

# Chiropterologie



Kurz II

**Tomáš Bartonička**

Ústav botaniky a zoologie

Př MU

Další z “nej”:

*Tadarida  
brasiliensis  
mexicana*

tadarida guánová



**Fig. 1** Range of *Tadarida brasiliensis mexicana* with ranges of the putative migratory groups given as shaded areas (from Cockrum 1969). Sampled populations are indicated.





Bracken Cave Texas  
Tadarida guanová 40 mil.

*Tadarida brasiliensis*  
Lovná oblast kolonie  
ca 10000 km<sup>2</sup>



# Brazilian free-tailed bats (*Tadarida brasiliensis*: Molossidae, Chiroptera) at high altitude: links to migratory insect populations

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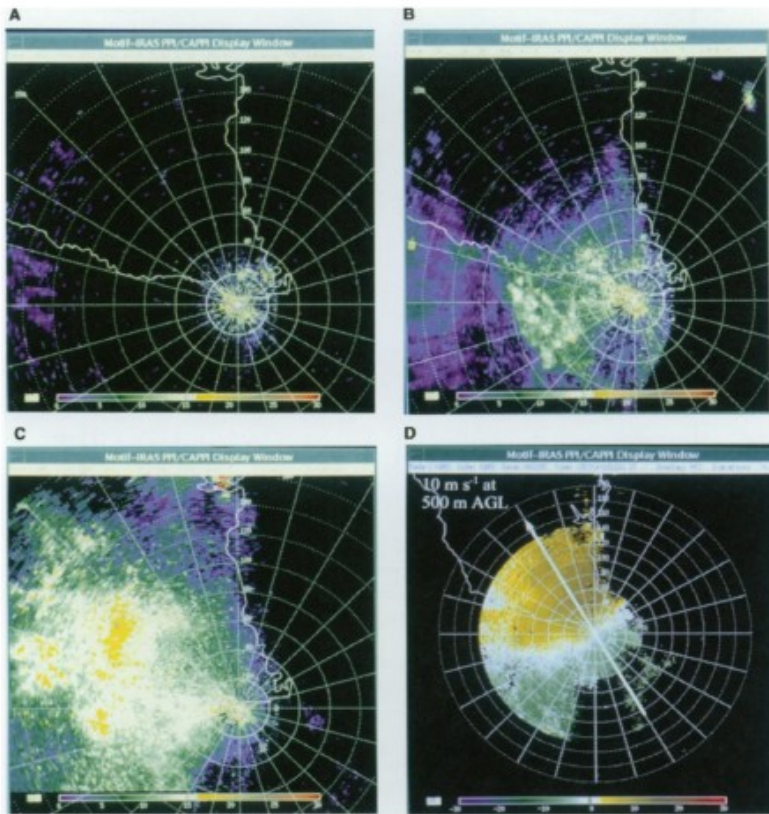


Fig. 2 Reflectivity images taken at (A) 20:00 CDT, (B) 21:00 CDT, (C) 22:00 CDT from the NEXRAD WSR-88D Doppler radar at Brownsville, TX, showing moth migration from the Lower Rio Grande Valley in clear weather on the night of June 1, 1995. (D) Net vector of north-northwestward movement of the moth population at 24:00 (or 0:00 CDT) on June 1, 1995.

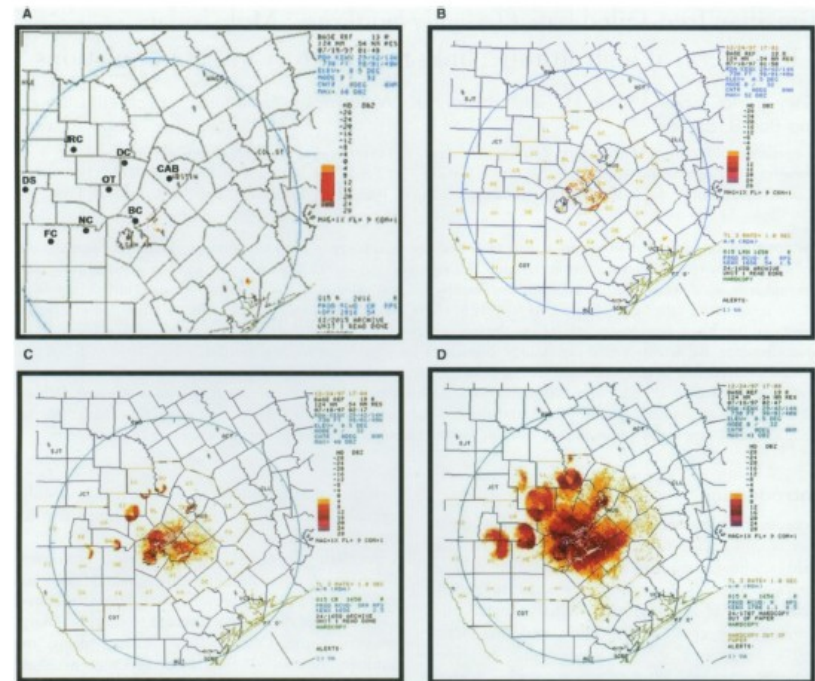
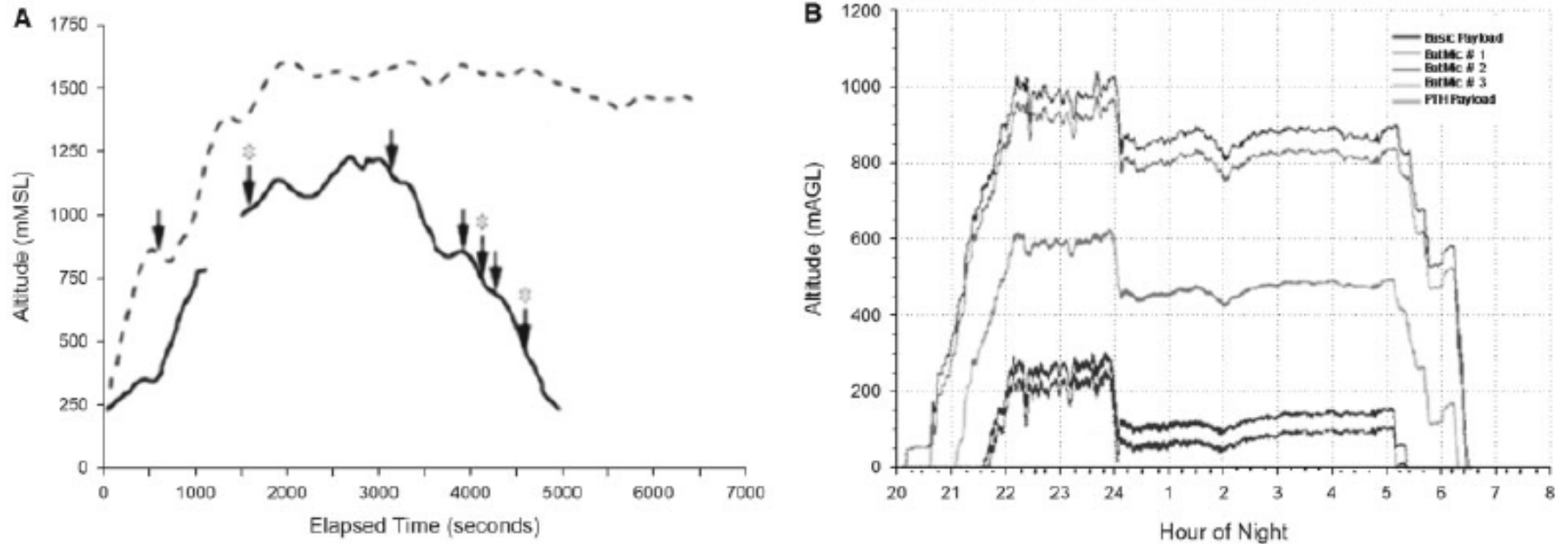
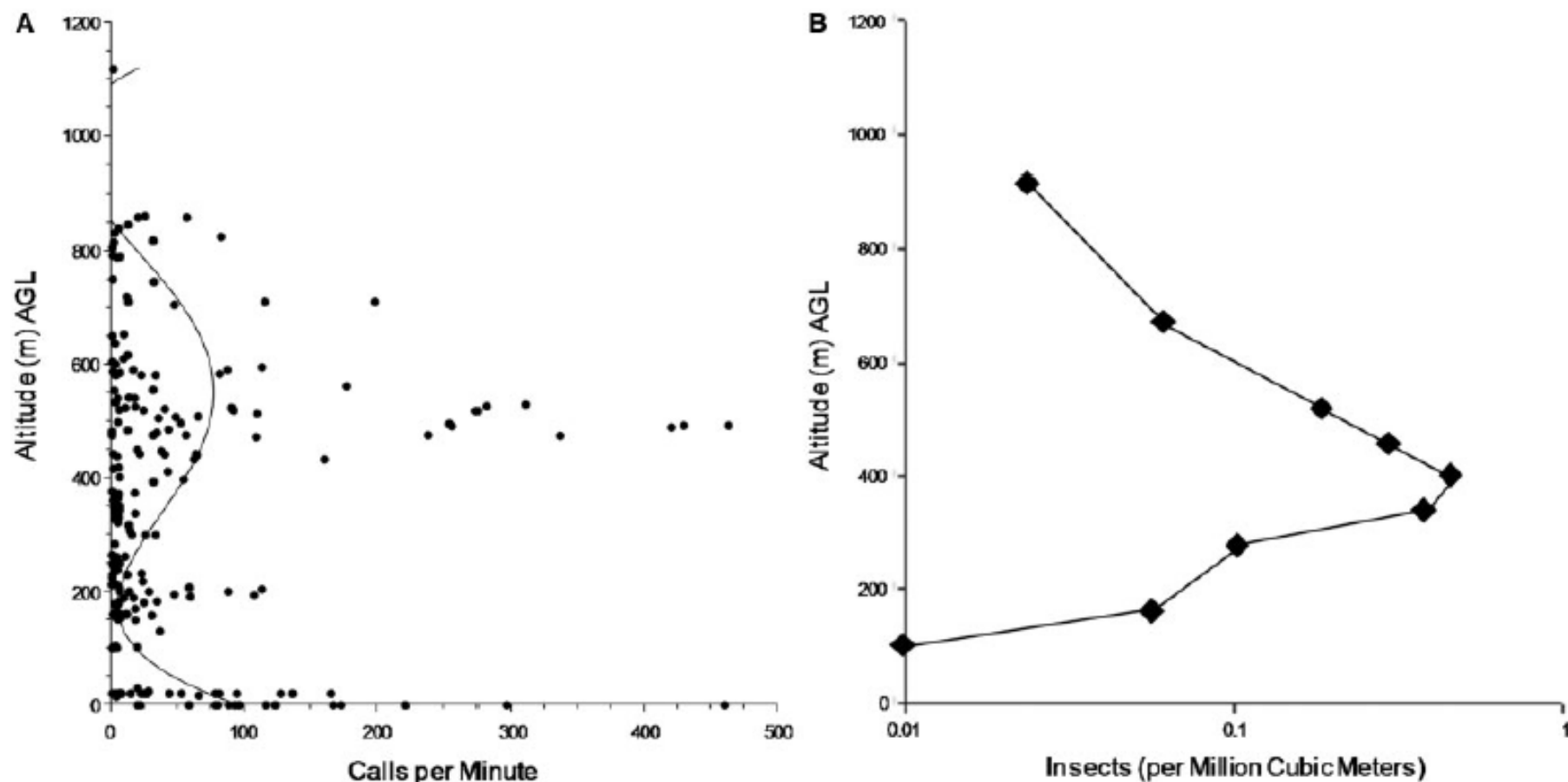


Fig. 1 Locations of large roosts of Brazilian free-tailed bats in central Texas. Reflectivity images from NEXRAD WSR-88D Doppler radar at New Braunfels, TX, (A) showing emergence and movements of Brazilian free-tailed bats from major roost sites in clear weather on the night of July 18, 1997. (B) ~15 min, (C) 30 min, and (D) 45 min after the onset of the bats' emergence. DS, Devil's Sinkhole; FC, Frio Cave; NC, Ney Cave; JRC, James River Cave; OT, Old Tunnel; DC, Davis Cave; BC, Bracken Cave; CAB, Congress Avenue Bridge.

NEXRAD doppler radar



**Fig. 4** Vertical profiles of **(A)** free-floating tetraon flights on July 8 and 10, 1996; arrows indicate times and altitudes at which echolocation calls were detected and arrows with \* are call sequences that included a feeding buzz or partial buzz and **(B)** kite recordings on July 17–18, 1997; the top line indicates the altitudinal profile of the kite with attached radiosonde and the three lines below the kite are the profiles of the radio microphones at the highest, middle, and lowest altitudes.

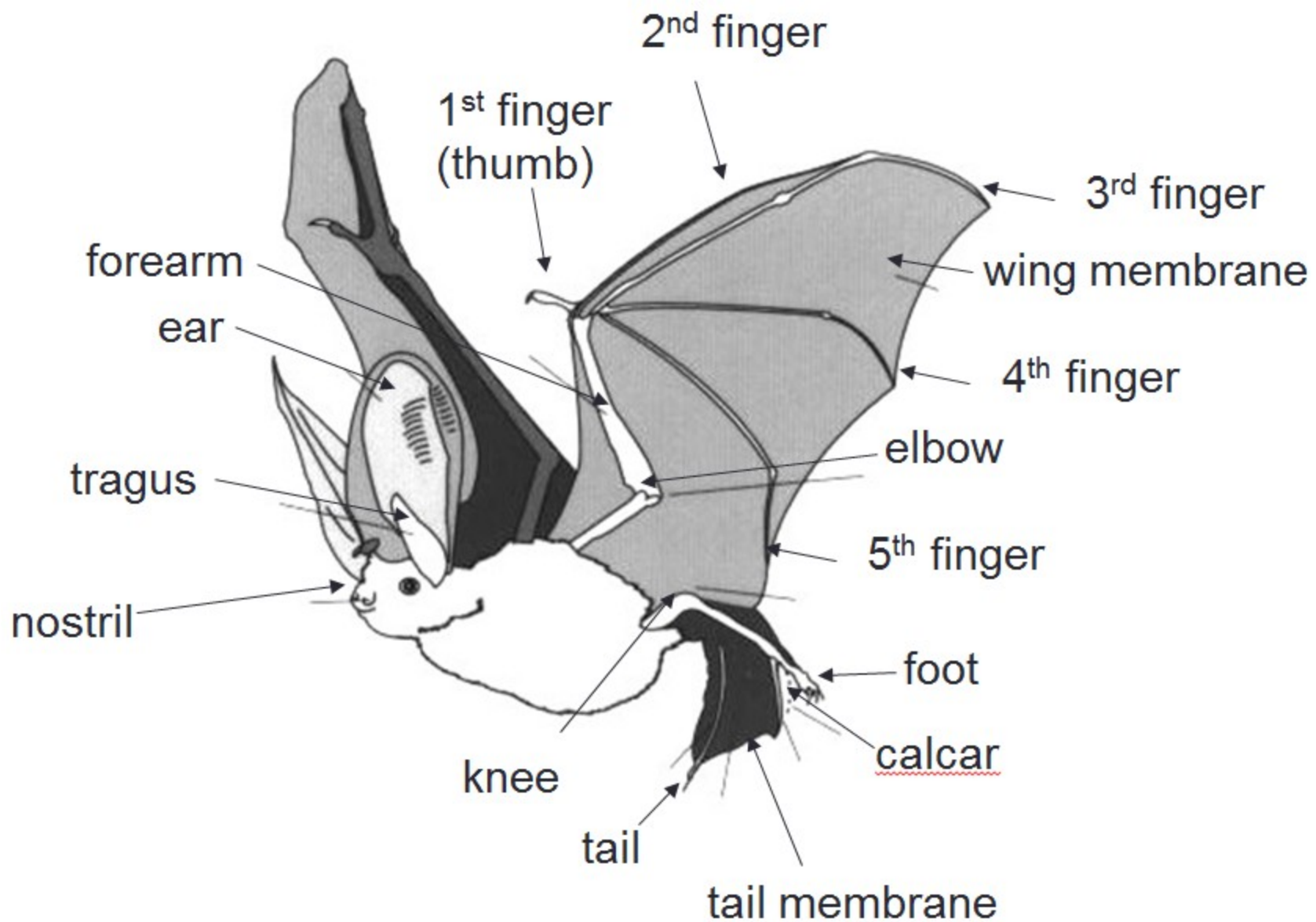


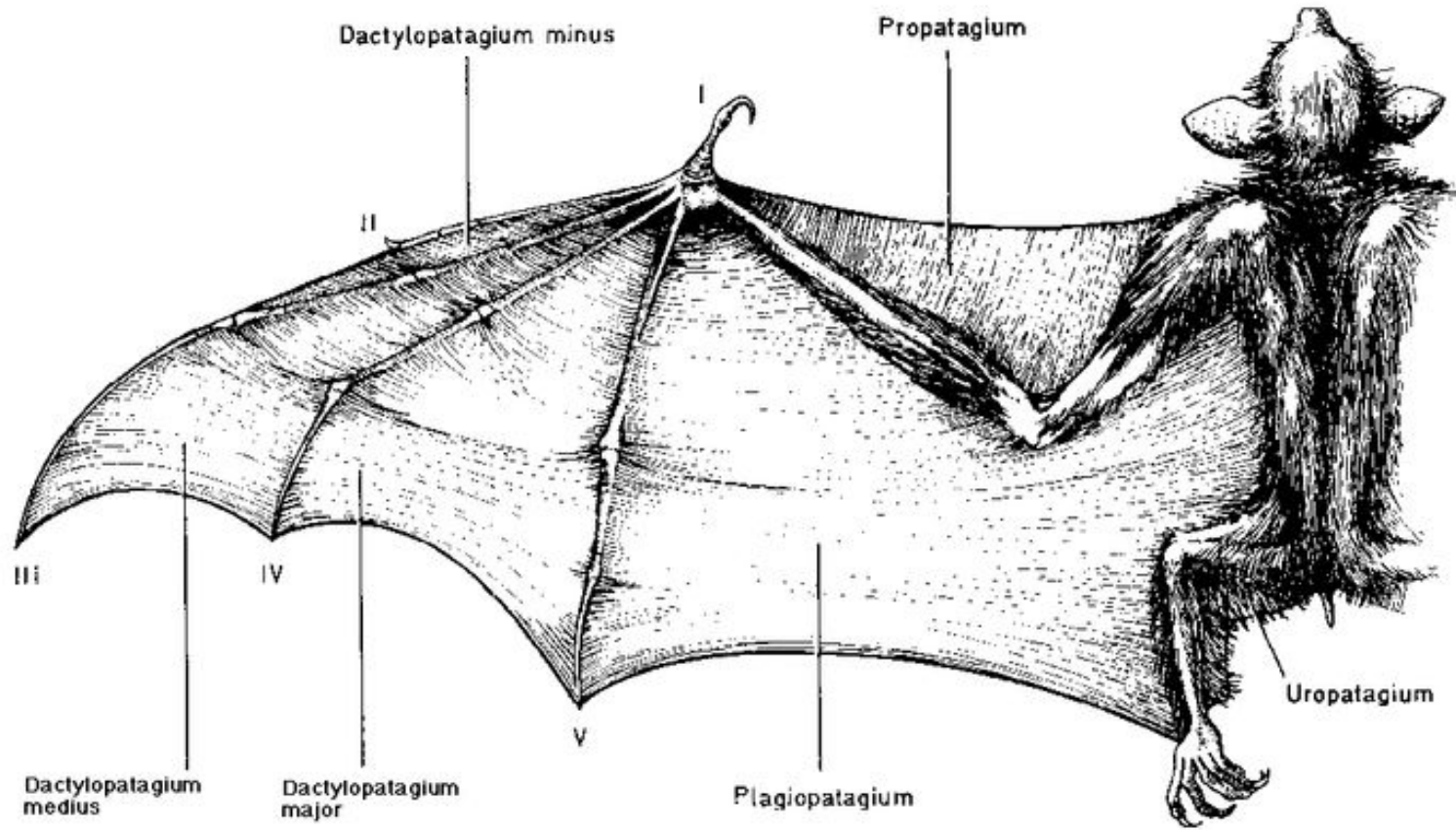
**Fig. 5 (A)** Altitude versus calls per minute recorded by radio microphones suspended from kites. Data show a significant fourth-order polynomial fit of calls per minute versus recording altitude ( $R^2=0.13$ ,  $P<0.0001$ ,  $Y = 94.80 - 1.219x + 0.00523 \times 2 - 7.36E - 6 \times 3 + 3.22E - 9 \times 4$ ), with the highest levels of bat activity at ground level and at 400–600 m AGL. While altitude is the independent variable for this regression, it is shown on the Y-axis for comparison to **(B)**. **(B)** Altitude versus noctuid moth densities as estimated from X-band radar. Peaks of bat activity and moth density correspond at the altitude that is typical for the low-level wind jet in central Texas.

# aktivní let + echolokace

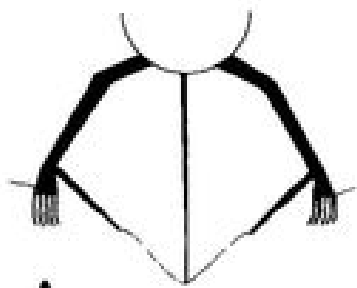




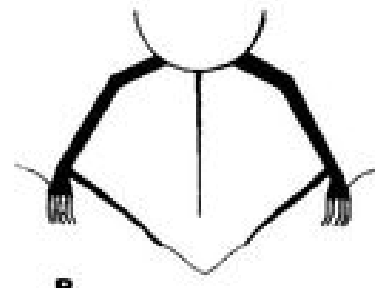




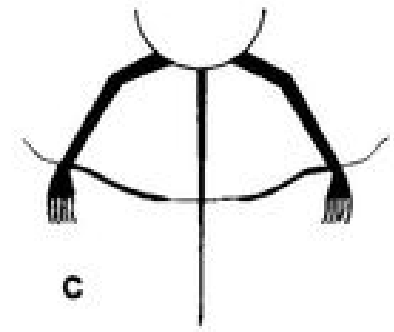
Dorsal view of left wing of the straw-colored fruit bat (*Eidolon helvum*, Pteropodidae)



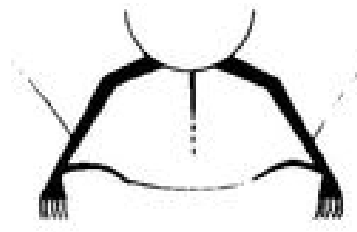
**A**



**B**



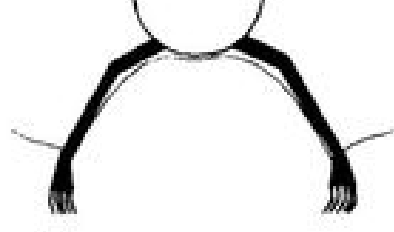
**C**



**D**

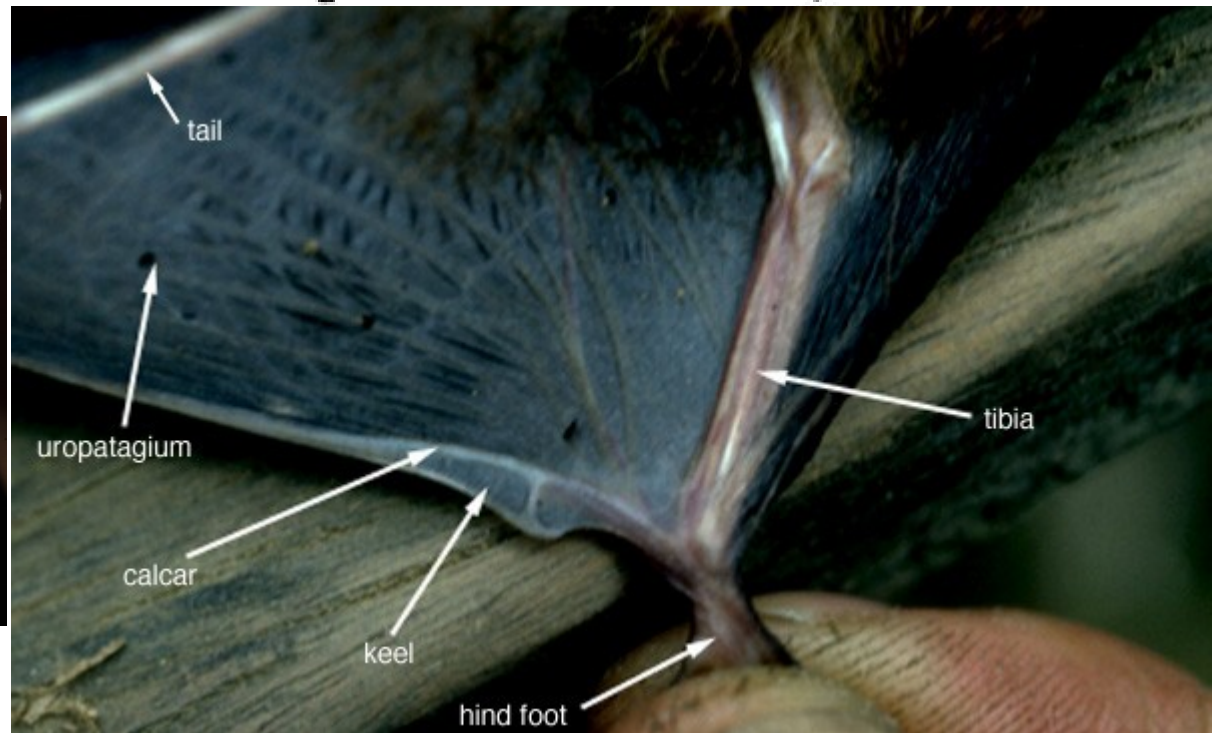


**E**



**F**

uropatagium



[https://youtu.be/MgRh\\_Q\\_xwys](https://youtu.be/MgRh_Q_xwys)

Lov mŕy

[https://www.youtube.com/watch?v=342Y\\_040f1Y](https://www.youtube.com/watch?v=342Y_040f1Y)

landing, kolena



## Airplane tracking documents the fastest flight speeds recorded for bats

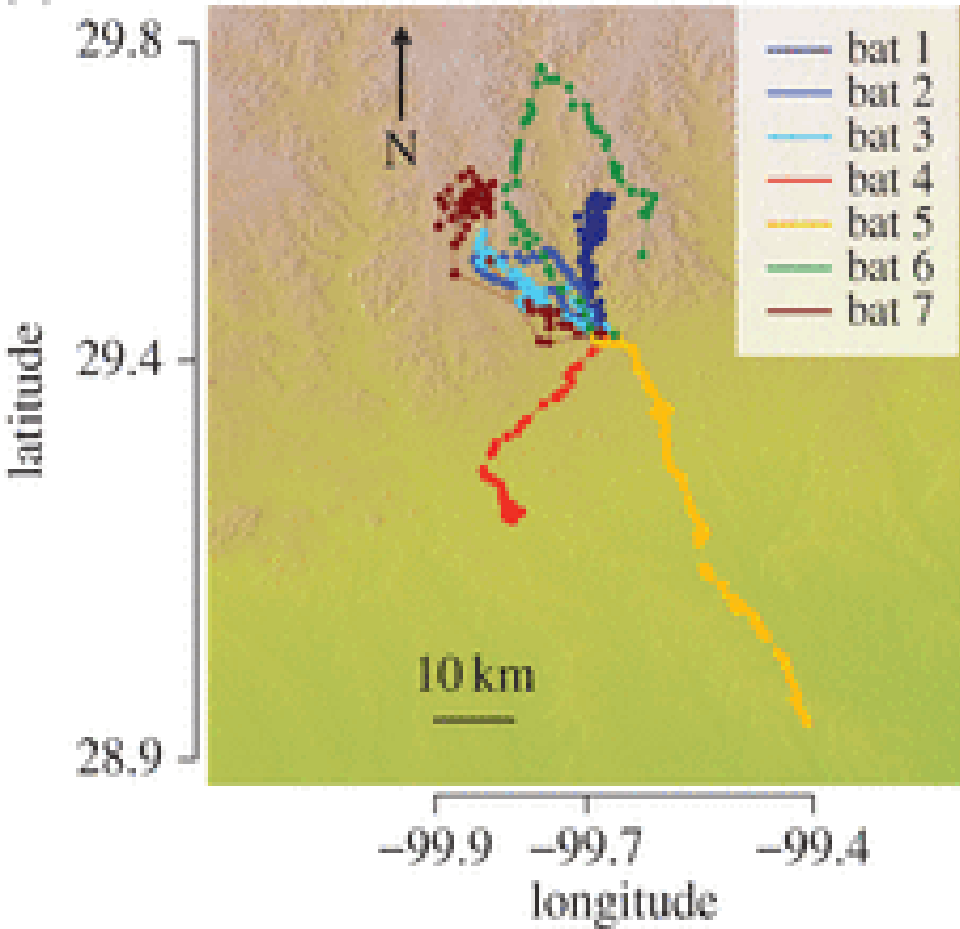
Gary F. McCracken, Kamran Safi, Thomas H. Kunz, Dina K. N. Dechmann, Sharon M. Swartz, Martin Wikelski

Published 9 November 2016. DOI: [10.1098/rsos.160398](https://doi.org/10.1098/rsos.160398)

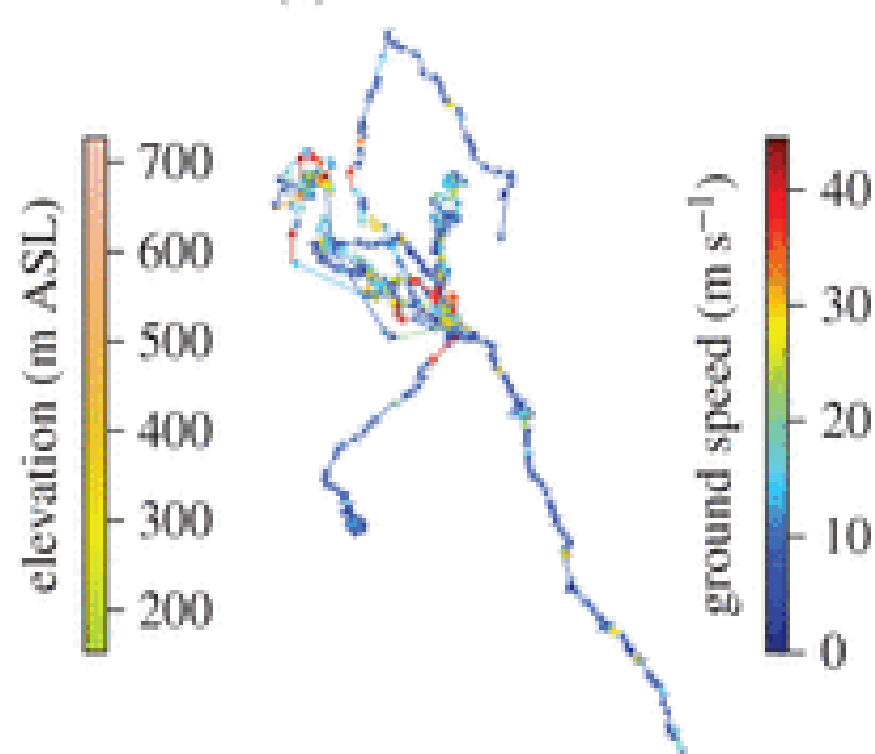
Metrics for flight trajectories of seven Brazilian free-tailed bats.

