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Veterinary Dermatology

BRIEF COMMUNICATION

# Claw growth rates in a subset of adult, indoor, domestic cats (*Felis catus*)

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**Abstract**

**Background:** Keratinised tissues, such as nails and claws, accumulate hormones over time; the claws' hormone concentrations are being explored as potential biomarkers. Timelines for hormone deposition can be established if claw growth rates are known. Hormone concentration within cat claws has been recently evaluated, yet the growth rates of cat claws remain unknown.

**Hypothesis/Objectives:** To estimate the growth rate of adult cats' claws, we hypothesised that front claw growth rates would differ from those of rear claws.

**Animals:** Seventeen client-owned, indoor, neutered, adult cats.

**Materials and Methods:** Cats' claws were clipped and then measured lengthwise. Claws were repeatedly measured over time with repeat claw trims after approximately 1 month, followed by repeat measurements. Average claw growth rates were calculated for three digit groups: forelimb digit 1, forelimb digits 2–5 (front) and hind limb (rear). Growth rates of the front compared to the rear and digit 1 were compared through linear mixed effects regression modelling.

**Results:** The daily mean claw growth rates were 0.13 mm for front and digit 1, and 0.08 mm for rear. The growth rate of rear claws was significantly lower ($p < 0.001$) than for front claws; rear claws grew, on average, 0.04 mm less per day than front claws.

**Conclusions and Clinical Relevance:** Our study provides the first measurement of claw growth rates in cats. The significantly slower growth rate of rear claws compared to front claws should be considered when evaluating metabolites within cat claws.

**KEYWORDS**
biomarker, cortisol, feline, nail

## INTRODUCTION

Chemicals, pharmaceuticals, hormones, and metabolites are deposited within keratinised end organs (e.g. nails, claws) over extended periods (weeks to months).[1,2] Measuring hormone concentrations in claws has recently emerged as an innovative method to evaluate physiological processes over long intervals and may serve as long-term biomarkers of health and welfare.[2,3]

Before using claw-based biomarkers, it is essential to understand the species' claw growth rates, as the timeline for substance deposition depends upon keratinised tissue turnover. Hormone concentrations have been measured in dog and cat claws.[4–6] The reported growth rate for dog claws is between 0.70 and 2.10 mm/week,[7] extrapolated as 1.90 mm/week.[8] For cats, a growth rate of 1.90 mm/week is frequently cited;[9–11] however, the original source traces back to the dog claw growth rate data.[7] A recent study[4] reported unpublished data of the cat's average front claw growth rate of 2.40 and 1.70 mm/21 days for the rear claws. These unpublished findings require confirmation by a prospective study.

Human nail growth rates differ between fingernails, toenails, and the first great toenail.[12] Considering the

functional and morphological differences in cats' front versus rear digits and limbs,[13] the growth rate of cats' front and rear claws might differ.

The objective of this study was to estimate the growth rate of adult cats' claws. The goal was to establish an exposure time frame when evaluating hormone deposition into the keratinous matrix of cat claws. We hypothesised that the front claw growth rate would differ from the rear claw growth rate.

## MATERIALS AND METHODS

### Cats

Adult cats were sampled in 2018 and 2022. The 2018 cats were owned by the authors (ETC, KB) and sampled during a different study.[4] The 2022 cats were recruited via email request to veterinary students, faculty, and staff. All cats had to be extremely amenable to handling and tolerate gentle paw and digit holding and claw trimming. Some of the cats received 20 mg/kg of oral gabapentin 90–120 min before claw measurement.[14] Cats exhibiting distress or reluctance were excluded from participation. Informed written consent was obtained from owners, and Institutional Animal Care and Use Committee approval was granted (Long Island University IACUC no. 2020-009).

### Sampling measurements and data collected

Gentle, calm handling techniques were used during sampling. Claws were clipped just distal to the quick from all front and rear paw digits. Each claw was then gently protracted by applying light pressure to the skin pouch. A flexible millimetre tape was used to measure the length (to the nearest mm) from just beyond the unguicular pleat to the apex point of the claw (Figure 1). For the 2018 cohort, claws were measured at 5-day intervals (range 3–11 days), followed by claw trims after 21–22 days, and this sequence was repeated. Preliminary findings indicated no difference in claw growth rate by interval (unpublished data); thus, in 2022, claws were measured at 5-week intervals (range 35–42 days) to emulate time between regular feline claw trims. Each 5-week measurement was followed by trimming and measurements, and this sequence was repeated three times. All measurements were taken by one veterinarian (ETC).

