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Spatio-temporal pattern of clupeids and the changes in quality of *Coilia dussumieri* caught off Gujarat coast, India

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Original Article

Abstract

The present study is the analysis and visualization of the spatio-temporal distribution of clupeids caught in both single day and multiday trawls off Gujarat coast summarized by using Geographic Information System (GIS). In multiday trawl, clupeids showed almost same abundance round the year, but the peak catch was in nearshore waters off Gujarat in winter followed by post-monsoon and pre-monsoon, whereas in single-day trawl, the highest abundance occurred immediately after the monsoon ban at 10 to 30 m depth zone.The catch quality of the clupeid (*Coilia dussumieri,* Valenciennes, 1848) was determined by using the standard method of sensory, biochemical, and microbiological quality parameters for Zero, fifth, tenth, and fifteenth day of storage in the trawl hull for both single day and multiday trawler to know the optimum time period of storage for safe human consumption. The Total Volatile Base – Nitrogen (TVBN) of muscle was 19.13 $\pm$ 0.81 mg N/100g and 35.28 $\pm$ 0.37 mg N/100 g at 0thday and 15th day respectively which indicates the acceptability limit to 15th day. The shelf life of *C. dussumieri* stored in ice as determined by overall acceptability sensory scores, bio-chemical quality and microbial data is 15 days.

Keywords: *Clupeid, multi-day trawler, Geographic Information System (GIS), catch*

Introduction

Forecasting location and spatial characteristics of resources are important for conservation and profit optimization (Stoner *et al.*, 2001). However, majority of current problems in fishery resources are in the spatial domain due to over exploitation of specific fishing grounds, habitat loss and exploitation of small and medium sized fishes. Any temporal analysis without spatial concepts will lead to incomplete results and vice versa. Trawl surveys form an important tool in assessing fish populations, their locations and habitat use (Stoner *et al.*, 2001). Data collected from trawl surveys are used to make important decisions on how to manage commercial and recreational fisheries and to limit their rate of exploitation, while maximizing the economic yield of resources. Kemp *et al.* (2002) suggested that visualization is a very potent tool in the provision of decision support in fisheries information systems. Information on catch per unit effort (CPUE) from GIS map gives insight on the catch quantity and the pattern of fishing in the estuarine area (Pradhan *et al.*, 2019). The importance of GIS in fisheries is not restricted to estuarine and inshore waters, but also used in the Exclusive Economic Zone (EEZ) which was described by Caddy and Garcia (1986) for developing countries. The seasonal variation of catch rate gives an idea about the species abundance and their distribution pattern in the Arabian Sea. In India, use of GIS

in marine fisheries is not very prevalent though some authors (Selvaraj *et al.*, 2007; Dineshbabu *et al.*, 2012; Azeez *et al.*, 2016) worked on the fisheries resource management by using GIS. The availability of open source GIS software makes this tool more user-friendly and accessible for data storing, analyzing and visualization.

Arabian Sea is one of the major upwelling areas in the world and is considered as the most productive component of the Indian Ocean. Biological productivity of Arabian Sea is under the influence of monsoonal wind forcing and winter convective mixing (Lotliker *et al.*, 2018). The Arabian Sea has been divided into two regions; south and north of 15^0 latitude and though the catch composition is almost similar in both the regions, the planktivore fish are dominant in south and carnivores dominate in north (Madhupratap *et al.*, 2001).

The quality of fish is a complex concept as it is affected by several factors such as species, age, proximate composition, fishing area, season, and nutritional status. Fish freshness is considered as the most important quality parameter since it is directly related to the sensory attributes perceived by consumers such as appearance, texture, odor, and taste (Alasalvar *et al.*, 2011; Cheng *et al.*, 2016). Non-sensory methods like biochemical, physical and microbiological analyses, are also used to assess the quality of fish (Gill, 1987; Gill, 1992). Total volatile base nitrogen (TVB-N), trimethyl amine nitrogen (TMA-N) and formation of biogenic amines (Botta *et al.,* 1984; Hebard *et al.,* 1982; Karmas and Mietz, 1978) are some of the indicators for freshness test. The changes in biochemical and microbial spoilage lead to the deterioration of fish and alter the sensory quality of the fish (Yamanaka *et al.*, 1989; Chang *et al.,* 1998; Kyrana and Lougovois, 2002; Özogul *et al.*, 2005). *Coilia dussunieri* commonly known as '*Mandeli*' is preferred in the local market due to its crispy nature of meat after frying, so the present paper reports on the catch quality of *C. dussumeiri* along with the mapping of the distribution pattern of the clupeids as a group.

