LE JOURNAL CLUB

# Episode #Biome+

Adrien Saint-Sardos
Et le Pôle Num Ceebios

Novembre 2021

LE JOURNAL CLUB

# Devinette

- Quel est le point commun ?

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## Contexte Biologique

***Pterocles namaqua***
*Le Ganga namaqua (FR)*
*The Namaqua sandgrouse (EN)*

*Taille : 28 cm*
*Envergure : -*
*Poids : 143 à 192 g*

Auteur : B. Horsbrugh

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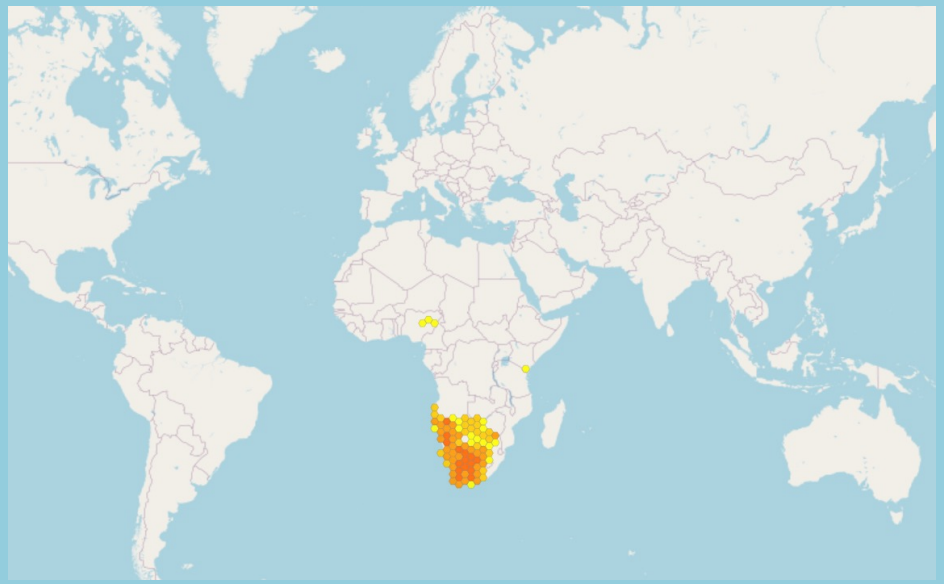
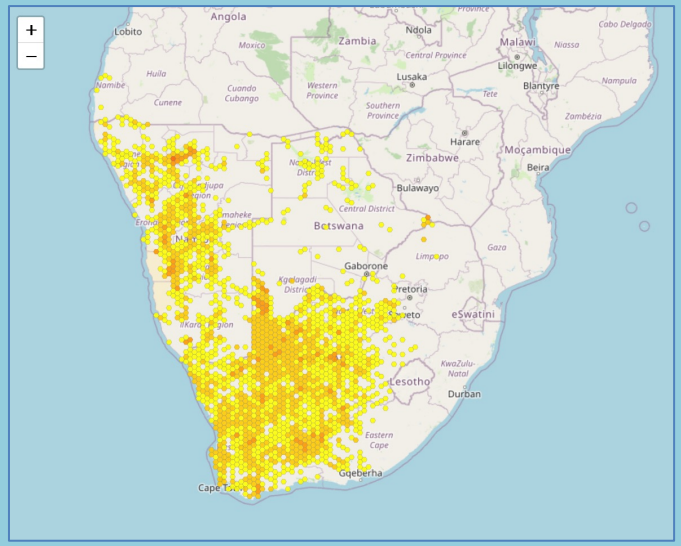
## *Pterocles namaqua*

### Contexte Biologique



Source GBIF- Carte des Occurrences de P. namaqua



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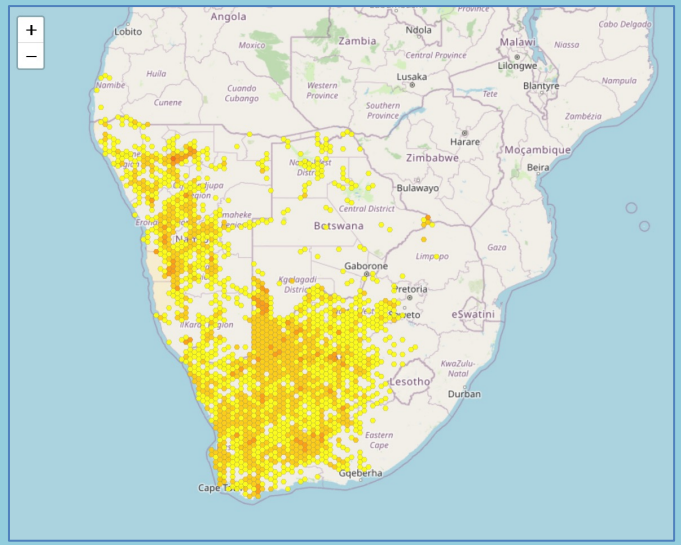
# *Pterocles namaqua*