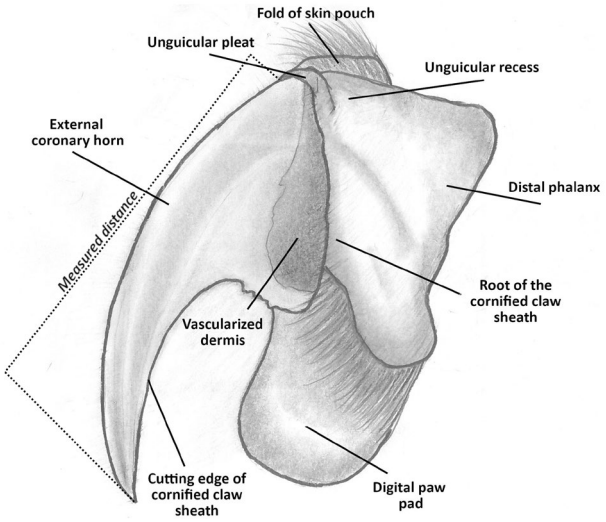


**FIGURE 1** Illustrative drawing of a retracted feline claw depicting its anatomical structures. Drawing by Courtney Hegwer.

Claw growth rate was calculated for three digit groups: 1st digit of the forelimb (digit 1),[12] digits 2–5 of the forelimb (front), and digits 2–5 of the hind limb (rear). Within each digit group, the average claw length (mm) for each time interval for each cat was calculated, and the length difference between intervals was divided by the number of days in that time interval to obtain a growth rate (mm) per day.

Age, sex, neuter status, weight, body condition score (BCS), information regarding general living environment, and owner-reported medical information were recorded for each cat.

### Statistical analyses

Data were analysed using STATA v14.2 (StataCorp. 2015). Descriptive statistics were calculated, and categorical data were expressed as frequencies and percentages. To provide comprehensive data for the reader and future research, continuous data were expressed as medians, means, and ranges.

Linear mixed-effects regression modelling was used to test for differences in claw growth rates in cohort years (2018 vs. 2022) and claw type (front vs. rear, front vs. digit 1), and to screen other factors for associations. This model accounted for repeated measurements within each cat, and cat ID was included as a random effect. Statistical significance was set at $p<0.05$.

## RESULTS

Seventeen adult, neutered, indoor cats were sampled (Table 1). None had known or diagnosed claw or clawfold pathologies, or visible claw, digit, or dermatological abnormalities. All cats had scratching surfaces in their households and received regular claw trims.

There were 116 front and rear claw measurements: 84 from nine cats in 2018 and 32 from eight cats in 2022.

Cohort year (2018 vs. 2022) was not significantly associated with claw growth rate of front ($p=0.31$), digit 1 ($p=0.17$) or rear claws ($p=0.05$) (see Table S1 in Supporting information); therefore, data were pooled (Table 2). Median growth rates per day were 0.13 mm for front, 0.10 mm for digit 1, and 0.08 mm for rear claws. The growth rate of rear claws was significantly lower ($p<0.001$) than that for front claws; rear claws grew, on average, 0.04 mm less per day than front claws. The growth rate of digit 1 was not different from the growth rate of front claws ($p=0.35$). Claw growth rate was not significantly associated with other evaluated factors (Table 3).

**TABLE 1** Demographics and characteristics of the cat claw growth investigation cohort.

| Factor | |
|---|---|
| Age (years) | 6.0 (3.5–16.0) |
| Body weight (kg) | 5.0 (3.1–6.7) |
| Body condition score (1–9) | 5 (4–7) |
| Breed | |
| Domestic short hair | *N*=12 (70.6%) |
| Domestic medium hair | *N*=2 (11.8%) |
| Domestic long hair | *N*=3 (17.6%) |
| Sex | |
| Spayed female | *N*=4 (23.5%) |
| Neutered male | *N*=13 (76.5%) |
| Managed medical conditions | |
| Chronic kidney disease | *N*=2 (11.8%) |
| Chronic rhinitis | *N*=2 (11.8%) |
| Feline immunodeficiency virus (FIV) | *N*=3 (17.6%) |
| Daily oral medications received | |
| Doxycycline | *N*=1 (5.9%) |
| Gabapentin | *N*=1 (5.9%) |
| Fluoxetine | *N*=1 (5.9%) |

*Note*: Age, body weight and body condition score are represented as median and range. Other factors are represented as counts and percentage of total number of cats.