Material and methods

Study area

The trawl fishery along Gujarat coast contributes significantly to the state and country's total catch. Three major sampling sites were fixed for data collection according to their magnitude in trawling and belonging to 3 districts i.e. Veraval (20.905401^{0}N, 70.375217^{0}E), Mangrol (21.107787^{0}N, 70.100019^{0}E) and Porbandar (21.640813^{0}N, 69.596152^{0}E) (Fig.1).

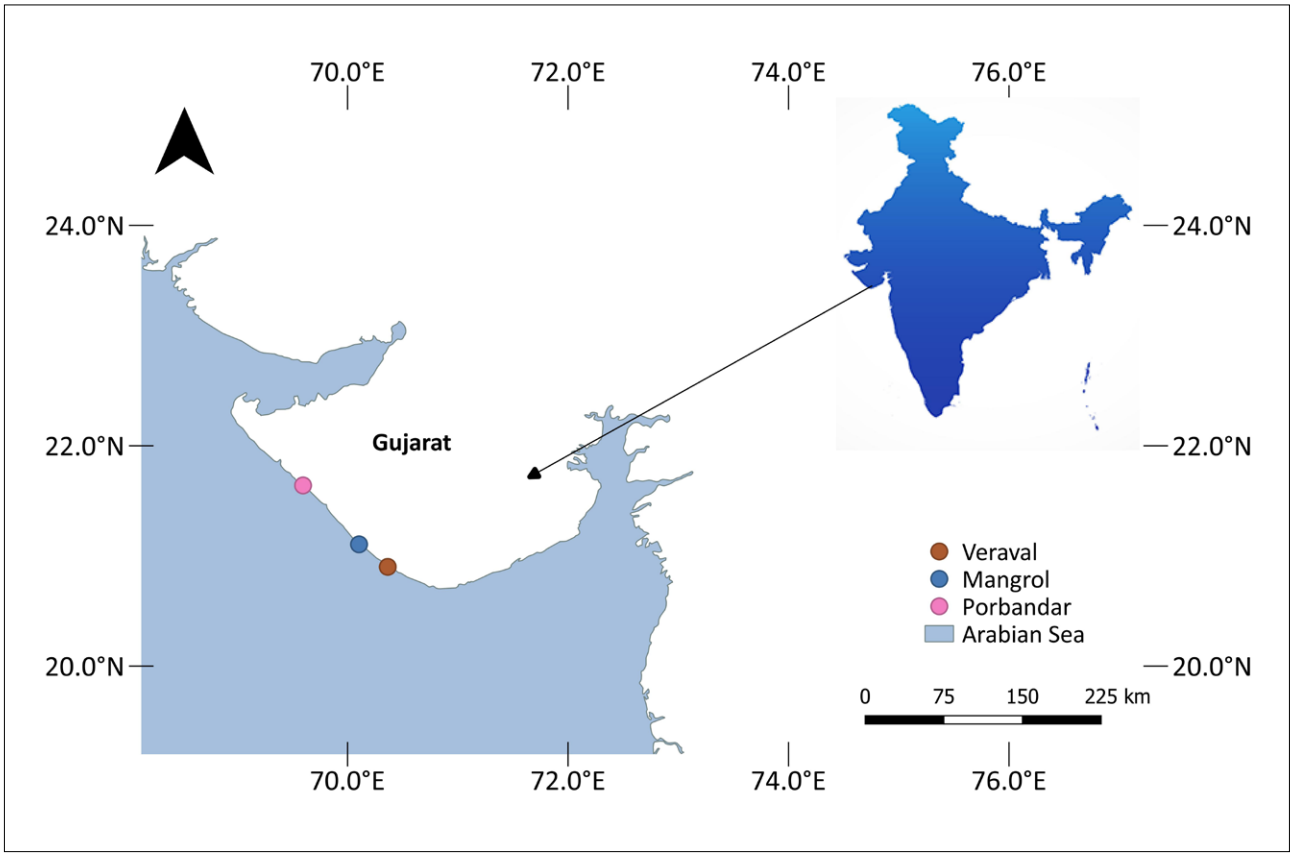

Fig. 1. Map illustrating the sampling locations in Gujarat

Data collection and Mapping

Shore based catch assessment was done from selected single-day and multiday trawlers fortnightly from January to December 2017. A questionnaire was prepared in the vernacular language to collect information on catch details of each haul performed during the entire voyage from both single and multiday trawlers. GPS points were recorded with help of the Skipper of surveyed boat for each haul to analyse spatial and temporal distribution of clupeids in the fishing ground.