## Contexte Biologique

Climate statistics over Pterocles namaqua's distribution range.

| | Metric (Monthly) | Value | Range | Unit |
|---|---|---|---|---|
| | MAX Temperature | 30.8 | -30.8 - 48.5 | C |
| REQUEST | MIN Temperature | | | C |
| | MIN Rainfall | 3.9 | 0.0 - 507.0 | mm |
| | MAX Rainfall | 65.9 | 0.0 - 2768.0 | mm |
| REQUEST | MAX Wind speed | | | m/s |
| | MAX Solar irradiance | 25160.9 | 0.0 - 45554.0 | kJ/m2 |
| REQUEST | Elevation | | | m |




Source Ceebios – Statistiques climatiques rencontrées par *P. namaqua*

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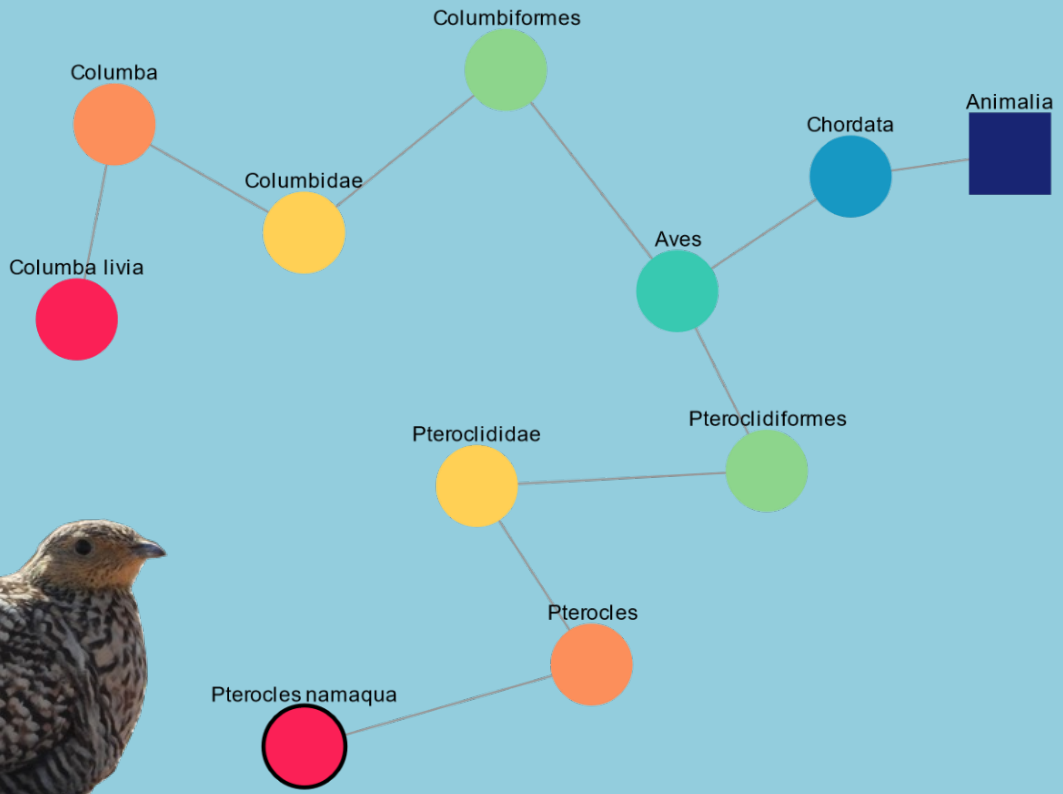
## Contexte Biologique




**Classification taxonomique, Source Ceebios/GBIF.**

# Premier contact

Contexte Biologique | Première Observation

"As soon as the young were out of the nest (when twelve hours old) a very curious habit developed itself in the male. He would rub his breast violently up and down on the ground, a motion quite distinct from dusting, and when all awry he would get into his drinking water and saturate the feathers of the under parts. When soaked he would go through the motions of flying away, nodding his head, etc. Then, remembering his family were close by, would run up to the hen, make a demonstration, when the young would run out, get under him, and suck the water from his breast. This is no doubt the way that water is conveyed to the young when far out on waterless plains "

*Edmund* Gustavus Bloomfield *Meade-Waldo* (1855-1934) est un ornithologue et protecteur de la nature anglais. Le blason de son château.

1.
Meade-Waldo, Sand grouse breeding in captivity (1896)

Mr. E. G. B. Meade-Waldo. Nature 133, 601–602 (1934)

# Premier contact et incrédulité



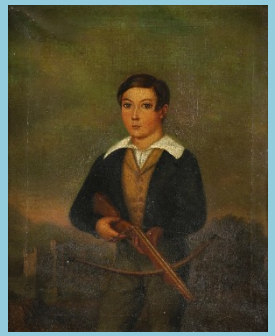

*Edmund* Gustavus Bloomfield *Meade-Waldo* (1855-1934) est un ornithologue et protecteur de la nature anglais. Le blason de son château.

