



A diagnostic character revisited: is there a fifth toe in the forefoot of *Dasyopus novemcinctus* (Xenarthra: Dasypodidae)?

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Armadillos (Xenarthra: Dasypodidae) are among the most conspicuous and peculiar groups of mammals, and are characterized by an armor of osteoderms covered by keratinized scutes. They are widespread in South America, with one species (*Dasyopus novemcinctus* Linnaeus) also reaching southern North America (Wetzel 1985, Aguiar & Fonseca 2008; Gardner 2008). Following the latest revision of the subfamily Dasypodinae (Wetzel & Mondolfi 1979), the single genus *Dasyopus* is partitioned into three subgenera: *Dasyopus*, *Cryptophractus* and *Hyperoambon*. *Cryptophractus* comprises the single species *D. pilosus* Fitzinger, and *Hyperoambon* was proposed for *D. kappleri* Krauss (Gardner 2008). *Dasyopus* (*Dasyopus*) contains five species (Wetzel & Mondolfi 1979; Vizcaíno 1995): *D. septemcinctus* Linnaeus, *D. hybridus* Desmarest, *D. novemcinctus*, *D. sabanicola* Mondolfi and *D. yepesi* Vizcaíno. Only *D. (H.) kappleri* is reported to retain five toes in the forefoot (Wetzel & Mondolfi 1979), while *D. (D.) novemcinctus* and *D. (C.) pilosus* are described as having only four toes on the forefoot (Hamlett 1939; Wetzel & Mondolfi 1979), the middle pair being the largest. *D. (C.) pilosus* is an enigmatic species because little is known about most aspects of its biology and morphology (see Vizcaíno & Loughry 2008). Much more has been published on the species of *D. (D.) novemcinctus*, particularly *D. novemcinctus*. Despite the substantial literature on this species (see Vizcaíno & Loughry 2008 for an extensive compilation), little is known about several aspects of the descriptive (e.g. Taylor 1976; Windle & Parsons 1899) and functional (e.g. Vizcaíno & Milne 2002) morphology of its limbs. Detailed studies on its fore and hindfeet morphology are not available.

The dissection of the forefeet of *D. (D.) novemcinctus* reveals features that might reevaluate the four toe anatomy as a diagnostic character of the subgenera *Dasyopus* and *Cryptophractus*.

Two male individuals of *D. (D.) novemcinctus*, an adult and a juvenile, from the center west of São Paulo State, were provided by the Department of Microbiology of UNESP—Botucatu campus, São Paulo State, Brazil, for a preliminary anatomical study of their feet (Fig. 1a). The specimens are housed at the Museu Nacional / UFRJ, Rio de Janeiro (MN 73384 and MN 73385, juvenile and adult, respectively). They were dissected and the fore limbs were detached from their respective girdles. Skin and soft tissues (muscles, tendons and ligaments) were carefully removed using scalpel. The bony elements (phalanges, carpals and metacarpals) were maintained *in situ* to permit descriptions of the joints. They were defleshed and placed in a peroxide (10 % volume) immersion bath for several hours until whitened and then sun dried. A video camera (Olympus DP25) coupled to an Olympus stereomicroscope were used to get a better view of the fingers and their structures.

Observation of the manus of the juvenile (MN 73384) revealed a reduced fifth toe lateral to the four toes described in the literature (Figs. 1b–c). Dissection showed that the fifth toe had the same anatomical arrangement of the first, with a metacarpal and two phalanges, the distal one being the ungueal that emerges from the skin. The phalangeal formula is thus 2-3-3-3-2. In the adult specimen (MN 73385), the fifth toe was not present externally. Internally phalanges were also absent, but a metacarpal was present (Figs. 1d–e). Consequently, the phalangeal formula is 2-3-3-3. Table 1 provides length measurements for the metacarpals and phalanges.

As mentioned above, five complete manual toes have so far been reported only for *D. (H.) kappleri*. The presence of five toes in the specimens under study is clearly not due to misidentification. Adult specimens of *D. (H.) kappleri* and *D. (D.) novemcinctus* are clearly distinguishable by their different body sizes (head + body length 240–314 vs. 365–573 mm, condylonasal length 57.9–75.5 vs. 78.7–110.9 mm; see Wetzel 1985). Additional morphological features are also diagnostic: scutes on fourth movable bands 43–62 vs. 54–64 mm, tail shorter (125–205 mm) and less than 70% of the length of head + body vs. tail longer (265–450 mm) and 70% or more of the length of head + body, less yellow on carapace vs. more yellow on sides of carapace, shorter palate 63–66% vs. longer palate 69% of condylonasal length (see Wetzel 1985). Further, two rows of long, projecting, spur-like scutes, bordered by non-protruding scale-rows on the knee

(Emmons & Feer 1997), a diagnostic character of *D. (H.) kappleri*, were absent in the specimens under study. Eventually, molecular and cytogenetic analyses on other specimens collected from the same region and with external characteristics identical to the specimens considered here were identified as *D. (D.) novemcinctus*, which has a very different genetic profile than *D. (H.) kappleri* (Pereira Jr. 2007).