The arc Arc GIS 10.3, one of the most powerful GIS software for mapping, developed by Environmental System Research Institute (ESRI) Redlands, California was used for analyzing the geographic data. Primary data collected from various sources, along with the geographic position in Degree decimal minute, which was converted to Degree decimal format were entered into Microsoft Excel sheet. Then these were converted into a database file and CSV (Comma Delimited) format. Before entering the catch data to the Arc GIS 10.3, Excel data was converted to DBF (Data Base File) format. Data interpolation was done in IDW (Inverse Distance Weighting) format. These database files were used for creating the geodatabase and with its natural editing features, followed by Arc- catalogue with WGS 84 spatial reference, the Arc map were created.

Catch quality study

Samples of *C. dussumieri* from trawl hull of 0th, 5th, 10th and 15th day were collected for the biochemical and microbiological analysis whereas those up to 20th day were considered for the sensory analysis. The catch quality was determined by measuring the sensory (appearance, colour, texture, odour) biochemical as well as microbiological quality parameters such as trimethyl amine nitrogen (TMA-N), total volatile base nitrogen (TVB-N), pH and total plate count (TPC). The pH value of fish homogenate was measured by digital pH meter (Eutech tutor pH/ºC meter, Eutech Instruments, Singapore) after homogenizing 10 g of meat with 50 ml of distilled water in the mortar and pestle for 10 minutes. The trimethyl amine (TMA) and total volatile base nitrogen (TVB-N) was determined based on an adaptation of the current official European steam-distillation method (EU, 1995). For total plate count (TPC), fish samples (10 g) were mixed with 90 ml of sterile Ringer solution (1/4 strength) and then stored for 3 min. Further decimal dilutions were made, and then, 0.1 ml of each dilution was pipetted onto the surface of nutrient agar (Hi-Media, Mumbai, India) plates in triplicate. Total plate count was estimated (log cfu/g of sample) according to the US Food and Drug Administration, (Bacteriological analytical manual, 1998) methods followed by incubated at 37˚C for 24hrs.

The sensory evaluation (Mailgaad *et al.,* 1999) for overall acceptability of the selected fish sampleswere done by trained panel members using 9 point hedonic scales with 1 being the lowest and 9 being the highest score. The point 5 was taken as the border of acceptability. The attributes evaluated were appearance, colour, odour, texture and overall acceptability.

Statistical analysis

Analysis of variance (ANOVA) was carried out and the significant difference among the treatments were determined by Tukeys HSD. The level of significance was set up at $p \leq 0.05$. All the above experiments were carried out in triplicates and the results were expressed as a Mean ± Standard deviation.

Results

The multiday trawl catches of clupeids showed nearly same abundance level CPUE/day (in kg) round the year. The exploitation of these resources peaked in nearshore waters off Gujarat upto 200 m depth in winter (25 kg/day) followed by post-monsoon off Maharashtra and Gulf of Khambhat (23 kg/day). In pre-monsoon the highest catch rate observed was 20kg/day off Veraval and southern part off Maharashtra coast (Fig. 2). The lowest abundance of these resources was found in the northern most trawling ground off Kutch and Porbander in post-monsoon whereas the lowest abundance was observed off Goa during winter. Single-day trawl showed highest catch rate (25kg/day) immediately after monsoon ban up to 30 m depth off Veraval coast. Whereas these resources were exploited from 40 m depth zone in winter at a catch rate of 14 kg /day and decreased to 8 kg/day in pre-monsoon at 30-40 m depth off Veraval (Fig. 3).

Biochemical analysis of TMA-N, pH, TVB-N, and TPC value considerably increased from the 0th day to 15th day (Figs. 4, 5 and 6) and the changes in the parameters are shown in Table 1. The value of TMA-N (1.28 ± 0.14 to 7.02 ± 0.18), TVB-N (19.13

Table 1. Temporal changes in TMA, TVBN, pH and TPC (mean ± SD) of *C. dussumieri* during 0th, 5th, 10th and 15th day post storage in ice.