**TABLE 2** Median, mean, and range of increase in feline claw length (mm) per day by different digit groupings.

| Paw grouping | Time interval | Median (mm) | Mean (mm) | Range (mm) |
|---|---|---|---|---|
| Front (digits 2–5) | Day | 0.13 | 0.13 | 0.01–0.27 |
| Front digit 1 | Day | 0.10 | 0.12 | 0.01–0.45 |
| Rear (digits 2–5) | Day | 0.08 | 0.08 | 0.01–0.30 |

**TABLE 3** Significance (*p*-values) for associations of factors with growth rates of claws by different digit groupings.

| Factors | Digit groupings | | |
|---|---|---|---|
| | Front (digits 2–5) | Front digit 1 | Rear (digits 2–5) |
| Age | 0.28 | 0.74 | 0.71 |
| Sex | 0.96 | 0.11 | 0.84 |
| Weight | 0.05 | 0.62 | 0.13 |
| Chronic illness (*n*=4) | 0.37 | 0.45 | 0.91 |
| FIV positive (*n*=3) | 0.62 | 0.92 | 0.96 |
| Daily medications (*n*=3) | 0.71 | 0.72 | 0.72 |

Abbreviation: FIV, feline immunodeficiency virus.

## DISCUSSION

This is the first study to measure and report claw growth rates for a group of indoor, adult domestic cats. Our calculated median rates differ markedly from cited rates[9–11] extrapolated from dogs.[7]

Cat claws differ from dog claws in morphology, function, and structure, including their retractile mechanism, pointed tips, and sharp edges. Unlike dog claws, cat claws have a retractile mechanism that sheaths the proximal portion of the cat's claw beneath the unguicular pleat during regular locomotion, with the claw extruding during, for example, climbing or grasping (Figure 1).[15] The dorsal side of the cat's claw has deep unguicular recesses that add to an area of proliferating living epidermis; there is thus a higher rate of production on the dorsal side of the claw as compared to the lateral, medial, and ventral aspects, creating the characteristic curvature of the claw and contributing to the sharp edges and tips.[10,16]

Our hypothesis that rear claw growth would differ from front claw growth was confirmed. The cats' front limbs, digits and claws differ from the rear in function, musculature and innervation.[13] Cats' front claws and forelimbs are specialised for grasping, prehending, and capturing prey,[15,16] with front digits that can be splayed, while the hind limbs and digits provide more support and leverage.[13,17] Rear cat claws also do not curve into as large an angle as the front claws.[17] Our findings, combined with the knowledge of differing functions of front versus rear limbs, digits, and claws in cats, underscore the importance of considering claw location when evaluating metabolite deposition in cat claws.

Because hormones accumulate over time in keratinised tissues, hormones including cortisol, progesterone, testosterone, 17-B-estradiol, and dehydroepiandrosterone can be measured in claws.[5,18] Cortisol is a hormone frequently evaluated, and its concentration in claws is an emerging potential chronic stress biomarker in multiple species.[3,4,6,18] Our study's findings of an approximate cat claw daily growth rate are therefore important additions to the literature, so that the time period represented by a clipped claw segment and the deposition of hormones into that segment can be approximated. However, caution in assigning specific time periods to a segment is warranted, as it is also possible that there is a time lag between the deposition of a hormone into the keratinised segment and the subsequent emergence of the claw distally.

This study had several limitations. Objective data from medical records and diagnostics were not collected. As parasitism, inflammatory conditions, and systemic diseases can influence claw growth,[19] future studies using feline claw growth rates should consider obtaining bloodwork, medical record data, and dietary and behavioural histories. The study also had a small sample size; however, we feel that the sample was representative of stable, adult cats of varied ages. Furthermore, multiple measurements were obtained from each cat over different time periods, providing many measurements from which to obtain average or median growth rates. Future studies also might evaluate outdoor cats' claws and cats who rarely or never have claw trims, as their claw growth rates might differ from our study sample rates.

