Epidermal Structures of the Bill and Lingua of the Eurasian Collared Dove (*Streptopelia decaocto*)

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ABSTRACT

Epidermal structures of the head, bill, lingua and buccal cavity of the Eurasian Collared Dove (S*treptopelia decaocto*) are studied to investigate the likely existence of an eco-morphological (i.e. form-function) pattern relating morphology of epidermal structures to food and feeding behaviour in ecological conditions (i.e. habit and habitat use). A total four specimens of adult birds are obtained for examination from natural mortalities in rural, urban and forest habitats of Central Saurashtra of Western India. All the morphological features of species are observed in living as well as in freshly preserved (40% formalin sol.) with the help of a pair of binoculars in field and in laboratory with the help of Stereo-zoom dissecting microscope and camera-Lucida are used for illustrations. Usually, the Eurasian Collared Dove chiefly feeds upon plant matters i.e. grain and seed in various microhabitats like vegetation layers, crop fields, grass lands, foliage, garbage and food offering places. Its epidermal structures of the jaws, lingua and buccal cavity are adapted to feed on such food items and assist in foraging and plucking, gapping, picking and pecking feeding technique of the bird species.

Key Words: Epidermal structures, feeding apparatus, Eurasian Collared Dove.

INTRODUCTION

The avian bill is frequently regarded as the primary food obtaining organ and the tongue is especially used in handling or conveying food particles into buccal cavity and esophagus (Richards and Bock, 1973). Epidermal papillae of the tongue, larynx and palate are important for thrusting food in buccal cavity and aid swallowing (Burton, 1974) for waders. In certain Indian passerine birds Malhotra (1968), Dubale and Malhotra (1969) has given an account of functional anatomy of the tongue and stated their role in the manipulation and transportation of food. The epidermal structures of tongue and their supporting elements in feeding operations like probing (Dubale, 1978); in columbid birds are reported by Bhattacharyya (1994). Gaping, picking and pecking habits are most common feeding technique in genus *Streptopelia* and their diverse feeding behaviours are in various microhabitats (Trivedi, 2012).

Eurasian Collared Dove *Streptopelia decaocto* (family Columbidae: order columbiformes) is a resident bird found in Gujarat and locally nomadic depending upon food supply. Their food includes chiefly the seeds and grains of cereals and other useful plants to human and his livestock. Very often feeds on seeds of mustard, linseed and lentil's grass and weed – seeds (Mason and Maxwell-Lefroy, 1912). Presence of grit in their gut reflects the remarkable and efficient grinding up of plant fragments and some hard seeds (Trivedi, 2012). In unusual circumstances like small insects as food has been reported by Rana (1991); however, yet no such reference as animal matter so far consider for food. Due to the diverse feeding habits, numerous structural modifications are found in the epidermal structures of bill and tongue. These structures have been studied by Lucas and Stettenheim (1972), Van Tyne and Berger (1976), Soni (1976, 1982), Mansuri and Dubale (1977), Dubale and Thomas (1978) and others. The present paper deals with detailed study of epidermal structures of the bill, tongue and buccal cavity including head region of Eurasian Collared Dove (*S. decaocto*) and their relationship with the feeding habits.

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MATERIAL AND METHODS

Study area and species

The study area is situated in the middle Saurashtra region of Western India, Rajkot (22˚19'N, 70˚47'E, 138m above MSL). Climate of Rajkot is tropical arid to marginal semi arid and strongly periodic and seasonal. To examine the epidermal structures of

bill and lingua, total four freshly died adult birds (02 male and female i.e. UM1, SM2, UF1 and UF2; here urban sample coded as 'U' and Sasan forest area as 'S') were chosen and soon after they were decapitated and preserved in 40% formalin solution. Epidermal structures were studied carefully with the help of stereo-zoom dissecting microscope and through photograph (by using DSC – W7, 2434351, digital still camera, Sony) and camera lucida were used for drawings. Angle of craniofacialis hinge is measured by goniometer. Nomenclature of various epidermal elements followed Baumel *et al.* (1979).

Morphological Measurements

Morphometrical data of bill and lingua including head region were obtained as per Fig. 3A and B using digital callipers, divider and thread in four specimens of the dove birds. Sex - wise studies of Eurasian Collared Dove obtained from four specimens; whether are there any differences in their morphometry? Testing wild and urban sampling of *S. decaocto;* only one male specimen of *S. decaocto* (SM2) obtained by natural death from Sasan forest considered in study to check such differences.

