

Print ISSN : 0972-8813
e-ISSN : 2582-2780

[Vol. 24(2) May-August 2026]

Pantnagar Journal of Research

(Formerly International Journal of Basic and
Applied Agricultural Research ISSN : 2349-8765)



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Vol. 24(2)

May-August, 2026

CONTENTS

- AI and geospatial innovations for Indian agriculture: Applications, policy support and emerging research frontiers (Review)** 233-247
ABHISHEK DANODIA, SURESH KUMAR and AJEET SINGH NAIN
- Optimizing nitrogen use efficiency and grain quality in basmati rice through Integrated weed management: Insights into nutrient partitioning and Crop-weed competition** 248-255
ROMAN NISSAR, MANZOOR A GANAI, MEHRAJ UD DIN SOFI, ASHAQ HUSSAIN and F. A. BAHAR
- Performance evaluation of brown top millet (*Brachiaria ramosa* L.) genotypes under rainfed upland ecology of the Bastar plateau of Chhattisgarh** 256-266
PRAFULL KUMAR
- Effect of pre-harvest sprays of nanofertilizers on fruit quality in litchi (*Litchi chinensis* Sonn.) cv. Rose Scented** 267-274
NITIN PANWAR, RATNA RAI and RAJEEW KUMAR
- Ethrel induced ripening optimally modulates physicochemical quality, antioxidant properties and shelf life of sapota (*Manilkara zapota* L.) cv. Cricket Ball** 275-285
ASHOK KUMAR SINGH, KIRTI CHETRI, RISHABH RAJ, S. K. GURU and N. C. SHAHI
- Influence of drip irrigation and mulching practices on fruit set, yield and water use efficiency of litchi cv. rose scented in the Tarai region of Uttarakhand** 286-292
SHANKAR LAL, N. SINGH, N.K. BIND, PRERNA PRACHI, RAJSHREE, RIYA THAPA and AKHIL RUHELA
- Spatial distribution and survey of soybean anthracnose in the Kumaon region of Uttarakhand, India** 293-300
MANISHA DEV and K.P. SINGH
- Dimensionality reduction of part milk yield in crossbred cattle using Principal Component Analysis** 301-307
SIMRAN KAUR, ASHIS KUMAR GHOSH, OLYMPICA SARMA and RAVINDER SINGH BARWAL
- Comparative histomorphological and histochemical studies on the abomasum of adult Bakerwali goats, non-descript goats and non-descript sheep of the Jammu region** 308-318
JASVINDER SINGH SASAN, SHALINI SURI and KAMAL SARMA
- Gross morphology and biometry on the abomasum of adult Bakerwali goat, non-descript goats and non-descript sheep of Jammu region: A comparative study** 319-325
JASVINDER SINGH SASAN, SHALINI SURI and KAMAL SARMA

Arterial blood gas analysis in bovine pneumonia: Comparative study of healthy and diseased cattle ASMITA NARANG and CHARANJIT SINGH	326-331
Assessment of commonly used insecticide residues using gas chromatography in buffalo liver samples collected from North India S. K. JAIN, VINOD KUMAR, VINAY KANT, PREETI BAGRI, ARCHANA LOHIYA, GAURI CHANDRATRE and GAURAV GUPTA	332-339
<i>In silico</i> molecular docking analysis of squalene with major ageing-related molecular targets: matrix metalloproteinase-1, matrix metalloproteinase-9, cyclooxygenase-2, Tumor Necrosis Factor-α, hyaluronidase-1 and B-cell lymphoma-2 PAWANESH TAMTA, KULDIP CHANDRA VERMA and APARNA DIXIT	340-352
Characterization of agro-waste (<i>Parthenium hysterophorus</i>) derived Carbon Dots and to assess their potential as a sustainable adsorbent NISHTHA NAUDIYAL and R.K. SRIVASTAVA	353-360
Assessment of the antibacterial efficacy of endophytic bacteria in combination with neem leaf powder against bacterial pathogens SHIVANI SINGH, AJAY VEER SINGH and VELLAICHAMY MAGESHWARAN	361-370
Exploration of endophytic bacterial isolates from Kasni leaves (<i>Cichorium intybus</i>) for Phyto-hormone and Phyto-stimulating metabolite production VARSHA MISHRA, SEEMA BISHT, DIVYA PANT, ANUPAMA PANDEY and LAKSHMI TEWARI	371-382
Mitigation of dexamethasone-induced cardiac oxidative damage by <i>Moringa oleifera</i> and Vitamin E-Selenium: A biochemical study in broilers LATA PALIWAL, SONU AMBWANI and TANUJ KUMAR AMBWANI	383-395
Adaptive Neural Networks for dynamic prioritization in autonomous vehicles for road users MUMUKSHU BHATT, SUBODH PRASAD, RAJESH SINGH, ASHOK KUMAR and POOJA TAMTA	396-403
Assessing the impact of Geopolitical Disturbances on India's agricultural trade performance JYOTI, SUMAN GHALAWAT, MEGHA GOYAL, SUNIL KUMAR, AMITA GIRDHAR and SUBODH AGARWAL	404-409
Black soybean (<i>Glycine max</i> (L.) Merrill): Nutritional and functional analysis of whole seed, dehusked seed and husk fractions RITA SINGH RAGHUVANSHI, GUNJAN TEWARI, AABHA RAWAT and APURVA	410-421
<i>In silico</i> bioprospecting of bioactive phytochemicals with potential protective effects against exercise-induced muscle stiffness NAGARJUN G. S., PAL MURUGAN M., KRISHNANDU MONDAL, PADMASHREE A., WADIKAR D. D. and KUMAR R.	422-433

