

## Morphometric Analysis of Body and Internal Organs of Male Dusky Pademelon (*Thylogale brunii*) from Traditional Hunting in Merauke Regency

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### Abstract

**Background:** The dusky pademelon (*Thylogale brunii*) is an endemic marsupial of southern Papua for which morphometric information related to developmental maturity remains limited. This study aimed to evaluate differences in external body measurements and internal organ morphometry of male dusky pademelons across maturity stages (subadult and adult) and to identify practical morphological indicators relevant to conservation and sustainable use.

**Methodology:** Four male individuals (two subadults and two adults) obtained through traditional hunting in Kampung Wasur, Merauke Regency, were examined. External measurements included body weight, body length, head length, tail length, ear length, limb lengths, and chest circumference. Internal observations comprised pelage colour, dentition characteristics, and the weights of the liver, kidneys, and testes. Differences between maturity stages were assessed using nonparametric statistical analyses.

**Findings:** Chest circumference was the only external parameter showing a significant difference between subadult and adult males ( $p = 0.0237$ ), indicating greater thoracic development in mature individuals. Other external measurements were not statistically different, although adults consistently showed larger body dimensions. In contrast, internal organ morphometry revealed marked increases in liver, kidney, and testicular weights in adults, reflecting advanced metabolic and reproductive maturity. Age-related changes in dentition and fur coloration further supported maturity differentiation. Given the limited sample size, these findings should be interpreted cautiously.

**Contributions:** This study provides the first integrated morphometric baseline for male *T. brunii* in southern Papua. Chest circumference and internal organ development emerge as informative indicators of maturity, offering practical value for field-based age classification and community based wildlife management.

**Keywords:** Morphometrics; Internal Organs; Maturity Stage; Traditional Hunting; *Thylogale brunii*



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## INTRODUCTION

Papua is one of the regions with the highest biodiversity in Indonesia. This area is rich in natural resources, flora, and fauna, and serves as a biogeographical transition zone between Asia and Australia, as illustrated by the Wallace and Weber lines (Lohman et al., 2011). This exceptional biodiversity also implies a high responsibility for species documentation and management, particularly for endemic fauna that are subject to local utilisation. Among the endemic species found in this region is the dusky pademelon (*Thylogale brunii*), a member of the Macropodidae family and part of the marsupial group. This species is known to inhabit only the southern region of Papua and parts of Australia, giving it high ecological and conservation value (Marshall & Beehler, 2007). Although typically associated with the Australian continent, this animal is also found in southern Papua, particularly in Merauke Regency.

Previous studies on *Thylogale brunii* have primarily focused on its distribution, habitat preference, and general ecology (Marshall & Beehler, 2007), while detailed morphometric and developmental-stage-based assessments remain scarce, especially for populations in Papua. More broadly, morphometric studies on marsupials have been widely used to distinguish age classes, assess growth patterns, and support population management (Moraes et al., 2000), yet such approaches have rarely been applied to pademelon species in eastern Indonesia. To date, no published study has specifically quantified morphometric variation between developmental stages of *T. brunii* in the Merauke region.

Therefore, the novelty of this study lies in providing the first morphometric baseline data for *Thylogale brunii* in southern Papua, with a particular emphasis on distinguishing subadult and adult individuals using external body measurements and organ-related traits. This contribution is expected to fill a critical knowledge gap and to support evidence-based conservation and sustainable wildlife management, especially in areas where traditional hunting remains an integral part of local livelihoods.

Dusky pademelons play a vital role in maintaining ecosystem balance, particularly in savanna habitats, as they serve as primary herbivores. However, their populations are increasingly threatened by ongoing hunting activities, conducted both for protein needs and economic purposes. Dusky pademelons are an important source of animal protein for local communities (Maturbongs et al., 2023). Although most hunting is carried out traditionally, high-intensity practices without proper management can potentially lead to drastic population declines (Pattiselanno et al., 2023). Therefore, accurate information regarding species identity, population status, and biological characteristics is essential for effective wildlife management and conservation planning (Witmer, 2005). In this context, morphometric data are particularly important because they provide practical tools for distinguishing developmental stages and identifying individuals harvested through hunting, which is critical for monitoring population structure and ensuring sustainable use. Population dynamics are influenced not only by birth and death rates, but also by a species' ability to adapt, migrate, and respond to changes in landscape and climate (Sodhi & Ehrlich, 2010). Thus, baseline morphometric information can contribute to

more evidence-based conservation strategies, especially in regions where traditional hunting remains common.