1.
Meade-Waldo, Sand grouse breeding in captivity (1896)

Mr. E. G. B. Meade-Waldo. Nature 133, 601–602 (1934)

Arnold Schwarzenegger dans Junior de Ivan Reitman (1994)

1896



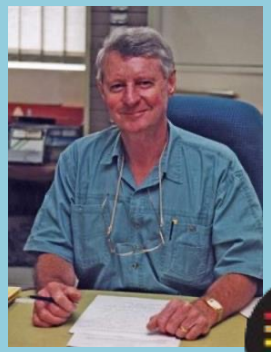
1967

THE CONDOR

VOLUME 69 JULY-AUGUST, 1967 NUMBER 4

TRANSPORT OF WATER BY ADULT SANDGROUSE TO THEIR YOUNG

Tom J. Cade and Gordon L. Maclean



TheCornellLab of Ornithology

UNIVERSITY OF KWAZULU-NATAL

# Nouvelle observation et photographies



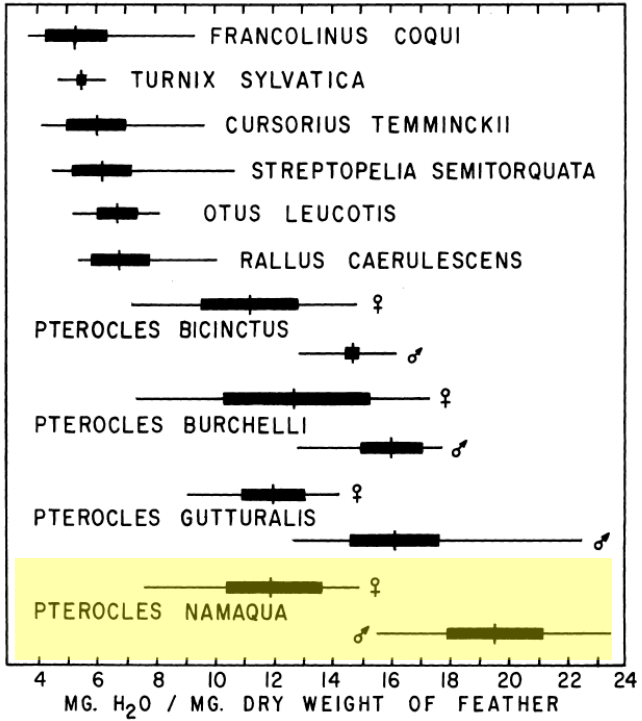
"Adult male sandgrouse (*Pterocles namaqua*) soaking his belly at a water hole in the Kalahari Desert. The bird is resting after a period of rocking."

"Young sandgrouse (Pterocles namaqua) clustered around the wet abdomen of adult male in the Kalahari Desert."

Cade TJ, Maclean GL.
Transport of Water by Adult Sandgrouse to Their Young.
The Condor. (1967)

# Mais surtout les premières mesures !

Contexte Biologique | Première Observation | Papier fondateur

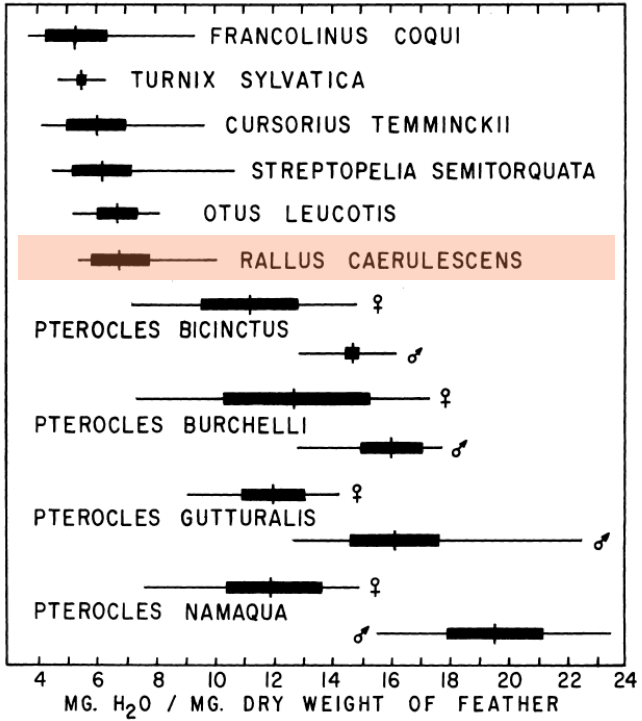


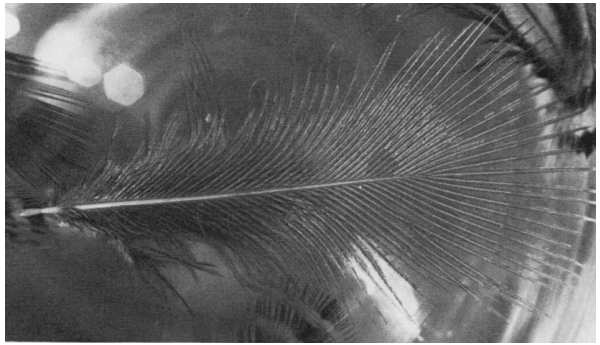

Cade TJ, Maclean GL. Transport of Water by Adult Sandgrouse to Their Young. The Condor. (1967)

