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Image analysis in the morphometry of the Indian mackerel, *Rastrelliger kanagurta* (Cuv.)

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Abstract

Morphometrics are important in fish taxonomy and fishery biology studies. Nine standard morphometric lengths, *viz;* total length, fork length, standard length, body depth, eye diameter, snout length, post orbital length, head length and caudal peduncle height of the Indian mackerel *Rastrelliger kanagurta* were measured by the conventional morphometric method and also using an image analysis technique. Algorithm for the same is described. The image analysis showed good validation with corresponding conventional measurements. Nearly 50 per cent of the measurements representing the nine morphometric lengths showed no difference and 31 to 34 per cent showed a difference of < 3 per cent. Another 11 to 19 per cent showed a difference < 5 per cent. The results proved that digital image processing and morphometric measurements using image analysis are dependable.

Keywords: Morphometry, image analysis, mackerel, digital imaging

Introduction

Among some of the standard methods applied for gathering reliable biological information, morphometric measurements play a significant role. Measurable characters such as total length, standard length, fork length, body depth, head length, pre-opercular length, eye diameter, pre-dorsal length, post-opercular length of fins, including the first dorsal, second dorsal, pre-anal, and the upper and lower lobes of the caudal fin are generally measured manually using fine draftsman dividers and a measuring board. Measurement of fish at the site of catch or landing centre/market place often poses serious hassles, whereas transporting them to the laboratories can be difficult and tedious. Digital imaging as an alternate method has facilitated a non destructive method of immediately capturing the image of the fish being studied and storing the images in the digital camera. The images can be later transferred to a computer and by applying appropriate application software, it can be subjected to morphometric measurements using image analysis. However, the accuracy of the digital image analysis method has to be tested *vis-à-vis* the conventional technique which was attempted in the present study using 288 numbers of mackerel samples.

When the objective of a study using computer vision is image analysis, the algorithm plays a vital role in achieving the type of analysis required and also in arriving at meaningful interpretations. Wagner and Walter (1983) while studying computer based species identification techniques, carried out measurement of the backline of a fish from the nose to the caudal peduncle using image processing as a criterion for distinction. Arnarson *et al.* (1991), emphasised the need for application of image analysis in morphometric length measurements. Dunbrack (2006) had conducted *in situ* measurements of fish body length using perspective based remote stereo video. Kiessling *et al.* (2006) used image analysis to measure whole fillet contraction while studying the effect of pre and post-mortem temperature on rigor. Morphometric measurements on preserved lampreys using image analysis techniques were successfully carried out by Neave *et al.* (2006). Morphometric parameters on the embryonic development of the blue king crab *Paralithodes platypus* were studied using image analysis by Stevens (2006). White *et al.* (2006) used moment invariant technique to differentiate morphological make up of fish by computer vision. Imai and Yamamoto (2007) reported application of image analysis in measuring fork length of fishes inside polystyrene containers at the landing centres. Misimi *et al*. (2008) reported a measurement technique to evaluate changes to the shape and size of pre and post-rigor salmon and cod fillets using computer vision.

Material and Methods

A 5 mega pixel digital camera was used for image acquisition. For uniformity of illumination, an image recording box made of fibre board 36.5cm x 27.5cm x 20.5cm dimensions covered with white matt finish paper on the inside was set up. Lighting with 10 lux brightness was provided and the camera positioned at the top. The images were transferred to computers. Custom made image analysis software was loaded into the computers for carrying out the required morphometric measurements.

Morphometric measurements were carried out on 288 numbers of the Indian mackerel, *Rastrelliger kanagurta* of varying sizes collected from the markets over a period of more than one year. Manual morphometric measurements were made using fine draftsman dividers and a graduated ruler (Venkataramanujam and Ramanathan, 1994) for measuring total length, fork length, standard length, body length, eye diameter, snout length, post orbital length, head length and caudal peduncle height. The same fishes were digitally imaged inside the image recording box, and the images were then transferred to the computer. Using the image analysis software, each one of the nine morphometric measurements were performed on the images on screen (Fig. 1). The algorithm followed was**:** *select image – filter – select measure – select length – calibrate – measure – open spread sheet – print.*

The data thus obtained were subjected to

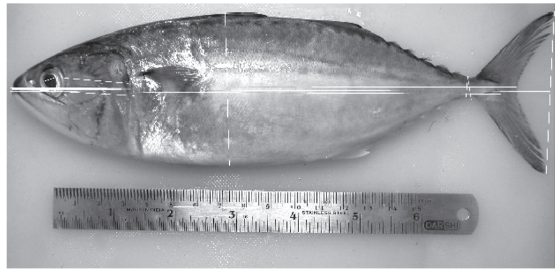

Fig. 1. Morphometric measurements of Indian mackerel using image analysis software

processing. The difference between each manual measurement and its corresponding image analysis measurement in the case of every morphometric length was computed and classified as class intervals from 0 to 9 per cent difference on both the positive and negative sides. The conventional method was taken as standard and hence the variation shown by the image analysis measurement was classed as zero/ positive/negative. One per cent difference on both the positive and negative sides was considered as zero difference and represented by a single class interval. The other class intervals were +1 to +3 per cent; +3 to +5 per cent; +5 to +7 per cent and +7 to +9 per cent respectively. Similarly 4 class intervals existed on the negative side too thus making up a total of 9 class intervals for each morphometric length. The frequency and percentage distributions were determined and tabulated in Tables 1 and 2, respectively.

