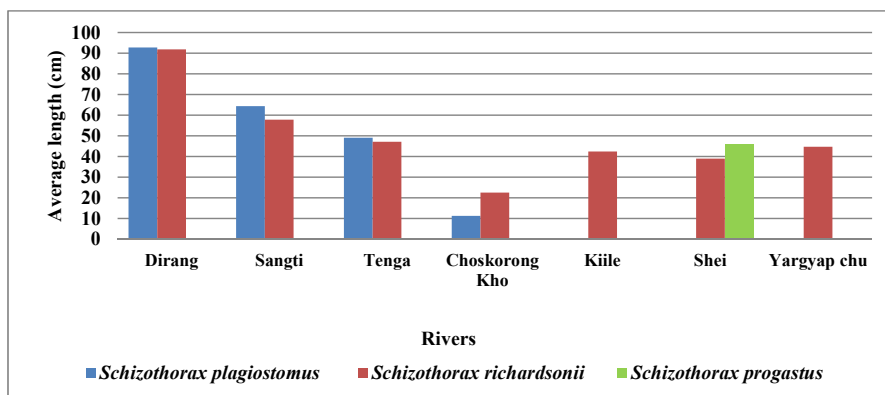
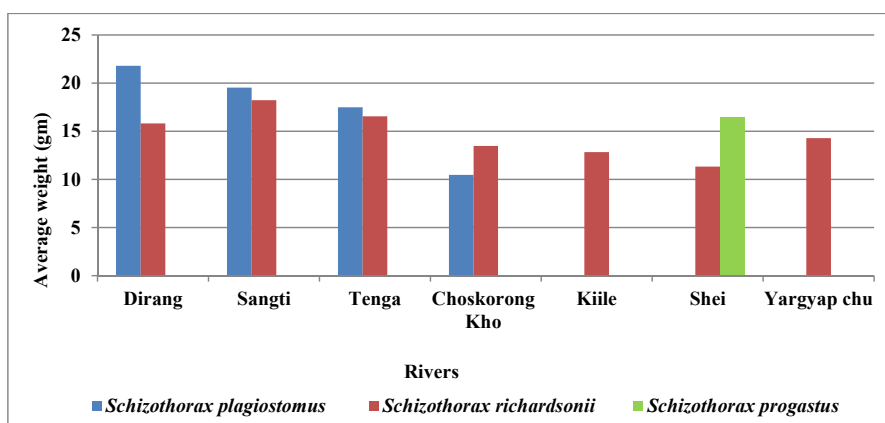


Fig. 2: Average weight (g) of snow trout from different sampling stations.



inferior, lower jaw very wide and deep, short and with a sharp keratized anteroventral cutting edge, lower lip fold expanded and papillose.

S. progastus recorded an average length of 16.44 ± 1.02 and an average weight of 45.63 ± 14.34 . The mouth of the fish is protractile, lips thick and fleshy, lower labial fold uninterrupted and trilobed, median lobe insignificantly small. The dorsal spine is strong and serrated behind.

The maximum length of the fish recorded in these snow fed tributaries of Arunachal Pradesh was 52.5 cm weighing 1.20 kg. The snow trout constitute an important part of capture fishery in the region and form a major component in the diets of the local people. The average length and weight of *S. richardsonii*, *S. plagiostomus* and *S. progastus* captured and recorded from different sampling stations are shown in figures 1 and 2. Fishes such as *Garra* sp., *Glyphothorax* sp., and *Psilorhynchus* sp. loaches were also captured from different sampling stations but in limited numbers. Cypriniformes represents 44% of the catch in the rivers of Kameng drainage, which are dominated by the snow trout group (Fig. 3). *Schizothorax* species represent 15% of the total catch composition in Shei River (Fig. 4). Yargyap River in Shi Yomi District recorded a major catch of

Fig. 3: Distribution of fish orders in Kameng drainage.