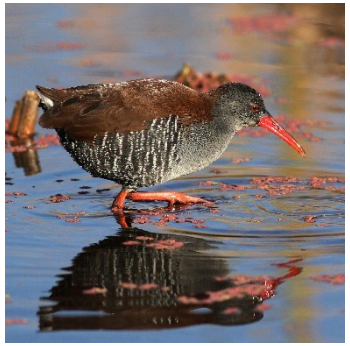
*in all cases, individual feathers were allowed to become thoroughly wetted in water, then were removed with forceps, were suspended in air until all excess water dripped off, and then were immediately weighed on a Mettler balance accurate to 0.1 mg*

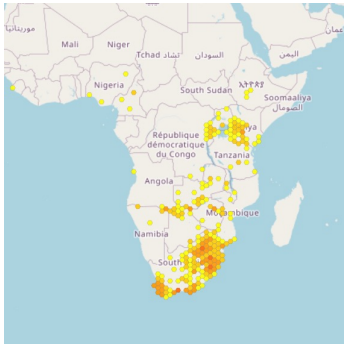
# Mais surtout les premières mesures !

Contexte Biologique | Première Observation | Papier fondateur








Cade TJ, Maclean GL. Transport of Water by Adult Sandgrouse to Their Young. The Condor. (1967)

*in all cases, individual feathers were allowed to become thoroughly wetted in water, then were removed with forceps, were suspended in air until all excess water dripped off, and then were immediately weighed on a Mettler balance accurate to 0.1 mg*

# Et un début de réflexion biomimétique



COMPARISON OF WATER-HOLDING CAPACITY OF FEATHERS AND OTHER MATERIALS

| Material sampled | g dry wt. | g wet wt. | g $H_2O$/g dry wt. |
|---|---|---|---|
| Synthetic sponge | 8.1 | 51.3 | 5.3 |
| Paper towel | 4.0 | 24.4 | 5.1 |
| *Passer melanurus* breast feathers | 0.35 | 2.15 | 5.1 |
| *Pterocles namaqua* male breast feathers | 0.90 | 8.10 | 8.0 |

Cade TJ, Maclean GL. Transport of Water by Adult Sandgrouse to Their Young. The Condor. (1967)

*Although feathers are not very wettable, they do have a good water-holding capacity when saturated.*

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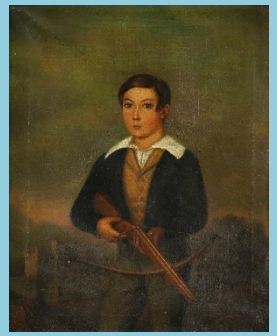
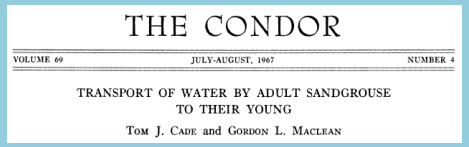
## *Un papier qui fait des vagues*

1896 // 1967 * 1972 * 1973 * 1983 * 2018





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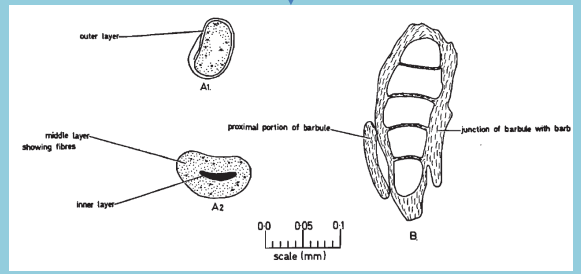
Rijke AM. The Water-Holding Mechanism of Sandgrouse Feathers. Journal of Experimental Biology. (1972)

MacLean GL. Water Transport by Sandgrouse. BioScience. (1983)

Comanns P. Passive water collection with the integument: mechanisms and their biomimetic potential. Journal of Experimental Biology. (2018)




Joubert CSW, Maclean GL. The Structure of the Water-Holding Feathers of the Namaqua Sandgrouse. Zoologica Africana. (1973)

# LE JOURNAL CLUB
## *De la biologie à la Science des Matériaux*

INTERFACE

royalsocietypublishing.org/journal/rsif

Research

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**Cite this article:** Mueller J, Gibson LJ. 2023