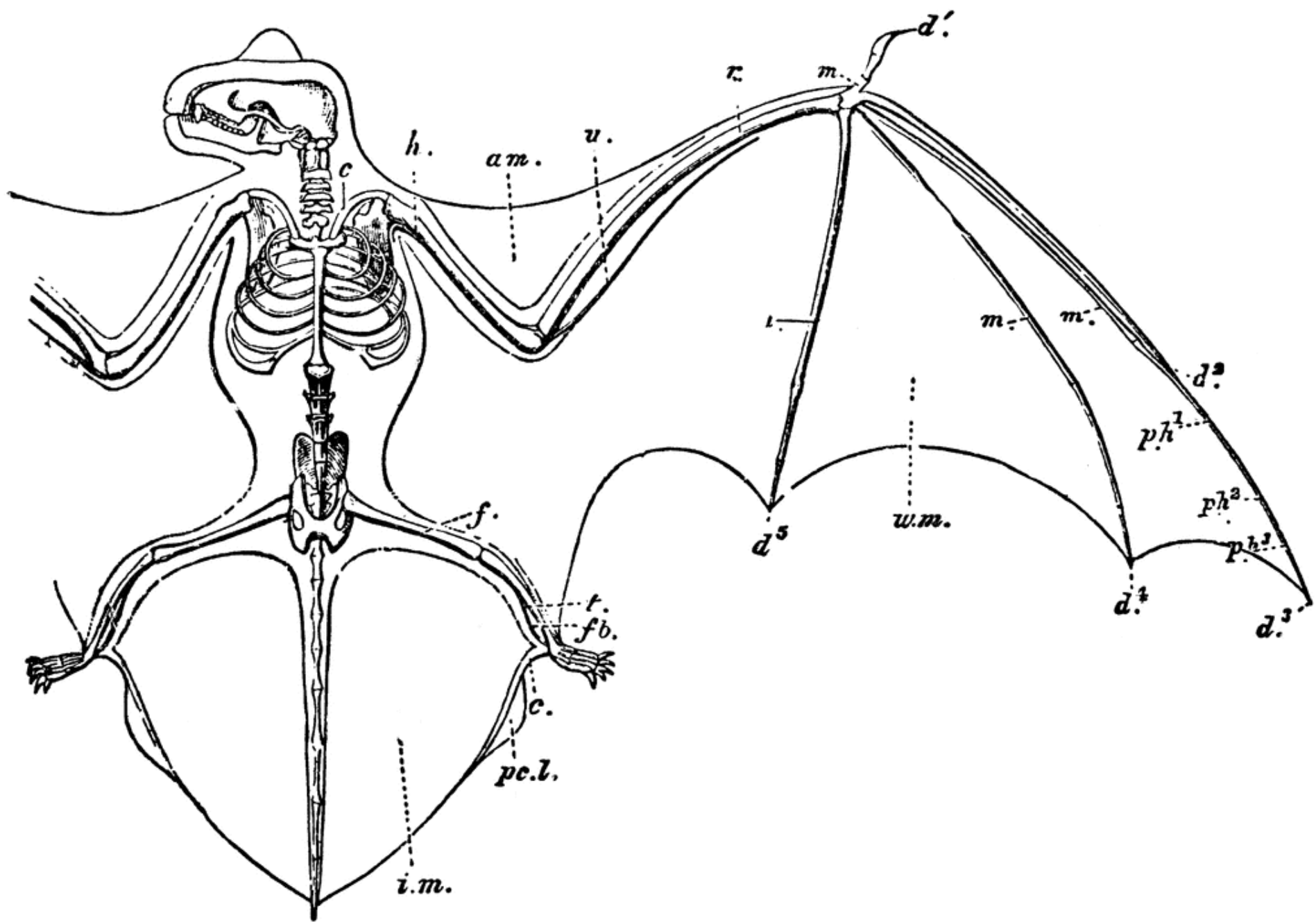
	no. locations	total travel distance (km)	total duration (h)	mean $\pm$ s.d. distance between consecutive locations (m)	max distance between consecutive locations (m)	min distance between consecutive locations (m)	mean $\pm$ s.d. time lag between consecutive locations (s)	mean $\pm$ s.d. ground speed ( $\text{m s}^{-1}$ )	median ground speed ( $\text{m s}^{-1}$ )	max ground speed ( $\text{m s}^{-1}$ )
bat 1	116	100.5	4.03	873.72 $\pm$ 461.67	1980.5	122.6	126.26 $\pm$ 65.76	9.82 $\pm$ 8.58	6.98	39.65
bat 2	64	53.8	3.33	854.57 $\pm$ 454.94	2266.1	37.5	190.47 $\pm$ 109.50	6.77 $\pm$ 6.49	3.69	27.23
bat 3	54	62	2.65	1170.72 $\pm$ 692.29	3593.4	231.1	180.07 $\pm$ 132.22	10.3 $\pm$ 7.95	8.28	30.71
bat 4	86	71.4	4.73	840.66 $\pm$ 739.49	5189.3	119.9	200.14 $\pm$ 225.48	5.35 $\pm$ 5.08	4.41	38.73
bat 5	117	102.4	5.54	883.03 $\pm$ 603.52	4039.5	42	172.06 $\pm$ 84.50	6.45 $\pm$ 5.88	4.7	29.71
bat 6	56	88	3.75	1600.84 $\pm$ 972.11	5688.5	174.5	245.54 $\pm$ 191.36	10.28 $\pm$ 10.02	6.63	38.41
bat 7	71	159.8	4.58	2316.06 $\pm$ 2243.63	12799	0	239.13 $\pm$ 309.27	17 $\pm$ 12.08	14.33	44.5

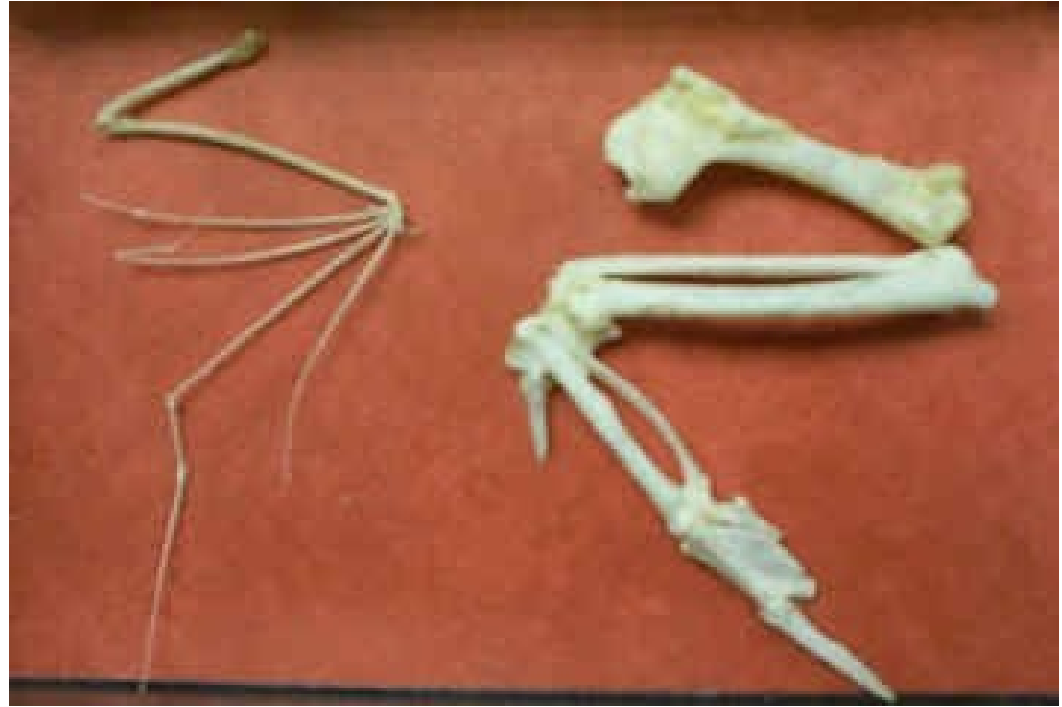
(a)



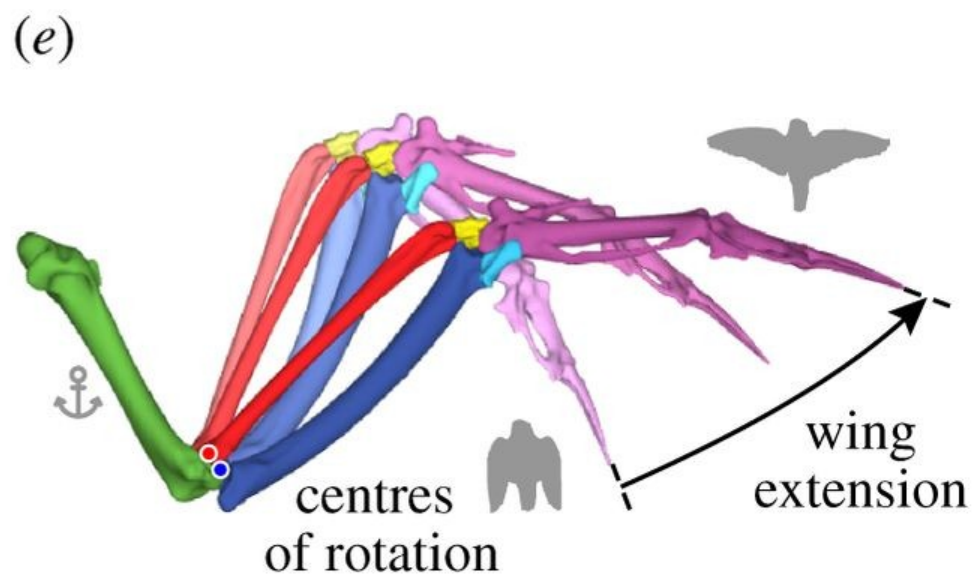
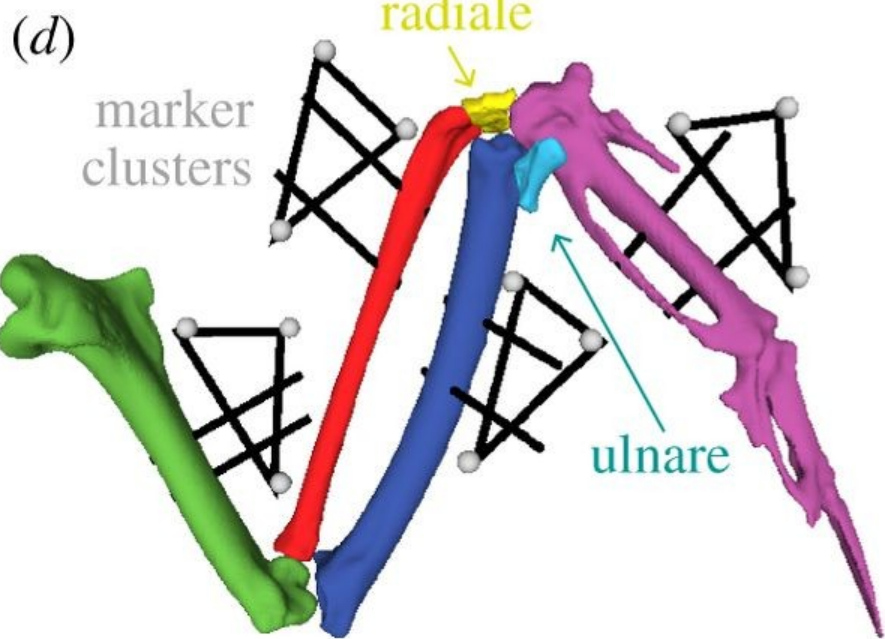
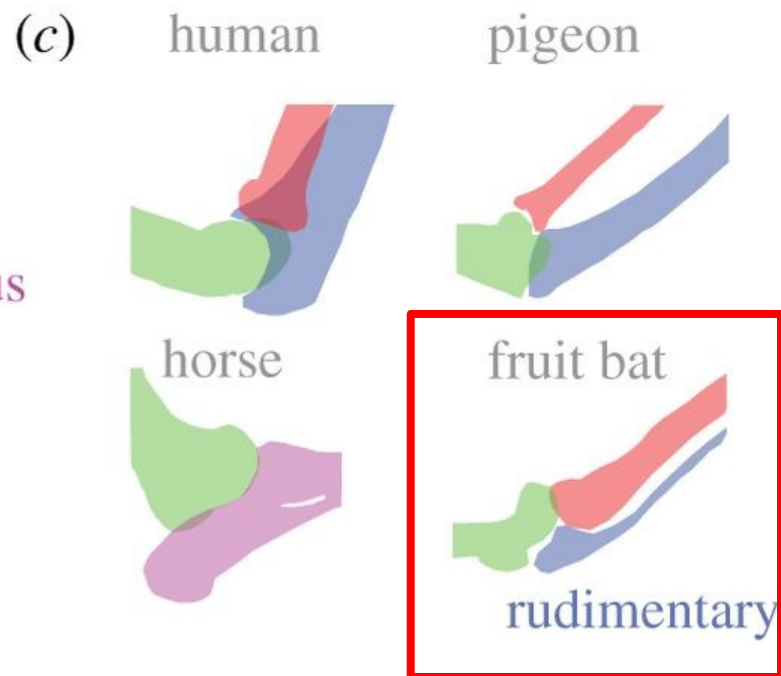
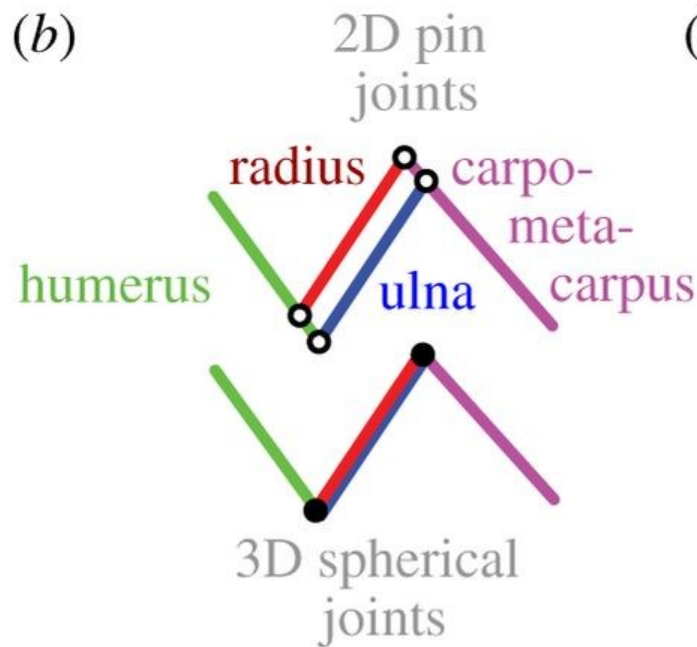
(b)







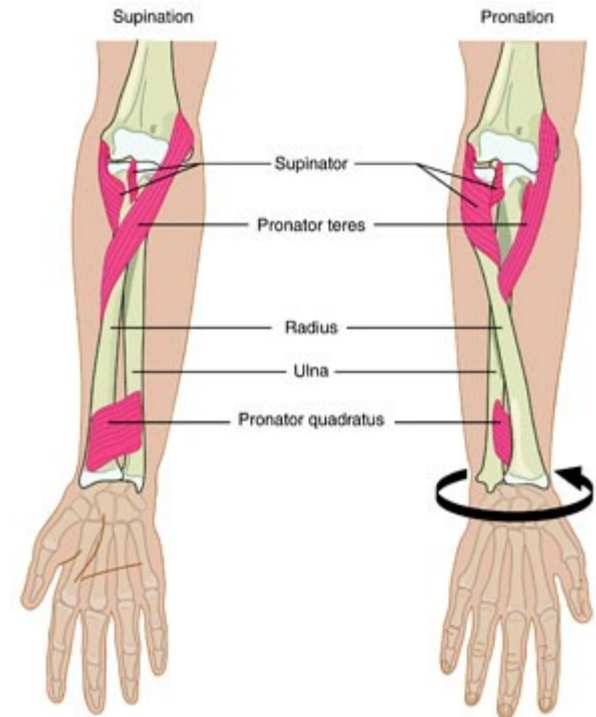
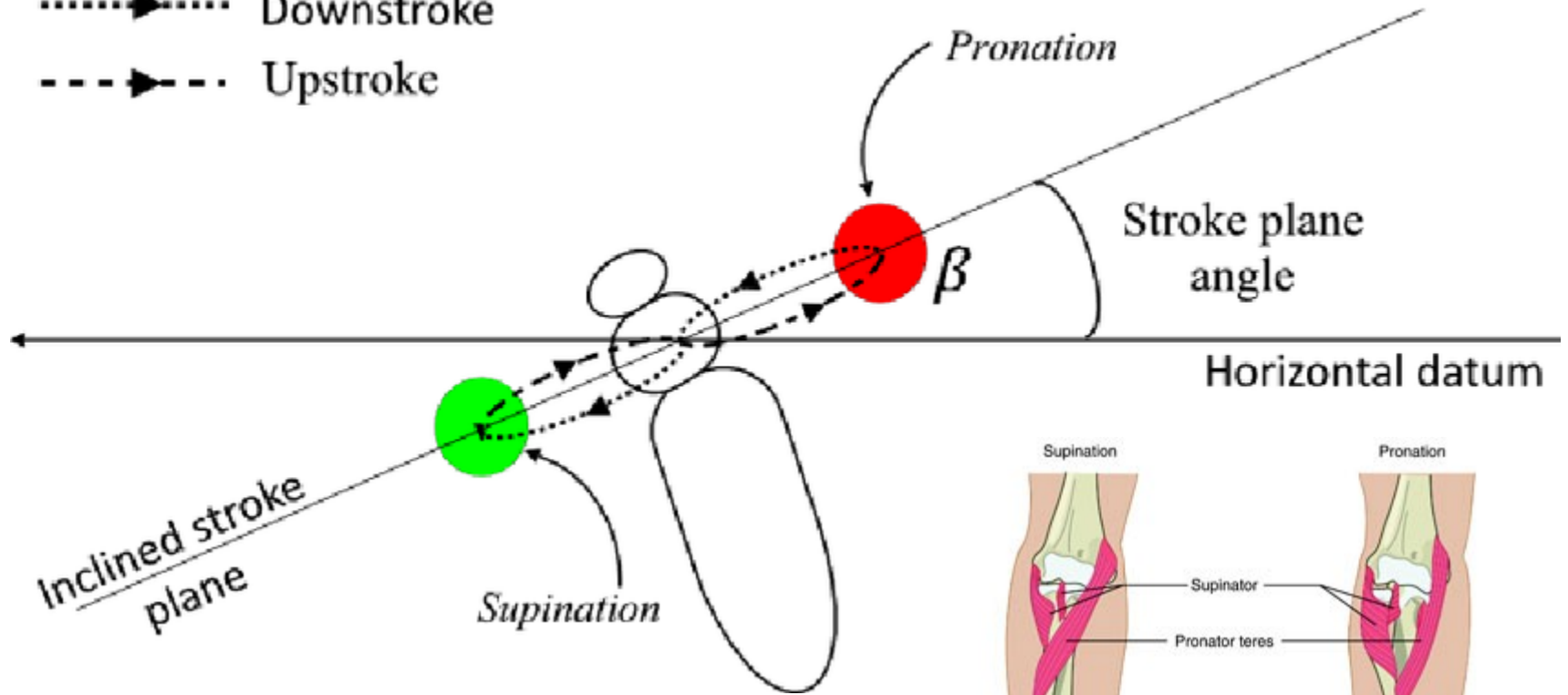




# Radius ztrácí schopnost rotace (pronace i supinace)

.....▶..... Downstroke

---▶--- Upstroke



## **Meet Ro-bat, Brown University's Robotic Bat Wing**

<https://www.youtube.com/watch?v=R1iYXXaKvDE>

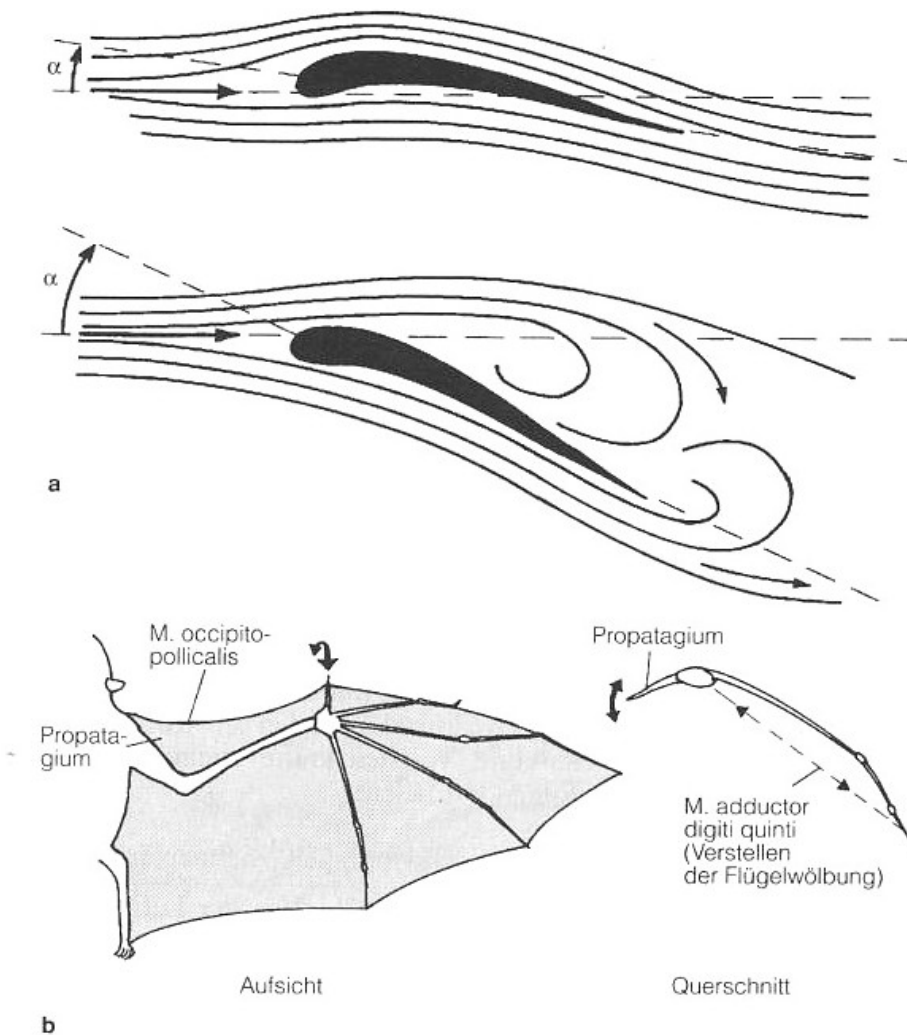
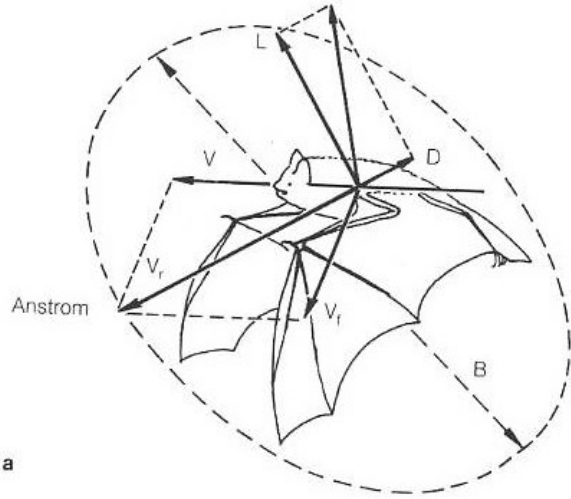
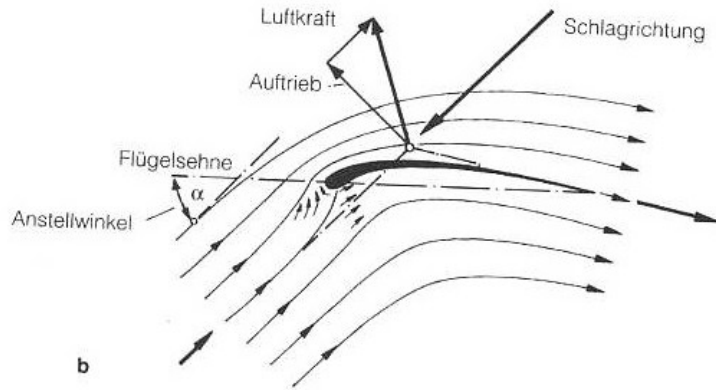


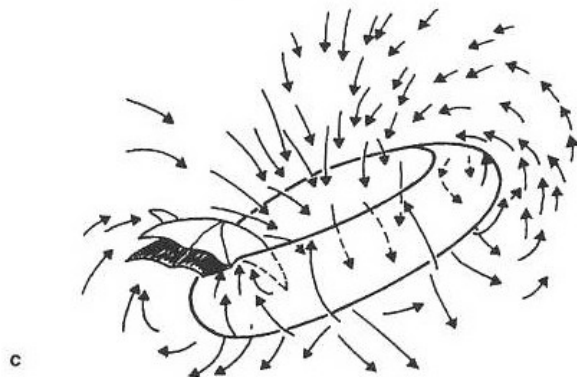
Abb. 1.11 Laminarer Luftstrom a: Laminarer Luftstrom bei flachem Anstellwinkel (oberes Bild) und Abreißen der Luftgrenzschicht durch Wirbelbildungen am Heck bei steilem Anstellwinkel (unteres Bild). b) Durch eine verstellbare „Flügel Nase“ kann das Abreißen auch bei steilem Anstellwinkel verhindert werden. Fledermäuse haben mit dem Propatagium (Vorflügel) eine solche Flügel Nase, deren Neigung durch die Stellung des Daumens verstellbar ist (Doppelpfeil). Der M.occipitopollicalis bildet dabei die harte Vorderkante der Flügel Nase. Die Flügelwölbung kann zusätzlich durch den Zug des M.adductor digiti quinti erhöht werden. Nach J.M.V.Rayner 1981 und C. J. Pennycuik 1971.



a



b



c

### Das Abreißen des laminaren Luftstroms

An der Flügeloberfläche entsteht durch die Reibung eine Luftsicht verminderter Geschwindigkeit, die sogenannte Grenzschicht. Damit die Auftriebskräfte wirksam werden, muß diese Grenzschicht auf der Flügeloberfläche haften. Die Gefahr des Abreißen besteht, wenn der Flügel zu steil in den Wind steht (Abb. 1.11a), oder wenn ein Druckstau am Hinterflügel die Luft von der Flughaut drängt. Im Horizontalflug ist der Druck auf den Flügel vorne am Bug am größten. Am Scheitelpunkt der Flügelwölbung, wo die Umströmungsgeschwindigkeit am größten ist, erreicht der Druck ein Minimum. Am Heck erzeugt die durch den Flügelunterseite hochgespülte Luft einen höheren Druck, durch den die laminar strömende Grenzschicht aufgestaut und von der Flughaut abgedrängt werden kann.

