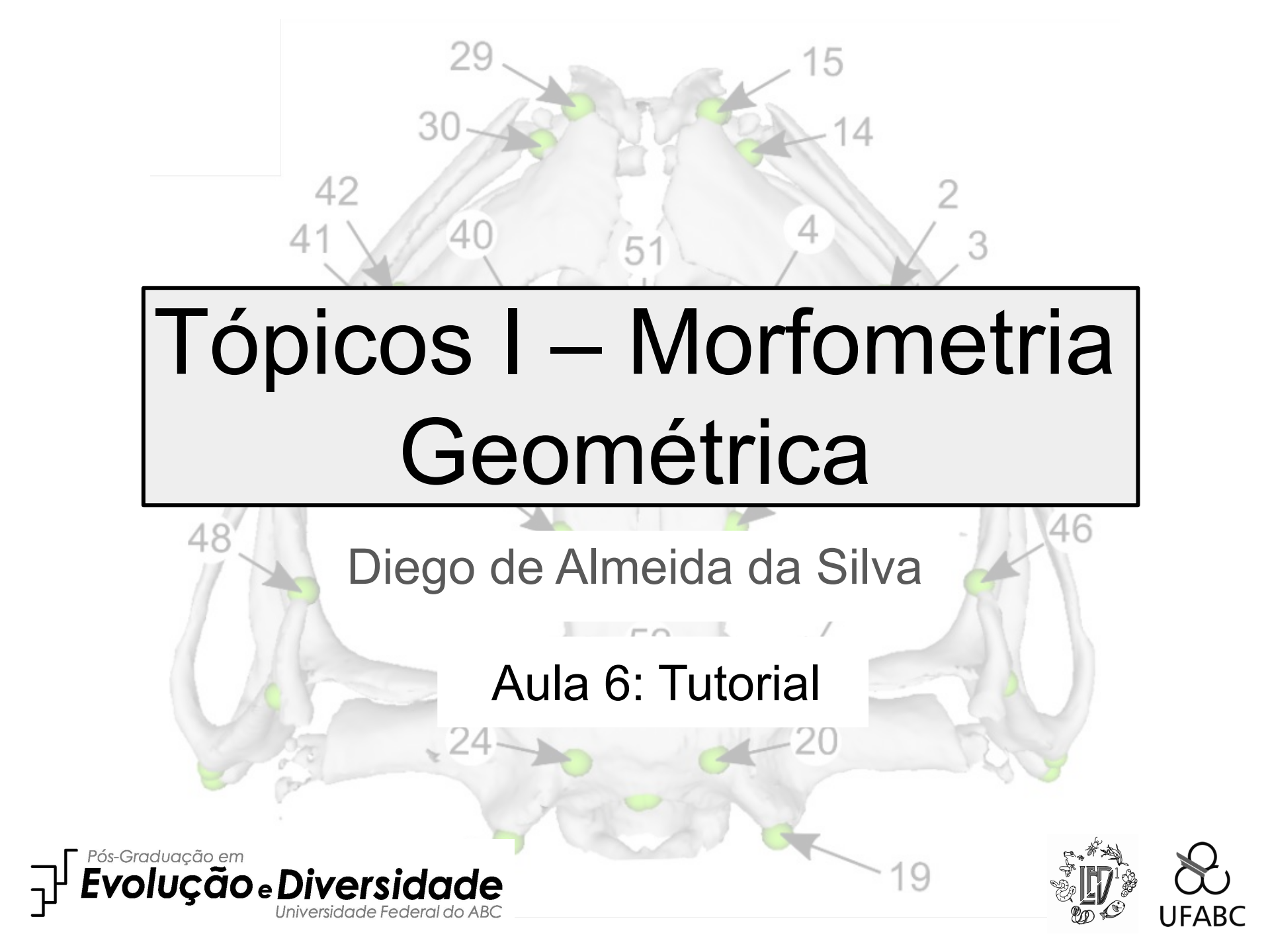


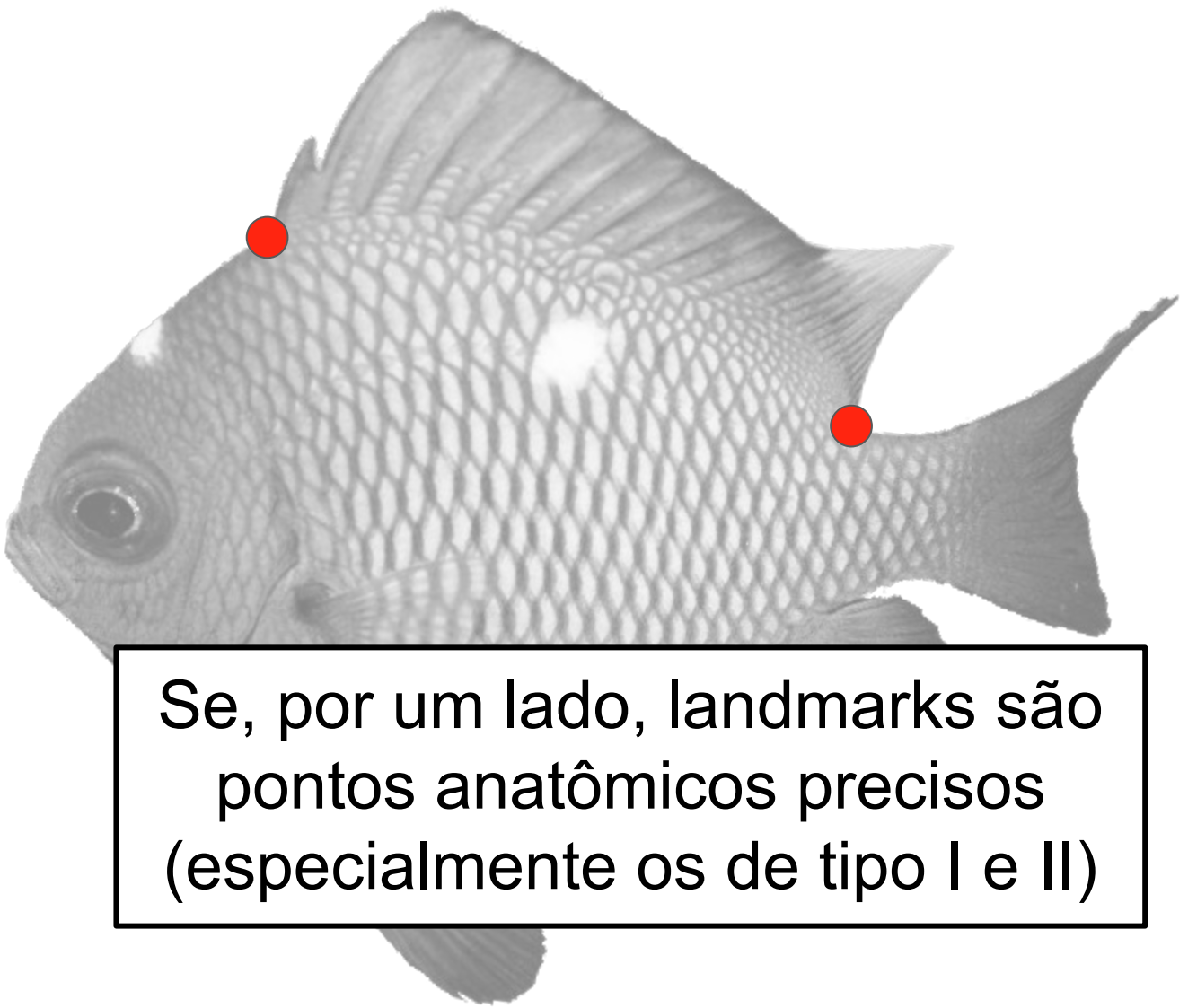
Tópicos I – Morfometria Geométrica

Diego de Almeida da Silva

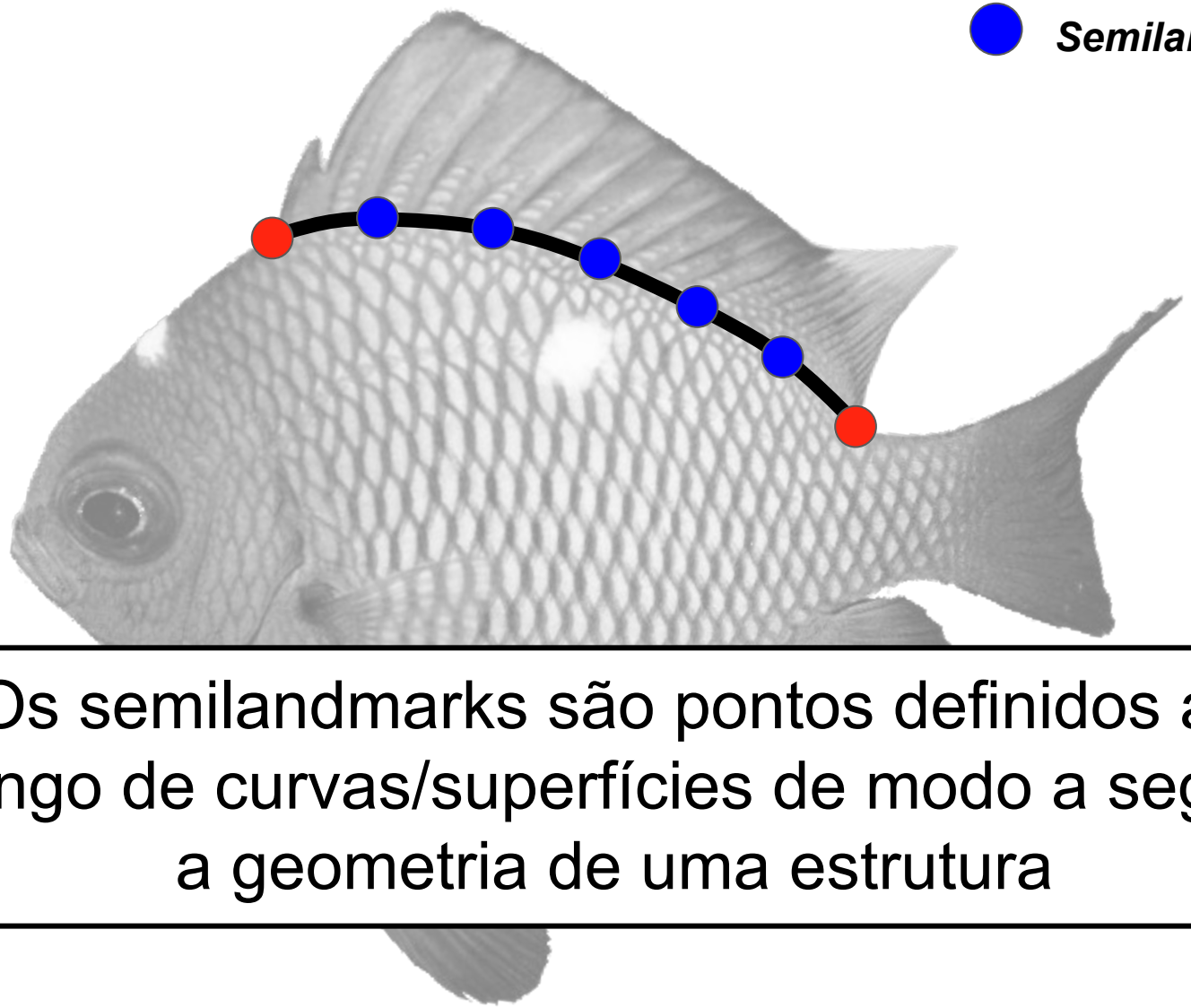
Aula 6: Tutorial

Pós-Graduação em Evolução e Diversidade
Universidade Federal do ABC

UFABC

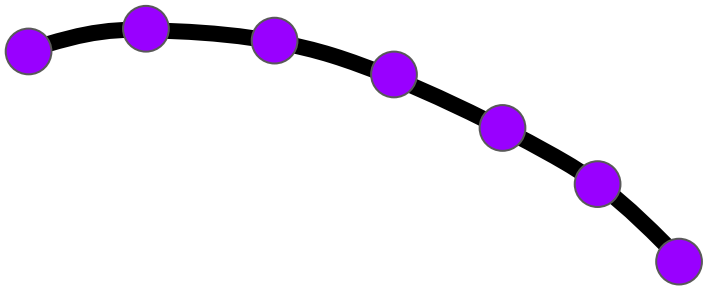


Se, por um lado, landmarks são pontos anatômicos precisos (especialmente os de tipo I e II)