Foraging Observations

To study the food and feeding habits of the *S. decaocto* random focal samplings technique were used (Altmann, 1974) in the field using a pair of binoculars (10X50, Olympus) during time schedule 0700 to 0900hrs and 1600 to1800hrs in monsoon (July and August) and winter (November) 2008, 2009 and 2011. Use of several microhabitats during foraging, feeding patterns and other several behavioural activities were recorded.
Different parts of the gut were exposed and all food contents were recorded for a single specimen.

RESULTS

Morphology

Epidermal structures of head, bill, buccal cavity and lingua of Eurasian Collared Dove are as followed:

A. Epidermal structure of head:

The major divisions of the cranial head include regio forehead, crown, base of head, regio orbital, auricular, nasal, oral, rectal, malaris, submalaris, interramal etc. Regio forehead is relatively large begins from zona elastica craniofacialis (hinge line) end to the lid slit (in a plane with the narrowest point) middle of the regio frontal. An angulus craniofacialis is short establishes the bending zone by skeletal mechanism and zona elastica craniofacialis across the region of junction of the nasal and premaxillary bones. An angulus craniofacialis is less (angle is an average 22°, n=4) than 90 degrees formed at the junction of the cere with the slope of regio frontal and position is more cranial. Regio crown is relatively short appears triangle shape dorsally. Regio nuchal separate the regio crown to the base of head.

Regio orbital is situated more lateral and the peripheral margin of the globe is extensive extends cranially. In regio orbital the lids are movable parts and defined as the skin overlying the conjunctival cavity *viz.* palpebra dorsalis and palpebra ventralis (upper and lower lid). The palpebra dorsalis is folded under the stationary and mobile parts are short. Regio auricular has nearly oval external ear opening and situated below the region orbit. Regio nasal is plate like structure forms a complete covering flap over nasal aperture called operculum nasale and it opens into the choanal field internally. Regio oral made of ramphotheca. Regio rectal has mouth opening slit. It is a simple fold extends along the edge of the jaws. The rostral end of the rictus pars maxillaris *et* pars mandibularis exit just below the cere at same level of the lower jaw respectively. Regio malaris is soft tissues caudal to the bill and relatively large area. Regio interramal (Fig.1c, imr) is the triangular area between the two mandibular rami; and it is flaked white character of the deplumed skin behind the gonys. Regio submalaris is the caudal part of the interramal region forming the throat or floor of the pharynx, continuous with the mentum at rostral and caudal with the ventral neck region. It produced broad right angles longer neck (8 to 12mm) as found in the pigeon (Lucas and Stettenheim, 1972). Diameter of regio submalaris is short (23 to 25mm) in urban sampling than wild specimen (SM2- 31mm).

B. Epidermal structure of the bill and buccal cavity: (Fig. 1, 2)

Keratinized, hard and horny covering, nonfeathered integument of the bill is called ramphotheca. Upper bill is called rostrum maxillare (rhinotheca) and lower bill is called rostrum mandibulare (gnathotheca); their cutting edges are tomium maxillare and tomium mandibulare respectively. Rostrum maxillare is larger (0.5mm prominent) than rostrum mandibulare. A narrow gap exists between the two arms of the bill.

Rostrum maxillare and buccal roof: (Fig.1, 2A)

The rostrum maxillare is short (17 to 22mm) within a total of length of crown to bill tip (38 to 48mm); stout and curved cranially. Rhinotheca is horny like nails high, thick and black colour extends dorsally

up to the caudal margin of operculum naris and laterally till the articulation of Os quadratojugale. Tomium maxillare is sharp cranially and nail is found at the tip. Cranial tip remains free and cover the tip of tomium mandibular when mouth is closed and laterally edge to edge. Culmen is long (6.5 to 8mm) extends cranially up to the symphysialis and bifurcate caudally towards the cere. Cere is small (5.5 to 9mm) and feathered which forms the basal part of rostrum maxillare.

On the buccal surface ruga palatina mediana (Fig. 2A) is long (13 to 14mm) and ruga palatina intermedialis is small (3mm) and visible, bifurcates from caudal ruga palatina mediana. Both branches contain elevated ridge with fine papillae. Ruga palatina lateralis is well developed 23mm long, with distinct high ridge houses the tomium maxillare cranially, passes from cranial buccal region to choanal field, exit near the corner of choanal caudalis and no papillae over entire lateralis edge. A groove (3 to 6mm wide) is formed between the ruga palatina lateralis and tomium maxillare; which houses the tomium mandibulare in the closed bill.