## Structure and mechanics of water-holding feathers of Namaqua sandgrouse (*Pterocles namaqua*)

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[2]Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, MA, USA

JM, 0000-0002-4808-2223; LJG, 0000-0001-7559-7815

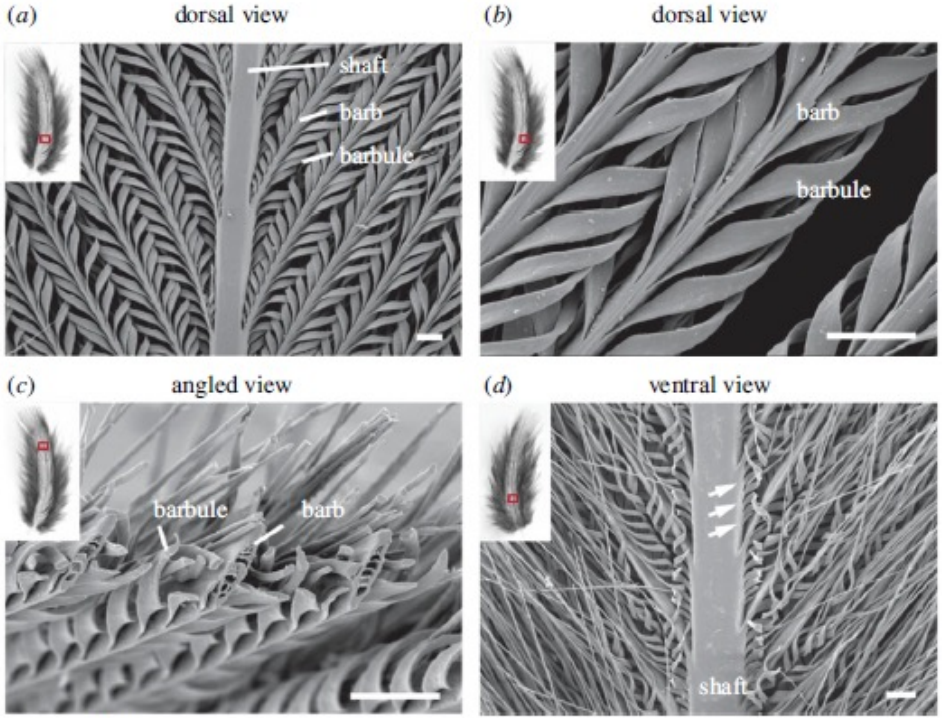
2023

JOHNS HOPKINS
WHITING SCHOOL of ENGINEERING

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

# La géométrie de la plume






*Here, we use scanning electron microscopy and micro-computed tomography as well as videography to characterize the geometry of different components of the belly feathers and to show how differences in their bending stiffnesses contribute to the water-holding mechanism.*

Mueller J, Gibson LJ. Structure and mechanics of water-holding feathers of Namaqua sandgrouse ( *Pterocles namaqua* ). J R Soc Interface. 2023 .

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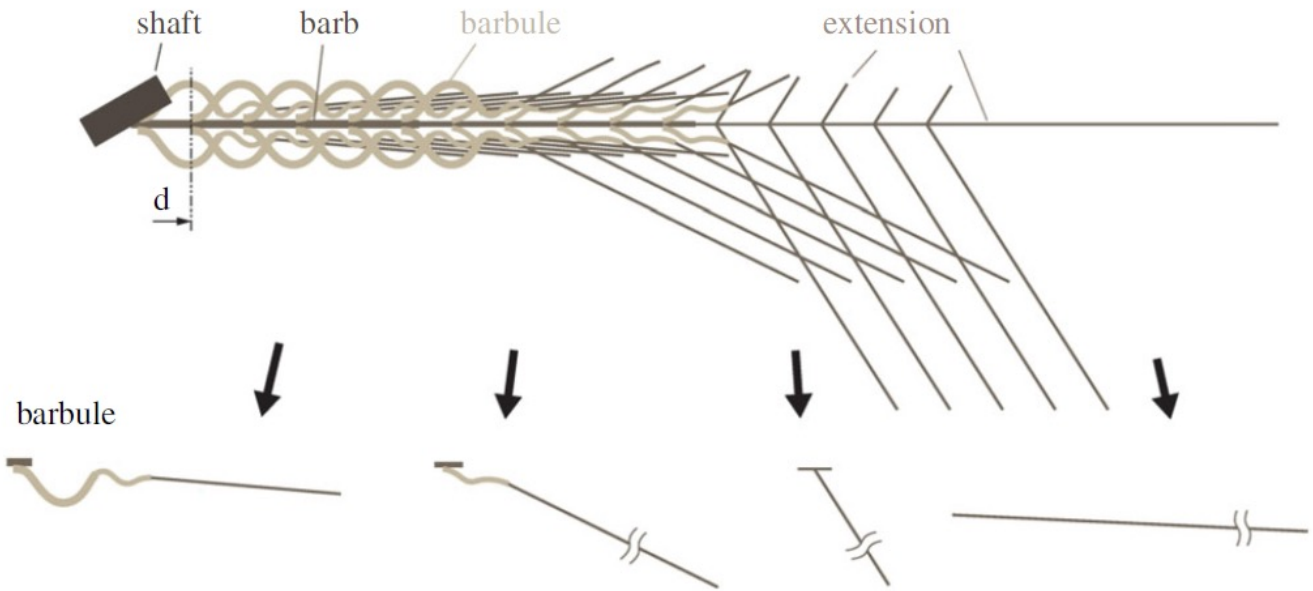