Aus strömungstechnischen Gründen muß der Anstellwinkel klein bleiben, da bei steiler Flügelstellung die Luftströmung an der Flügeloberseite abreißen kann (Abb. 1.11).

**Reynolds-Zahl.** Die Gefahr des „laminaren Abreißen“ der Grenzschicht ist bei Fledermausflug besonders akut. Das hängt mit der sogenannten Reynolds-Zahl zusammen, die das Verhältnis der auf den Flügel einwirkenden Zähigkeits- und Trägheitskräfte zueinander ausdrückt. Sie berechnet sich folgendermaßen:

$$\text{Reynolds-Zahl} = \frac{\text{Anströmgeschwindigkeit} \cdot \text{Sehnenlänge}}{\text{kinematische Zähigkeit der Luft}}$$

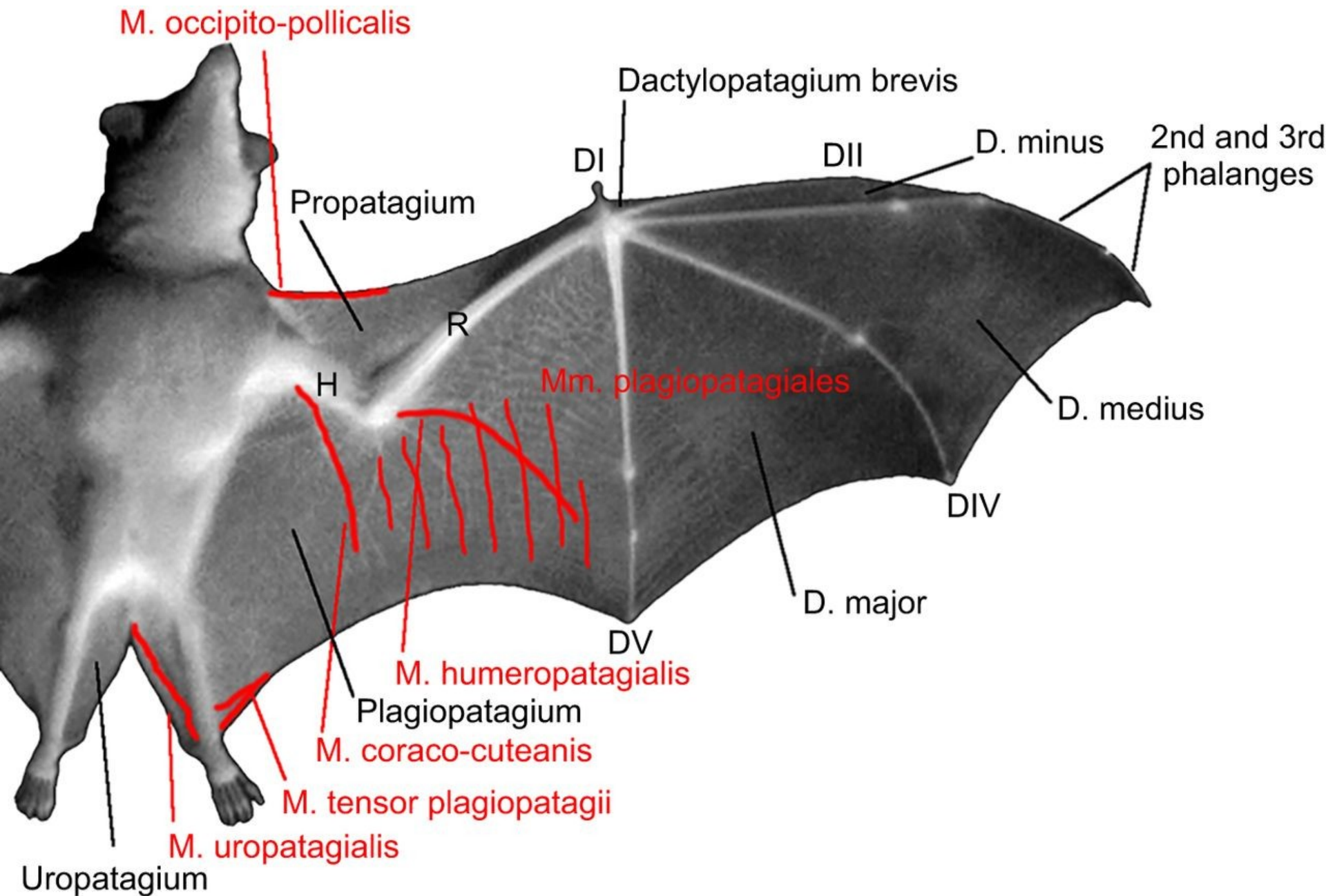
Abb. 1.10 Aerodynamik beim Horizontalflug.

a) Entstehung von Hub und Schub durch den Flügelschlag. D Luftkraft, L Auftrieb, R Luftkraft, V Fluggeschwindigkeit, V<sub>r</sub> Geschw. des Flügels, V<sub>f</sub> resultierende Geschwindigkeit. Der Durchmesser der Flügelscheitel (gestricheltes Oval) entspricht der Flügelspannweite B.

b) Erzeugung von Luftkraft am angeströmten Profil der „gewölbten“ Flügeloberseite (nach Hertel).

c) Luftwirbel, die eine mit 1,5 m/s fliegende Fledermaus (Plecotus Vespertilionidae) beim Abschlag erzeugt. Das Tier „reitet“ auf der Oberseite des schräg nach hinten und unten gerichteten Wirbelschlauches.

a nach U. Norberg 1986, b nach H. Hertel 1963, c nach J. M. V. Rayne und A. Thomas 1986.



# svalstvo

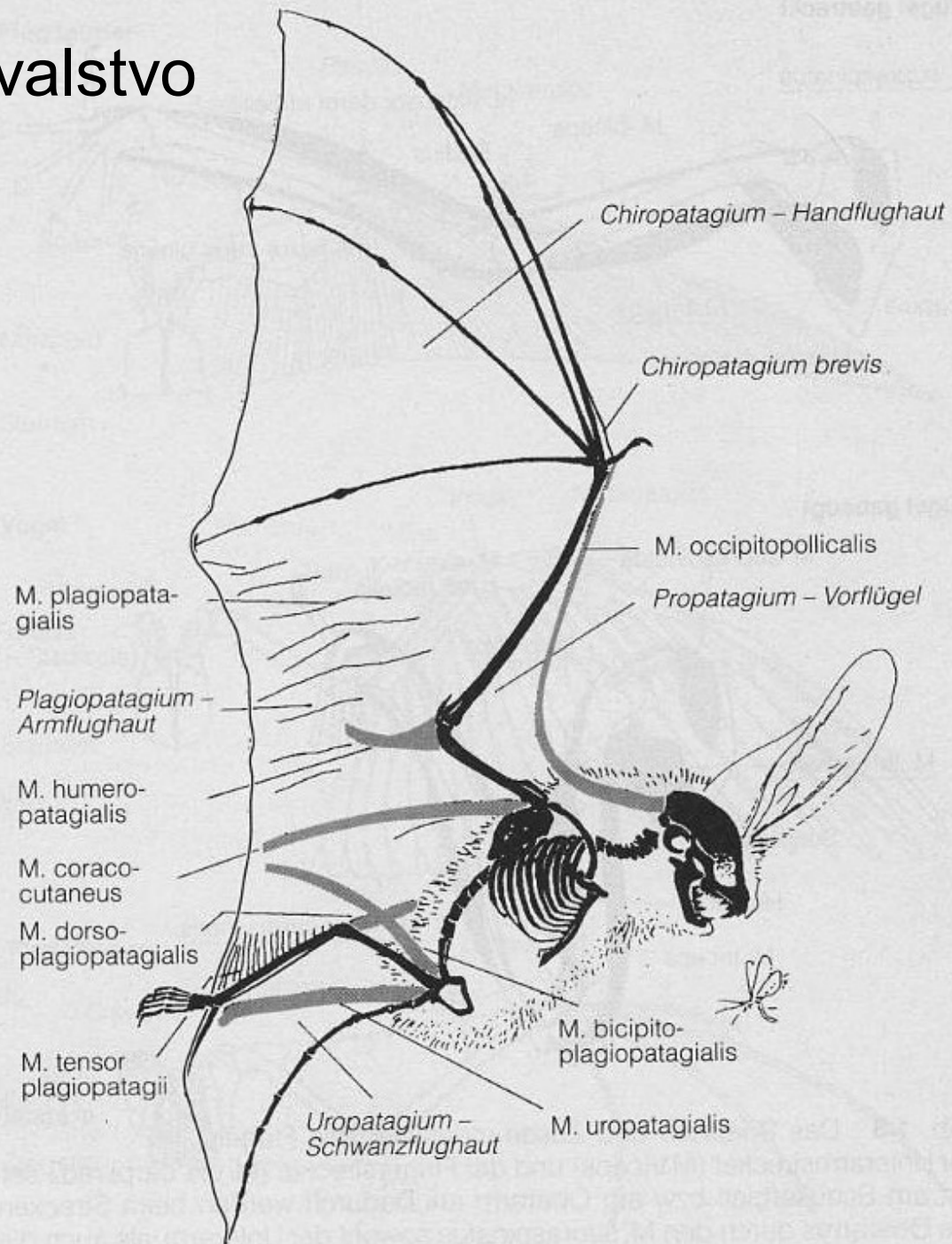


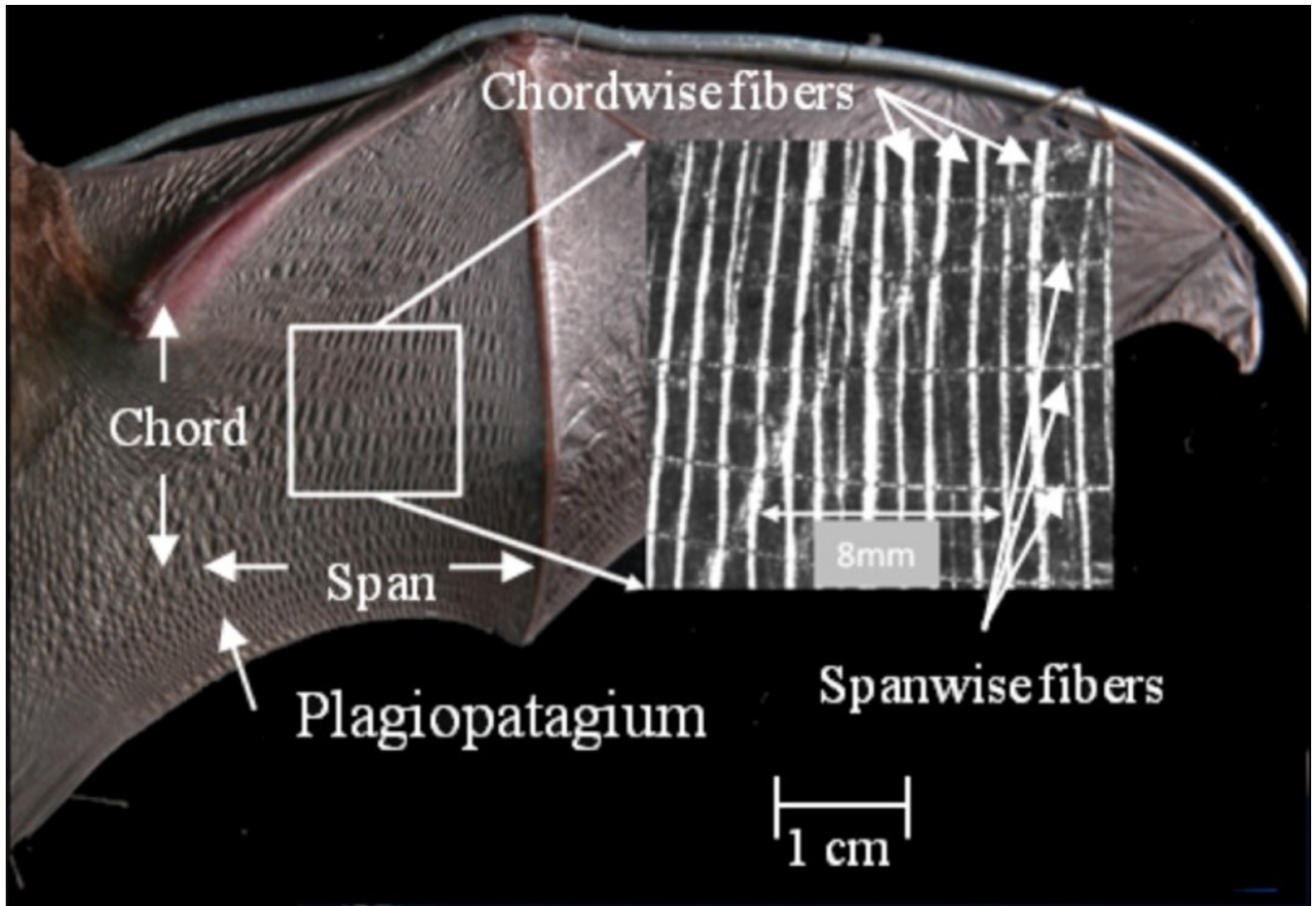


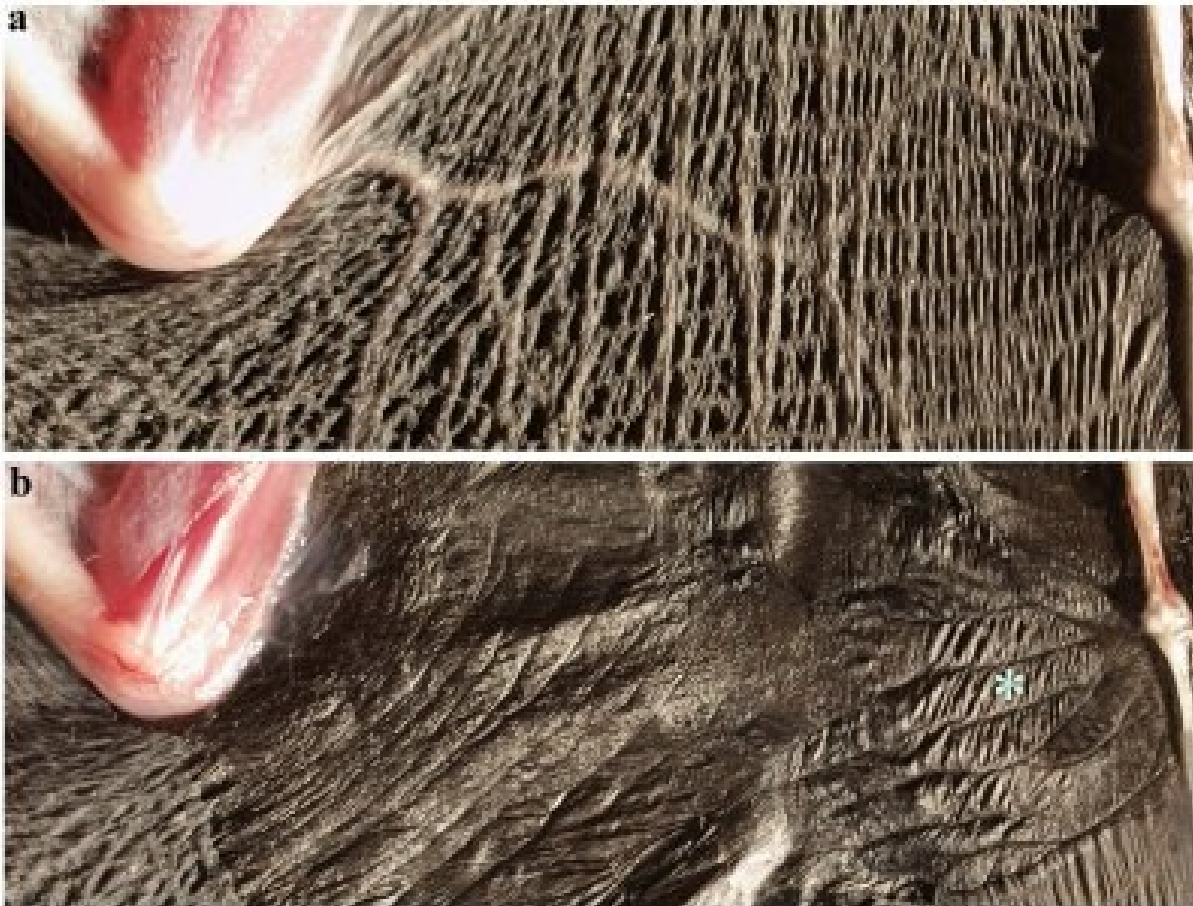


TABLE 2.1 Some physical properties of bat wings compared to other materials.

Subject	N	Thickness (mm)	Puncture strength (kg mm)	Elasticity (mm/kg)
Rubber glove	10	0.234	2.80	35.1
Sandwich bag	10	0.020	8.63	18.7
<i>Myotis lucifugus</i>	10	0.030	5.81	14.0
<i>Myotis thysanodes</i>	10	0.243	9.37	12.9
<i>Myotis yumanensis</i>	3	0.023	7.28	15.5
<i>Eptesicus fuscus</i> (adult)	7	0.038	9.72	9.5
<i>Eptesicus fuscus</i> (young)	8	0.034	5.62	14.0
<i>Plecotus townsendii</i>	1	0.032	7.19	12.3
<i>Antrozous pallidus</i>	2	0.033	7.72	11.9
<i>Tadarida brasiliensis</i>	1	0.063	3.00	15.4

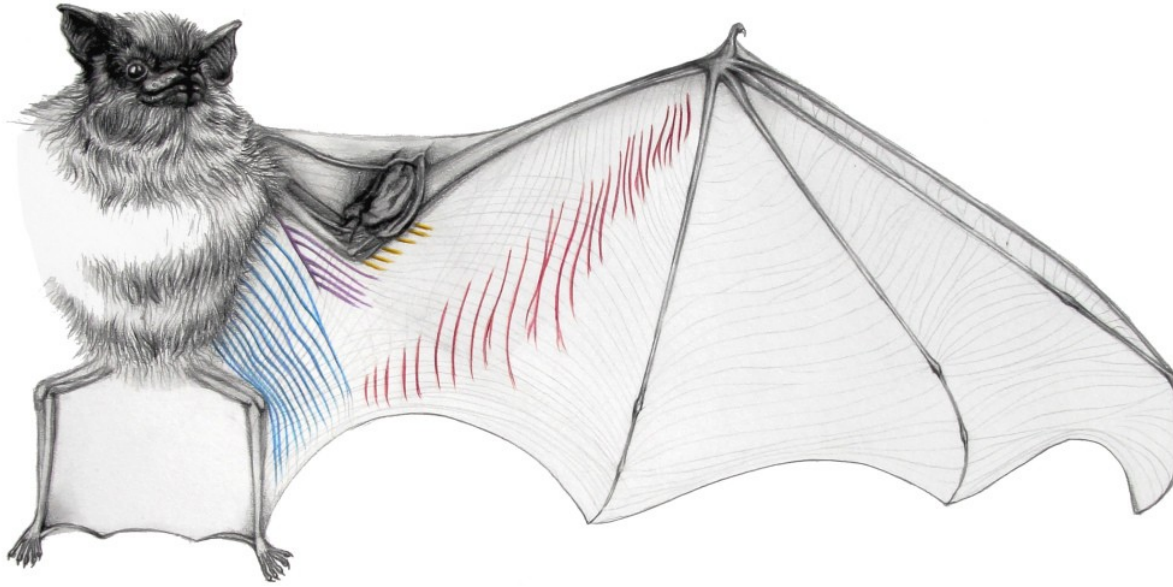
Numbers are mean values; N - number examined. Puncture strength determined as the weight (kg) required to puncture membrane per mm of membrane thickness. Elasticity determined as mm of depression per kg of weight added. (After Studier, 1972).



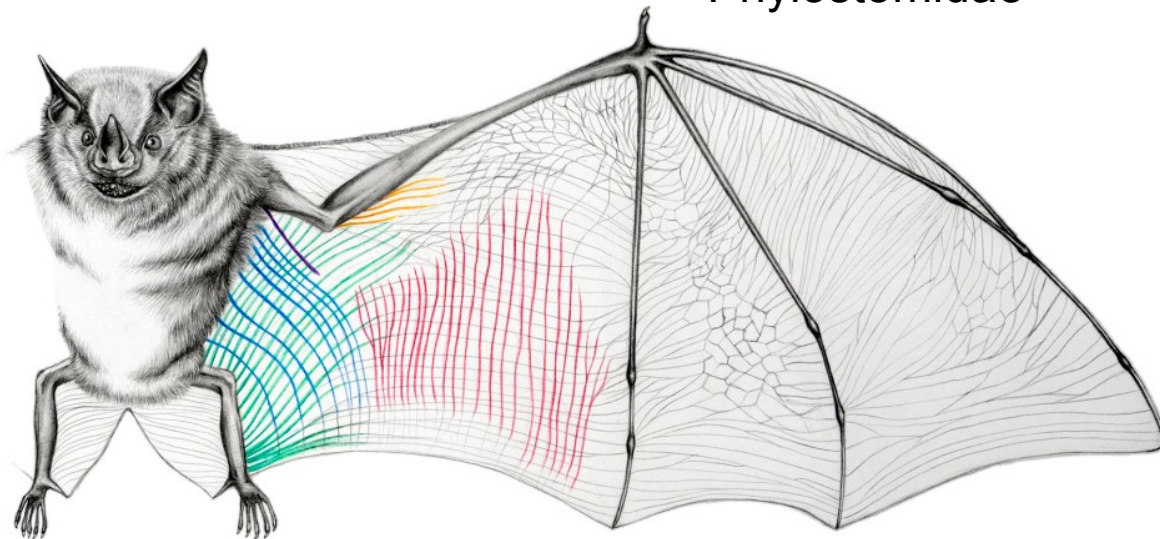


Wing membrane 'pleating' with elastin fibres intact (a) and smooth membrane with fibres removed (b).

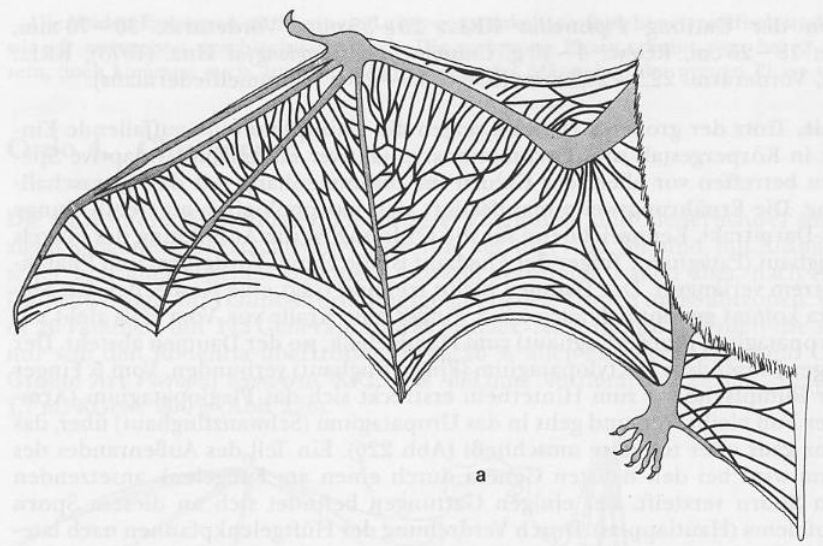
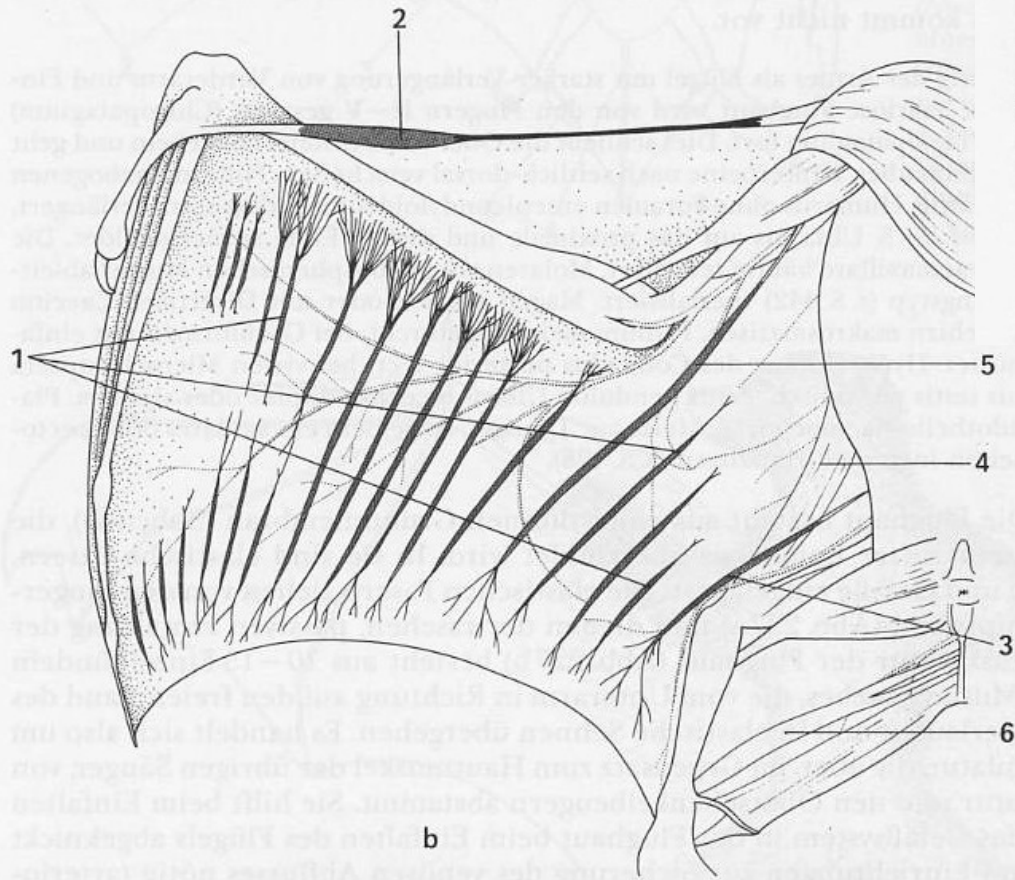
## Emballonuridae



## Phyllostomidae

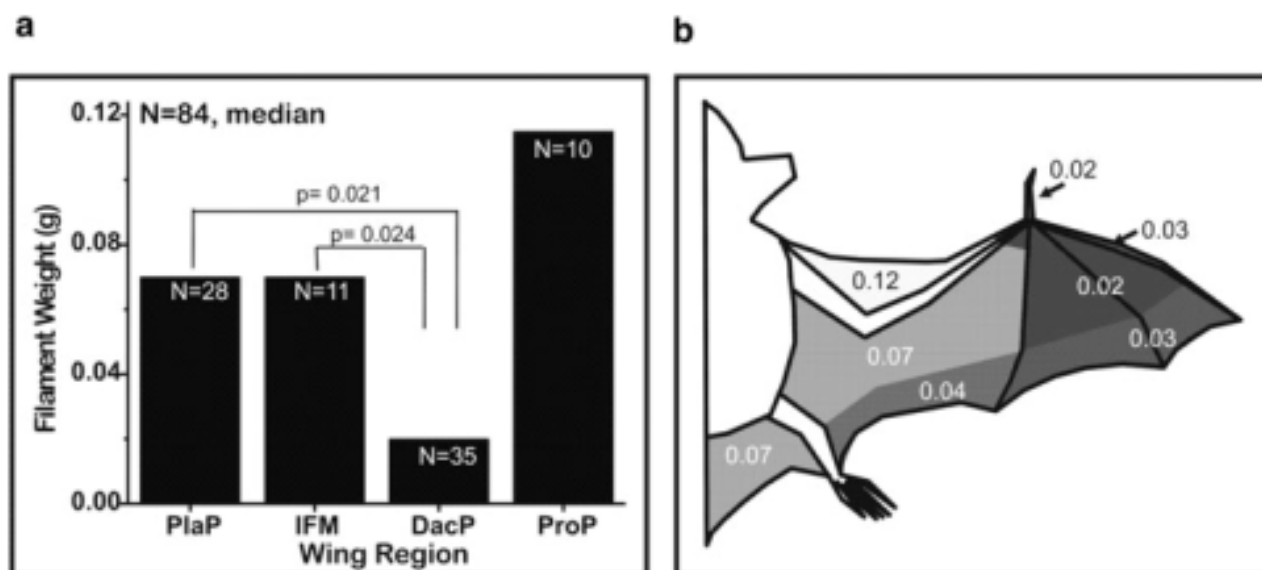


plagiopatagiales in a sheath-tailed bat (*Emballonuridae* sp., top) and the Jamaican fruit bat (*Artibeus jamaicensis*, bottom). The network of elastin fibres is also visible here in grey, stretching across the wing laterally.