A long median slit is found in the roof of the palate which communicates with the nasal chamber. Choanal slit is divided into two parts viz. choanal rostralis and choanal caudalis. Choanal rostralis is narrow, long (6.5 to 8mm) and its entire edge bears backwardly directed muscular spines. Rostral choanal surface is well marked and provided with papillae and numerous taste pits. Choanal caudalis is broad and long (8mm), no spine on entire margin and over choanal field. Immediately behind the choanal caudalis has a small slit, 6mm long called rima infundibuli, which communicates the auditory chamber. Taste pits are more concentrated near rima infundibuli and its caudal margin bears a single row of backwardly directed long comb like spines of papillae pharyngeales.

Rostrum mandibulare and buccal floor: (Fig.1 and 2B)

Rostrum mandibulare is little short (21mm) than maxillare part (22mm). Gnathotheca is hard and thick extends up to whole length of Os dentale. Gonys (prominent part of gnathotheca investing the whole line of union of the mandibular rami) is small (4.5 to 6mm) and gable shape. Mentum is smooth, wide and continuous caudally with the regio submalaris. Tomium mandibulare is round cranially and blunt near the junction of caudal corner of lingua and mons laryngealis. Floor of the buccal surface has many small size taste pits and deep middle notch lodges the 'V' shaped lingua and lateral notch lodges the lingua caudally where the epidermal lining thrown into a number of enfolding called frenulum linguae. A single row of large taste pits commence near the base of lingua.

C. Epidermal structure of Lingua: (Fig. 2B)

Lingua is long (9 to 11.5mm) extends up to the base of pars symphysialis, lanceolate, hard, concave and free end. Tip of the lingua is long and pointed. It is narrow cranially and 3.5mm broad caudally. Caudal corner of the lingua bordered by two long, thick backwardly directed lateral muscular smooth spines and small 9 to 12 central spines called papillae linguales. Caudal margin of the lingua is 'V' shape. Gap between lingua and glottis is wide, soft, elevated fleshy surface which provided with numerous various sizes an orderly arranged taste pits. Oval shape glottis is 6mm long and 3mm wide bordered by a pair of thick, high triangle shape lateral pads are mons laryngealis. This is provided with fine to large numerous taste pits. Caudal margin of mons laryngealis bears backwardly directed smooth lateral papillae. Caudal and lateral side of mons laryngealis comprise numbers of enfolding are called frenulum linguae; is large and caudal part is triangular shape. Ventral surface of lingua is covered by muscle M. Genioglossus.

Morphometrical data

Length and width of head region, bill and lingua and their epidermal elements are shown in Table 1; the short (17 to 22mm) rostrum maxillare within a total of length of crown to bill tip (38 to 48mm); almost one half long lingua (10.33mm) a total length of rictus commissure (20mm), little long rostrum maxillare (20.17mm) than rostrum mandibulare (19.50) related to the diet of the birds reflects more suited adaptive features to them (Fig.3A and B). As they feed on small size to moderate size grain and seeds; do not require long beak than head. Wild and urban samplings epidermal elements reveal that larger sizes in such features than urban samplings and same it follows for female than male samplings also.

Foraging Behaviour

Diversity of Food and feeding habits

Eurasian Collared Dove feeds mainly on plant matter as grains: paddy, wheat, millet, jowar (*Sorghum* sp.) and other cereals and pulses at several microhabitats. Licking of salty bordered earthen pot, the seeds of 'vevadi' (*Cocculus villosus*) plant fed by the bird (own observation), seeds of sesame in agro-ecosystem as food reported by Bhalodia *et al* (1997); unusual feeding habits like feeding on roasted gram and 'Ganthia" (a fried