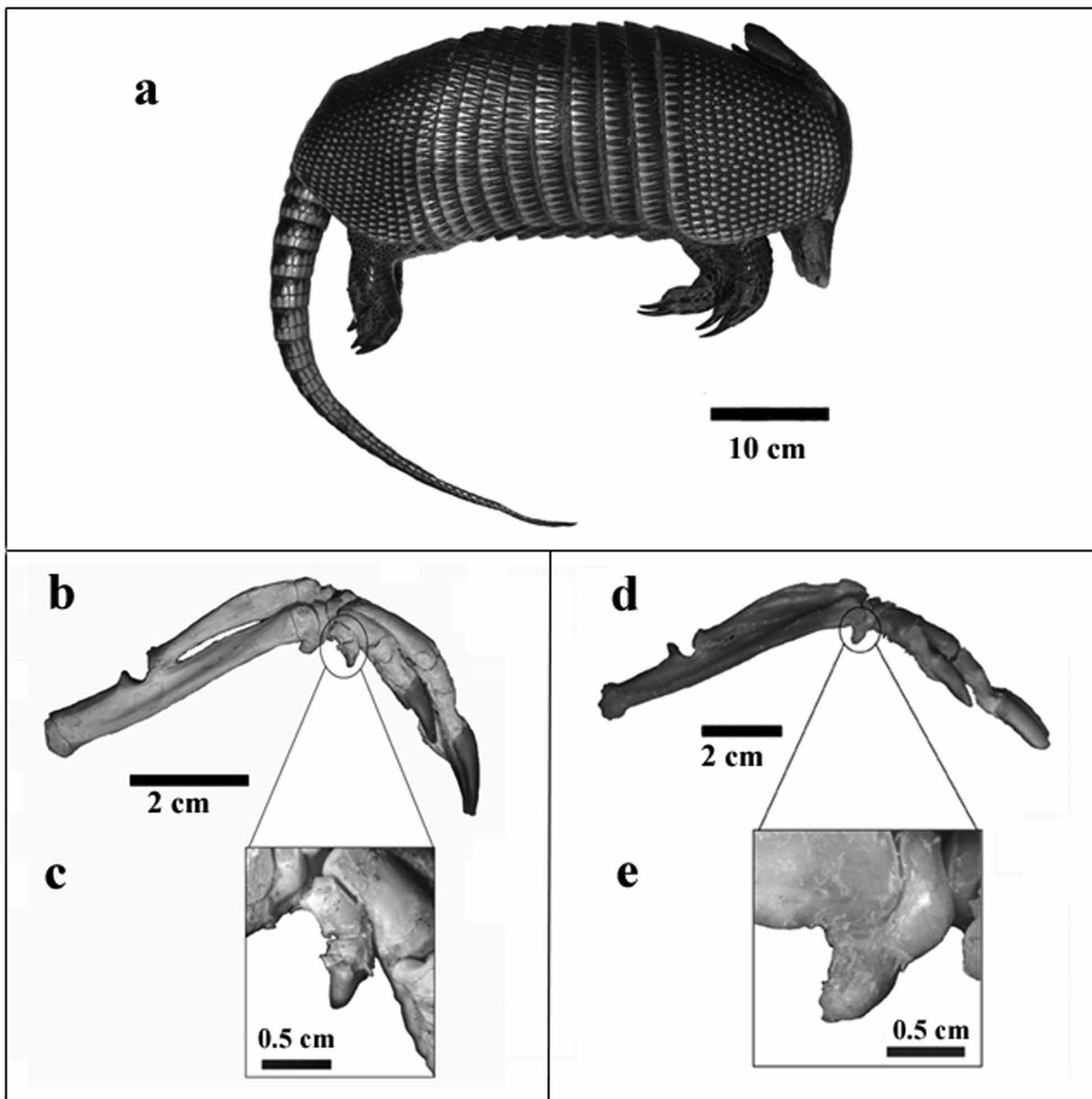


FIGURE 1. General aspect (a), forefoot (b) and fifth finger (c) of the juvenile specimen of *D. (D.) novemcinctus* (MN 73384); forefoot (d) and fifth finger (e) of the adult specimen (MN 73385).