	0th day	5th day	10th day	15th day
TMA	1.28 ± 0.14	2.49 ± 0.16	5.52 ± 0.14	7.02 ± 0.18
TVBN	19.13 ± 0.81	21.98 ± 0.37	30.85 ± 0.28	35.28 ± 0.37
pH	6.78 ± 0.03	6.55 ± 0.05	7.07 ± 0.06	7.24 ± 0.04
TPC	2.46 ± 0.15	2.98 ± 0.13	5.29 ± 0.21	7.48 ± 0.21

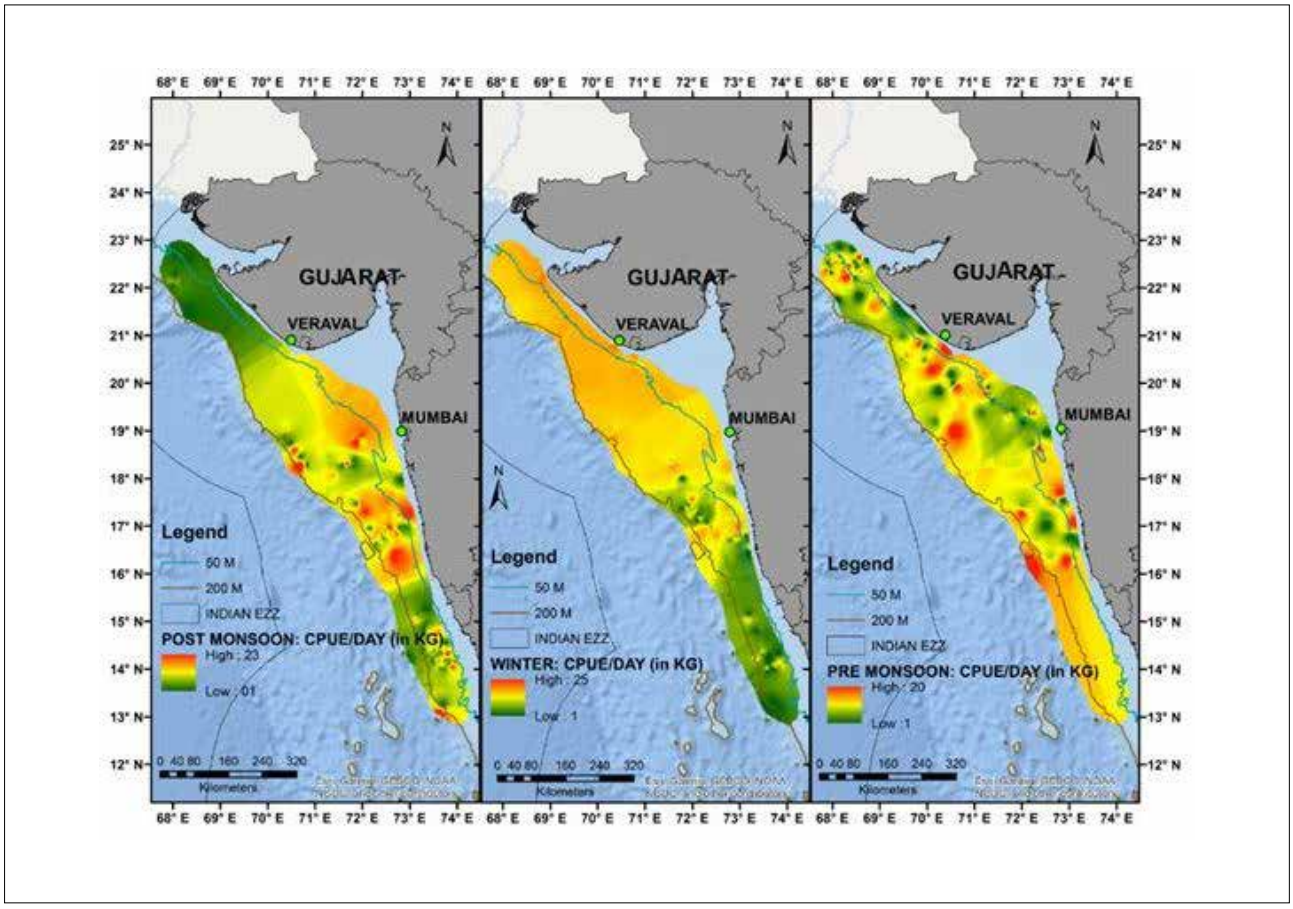

Fig.2. Seasonal variation in CPUE (catch in kg per day) of Clupeids in multiday trawlers