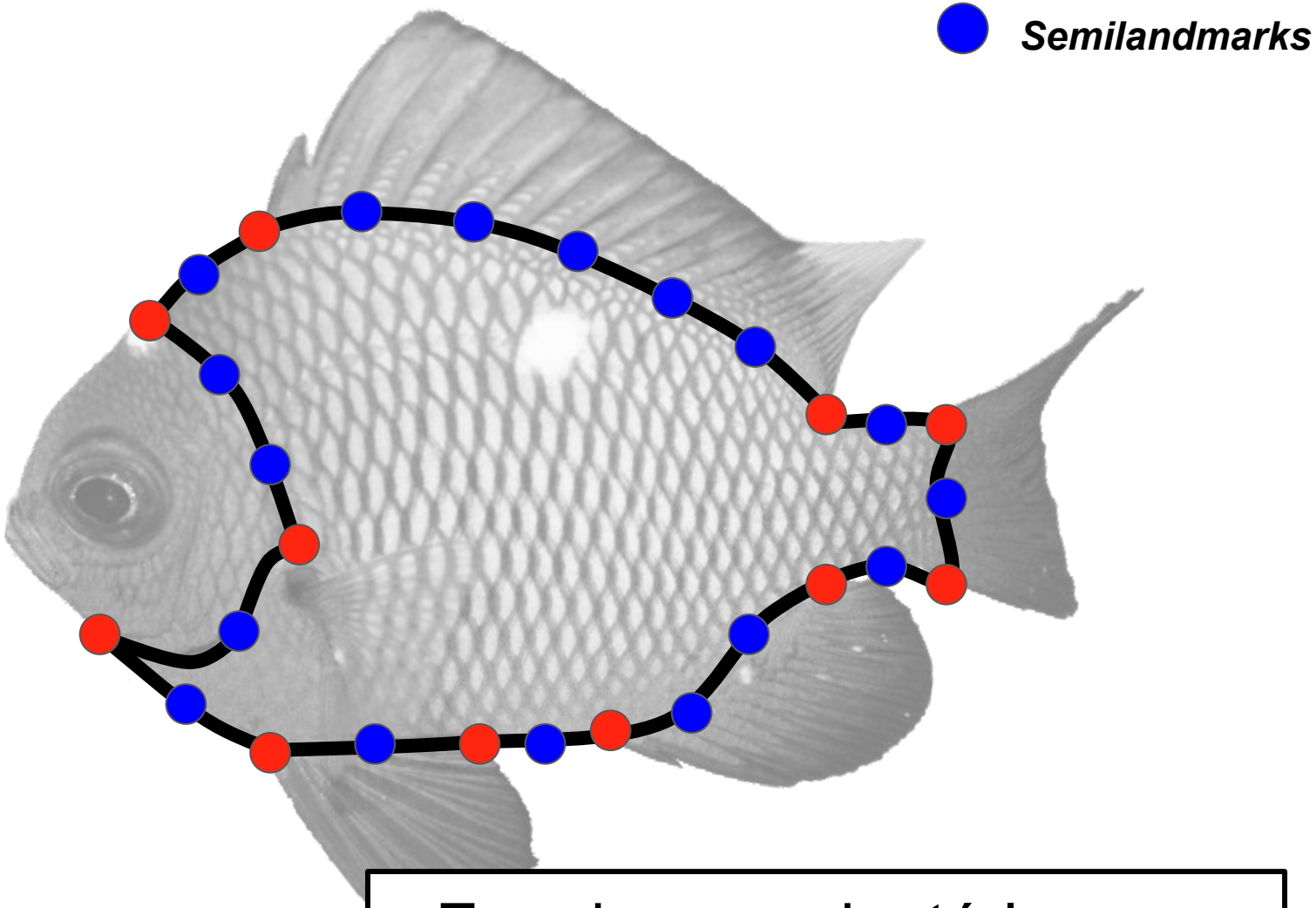


Os semilandmarks são pontos definidos ao longo de curvas/superfícies de modo a seguir a geometria de uma estrutura