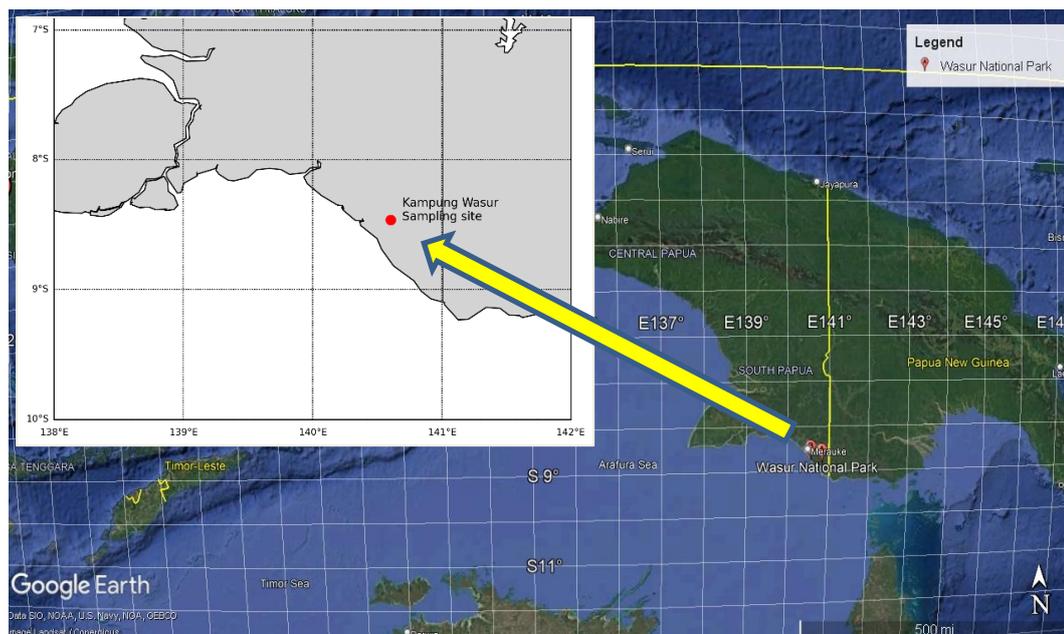
The primary threat to the survival of this species is ongoing illegal hunting. Although the 1991 workshop agreement on the establishment of Wasur National Park only recommended traditional hunting for household consumption, in practice, hunting is often conducted for economic purposes, such as selling meat in local markets. A fundamental issue frequently encountered in the field is the difficulty among local communities in distinguishing between subadult and adult individuals, or between morphologically similar species such as wallabies and dusky pademelons. This challenge arises from the limited availability of accessible scientific information, particularly concerning the morphological characteristics of the species. Understanding morphology is essential in the context of species identification, population management, and conservation (Feldhamer et al., 2007). Morphological and morphometric studies have long been applied in marsupials to distinguish developmental stages, assess growth patterns, and support sustainable population management (Tyndale-Biscoe, 2006). More recently, advances in quantitative morphometric approaches, including geometric and landmark-free morphometrics, have further improved the ability to detect subtle morphological variation and enhance species and age-class differentiation in marsupials and other mammals (Saguir et al., 2025). Characteristics such as body size, dentition, pelage colour, and organ weights (e.g., liver and testes) can serve as reliable distinguishing parameters. Moreover, morphometric research contributes significantly to conservation efforts by enabling individual identification in the field, monitoring wildlife health, and informing evidence-based population management strategies, particularly in hunted species.

This study aims to analyse differences in external body measurements and internal organ morphometry of male dusky pademelons (*Thylogale brunii*) obtained through traditional hunting, based on developmental maturity level (subadult and adult). Although morphometric approaches have been widely used to assess growth patterns and distinguish age classes in marsupials (Tyndale-Biscoe, 2006; Mein et al., 2022), previous studies particularly those in paleontological contexts have also demonstrated the broad utility of morphometric approaches within Macropodoidea for taxonomic classification and differentiation. Detailed morphometric baseline data for *T. brunii* populations in southern Papua remain extremely limited. This lack of accessible scientific information represents a critical knowledge gap, particularly in regions where hunting pressure is increasing and accurate identification of harvested individuals is necessary for sustainable management. Therefore, this research also seeks to determine the most informative morphological parameters for distinguishing maturity stages in this species. The scientific contribution of this study lies in providing the first quantitative morphometric reference for male dusky pademelons in the Merauke region, which can support population monitoring, improve field-based identification, and inform evidence-based conservation and wildlife management policies in the context of traditional hunting.