Results and Discussion

For total length, 51 per cent showed no difference, 31 per cent showed a difference within 3 per cent and 14 per cent and 4 per cent showed a difference within 5 per cent and 7 per cent respectively. In the case of fork length measurement while 53 per cent showed no difference, 30 per cent of them showed less than 3 per cent difference. As for standard length measurement 47 per cent showed no difference while 33 per cent showed a difference of less than 3 per cent. Body depth measurements showed 38 per cent with no difference 35 per cent under 3 per cent and 19 per cent under 5 per cent difference. These readings were slightly skewed towards the positive side only 5 per cent of the image analysis measurements being lower in value

Table 1. Deviation in image analysis measurement from conventional morphometric measurement of nine morphometric characteristics of the Indian mackerel *Rastrelliger kanagurta*; the numbers represent number of fishes in each class interval

Deviation	A	B	C	D	E	F	G	H	I
+7 to +9 per cent	0	0	2	6	0	0	2	0	2
+5 to +7 per cent	9	4	2	18	8	16	10	6	8
+3 to +5 per cent	18	21	27	54	11	17	12	18	28
+1 to +3 per cent	46	39	49	88	69	63	68	68	60
-1 to +1 per cent	147	153	135	108	87	99	106	100	88
-1 to -3 per cent	42	48	45	14	80	45	66	71	51
-3 to -5 per cent	23	14	18	0	20	36	14	15	39
-5 to -7 per cent	3	9	10	0	9	12	8	10	6
-7 to -9 per cent	0	0	0	0	4	0	2	0	6

(A- Total length, B - Fork length, C - Standard length, D - Body depth, E - Snout length, F - Eye diameter, G - Post orbital length, H - Head length, I - Caudal peduncle height)

than manual measurements. Snout length showed that 30 per cent had no difference while 52 per cent showed less than 3 per cent difference.

Eye diameter measurements had 34 per cent with no difference and 38 per cent with below 3 per cent difference while 18 per cent showed a less than 5 per cent difference. Post orbital length showed 34 per cent with no difference and 47 per cent with less than 3 per cent difference. For head length measurements 35 per cent showed no difference and 48 per cent showed less than 3 per cent difference. The caudal peduncle measurements showed that there was no difference for 31 per cent of the readings and under 3 per cent difference for 39 per cent. A below 5 per cent difference was shown by 23 per cent, while 5 per cent of the readings displayed less than 7 per cent difference. Under 9 per cent difference was shown by a meagre 3 per cent (Table 2).

Since nine morphometric lengths were compared the differences would provide meaningful interpretations only if they are expressed in percentage (Table 2) rather than real scale values. A normal distribution curve was observed in all nine cases. Nearly 50 per cent of the data showed no difference, 30 per cent showed a difference of under 3 per cent. While about 80 per cent of the entire data showed less than 3 per cent variation, nearly 95 per cent of the entire data recorded had less than 5 per cent difference.

Thus comparisons between morphometric measurements by the conventional manual method and the same *via* the image analysis technique showed remarkable closeness between the values. The reliability in the application of a computer vision based technique in morphometrics is quite evident. The results obtained were very well in consonance

Table 2. Deviation in image analysis measurement of the Indian mackerel *Rastrelliger kanagurta*; the numbers represent percentage of fishes in each class interval

Deviation	A	B	C	D	E	F	G	H	I
0 %	51	53	47	38	30	34	34	35	31
< 3%	31	30	33	35	52	38	47	48	39
< 5%	14	12	16	19	11	18.5	9	11.5	23
< 7%	4	4.5	4	6	6	10	6	5.5	5
< 9%	0	0	0.7	2	1	0	1.4	0	3
Total	100	99.5	100.7	100	100	100.5	100.4	100	101

(A - Total length, B - Fork length, C - Standard length, D - Body depth, E - Snout length, F - Eye diameter, G - Post orbital length, H - Head length, I - Caudal peduncle height) with the results and inference reported by Arnarson (1991) in his studies on morphometric length measurements in cod fish for the purpose of sorting before feeding them to decapitating and /or filleting machines.

Arnarson *et al.* (1991) in their work on vision applications in the fishing and fish product industries had emphasized the importance of length measurements by the image analysis technique. Such measurements could serve as important input attributes for processing machines that went on to decapitate, eviscerate or fillet the fish. Product sorting involved dispatching products by shape, size, weight etc. and the measurement of dimensions for this purpose used image analysis as a technique. Nielsen *et al.* (1991) in an overview of vision opportunities in quality assurance had stated that image analysis based measurements had a future because of its accuracy. Zion *et al.* (1999) who did sorting of fish by computer vision had stated that high correlation was found between manual measurements and binary image measurements using image analysis. De Wet *et al.* (2005) worked on computer assisted image analysis as an alternative method to determine body weight and condition of fish with allometric growth. A relationship between body weight, length, depth, image pixel surface count and image pixel periphery count of the same species in a fixed weight range was studied and a goodness of fit regression equation computed by them. Replicate length measurements conducted by Dunbrack (2006) on free-swimming bluntnose six gill sharks *Hexanchus griseus* differed by an average of only 1.6 per cent. Neave *et al.* (2006) while studying the effects of preservation by formalin or alcohol on length variations of preserved specimen for biological studies applied image analysis based length measurements on the specimen samples for six standard morphometric length measurements and ten areas of pigmentation. These were measured and analysed by multiple measurements over time and the results subjected to regression analysis. The regression equations allowed correction of preservation effects on morphometrics.

The application of image analysis in morphometry has a future since digital imaging can be done very easily under any sort of field conditions. The process is non-destructive and the advantage of storing the images in the archives for the morphometric measurements to be carried out at a future date, place and time is of interest to all biologists. The scope for morphometric measurements prior to the fish being fed into processing machinery such as the beheader, eviscerator or filleter, and the possibilities of integrating digital cameras with processing machinery also show tremendous promise.

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