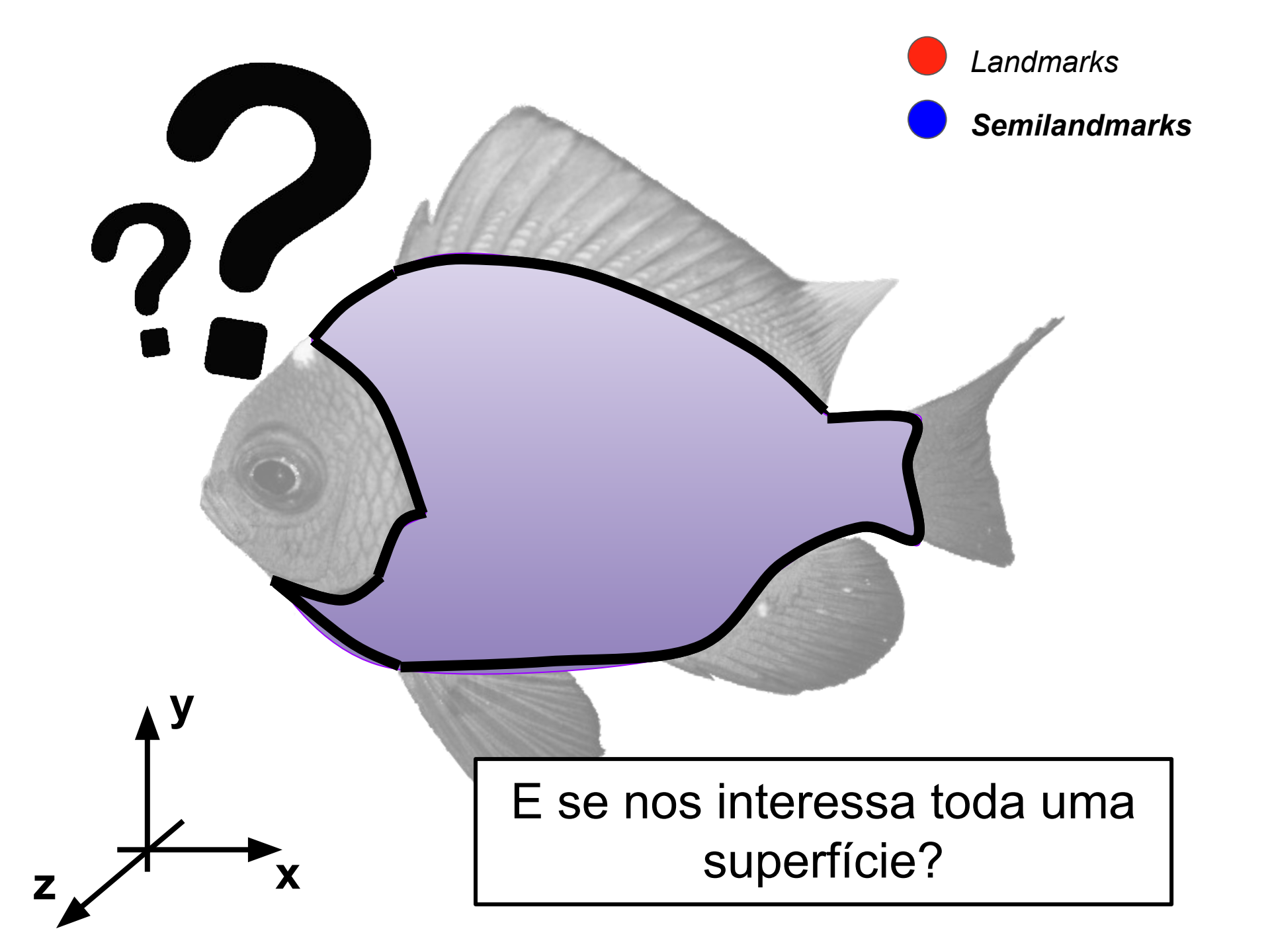
Curvas

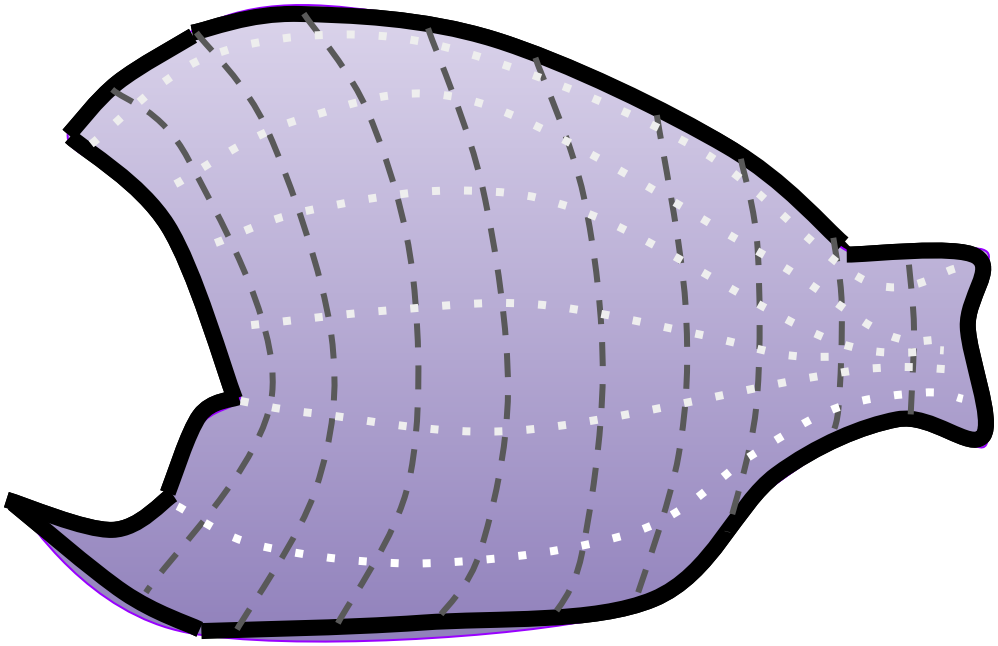


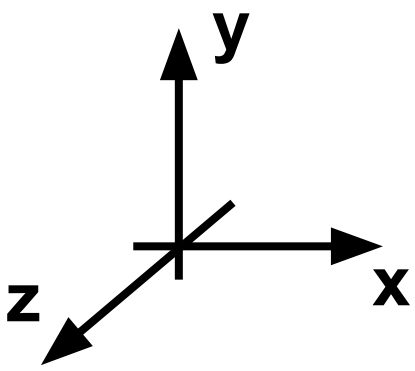
Tipo mais simples de distribuição de semilandmarks



E podemos adaptá-lo a um número indefinido de curvas


Landmarks
Semilandmarks
y
x
z
E se nos interessa toda uma superfície?





Principalmente a
tridimensionalidade dela

Por que utilizar dados 3D?