## METHOD

### Study Location

This study was conducted in Merauke Regency, South Papua Province, Indonesia, with laboratory measurements performed at the Animal Husbandry Laboratory, Faculty of Agriculture, Musamus University. Male dusky pademelons (*Thylogale brunii*) were obtained through traditional hunting activities carried out by local communities in Kampung Wasur, Merauke Regency (8.5530° S, 140.4170° E; approximately 15–20 m above sea level). The location is situated within the savanna-wetland mosaic of the Wasur National Park area. A map of the sampling location is presented in Figure 1. The geographic coordinates of the sampling location were recorded using Google Maps and visualised to illustrate the study area.



**Figure 1.** Map of sampling location (Kampung Wasur, Merauke Regency, South Papua Province, Indonesia)

The study area represents a lowland savanna ecosystem characterised by grassland vegetation interspersed with shrubs and seasonally inundated patches. Dominant food plants recorded at the hunting sites included *Imperata cylindrica*, *Cyperus cephalotes*, *Eleocharis obtusa*, and *Juncus capillaceus*. Specimens were collected using manual night-hunting techniques, in which hunters used hand-held flashlights to detect and approach animals during nocturnal activity. This method reflects common subsistence hunting practices in the Wasur area and provided specimens for subsequent morphometric and organ measurement analyses.

### Population and Sample

A total of four male dusky pademelons were used as research samples. Each individual was categorised into either subadult or adult age groups based on external physical characteristics, including body size, body weight, and testicular development.

Age determination followed morphological approaches described in previous literature (Saber & Gummow, 2014). After collection in the field, specimens were handled following standard wildlife sampling procedures. Carcasses were immediately transported from the hunting site to the laboratory under cooled conditions using insulated containers with ice packs to minimise tissue degradation. Upon arrival, each specimen was cleaned, labelled, and recorded prior to morphometric measurements. Internal organs (liver, kidneys, and testes) were carefully dissected and weighed shortly after sampling. When immediate analysis was not possible, organ samples were temporarily stored at approximately 4 °C for short-term preservation before further examination. This preparation ensured the accuracy and reliability of both external and internal morphometric assessments.

### **Observed Parameters**

Observations were grouped into two main categories: external morphometric parameters and internal anatomical characteristics. Prior to measurement, each specimen was taxonomically confirmed as dusky pademelon (*Thylogale brunii*) based on diagnostic morphological traits and distribution records described in standard mammal identification references (Marshall & Beehler, 2007). Species confirmation included body size, pelage characteristics, tail morphology, and dentition patterns.

External morphometric measurements included body weight (kg), total body length (TBL, mm), head length (HL, mm), tail length (TL, mm), ear length (EL, mm), hindlimb length (HLL, mm), forelimb length (FLL, mm), and chest circumference (CC, mm). Internal characteristics recorded included pelage colour, number and length of upper and lower teeth, as well as the weights of major visceral and reproductive organs, namely the liver, kidneys, and testes (g).

Necropsy was performed following standard veterinary anatomical procedures. After a midline abdominal incision, organs were carefully removed, cleaned of excess connective tissue and blood, and weighed immediately to minimise post-mortem changes. Organ collection and measurement protocols followed guidelines in veterinary anatomy and necropsy manuals (Lamberski & Calle, 2019). All measurements were conducted using a digital balance and manual measuring tools (measuring tape and callipers), with an accuracy of 0.1 g for organ weights and 0.1 mm for linear morphometric parameters.

### **Data analysis**

Data were analysed using descriptive and inferential statistical approaches. Descriptive analysis was applied to summarise morphometric variation between subadult and adult individuals. Differences between age groups for each measured parameter were tested using the Mann–Whitney U test. Statistical significance was assessed at the 5% level ( $p < 0.05$ ), and all analyses were performed using SPSS software version 25.

