Indian J Physiol Pharmacol 1998; 42 (2) : 231–238

PANCREATIC JUICE AND DUODENAL FLUID FLOW RATE IN COW CALVES FROM BIRTH TO EARLY RUMINANT STATE

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(Received on July 3, 1997)

Abstract : The present investigation on pancreatic juice (PJ) and duodenal fluid (DF) was carried out in 10 crossbred (Jersey × Kankrej) male cow calves from birth to early ruminant state (15 week). The respective samples were measured *in situ* by cannulating the pancreatic duct and duodenal lumen, 30 minutes before feeding (BF) and 30 minutes after feeding (AF) both during morning (MH) and evening (EH). The results revealed significant increase in PJ and DF flow rate with age. Diurnal effect was nonsignificant except a significant increase recorded during EH on 4 d for PJ and 3 d for DF.

Key words : pancereatic juice duodenal fluid flow rate cow calves age and diurnal variations

INTRODUCTION

Digestive system in the offsprings of ruminants undergoes to vital functional changes. While in the early age after birth rumen is non–functional but with advancement in age the rumen becomes functional. The rate of passage of the digesta in the intestinal tract is one of the factors which can control the degree of digestion of ruminants and is generally inversely proportional due to less time available for enzymes to act on the substrates. The conditions like diarrhoea is associated with increase in intestinal motility and loss of nutrients (1). The pancreatic and duodenum secretions contribute a large number of digestive enzymes and proenzymes to carryout hydrolysis of dietary substrate in the intestinal lumen (2). But only few attempts have been made to study its role in digestion, subsequent metabolism, its adaptive changes in exocrine secretion and composition in relation to nutritional changes in cow calves (3), sheep (4) pig(s) and buffalo calves (6, 7). The information on the effects of age and diurnal variations is meager. Keeping this in view, the present investigation has been carried out to PJ and DF flow rate in relation to age and diurnal variations from birth to early ruminant stage (15 wk) of cow calves.

METHODS

The present study, on the flow rate of PJ and DF was carried out on 10 cross bred

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male cow calves after pancreatic duct and duodenal lumen cannulation as per the method described below.

1 *Prparation of cannula* : The pancreatic duct cannula was prepared from sufficiently hard polythylene tubing having 2 mm internal diameter and having one corrugated end for fixing it in the duct. The duodenal cannula was prepared from soft polyethylene tubing having 5 mm internal diameter with an adapter fixed at one end for fixing it in the duodenal lumen.

2. *Pe –and operative procedures* : The calves were prepared for aseptic surgery under deep narcosis achieved by infusing chloral hydrous 7% solution intraveously @ 130 mg/kg b. wt. (8). Regional `T' block anaesthesia was given by infiltrating lignocain hydrochloride @ 1 ml/cm^2 at right paralumber fossa (9).

After scrubbing and draping of the operative site, 12–15 cm long incision was made through the skin, one inch posterior to the rib starting approximately 5 cm from the transverse process of the vertebra extending ventrally. Following effective haemostasis, the muscles, fascia and the peritoneum were incised. The laparotomy incision was kept wide open using self retaining Balfour retractor. The pancreatic duct felt like a small cord, when stretched over a finger, appeared as a white fibrous band. After isolating the duodenal loop along with distal end of pancreas and pancreatic duct, a longitudinal incision was made over the duct 1 cm above its insersion into the duodenal wall. The corrugated end of the pancreatic duct cannula was then inserted nearly 2 cm deep into the duct towards the pancreas. The cannula was fixed by applying an encircling stay suture over the corrugation of the cannula. The second stay suture was tied just behind the corrugation.

The duodenum was cannulated by making a small stab incision on antimesentric border just anterior to the opening of the pancreatic duct. The duodenal cannula was inserted and fixed in the lumen by previously placed pursestring sutures including serosa and musculosa of the intestine to prevent leakage.