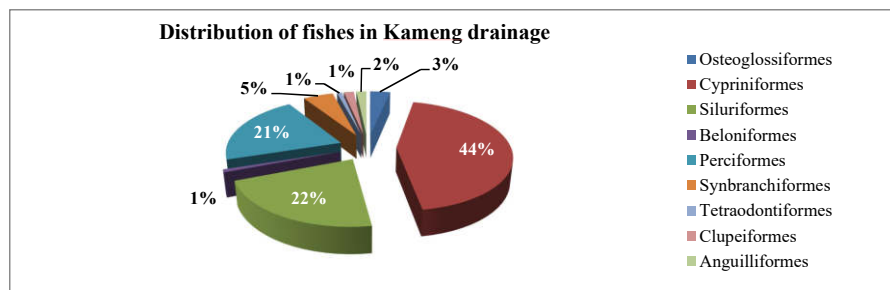
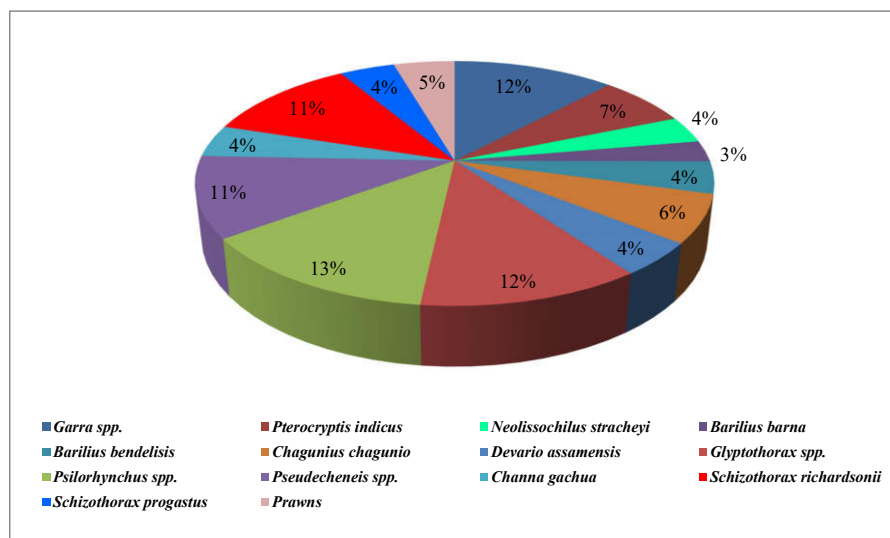


Fig. 4: Percentage distribution of fish species in Lipums operated in the Shei River.



brown trout (*Salmo trutta fario*) and the snow trout are restricted to upstream tributaries of the main river.

Snow trout fishing methods

The fishers of Arunachal Pradesh are neither inborn fishers nor belong to any fishing community and therefore fishing of snow trout is restricted on traditional lines. This group of fish is not harvested commercially reasons for export and thus the catch is usually consumed locally for household usage. It was observed that the fishing gears applied for catching snow trout are mostly indigenous and specific to a particular area depending on the nature of the river and skills of the tribespeople operating the gears.

Noose and line: This method of fishing is selective for catching snow trout inhabiting the deeper pools and turbulent lotic water of Dirang and Sangti rivers. This fishing device consists of a rod, reel, long-line with nooses, rings,

bait and weight. The rods are made of bamboo measuring 2.5-5.0 m in length and 0.9-3.2 cm girth diameter and the lines are made of nylon monofilament material of 0.30-0.41 mm diameter. 7-20 nooses are prepared on one line, keeping an space of 5-8 cm in between. The reel in this gear is unique of its kind as it is prepared indigenously imitating a professionally designed one used by avid anglers. The reel is not supported by an actual wheel and a lever to cast and retract the monofilament line. Instead, the reel is made of an aluminium wire of 2-3 mm diameter in thickness and attached firmly to the rod by rubber strips. The line contains 1-3 of baits made of lead material and is attached few centimetres above the anterior most nooses on the line. A sinker, usually a stone weighing 100-250 g in weight is tied to the line for proper dipping of the loops in water. The gear is mostly operated during November to February when water is mostly clear and transparent. Average catch per unit effort (CPUE) of the gear was recorded to be 1.8-2.2 kg/h and average catch size in weight was 136.3

± 116.34 kg. Noose and line fishing is highly energy efficient and accounts for high fish quality with low investment.