## RESULT AND DISCUSSION

### External Morphology of Dusky Pademelon *Thylogale brunii*

Table 1 presents the external morphometric measurements of four male dusky pademelons (*Thylogale brunii*) obtained through traditional hunting by local communities in the Wasur National Park area, Merauke Regency. The measured parameters included body weight (BW), total body length (TBL), head length (HL), tail length (TL), ear length (EL), hindlimb length (HLL), forelimb length (FLL), and chest circumference (CC). Based on visual maturity characteristics, body size, and reproductive development, individuals were classified into two developmental stages: subadult (Walabi 1–2) and adult (Walabi 3–4). This classification provides a framework to examine how morphological traits develop ontogenetically in marsupials and how these changes are associated with age-related functional differences (Wilson et al., 2023).

The results indicate clear differences in overall body size between the two maturity groups. Adult individuals exhibited substantially greater body weight (10.5–18.0 kg) and total body length (115–183 mm) compared to subadults, which ranged from 3.33–4.50 kg and 88–98 mm, respectively. Similar increasing trends were also observed in other morphometric traits, including limb dimensions and ear length.

For example, hindlimb length increased from 36–40 mm in subadults to 48–60 mm in adults, reflecting the importance of limb development for locomotion and mobility in macropod marsupials (Feldhamer et al., 2007). Chest circumference (CC) also tended to be larger in adults, suggesting enhanced thoracic development associated with increased respiratory capacity and physical activity.

**Table 1.** External Morphometric Measurements of Male Dusky Pademelons (*Thylogale brunii*)

Parameter	Walabi 1 (Subadult)	Walabi 2 (Subadult)	Walabi 3 (Adult)	Walabi 4 (Adult)
Body weight (BW, kg)	3.33	4.50	10.50	18.00
Total body length (TBL, mm)	88	98	115	183
Head length (HL, mm)	11	13	18	22
Tail length (TL, mm)	37.5	44.0	57.0	68.0
Ear length (EL, mm)	6.0	6.8	7.0	9.0
Hindlimb length (HLL, mm)	36	40	48	60
Forelimb length (FLL, mm)	15	14	20	30
Chest circumference (CC, mm)	39	45	63	67

**Note:** Subadult individuals correspond to Walabi 1–2, while adult individuals correspond to Walabi 3–4.

### Statistical Comparison Between Maturity Stages

A comparison of external morphometric parameters between subadult and adult individuals is summarised in Table 2. Due to the limited sample size, nonparametric analysis was applied. The results showed that chest circumference (CC) was the only parameter that differed significantly between maturity stages ( $p = 0.0237$ ), indicating greater thoracic development in adult individuals. Other parameters such as head length (HL) and tail length (TL) approached significance ( $p = 0.0700$  and  $p = 0.0765$ , respectively), suggesting a general trend of increasing body dimensions with advancing maturity, although statistical power was constrained by the small number of samples.

**Table 2.** Comparison of External Morphometric Parameters Between Subadult and Adult Male Dusky Pademelons

Parameter (unit)	Subadult (Mean $\pm$ SD)	Adult (Mean $\pm$ SD)	p-value	Interpretation
BW (kg)	3.92 $\pm$ 0.83	14.25 $\pm$ 5.30	0.1301	Not significant
TBL (mm)	93.00 $\pm$ 7.07	149.00 $\pm$ 48.08	0.2448	Not significant
HL (mm)	12.00 $\pm$ 1.41	20.00 $\pm$ 2.83	0.0700	Approaching significance
TL (mm)	40.75 $\pm$ 4.60	62.50 $\pm$ 7.78	0.0765	Approaching significance
CC (mm)	39.50 $\pm$ 0.71	46.00 $\pm$ 2.83	0.0237*	Significant

Note: body weight (BW); total body length (TBL); head length (HL); tail length (TL); chest circumference (CC)

Other parameters did not show statistically significant differences, which may be influenced by the limited sample size in this study. Among the measured external traits, chest circumference (CC) was the only parameter that differed significantly between subadult and adult individuals ( $p = 0.0237$ ), indicating greater thoracic development in mature males. This suggests that chest circumference may serve as a practical indicator of age progression and physical maturity in male dusky pademelons.

Other parameters, such as head length (HL) and tail length (TL), showed increasing trends with maturity, although these differences were not statistically significant ( $p = 0.0700$  and  $p = 0.0765$ , respectively). These growth-related patterns support previous findings that morphological development in marsupials, particularly within the genus *Thylogale*, occurs gradually with age and may also be influenced by environmental conditions and food availability (Feldhamer et al., 2007). In addition, traits such as hindlimb length, forelimb length, body weight, and tail length tended to be higher in adult individuals, reflecting the functional importance of these structures for pentapedal locomotion and dynamic movement in macropod marsupials (Dawson, 2015; Kear et al., 2008).