## CONCLUSIONS

Our study provides the first accurate measurement of claw growth rates in a group of adult, indoor, neutered cats, underscoring the need to update existing resources. The significantly slower growth rate of rear versus front claws should be considered when evaluating metabolites within all claws combined or when analysing rear claws in front-declawed cats. Overall, our findings offer a foundation for future research, now that a time frame for trimmed segments has been estimated.

### AUTHOR CONTRIBUTIONS

**Elena T. Contreras:** Conceptualization; data curation; formal analysis; methodology; project administration; resources; supervision; visualization; writing – review and editing; writing – original draft; investigation. **Kate Bruner:** Investigation; resources; writing – review and editing. **Courtney Hegwer:** Investigation; resources; visualization; writing – review and editing. **Andrew Simpson:** Conceptualization; supervision; validation; visualization; writing – original draft; writing – review and editing.

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### FUNDING INFORMATION

Self-funded.

### CONFLICT OF INTEREST STATEMENT

No conflicts of interest have been declared.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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### SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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**Zusammenfassung**
**Hintergrund:** Keratinisiertes Gewebe wie Nägel und Krallen akkumulieren mit der Zeit Hormone; die Hormonkonzentrationen der Krallen werden als Biomarker untersucht. Eine Zeitachse für die Hormonablagerung kann erstellt werden, wenn die Wachstumsraten der Krallen bekannt sind. Hormonkonzentrationen in Katzenkrallen sind unlängst evaluiert worden, allerdings ist die Geschwindigkeit des Krallenwachstums bei Katzen nicht bekannt.
**Hypothese/Ziele:** Eine Erstellung der Wachstumsrate bei den Krallen erwachsener Katzen. Wir hypothetisierten, dass die Wachstumsraten der vorderen im Vergleich zu den hinteren Krallen unterschiedlich waren.
**Tiere:** 17 kastrierte, erwachsene Wohnungskatzen in Privatbesitz
**Materialien und Methoden:** Die Katzenkrallen wurden geschnitten und dann im Längsschnitt gemessen. Die Krallen wurden mit der Zeit wiederholt gemessen, wobei die Krallen nach einem Monat wieder geschnitten wurden, gefolgt von einer wiederholten Messung. Das durchschnittliche Krallenwachstum wurde in drei Zehen-Gruppen kalkuliert: Vorderextremität Zehe 1, Vorderextremität Zehe 2–5 (vorne) und Hinterextremität (hinten). Die Wachstumsraten von vorne und hinten wurden verglichen und Zehe 1 wurde mittels Mehrebenen-Regressionsmodell verglichen.
**Ergebnisse:** Die täglichen durchschnittlichen Wachstumsraten der Kallen waren 0,13 mm für die vorderen und Zehe 1, und 0,08 mm für die hinteren. Die Wachstumsrate der hinteren Krallen war signifikant niedriger ($p<0,001$) als die der vorderen Krallen; die hinteren Krallen wuchsen im Durchschnitt 0,04 mm weniger pro Tag als die vorderen Krallen.
**Schlussfolgerungen und klinische Bedeutung:** Unsere Studie liefert die ersten Messungen vom Krallenwachstum bei Katzen. Die signifikant niedrigere Wachstumsrate der hinteren Krallen im Vergleich zu den vorderen Krallen sollte bei der Evaluierung von Metaboliten in den Katzenkrallen bedacht werden.

