FUNCTIONAL MORPHOLOGY OF THE POISON APPARATUS AND HISTOLOGY OF THE VENOM GLANDS OF THREE INDIAN SPIDERS[1]

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(With three plates and seven text-figures)

The morphology of the poison apparatus and the histology of the venom glands of three large Indian spiders, representing two major suborders, are described. Data pertaining to the morphometry of the poison apparatus of the three spiders are presented. Anatomically, the gland structure is fairly uniform consisting of two principal layers. However, differences were observed in the nature of the muscle layer and the venom secreting cells not only within the three species studied but also within the same species at different stages of their venom secretion.

INTRODUCTION

As spiders are obligate suctorial carnivores the study of the mouth parts, particularly the venom injecting apparatus, has been a subject of great interest to morphologists and physiologists, as reviewed by Bristowe (1954).

As early as 1878, Lebert described the poison glands of spiders as salivary glands situated in the cephalothorax with a pair of ducts opening at the tip of the "mandibulae falciformes". Berland (1922) made a comparative study of the anatomy of the poison glands of spiders and suggested that the glands might be concerned with digestion. Millot (1931) studied the poison glands of spiders from several points of view and explained their relation to the large ganglionic mass in the cephalothorax as having a certain taxonomic value.

Since most research on venomous spiders has been conducted by scientists working in the Pacific area, in the present investigation an attempt has been made to study the poison apparatus, the nature of the venom-secreting cells and venom of some Indian spiders.

MATERIALS AND METHODS

The specimens used in the present investigation were collected periodically within the 363 acre scrub jungle of the Madras Christian College and also from fields and deserted houses in the neighbouring villages on the outskirts of Madras. *Plesiophirctus collinus* Pocock 1899, the common funnel-web spider is a mygalomorph and *Heteropoda venatoria* Linn. 1766, the common house spider, and *Lycosa indagastrix* Walck 1837, the wolf-spider, are araneomorphs chosen for the present study.

Morphometric studies were carried out by measuring the different parts of the poison apparatus using a fine pointed divider and an ocular micrometer. The statistical methods employed in the study include correlation coefficient (r), Regression ($y = a + bx$, variation of Y (sd^2), 't' regression, F. variance and F. regression.

For histological studies, live spiders were allowed to bite a cockroach until the chelicerae were completely inserted into the victim. The glands from such spiders and from those that were not fed were removed and fixed in 10% buffered formalin, sectioned at 5 to 8 m thickness and stained in Hematoxylin and Eosin for observations under the light microscope, to document the nature of the secretory products and the mode of secretion of venom.

RESULTS AND DISCUSSION

Venom apparatus: The venom apparatus of spiders consists of a pair of chelicerae and a pair of venom glands. However, the position of the venom glands differs between the araeneomorphs

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or 'True spiders' and mygalomorphs or 'Tarantulas' as they are popularly known. Bertkau (1891) noticed differences in the size and site of the glands in several species of spiders, and described the compound gland of *Atypus*, the multilobular glands of *Filistata* and the bilobular glands of *Scytodes*. The position of the venom glands of the spiders studied are given in Fig. 1. In *P. collinus* the venom glands are situated dorsally in the basal article of the chelicerae, between the adductor and abductor muscles. The glands are carrot-like in form (Plate lc) with the broader end towards the base of the fang and the narrower posterior end inserted by an elastic fiber to the posterior border of the basal segment. This muscle fibre holds the gland firmly in its position.

The glands are white in colour, measuring about 3.5 mm to 4.0 mm in length, and about 0.8 to 1.0 mm in width, depending on the secretory state of the gland. In the true spiders *Heteropoda venatoria* and *Lycosa indagastrix*, the venom glands are situated in the cephalothorax with the adductor and abductor muscles holding them in position. The glands are sac-like or cylindrical and consist of two lobes (Plate 1a & b). Their length varies from 4.5 to 6.0 mm in *L. indagastrix* and are considerably smaller in *H. venatoria* measuring 3.0 to 4.0 mm.

The excreting canal is a long white tube. Its length in *P. collinus* corresponds to the length of the fangs, while in *Lycosa* and *Heteropoda* it corresponds to the length of both the articles of chelicerae. In true spiders the canal bears a spherical ampule at the junction of the fangs and the paturon. Its diameter varies from 0.35 mm to 0.45 mm in *L. indagastrix* and 0.10 to 0.15 mm in *H. venatoria*. Although the ampule is absent in the mygalomorph, the venom is ejected very efficiently, as the channel is short.

Morphometry: The following measurements were made to assess the growth rate of the poison apparatus in the spiders: length and width of

(1) the cephalothorax
(2) the paturon
(3) the fang
(4) the gland, and
(5) the duct.

It was observed that the determination of the growth rate of the venom apparatus and the comparison of the same in the three spiders based on allometric principle may reveal a better picture of the trend in the growth rate rather than the raw morphometric data. The allometric principle of growth, first proposed by Dubois (1897) explains the existence of a relation between the dimensions of various organs on the one hand and the dimension of a particular reference organ (X) on the other. The relationship is simplified by the formula $y = bx^a$. If $a>1$, it indicates that the rate of growth of a part is more than that of the reference organ; $a<1$ indicates a lower growth rate.