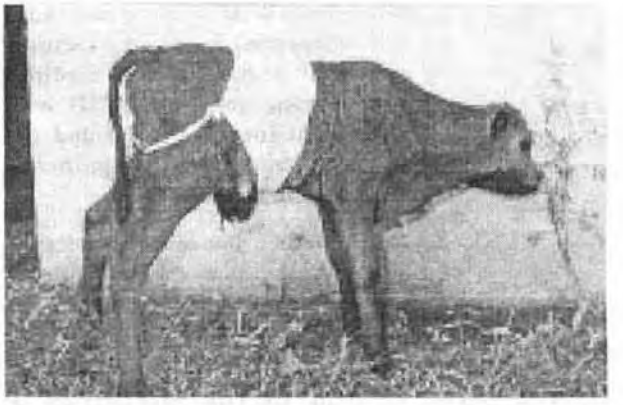

Fig. 1 : Pancreatic juice and duodenal fluid collection from a cow calf.

Polypropylene graduated conical tube (15 ml) were attached to the lids for the respective sample collection (Fig. 1). The flow rate of PJ was measured for 30 minutes and that of DF was measured for 5 minutes. The collection was made both during MH and EH period as well as both at 30 minutes BF and AF the calves.

3. *Post operative calf management* : Daily postoperative aseptic dressing of surgical wound and antibiotics coverage (oxyteracyclin injection 4 mg/kg b.wt; i.m.)

was carried out for four days. Skin sutures were removed on sixth postoperative day.

4. *Experimental design* : The calves were maintained in well ventilated, clean individual calf pan. Feeding schedule employed per calf per feeding during different developmental stages of experimental period is given in Table I.

Feed was offered at 08.00 and 16.00 hr, respectively. Water was supplied *ad libitum*. The health of the calves was monitored through recording the rectal temperature and body weights over and above the examination of faecal samples for the presence of any parasitic infestation. The proximate components and gross energy values of MRP were measured and are given in Table II.

5. *Statistical analysis*: The data were analysed for age effect using ANOVA and the diurnal variations were tested using paired `t' test, respectively as per the standard statistical methods (10).

RESULTS AND DISCUSSION

The surgical procedure used was most successful for cannulation of pancreatic duct and duodenal lumen except for a few complications like removal of cannulas, leakage and adhesion which prevented cannulation of duct and lumen. These were rectified according to the problem. Of the

TABLE I : Feeding schedule per calf per feeding.

Develop-mental stages	*Age*	*Colostrum (L)*	*MRP* (g/2L)*	*Mineral mixture (g)*	*Concentrate (g)*	*Hay (g)*	*Green fooder (kg)*	*Dry fooder (kg)*
A	0–1 d	1.5	–	–	–	–	–	–
	2–6 d	–	300	5.0	–	–	–	–
B	2–4 wk	–	350	5.0	25	100	–	–
	5–8 wk	–	400	5.0	25	200	–	–
C	9–10 wk	–	300	5.0	50	300	1.0	0.5
	11–15 wk	–	200	5.0	100	–	2.0	1.0

* MRP Milk Replacer Powder
A : Preweaning B : Weaning and C : Early ruminant stage

TABLE II : Proximate components and gross energy values of MRP.

Sr. No.	*Component of proxtmate analysis*	*Percent value*	*Sr. No.*	*Component of proximate analysis*	*Percent value*
1.	Crude protein	26.93	5.	Solica	0.27
2.	Crude fiber	0.27	6.	Phosphorous	0.86
3.	Crude fat	24.35	7.	Calcium	1.62
4.	Ash	5.88	8.	NFE	42.57
			9.	Gross energy (Calories/g MRP)	5034.60

TABLE III : Average (Mean ± S.E) flow rate (ml/30 min) of pancreatic juice in cow calves during early neonatal life.