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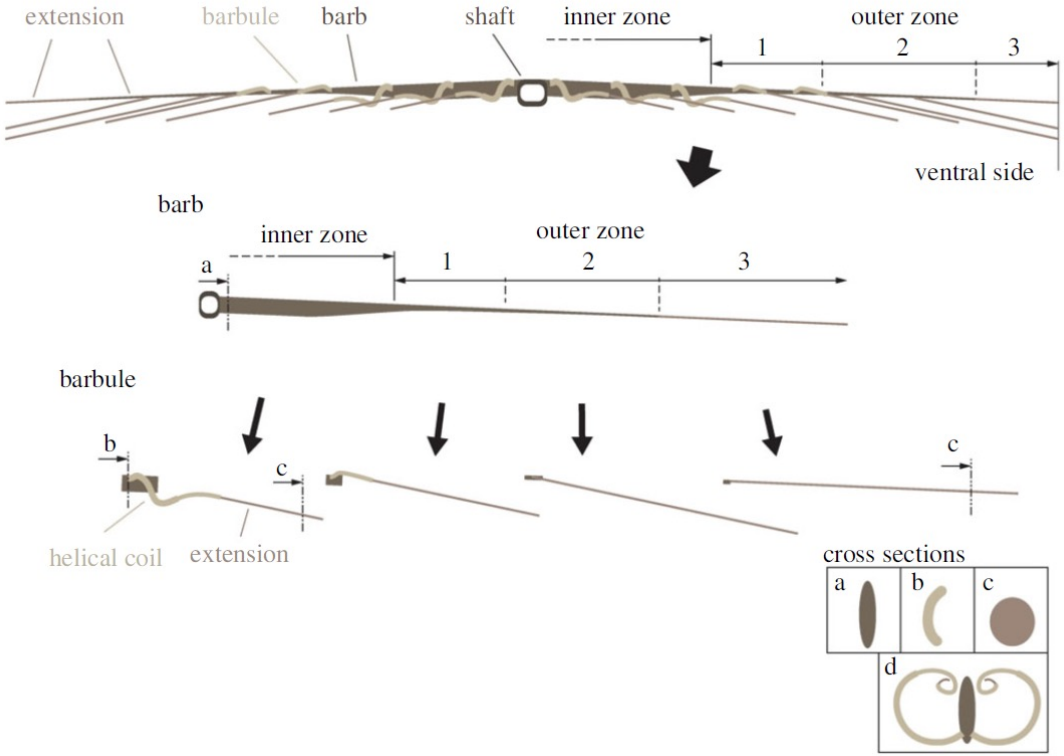
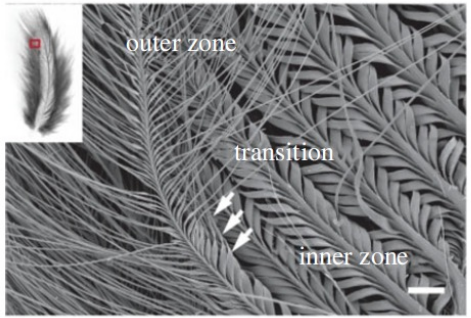



Mueller J, Gibson LJ. Structure and mechanics of water-holding feathers of Namaqua sandgrouse ( *Pterocles namaqua* ). J R Soc Interface. (2023)