The unanticipated occurrence of a fifth toe in a juvenile of *D. (D.) novemcinctus* draws attention to the value of its loss as a diagnostic character for the subgenera *Dasypus* and *Cryptophractus*. Possibly, the few works that mentioned the character only considered the external morphology of adult specimens. If the results here point to anatomic misinterpretation due to a lack of careful dissection of the forefeet of *D. (D.) novemcinctus* at different ontogenetic stages, it can be tested further by collection and dissection of *D. (D.) novemcinctus* from different parts of its range if other populations also present a fifth toe (genuine or residual). If so, there will be a need to review the taxonomic key that separates *D. (H.) kappleri* from the subgenus *Dasypus* based on the presence of a fifth toe on the forefoot (Hamlett 1939; Wetzel & Mondolfi 1979). From our observations, we emit the hypothesis that *D. (D.) novemcinctus* may have a fifth digit at birth and during infancy, subsequently lost when individuals start digging seriously (this could be extended to other armadillos as well). Such a hypothesis in turn could question the digging style of *D. (H.) kappleri*, being

sufficiently 'unusual' to avoid the subsequent loss of the fifth toe. Or conversely, it is also possible that the observations reported here (character retention) may be confined to the specific population, and perhaps to a particular individual, of *D. (D.) novemcinctus* from the center west of São Paulo State (Fig. 2). As a conclusion, more investigation efforts are needed to solve the taxonomic issue of the genuine presence of a fifth toe in *D. (D.) novemcinctus*, notably by extending the work to *D. (C.) pilosus*.

TABLE 1. Measurements of metacarpal bones and phalanges (in mm) in the two specimens of *D. (D.) novemcinctus*.

| Fingers | Phalanges | Juvenile (MN 73384) | Adult (MN 73385) |
|------------------------|-------------------------|---------------------|------------------|
| 1 st finger | Metacarpal | 4.8 | 7.2 |
| | 1 st phalanx | 3.9 | 4.3 |
| | Ungueal phalanx | 9.1 | 10.2 |
| 2 nd finger | Metacarpal | 13.3 | 15.0 |
| | 1 st phalanx | 6.3 | 6.9 |
| | 2 nd phalanx | 8.4 | 10.2 |
| | Ungueal phalanx | 15.0 | 17.4 |
| 3 rd finger | Metacarpal | 16.0 | 18.6 |
| | 1 st phalanx | 4.8 | 5.7 |
| | 2 nd phalanx | 6.8 | 8.2 |
| | Ungueal phalanx | 16.4 | 16.9 |
| 4 th finger | Metacarpal | 8.1 | 8.9 |
| | 1 st phalanx | 2.9 | 3.7 |
| | 2 nd phalanx | 5.5 | 6.5 |
| | Ungueal phalanx | 12.2 | 15.3 |
| 5 th finger | Metacarpal | 4.1 | 3.7 |
| | 1 st phalanx | 2.1 | - |
| | Ungueal phalanx | 2.8 | - |

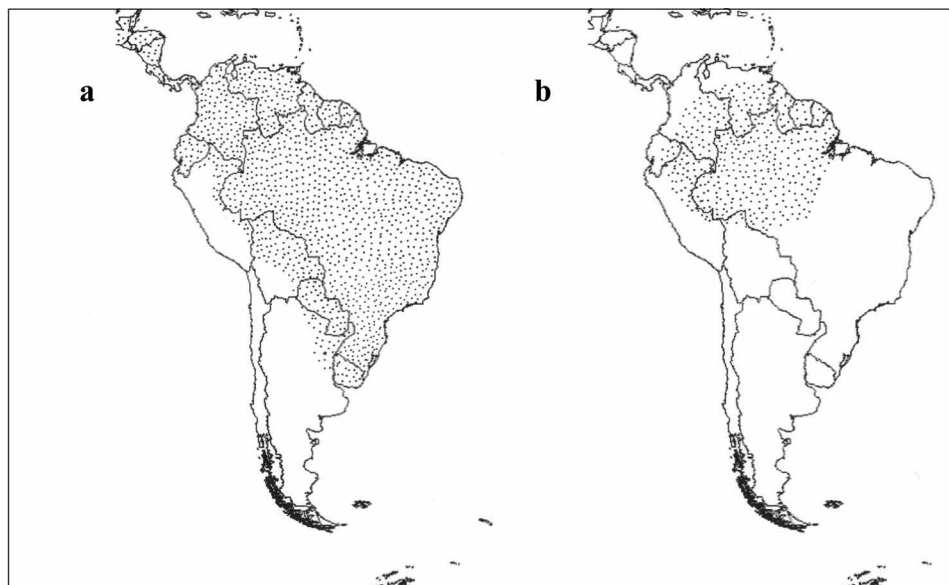


FIGURE 2. Geographical range of *D. (D.) novemcinctus* (a) and *D. (H.) kappleri* (b) in South and Central America (based on Aguiar & Fonseca 2008, and Vizcaíno & Loughry 2008).

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