### Internal Morphological Characteristics

Internal morphological observations included fur colour, dentition, and organ weights (liver, kidneys, and testes), as presented in Table 3. Fur colour tended to shift from brown in subadult individuals to dark brown or nearly black in adults. Coat colour variation in marsupials may be associated with hormonal status, sexual maturity, and ecological adaptation (Bond et al., 2024).

Internal organ weights increased markedly with advancing maturity. Testicular weight showed the most pronounced difference, increasing from 2–3 g in subadult individuals to 26–37 g in adults, confirming reproductive development as a key indicator of maturity stage in male dusky pademelons. Similar patterns of testicular growth have been reported in other macropod marsupials and are closely associated with the onset of sexual maturity (Dawson et al., 2021).

Liver and kidney weights also increased substantially, reflecting enhanced metabolic and physiological function in adult individuals. Organ scaling is recognised as an important indicator of nutritional ecology and physiological development in marsupials (Bradshaw & Bradshaw, 2011). Liver and kidney weights also increased substantially, reflecting enhanced metabolic and physiological function in adult individuals.

Dentition patterns showed a progressive increase in the number of upper maxillary teeth with age, from 4–6 teeth in subadults to 8 teeth in adults. This pattern is consistent with previous reports that tooth eruption and wear provide reliable indicators of developmental stage in macropod marsupials (Dawson et al., 2021).

**Table 3.** Internal Morphological Characteristics of Male Dusky Pademelons

Sample	Fur Colour	Maxilla Teeth (count)	Mandible Teeth (count)	Mandible Length (cm)	Maxilla Length (cm)	Liver Weight (g)	Kidney Weight (g)	Testis Weight (g)
1 (Subadult)	Brown	4	2	2.0	1.0	69	13	2
2 (Subadult)	Dark Brown	6	2	1.2	0.5	81	16	3
3 (Adult)	Dark Brown	8	2	2.0	1.0	144	27	26
4 (Adult)	Dark Brown	8	2	2.2	1.0	804	61	37

The observed differences in the number and size of maxillary and mandibular teeth in *Thylogale brunii* are consistent with patterns reported in other macropod species, such as *Macropus giganteus*. These patterns reflect common processes of tooth eruption, wear, and replacement in kangaroos. Dental damage or asymmetry may arise from several factors, including *Fusobacterium* infection, molar replacement dynamics, and spatial limitations of the mandibular arch, which can result in tooth crowding when compared to the more regularly arranged maxilla (Kierdorf et al., 2016; Kido et al., 2018). Furthermore, variation in mandibular and maxillary tooth density is not only linked to dietary adaptation and evolutionary transitions in marsupials but also reflects ontogenetic development, making

dental characteristics useful indicators for age and maturity differentiation (Mckay et al., 2023).

Significant development of the testes and liver indicates physiological maturity, especially in terms of reproductive and metabolic function (Rumsayor et al., 2022). The morphometric data of internal organs revealed marked increases in liver, kidney, and testis weights in adult individuals compared to subadults (Table 3). Liver weight increased substantially from 69 g in subadults to 804 g in adults, while kidney weight increased from 13 g to 61 g, and testicular weight from 2 g to 37 g. These pronounced changes reflect the enhanced metabolic capacity and reproductive readiness associated with adulthood.

The growth of internal organs such as the testes and kidneys in marsupials has been widely linked to the attainment of sexual maturity and reproductive competence (Bradshaw & Bradshaw, 2011). Although increased testicular mass does not necessarily determine breeding seasonality, it has been associated with changes in sperm morphology, including reduced sperm head length and the occurrence of abnormal spermatozoa (Martin et al., 2018).

Overall, the internal morphometric results indicate clear age-related variation in tooth characteristics and organ dimensions among male dusky pademelons. As summarised in Table 3, differences in tooth number and internal organ size reflect progressive physiological development associated with maturity. Such variation is likely driven by intrinsic factors, including age and reproductive status, as well as extrinsic influences such as habitat conditions and dietary availability.

Fur colour variation further supported age differentiation, with subadult individuals generally exhibiting lighter brown coats, whereas adult individuals tended to display darker brown to nearly black fur. Coat colour variation in marsupials has been linked to hormonal changes, sexual maturity, and adaptive responses to environmental conditions, particularly in open or savanna-dominated habitats (Bond et al., 2024).