Cast nets: Cast nets are most frequently operated in the fast flowing rivers of Arunachal Pradesh. The nets are made of multifilament and are heavily weighted around the base by fixing iron weights to the free edges of the pockets and each is provided with a retrieving line attached to the apical portion. The CPUE of cast nets vary widely from 0.5-5.2 kg/per hour/gear. Cast nets are operated round the year. Monofilament cast nets are also operated in the region but have a low durability. The mesh size of the cast nets varies from 1.5 to 2.5 cm.

Damming: Partial damming on the Choskorong Kho River is another technique for catching snow trout in the Shergaon region of West Kameng District by local fishers. Short dams are constructed manually across the entire breadth of the river with rocks and boulders found on the river bed. This process of damming the river is called *kholeya* (*kho* = water; *leya* = enclosure) in local language and is practised during the pre-monsoon season when water level starts rising during the month of March-April. The bark of oak tree and walnut are ground and an extract is prepared out of it. This extract serves as a fish poison and its application in water slows down the movement of the fishes or temporarily paralyses them. The catch is erratic accounting a CPUE of 2.0-15.0 kg/day and the fish is either consumed locally or is sold at a price of Rs. 300-400

Water diversion: This is another method of fishing on the Choskorong Kho River, where water is diverted towards a bamboo passage, locally called as *neuta* (*neu* = fish and *ta* = place). This method of fishing is mostly seen during the post monsoon season whence the water starts receding and the fishes migrate downstream during September-October after spending a considerable time upstream during monsoon. The diversion of river water causes the flow to pass through the bamboo passage with the fishes. The water percolates through the bamboo mesh whereas the fishes remain within the platform. An average catch of 0.5-4.2 kg/day has been recorded in this method of fishing.



Noose and line method at Dirang River.



Fishing for snow trout by cast net at Sangti River.

Fish trap: *Hoap* is a kind of tubular shaped fishing trap which is well fabricated of bamboo. One of the ends has a non-retractable mouth piece guarded with inwardly pointed labyrinths. The tail end has a similar kind of labyrinths but is outwardly projected. The fishes once entering the trap are neither able to retract back through the mouth nor escape from the tail end. The mouth part has a diameter of 15-30 cm and the length of the trap varies from 40-90 cm. These traps are placed over night against the flow of stream water and the fishes are harvested in the early morning hours of the day. A maximum CPUE of 2-4 kg/day/gear is recorded in this gear.

Fish aggregating structures: *Lipums* are the only method of capturing fishes in the river systems of the Basar area situated at mid-altitude 594-787 m of West Siang District. These are installed by aggregating stones and boulders from the river bed, engrossing an area of 1.5-2.0 m² to lure fish naturally seeking for shelter, protection from predators and in search of food adhering to the structures. The lipums are operated during winter season having a water level within one metre depth and relatively less water flow. Fish harvesting from the lipums is done by two indigenous made bamboo devices, a rectangular shaped mat *eechir* is used to encircle the lipums and funnel shaped traps *kabulu* or *odur* measuring 0.7-1.0 m in length and 0.08-0.20 m girth diameter are used to retrieve the fishes alive and intact. A local biodiversity conservation society, GRK, ensures the protection of the river biodiversity by restricting lipums as the only means of fishing. The relative abundance of aggregated fishes in lipums was higher for those having inferior or adhesive mouths (70%) viz., *Garra* spp., *Pterocryptis indicus*, *Schizothorax* spp., followed by shiners (30%) viz., *Channa* spp., prawns and sporadically *Neolissochilus stracheyi*, *Chagunius* spp. and lesser barils, yielding an average catch of 2.5-12.0 kg per lipum. Altogether, fishes aggregated in lipums belonged to

four orders, six families and fourteen species. The major species of snow trout recorded in the lipums are *S. richardsonii* and *S. progastus*.

