



Eruption of posterior teeth in the maxilla and mandible for age determination of water deer



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ABSTRACT

Objective: Eruption of posterior teeth, including premolars and molars in the mandible rather than in the maxilla, is accepted as an accurate reference for age determination of deer. In water deer, *Hydropotes inermis*, the eruption age of mandibular molars has been described in two studies, but the ages were inconsistent with each other. In this study, we aimed to confirm the eruption age of mandibular posterior teeth for the accurate age determination of water deer and to evaluate the efficacy of maxillary posterior teeth for the age determination of deer.

Design: The eruption of mandibular and maxillary posterior teeth was investigated in the dry skulls of individual wild water deer of both sexes, up to an age of about 15 months.

Results: The eruption age of mandibular molars in water deer was consistent with that of a previous study. The eruption age of posterior teeth was almost the same in the maxilla and mandible of individual water deer. The deciduous mandibular fourth premolar and the permanent maxillary fourth premolar were two easiest teeth to be identified for the age determination.

Conclusions: The former controversial eruption age of mandibular posterior teeth in water deer was confirmed. Our study first presented the eruption age of maxillary posterior teeth in water deer. It is suggested that posterior teeth not only in the mandible but also in the maxilla are useful indicators for the age determination of water deer.

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1. Introduction

In Pecora, such as deer, giraffes, antelopes, sheep, and cattle, molars are selenodont with crescent-shaped ridges. The curvatures of the ridges are opposed between the posterior teeth of the maxilla and mandible. The concave side of the curvature faces buccally in the maxillary molars, while it faces lingually in the mandibular molars to effectively shear fibrous plant material by medial jaw movements (Rowe, Johns, & Osborn, 1981). The following dental formula is almost universal in Pecora. Pecora have three incisors, a canine, three premolars, and three molars in a quadrant of the mandible, but it has six posterior teeth in a

quadrant of the maxilla. There are neither incisors nor canines in the maxilla. The six posterior teeth are the second premolar, third premolar, fourth premolar, first molar, second molar, and third molar. Some deer in Pecora, such as musk deer and water deer, lack horns or antlers but have a canine in a maxillary quadrant. The males in particular develop large, continuously growing maxillary canine tusks (Rowe et al., 1981). Deer have both deciduous and permanent premolars characterized by the orderly replacement of deciduous premolars by successive permanent premolars (Severinghaus, 1949).

The age determination of the animals represented within archaeological assemblages has always been the main concern of zooarchaeology, and the reliable ageing technique is necessary for the establishment of the hunting and management strategies for wild animals (Bowen et al., 2016).

As the clearly recognizable stages of tooth development provide a useful tool for the age determination of individuals with forming dentitions in most mammal species (Hillson, 2005), posterior teeth

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have been used as an important indicator in determining the age of deer. A technique was outlined for assigning white-tailed deer (*Odocoileus virginianus*) an age using the eruption and wear patterns of posterior teeth (Severinghaus, 1949). The correlation between tooth eruption, tooth wear, and age has been studied in many other species of deer, such as fallow deer (*Dama dama*), red deer (*Cervus elaphus*), and roe deer (*Capreolus capreolus*) (Brown & Chapman, 1991a, 1991b; Carter, 1997; Kierdorf, Hommelsheim, & Kierdorf, 2012). Tooth eruption is accepted as an accurate reference for age determination of white-tailed deer younger than two years old, while tooth wear was not consistent and reliable for accurate age determination of individual deer (Cook & Hart, 1979; Gilbert & Stolt, 1970; Hamlin, Pac, Sime, DeSimone, & Dusek, 2000; Jacobson & Reiner, 1989; Mitchell & Smith, 1991; Ryel, Fay, & Van Etten, 1961; Sauer, 1971). The age of full molar eruption has also been described in water deer, *Hydropotes inermis* (Dubost, Charron, Courcou, & Rodier, 2008; Dubost, Charron, Courcou, & Rodier, 2011), but the ages in these previous studies were not consistent with each other. Furthermore, the age of premolar replacement has not been identified in water deer yet.

Mandibular premolars and molars were used as references for age determination in many species of deer, while the criteria for determining age using the eruption of maxillary premolars and molars has not been established sufficiently. It has been simply mentioned that maxillary posterior teeth were very similar to mandibular posterior teeth in eruption and wear (Severinghaus, 1949).

The aims of this study were (1) to provide a description of the eruption and replacement of the premolars and molars in the maxilla and mandible of water deer, based on macroscopic and radiographic assessments of individual water deer, and (2) to evaluate the efficacy of maxillary posterior teeth for the age determination of water deer by investigating their eruption and replacement.

2. Material and methods

All the dry skull samples studied here were preserved in the National Institute of Biological Resources (Incheon, Korea). Samples consist of wild water deer of both sexes ($n = 11$) up to an age of about 15 months postpartum. All water deer had died from car accidents, and the date of death had been recorded within a few days after death. Since the births of water deer took place during a period mostly between May 18 and June 20, on average on May 30–31, in each year (Dubost et al., 2008), their ages were estimated by calculating the elapsed months from May 31 of the same year or the previous year to the days of death in consideration of the tooth eruption pattern. The macroscopic images of skull samples were taken by digital camera, and the radiographic images were obtained by computed tomography (Alphard 3030, Asahi Roentgen Industry, Kyoto, Japan).