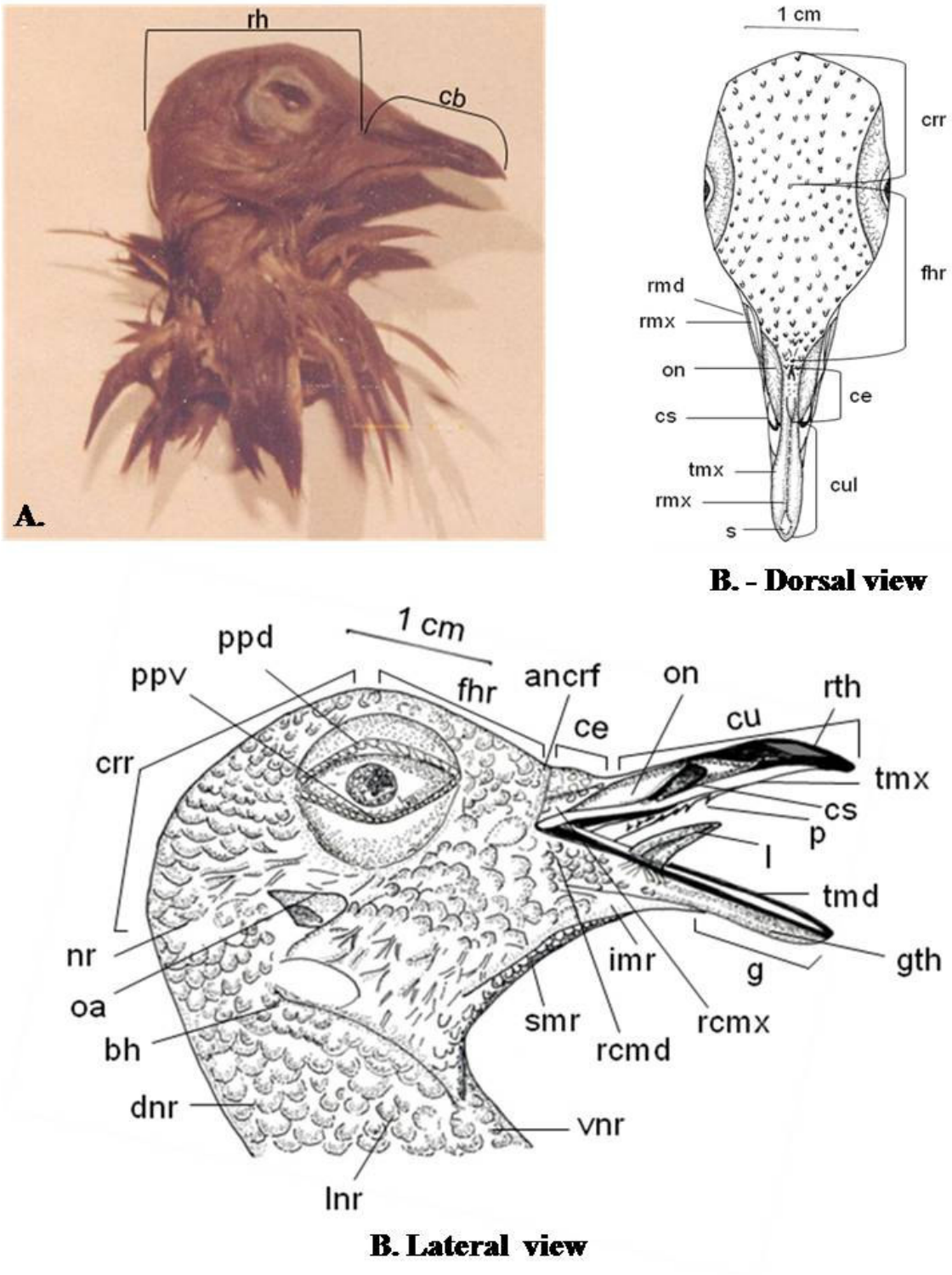

Fig. 1 Photograph of head region with feather (A), epidermal structure of semi deplumed head and rostral part with bill (B and C) of Eurasian Collared Dove (*S. decaocto*).