Gross morphology and biometry on the abomasum of adult Bakerwali goat, non-descript goats and non-descript sheep of Jammu region: A comparative study

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<https://doi.org/10.67063/pjr.vol.24.issue.02.10>

ABSTRACT: The present study was undertaken to compare the gross morphological and biometrical investigation of abomasum in adult Bakerwali goat with non-descript goats and non-descript sheep of Jammu region. The abomasum was an elongated pear-shaped sac with two extremities, two curvatures and two surfaces in all the three groups of goats and sheep species. Internally, abomasum presented obliquely oriented permanent longitudinal abomasal folds that extended from the sides of the abomasum in the direction of the greater curvature. These folds increased surface area which benefitted both excretory and absorptive functions. Towards pyloric area, instead of folds, substantially thicker ridges were seen. The empty weight of the abomasum was highest in Bakerwali goats (969.75 ± 23.17 gm) whereas capacity showed no significant variation. In all the three groups, the greater curvature was longer than the lesser curvature. The number of internal abomasal folds did not differ significantly among species. The width of the abomasum was maximum at the middle of the fundic region and minimum at the pyloric region. The thickness of the abomasal wall increased from the cardia to the pylorus, being greatest at the pyloric region. The length of both fundic and pyloric regions was higher in Bakerwali goats (19.00 ± 0.43 cm and 10.98 ± 0.41 cm, respectively) compared to the other species. Overall, the study indicated species-related variations in the biometrical characteristics of the abomasum in small ruminants.

Keywords: Abomasum, Bakerwali goat, Biometry, Goat, Sheep

Union territory of Jammu and Kashmir is generally provided with an environment and socio-cultural system which is conducive to small ruminant production. When compared to other farm animals, goats have the advantage of not requiring expensive structures or equipment. Furthermore, goats have a high digestion of dry matter and fibre, and can eat inferior woody vegetation that no other animal would eat. As a result, the goat is known as the 'Poor Man's Cow'. Similarly, sheep farming is popular among India's economically disadvantaged people and is seen as a "mortgage lifter" for poor farmers (Poonia *et al.*, 2012).

On the basis of foraging behaviour, ruminants can be classed as grazers, browsers, or intermediate grazers (Gordon, 2003). Sheep prefer to graze, but goats prefer to browse (Mosavat and Chamani, 2013). Browsers eat high-nutrient twigs and shrubs, while grazers eat lower-quality grasses.

Animal health should be good for better productivity.

A better nutrient supply, adequate digestion, and absorption are all necessary for an animal's optimal health. Ruminants have a digestive mechanism that permits them to use energy from fibrous plant material more efficiently than other herbivores. Ruminants, unlike monogastrics like pigs, have a digestive tract that is designed to ferment feedstuffs and create energy precursors for the animal.