Research Article

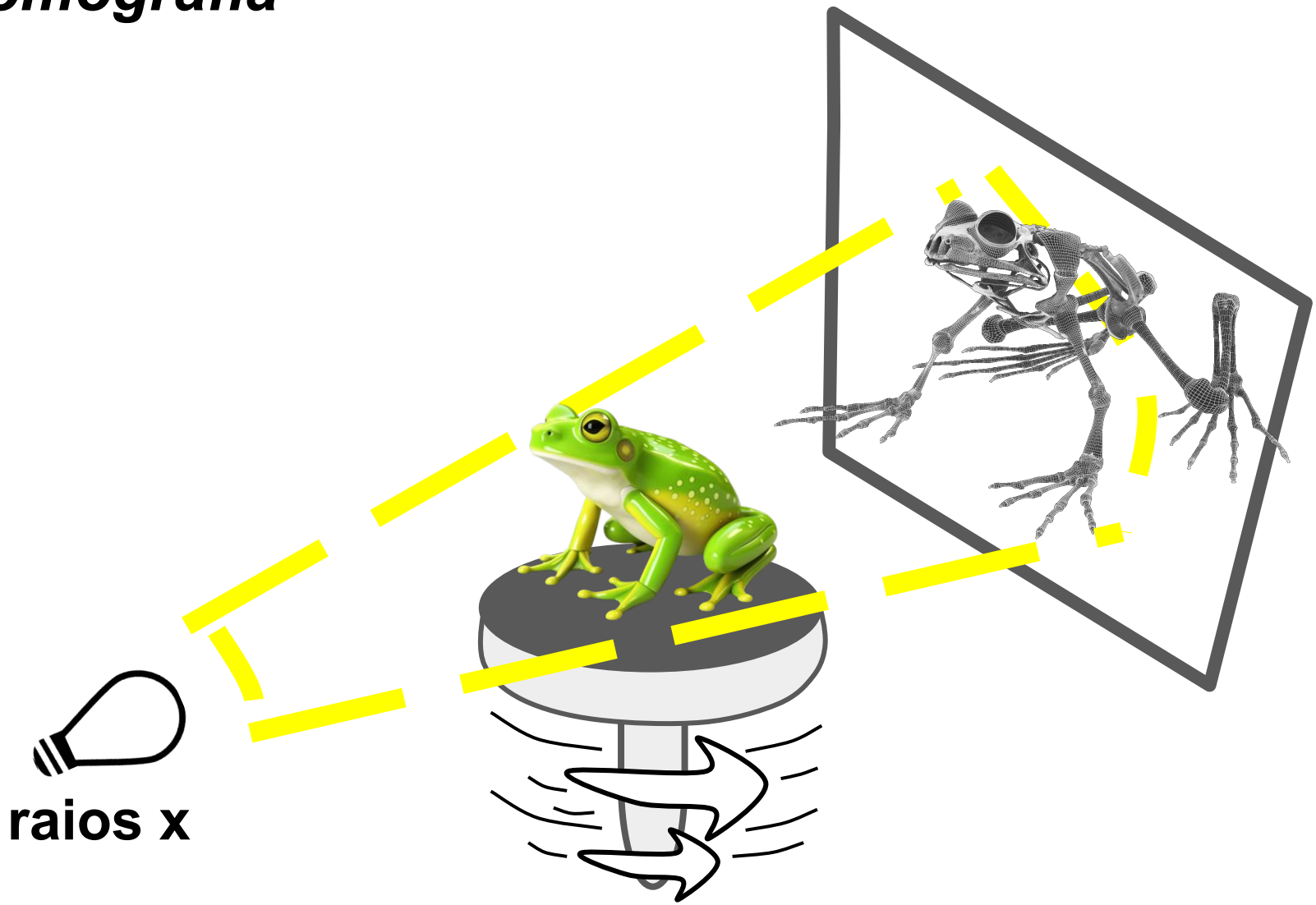
Missing the third dimension in geometric morphometrics: how to assess if 2D images really are a good proxy for 3D structures?

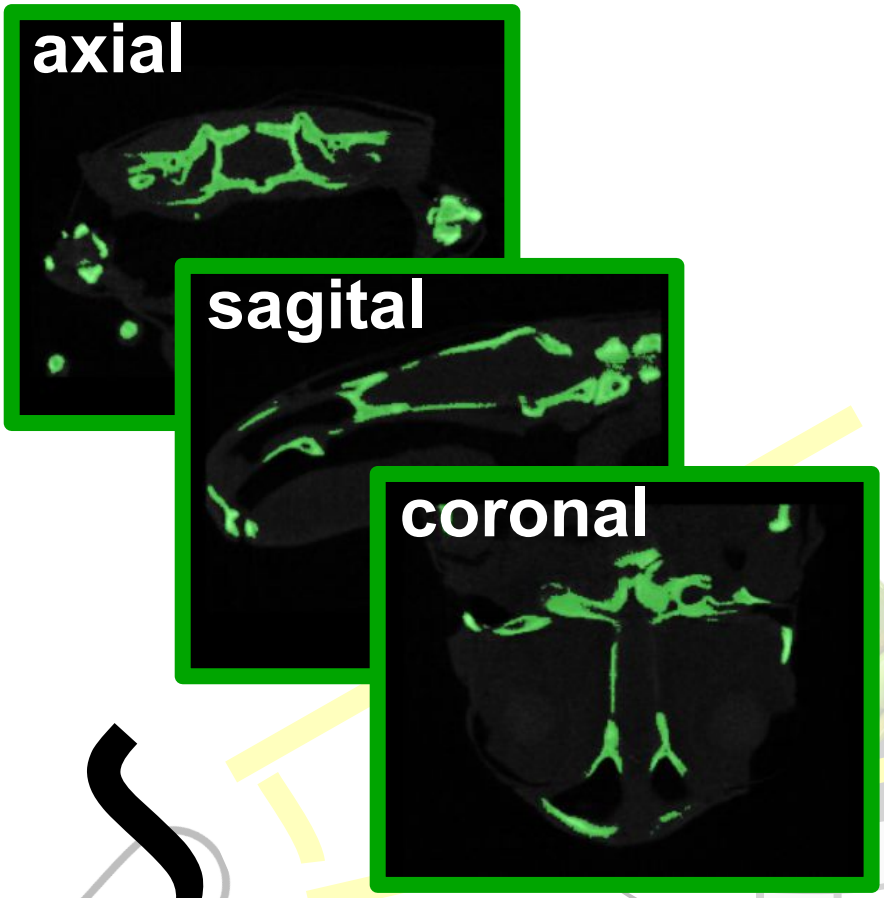
Andrea CARDINI[a,b,*]