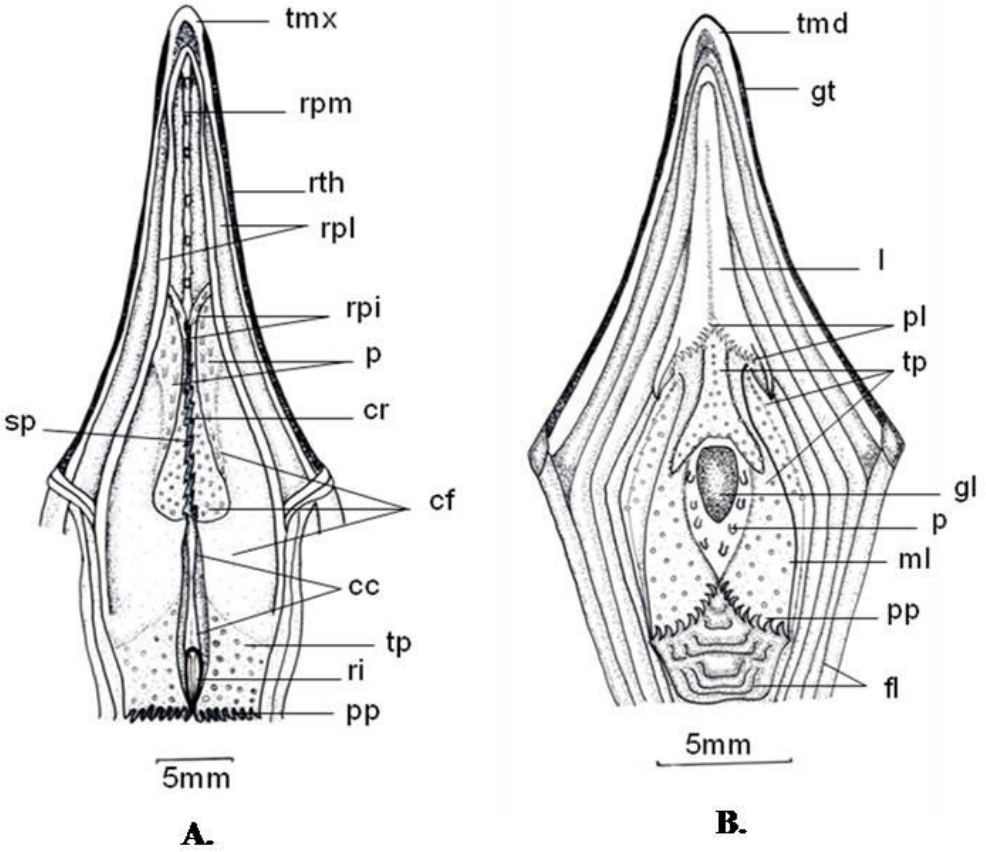

Fig. 2 Epidermal structures of buccal roof (A) and buccal floor (B) of Eurasian Collared Dove (*S. decaocto*).

Abbreviations: (Fig. 1 and 2)

ancrf	-angulus craniofacialis	bh	-base of head	cc	-choanal caudalis
ce	-cera (cere)	cf	-choanal field	cr	-choanal rostralis
crr	-crown region	cs	-choanal slit	cu	-culmen
dnr	-dorsal neck region	fl	-frenulum linguae	fhr	-region of forehead
g	-gonys	gl	-glottis	gth	-gnathotheca
imr	-intermalaris,	l	-lingua	lnr	-lateral neck region
ml	-mons laryngealis	nr	-nuchal region	oa	-operculum auris
on	-operculum nasale	p	-papillae	pl	-papillae linguales
pp	-papillae pharyngeales	ppd	-palpebra dorsalis	ppv	-palpebra ventralis
rcmd	-rictus pars mandibularis	remx	-rictus pars maxillaris		
ri	-rima infundibuli	rmd	-rostrum mandibulare		
rmx	-rostrum maxillare	rpi	-ruga palatina intermedialis		
rpl	-ruga palatina lateralis	rpm	-ruga palatina mediana		
rth	-rhinotheca	s	-symphysis		
smr	-submalaris region (gularis)	sp	-spine		
tmd	-tomium mandibulare	tmx	-tomium maxillare		
tp	-taste pits	vnr	-ventral neck region		

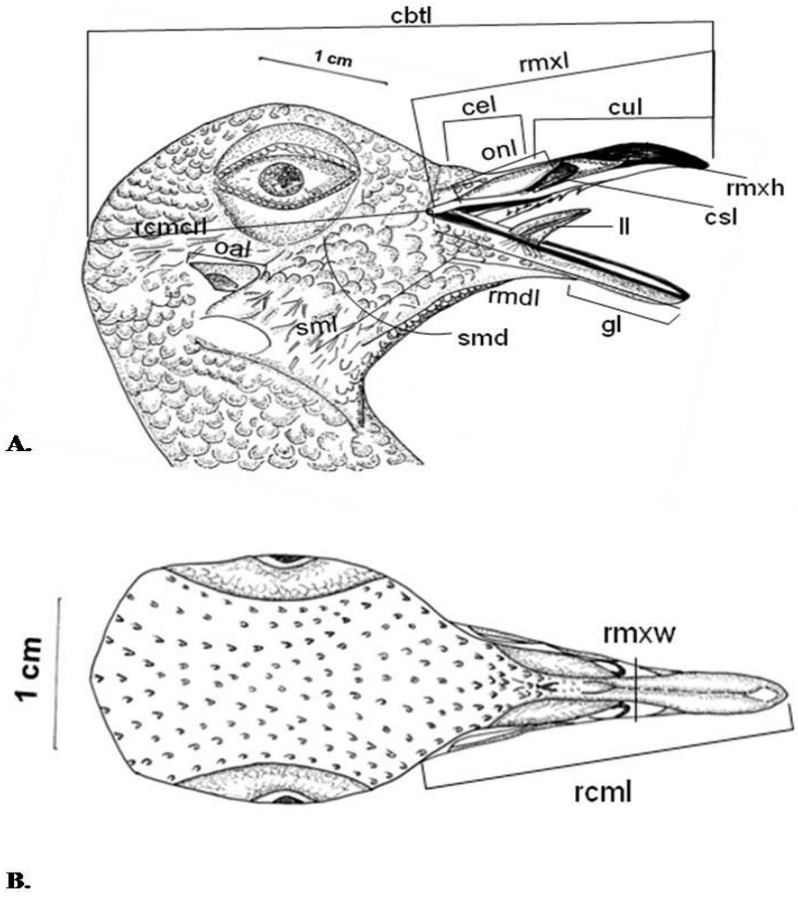

Fig. 3 Measurements of rostral part of head including bill of Eurasian Collared Dove: (A) Lateral view (B) Dorsal view.