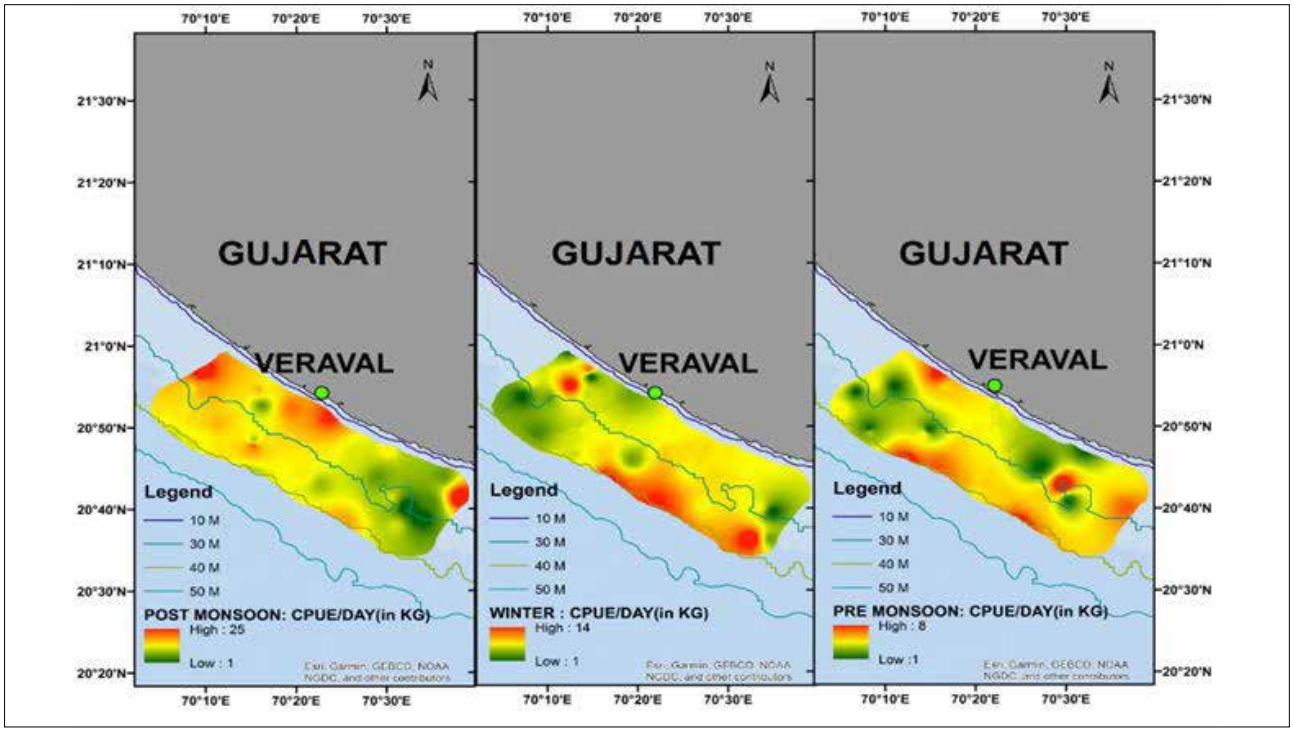

Fig. 3. Seasonal variation in CPUE (catch in kg per day) of Clupeids in singleday trawlers

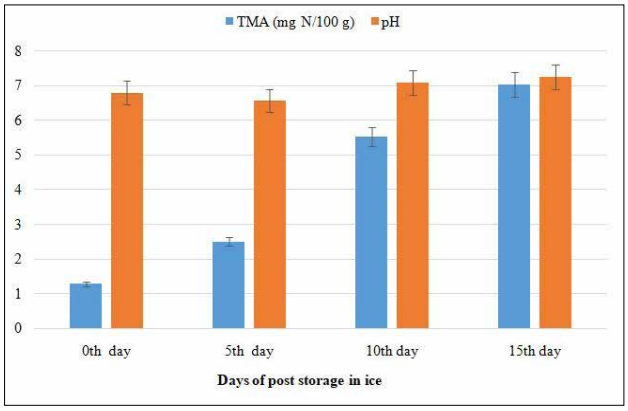

Fig. 4. Temporal changes in TMA, pH of *C. dussumieri* during post storage in ice.