[a] *Dipartimento di Scienze Chimiche e Geologiche, Università di Modena e Reggio Emilia, l.go S. Eufemia 19, 41121 Modena, Italy*
[b] *Centre for Forensic Science, The University of Western Australia, 35 Stirling Highway, Crawley, WA 6009, Australia*

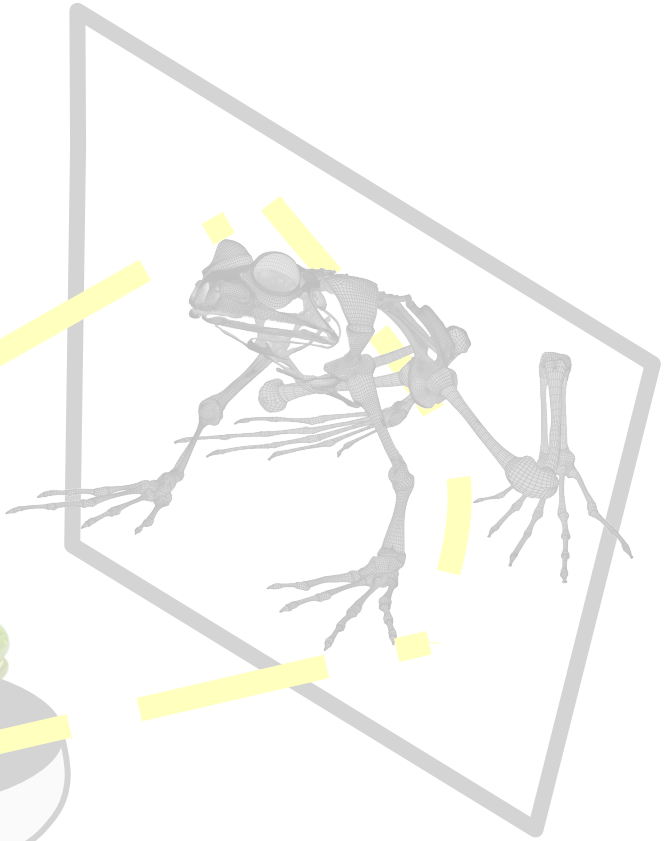
https://dx.doi.org/10.4404/hystrix-25.2-10993