A permanent tooth has been considered fully erupted when it had reached its full height above the gingiva (Severinghaus, 1949) or when it comes into wear (Brown & Chapman, 1991a). In human skeletal material where gingival tissues are absent, the cervical line is always at, or above, the level of the alveolar bone crest even in juvenile specimens where a tooth is fully erupted (Scheuer & Black, 2004). Therefore, in the present study, the tooth was defined to be fully erupted when the cervical line was observed.

3. Results

3.1. Eruption of mandibular posterior teeth of water deer

The deciduous premolars erupted earlier than the molars in the mandible (Fig. 1A and B). The first molar partially erupted at 1.5

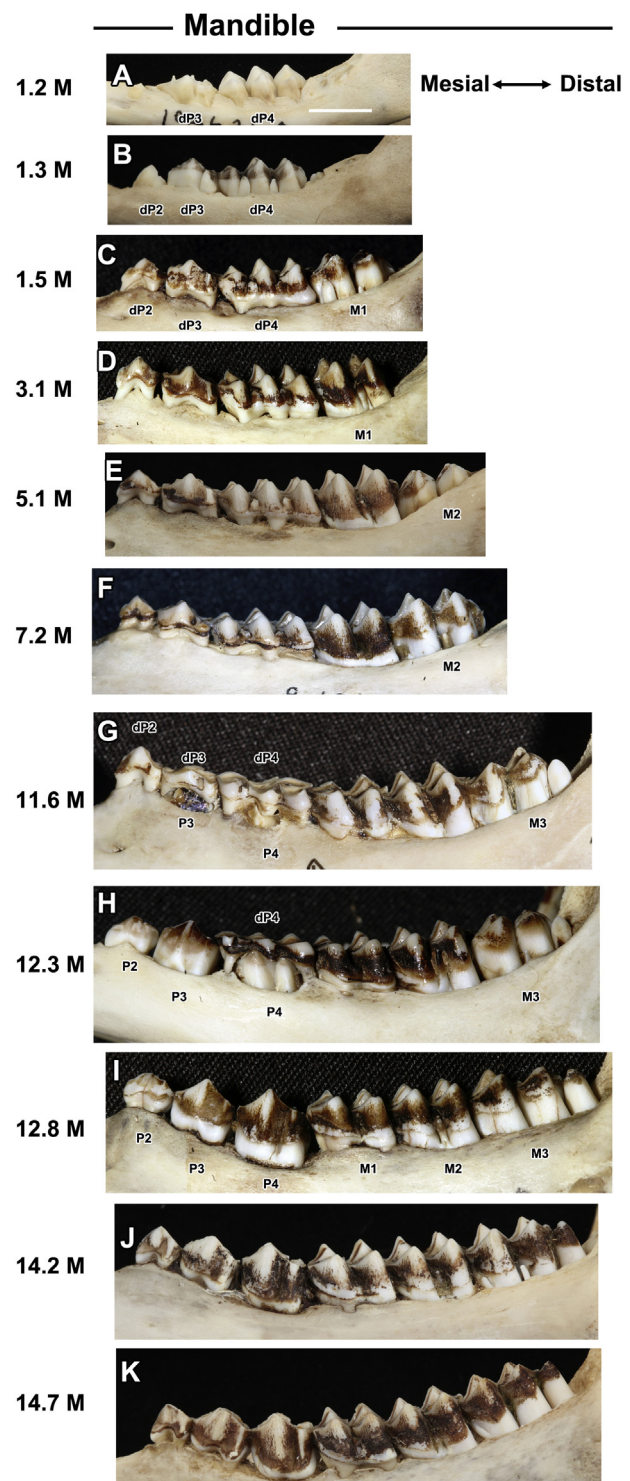


Fig. 1. Eruption of the mandibular posterior teeth of water deer according to age. (A and B) The deciduous second premolar (dP2), third premolar (dP3) and fourth premolar (dP4) are partially erupted at 1.2 months and 1.3 months of age and fully erupted at 1.5 months. (C and D) The deciduous fourth premolar (dP4) is fully erupted at 1.5 months. The first molar (M1) shows partial eruption at 1.5 months and almost full eruption at 3.1 months. (E and F) The eruption of the second molar (M2) is complete at 7.2 months. (G–I) Third molar (M3) eruption is partial at 11.6 months and 12.3 months. The permanent second premolar (P2) and third premolar (P3) erupt under their preceding deciduous premolars (dP2 and dP3) and are completely erupted in the samples at 12.8 months. The permanent fourth premolar (P4) erupts under the preceding deciduous premolar (dP4) and is completely erupted in the samples at 12.8 months. (J and K) The cusps of all posterior teeth have been clearly peaked due to attrition at 14.2 months and 14.7 months. Scale bar size: 1 cm

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