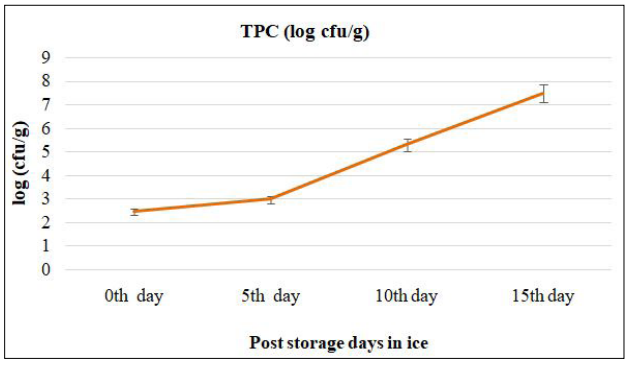

Fig. 6. Temporal change in TPC of *C. Dussumieri* during post storage in ice

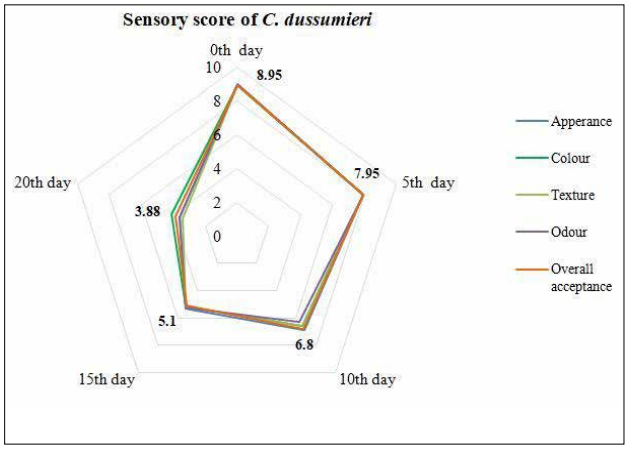

Fig. 7. Temporal changes in various sensory parameters appearance, colour, texture, odour and overall acceptance of *C. dussumieri* during post storage in ice

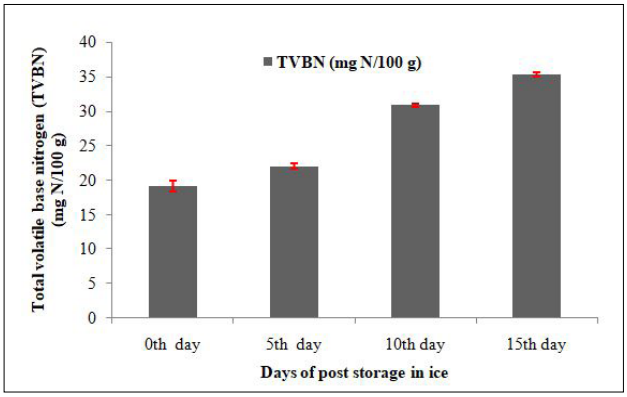

Fig. 5. Temporal change in TVBN of *C. dussumieri* during post storage in ice

± 0.81 to 35.28 ± 0.37) showed an increasing trend during the ice storage periods. The variation in pH from 0th day (from 6.78 ± 0.03) to the 15th day (7.24 ± 0.04) was meager. Total plate count (TPC) was estimated to know the total number of aerobic microorganisms in the selected fish samples. Total plate count (TPC) value increased from 2.46 to 7.48 cfu/g. for 0th to 15th days periods of ice storage respectively.

Sensory evaluation was done to measure the freshness and edibility of *C. dussumieri*. The scale value for all the sensory parameters (appearance, colour, texture, odour) decreased with the passing days (Fig. 7 and Table 2) and the lowest value for all the above parameters were recorded in 20th day of the observation. The overall acceptance varied from 8.95 ± 0.26 in the 0th day to 3.88 ± 0.38 in the 20th day. The appearance of the sample, which was quite prominent and fresh on day 0, faded with advancement of the storage period. On the 10th day appearance became increasingly weaker and became dull at the end of 15th day. The fresh natural color of the skin was observed in day 0 and faded moderately during day 5th to 10th. Texture of the sample changed from very firm and stiff on 0th day to firm on 5th day and soft, sunken and burst condition was observed on 10th, 15th and 20th day of post storage in ice. The odour of samples attributed as fresh, neutral, fishy, stale and spoilt were encountered on 0th, 5th, 10th, 15th and 20th day of post storage respectively. Result of this study indicate that the shelf life of *C. dussumieri* stored in ice as determined by the overall acceptability sensory scores, chemical quality and microbiological data is 15 days.