Tomografia

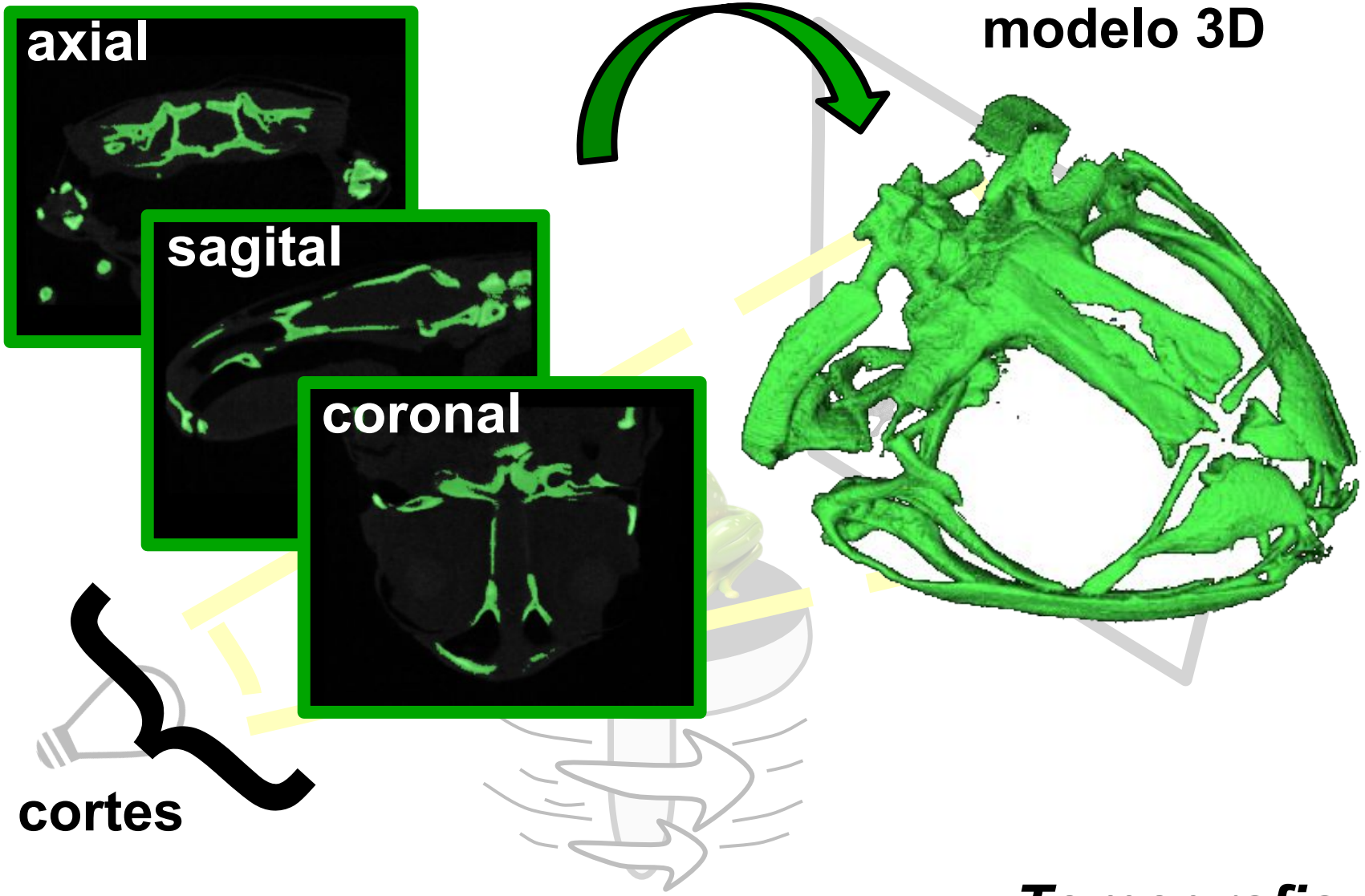