Abbreviations:

cbtl	-length of crown to bill tip,	cel	-length of cera (cere)
csl	-length of choanal slit,	cul	-length of culmen
gl	-length of gonys,	ll	-length of lingua
oal	-length of operculum auris,	onl	-length of operculum nasale
rcmcrl	-length of rictus commissure to crown,	rcml	-length of rictus commissure
rmdl	-length of rostrum mandibulare,	rmxh	-height of rostrum maxillare
rmxl	-length of rostrum maxillare,	rmxw	-width of rostrum maxillare
smd	-diameter of submalaris (gularis),	sml	-length of submalaris (gularis).

Table 1. Measurement (mm) of the rostral head including bill of Eurasian Collared Dove.

Name of epidermal elements	Male (mm)		Female (mm)	
	Sample	**Sample**	**Sample**	**Sample**
	UM1	SM2	UF1	UF2
Rostral head				
Length of rictus commissure to crown	21	38	28	26.5
Length of operculum auris	5	6	6	4.5
Length of submalaris	9	12	8	11
Diameter of submalaris	24	31	23	25
Length of crown to bill tip	38	48	48	47
Bill and Lingua				
Length of rostrum maxillare	17	21	22	21.5
Width of rostrum maxillare	2	4	3	3
Height of rostrum maxillare	1.5	2	2	2
Length of rostrum mandibulare	16.5	20	21	21
Length of gonys	4.5	6.5	5.5	6
Length of rictus commissure	17	21.5	22	21
Length of cera (cere)	8	5.5	9	9
Length of culmen	6.5	11	8	8
Length of operculum nasale	6.5	9	8	7
Length of choanal slit	4	5.5	5	5
Length of lingua	9	11.5	10.5	11.5
Width of lingua	3.5	4	4	4