Age	Before feeding			After feeding		
(d)	MH	EH	Mean	MH	EH	Mean
0	—	$2.10^{a} \pm 0.15$ (7)	2.10 ± 0.15 (7)	$2.00^{a} \pm 0.29$ (7)	$2.36^{a} \pm 0.18$ (8)	2.41 ± 0.19 (12)
1	$2.12^{a} \pm 0.26$ (8)	$2.05^{a} \pm 0.18$ (8)	2.09 ± 0.15 (16)	$2.66^{ab} \pm 0.28$ (8)	$2.95^{a} \pm 0.36$ (8)	2.80 ± 0.22(16)
2	$2.70^{ab} \pm 0.31$(8)	$2.69^{ab} \pm 0.21$(8)	2.69 ± 0.19 (16)	$3.46^{bc} \pm 0.46$ (8)	$3.81^{ab} \pm 0.38$ (8)	3.63 ± 0.29 (16)
3	$3.50^{bc} \pm 0.39$ (8)	$3.81^{bc} \pm 0.29$ (8)	3.66 ± 0.24 (16)	$4.62^{cd} \pm 0.43$ (8)	$5.57^{bc} \pm 0.77$ (8)	5.19 ± 0.44 (16)
4	$3.79^{c} \pm 0.28$ (8)	$4.15^{cd} \pm 0.45$ (8)	4.20 ± 0.29 (16)	$5.24^{d} \pm 0.62$ (8)	$6.06^{c} \pm 0.62$(8)	5.65±0.44 (16)
5	$3.86^{c} \pm 0.32$ (8)	$4.25^{cd} \pm 0.45$(8)	4.05 ± 0.27 (16)	$5.21^{d} \pm 0.63$ (8)	$5.82^{c} \pm 0.48$ (8)	5.51 ± 0.39 (16)
6	$4.37^{c} \pm 0.67$ (8)	$4.17^{cd} \pm 0.36$ (8)	4.27 ± 0.25 (16)	$5.57^{d} \pm 0.48$ (8)	$6.41^{cd} \pm 0.81$ (8)	5.99 ± 0.47 (16)
7	$3.60^{bc} \pm 0.30$ (8)	$3.68^{bc} \pm 0.53$(8)	3.64 ± 0.30 (16)	$5.32^{d} \pm 0.62$ (8)	$6.45^{cd} \pm 0.86$ (8)	5.89 ± 0.53(16)
8	$4.00^{c} \pm 0.50$ (8)	$4.45^{cd} \pm 0.52$ (8)	4.22 ± 0.35 (16)	$5.46^{d} \pm 0.83$ (8)	$6.45^{cd} \pm 0.79$ (8)	5.96 ± 0.59(16)
9	$4.46^{c} \pm 0.48$ (7)	$5.16^{d} \pm 0.57$(7)	4.80 ± 0.37 (14)	$6.97^{e} \pm 0.48$ (7)	$8.10^{d} \pm 0.81$ (7)	7.35 ± 0.49 (14)
$\overline{X}$ ±SE	3.59 ± 0.36 (71)	3.65 ± 0.56 (78)	3.63 ± 0.20 (149)	4.76 ± 0.58 (75)	5.36 ± 0.64 (79)	5.02±0.37 (154)
F value	4.29**	5.99**		6.54**	7.60**	

Mean with different superscripts differ significantly
Figures in parentheses indicate number of animals
MH : Morning hours EH : Evening hours **Significant at 1%

experimental calves 8 calves developed complications like peritonitis at 10 d, 2 wk, 9 wk and 15 wk (2 calves in each category) and cattarhal haemorrahage in one calf at 2 wk of age.

Physical examination of the PJ revealed it to be colourless, transparent and watery fluid throughout the period of study. While, DF revealed it to be yellowish from birth upto 6 wk of age which changed to greenish afterwards upto 15 wk of age.

Pancreatic juice

Age effect : During early neonatal period, the flow rate remained low for first 2 d and then increased progressively upto 9 d (Table III). Lower production of pancreatic secretion predisposes a calve to enteric infection (11). In our present study such enteric infection has not been recorded upto 9 d.

Weekly comparison of the data revealed highest flow rate between 12 to 15 wk over their respective birth values (Table IV). The results indicated that the flow rate changed significantly with age irrespective of feeding schedules and times of day. Present findings corroborated with the similar findings in other breeds of dairy cattle calves (11, 12, 13). The concurrent studies on both cow calves and buffalo calves relvealed that the

TABLE IV : Average (Mean±S.E.) flow rate (ml/30 min) of pancreatic juice in cow calves during first fifteen weeks of life.