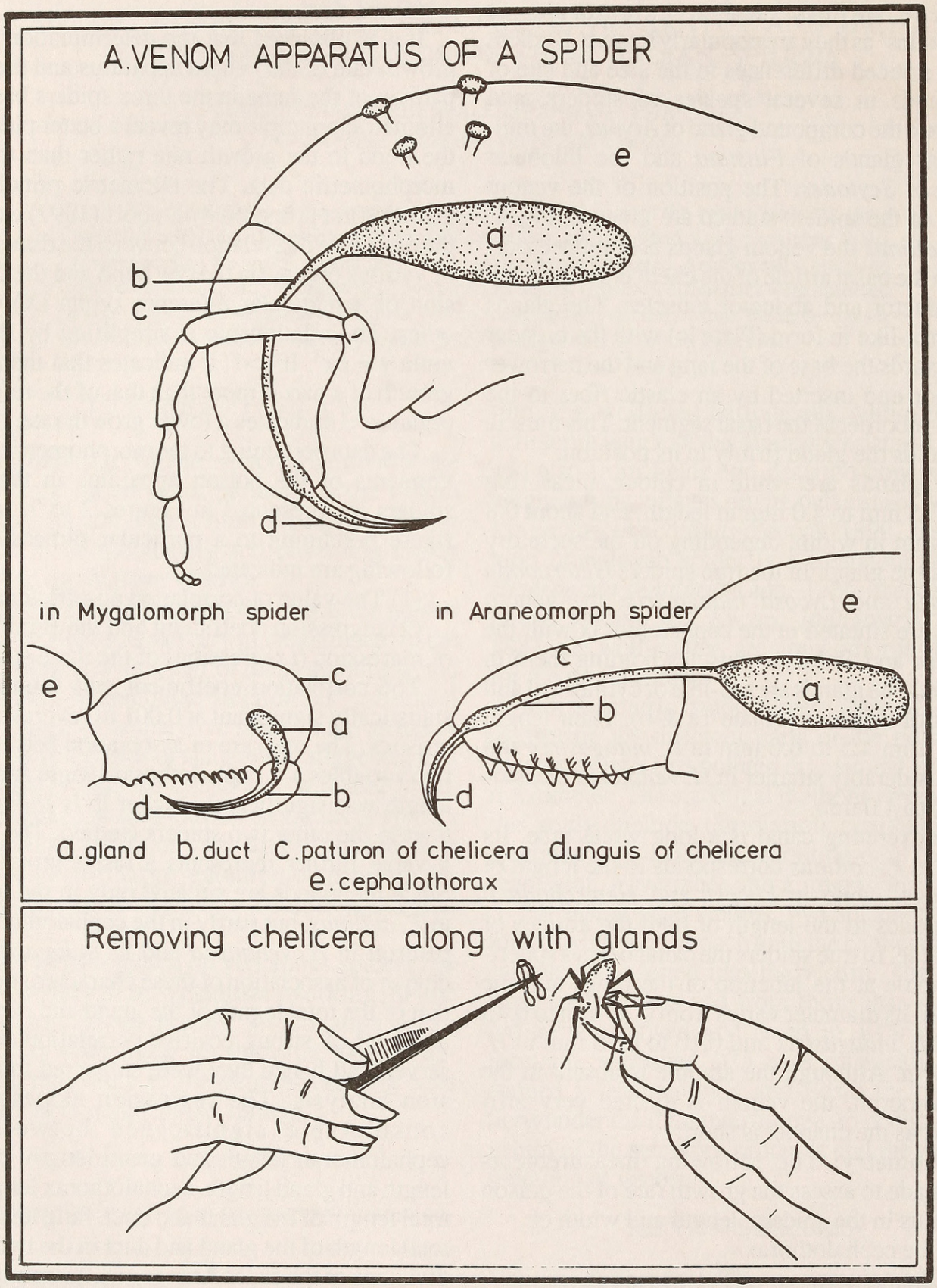
The data pertaining to the morphometric measurements of the poison apparatus in the three spiders are presented in Figures 2 to 7. In each figure pertaining to a particular dimension the following are indicated.

(1) The value of correlation co-efficient r

(2) regression coefficient and the significance of regression (t regression) of the three spiders.

The correlation coefficient was found to be statistically significant at 0.001 in several characteristics. The measure of association between the two variables, i.e. cephalothorax length and gland length was significantly higher in *L. indagastrix* than in the other two spiders studied. The higher b value further represents a faster growth rate. Since the glands are situated only in the paturon in *P. collinus*, but partly in the cephalothorax and paturon in *H. venatoria* and *L. indagastrix*, the degree of association of these characteristics with that of the total legnth of the gland and duct were analysed. A strong positive correlation was observed and hence they were subjected to regression analysis. The regression slopes reveal considerable significance between the cephalothorax length and gland length, paturon length and gland length, cephalothorax length and total length of the gland and duct, fang length and total length of the gland and duct in the two broad divisions of the order Aranea, the 'tarantulas' and 'true spiders'.