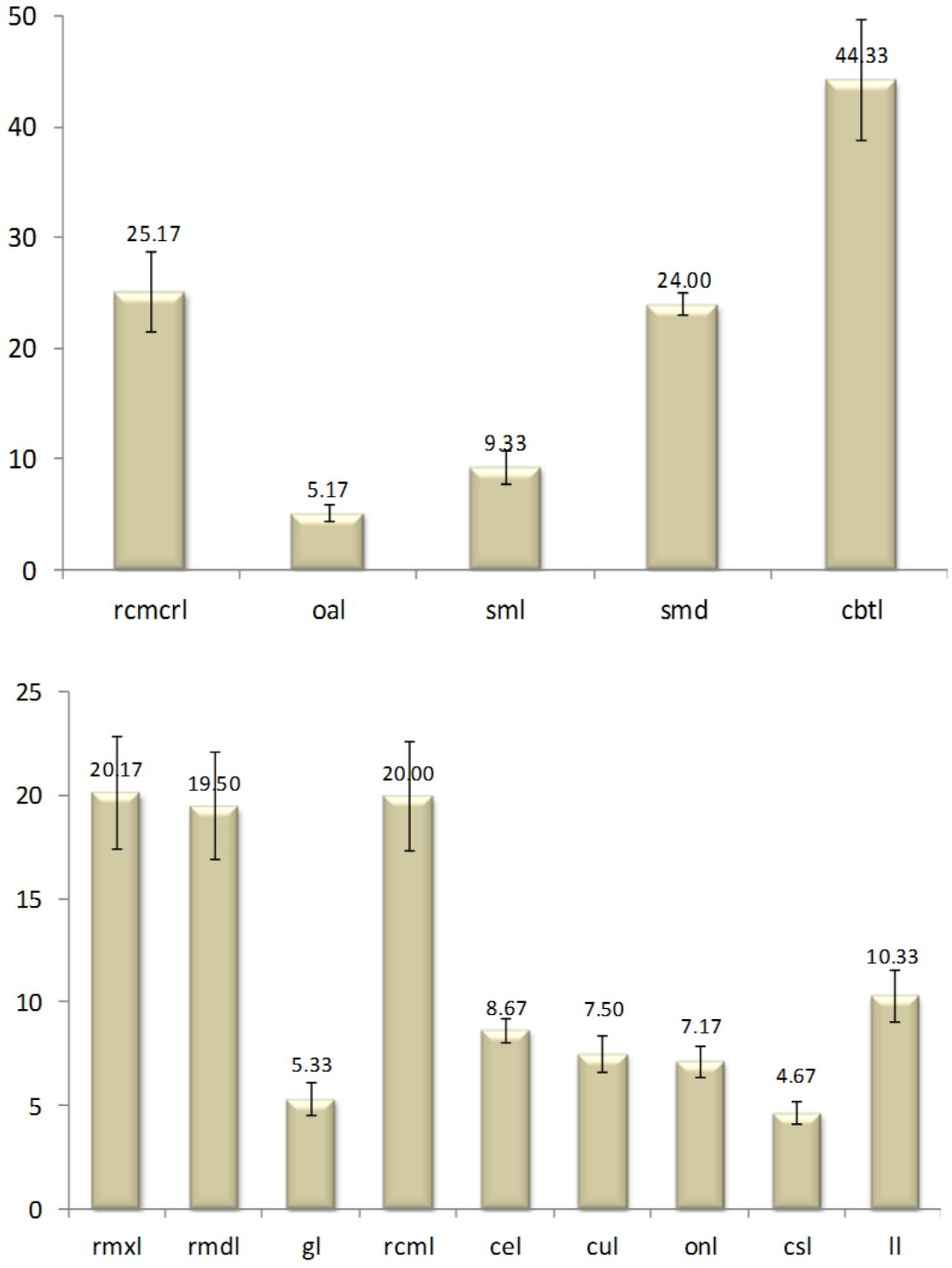

Fig. 4 Measurement and standard deviation of epidermal elements of rostral head (A) bill and lingua (B) of Eurasian Collared Dove (Abbreviations as per Fig 3A and B).

item of gram-flour) are reported by Hathi *et al.* (2004). It is reported that the ring dove changes its food-habit quite frequently, depending on the availability of food; in monsoon and the birds also feed on insects (Rana, 1991).

The gut content examination of single male Eurasian Collared Dove records various grass seed and grains such as grass seed of *Seteria glauca*, *Seteria tomentosa*, a seed of *Tragus rouxburghii*, seed of mustard, unidentified seed and grit. During field observation it was noted that diverse use of microhabitat like vegetation layers as large and small trees, shrub layers, crop fields i.e. cultivated as well as harvested lands, grass lands areas mainly herbs, small (less than 127mm) and high (more than 127mm), foliage, garbage and dumping patch near human habitats, wetlands and surroundings of water reservoirs, hard surface land like floor, open waste land i.e. outskirts areas of rural, urban, sub-urban places etc, food offering places in human habitats includes specific design chabutaro, open public places at temple, near garden and other open ground places, house-hold places where variable sizes and shape of feeding plates provide for feeding chiefly, round and square containers made of plastic and earthen pots, rough surface i.e. made of pebbles, small rocks, bricks, steps at ground surfaces etc. at study areas of rural, urban, sub-urban and forest areas of middle Saurashtra regions.

Biological role of epidermal feeding apparatus supports several behavioural activities such as food seeking, drinking, plucking seed of plant, preening, using beak in courtship preening, picking, probing (usually high in monsoon), nesting, territory fighting etc. in Eurasian Collared Dove (8,400secs/n=54).

DISCUSSION

Morphology and Foraging Behaviour

The bill, lingua and their epidermal structures form the main complexes of the feeding apparatus and together play a major biological role in the capture and ingestion of food. These structures are correlated with the feeding habits.

Eurasian Collared Dove is primarily feeding on grains and seeds pecked from the ground; do not require any massive or elongated bill for pecking and grasping their food grain. However quite often invade other food niches for which their bill and tongue epidermal structures have been suitably modified.