Snow trout habitat

Overall, the topography of the river sites is hilly in nature with steep slopes, situated at an altitude ranging from 1,411-1,934 metres. All these rivers are perennial and arise along the Indo-China border and in their total route confluence with many major and minor tributaries and carry all of the discharge to the Kameng, Subansiri and Siang basins. The dominant stream substrate in the Kameng drainage consists of large boulders along the banks and small boulders, cobbles and gravels on the beds. The Kiile and Shei rivers have small cobbles and pebbles along most of their length. The Yargyap River has small boulders along the banks and pebbles and gravel at the bed. Furthermore, the rivers of Kameng drainage feature mostly riffle and deep pools, the Shei and Kiile rivers shallow pools and runs, and the Yargyap River deep pools and riffles and runs in certain stretches.

Abiotic variables of water: The abiotic variables of water from the sampling stations were analysed with standard methods. All the sampled river sites of Kameng drainage and Yargyap River, being snow fed in origin, remained clear and transparent during the study period. Most of the essential water quality parameters were within the optimum level indicating good health of the water body and conducive conditions for the abundance of the snow trout. On this basis of alkalinity studied, the rivers fall under the category of moderately nutrient rich (Spence, 1964) and the measure of hardness (Moyle, 1946) reveals that water of the river sites are soft except in the Tenga, Choskorong Kho and Kiile rivers, which may be attributed due to higher human population around the sampling sites.

Biotic variable analysis of water: Phytoplankton in the river ecosystems at different sampling locations was estimated. Altogether, 30 species of plankton were identified belonging to 24 families, 19 orders and 6 classes from the upland rivers of Kameng drainage. The species of *Navicula* (27%) dominated in Dirang River followed by *Oscillatoria* (23%) and *Nitzschia* (18%); *Meridion* (36%) dominated in the Sangti followed with *Nitzschia* (26%) and *Fragilaria* (17%); *Spirogyra* (50%) dominated in Tenga River followed with *Nitzschia* (17%) and *Pinnularia* (14%); *Stigeoclonium* (23%) dominated

in the Choskorong Kho River followed with *Nitzschia* (17%) and *Anabaena* (14%) and *Spirogyra* (24%) dominated in Kiile River followed with *Spirulina* (12%) and *Nitzschia* (11%). *Anabaena* (34%) dominated in Shei River followed with *Spirogyra* (22%) and *Navicula* (17%); *Oocystis* (43%) dominated in Yargyap River followed with *Stigeoclonium* (21%) and *Nitzschia* (12%).

Food and feeding habits

The availability of food in fast flowing streams is a determining factor for distribution of the snow trout fishes in terms of their energy requirement for growth, development and reproduction. Snow trout is a phytophagous fish having transverse inferior mouth adapted for scraping attached algae from the



Damming the river to facilitate fishing.



Operation of neuta over the Choskorong Kho River.



Fishing for snow trout with lipums in the Shei River.



Operation of neuta over the Choskorong Kho River.



Fishing for snow trout by cast net at the Sangti and Tenga rivers.

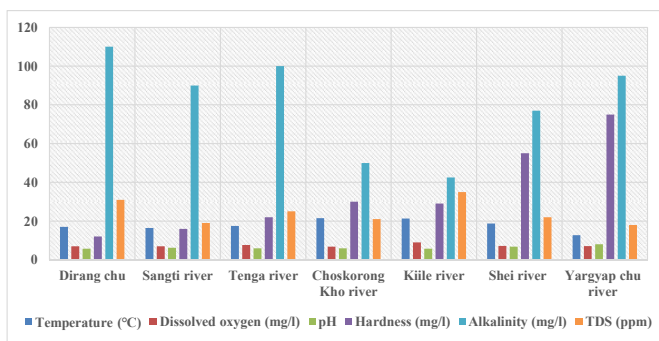


Table1: Gut content analysis (plankton abundance in gut) of the snow trout at the sampling stations in different rivers.