Age	*Before feeding*			*After feeding*		
(wk)	*MH*	*EH*	*Mean*	*MH*	*EH*	*Mean*
0	—	2.10^{a}±0.15 (7)	2.10±0.15 (7)	2.00^{a}±0.29 (4)	2.36^{a}±0.18 (8)	2.41±0.19 (12)
1	4.37^{a} ± 0.37 (8)	4.17^{ab}±0.36 (8)	4.27±0. 25(16)	5.57^{b}±0.48 (8)	6.41^{b}±0.81 (8)	5.99±0.47 (16)
2	5.60^{ab} ± 0.29 (5)	5.80^{bc}±0.53 (5)	5.34±0.30 (10)	7.72^{bc}±0.39 (5)	7.94^{bcd}±1.03 (5)	7.83±0.48 (10)
3	8.42^{cd} ± 0.48 (5)	5.90^{bcd}±0.30 (5)	7.16±0.50 (10)	8.36^{cd}±0.65 (5)	9.08^{cdc}±0.31 (5)	8.12±0.36 (10)
4	7.68^{bc} ± 0.89 (5)	7.56^{cde}±0.47 (5)	7.60±0.50 (10)	8.56^{cd}±0.73 (5)	7.52^{bc}±1.01 (5)	8.06±0.62 (10)
5	8.55^{cde} ± 0.92 (6)	6.83^{bcd}±0.51 (6)	7.70±0.56 (12)	7.93^{c}±0.57 (6)	8.95^{cde}±0.97 (6)	8.41±0.56 (12)
6	9.23^{cdef} ± 0.76 (6)	7.60^{cde}±0.90 (6)	8.42±0.61 (12)	8.85^{cdef}±0.36 (6)	10.13^{def}±1.18 (6)	9.49±0.62 (12)
7	8.58^{cde} ± 0.98 (6)	8.93^{def}±1.01 (6)	8.75±0.67 (12)	8.63^{cde}±0.93 (6)	9.57^{cde}±0.62 (6)	9.10±0.55 (12)
8	9.05^{cdef} ± 1.48 (4)	10.05^{efg}±0.87 (4)	9.55±0.82 (8)	10.87^{efgh}±0.38 (4)	9.97^{def}±0.80 (4)	10.42±0.44 (8)
9	10.97^{defg} ± 1.05 (4)	9.97^{efg}±0.37 (4)	10.47±0.55 (8)	10.97^{fgh}±1.29 (5)	10.60^{ef}±1.20 (4)	10.78±0.82 (8)
10	8.95^{cdef} ± 0.62 (4)	8.42^{de}±0.95 (4)	8.69±0.53 (8)	10.32^{defgh}±0.78 (4)	10.32^{def}±0.66 (4)	10.32±0.47 (8)
11	11.50^{fg} ± 1.48 (4)	11.60^{fgh}±0.73 (4)	11.55±0.76 (8)	9.85^{cdefg}±0.80 (4)	12.15^{fg}±1.27 (4)	11.00±0.82 (8)
12	12.87^{g} ± 1.05 (4)	12.15^{gh}±1.87 (4)	12.51±1.100 (8)	12.55^{h}±0.94 (4)	12.35^{fg}±1.13 (4)	12.45±0.68 (8)
13	11.26^{efg} ± 1.12 (4)	12.20^{gh}±1.33 (4)	11.73±0.82 (8)	11.30^{h}±1.01 (4)	13.65^{g}±0.63 (4)	12.47±0.71 (8)
14	12.84^{g} ± 1.55 (4)	13.20^{h}± 0.64 (4)	13.02±0.77 (8)	10.95^{fgh}±1.49 (4)	14.17^{g}±0.48 (4)	12.56±0.94 (8)
15	12.67^{g} ± 1.48 (4)	12.00^{gh}±0.69 (4)	12.33±0.77 (8)	12.55^{h}±0.98 (4)	13.62^{g}±0.46 (4)	13.08±0.54 (8)
$\overline{X}$ ±SE	9.07 ± 0.90 (73)	7.99±1.52 (80)	9.07±0.52 (153)	8.90±0.79 (77)	9.29±0.86 (81)	9.55±0.50 (158)
F value	7.76**	11.18**		8.06**	15.09**	

Means with different superscripts differ significantly
Figures in parentheses indicate number of animals
MH: Morning hours; EH: Evening hours; **Significant at 1%

flow rate of PJ was lower in cow calves as compared to buffalo calves maintained under identical conditions (6).