Major divisions of the cranial head epidermal structures and their location viz regio forehead, regio crown, regio orbit, regio submalaris etc; which supporting in diverse food and feeding habits in such semiarid tropical area of Western India during field observations. Stout and thick bill is useful in scratching the soil and handling the hard coats of the seeds. Rostrum maxillare is short in relation to length of crown to bill tip and slightly pointed; but stout and pointed rostrum maxillare helps the birds in picking and holding the food grains and prevents the food from slipping. Their gable shaped roof and concave surface of the lingua provide storage space for the transport of food towards the esophagus. Thick and moderate toughness of the rostrum is an adaptation to tolerate the force while scratching the soil and probing. The smooth and keratinized culmen of rostrum maxillare also ensure the effectiveness of scratching and probing. Cranially sharp tomium maxillare manipulate the seed and provision of the ruga palatina lateralis on the roof of buccal cavity house the tomium mandibulare; such an arrangement provides a grip for the closure of the bill and also it does not allow the stored seed grains to escape out. The sharp tomium are also helpful in scraping the viscous food from the ground (Soni, 1982). An angulus craniofacialis is less (average 22°) than 90 degrees provide prokinetic condition to the upper jaw (Bock, 1964; Zusi, 1967). Cere is well developed in *Streptopelia decaocto*; which is not found in family anatidae (Ashalatadevi, 2005), family threskiornithidae and gruidae (Shukla, 1999) and phasianidae (Soni, 1976). The columbiformes as one of the order in which cere is present, also in parrots, in birds of prey and in plovers has been described by Lucas and Stettenheim, 1972.

Ruga palatina mediana *et* intermedialis *et* lateralis ridge occur in grainivorous passerines, and in most seed-eating passerines. A groove occurs between the lateral palatines and tomium of the beak stated by Ziswiller (1965). Eurasian Collared Doves are mainly grainy and seed eaters and this greater development of epidermal structures support in their food habits.

The dorsally concave, ventrally convex, cranially pointed and slimy lingua helps the beak in picking up the food and must be playing a major role in drinking water. The lingua rotates the food matter in the buccal cavity with the help of its lateral surface and a pair of long caudo-lateral and many small sizes backwardly directed middle papillae linguales. These channelize the food towards the esophagus and an adaptation of lingua for swallowing support with Gardener (1926). The papillae of the choanal field and papillae pharyngeal also help in transportation of food towards esophagus during linear movements of the lingua. The palatal folds and the spiny outgrowths of the epidermis help in holding the food as well as transporting it towards the gullets (Dubale and Thomas, 1978). The passing food does not enter the choanal slit as it is narrow cranially and further having well developed muscular smooth lining of spines; which prevents the food from entering the choanal slit (Malhotra, 1968).

Length and width of head region, bill and lingua which reflects that the wild specimen (i.e. Sasan forest taxon) is larger in size compare to urban areas and field observation also follow the same. Various epidermal elements show that these elements are fairly larger in female compare to male.

The short (17 to 22mm) rostrum maxillare within a total of length of crown to bill tip (38 to 48mm); almost one half long lingua (10.33mm) within a total length of rictus commissure (20mm), little long rostrum maxillare (20.17mm) than rostrum mandibulare (19.50mm) related to the diet of the birds reflects more suited adaptive features to them (Fig.4A and B). As they feed on small size to moderate size grain and seeds; do not require long beak than head.

Food and feeding habits while foraging

The various fragments of plant matter, grass seeds, grains of medicinal plants and grit of gut contents reveal diverse feeding habits of Eurasian Collared Dove. Grit provides the efficiency of the gizzard in grinding up food. Van Tyane Berger (1976) stated that many seed-eating and herbivorous birds eat grit may provide important source of calcium and phosphorus also. Occasionally they feed on animal matter like insects (Rana, 1991).

Gaping, picking and pecking habits are main characteristic and most commonly used feeding behaviour while feeding and diverse use of microhabitat (Trivedi, 2012).

Biological role of feeding apparatus supports several behavioural activities and feeding habits as per use of different microhabitats shown most suitability with their epidermal morphology.

SUMMARY AND CONCLUSIONS

- A stout and thick bill, slightly pointed but stout rostrum maxillare *et* mandibulare, sharp tomium, smooth culmen, well developed cere, gable shaped roof and concave surface of the lingua.
- The ruga palatina lateralis on the roof of buccal cavity houses the tomium mandibulare. Well developed ridge of ruga palatina mediana *et* intermedialis *et* lateralis provide tight grip of buccal cavity and storage of food grains.
- Dorsally concave, ventrally convex, cranially pointed and slimy lingua helps in picking up the food, transportation and major support in drinking.
- Backwardly directed papillae linguales, papillae of the choanal field, papillae pharyngeal and palatal folds is an adaptation for swallowing, storage and transportation of food towards esophagus.
- Gaping, picking and pecking feeding habits are the main characteristic while feeding and diverse use of microhabitat. Biological role of epidermal feeding apparatus supports several behavioural activities such as food seeking, drinking, preening, picking, probing, nesting, territory fighting etc. More picking and preening habits of Eurasian Collared Dove (8,400secs/n=54) shown most suitability with their epidermal morphology.

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