Histology of the venom glands:. Anatomically


A.VENOM APPARATUS OF A SPIDER
e
a
b
c
d
in Mygalomorph spider
in Araneomorph spider
e
c
a
b
d
e
c
a
b
d
a.gland b.duct c.paturon of chelicera d.unguis of chelicera
e.cephalothorax
Removing chelicera along with glands

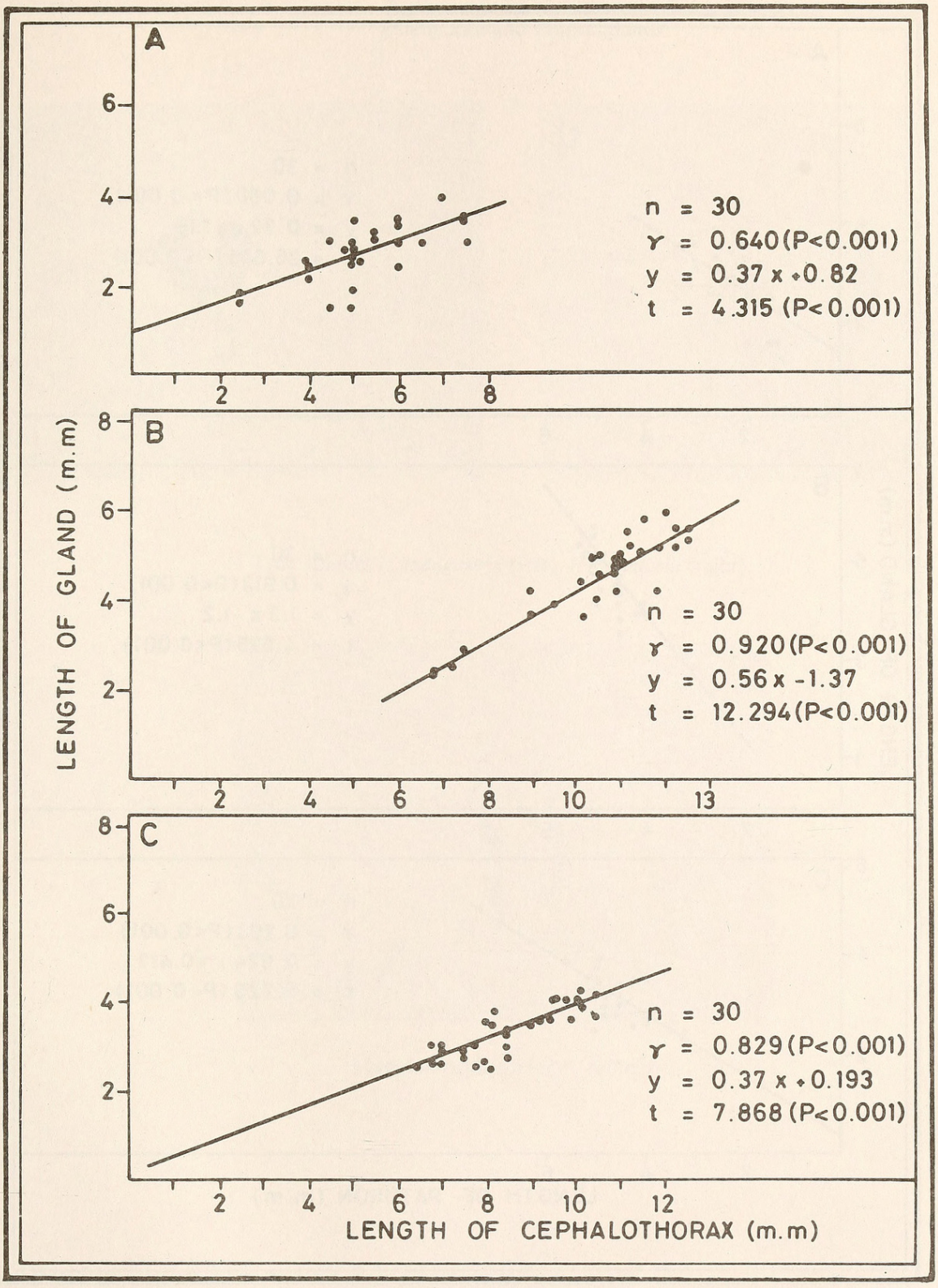


Fig. 2. Morphometric relationship of cephalothorax length to gland length for the three spiders: A: *Heteropoda venatoria*; B: *Lycosa indagastrix*; C: *Pleisiophirctus collinus*.