The present findings of age effect on flow rate could be attributed to the increase in number of receptors for the hormones like CCK and secretin which occurs with age or to an increase on `sensitivization' of the receptors by the parasympathetic nervous system as postulated by others (3). Further, pancreatic adaptation has been found to occur through changes in the synthetic rates of mRNA level (14).

The flow rate for 1 wk was comparable with Holstein bull calves (15). However, their values reported only at 14 d and 21 d were lower as compared to the recorded values at the comparative age in the present study.

Diurnal effects : Although PJ flow rate remained uniform both during MH and EH,

overall flow rate was higher to the extent of 4.87% (0.33 ml) in cow calves (EH: 7.11 ± 0.21; MH : 6.78 ± 0.21). However, some slight diurnal variations in sheep have been reported to occur with the rate being greater at night than that during after meal (16). The concurrent studies on buffalo calves also revealed uniform secretion of PJ when compared for MH and EH under the identical situations (6) (MH : 8.30 ± 0.22; EH: 9.25 ± 0.27).

Duodenal fluid

Age effect : The secretory rate of DF throughout the study period revealed changes and increased with age during ealry stages. The rate remained low during first 2 d (Table V). Weekly comparison revealed significant highest flow rate between 13-15 wk (Table VI).

The flow rate was found increased earlier AF schedule as compared to BF during early neonatal period. The observed higher flow rate with age could be due to net secretory contribution to the total abomasal digesta from salivary, gastric and bile sources as well as the propulsive movement of preduodenal gastrointestinal tract. Contrary to the present findings, non significant age effect was observed in duodenal digesta flow rate in Friesian bull calves consisting of a group of 30–60 d and 80–120 d (17).

TABLE V : Average (Meant±S.E.) flow rate (ml/5 min) of duodenal digesta in cow calves during early neonatal life.

Age	*Before feeding*			*After feeding*		
(d)	*MH*	*EH*	*MEAN*	*MH*	*EH*	*Mean*
0	—	3.80^{a} ± 0.74 (7)	3.82 ± 0.74 (7)	5.80^{a} ± 0.80 (4)	8.23^{a} ± 1.19 (8)	8.27 ± 1.37 (12)
1	4.96^{a} ± 0.39 (8)	6.15^{ab} ± 0.70 (8)	5.56 ± 42 (16)	10.00^{b} ± 0.73 (8)	10.33^{ab} ± 1.13 (8)	10.17 ± 0.65 (16)
2	7.09^{b} ± 0.55 (8)	8.04^{bc} ± 0.96 (8)	7.56 ± 0.55 (16)	11.84^{bc} ± 1.22 (8)	12.45^{bc} ± 1.07 (8)	12.13 ± 0.79 (16)
3	7.51^{bc} ± 0.59 (8)	8.51^{bcd} ± 0.89 (8)	8.02 ± 0.69 (16)	11.88^{bc} ± 0.99 (8)	14.04^{c} ± 0.89 (8)	12.96 ± 0.70 (16)
4	7.67^{bcd} ± 0.64 (8)	8.66^{bcd} ± 1.25 (8)	8.16 ± 0.54 (16)	14.40^{c} ± 0.47 (8)	14.30^{c} ± 0.52 (8)	14.35 ± 0.33 (16)
5	8.31^{bcd} ± 0.60 (8)	10.04^{cd} ± 0.88 (8)	9.17 ± 0.56 (16)	12.56^{bc} ± 1.25 (8)	13.90^{c} ± 1.19 (8)	13.23 ± 0.85 (16)
6	9.45^{d} ± 0.73 (8)	9.22^{cd} ± 1.43 (8)	9.38 ± 0.77 (16)	13.25^{c} ± 0.90 (8)	13.25^{c} ± 0.90 (8)	13.25 ± 0.60 (16)
7	9.10^{cd} ± 0.46 (8)	10.40^{cd} ± 1.10 (8)	9.76 ± 0.60 (16)	1403^{c} ± 1.08 (8)	13.54^{c} ± 1.34 (8)	13.78 ± 0.68 (16)
8	9.29^{cd} ± 0.71 (8)	10.40^{cd} ± 0.94 (8)	9.86 ± 0.58 (16)	13.71^{c} ± 1.22 (8)	14.23^{c} ± 0.94 (8)	13.97 ± 0.74 (16)
9	11.98^{e} ± 0.95 (7)	11.34^{d} ± 1.04 (7)	11.51 ± 0.72 (14)	13.20^{c} ± 0.98 (7)	11.71^{c} ± 1.41 (7)	13.30 ± 0.82 (14)
$\overline{X}$ ±SE	8.32 ± 064 (71)	8.69 ± 1.03 (78)	8.52 ± 0.47 (149)	12.38 ± 1.04 (75)	12.87 ± 1.28 (79)	12.33 ± 0.50 (154)
F value	8.98**	4.55**		4.28**	2.66**	