**摘要**
**背景:** 角质化组织(如指甲和爪子)会随着时间的推移积累激素 ; 人们正在探索爪子的激素浓度作为潜在的生物标记。如果知道爪子的生长率 , 就可以确定激素沉积的时间表。最近有人评估了猫爪内的激素浓度 , 但猫爪的生长率尚不清楚。
**假设/目标:** 估计成年猫爪子的生长率。我们假设前爪的生长率与后爪的生长率不同。
**动物:** 17只客户拥有的、室内的、已绝育的成年猫
**材料和方法:** 修剪猫爪 , 然后纵向测量。在大约 1 个月后重复修剪爪子 , 然后重复测量 , 并随时间反复测量爪子。计算了三个数字组的平均爪子生长率:前肢数字 1、前肢数字 2–5(前)和后肢(后)。通过线性混合效应回归模型比较了前爪与后爪和第 1 趾的生长率。
**结果:** 前爪和第 1 趾的日平均爪生长率为 0.13 毫米 , 后爪的日平均爪生长率为 0.08 毫米。后爪的生长率明显低于($p<0.001$)前爪 ; 后爪平均每天比前爪少长 0.04 毫米。
**结论和临床意义:** 我们的研究首次测量了猫爪的生长率。在评估猫爪内的代谢物时 , 应考虑后爪比前爪生长率明显较慢这一因素。

**Résumé**
**Contexte:** Les tissus kératinisés, tels que les ongles et les griffes, accumulent des hormones au fil du temps ; les concentrations d'hormones dans les griffes sont étudiées en tant que biomarqueurs potentiels. Les taux de croissance des griffes permettent d'établir des calendriers de dépôt d'hormones. La concentration d'hormones dans les griffes de chat a été récemment évaluée, mais les taux de croissance des griffes de chat sont inconnus.
**Hypothèse/Objectifs:** Estimer le taux de croissance des griffes des chats adultes. Nous avons émis l'hypothèse que le taux de croissance des griffes avant serait différent de celui des griffes arrière.
**Animaux:** 17 chats adultes d'intérieur, castrés et appartenant à des clients.
**Matériels et méthodes:** Les griffes des chats ont été coupées puis mesurées dans le sens de la longueur. Les griffes ont été mesurées à plusieurs reprises au fil du temps, avec des coupes répétées après environ 1 mois, suivies de mesures répétées. Les taux de croissance moyens des griffes ont été calculés pour trois groupes de doigts : le doigt 1 du membre antérieur, les doigts 2 à 5 du membre antérieur (avant) et le membre postérieur (arrière). Les taux de croissance de l'avant par rapport à l'arrière et au doigt 1 ont été comparés par le biais d'un modèle de régression linéaire à effets mixtes.
**Résultats:** Les taux de croissance quotidiens moyens des griffes étaient de 0,13 mm pour les griffes antérieures et le doigt 1, et de 0,08 mm pour les griffes postérieures. Le taux de croissance des griffes arrière était significativement plus faible ($p<0,001$) que celui des griffes avant ; les griffes arrière ont grandi, en moyenne, de 0,04 mm de moins par jour que les griffes avant.
**Conclusions et pertinence clinique:** Notre étude fournit la première mesure des taux de croissance des griffes chez les chats. Le taux de croissance significativement plus lent des griffes arrière par rapport aux griffes avant doit être pris en compte lors de l'évaluation des métabolites dans les griffes des chats.

**要約**
**背景:** 爪や鉤爪などの角化組織は、時間の経過とともにホルモンを蓄積する。鉤爪のホルモン濃度は、潜在的なバイオマーカーとして研究されている。爪の成長速度がわかっていれば、ホルモンが蓄積される時期を特定することができる。猫の爪内のホルモン濃度は最近評価されたが、猫の爪の成長速度は不明である。
**仮説/目的:** 本研究の目的は、成猫の鉤爪の成長率を推定することであった。前鉤爪の成長速度と後鉤爪の成長速度は異なると仮定した。

**供試動物:** 室内飼い、去勢済みのオーナー所有成猫17頭。
**材料と方法:** 猫の鉤爪を切り取り、長さを測定した。約1ヵ月後に爪切りを繰り返し、その後繰り返し測定した。前肢第1指、前肢第2~5指(前肢)、後肢(後肢)の3つの指群について、鉤爪の平均成長率を算出した。前肢と後肢の成長率を線形混合効果回帰モデリングにより比較した。
**結果:** 鉤爪の日平均成長率は前肢と第1指が0.13mm、後肢が0.08mmであった。後肢の鉤爪の成長率は前肢の鉤爪より有意に低かった($p<0.001$);後肢の鉤爪の成長率は前肢の鉤爪より1日平均0.04mm低かった。
**結論と臨床的意義:** 本研究は、猫における鉤爪の成長速度を初めて測定したものである。猫の鉤爪内の代謝物を評価する際には、後肢鉤爪の成長速度が前肢鉤爪に比べて有意に遅いことを考慮すべきである。

