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Research paper

# Strain-dependence of age-related cochlear hearing loss in wild and domesticated Mongolian gerbils

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**Abstract**

The Mongolian gerbil (*Meriones unguiculatus)* is one of the animal models in auditory research that has been used in several studies on age-related hearing loss. The standard laboratory strain is domesticated as it was bred in captivity for more than 70 years. We compared properties of distortion product otoacoustic emissions (DPOAEs) in domesticated gerbils with wild-type gerbils from F6–F7 generations of a strain originating from animals trapped in Central Asia in 1995. Up to an age of 9 months, DPOAE thresholds were comparable between both strains and were below 10 dB SPL for *f*2 frequencies between 4 and 44 kHz. In older domesticated animals, the thresholds were increased by up to 12 dB. Significant increases were found at stimulus frequencies of 2 kHz, 12–20 kHz, and 56–60 kHz. The best frequency ratio *f*2/*f*1 to evoke maximum DPOAE amplitude was larger in domesticated animals at the age of 9 months or older. While these data show that there is a deterioration of cochlear sensitivity due to domestication, the magnitude of the described changes is small. Thus, the general suitability of domesticated gerbils for auditory research seems not to be affected.
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*Keywords:* DPOAE; Otoacoustic emission; Cochlear mechanics; *Meriones unguiculatus*

## 1. Introduction

The Mongolian gerbil (*Meriones unguiculatus*) is a small rodent living in Mongolia, southern Russia, and northern China. Its hearing range covers most of the human audiogram and extends into the ultrasonic frequency range (Ryan, 1976). Gerbils are available from commercial breeders and can easily be kept under standard laboratory housing conditions. Almost all animals of those colonies descend from a group of 20 founders trapped in 1935 in Mongolia. Due to a long period of inbreeding and domestication in animals descending from those colonies, many changes are reported (Stuermer et al., 2003), like 18% decrease of brain weight (Stuermer et al., 1997), higher testicular activity (Blottner et al., 2000), increased sperm production (Blottner and Stuermer, 2006), and improved reproductive fitness (Stuermer et al., 2006). These domestication effects are an adaptation to the modified living conditions in laboratory breeding colonies. Since there are various physiological changes, the sensory systems could be affected, also. Anatomical data show, for example, that domestication differentially affects cochlear nucleus subdivisions in gerbils (Gleich et al., 2000). The primary aim of the present study was to evaluate possible effects of domestication on cochlear sensitivity and to assess if

*Abbreviations:* ANOVA, analysis of variance; DPOAE, distortion product otoacoustic emission; EP, endocochlear potential; OHC, outer hair cell; SPL, sound pressure level

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age-dependent deterioration of hearing as it is described for gerbils (e.g., Mills et al., 1990; Schmiedt et al., 1990; Tarnowski et al., 1991; Boettcher et al., 1993, 1996; Sinnott et al., 1997; Hamann et al., 2002) or mice (Jacobson et al., 2003; Guimaraes et al., 2004) differs between domesticated and wild-type gerbils.

In this study auditory thresholds were measured using distortion product otoacoustic emissions (DPOAEs). DPOAEs are a consequence of nonlinear mechanical amplification of low level sounds by cochlear amplification mechanisms. Auditory threshold curves based on DPOAEs represent relative hearing thresholds that in many vertebrates investigated usually are parallel to behavioural or neuronal threshold curves (bats: Kössl, 1992, 1994; Echidna: Mills and Shepherd, 2001; Tenrec: Drexl et al., 2003; human: e.g. Boege and Janssen, 2002) but are slightly less sensitive. There can be differences, too, between the shapes of DPOAE- and behavioural or neuronal threshold curves due to frequency specific pinna gain or neuronal processing (Wittekindt et al., 2005). In the gerbil, for frequencies above about 2 kHz the shape of DPOAE threshold curves is comparable to neuronal or behavioural data, while for lower frequencies DPOAE thresholds are clearly less sensitive (Ryan, 1976; Müller, 1996; Faulstich and Kössl, 2000). Despite such differences, DPOAE thresholds obtained under the same recording conditions are ideally suited to compare cochlear sensitivity across different animal strains or age groups.