Means with different superscripts differ significantly
Figures in parentheses indicate number of animals
MH: Morning hours; EH: Evening hours; **Significant at 1%

TABLE VI : Average (Mean ±SE.) flow rate (ml/5 min) of duodenal digesta in cow calves during first fifteen weeks of life.

Age	*Before feeding*			*After feeding*		
(d)	*MH*	*EH*	*Mean*	*MH*	*EH*	*Mean*
0	—	$3.80^{a} \pm 0.74$ (7)	3.82 ± 0.72 (7)	$5.80^{a} \pm 0.80$ (4)	$8.23^{a} \pm 1.19$ (8)	8.27 ± 1.37 (12)
1	$9.45^{d} \pm 0.73$ (8)	$9.22^{bc} \pm 1.43$ (8)	9.38 ± 0.77 (16)	$13.25^{b} \pm 0.90$ (8)	$13.25^{b} \pm 0.88$ (8)	13.25 ± 0.60 (16)
2	$12.10^{ab} \pm 0.85$ (5)	$12.68^{cde} \pm 0.91$ (5)	12.39 ± 0.60 (10)	$17.98^{bcdc} \pm 1.57$ (5)	$14.98^{bc} \pm 1.24$ (5)	16.48 ± 1.06 (10)
3	$11.98^{ab} \pm 1.08$ (5)	$10.84^{bcd} \pm 0.60$ (5)	11.41 ± 0.62 (10)	$14.30^{bc} \pm 1.25$ (5)	$13.22^{b} \pm 1.02$ (5)	12.68 ± 1.49 (10)
4	$11.68^{ab} \pm 1.10$ (5)	$10.18^{bc} \pm 2.10$ (5)	10.93 ± 1.15 (10)	$15.73^{bcd} \pm 1.75$ (5)	$14.00^{bc} \pm 2.12$ (5)	14.86 ± 1.32 (10)
5	$13.13^{abc} \pm 0.79$ (6)	$10.68^{bcd} \pm 1.03$ (6)	11.90 ± 0.72 (12)	$19.11^{cdef} \pm 2.46$ (6)	$15.61^{bcd} \pm 1.66$ (6)	17.37 ± 1.51 (12)
6	$12.95^{abc} \pm 1.39$ (6)	$11.20^{bcde} \pm 0.91$ (6)	12.07 ± 0.83 (12)	$19.27^{cdef} \pm 0.46$ (6)	$16.76^{bcde} \pm 1.30$ (6)	18.01 ± 0.76 (12)
7	$12.52^{ab} \pm 1.34$ (6)	$9.53^{bc} \pm 0.43$ (6)	10.97 ± 0.80 (12)	$18.43^{cdef} \pm 0.94$ (6)	$16.88^{bcde} \pm 0.66$ (6)	17.65 ± 0.59 (12)
8	$15.75^{bcde} \pm 1.78$ (4)	$12.42^{cde} \pm 1.61$ (4)	14.01 ± 1.25 (8)	$14.65^{bc} \pm 1.61$ (4)	$18.00^{cde} \pm 1.76$ (4)	16.32 ± 1.27 (8)
9	$16.55^{bcde} \pm 2.10$ (4)	$12.42^{cde} \pm 1.75$ (4)	14.49 ± 1.49 (8)	$18.67^{bcdef} \pm 3.78$ (4)	$19.72^{def} \pm 2.10$ (4)	19.20 ± 2.01 (8)
10	$15.15^{bcd} \pm 1.84$ (4)	$7.37^{ab} \pm 1.45$ (4)	11.26 ± 1.82 (8)	$17.32^{bcde} \pm 1.17$ (4)	$20.17^{def} \pm 2.16$ (4)	18.75 ± 1.26 (8)
11	$17.67^{cde} \pm 2.68$ (4)	$13.15^{cde} \pm 3.17$ (4)	15.41 ± 2.09 (8)	$20.65^{ef} \pm 2.11$ (4)	$19.67^{def} \pm 2.07$ (4)	20.16 ± 1.38 (8)
12	$19.52^{de} \pm 2.57$ (4)	$15.74^{ef} \pm 2.44$ (4)	17.63 ± 1.79 (8)	$21.75^{ef} \pm 2.33$ (4)	$17.97^{cde} \pm 2.45$ (4)	19.86 ± 1.72 (8)
13	$20.07^{de} \pm 2.88$ (4)	$14.90^{de} \pm 0.94$ (4)	17.48 ± 1.71 (8)	$23.87^{f} \pm 3.86$ (4)	$19.97^{def} \pm 3.25$ (4)	21.92 ± 2.39 (8)
14	$20.52^{e} \pm 2.55$ (4)	$15.71^{ef} \pm 1.55$ (4)	18.17 ± 1.54 (8)	$23.72^{f} \pm 2.14$ (4)	$21.20^{ef} \pm 3.23$ (4)	22.46 ± 1.86 (8)
15	$20.17^{e} \pm 3.38$ (4)	$20.12^{f} \pm 3.54$ (4)	20.14 ± 2.27 (8)	$20.22^{def} \pm 2.57$ (4)	$23.14^{f} \pm 2.16$ (4)	21.68 ± 1.52 (8)
$\overline{X}$ ±SE	14.60 ± 1.62 (73)	11.31 ± 1.64 (80)	13.52 ± 0.72 (153)	17.57 ± 1.92 (77)	16.33 ± 1.65 (81)	17.42 ± 0.72 (158)
F value	4.56**	5.93**		5.08**	5.96**	