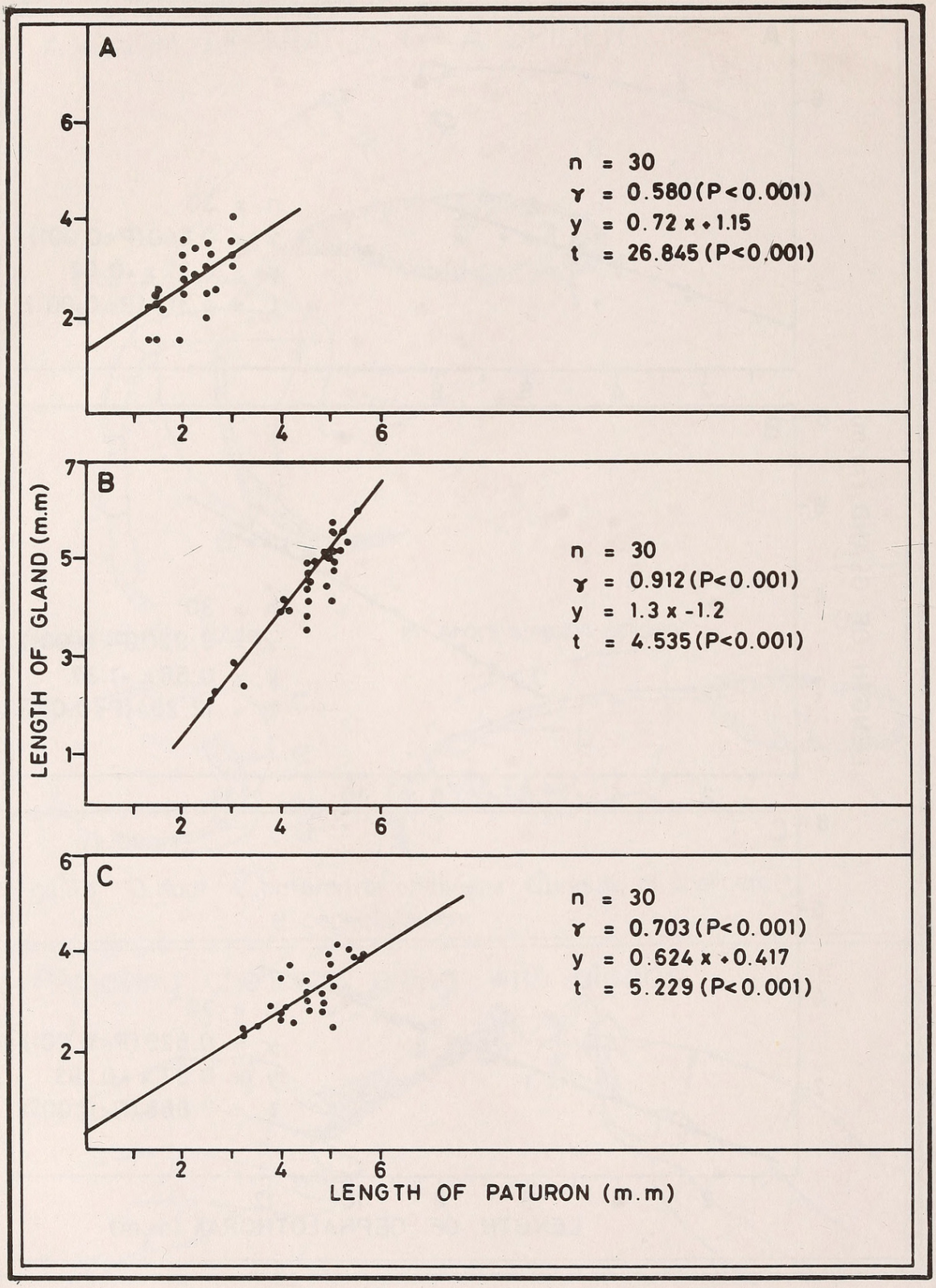
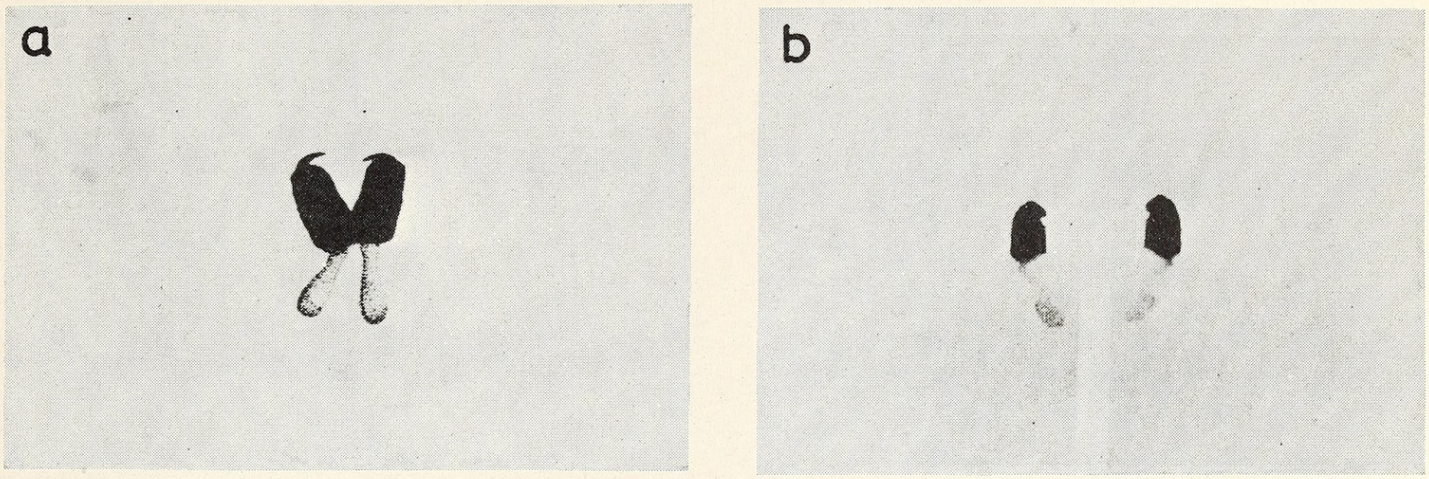