### **Biological and Conservation Implications**

The present findings demonstrate that external morphometric traits, particularly chest circumference, body size, and fur colour together with indicators of internal organ development, can serve as practical baseline criteria for distinguishing maturity stages in male dusky pademelons. This information is especially critical in traditionally hunted populations, where local hunters often experience difficulties in differentiating subadult individuals from reproductively mature adults, increasing the risk of unintended overharvesting.

Educational approaches based on simple and easily recognisable morphological cues, such as body size, chest circumference, and coat colour, should therefore be developed and disseminated to support sustainable and culturally rooted wildlife utilisation. Morphological identification offers a practical field-based tool, particularly in remote areas where advanced techniques such as genetic analysis, tagging, or long-term population monitoring are not feasible (Barron et al., 2022).

Integrating morphometric knowledge into local hunting practices and community-based monitoring programs can enhance the inclusivity and effectiveness

of conservation efforts, while remaining respectful of indigenous knowledge systems and traditional livelihoods. Involving local hunters in monitoring based on visible morphological characteristics not only improves data reliability but also fosters a sense of ownership, stewardship, and responsibility toward wildlife resources (Pattiselanno et al., 2023).

Moreover, recognising and prioritising the protection of reproductively mature individuals is essential for maintaining population structure and long-term viability, given their key role in reproduction and population renewal. In the long term, the incorporation of morphometric criteria into community regulations, customary laws, or co-management frameworks may help balance traditional hunting practices with biodiversity conservation goals, particularly within protected areas such as Wasur National Park. Such integrative, evidence-based approaches are fundamental for sustaining ecological integrity while supporting local socio-cultural systems.

Educational approaches based on simple and easily recognisable morphological cues—such as body size, fur colour, and chest circumference should be developed and disseminated to support sustainable and culturally rooted wildlife utilisation. The ability to distinguish age groups using visible morphological markers provides a practical and cost-effective tool for field identification, particularly in remote areas where advanced techniques such as genetic analysis, tagging, or telemetry are not feasible (Feldhamer et al., 2007).

Integrating morphometric knowledge into local knowledge systems can enhance the inclusivity and effectiveness of conservation efforts, while remaining respectful of indigenous practices and traditional hunting norms. Community involvement in wildlife monitoring based on observable characteristics has been shown to improve data reliability and promote a sense of ownership and stewardship over wildlife resources (Pattiselanno et al., 2023).

Moreover, recognising and prioritising the protection of reproductively mature individuals given their essential role in reproduction and population structure—is critical for maintaining population viability in hunted species (Bradshaw & Bradshaw, 2011). In the long term, incorporating morphometric criteria into community regulations, customary laws, or co-management frameworks offers a viable approach to balancing traditional hunting practices with biodiversity conservation goals (Barron et al., 2022). Such integrative strategies are fundamental for sustaining ecological integrity in protected areas such as Wasur National Park. These findings reinforce the value of simple morphometric indicators as cost-effective tools for bridging scientific research and community-based wildlife management in traditionally hunted species

## CONCLUSION

This study aimed to characterise external and internal morphometric variation in dusky pademelons (*Thylogale brunii*) across age groups in order to identify practical morphological indicators of physiological maturity relevant to conservation and sustainable use. The results confirm that this objective was achieved, as significant differences were observed in tooth dimensions, organ size, and organ weight between

juvenile and adult individuals. Internal organ development, particularly of the liver, kidneys, and testes, proved to be the most reliable indicators of metabolic and reproductive maturity, while external traits such as chest circumference and body size offer practical, non-invasive markers for age classification. These morphometric differences reflect functional and ecological transitions associated with maturity, rather than simple size variation, underscoring their biological and applied significance.

The novelty of this study lies in its integrative morphometric approach, combining dental, internal organ, and external body measurements to provide the first comprehensive baseline data for male *T. brunii* in southern Papua, where empirical information remains scarce. This study is limited by a relatively small sample size and the absence of seasonal and environmental variation analysis, which may constrain broader generalisation. Future research incorporating larger samples and temporal factors is recommended. Overall, the findings demonstrate that simple, observable morphometric indicators can serve as effective tools for age differentiation, supporting community-based monitoring, sustainable traditional hunting, and evidence-based conservation management in protected areas such as Wasur National Park.

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