Means with different superscripts differ significantly
Figures in parentheses indicate number of animals
MH: Morning hours; EH: Evening hours; **Significant at 1%

The concurrent studies on both cow calves and buffalo calves revealed a species variations at 7, 24 and 63 d of age which has also been reported in newborn Friesian and Ayreshire bull calves (11) on the basis of 12 hr recording against 5 min in the present study and hence comparison could not be made. However, on these days higher flow rate was recorded in cow calves as compared to buffalo calves.

Diurnal effect : Diurnal variations were non significant except a significant increase in rate on 3 d EH. Overall, the flow rate was higher at EH to the extent of 4.56% (0.59 ml) in cow calves (MH: 13.53 ± 0.34; EH: 12.94 ± 0.29). The concurrent studies on buffalo calves also revealed uniform flow rate when compared for MH and EH under the identical situations (6) (EH : 13.44 ± 0.38; MH: 12.89 ± 0.34).

Pancreatic juice vs duodenal fluid

The operative procedure for pancreatic duct cannulation is more skill oriented as complications were more as comapred to duodenum cannulation. PJ nature was

colourless and watery fluid which did not change throughout the study whereas that of DF initially was yellowish (birth to 6 wk) which changed to greenish afterwords. Both PJ and DF flow rate changed significantly with age. Diurnal variations were non significant and indicated that cow calves do not discriminate between the periods of the day. The flow rate remained low for first 2 days and highest between 12 to 15 wk for PJ and between 13 to 15 wk for DF. Overall flow rate at a given age for DF was faster than that of PJ. Postprandial flow rate of both the fluids were found to increase which was 4.87% for PJ and 4.56% for DF.