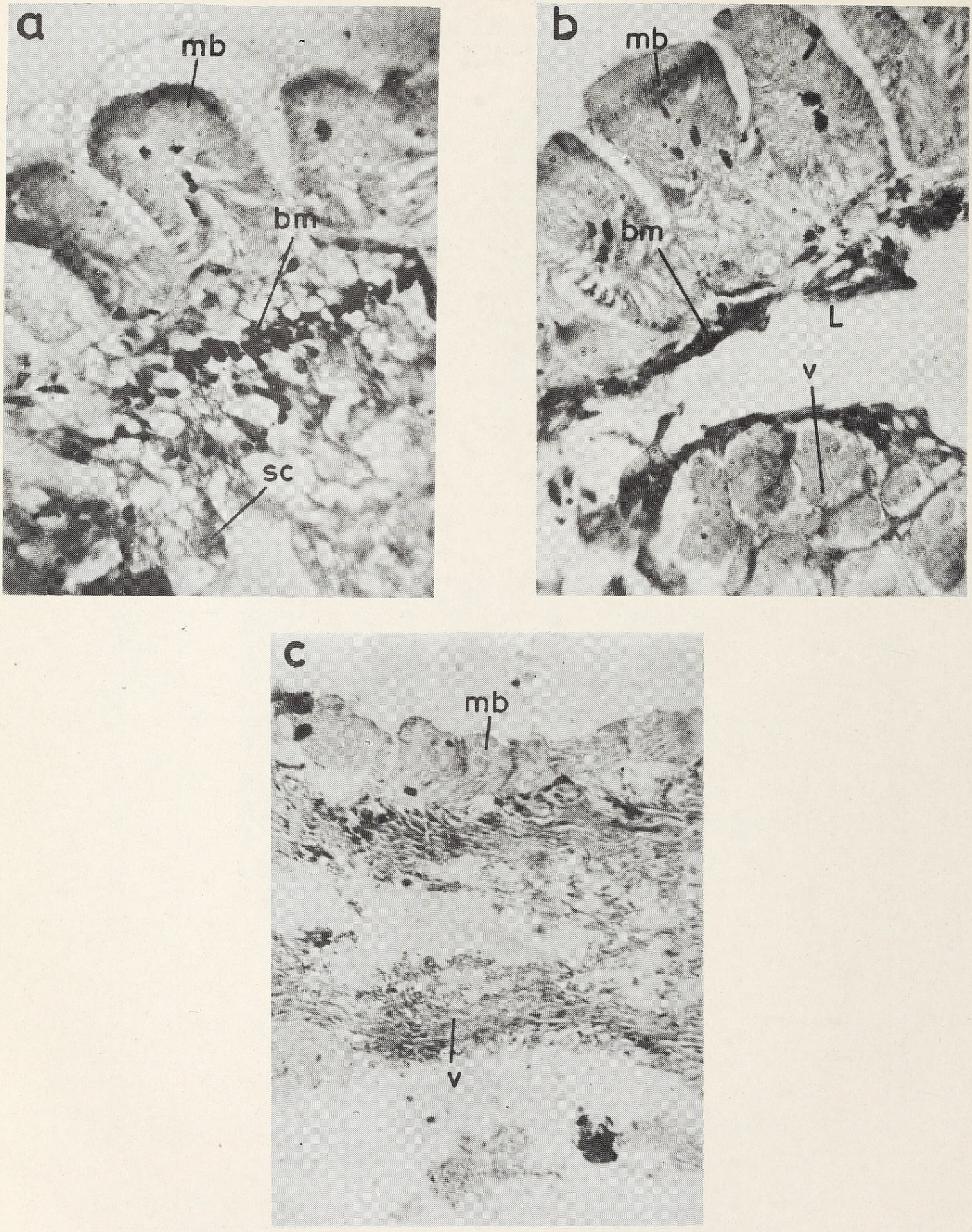
Fig. 3. Morphometric relationship of paturon length to gland length for the three spiders: A: *Heteropoda venatoria*; B: *Lycosa indagastrix*; C: *Pleisiophirctus collinus*.