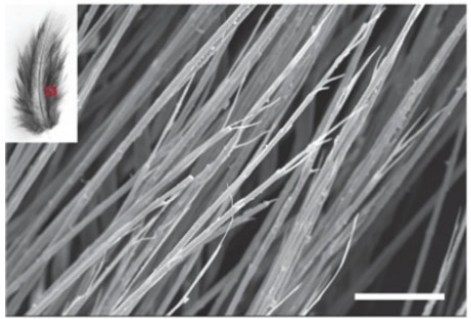
# La géométrie de la plume



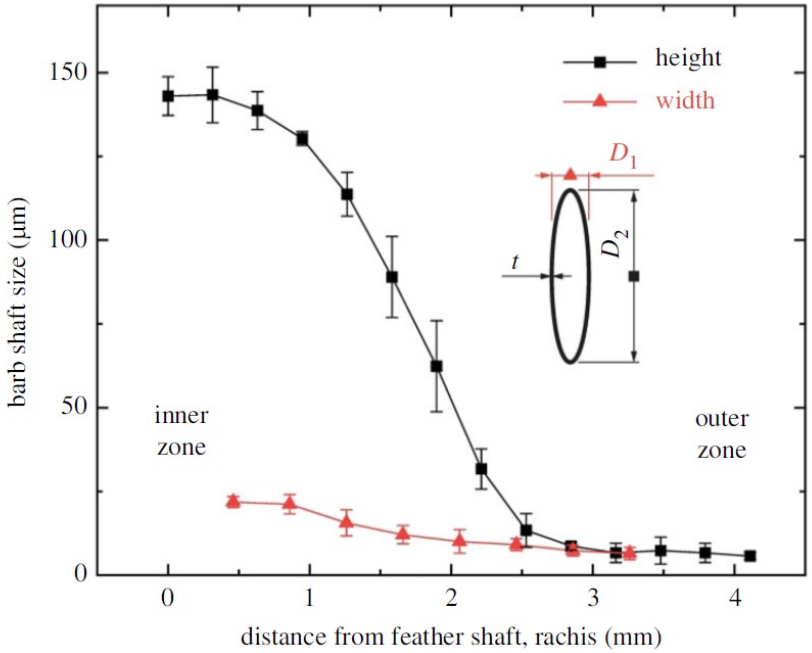
(a) transition zone




(b) outer zone



(c) barb dimensions along its length

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# Des conséquences mécaniques



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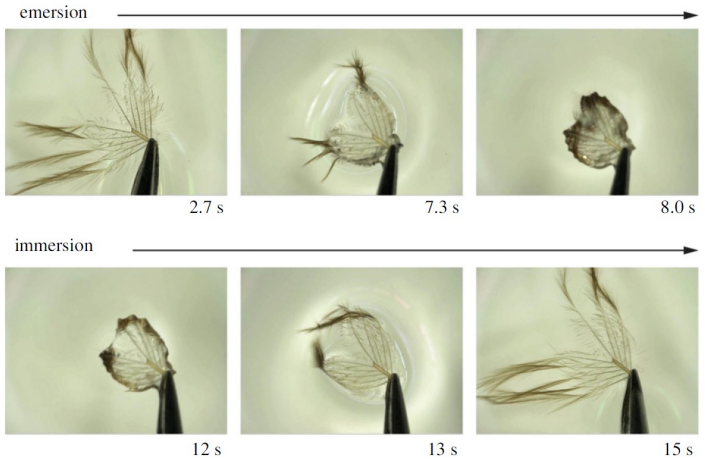


# Des conséquences mécaniques



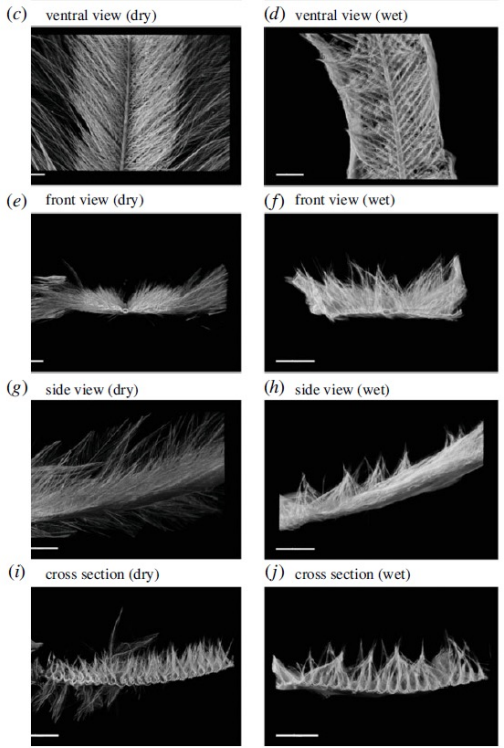
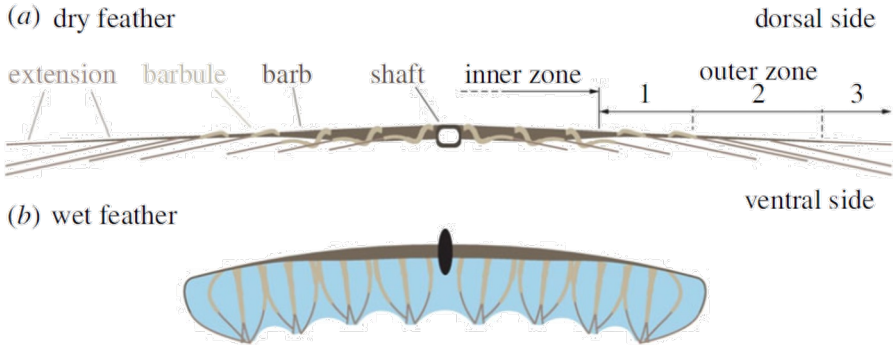



Figure 12. Micro-CT scan of a shaft–barbs–barbules ensemble.