**Resumo**
**Contexto:** Tecidos queratinizados, como unhas e garras, acumulam hormônios ao longo do tempo; as concentrações hormonais das garras estão sendo exploradas como potenciais biomarcadores. Os cronogramas para a deposição de hormônios podem ser estabelecidos se as taxas de crescimento das garras forem conhecidas. A concentração de hormônios nas garras dos gatos foi avaliada recentemente, apesar de as taxas de crescimento das garras dos gatos não serem desconhecidas.
**Hipótese/Objetivos:** Estimar a taxa de crescimento das garras de gatos adultos. Nossa hipótese é que as taxas de crescimento das garras dianteiras seriam diferentes daquelas das garras traseiras.
**Animais:** 17 gatos adultos, castrados, de propriedade de clientes.
**Materiais e métodos:** As garras dos gatos foram cortadas e medidas longitudinalmente. As garras foram medidas repetidamente ao longo do tempo, com aparas repetidas das garras após aproximadamente 1 mês, seguidas de medições repetidas. As taxas médias de crescimento das garras foram calculadas para três grupos de dígitos: dígito 1 do membro anterior, dígitos 2–5 do membro anterior (dianteiro) e membro posterior (traseiro). As taxas de crescimento da frente em comparação com a traseira e do dígito 1 foram comparadas por meio de regressão linear de efeitos mistos.
**Resultados:** As taxas médias diárias de crescimento das garras foram de 0,13 mm para os membros dianteiros e dígito 1, e 0,08 mm para os membros traseiras. A taxa de crescimento das garras traseiras foi significativamente menor ($p<0,001$) do que as garras dianteiras; as garras traseiras cresceram, em média, 0,04 mm menos por dia do que as garras dianteiras.
**Conclusões e relevância clínica:** Nosso estudo fornece a primeira mensuração das taxas de crescimento de garras em gatos. A taxa de crescimento significativamente mais lenta das garras traseiras em comparação às garras dianteiras deve ser considerada ao avaliar os metabólitos nas garras dos gatos.

**RESUMEN**
**Introducción:** Los tejidos queratinizados, como las uñas y las garras, acumulan hormonas con el tiempo; las concentraciones hormonales de las garras se están explorando como posibles biomarcadores. Se pueden establecer cronogramas para la deposición de hormonas si se conocen las tasas de crecimiento de las garras. Recientemente se ha evaluado la concentración hormonal en las garras de los gatos, pero se desconocen las tasas de crecimiento de las garras de los gatos.
**Hipótesis/Objetivos:** Estimar la tasa de crecimiento de las garras de los gatos adultos. Planteamos la hipótesis de que las tasas de crecimiento de las garras delanteras serían diferentes a las de las garras traseras.
**Animales:** 17 gatos adultos castrados, de interior y de propietarios particulares.
**Materiales y métodos:** Se cortaron las garras de los gatos y luego se midieron longitudinalmente. Las garras se midieron repetidamente a lo largo del tiempo con cortes repetidos de garras después de aproximadamente 1 mes, seguidos de mediciones repetidas. Las tasas de crecimiento promedio de las garras se calcularon para tres grupos de dígitos: dedo 1 de la extremidad anterior, dígitos 2 a 5 de la extremidad anterior (delanteros) y extremidad trasera (traseros). Las tasas de crecimiento de las garras delanteras en comparación con las traseras y el dedo 1 se compararon mediante un modelo de regresión lineal de efectos mixtos.
**Resultados:** Las tasas de crecimiento diarias promedio de las garras fueron de 0,13 mm para las delanteras y el dedo 1, y de 0,08 mm para las traseras. La tasa de crecimiento de las garras traseras fue significativamente menor ($p<0,001$) que la de las garras delanteras; las garras traseras crecieron, en promedio, 0,04 mm menos por día que las garras delanteras.
**Conclusiones y relevancia clínica:** Nuestro estudio proporciona la primera medición de las tasas de crecimiento de las garras en gatos. La tasa de crecimiento significativamente más lenta de las garras traseras en comparación con las garras delanteras debe tenerse en cuenta al evaluar los metabolitos en las garras de los gatos.