Chelicerae and venom glands

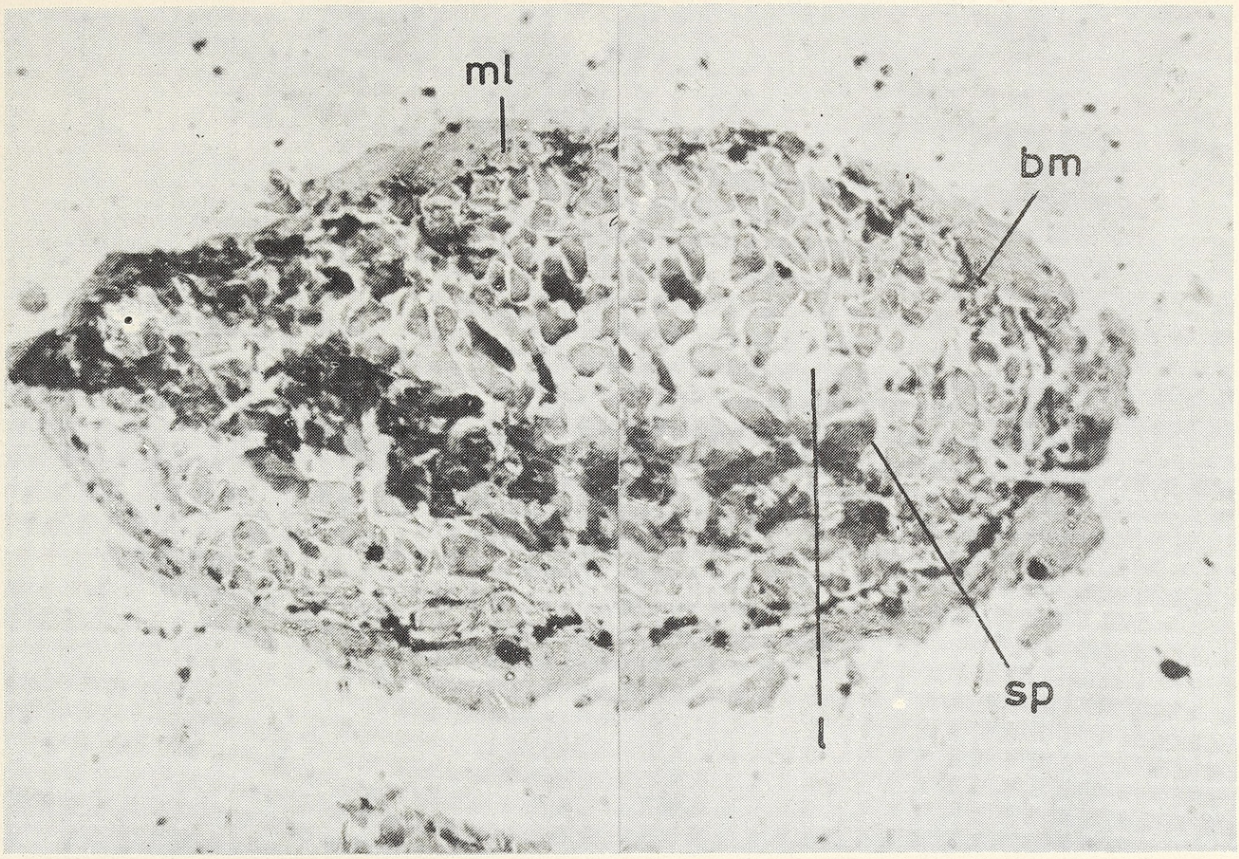


True spiders *L. indagastrix* (left), *H. venatoria* (right).