The abomasum is a ruminant's "true stomach". It gets the food ready for enzymatic digestion and absorption in the small intestine (Dellmann and Brown, 1987). The cardiac, fundic, and pyloric gland regions make up the inside of the abomasum as reported by Konig and Liebich (2020). Cardiac glands secrete mucus to protect the abomasal wall from acid damage. Fundic glands secrete acids, electrolytes, and digestive enzymes like pepsin to break down proteins, while the pyloric gland secretes the hormone gastrin into the abomasum to protect the abomasal wall from acid damage (Banerjee, 1998).

Literature is available on the gross morphology and biometry of forestomach of Black buck (Kumari *et al.*, 2013), morphology of stomach of Swamp buffalo (Nurliani *et al.*, 2015), biometry of rumen of Surti goat (Soni and Panchal, 2018). However, comparative information regarding gross morphology and biometry is unavailable on abomasum of small ruminants of Jammu region which prompted this study. The present study was aimed to compare gross anatomical structure and biometry of abomasum between the small ruminants of Jammu region as sheep are more of a grazer whereas goats are browser. It may guide us to a better understanding of the organ and thereby correlate with the digestive physiology of small ruminants. By better understanding how the digestive system of the ruminant works, livestock producers can better understand how to care for and feed ruminant animals. Developing a good understanding of ruminant digestive anatomy and function can help livestock producers better plan appropriate nutritional programs and properly manage ruminant animals in various production systems.

MATERIALS AND METHODS

The present study was conducted in the Division of Veterinary Anatomy, Faculty of Veterinary Sciences & A. H., SKUAST-J, R. S. Pura, Jammu. The stomach samples (N=06) from apparently healthy adult Bakerwali goat, non-descript goats and non-descript sheep were collected from the slaughter houses in and around Jammu city. The age was estimated by dentition (Solaiman, 2010). Immediately after collection, the stomach was washed with running tap water and brought to the gross anatomy laboratory for recording the gross morphological and biometrical studies.

Immediately after the slaughter of animals, the stomach was separated by cutting at the atrium ventriculi and pylorus in the cranial and caudal directions, respectively. All four compartments were excised for evacuation at the point of their greatest curvature. After thorough cleaning and removal of omental coverings, photography was done to document the gross morphology of the abomasum.

The biometry was recorded with the help of non-stretchable thread, scale, Vernier Calliper and Monopan balance and it included the following parameters:

- i. Total empty weight of stomach (gm) with the help of Monopan balance.
- ii. Total capacity of stomach (ml) was calculated by filling stomach with water and measuring with the help of measuring cylinder.
- iii. Weight (gm) and capacity (ml) of empty abomasum
- iv. Length (cm) of abomasum at its greater and lesser curvature
- v. Number and arrangement of abomasal folds
- vi. Width (cm) of abomasum at cardia, middle of fundus and pyloric region
- vii. Wall thickness (cm) of abomasum at cardia, middle of fundus and pyloric region
- viii. Length (cm) of fundic and pyloric region of abomasum

The data recorded was expressed as Mean $\pm$ SE (Standard Error of Mean) and was subjected to Standard Statistical Analysis (Snedecor and Cochran, 1994).

RESULTS AND DISCUSSION

Gross morphology: In present study, the abomasum was observed as an elongated pear-shaped sac (Fig. 1) in all the three species which was similar to the previous findings by Bhamburkar (2021) in ruminants. According to Mansour *et al.* (2023) abomasum in ruminants had J shaped appearance. The abomasum exhibited two extremities, namely omasal and duodenal, two curvatures (greater and lesser), and two surfaces (parietal and visceral) (Fig. 1). Similar anatomical features were described in Surti goats by Mahendrakumar (2017). Internally, abomasum differed from other compartments by absence of papillae as seen in Surti goat (Mahendrakumar, 2017). However, the obliquely oriented permanent longitudinal folds known as abomasal folds were seen in the interior of abomasum (Fig. 2). Comparable observations were recorded by Malik (2014) in Gaddi sheep,

Mahendrakumar (2017) in Surti goats and Mansour *et al.* (2023) in ruminants. Agungpriyono *et al.* (1992) in mouse deer observed spiral mucosal folds running longitudinally in the fundus of abomasum. These folds extended from the sides of the abomasum in the direction of the greater curvature and were characterized by convex free border. Similar observation was made by Bhamburkar (2021) in ruminants. Ellis (2013) reported that in ruminants the abomasal folds were more prominent near the omasal end which gradually tapered towards the pyloric region. Functionally, these folds increased the internal surface area of the abomasum, thereby enhancing both secretory and absorptive activities.