Table 2. Temporal change in appearance, colour, texture, odour and overall acceptance level of *C. dussumieri* during 0th, 5th, 10th, 15th and 20th day post storage in ice.

	0th day	5th day	10th day	15th day	20th day
Appearance	8.95 ± 0.26	7.90 ± 0.21	6.85 ± 0.67	5.25 ± 0.67	3.62 ± 0.48
Colour	8.90 ± 0.26	7.90 ± 0.21	6.60 ± 0.84	5.20 ± 0.84	4.10 ± 0.44
Texture	8.95 ± 0.26	7.90 ± 0.21	6.60 ± 0.88	5.15 ± 0.88	3.40 ± 0.32
Odour	8.99 ± 0.26	7.90 ± 0.2	6.30 ± 0.67	5.25 ± 0.63	3.60 ± 0.52
Overall acceptance	8.95 ± 0.26	7.95 ± 0.28	6.80 ± 0.26	5.10 ± 0.26	3.88 ± 0.38

Discussion

Similar catch per day observed for the clupeids throughout the year in the nearshore waters in the present study revealed their preference to the shallow water depth region. The nutrient rich zone of off Gulf of Khambhat having higher productivity encourages the production of the favorable food items for clupeids. Southern Saurashtra coast is close to the mouth of Gulf of Khambhat, a high productive zone, influenced by the large amount of nutrients brought in by many perennial and seasonal rivers and high tidal range (Azeez *et al*., 2016). The coastal shallow waters of this area are detritus rich zones that provide a preferred feeding habit for *Acetes* species (Deshmukh, 2002) leading to their higher level of abundance. Bapat and Bal (1952) provided detailed insight on the abundance and feeding habit of some young clupeids, and the results of the study revealed that this group remains abundant throughout the year and mostly feeds up on the copepods, prawn larvae, bivalve, cypris, gastropods, fish remains and other such planktonic food items in Bombay waters. The availability of these food items in nearshore waters up to 40 m depth enhance occurrence of clupeids in those areas off Gulf of Khambhat. Single day trawlers also target *Acetes* rich fishing grounds which simultaneously caught large quantities of clupeids.

The observed TMA value for *C. dussumieri* was 1.28 $\pm$ 0.14 at 0th day and 7.02 $\pm$ 0.18 on 15thday. The acceptable limit is usually considered as 5–10 mg of TMA-N per 100 g of muscle, but for some fatty fishes it is limited to 5 mg of TMA-N per 100 g of muscle. The quantitative level of TMA in fish is considered as a major index of the quality of marine fish (Zhang *et al*., 2003). Trimethyl amine oxide (TMAO), found in a large number of marine fish, is broken down to trimethyl amine (TMA) by either endogenous enzymes or by the bacterial enzyme trimethyl amine oxidase (Ashie *et al*., 1996; Debevere *et al*., 2001). The TMA values for sardines (*Sardina pilchardus*) was 2.5 $\pm$ 0.07 and 4.16 $\pm$ 0.21 for 1st day and 9th day respectively (Erkan and Ozden, 2008).

The physicochemical methods used for quality evaluation of fish and other seafoods are based on the determination of the total volatile basic nitrogen (TVB-N) and other volatile amines (Hassoun and Karoui, 2017). The TVB-N content of *C. dussumieri* increased continuously from 0th (19.13 $\pm$ 0.81) to 15thday (35.28 $\pm$ 0.37) mg N/100g without any sign of decreasing value which indicates the accumulation of the alkaline compounds in the muscle. Ozogul and Ozgul (2006) reported that the TVB-N value for the ice stored turbot was 12.1 mg/100 g flesh in the 1st day followed by decreasing value of 9.99 mg/100 g. by 8th day and then again started increasing up to 31.1 mg/100 g. at the end of 19th day. In the present study the value of TVB-N exceeding 30 mg/100 g is considered as spoiled fish, but 30-35 mg N/100 g of muscle considered as acceptability limit for the ice storage fishes (Connel, 1995; Huss, 1988). Fluctuation in TVB-N value is not a good indicator of quality test as reported by Ozogul and Ozogul (2006), whereas in the present study the continuous increase trend of TVBN indicates that it can be a good biochemical indicator for the quality assessment of the *Coilia* species. Similar finding was observed in sardine (Ababouch *et al*., 1996; Ozogul *et al*., 2004). The TVB-N values was 12.4 mg TVB-N/100 g for eel stored in ice when the eels were rejected by panelists after 15 days of storage (Ozogul *et al*., 2004), which is similar to the results of the present study. At the end of the storage period on 9th day, the TVB-N values reached 6.27 and 6.20 for whole ungutted and gutted sardines, respectively (Erkan and Ozden, 2008).