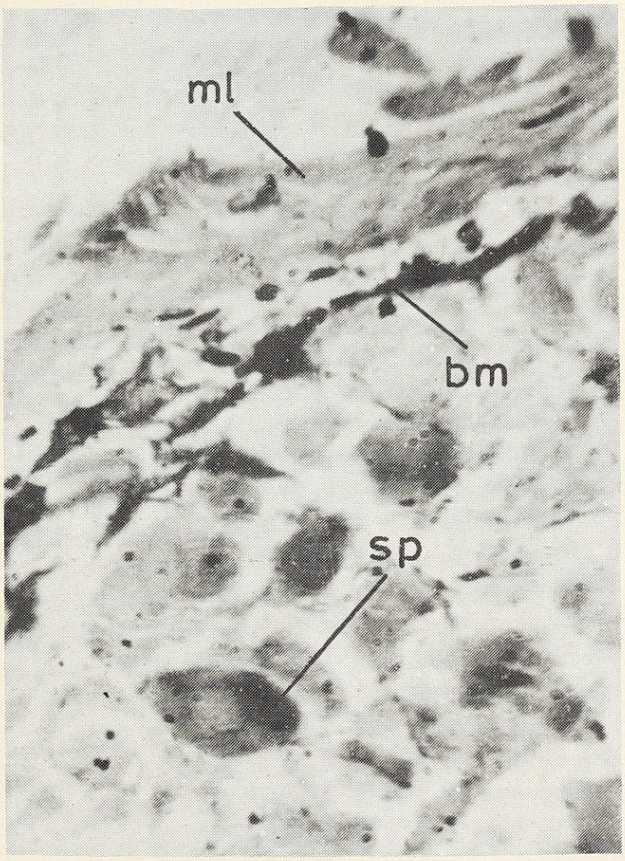
Mygalomorph spider *P. collinus*



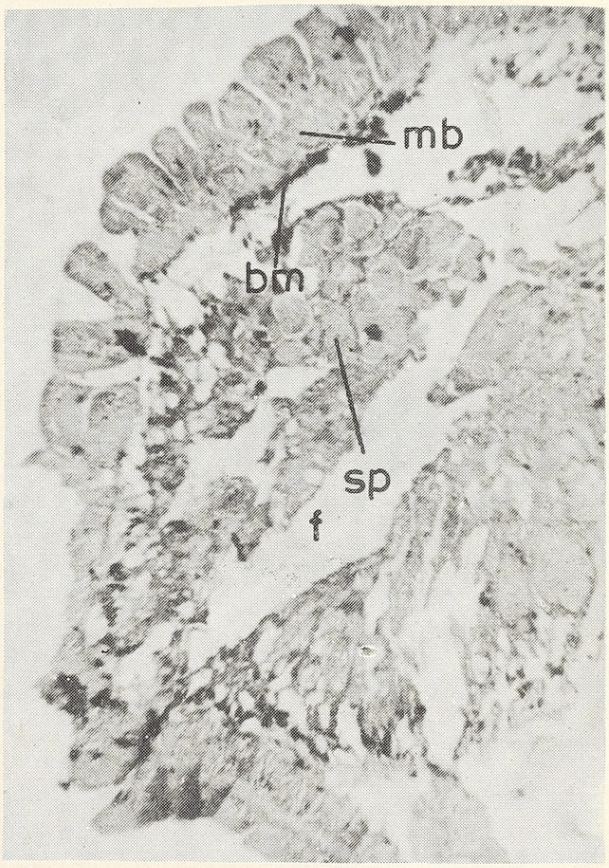
A cross section of the poison gland of *L. indagastrix* (unfed) showing the muscle blocks (mb), basement membrane (bm) and the secretory products—Venom (Sc & v) in the lumen (L).



a



b



c

a, b: A cross section of the poison gland of *H. venatoria* (unfed) showing the retention of the secretory products (sp) in the lumen (1) of the gland and also the muscle layer (ml) and the basement membrane (bm).

c: A cross section of the poison gland of *P. collinus* showing the muscle blocks (mb), basement membrane (bm), the basement processes extending into the lumen of the gland and the secretory products (sp).