**Abb. 227.** a) *Vespertilio murinus* (Microchiroptera, Vespertilionidae). Darstellung der elastischen Balken in der Flughaut, b) *Pteropus* spec. (Megachiroptera), Muskulatur der Flughaut. Nach SCHUMACHER 1932.

1. Mm. plagiopatagii proprii, 2. M. propatagialis mit Sehne, 3. M. dorsoplagiopatagialis, 4. M. bicipitoplagiopatagialis, 5. M. coracoplagiopatagialis, 6. M. uropatagialis.

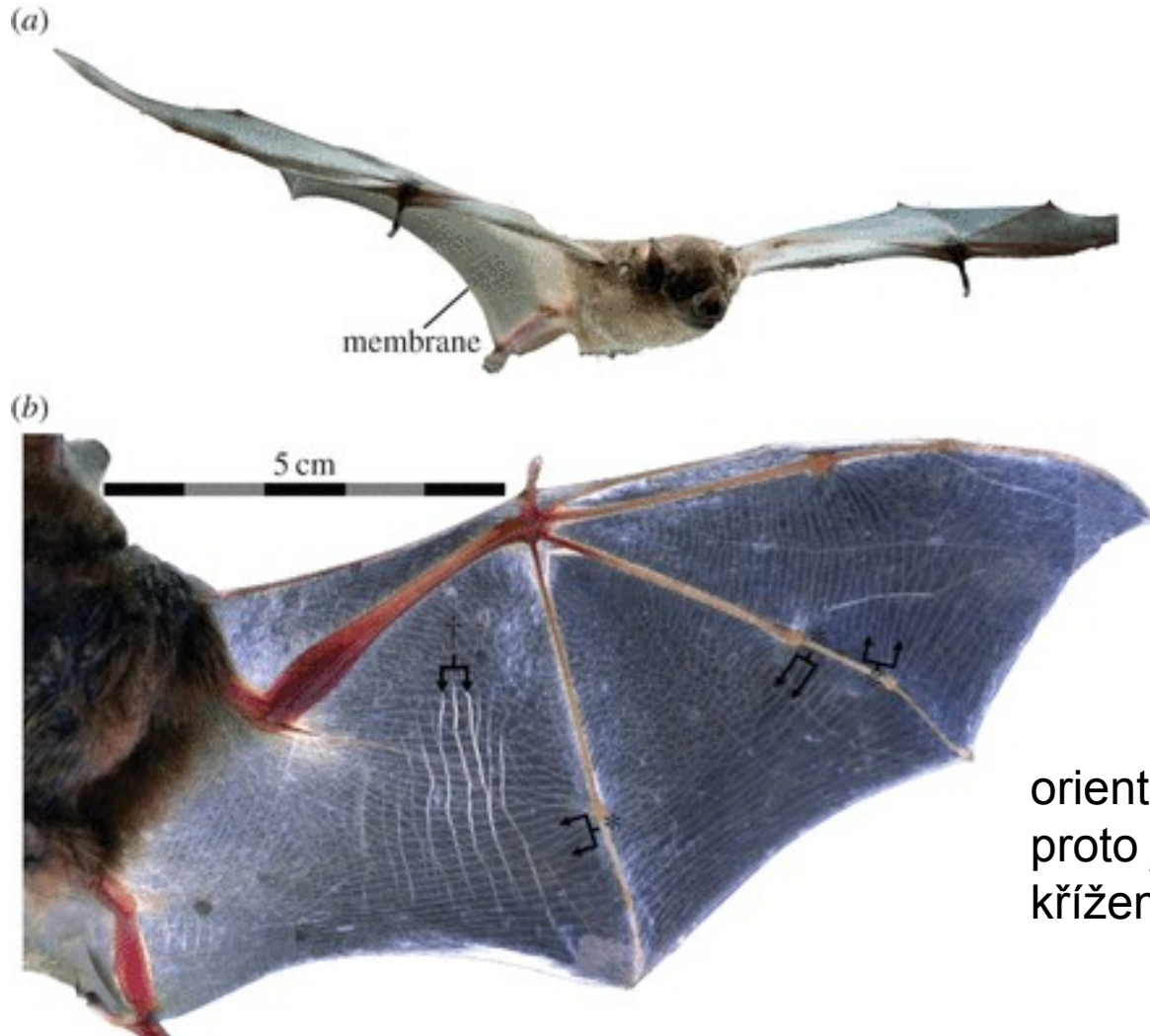


**Fig. 4** Tactile response threshold as determined using calibrated monofilaments (von Frey hairs). **a** data from four parts of the wing of five bats were pooled, the plagiopatagium (*PlaP*, see Fig. 1,  $N = 28$ ), the interfemoral membrane (*IFM*,  $N = 11$ ), the dactylopatagium (*DacP*,  $N = 35$ ), and the propatagium (*ProP*,  $N = 10$ ). The thresholds of the dactylopatagium were significantly different from the IFM, and

*PlaP* (Mood's Median Test  $p = 0.024$  and  $0.021$ , respectively). **b** Median thresholds in gram filament weight for different functional regions. The weight in g is equivalent to a ten-fold value in mN (e.g.,  $0.02$  g equals  $0.2$  mN). Darker shading indicates lower thresholds. Note that, e.g., the trailing edge of the *PlaP*, is more sensitive than the remainder of the *PlaP*

# A wrinkle in flight: the role of elastin fibres in the mechanical behaviour of bat wing membranes

Jorn A. Cheney, Nicolai Konow, Andrew Bearnot, Sharon M. Swartz



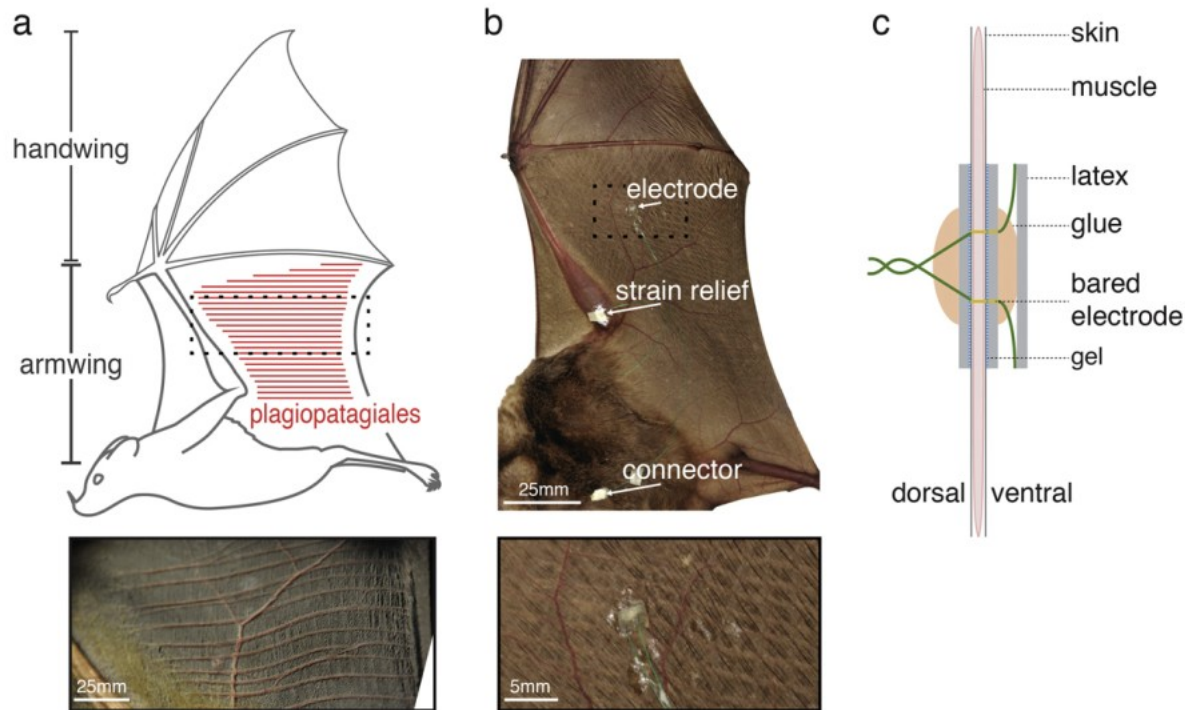
orientace blan často proti sobě  
proto jsou elastinová vlákna  
křížem

# Membrane muscle function in the compliant wings of bats

J A Cheney<sup>1</sup>, N Konow<sup>1</sup>, K M Middleton<sup>2</sup>, K S Breuer<sup>1,3</sup>, T J Roberts<sup>1</sup>,  
E L Giblin<sup>1</sup> and S M Swartz<sup>1,3</sup>

Bioinspir. Biomim. 9 (2014) 025007

J A Cheney *et al*



**Figure 1.** (a) Illustration of lateral view of flying bat at beginning of downstroke indicating location and orientation of the plagiopatagiales muscles. Dashed rectangle is location of plagiopatagiales photo, below, from a large pteropodid bat (*Eidolon helvum*; ~275 g). (b) *Artibeus jamaicensis* experimental subject following EMG electrode implantation. The electrode was anchored to the back and forearm. At the forearm, the electrode wire was looped to allow for strain-free displacement. During experiments, the electrode was connected to a shielded cable running to an amplifier. Dashed rectangle is location of higher magnification photo below. (c) Design of EMG electrode as implanted in a wing cross-section.

**plagiopatagiales propriae** zvyšují tuhost membrány a snižují její deformaci, netopýr je může aktivovat synchronně, k maximalizaci sil (jeden je příliš slabý).



<https://www.youtube.com/watch?v=Upq7LyhCGXE>

Video k článku

# Somatosensory Substrates of Flight Control in Bats

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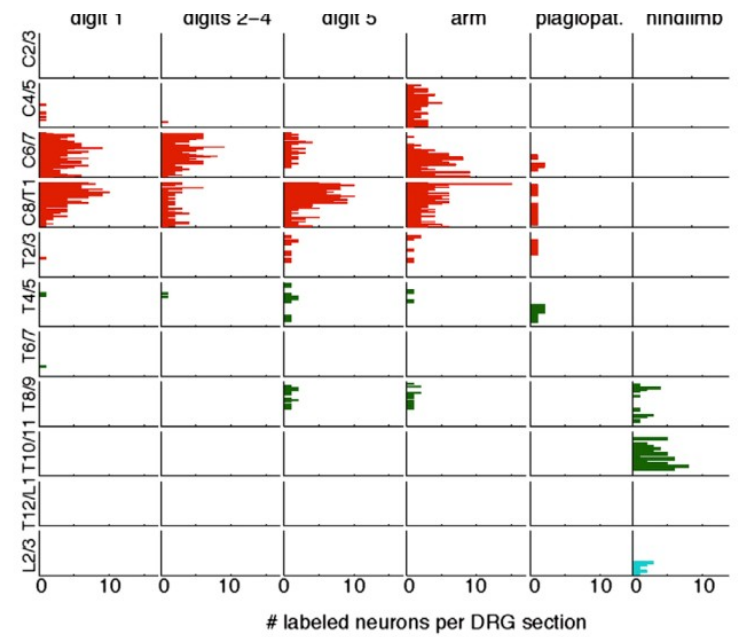
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<http://dx.doi.org/10.1016/j.celrep.2015.04.001>

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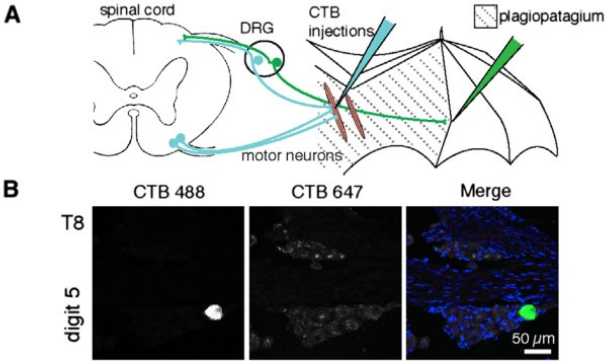
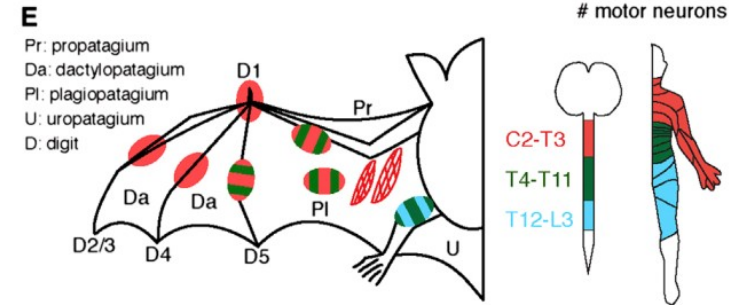
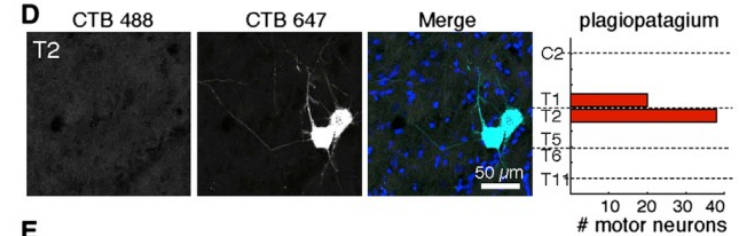


**Figure 1. Bat Wing Neuronal Tracing Reveals Atypical Somatosensory-Motor Innervation**

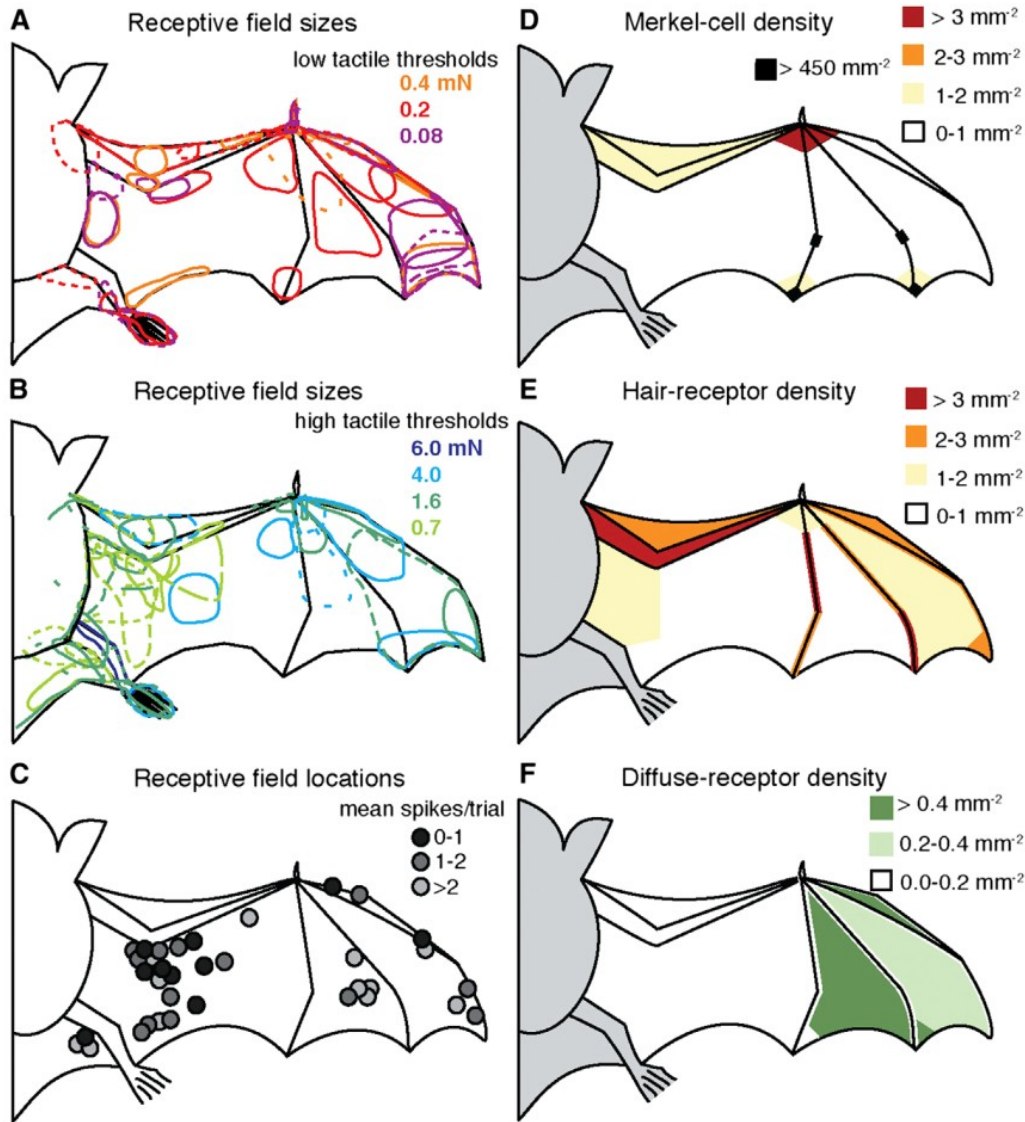
(A) Schematic of neuronal tracing approach.

(B) T8 DRG section from bat wing injected at digit 5 with CTB Alexa 488 (green). Merged image shows DAPI-stained nuclei (blue).

(C) Histograms show the number of neurons labeled at each spinal level from all injections ( $\leq 1.5 \mu\text{l}$  per injection). Each column shows labeling from a separate wing site ( $n = 2-3$  injections per site from two to three bats). See also Figure S1. Color key in (E).



Nervová zakončení zcela jiné organizace (topografie) než u ostatních obratlovců.

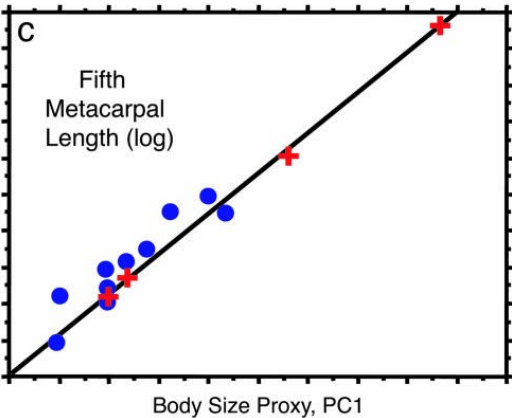
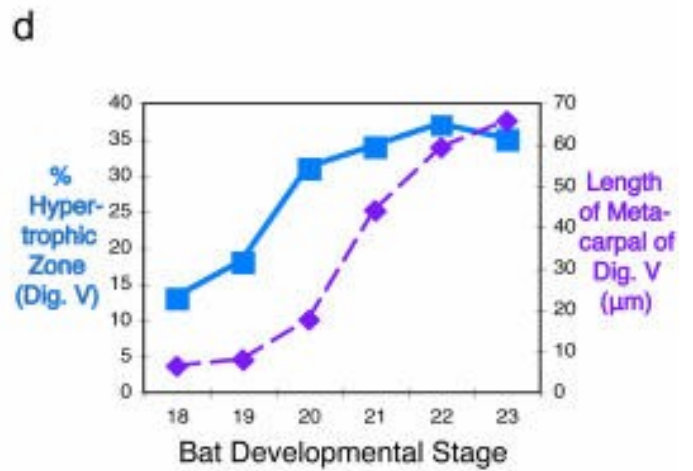
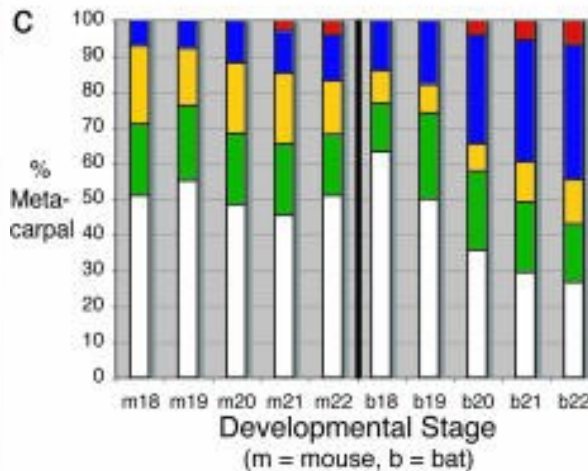
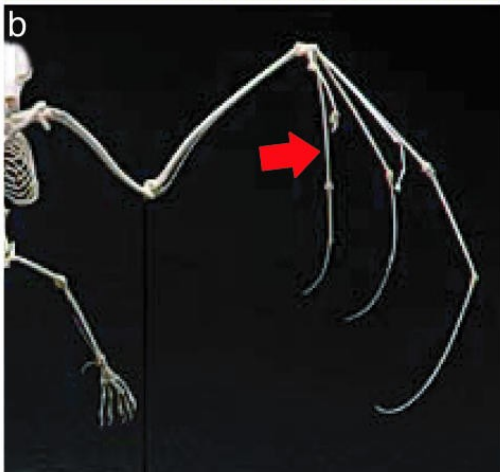
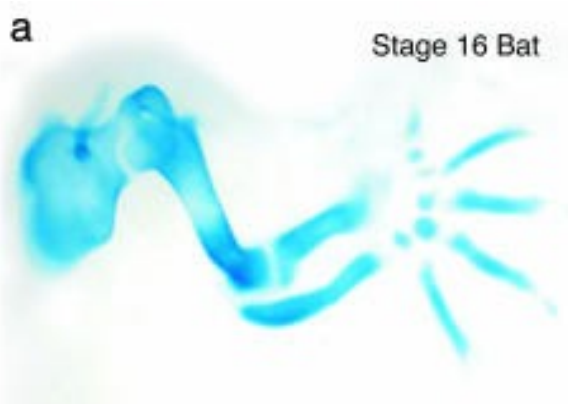
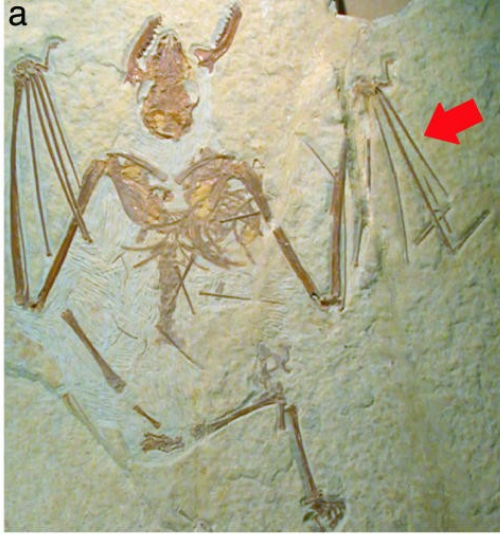


## Response Properties of SI Cortical Neuron Receptive Fields and Peripheral Receptor Densities

(A and B) Receptive field sizes and response thresholds for multiunit SI neurons responding to tactile stimulation. Colors correspond to von Frey thresholds.

(C) Receptive field locations for air-puff sensitive single units. Grayscale indicates mean spikes per trial.

(D-F) Density maps of anatomical sensory endings.