The abomasum of all the three groups of goats and sheep species under study was morphologically divided into three distinct regions, the cardiac region, the fundic region, and the pyloric region (Fig. 1). A similar regional division was reported by Orsini *et al.* (2022) and Mansour *et al.* (2023) in ruminants. In contrast, Akers and Denbow (2008) divided abomasum of goat into fundic and pyloric regions. In the present study, the cardiac zone was restricted to omaso-abomasal orifice. Membrive (2016)

divided abomasum of goat into fundus, body and pylorus. He observed visible constriction between the pyloric and fundic gland regions. In the pyloric region, the mucosal surface exhibited thickened ridges rather than typical folds (Fig. 2). Similar structural features were reported by Agungpriyono *et al.* (1992) in mouse deer, Stafford (1995) in sambar deer, and Akers and Denbow (2008) in goats. Bhamburkar (2021) in ruminants also reported that the pyloric part was devoid of any folds. Additionally, a small but prominent thickened structure known as the torus pyloricus was observed near the pyloric extremity (Fig. 3) similar to the finding of Mahendrakumar (2017) in Surti goat and Mansour *et al.* (2023) in ruminants. According to Mansour *et al.* (2023), torus pyloricus adds strength to the pyloric sphincter in ruminants.

Biometry: The biometrical data is summarized in Table 1. The total empty weight of stomach was significantly higher in adult Bakerwali goat (969.75 ± 23.17 gm) and least in non-descript goat (760.07 ± 38.69 gm) of same age group. However, the total capacity of stomach did not show any significant difference between species under study ($P > 0.05$). In cattle of medium size, capacity of

Table 1: Showing biometrical parameters of abomasum of Bakerwali goat, non-descript goats and non-descript sheep of Jammu region

S. No.	Parameter	Bakerwali goat	Non-descript goat	Non-descript Sheep
1.	Total empty weight (gm) of stomach	$969.75^{a \pm 23.17}$	$760.07^{b \pm 38.69}$	$913.30^{ab \pm 78.84}$
2.	Total capacity (ml) of stomach	9965.00 ± 1016.75	10301.05 ± 610.76	10770 ± 575.64
3.	Total empty weight (gm) of abomasum	$150.08^{a \pm 8.86}$	$136.62^{ab \pm 4.41}$	$129.53^{b \pm 1.54}$
4.	% Abomasum weight	$15.42^{ab \pm 0.57}$	$18.11^{a \pm 0.72}$	$14.72^{b \pm 1.27}$
5.	Total capacity (ml) of abomasum	1125.00 ± 62.92	1191.67 ± 62.09	1040.00 ± 73.30
6.	% Abomasum capacity	$10.92^{ab \pm 0.77}$	$11.68^{a \pm 0.62}$	$9.48^{b \pm 0.28}$
7.	Length of greater curvature of abomasum (cm)	$37.58^{ab \pm 0.58}$	$34.54^{a \pm 0.81}$	$41.10^{b \pm 1.94}$
8.	Length of lesser curvature of abomasum (cm)	25.90 ± 1.83	26.40 ± 0.51	25.97 ± 1.44
9.	Number of abomasal folds	20.00 ± 1.89	18.17 ± 0.79	18.00 ± 0.89
10.	Width (cm) of abomasum at cardia	$7.38^{a1 \pm 0.49}$	$5.45^{b1 \pm 0.56}$	$7.83^{a1 \pm 0.38}$
11.	Width (cm) of abomasum at middle of fundus	$9.81^{a2 \pm 0.39}$	$6.49^{b1 \pm 0.65}$	$9.20^{a2 \pm 0.40}$
12.	Width (cm) of abomasum at pylorus	$4.10^{ab3 \pm 0.33}$	$3.50^{a2 \pm 0.24}$	$4.65^{b3 \pm 0.22}$
13.	Wall thickness (cm) of abomasum at cardia	$0.16^{aX \pm 0.01}$	$0.16^{aX \pm 0.01}$	$0.14^{aX \pm 0.02}$
14.	Wall thickness (cm) of abomasum at middle of fundus	$0.16^{aX \pm 0.01}$	$0.18^{aX \pm 0.03}$	$0.20^{aY \pm 0.01}$
15.	Wall thickness (cm) of abomasum at pylorus	$0.30^{aY \pm 0.01}$	$0.25^{bY \pm 0.01}$	$0.34^{aZ \pm 0.01}$
16.	Length of fundic part (cm)	$19.00^{a \pm 0.43}$	$16.00^{b \pm 0.57}$	$18.67^{a \pm 1.28}$
17.	Length of pyloric part (cm)	$10.98^{a \pm 0.41}$	$8.22^{b \pm 0.79}$	$10.73^{a \pm 0.94}$
18.	Ratio of fundic to pyloric part	1.73 : 1	1.95 : 1	1.74 : 1