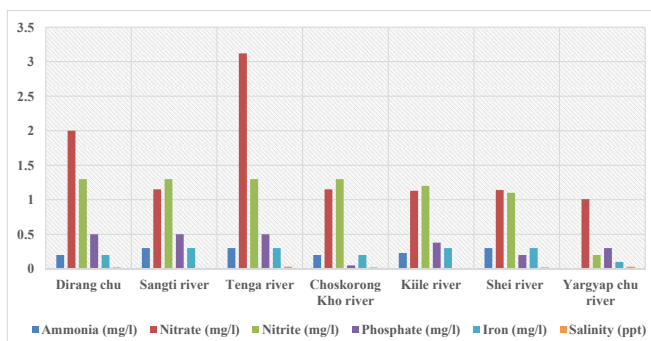
Species	Dirang chu		Sangti		Choskorong Kho		Tenga		Kiile	Shei	Yargyapchu
	SRI	SPI	SRI	SPI	SRI	SPI	SRI	SPI	SRI	SPr	SRI
<i>Pinnularia</i>	***	**			*	*	***	***	**	**	*
<i>Navicula</i>	**	**	*	**	**	***	***	***	**	***	**
<i>Fragillaria</i>	**	***	*	**					***		**
<i>Chlorella</i>	*	***		*					*	*	
<i>Oscillatoria</i>	*										
<i>Cocconies</i>		**							*	*	
<i>Meridion</i>			**	***	*	*	*	*	*	*	*
<i>Nitzschia</i>			**	***	**	**	***	***	***	***	
<i>Achnanthes</i>					*	*	**	***	*	**	***
<i>Spirogyra</i>							**	**	**	***	
<i>Cymbella</i>					**	**	*	*			
<i>Stigeoclonium</i>	**				***	***					**
<i>Cladophora</i>		*									
<i>Oocystis</i>			***	***							***
<i>Achnanthes</i>			*	*			**				***
<i>Diploneis</i>			*	*							
<i>Eunotia</i>			*				**	*	*	*	*
<i>Synedra</i>				*		*			*	*	*
<i>Tabellaria</i>					*						
<i>Cymatopleura</i>							*	*	*	*	
<i>Dyctyospharium</i>							*	*			
<i>Spirulina</i>									*		
<i>Anabaena</i>										*	

SRI: *Schizothorax richardsonii*; SPI: *S. plagiostomus*; SPr: *S. progastus*
 ***High; **Moderate; *Least

Graphical representation of physico-chemical parameters of water at sampling stations.



Graphical representation of nutrient variables of water at sampling stations.



surfaces of stones. The gut content of *S. richardsonii* and *S. plagiostomus* is comprised of phytoplankton and their abundance is stated in Table. 1.

thick, creamy white in colour with oily surface, are lobed and extend to two thirds of the body cavity. A slight pressure on the belly releases milt from the genital papilla.

The snow trout breeding in the rivers

Field observations on the different stages of the reproductive organs reveal that the percentage of mature specimens was mostly recorded during May to August. The occurrence of the mature individuals in these months indicates the proximity of spawning period. The matured ovaries in females are yellowish in colour with a reddish tinge due to the increased vascular supply. The ovaries further increase in volume and weight and cover nearly the entire length of the body cavity. On the other hand, the mature testes in males become very

Aquaculture of snow trout

Aquaculture of snow trout in Arunachal Pradesh has not gained much popularity due to its slow growth rate and non-availability of hatchery produced young ones in useful numbers. However, seed are being procured from natural river water and stocked in small sized ponds and tanks by local fish farmers, due to the lack of a fish hatchery for producing fish seed of other commercially important fishes such as carps and catfishes. A few progressive farmers procure carp seed from other neighbouring states but then the unit price of the carp seeds rises manifold due to on-road transportation charges. Furthermore, survival and growth



Fishing for snow trout with lipums in the Shei River.