**Ontogenese křídla – velmi netriviální problém**

odpovědnost za růst  
chrupavek

**Bmp2**

aktivizace

chondrogenese

**Prx1** –

omezení růstu

mezenchymu mezi

klouby zadní končetiny

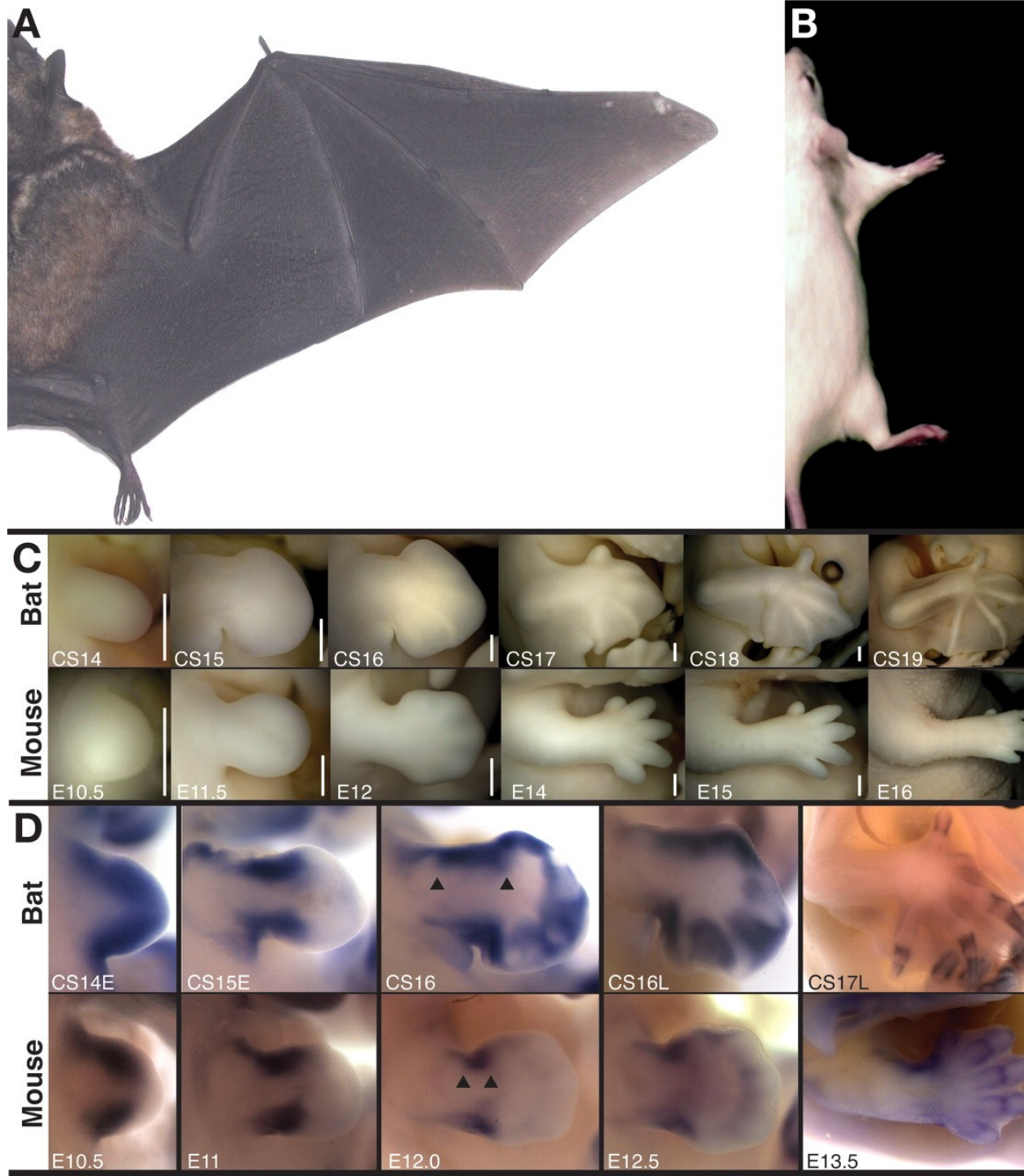
je inhibováno u

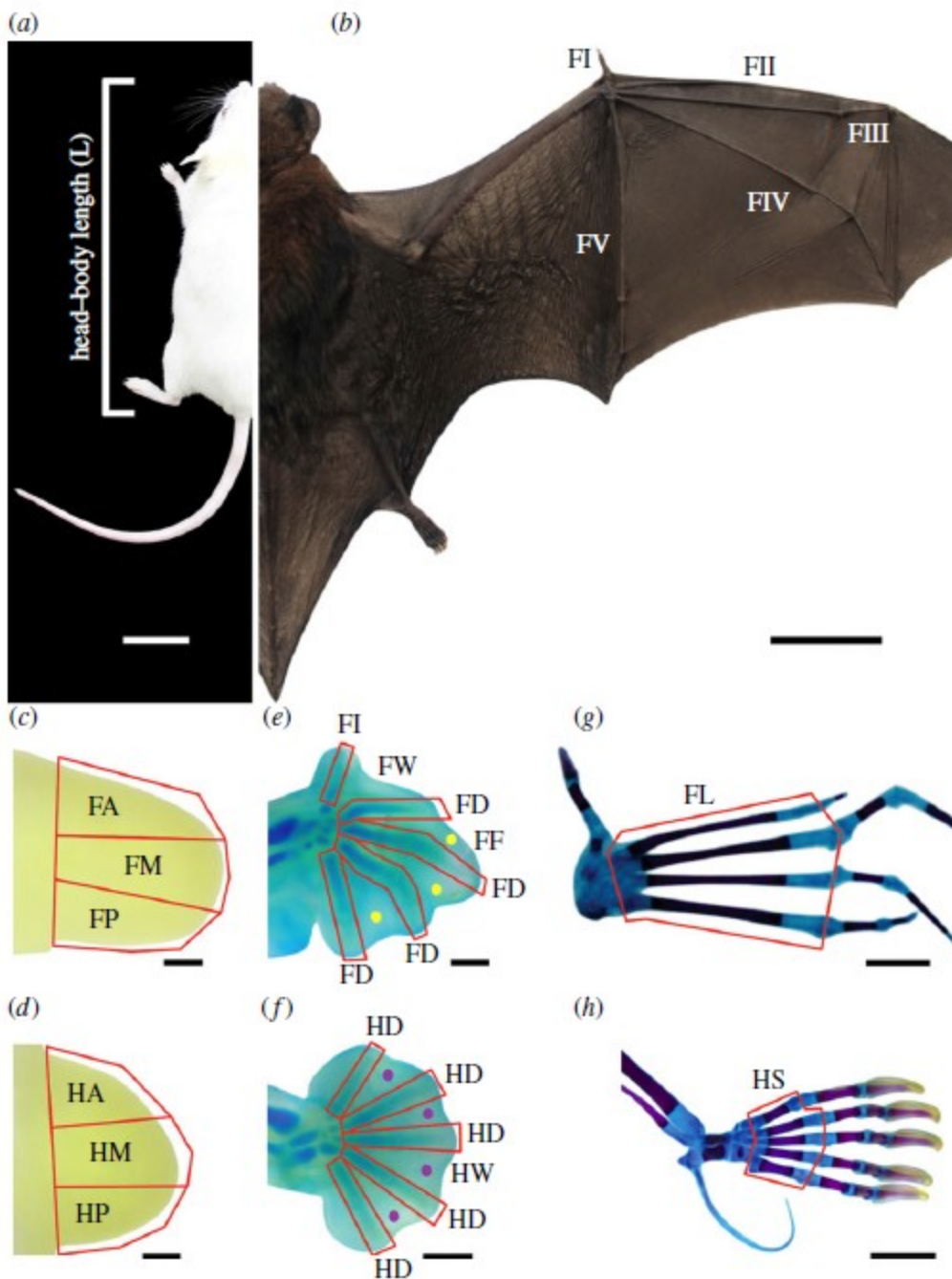
končetiny přední nohy

**Small changes, big results:  
evolution of morphological  
discontinuity in mammals**

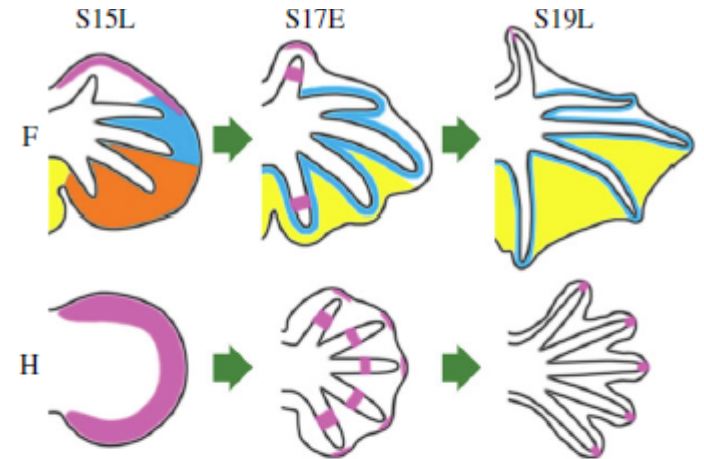
Rodney L Honeycutt 2008

J.Biol





## Unique expression patterns of multiple key genes associated with the evolution of mammalian flight

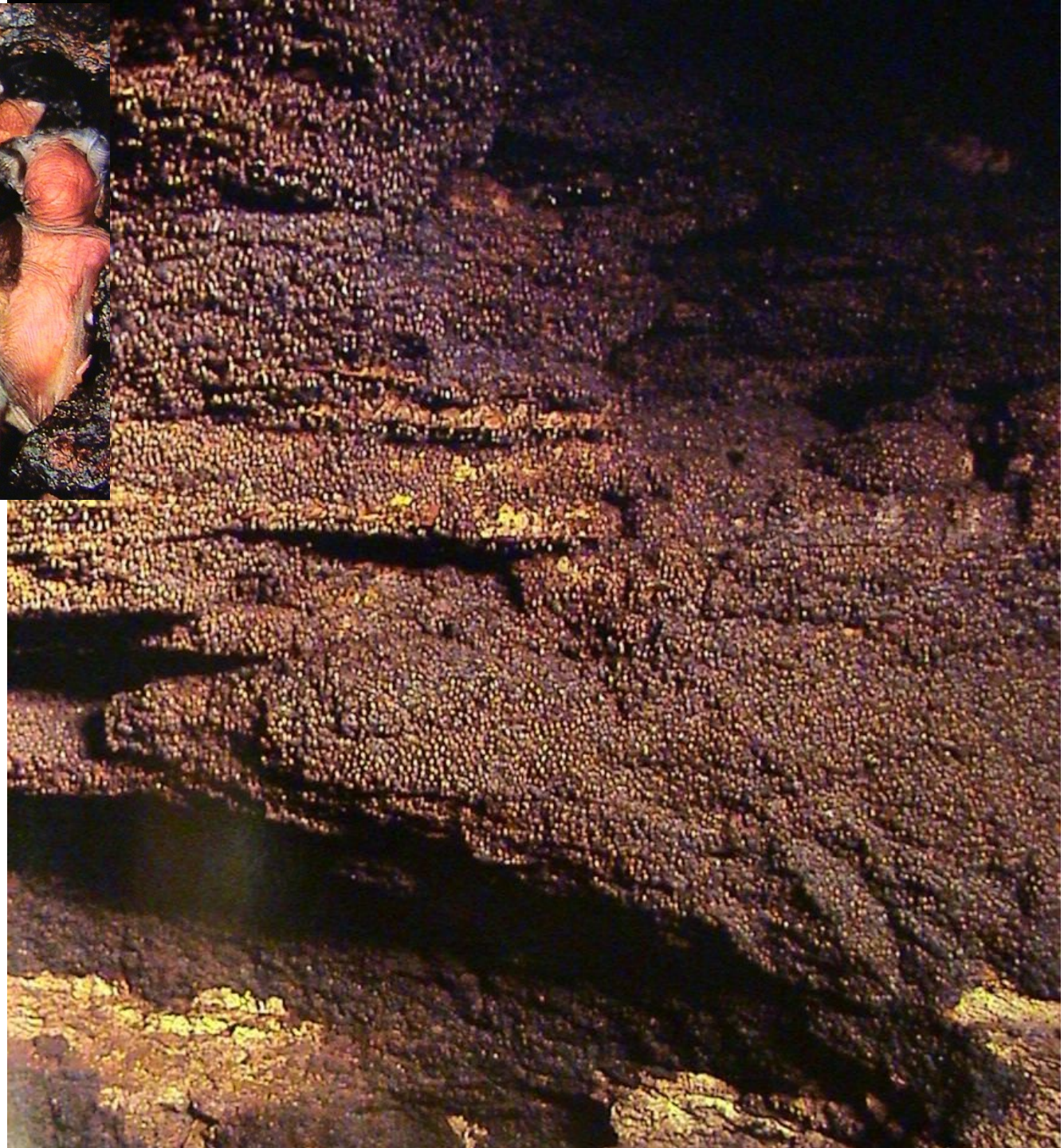


**Figure 4.** Schematic diagram of unique expression patterns of the genes investigated in this study during bat limb development. *5'HoxD* genes (blue and orange) are highly expressed in interdigital regions and in the perichondrium of hand digits II–V in early stages, and then reduced in the interdigital tissue and concentrated in the perichondrium of the elongating digits after stage 16. *Tbx3* expression (yellow and orange) is highly expressed and maintained in the interdigital regions and in the perichondrium of forelimbs throughout the investigated stages. *Fam5c* (pink) is highly expressed at the distal ends of the thumb and its immediate interdigital tissue and throughout the border of the entire foot plate at late stage 15 (S15L). Then, *Fam5c* nearly disappears in both fore- and hindlimbs in stage 16, but comes back at the tip and the forming articulations of the thumb and all the hindlimb digits, as well as the articulations of forelimb digit V in early stage 17 (S17E). At late stage 19 (S19L), *Fam5c* expression is obviously present at the tips of all the foot digits and faintly at the tip of thumb. Orientation of limbs as in figure 1. F, forelimb; H, hindlimb.



*Tadarida  
brasiliensis:*

Interior kolonie



## **Letouni:**

**dlouhověcí (až 40 let),  
1 mládě ročně,  
dokonalá paměť,  
sociální tradice**

Netopýři se mohou dožít vysokého věku ve srovnání s jinými savci podobné velikosti. Dlouhodobé (v letech 1948-2000) kroužkování netopýřů na území bývalého Československa poskytlo různé údaje o velkém množství jedinců - okroužkováno 89 108 netopýřů 23 (resp. 24) druhů, 12 552 zpětných hlášení. U 10 druhů byl díky tomu zjištěn vyšší věk než u dosud známých zahraničních dat, u netopýra velkého (*Myotis myotis*) byl prokázán nejvyšší doložený věk (více než 37 let) netopýra v Evropě a druhý nejvyšší na světě.



# sociální tradice, sociální učení dlouhověkost, filopatrie, fidelita

Rfer - sdílení lovišť matkou a potomkem

**poučení:**  
**Chiroptera-**  
**fenomenální**  
**psychické,**  
**sensorické a**  
**somatomotorické**  
**výkony ...**

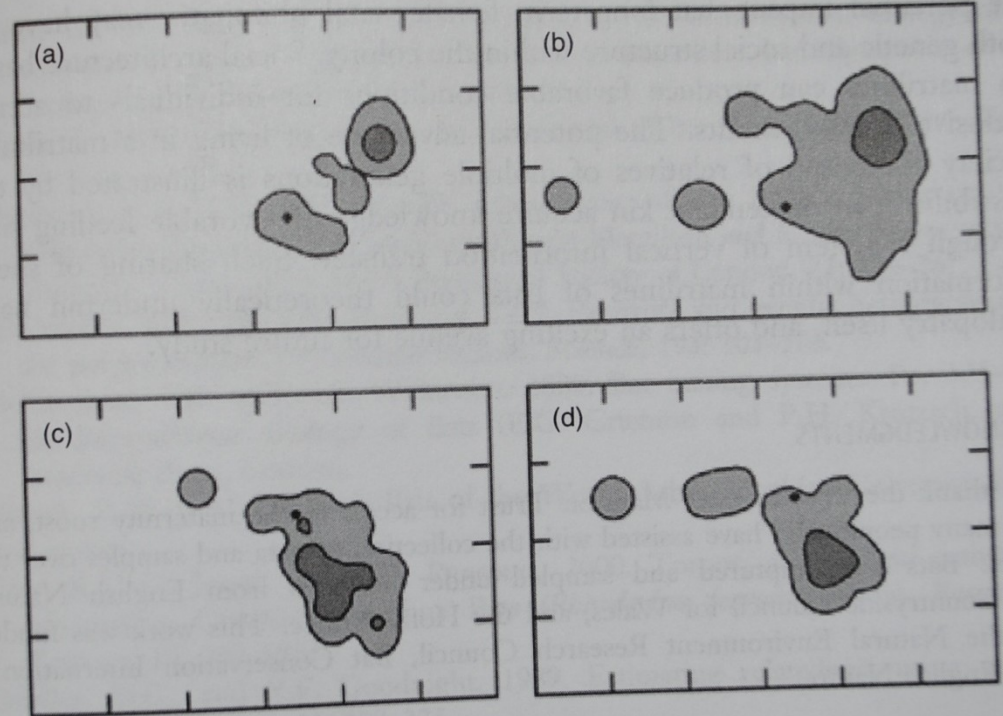


Figure 12.5 Utilization distribution (UD) for two mother-young pairs. Parts (a) and (b) represent the UD of individuals 9684 and 10930 respectively, and parts (c) and (d) represent individuals 10034 and 9668. Fifty percent and 80% UD are shown by light and dark shading, respectively. Woodchester Mansion is represented by a filled black circle for each grid; tick marks represent 2 km increments. (From Rossiter et al., 2002.)

# **Nervová soustava**

**fylogenetické vztahy na základě její stavby**

# ... ale: velmi nízká úroveň encephalisace, řada “plesiomorfii” ve stavbě CNS (zejména míchy)

Tabelle 5.1 Encephalisationsindices (EI) der Fledermausfamilien, bezogen auf basale Insektivoren (EI = 100 %)

Familie/ Unterordnung	EI [%]		
	Min	Max	Mittel
Megachiropteren	177	340	247
Mikrochiropteren			
Phyllostomatidae	148	284	235
Desmodontidae	216	243	232
Thyropteridae	230		
Megadermatidae	182	233	211
Nycteridae	182	233	211
Nycteridae	178	216	196
Mormoopidae	171	203	180
Noctilionidae	128	220	174
Rhinolophidae	139	186	164
Hipposideridae	87	174	164
Furipteridae	-	-	152
Emballonuridae	132	169	151
Molossidae	107	166	137
Vespertilionidae	77	179	128
-nur im Flug jagende, insektivore Mikrochir.			137
im Flug jagende und von Substrat ablesende Mikrochir.			156
nur von Substrat ablesende Mikrochiropteren			186
karnivore Mikrochiropteren			213

Aus H. Stephan 1977; H. Stephan und J. E. Nelson 1981; Stephan et al. 1987.

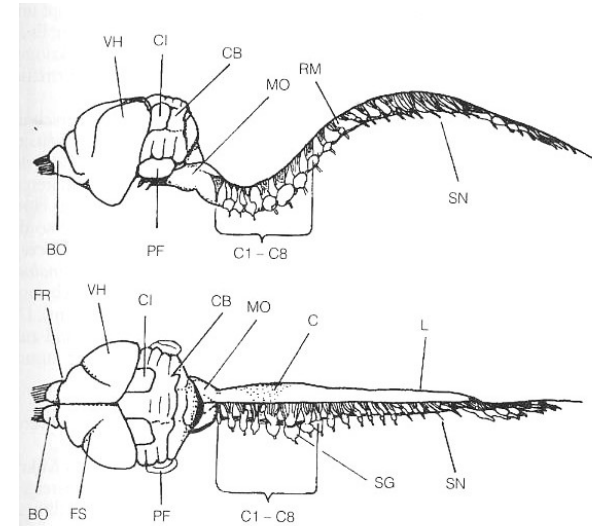
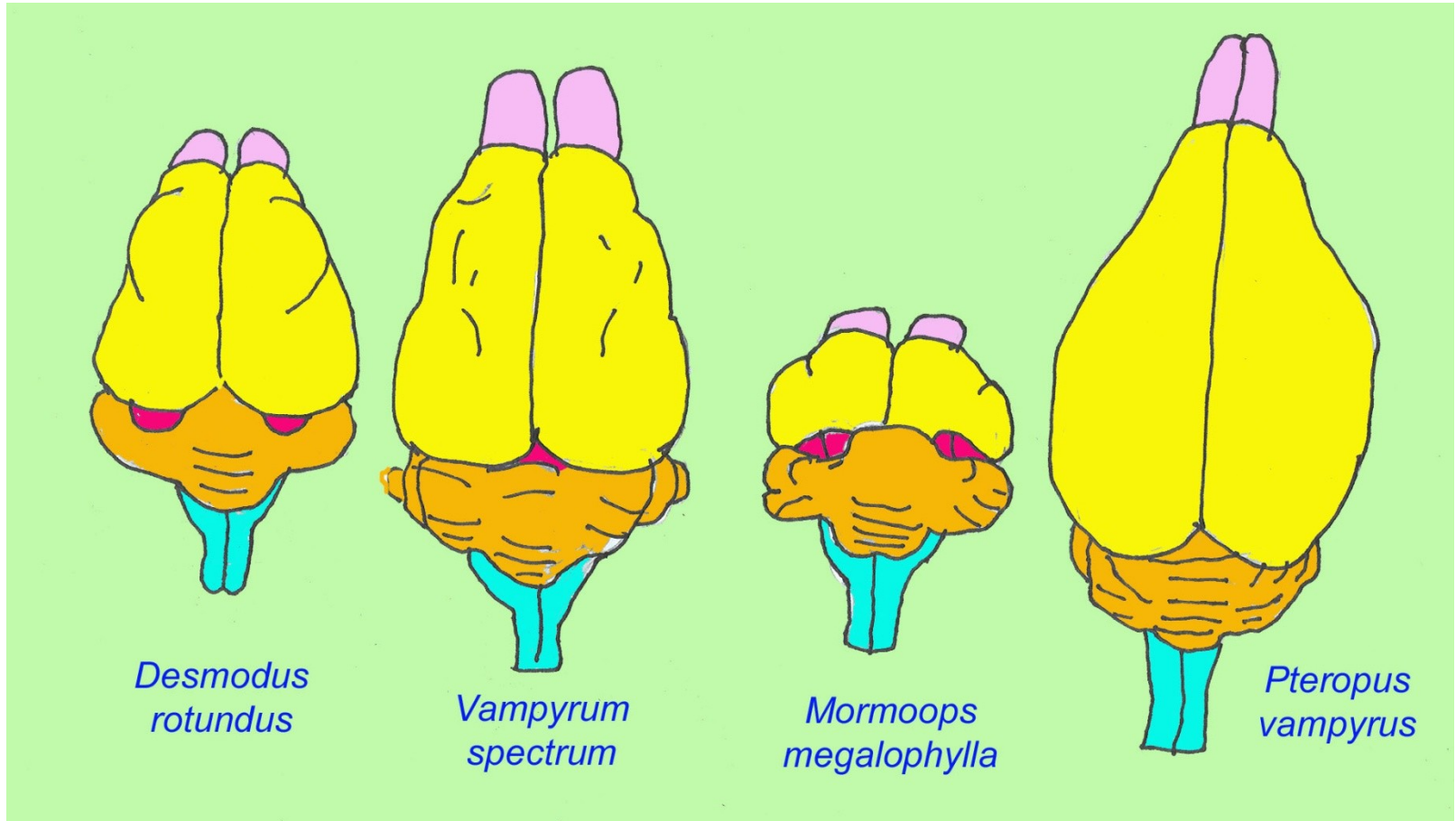


Abb. 5.3 Zentralnervensystem (ZNS) einer Fledermaus. Lateral- (oben) und Dorsalansicht (unten) auf das ZNS von *Pteronotus parnellii* (Mormoopidae). BO = Bulbus olfactorius, C = Halsaufreibung („Flügelgehirn“) des Rückenmarks, CB = Cerebellum, CI = Colliculus inferior (Mittelhirn), C1-C8 = Spinalnerven des 1.-8. Halswirbels, FS = Fissura Sylvii, FR = Fissura rhinalis, L = Lumlaufreibung des Rückenmarks, MO = Medulla oblongata (Nachhirn), PF = Fissura Sylvii (Kleinhirn), RM = Rückenmark, SG = Spinalganglion, SN = Spinalnerv, VH = Vorderhirn. Aus O. W. Henson in W. A. Wimsatt 1970.

The percentage of the total brain composed by individual regions of the brain vary in different bat species. The percentage of the total brain composed by the medulla can vary from 5.3-19.7%, midbrain 4.2-14.6%, cerebellum 11.5-28.9%, and telencephalon 37.7-70.2%. In humans, the telencephalon composes 85% of the total brain



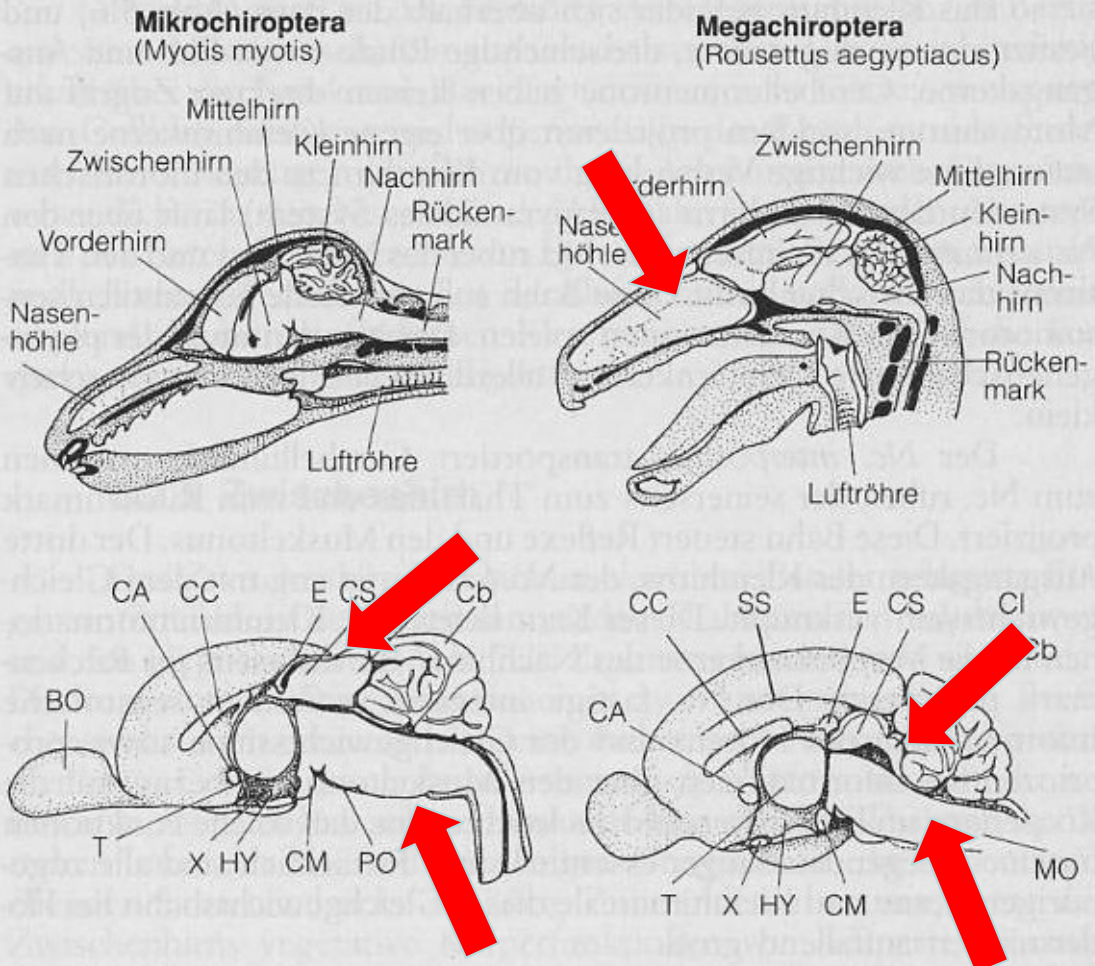


Abb. 5.6 Gehirn der Mikrochiropteren (*Myotis myotis*, unten *Hipposideros commersoni*) und Megachiropteren (*Rousettus aegyptiacus*, unten *Eidolon helvum*).  
 oben: Lage des Gehirns im Schädel.  
 unten: Mediansagittalschnitt durch das Gehirn.  
 BO = Bulbus olfactorius, CA = Commissura anterior, Cb = Cerebellum, CC = Corpus callosum, CI = Colliculus inferior (Mittelhirn), CM = Corpus mamillare (Zwischenhirn), CS = Colliculus superior (Mittelhirn), E = Epiphyse, HY = Hypothalamus (Zwischenhirn), MO = Medulla oblongata, PO = Pons, SS = Sulcus splenialis, T = Thalamus, X = Chiasma opticum. Nach O.W. Henson in W. A. Wimsatt 1970 und R. Schneider 1957.