Mean value with same superscript (a, b, c) within row do not differ significantly ($p > 0.05$)

Mean value with same superscript [(1, 2, 3) and (X, Y, Z)] within column do not differ significantly ($p > 0.05$)

stomach ranges from 115 to 150 L whereas in sheep and goat, it ranges from 15 to 18 L (Getty, 1975). In



Fig. 1: Photograph of pear-shaped abomasum of adult Bakerwali goat showing omasal extremity (O), duodenal extremity (D), lesser curvature (arrow) and greater curvature (dotted arrow), showing cardia (C), fundus (F) and pylorus (P)



Fig. 2: Photograph of abomasum of adult non-descript sheep showing presence of abomasal folds (arrow) in fundus (F) and thick ridges (R) in pylorus (P)

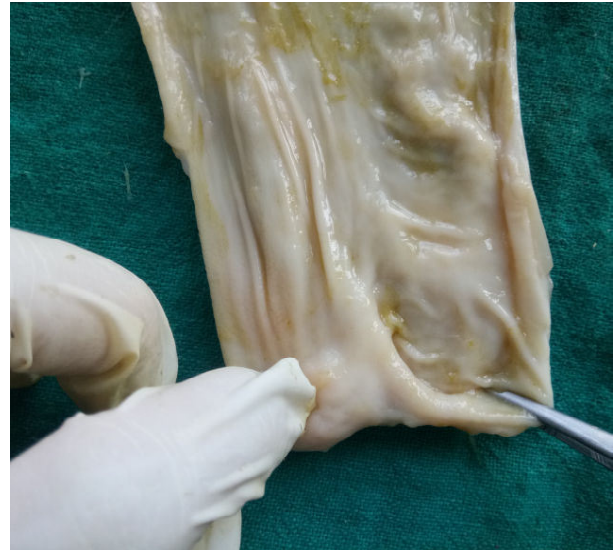


Fig. 3: Photograph of abomasum of adult non-descript sheep showing presence of Torus pyloricus (T) in towards pylorus

the present study, total empty weight of abomasum was significantly greater in Bakerwali goat (150.08 ± 8.86 gm) followed by non-descript goats (136.62 ± 4.41 gm) and least in non-descript sheep (129.53 ± 1.54 gm) but the total capacity of abomasum did not show any significant difference ($P > 0.05$). In Surti goat, the empty weight of abomasum was 137.42 ± 9.61 gm (Mahendrakumar, 2017). However, lower values were recorded in goats of 90–120 days of age (80.97 ± 7.49 gm) by Pachpande (2008), indicating that abomasal weight increased with age and development. The total capacity of abomasum in the present study was 1125.00±62.92 ml in Bakerwali goat, 1191.67±62.09 ml in non-descript goats and 1040.00±73.30 ml in non-descript sheep which was greater than that reported in younger goats (965.20 ± 92.51 cc) by Pachpande (2008). The average weight and volume of abomasum of Gaddi sheep was 145.67 ± 3.35 gm and 2.25 ± 0.08 L, respectively (Malik, 2014). In Bakerwali goat, abomasum weight was 15.42 ± 0.57 % of total empty weight of stomach whereas volume was 10.92 ± 0.77 % of total capacity of stomach. The same in non-descript goats were 18.11 ± 0.72 % and 11.68 ± 0.62 %, respectively. In non-descript sheep, the values were 14.72 ± 1.27 % and 9.48 ± 0.28 %, respectively. Dyce *et al.* (2002) reported that abomasum proportion in small ruminants was 13%.