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A single complete barb that is attached to a segment of a shaft laying on a flat surface is wetted by depositing a droplet near the outer region. As the water spreads, the barbules uncoil and rotate 90 degrees.

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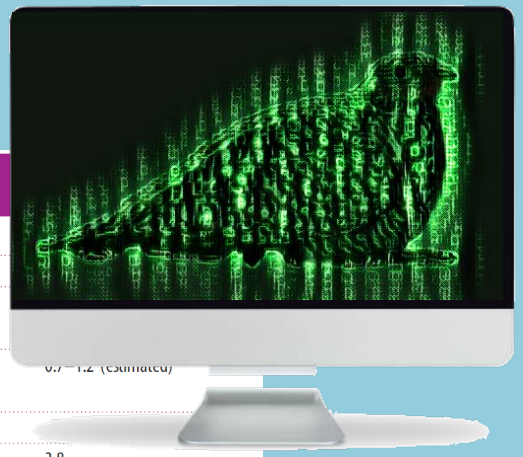
# *Pas encore d'application ?*

*Here, we use scanning electron microscopy and micro-computed tomography as well as videography to characterize the geometry of different components of the belly feathers and to show how differences in their bending stiffnesses contribute to the water-holding mechanism.* ***The results of this study will be used in a companion paper to model computationally water uptake by the feather.***

| component | shape | smaller dimension $D_1$ (μm) | larger dimension $D_2$ (μm) | length, $L$ (mm) | spacing[e] (μm) |
|---|---|---|---|---|---|
| *inner zone* | | | | | |
| barb shaft (ramis)[a,b] | elliptical tube, $t = 1.7 \pm 0.36$ μm ($n = 5$) | 24 ± 5.3 | 143 ± 14 | 2.9 ± 1.3 | 360 ± 62 ($n =$ |
| barbule helical coil section[a] | bean-shaped | | | | |
| barbule straight extension[c] | solid circle | | | | |
| *outer zone* | | | | | |
| barb shaft[d] | solid circle | | | | |
| barbule | solid circle | | | | |

| component | moment of inertia ($\mu m^4$)[b] | bending stiffness $P/\delta = EI/L^3$ (N $mm^{-1}$) | elasto-capillary length, $\ell_B$ (mm) | |
|---|---|---|---|---|
| *inner zone* | | | | |
| barb shaft (ramis) | $6.9 \times 10^5$ | $1.3 \times 10^{-1}$ | 2.18 | |
| barbule helical coil section[a] | $6.6 \times 10^3$ | n.a. | n.a. | |
| barbule straight extension | 35.9 | $2.5 \times 10^{-3}$ | 0.37 | 0.7–1.2 (estimated) |
| *outer zone* | | | | |
| barb shaft | 7.4 | $5.6 \times 10^{-7}$ | 0.21 | 3.8 |
| barbule | 7.4 | $5.6 \times 10^{-6}$ | 0.21 | 1.8 |



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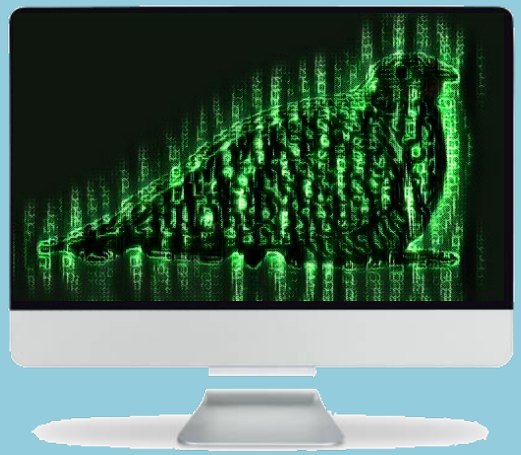
## *Vers un système*  *-inspired …*



# MERCI POUR VOTRE ATTENTION !

**Références images**

Tableau de Meade-Waldo : https://www.mutualart.com/Artwork/Portrait-of-Edmund-Waldo-Meade-Waldo--ho/373FE05B7BA28006

Sandgrouse feather (Slide 2) : Johns Hopkins University, https://www.eurekalert.org/multimedia/980697

Gordon Maclean : https://www.citizen.co.za/witness/archive/obituary-gordon-maclean-a-lifelong-passion-for-ornithology-20150430/

Lorna Gibson https://meche.mit.edu/people/faculty/LJGIBSON@MIT.EDU

Le ganga style Matrix : https://www9.lunapic.com/editor/

Eponge : Wikipedia https://fr.wikipedia.org/wiki/%C3%89ponge_%28objet%29

Fog Nets : https://edition.cnn.com/2016/11/18/africa/fog-catchers-morocco/index.html

Les vidéo « Supplémentary Mat. » de l'article sont hébergées sur https://rs.figshare.com/collections/_/6500604