relativní velikost **tecta**  
 a zejména **colliculus inferior**



výrazné rozdíly mezi Micro-  
 a Megachiroptera

cf. Pettigrew (1994)

a návazné hypotézy

Němec et al. (1996, 2000)

mozeček  
 neokortex  
 redukce pyramidálního  
 systému u netopýřů

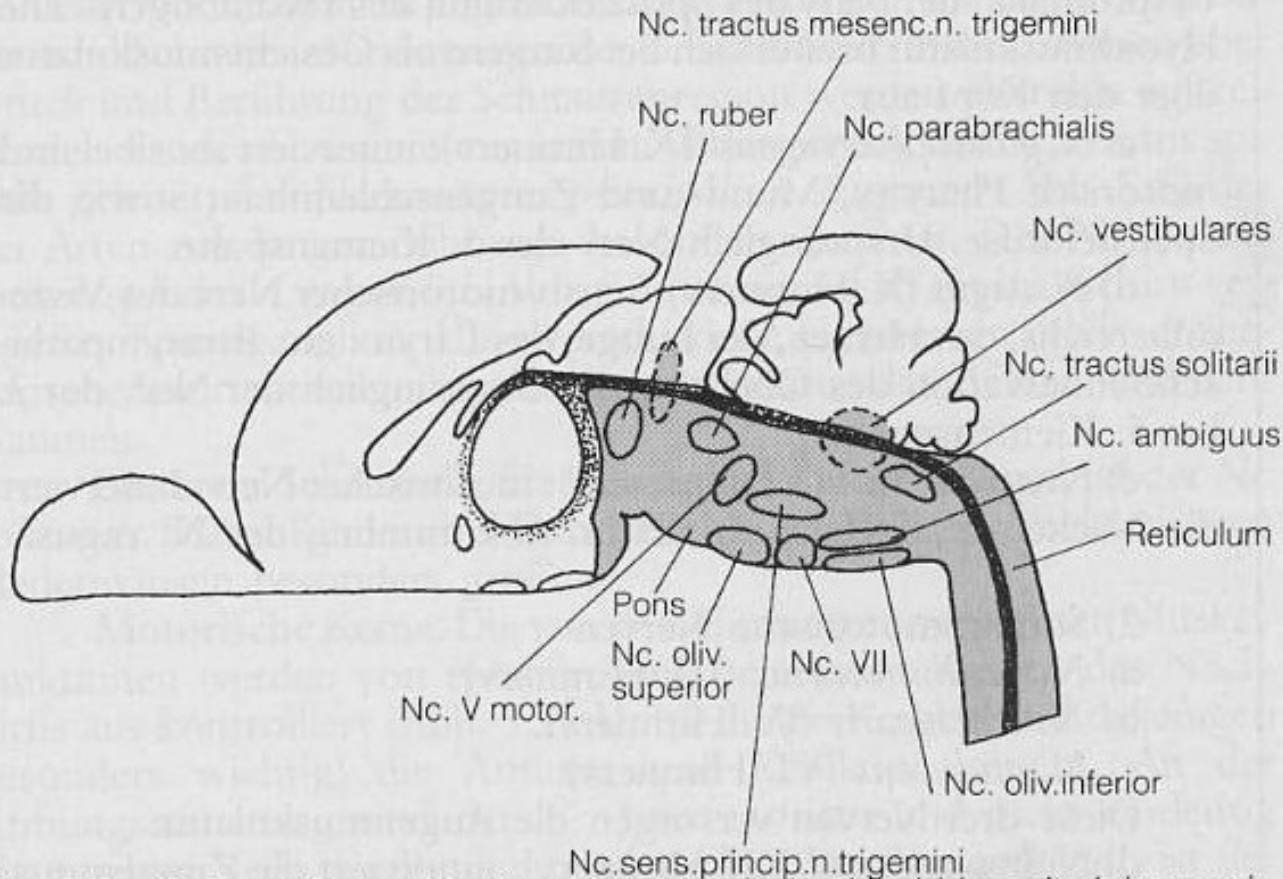
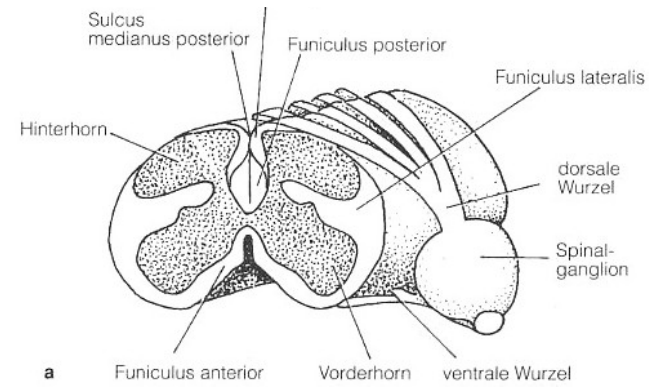
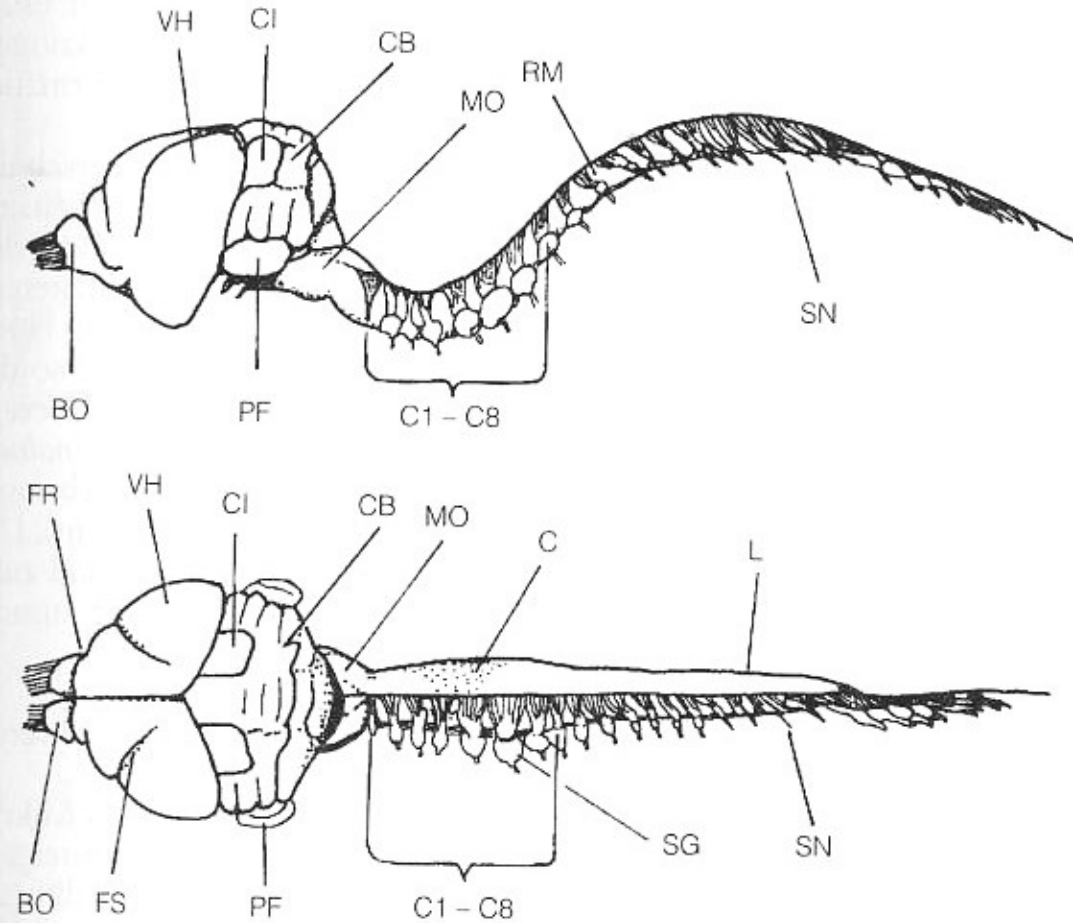


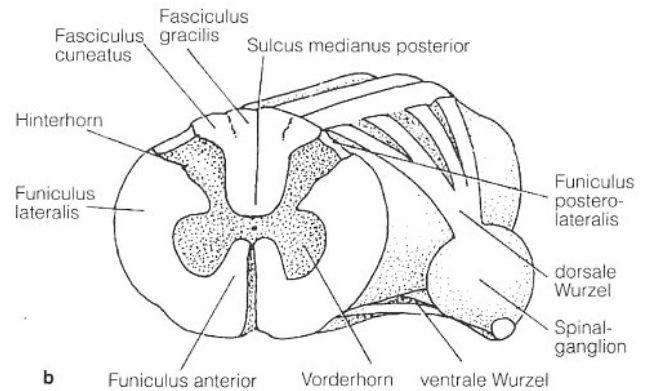
Abb. 5.5 Schematischer Medianschnitt durch das Nachhirn mit einigen seiner Kerne (Nc.). Grau das Reticulum des Nachhirns. Nc. V. motor. motorischer Kern des N. trigeminus, Nc. VII Kern des N. facialis.

Objemově dominantní složkou mozku – mozkový kmen (myelencephalon + tegmentum) s excesivně zvětšenými jádry vestibulokochleárního aparátu uvnitř mohutného retikula

# diff. Mega/Micro



a



b

Abb. 5.4 Querschnitt durch das Rückenmark

a) der Mikrochiropteren (*Pteronotus parnelli*) und

b) der Megachiropteren (*Eidolon helvum*).

(grau: graue Substanz, weiß: weiße Substanz)

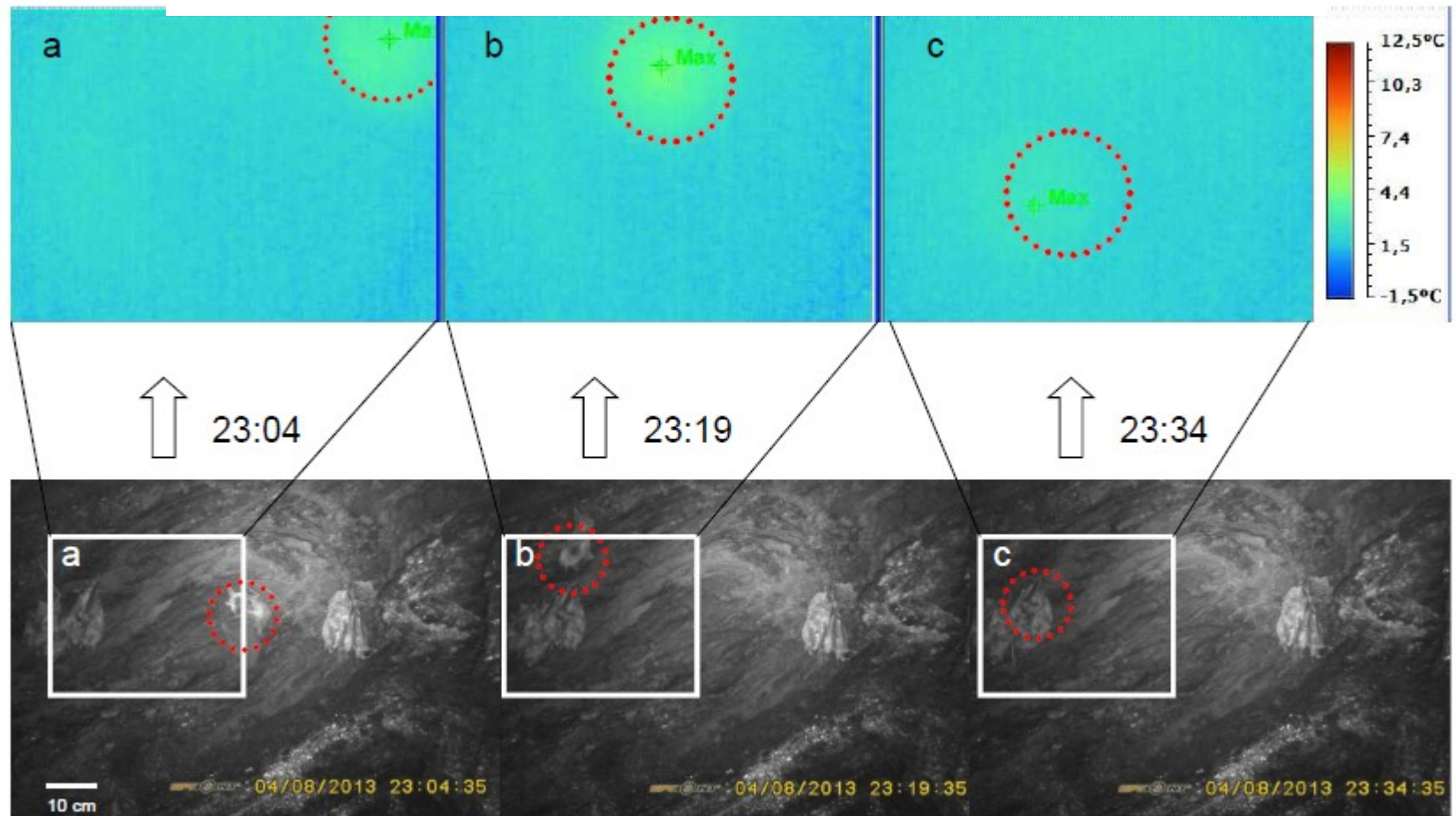
Funiculus anterior, Fasciculus cuneatus, F. gracilis sind sensorische Bahnen aus der hinteren Körperhälfte zum Gehirn, Funiculus posterior führt Informationen über Tast- und Tiefensensibilität zum Gehirn. Aus O.W. Henson in W. A. Wimsatt 1970.

## krátká mícha

netopýři – zbytnělá šedá hmota, detritické výběžky soustředěny do bílé hmoty  
**koordinální funkce (létání) řízeno mimo mozek!**

## Deeply torpid bats can change position without elevation of body temperature

Tomáš Bartonička <sup>a</sup> ✉, Hana Bandouchova <sup>b</sup>, Hana Berková <sup>d</sup>, Ján Blažek <sup>a</sup>, Radek Lučan <sup>c</sup>, Ivan Horáček <sup>c</sup>, Natália Martínková <sup>d, e</sup>, Jiri Pikula <sup>b</sup>, Zdeněk Řehák <sup>a, f</sup>, Jan Zúkal <sup>d</sup>





# Shrnutí CNS letounů

1. Kompletní přítomnost obecných savčích znaků
2. Četné autapomorfie - výrazné adaptivní přestavby
  - senzomorická integrace sluchových a polohových vjemů v myelencephalonu,
    - prostředky semantické analýzy v colliculii a v cortexu
  - rozvoj míchy – koordinační centrum motoriky křídla
  - extrémně nízká exprese calpainu (klíčový faktor!): velikost, dlouhověkost, paměťová přesnost
3. Velikostní škálování (cf. objem bílé/šedé hmoty v míše)

# **Ekomorfologie potravních adaptací**

**Dentice, zuby, lebka**

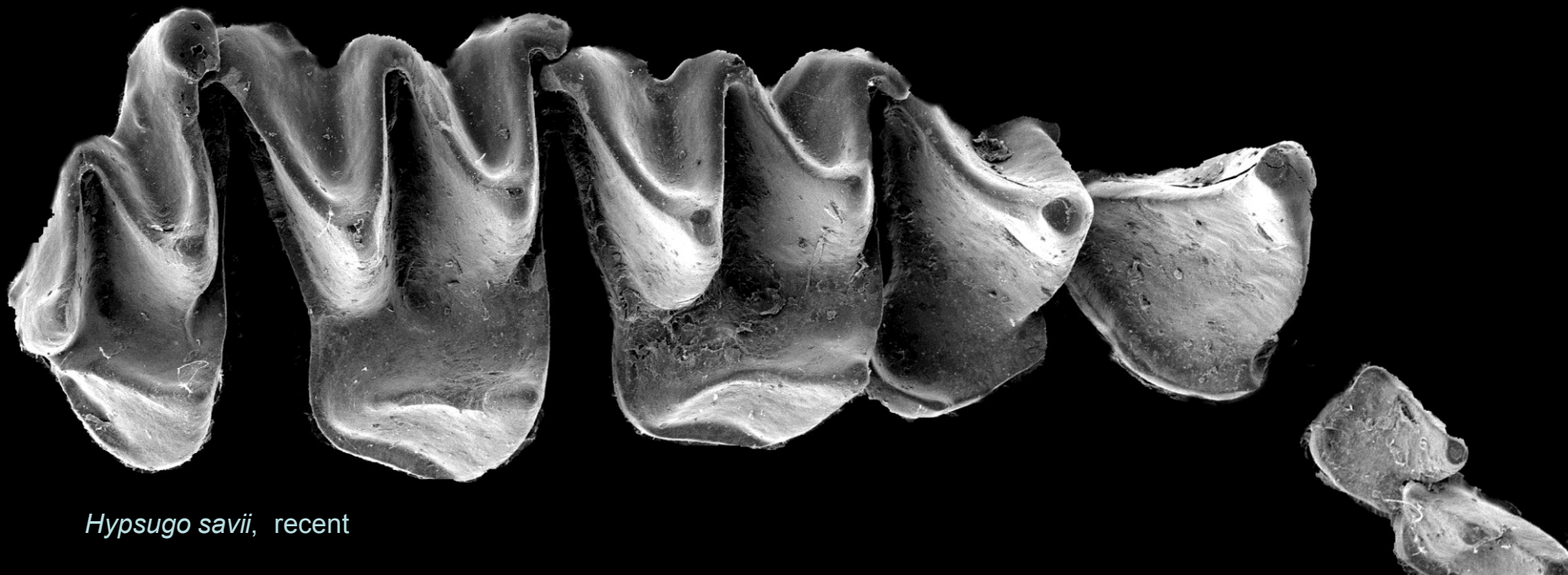


**Chiroptera:**

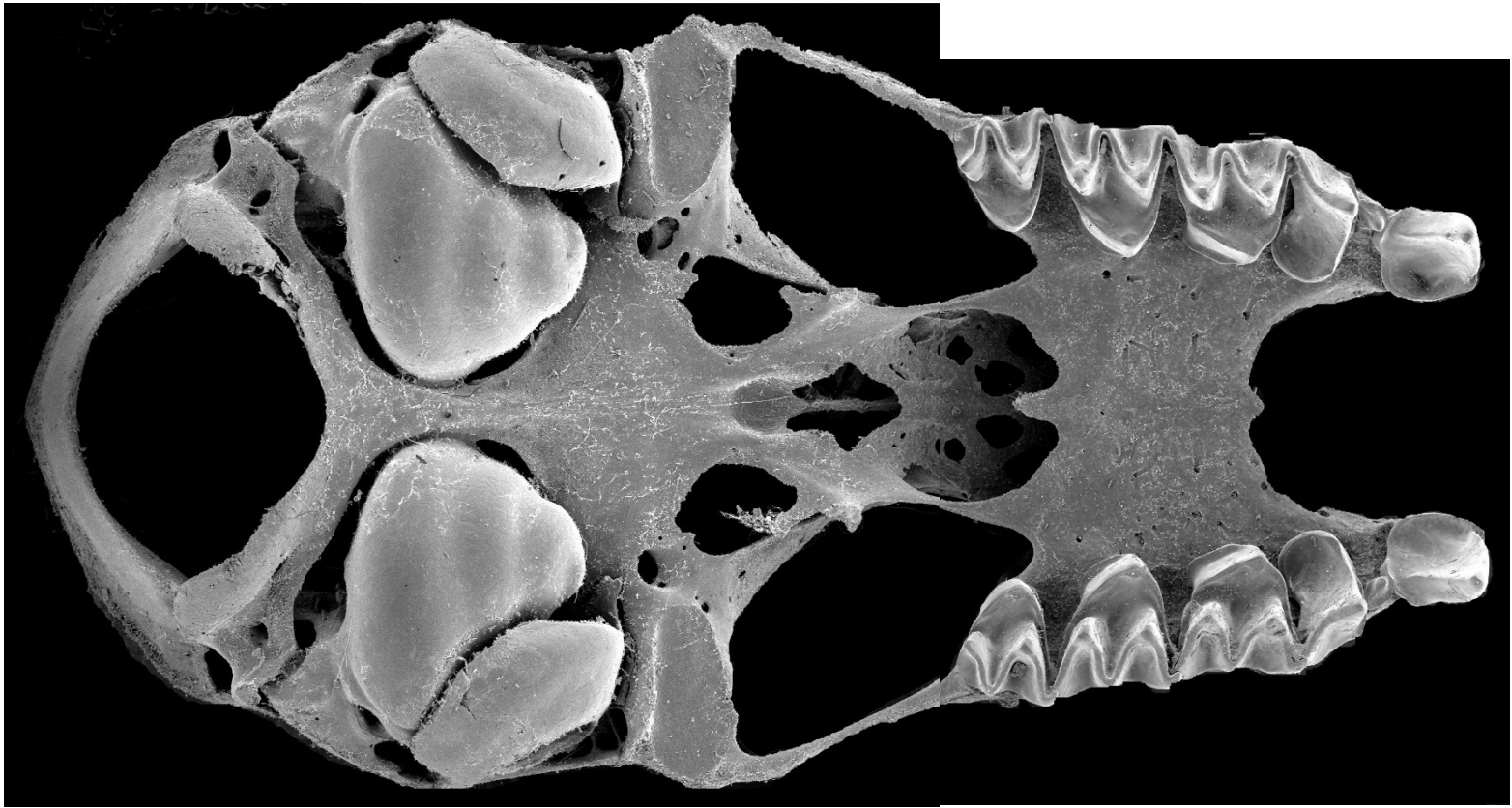
**Výrazně heterodontní  
savčí dentice –  
tribosfenické stoličky  
(výj.: kaloni)**



*Icaronycteris ? menui*, E-Eocene, Mutigny



*Hypsugo savii*, recent



- dentice je závislá na efektivitě zpracování potravy, dostupnost potravy nebo jiné faktory na její vývoj nemají žádný vliv.
- enamel, který je zodpovědný za biomechanické opotřebení, musí být finální již před prořezáním zubu.

# základní dilema faunivorie

**potrava:**

velká



malá, ale častá

*hodně energie na jeden pokus*



*málo energie, ale menší náklady*

zvětšit sílu skusu ► navýšit výšku dentice (špičáky)



zvětšení zpracované potravy ► zvětšit oklusní plochu

canidizace

**zkrácení dentice za špičákem**



molarizace P4

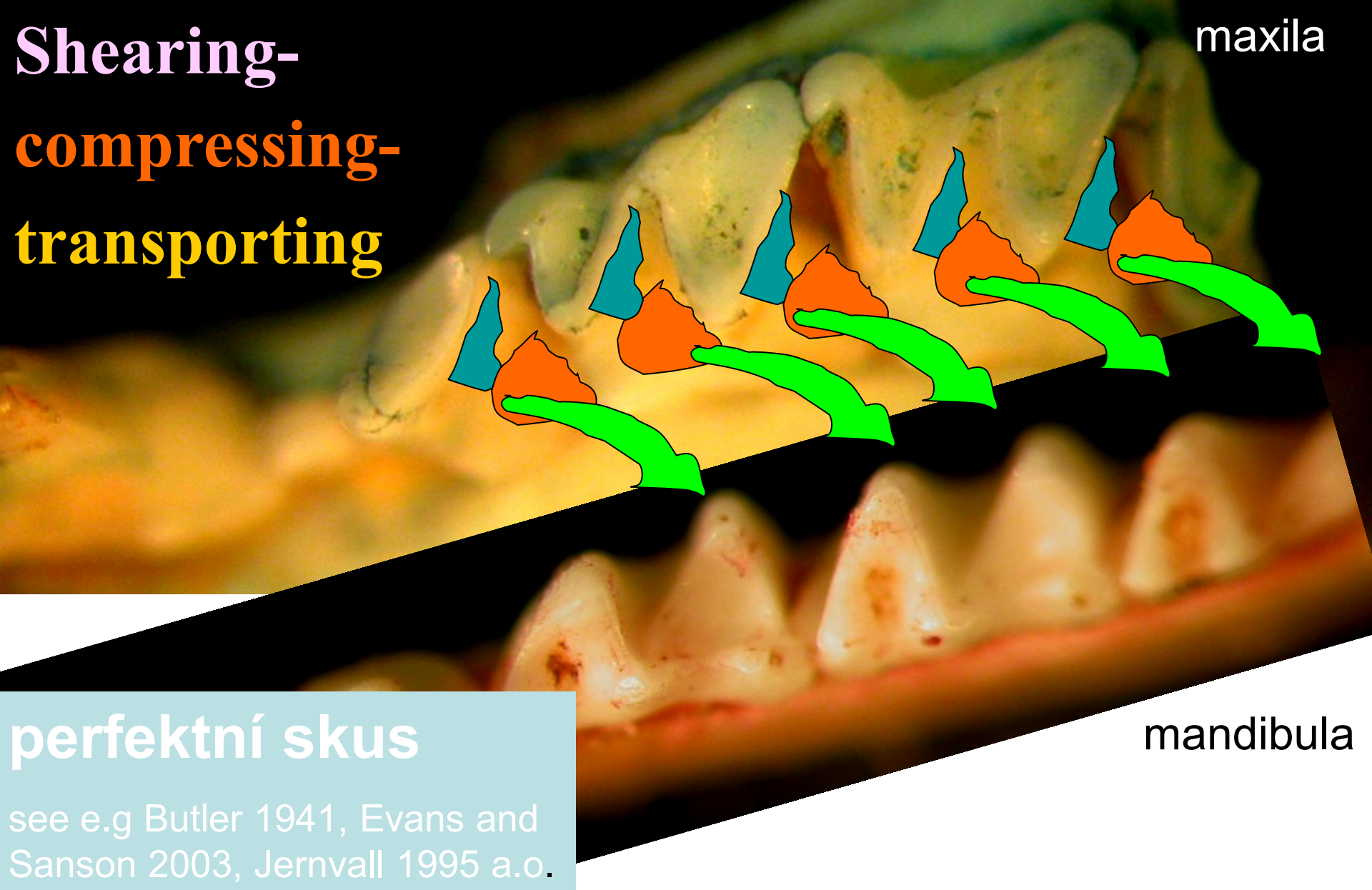
**zvětšit molariformní část dentice**

výsledek u většiny netopýrů

**redukce premolárů a M3/3**

**Shearing-  
compressing-  
transporting**

maxila



**perfektní skus**

mandibula

see e.g Butler 1941, Evans and Sanson 2003, Jernvall 1995 a.o.

**stoličky netopýrů jsou tribosfenického typu**

# tribosfenické zuby jsou designovány pro **insektivorii**

členovci: snadno trávitelní, je jich dost a jsou malí  
stačí jen odstranit chitinovou kutikulu

malá selekce k drcení potravy

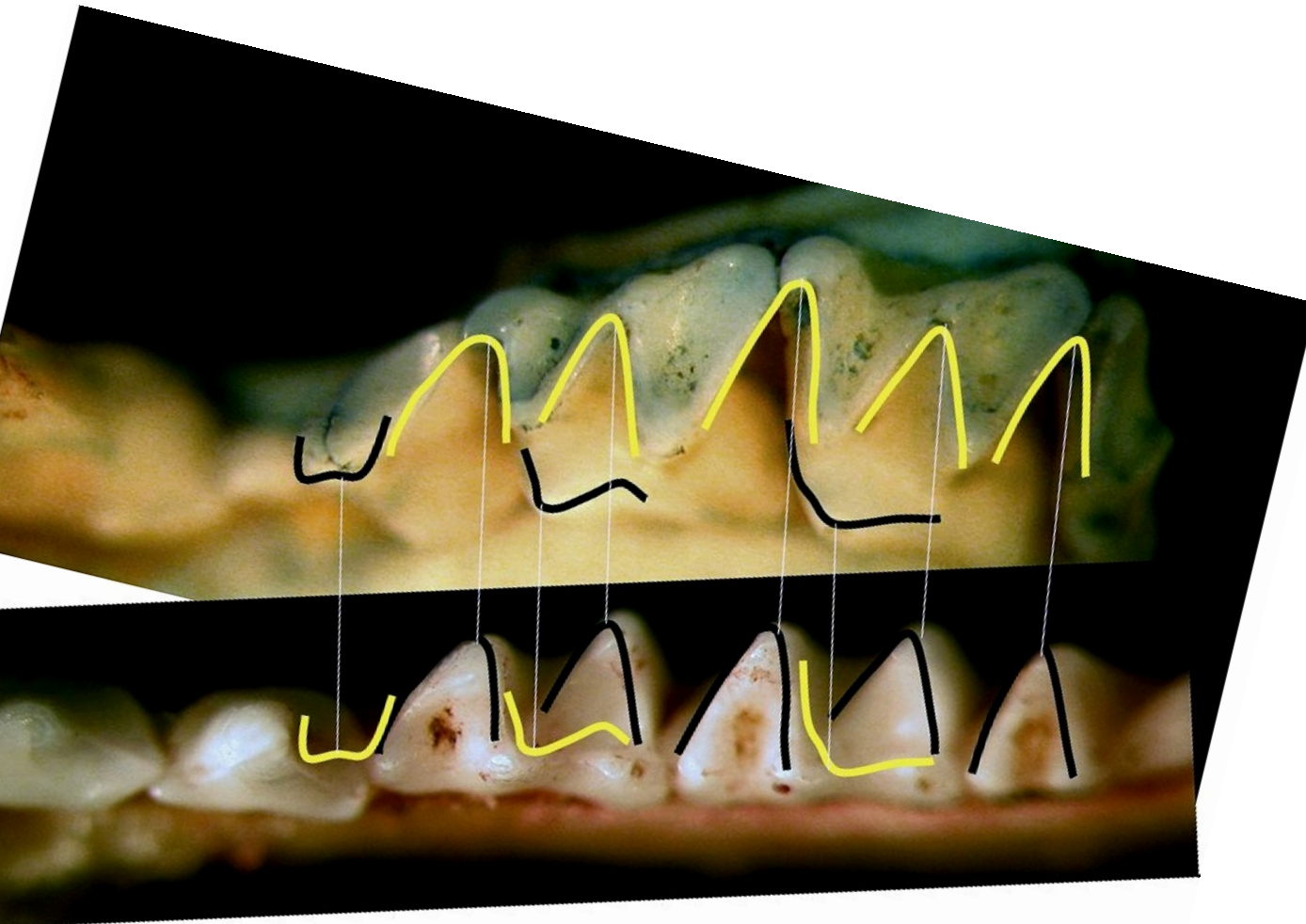
zvětšit tlak v dutinách (fossas) a  
zvýšit sílu stěn (enamel)

hlavní tlak (selekci) na  
„ukousnutí“



# .. vše v jediný okamžik

- nutnost perfektního zapadnutí struktur do sebe



- crests,
- cusps,
- walls,
- fossas
- etc.)