The pH value decreased from 0th day (6.78 $\pm$ 0.03) to 5th day (6.55 $\pm$ 0.05) and then followed with increasing value up to 7.24 $\pm$ 0.04 on 15th day. Similar findings were observed by Ozoguland Ozogul, (2006) where the pH value decreased on 8th and 12th day and then increased till last day of experiment at 19th day for iced stored turbot. Kyrana and Lougovois (2002) found similar pH values for European seabass over the period of iced storage. Marrakchi *et al.* (1990) found that the pH value of sardine (*Sardina pilchardus*) stored in ice was 5.8 on day 0 and 6.36 on day 9. Low pH value also indicates good quality of fish initially and the gradual increase in the pH reduces the meat quality.

Considering the midpoint of the scale i.e., 5 as the acceptability limit, the overall acceptance level for the species was up to 15th day of storage, but the quality deteriorated as time passed. The shelf life of whole un-gutted and gutted sardines stored in ice as determined by the sensory scores was 7 days (Erkan and Ozden, 2008). Chytiri *et al.* (2004) reported shelf life for un-gutted and filleted trout as 15–10 days and Taliadourou *et al.* (2003) reported shelf life for filleted and un-gutted seabassas 8–12 days based on the sensory evaluation. Microbiological standards as a critical parameter not only determines the acceptance, but also safeguard the public health safety associated with consumption of products. The ICMSF (1986) has established an aerobic mesophilic count limit of 7 log cfu/g by using the formula log CFU/ g$=$1.900$+$0.358xday ($R^2=0.927$) for fish that is fit for human consumption. As on the 15th day of storage the TPC count exceeded log 7 (i.e., log 7.48 cfu/g), so storage period in-between 10th to 14th day in ice from the 1st day may be considered as acceptable limit for safe human consumption. If the acceptability of TPC is less than 7, then the days up to which the fish should be stored in ice for safe consumption is maximum till 15thday, which confirms the result of sensory evaluation also (Fig. 8). Initial psychrophilic bacteria and mesophilic bacteria counts of un-gutted sardine *Sardina pilchardus* was 3.5–3.8 log cfu/g and 4–3.8 log cfu/g respectively for 1st day and 6 log

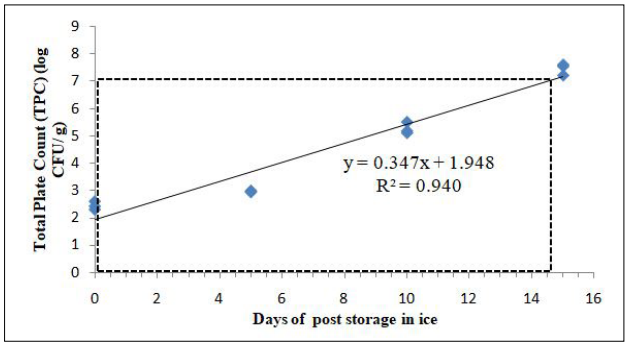

Fig. 8. Changes in TPC in *C. dussumieri* with the progressing days

cfu/g at 9th day (Erkan and Ozden, 2008). Whereas the present study revealed TPC value for *C. dussumieri* as 5.29 log cfu/g on the 10th day and it reached 7.48 log cfu/g in 15 days of post storage in ice which was above the permissible limit for human consumption.

Clupeids are one of the major groups landed and it also acts as prey for many higher trophic level species. The high demand of the species in local market and its availability throughout the year facilitate harvesting these small species. Appropriate use of sensory, biochemical and microbial methods are necessary as different species and fishery products spoil in different pattern. The current study advises to restrict the storage of *C. dussumieri* in ice up to 15 days for safe human consumption.

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