## 2. Material and methods

### 2.1. Animals

Animals from two different strains of Mongolian gerbils (*M. unguiculatus)* were used in this study for comparison. A group of 32 animals of both sexes weighing 48–76 g (mean 59 g) were from the strain Ugoe:MU95 (Stuermer et al., 2003). These animals were bred in the F6 or F7 generation from animals captured in Mongolia near 47 ° N, 105.5 ° E in 1995 (Stuermer et al., 2003). They will be referred to as "wild-types".

The second group (30 animals, both sexes, weighing 46–114 g) were from the domesticated laboratory strain (strain Tum:MON). The laboratory strain was bred from a group of 20 founders caught in 1935 in Central Asia. Six pairs of these were brought to the Tumblebrook Farm, Ltd., Brant Lake, New York (Cheal, 1986) in 1954 to build up a new breeding colony. Charles Rivers Laboratories obtained animals from this group in 1995 to breed them in Europe. These animals will be referred to as "domesticated".

All animals were kept and treated the same way. Water and food was available *ad libitum*. Animals were kept under a 12:12 h light/dark circle. The experiments reported here comply with NIH Guidelines for the Care and Use of Laboratory Animals (NIH publication No. 86–23, revised 1996). A respective animal experimentation permit was granted from the Hessonian government.

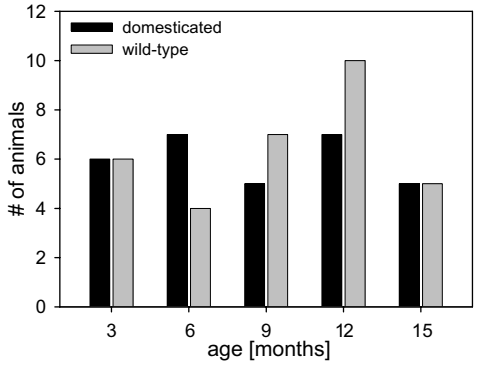


Fig. 1. Number of animals in the five age groups of domesticated gerbils (black bars) and wild-type gerbils (grey bars).

Animals from both strains were divided into five age groups as indicated in Fig. 1. In the youngest age group (3 months) they were 89–94 d old. In the 6-month age group the animals were 181–185 d old, in the 9-month group the age was between 271 and 283 d and in the 12-month group between 362 and 370 d. The last group (15–28 months) comprised animals older than 453 d.

### 2.2. Anaesthesia

Gerbils were lightly anaesthetised with an initial intramuscular injection of ketamine hydrochloride (Ketavet®, 55–78 mg/kg bodyweight) and xylazine hydrochloride (Rompun®, 2.5–3.5 mg/kg bodyweight). Anaesthesia was maintained throughout the experiment by means of a continuous subcutaneous injection of approximately 35% of the initial dose/h, using a syringe pump (SP100i Syringe Pump). The animals were kept under light anaesthesia such that limb withdrawal reflexes were brisk. After switching off the continuous anaesthetic injection, gerbils were fully awake after 30 min. Their body temperature was kept between 37.5 and 38.5 °C using a heating blanket. The body temperature was measured with a thermometer (Conrad Digital Immersion Thermometer) positioned between the heating blanket and the body of the gerbil. This thermometer was calibrated before starting the series of experiments reported here by using a rectal probe (Digital Precision Thermometer GTH 175/Pt Greisinger Electronic GmbH).

### 2.3. Experimental setup

The measurements were made in an acoustically insulated sound chamber. The head of the gerbil was fixed in a mouth holder to avoid injury of the tympanic membrane. It was ensured that the ear canal was free of earwax or other contaminations. Under visual control an acoustic coupler containing two loudspeakers (1/2 in. B&K 4133, Brüel&Kjaer, Narum, Denmark; 1/2 in. Microtech Gefell MK202) and a microphone (1/4 in. B&K 4135) was placed into the external meatus of the left ear close to the tympanum. In two cases the right ear was used for measurments because of debris in the left meatus.

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