ACKNOWLEDGEMENTS

The authors are thankful to the Council of Scientific and Industrial Research, New Delhi for providing financial assistance in the form of Senior Research Fellowship which has helped to carryout the present investigation. The authors are also thankful to the Principal, College of Veterinary Science & A. H., Anand for providing the necessary facilities for the present work.

REFERENCES

1. Toullec R, Guilloteau P, Patureau-Mirand P, Sissons JW. Digestion and absorption of protein in the preruminant. IVth Int. Symp. On "Protein Metabolism & Nutrition", held at Clermont-Ferrand (France) 5–9 Sept., 1983 Edited by INRA Publication. vol. I Reports 245–261.
2. LeHuerou I, Wicker C, Guilloteau P, Toullec R, Puigserver A. Specific regulation of the gene expression of some pancreatic enzymes during postnatal development and weaning. *Biochimica et Biophysica Acta*, 1990; 1048: 157–164.
3. Pierzionwski SG, Zabielski R, Westrom BR, Mikolajocyk M, Barej W. Development of the exocrine pancreatic function in chronically cannulated calves for the preweaning period upto early rumination *J Anim Physiol a Anim Nutr* 1991; 65: 165–172.
4. Shirazi-Beechey SP, Smith MW, Wang Y, James PS. Postnatal development of lamb intestinal digestive enzymes is not regulated by diet. *J Physiol* 1991; 437: 691–698.
5. Corring. T, Amaitre A, Durand G. Development of digestive enzymes in the piglet from birth to 8 weeks. I Pancreas and pancreatic enzymes. *Nutr Metab* 1978; 22: 231–243.
6. Christi KS, Vadodaria VP, Mehta VM, Barvalia DR, Parsania RR. Pancreatic juice and duodenal fluid flow rate in buffalo calves from birth to early ruminant stage (15 weeks). *Buffalo Journal* (In press) 1998.
7. Christ KS, Vadodaria VP, Mehta VM. Ontogenic pattern of pancreatic juice amylase in buffalo calves from birth to early ruminant stage. *Proceed 2nd Asian Buffalo Congress* Oct. 1996; Manila-Philippines 430–441.
8. Hall LW, Clarke KW. Anaesthesia of the ox. In *Veterinary Anasesthesia*. 8th edn. English Language Book Society Baillere Tindall, London. 1983; 246–272.
9. Hornay FD, Wallace CE. The digestive system: Surgery of the bovine digestive tract. In Jenings PB Jr. (Ed) *The Practice of Large Animal Surgery* Vol. I WB Saunders Company, Philadelphia. 1984, 493–554.
10. Snedcor GW, Cochran WG. In *Statistical Methods. 6th* edn. IBH Publishing Co., Calcutta. 1968, 94–100; 258–267.
11. Ternouth JH, Buttle HL. Concurrent studies on flow of digesta in the duodenum and exocrine pancreatic secretion of calves. *J Nutr* 1973; 29: 387–397.
12. McCormick RJ, Stewart WE. Pancreatic secretion in the bovine calf. *Dairy Sci* 1967; 50: 568–571.
13. Alive AA, Garanina NA. Secretory functions of pancreas in calves during early postnatal ontogenesis. *Sci Skokhozyaisvrennaya Biol* 1984, (4) 11–16 (*cited from Nutr Abstr Rev* (B) 55: 455).
14. Brannon PM. Adptation of the exocrine pancreas to the diet. *Annu Rev Nutr* 1990; 10: 85–105.
15. Gorril ADL, Thomas WE, Stewart WE, Morrill JL. Exocrine pancreatic secretion by calves fed soyabean and milk protein diets. *J Nutr* 1967; 62: 86–92.
16. Taylor RB. Pancreatic secretion in sheep. *Res Vet Sci* 1962; 3: 63–77.
17. Sissons JW, Smith RH. Effect of duodenal cannulation on abomasal emptying and secretion in preruminant calf. *J Physiol* 1982; 322 : 409–417.