Sampling site at Tenga River.

of carps is lower due to the colder regime of the region. Snowtrout seed (5-9 cm) are collected by sieving with cloths or sieves during the post-monsoon season (August-September) and are stocked in the ponds. The ponds are usually smaller in size measuring 100-1,500 m² depending on the slope and the topography. The ponds are provided with a continuous water flow through an inlet pipe from a stream source. Manure or fertilisers are not used for plankton production. Fish feeds are provided with local ingredients and household left overs which include maize flour, crushed maize

remains, cooked rice, buckwheat flour, finger millet waste and wheat balls. An average fish weight 150-200 g was estimated after one year of rearing. There is no season of harvesting the fishes and are consumed locally round the year.



Sampling site on the Dirangchu River.



Sampling site at the Sangti River.



A gravid female snow trout.



Study area in an upstream tributary of the Yargyap River.



A mature male snow trout.



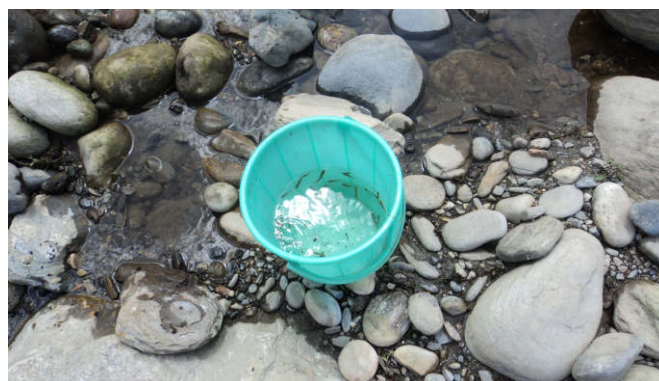
Study area in an upstream tributary of the Yargyap River.

Snow trout marketing

Snow trout are seldom sold in fresh conditions at local markets. The fresh fishes are usually sold to the villagers residing adjacent to the harvesting sites. The snow trout intended for sale at markets are smoked and preserved on a raised platform over a fireplace in the household kitchens so as to increase their shelf-life up to six months. These smoked fishes are packed in a small bunch consisting of 5-6 fish or into a bigger bunch of 10-12. The fishes are carried to the local markets packed in perforated bamboo baskets. In other cases, the whole fish is inserted onto a bamboo needle from mouth to peduncle for ease of handling. The fish are sold at the rate of Rs. 500 for the smaller bunches and Rs. 1000 for the bigger bunches. In restaurants, the fishes are preserved by slicing them into fillets and then hanging them on a wire over a fireplace for smoking. These smoked fish are then ground to serve as a paste blended with spices. The freshly caught fishes are also served as fishfries and fish curries.



Above, below: Riverine collection of snow trout seed.





Above, below: Release of wild-collected snow trout seeds in confined ponds.



This column: Aquaculture of snow trout in various pond configurations, Arunachal Pradesh.



Above, below: Preserved snow trout for sale in local markets.





Preserved snow trout for sale in local markets.



Snow trout served in restaurants.

Conclusion

Snow trout are very highly valued as sport and food fish in Arunachal Pradesh of the Eastern Himalayas. The catch of the snow trout is mostly confined to natural river drainages. The local people residing along these drainages could benefit by adopting to fish-based ecotourism ventures. Snow trout fetch a high price compared to carps and catfishes in the region. But to raise the fish in captivity needs proper feeding strategies and seed production protocols and this holds the major challenge for research. Therefore, overcoming the difficulties of ready feed and seed availability in the region, the young ones can be stocked for aquaculture and can also be released into the natural systems for their self-propagation.

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