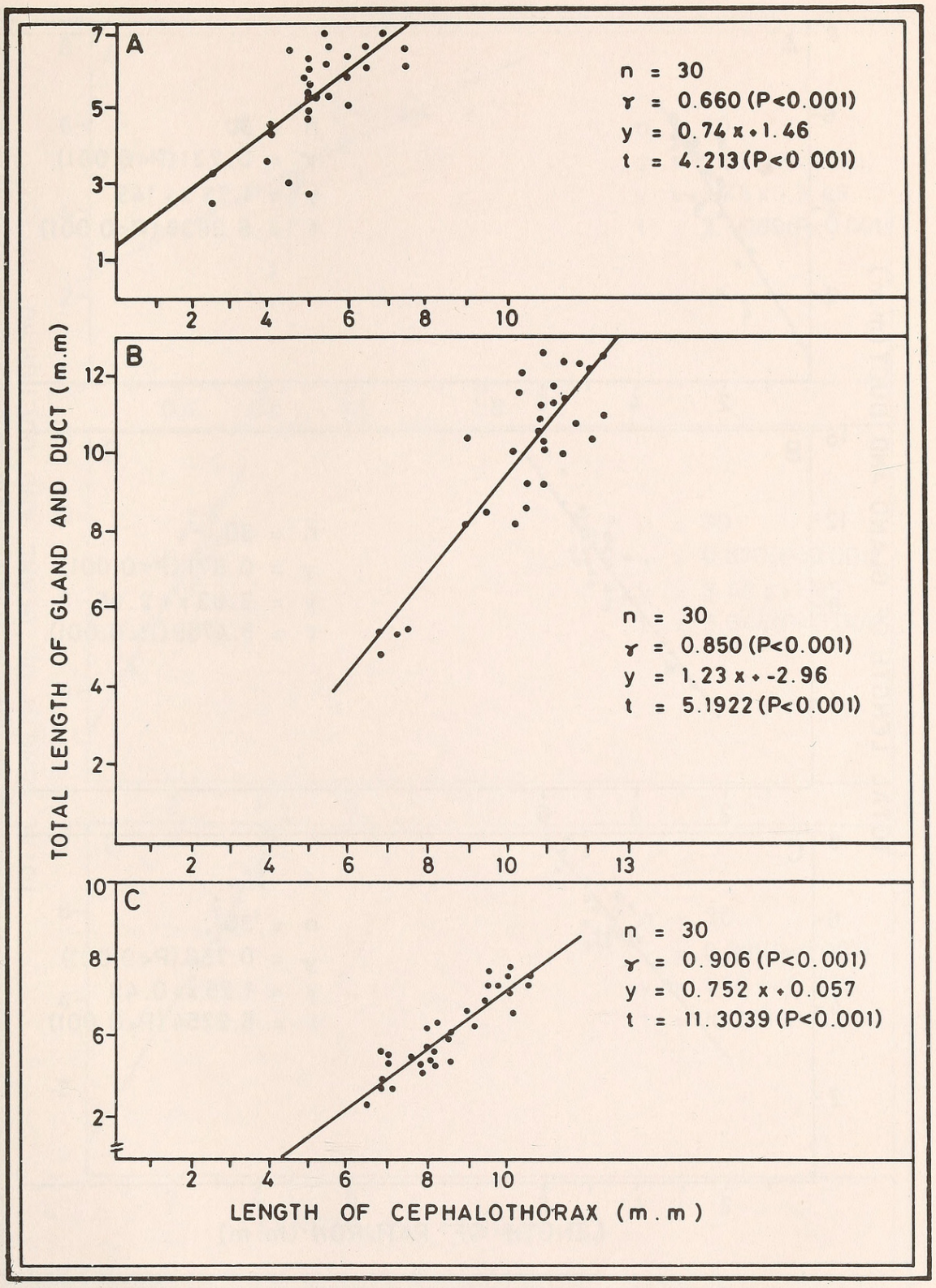


Fig. 4. Morphometric relationship of cephalothorax length to gland and duct length for the three spiders: A: *Heteropoda venatoria*; B: *Lycosa indagastrix*; C: *Pleisiophirctus collinus*.

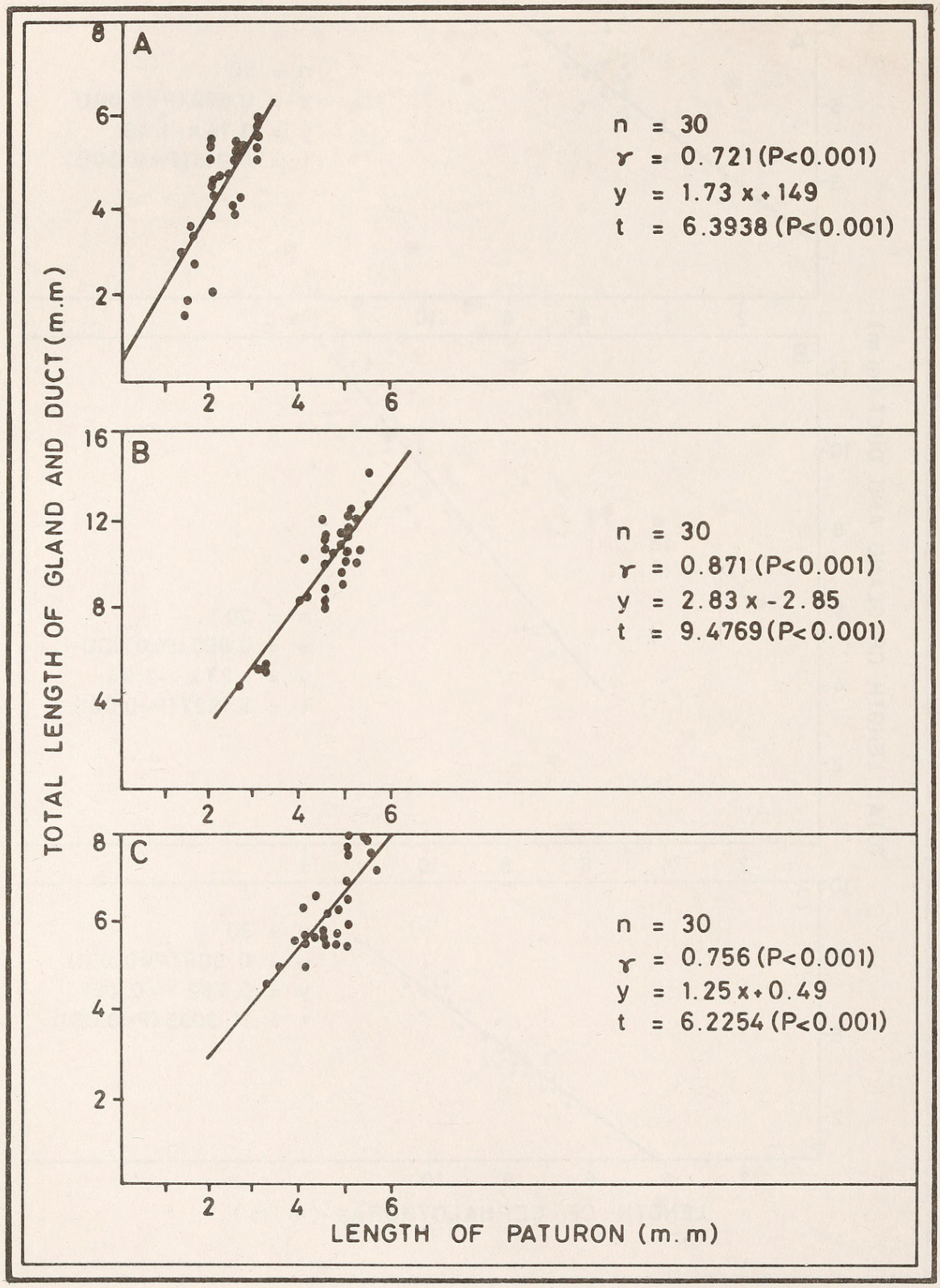


Fig. 5. Morphometric relationship of paturon length to gland and duct length for the three spiders: A: *Heteropoda venatoria*; B: *Lycosa indagastrix*; C: *Pleisiophirctus collinus*.