*Otonycteris  
hemprichii*

**jakékoliv  
vychýlení je  
fatální**



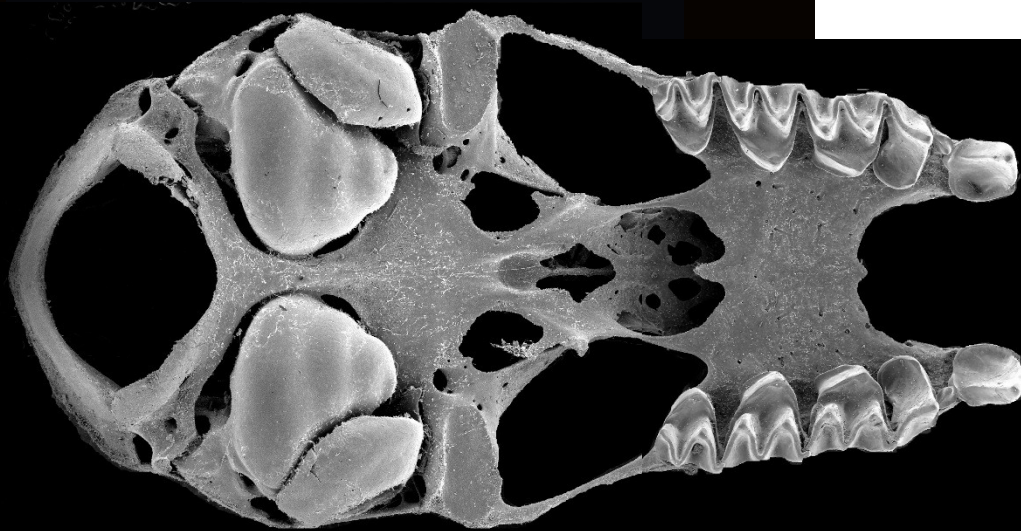
# Tribosfenická dentice – velmi komplexní

Musí být ve všech detailech zcela funkční a dokončená v době odstavu:

Tedy...

zásadní omezení na možné rozšíření zubní řady

**Chiroptera: vysoce specialisovaná  
vzdušná hmyzožravost**





# Listonosi (Phyllostomidae)

# Extrémní typy specialisací, nejpočetnější savci Jižní Ameriky



Listonosi (Phyllostomidae)

# Rozsáhlé adaptivní přestavby lebečné morfologie



**Listonosi (Phyllostomidae)**

# Potravní specializace

Hmyzožravost

Sanguivorie



© Dewynter

*Macrophyllum macrophyllum*

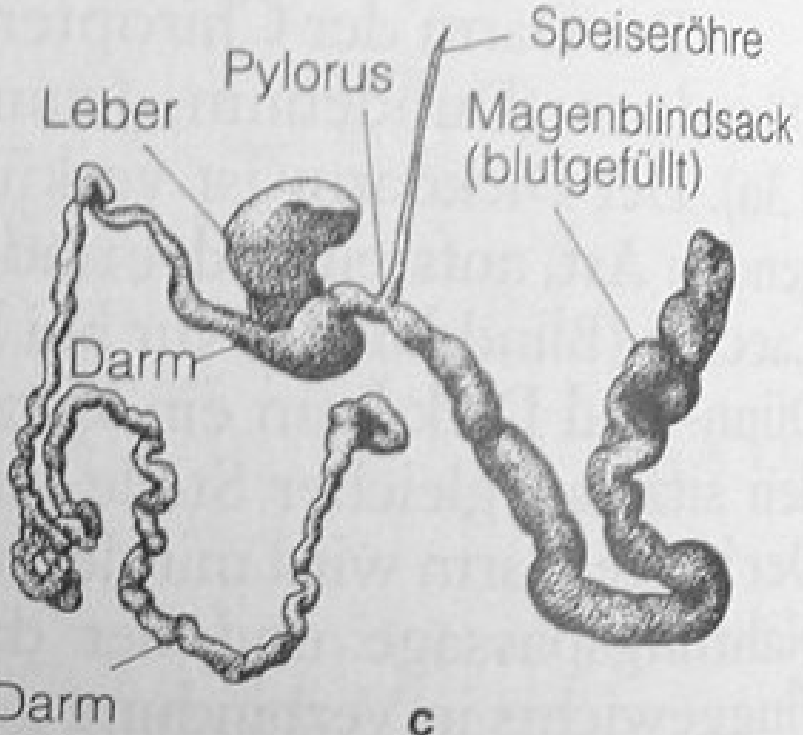
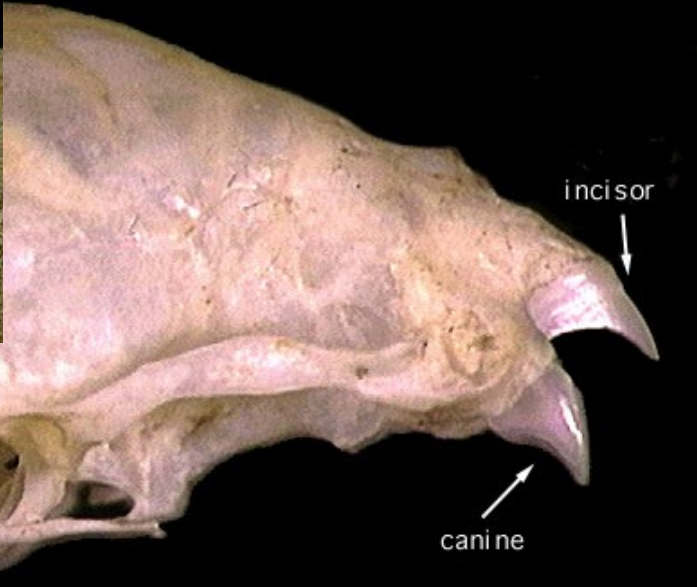


© Dewynter

*Desmodus rotundus*

Listonosi (Phyllostomidae)





*Desmodus rotundus*

Listonosi (Phyllostomidae)

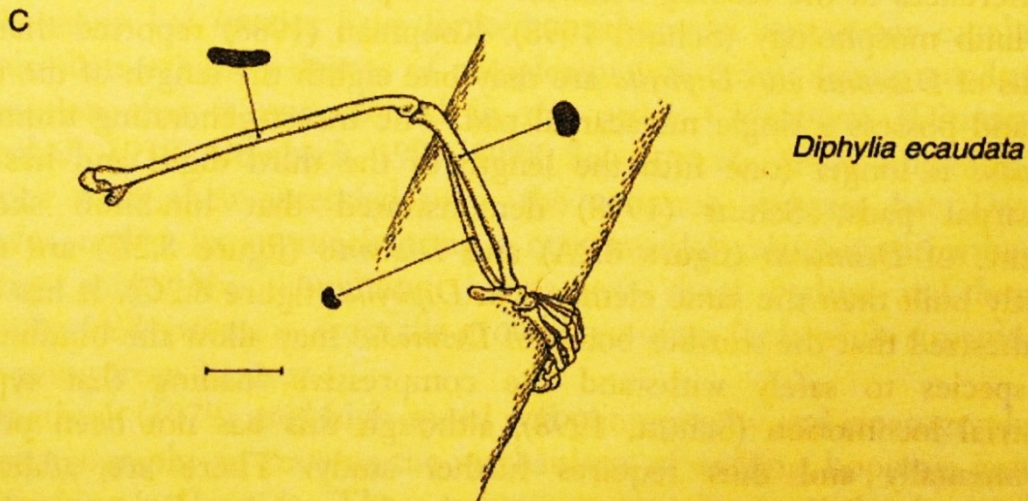
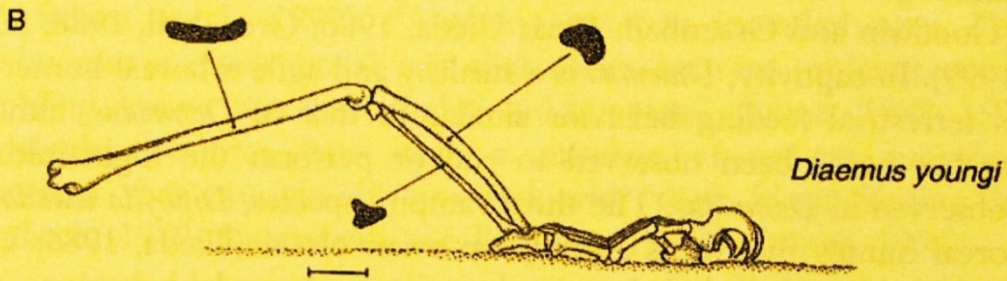
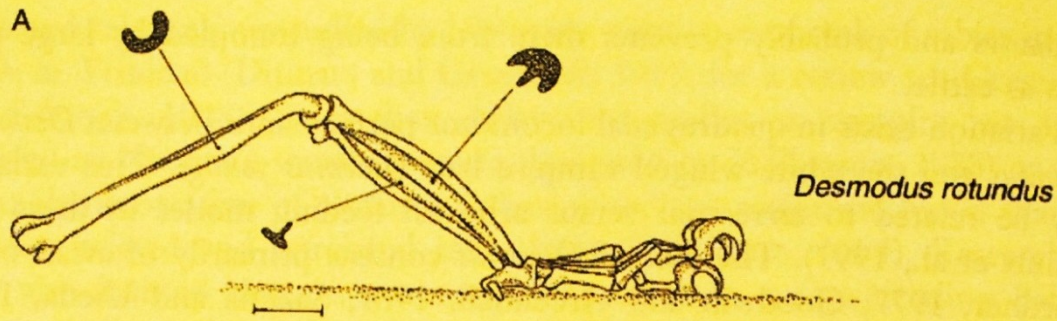


Figure 8.2 Hindlimb bones of (A) *Desmodus rotundus*, (B) *Diaemus youngi*, and (C) *Diphyllia ecaudata*. Dark shaded inserts represent cross-sectional views of the bone at the point indicated.



# Potravní specializace

Frugivorie



© Dewynter

*Ametrida centurio*



*Vampyroides caraccioli*

Listonosi (Phyllostomidae)

# Potravní specializace

Karnivorie



*Trachops cirrhosus*

Nektarivorie



*Anoura fistulata*

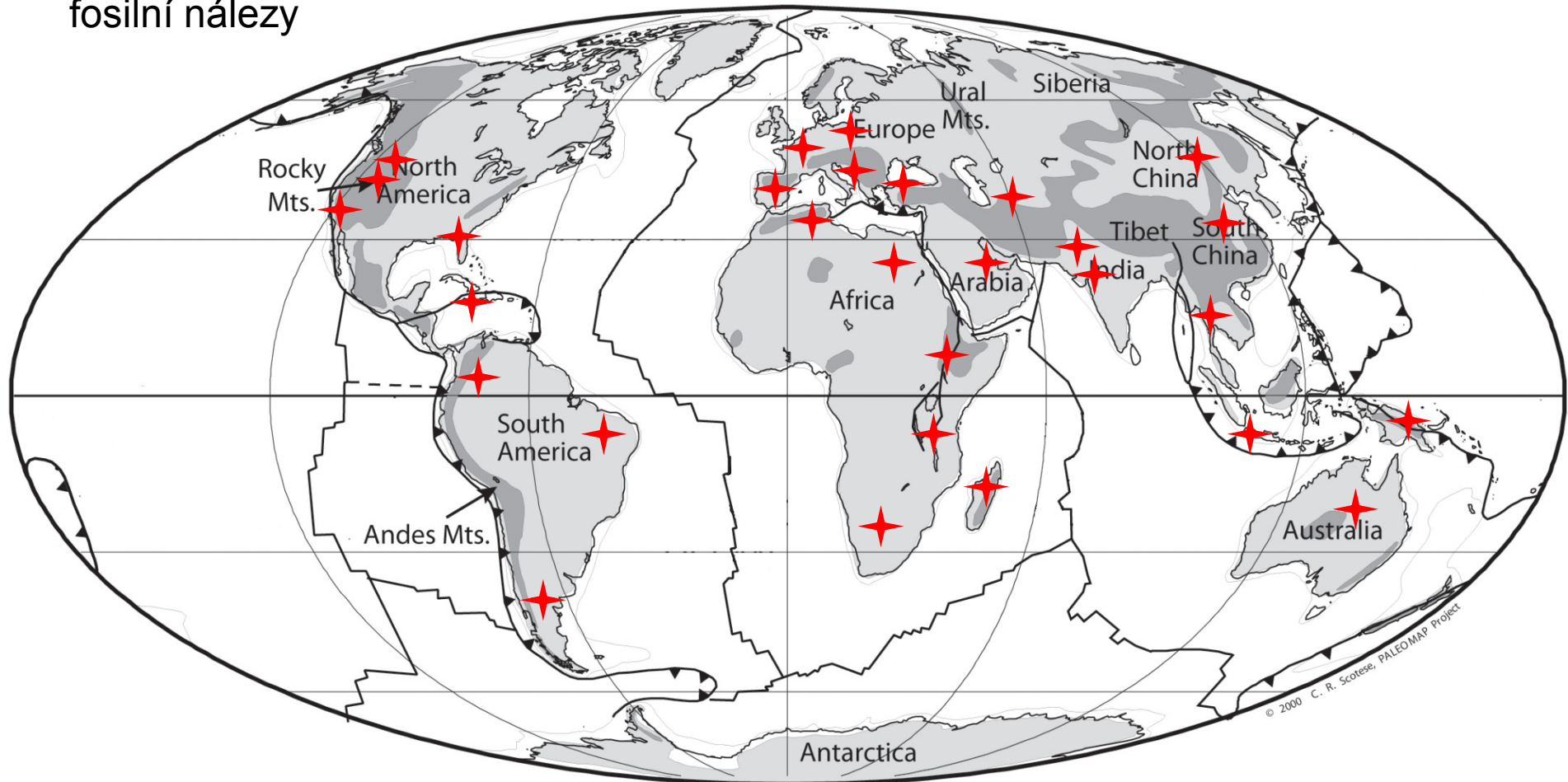
Listonosi (Phyllostomidae)

# Biogeografické okénko

Review of the Origins and Biogeography of Bats  
in South America

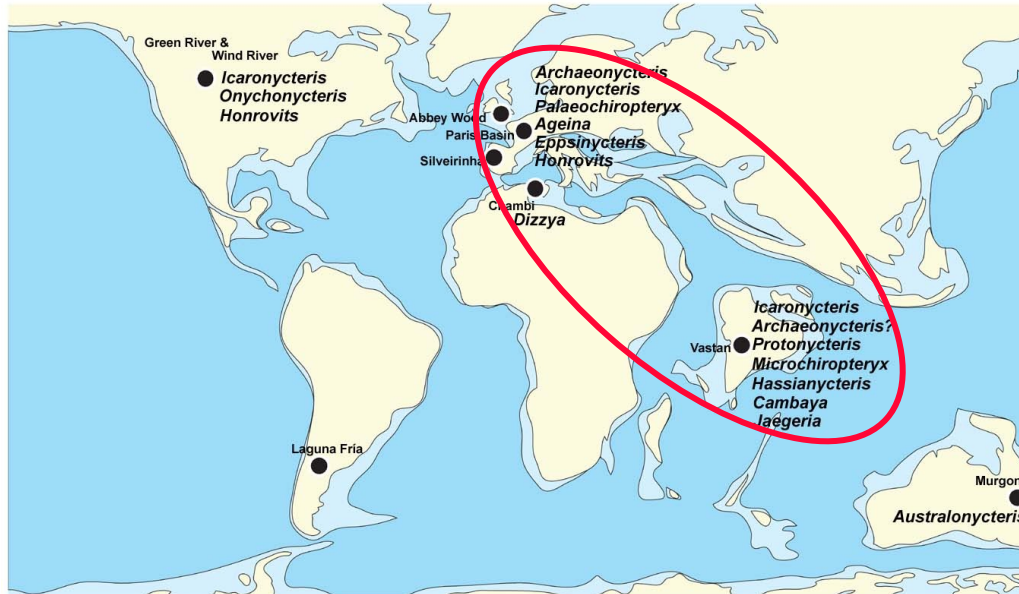
# Fylogeneze

fosilní nálezy



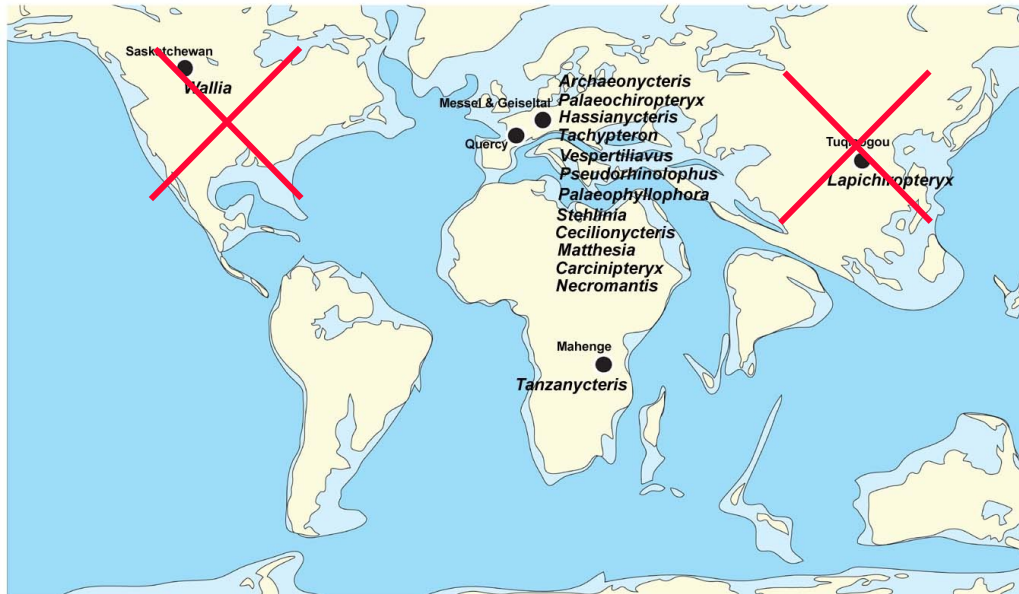
# Paleobiogeography

Early Eocene

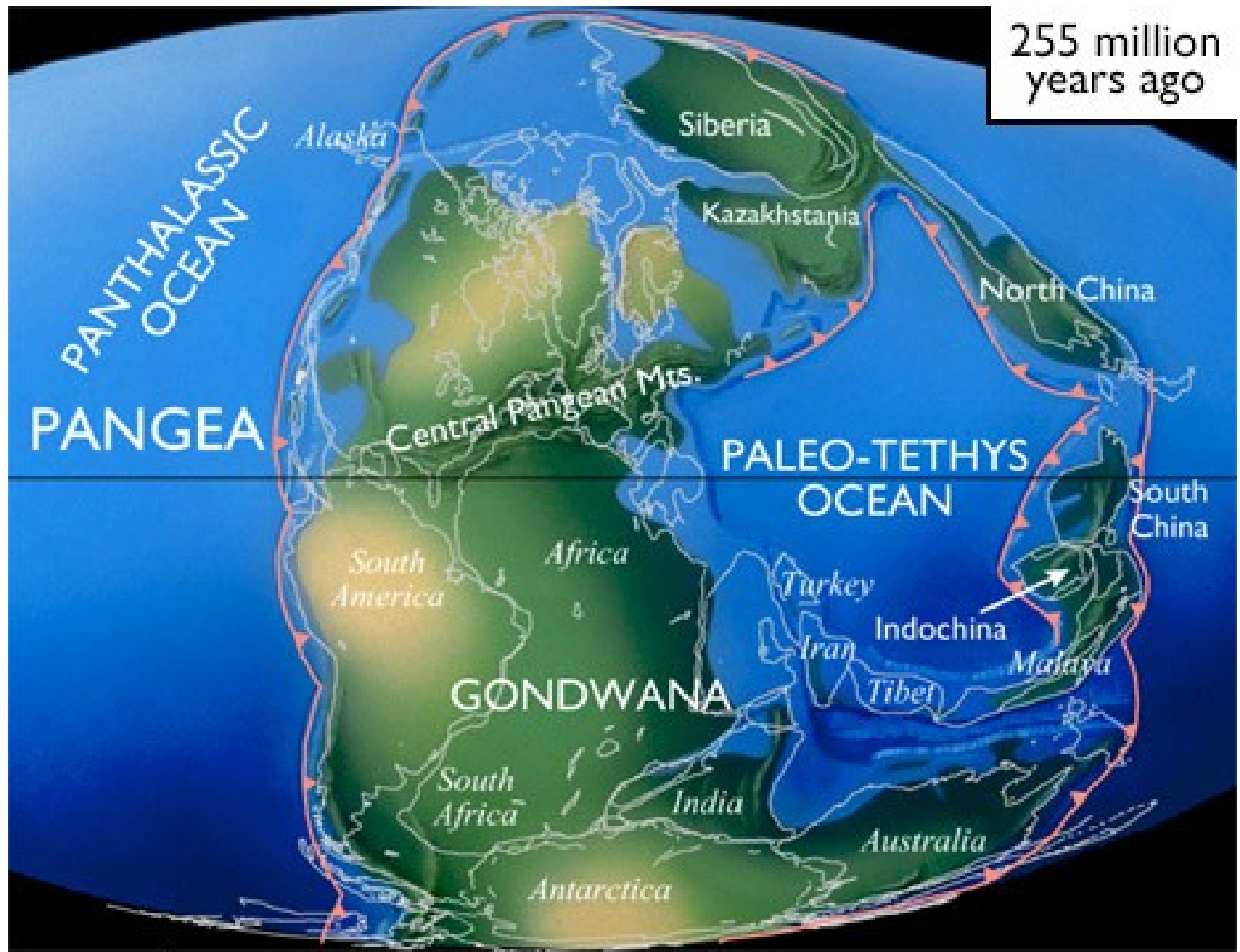


původ letounů z oblasti kolem paleo-tethys?

Middle Eocene



255 million years ago



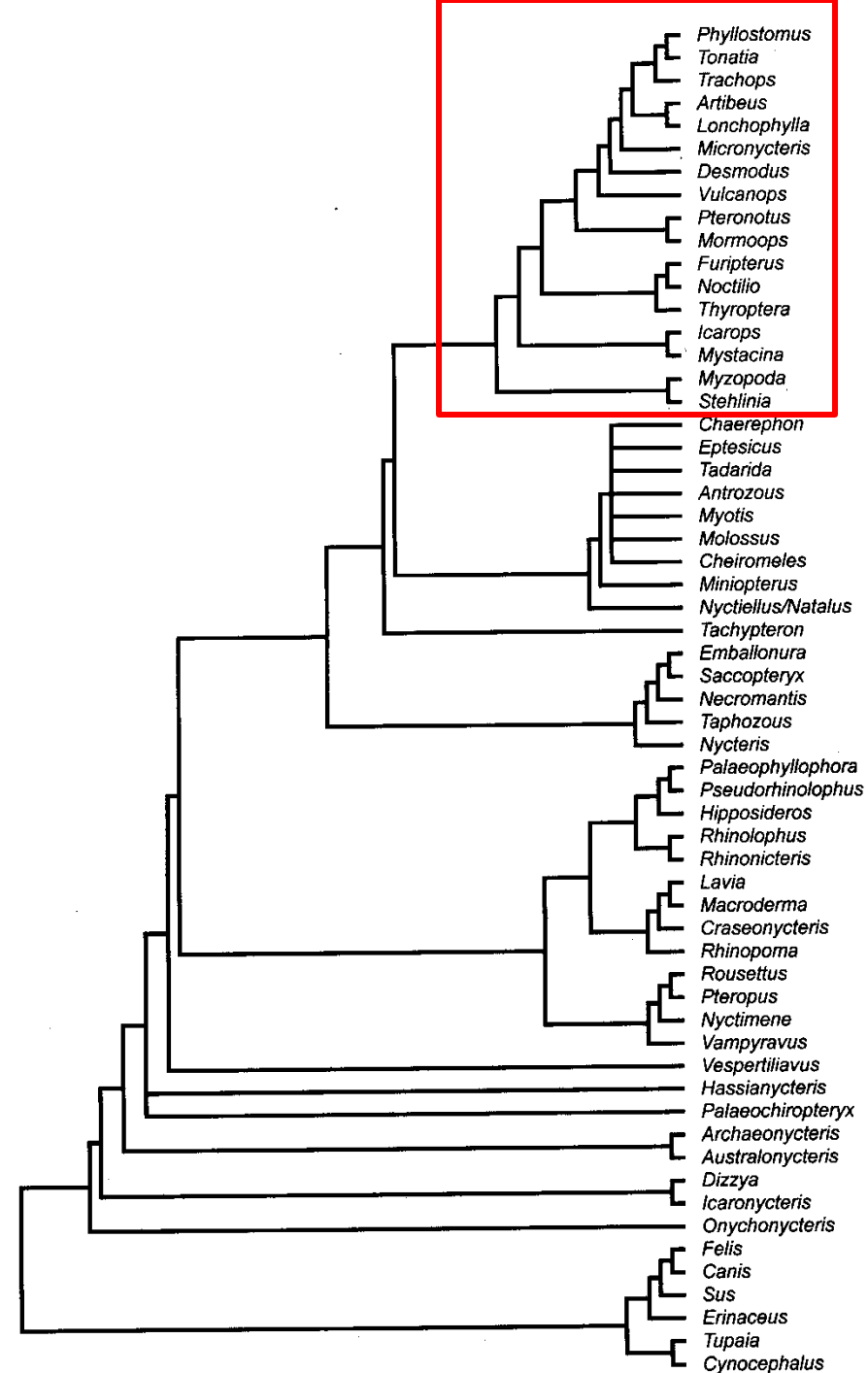
**MAP KEY**

- Ancient landmass** (Green and yellow shaded area)
- Modern landmass** (Blue outline)
- Ice caps & glaciers** (Blue and white shaded area)
- Subduction zone** (Red arrow pointing down) (direction of subduction)
- Sea floor spreading ridge** (Blue line with arrows pointing away from each other)