In goats between 90-120 days of age, the proportion of abomasum was 23.1 % which was higher than our findings (Pachpande, 2008).

In all the three groups of different species under study, the abomasum exhibited a greater length along the greater curvature than along the lesser curvature. The average length of greater curvature of abomasum was significantly higher in adult non-descript sheep (41.10 ± 1.94 cm) followed by Bakerwali goat (37.58 ± 0.58 cm) and least in non-descript goat (34.54 ± 0.81 cm). However, the mean length of lesser curvature did not show any significant difference between the three groups ($P > 0.05$). In goats of 90-120 days of age, the length of greater curvature and lesser curvature was 19.67 ± 1.46 cm and 12.95 ± 0.75 cm, respectively (Pachpande, 2008). In Gaddi sheep, greater curvature was 22.80 ± 0.40 cm long and lesser curvature was 12.23 ± 0.26 cm long (Malik, 2014). Mahendrakumar (2017) in Surti goat reported that the length of abomasum was 28.37 ± 1.11 cm at greater curvature and 20.43 ± 1.46 cm at lesser curvature.

In the present study, the number of internal abomasal folds were maximum in adult Bakerwali (20.00 ± 1.89) followed by non-descript goats (18.17 ± 0.79) and minimum in non-descript sheep (18.00 ± 0.89) but the difference was statistically non-significant ($P > 0.05$). However, comparatively fewer folds were recorded in earlier studies. In Gaddi sheep, number of abomasal folds were 11.2 ± 0.17 (Malik, 2014) whereas in Surti goat, the same was 17.83 ± 0.76 (Mahendrakumar, 2017). In wild ruminants, the mucosal folds were 6-7 in mouse deer (Agungpriyono *et al.*, 1992), 12 in Sambar deer (Stafford, 1995), 12 in pampas deer (Perez and Ungerfeld, 2012), 10 in brown brocket deer (Perez and Vazquez, 2012), 12 in axis deer (Perez *et al.*, 2015) and 17 in dorcas gazelle (Jerbi *et al.*, 2016).

In all the three groups of different species, the width of abomasum was maximum at middle of fundic region followed by cardia and least at pyloric region. At cardia, the width of abomasum was maximum in adult non-descript sheep (7.83 ± 0.38 cm) followed by Bakerwali goat (7.38 ± 0.49 cm) and minimum in

non-descript goats (5.45 ± 0.56 cm). In the middle of fundus, the width was highest in adult Bakerwali goat (9.81 ± 0.39 cm) followed by non-descript sheep (9.20 ± 0.40 cm) and lowest in non-descript goats (6.49 ± 0.65 cm). At pylorus, the width of abomasum was maximum in adult non-descript sheep (4.65 ± 0.22 cm) followed by Bakerwali goat (4.10 ± 0.33 cm) and minimum in non-descript goats (3.50 ± 0.24 cm). From cardia to pylorus, the thickness of abomasal wall showed an increasing pattern. In all the three groups, the thickness of abomasal wall was significantly higher in pyloric region. It was maximum in adult non-descript sheep (0.34 ± 0.01 cm) followed by Bakerwali goat (0.30 ± 0.01 cm) and least in non-descript goats (0.25 ± 0.01). Abomasal wall thickness at cardia and middle of fundus did not show any significant difference ($P > 0.05$). The average length of fundic and pyloric region was significantly greater in Bakerwali goat (19.00 ± 0.43 cm and 10.98 ± 0.41 cm, respectively) followed by non-descript sheep (18.67 ± 1.28 cm and 10.73 ± 0.94 cm, respectively) and least in non-descript goats (16.00 ± 0.57 cm and 8.22 ± 0.79 cm, respectively). However, the ratio of length of fundic to pyloric part was maximum in non-descript goats (1.95: 1), which was lesser than values recorded in Surti goat (2.20: 1) by Mahendrakumar (2017).

CONCLUSION

In conclusion, the present research extended the depth of the knowledge regarding gross anatomy of abomasum in these species of Jammu region. The detailed anatomical study further adds to the literature. The anatomy of abomasum can be correlated to their digestive physiology. This study can act as a useful guide for those wishing to understand the functional anatomy of the abomasum in these species.

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Received: May 07, 2026

Accepted: May 29, 2026