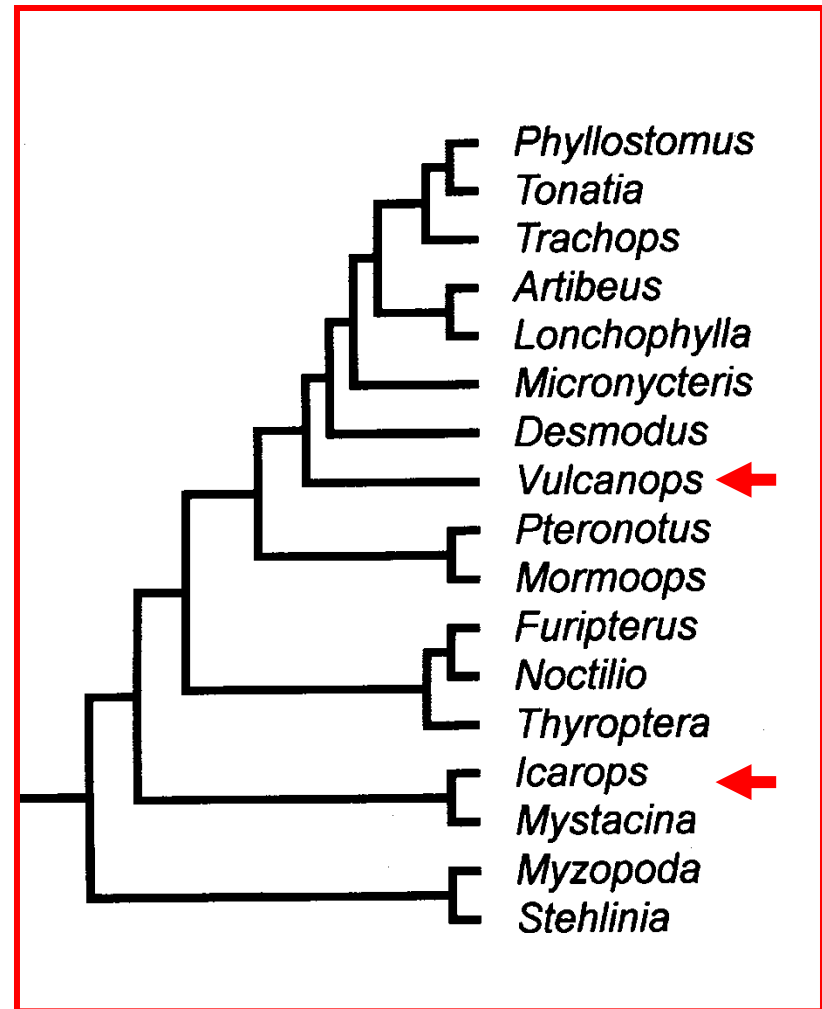
## Parsimony analysis PAUP\*

- 60 taxa and 300 characters
- morphological character matrix of Simmons *et al.* 2008
- plus 75 additional characters and 11 additional Eocene to Miocene fossil taxa
- combined with molecular matrix of Miller-Butterworth *et al.* 2007



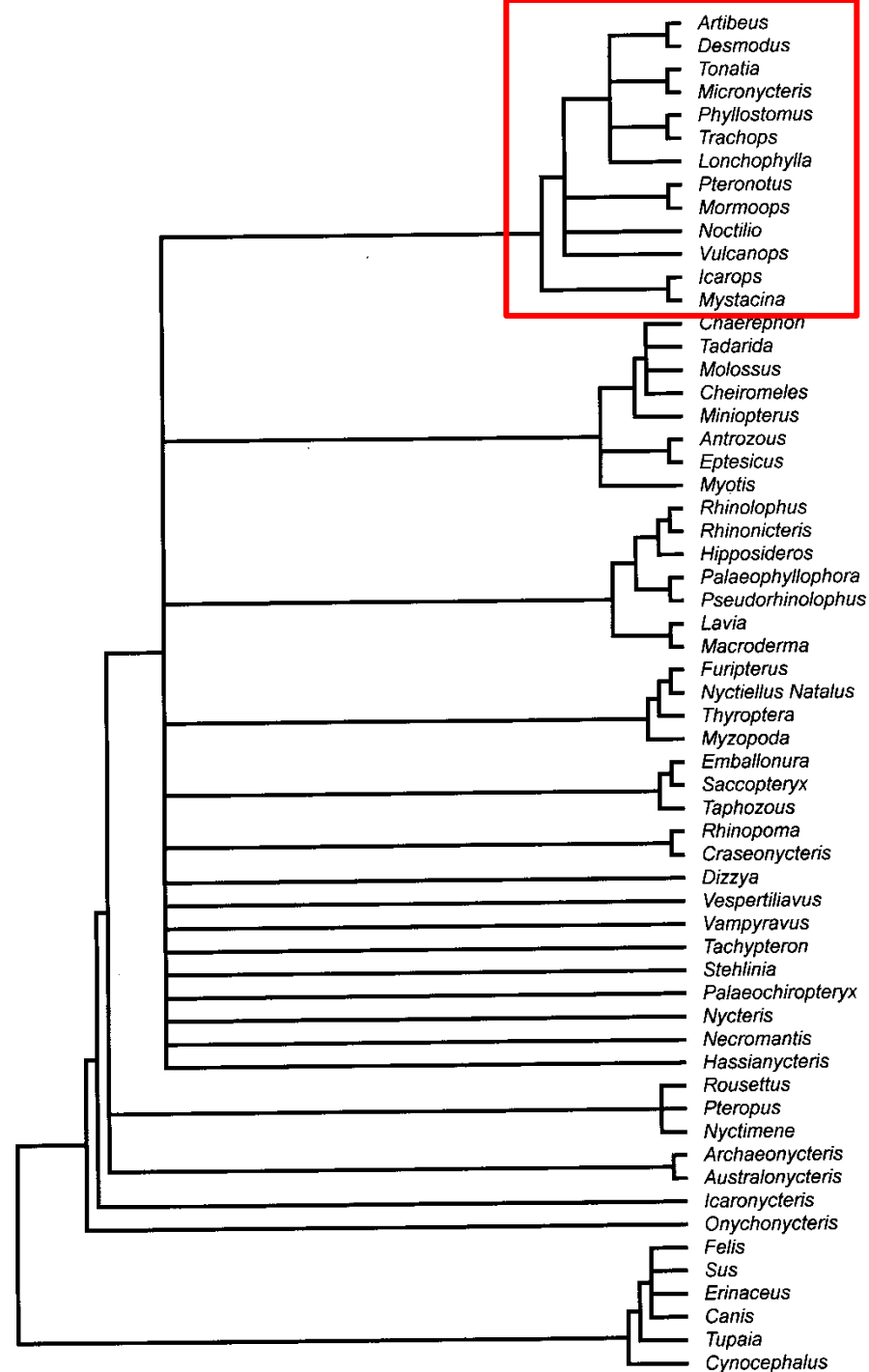
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- plus 75 additional characters and **11 additional fossil taxa**
- combined with molecular matrix of Miller-Butterworth *et al.* 2007



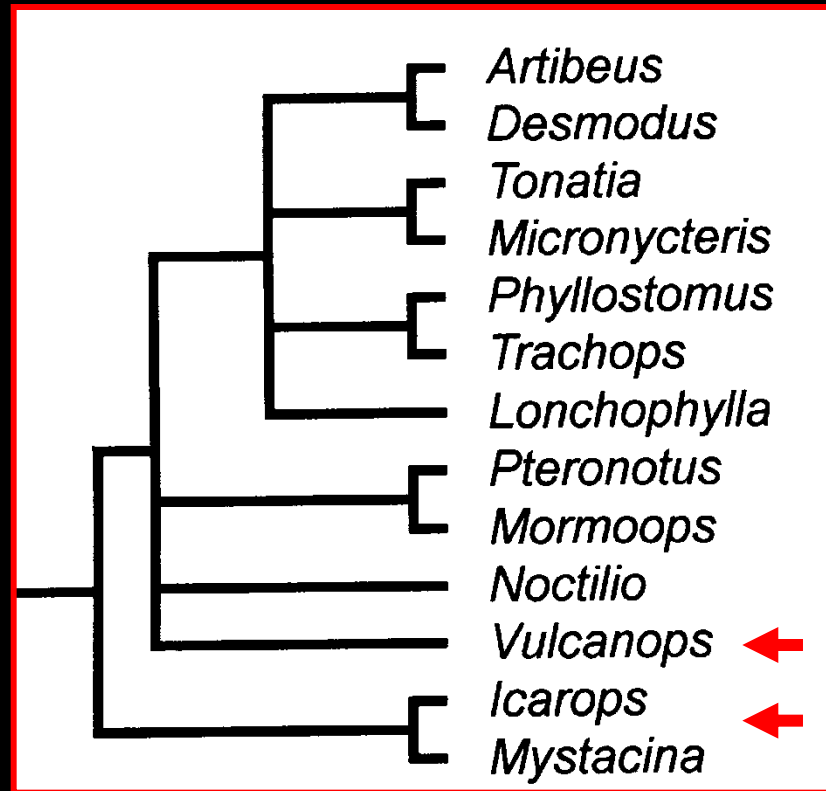
## Bayesian analysis Mr Bayes\*

- 60 taxa and 300 characters
- morphological character matrix of Simmons *et al.* 2008
- plus 75 additional characters and 11 additional fossil taxa



## Bayesian analysis Mr Bayes\*

- 60 taxa and 300 characters
- morphological character matrix of Simmons *et al.* 2008
- plus 75 additional characters and 11 additional **fossil taxa**

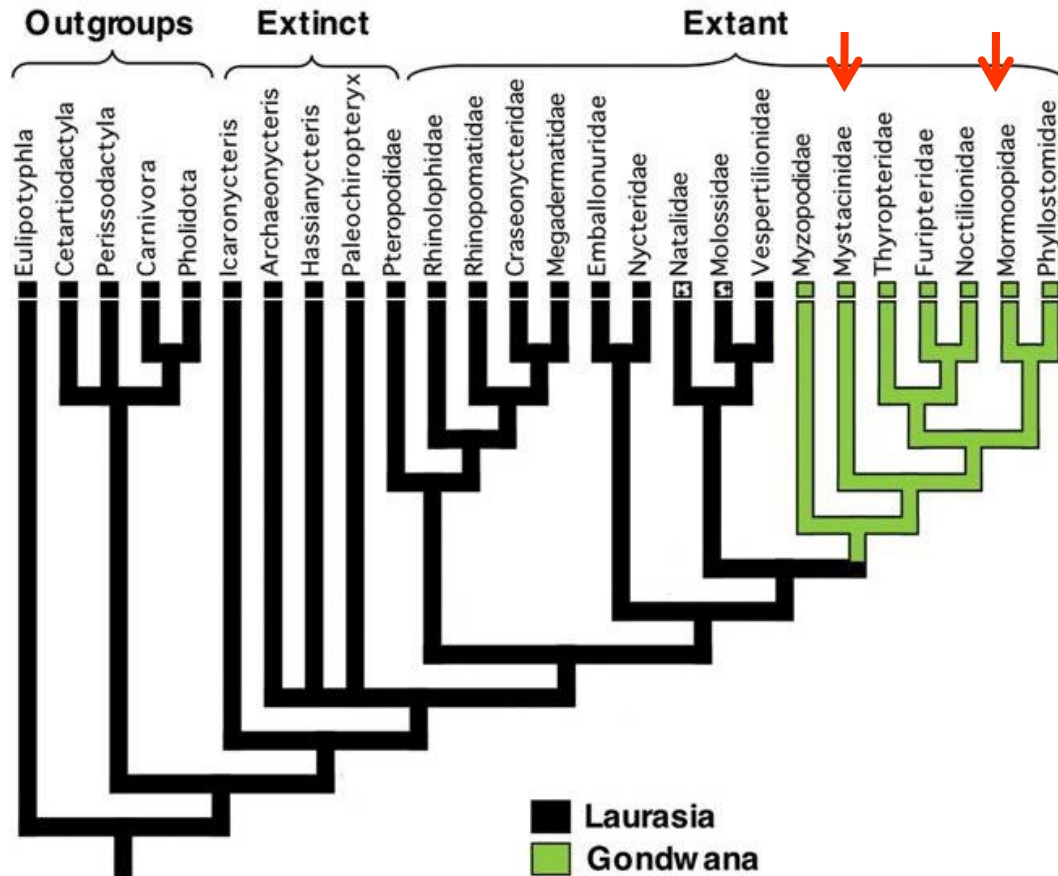


lov nad  
vodou?



Reconstruction T. Simpson

Zkameněliny a fylogenetické analýzy ukazují dvě čeledi noctilionoidních netopýrů v Australasii počátkem Miocénu

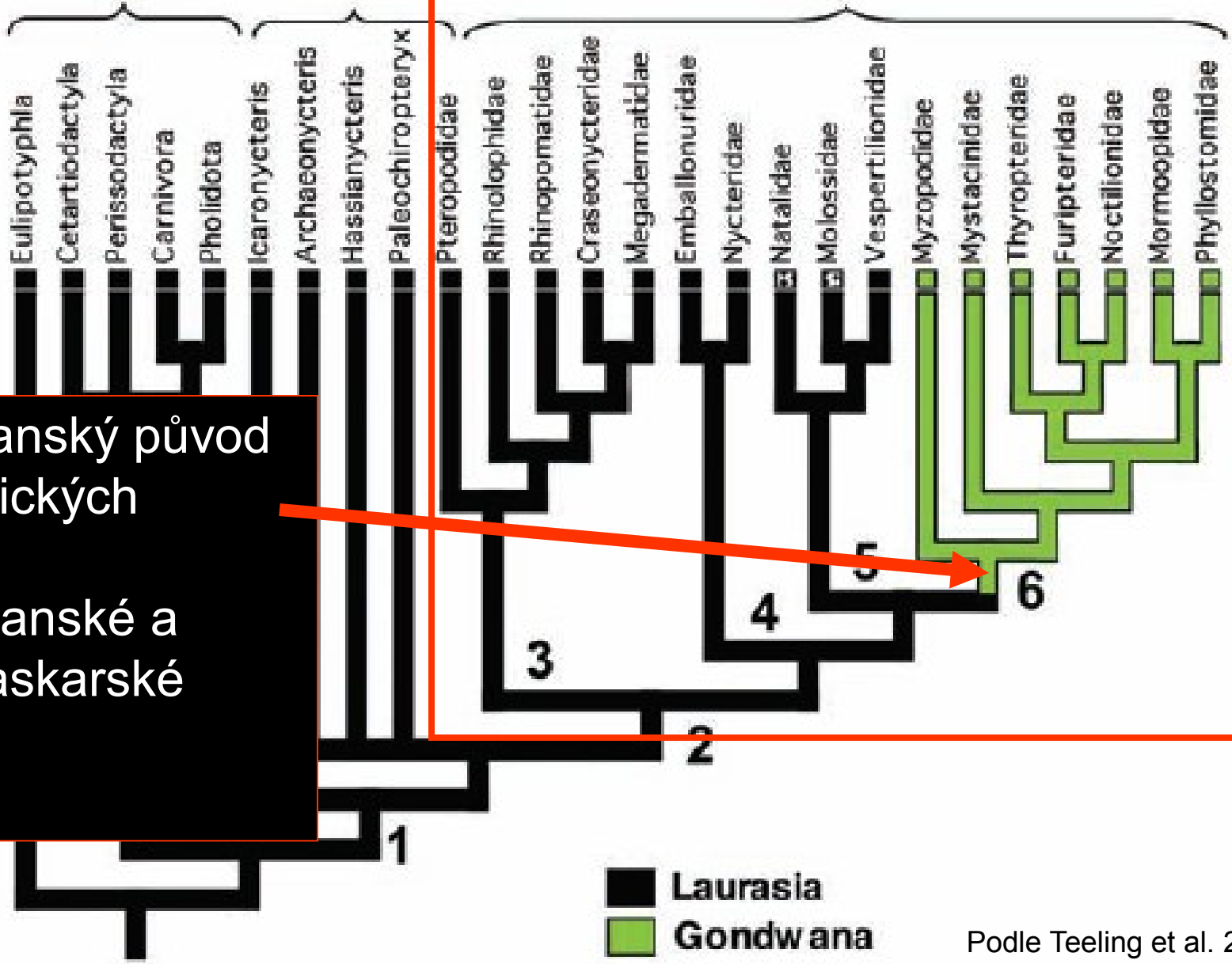


**A**

**Outgroups**

**Extinct**

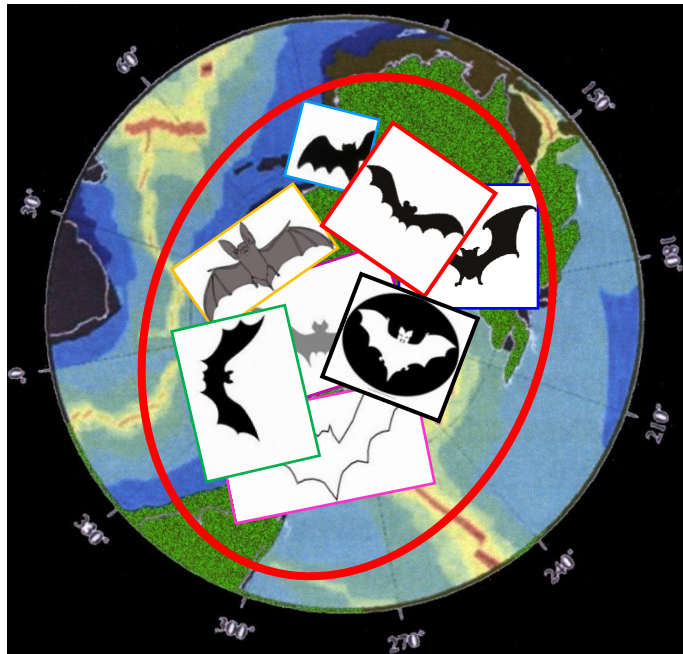
**Extant**



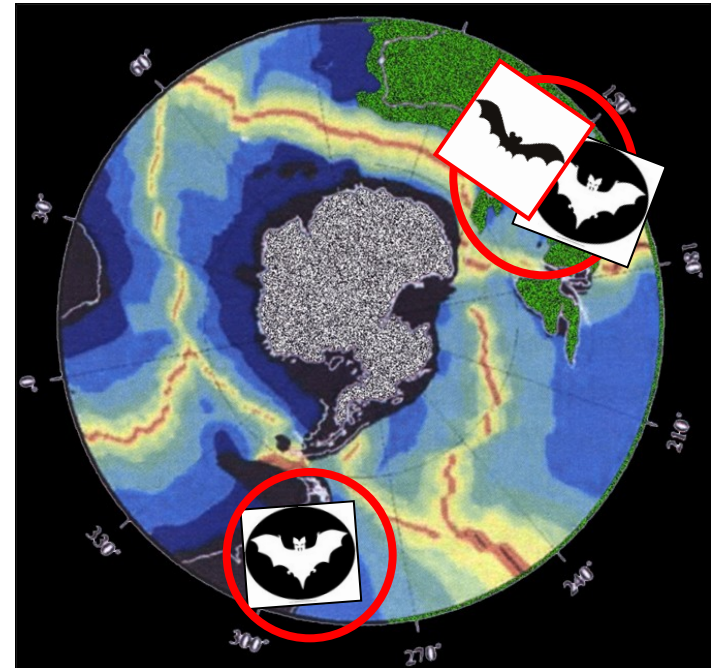
Gondwanský původ neotropických skupin, novozélandské a madagaskarské relikty

# Hypothesis 1

Australia, Antarctica and South America shared single noctilionoid fauna in early Paleogene, with differential extinctions resulting in subsequent faunal differences



Forested Antarctica

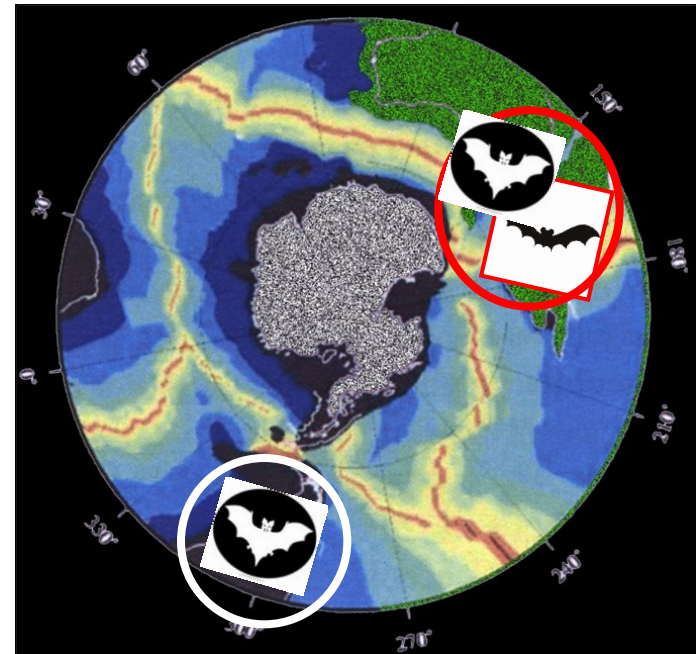
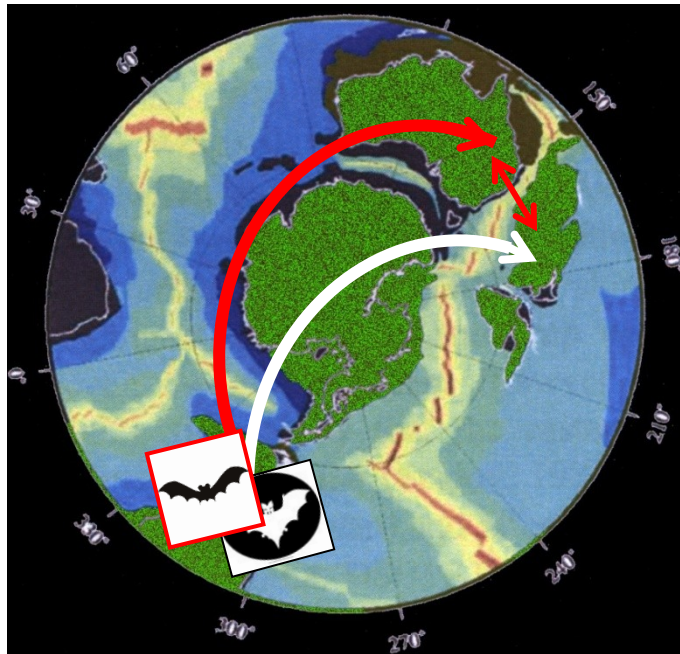


Freezing Antarctica



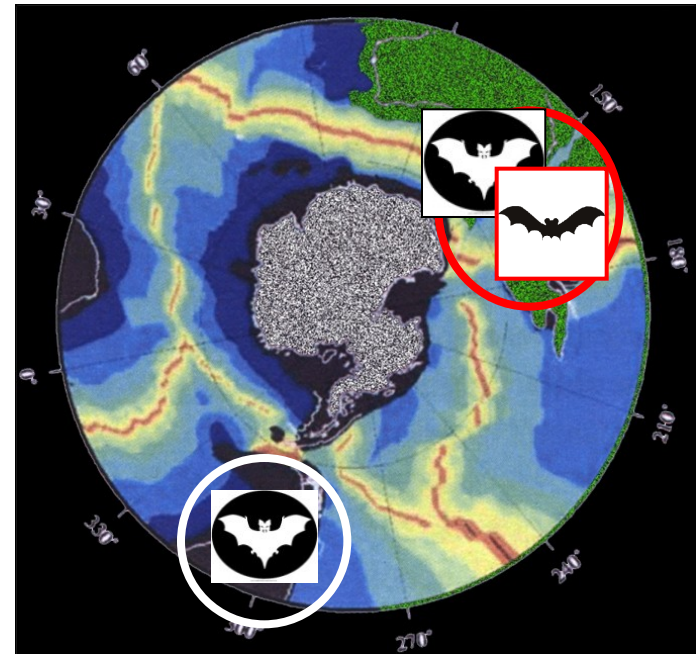
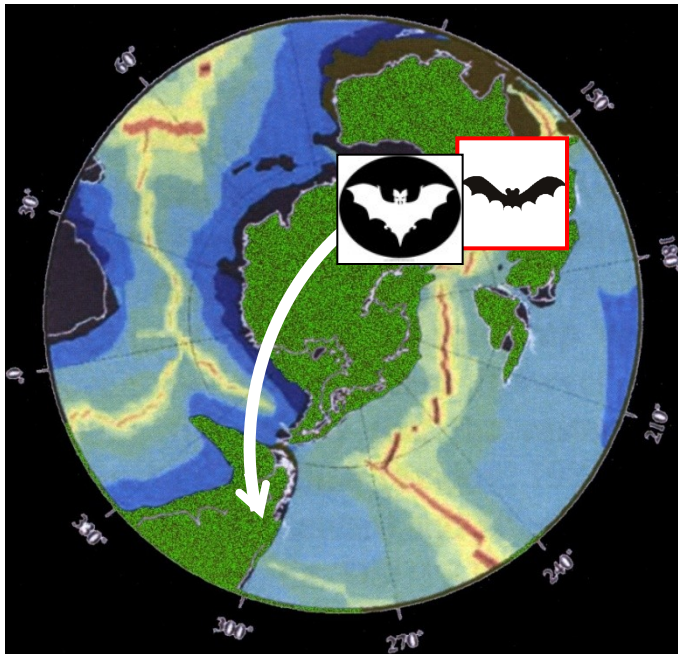
## Hypothesis 2

Two separate colonizations of New Zealand by noctilionoid bats from South America (possibly via Australia) sometime before Early Miocene (or perhaps 41 Ma)



# Hypothesis 3

Archaic noctilionoids gave rise to mystacinids and new family in Australia/Antarctica, more derived neotropical noctilionoid radiation represents back-dispersal from East Gondwana



# Evidence for and against hypotheses

**Hypothesis 1.** Nálezy *Australonycteris* 55 Ma – disperze z Austrálie od early Eocene, fosilní fauny jsou globální. **nejpravděpodobnější**

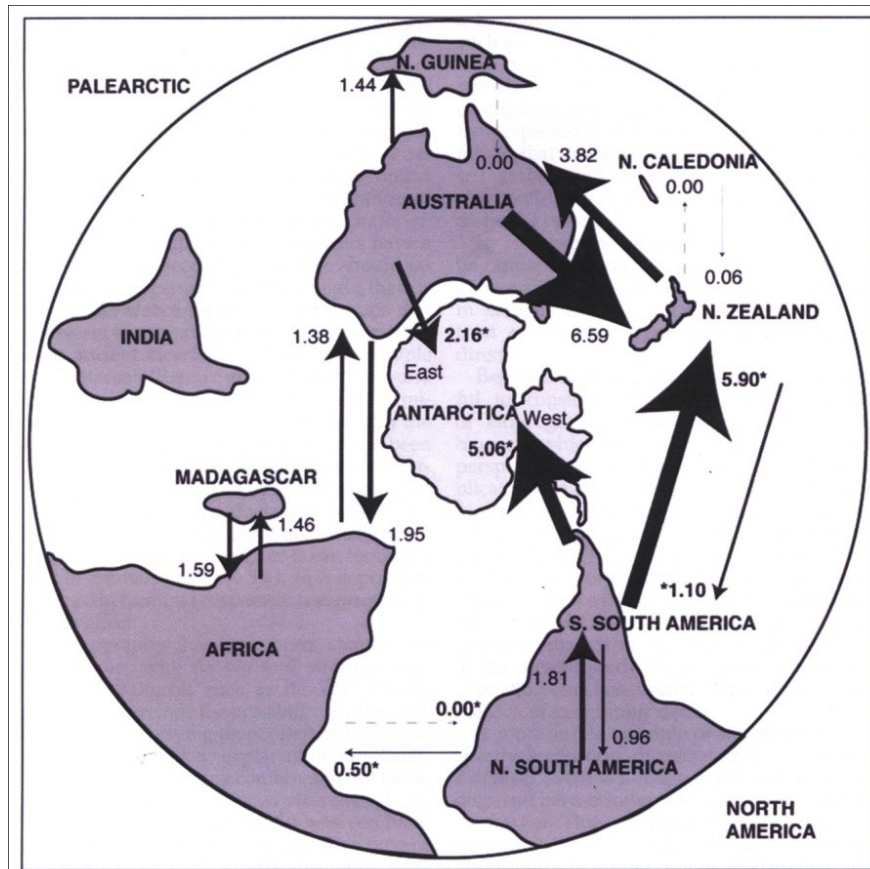
**Hypothesis 2.** Odlišné fauny J Ameriky a Austrálie, odlišné od late Oligocene, prozatím ale chybí doklady mystacinoidních netopýrů z J Ameriky.

**Hypothesis 3.** Bazální pozice mystacinoidních n. mezi noctilionoidními, což je v rozporu s původem noctilionoidní větve v Americe (Czaplewski & Morgan 2007)

# Animal dispersal in the Southern Hemisphere

Based on cladograms of  
modern taxa  
(insectivorous)

Sanmartin & Ronquist 2005



# Obecně: dosud řada nejasností

- **Předkovská skupina ? Nyctitheriidae?**
- **Místo a okolnosti vzniku letu**
- **Postup integrace jednotlivých klíčových adaptací (let, echolokace, metabolismus, etc.)**
- **Původ a časná historie většiny dnešních skupin (čeledí)**
- **Faktory jejich evoluce**
- **POZOR: četné konvergence, atd.**