cortes

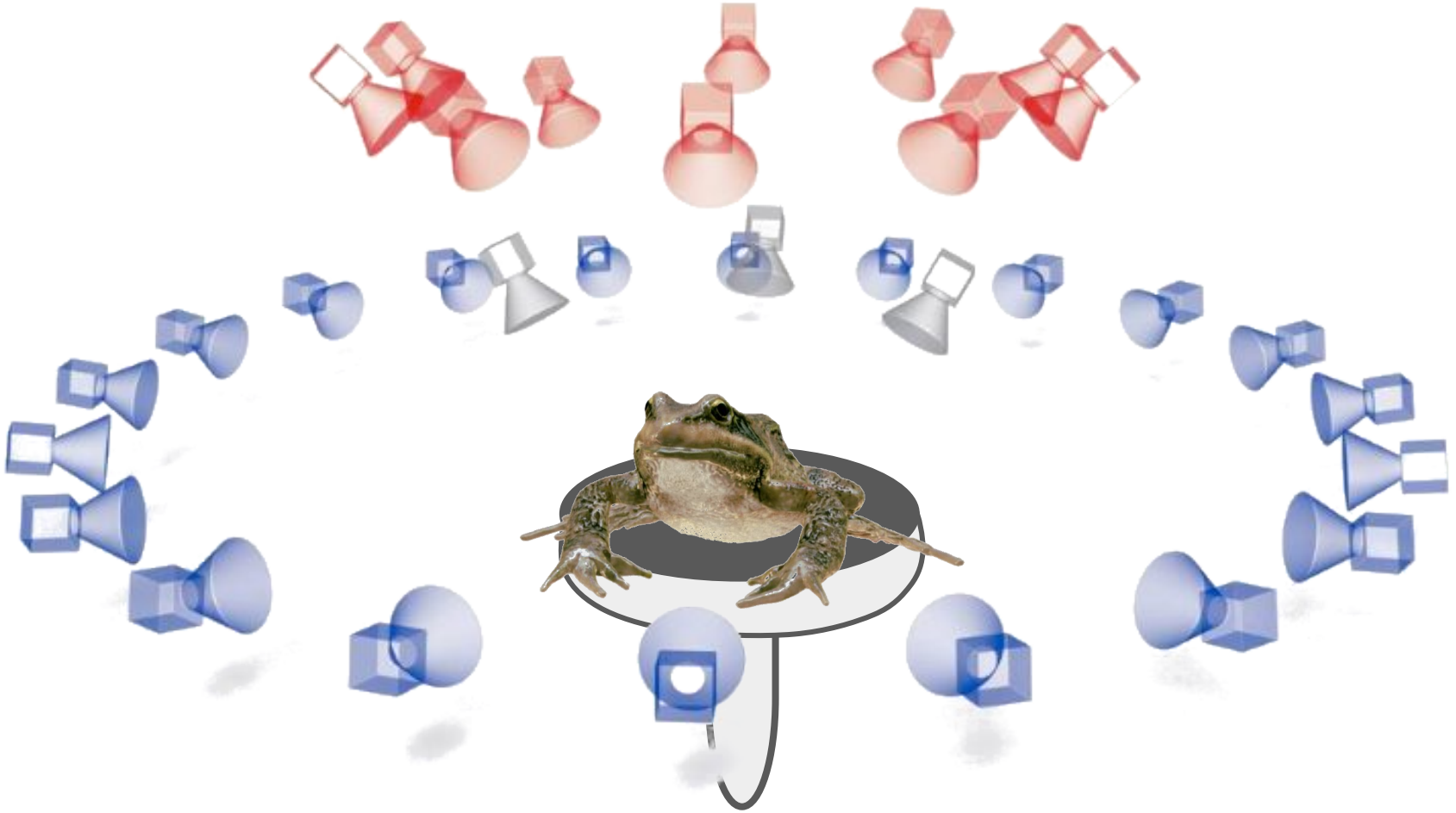


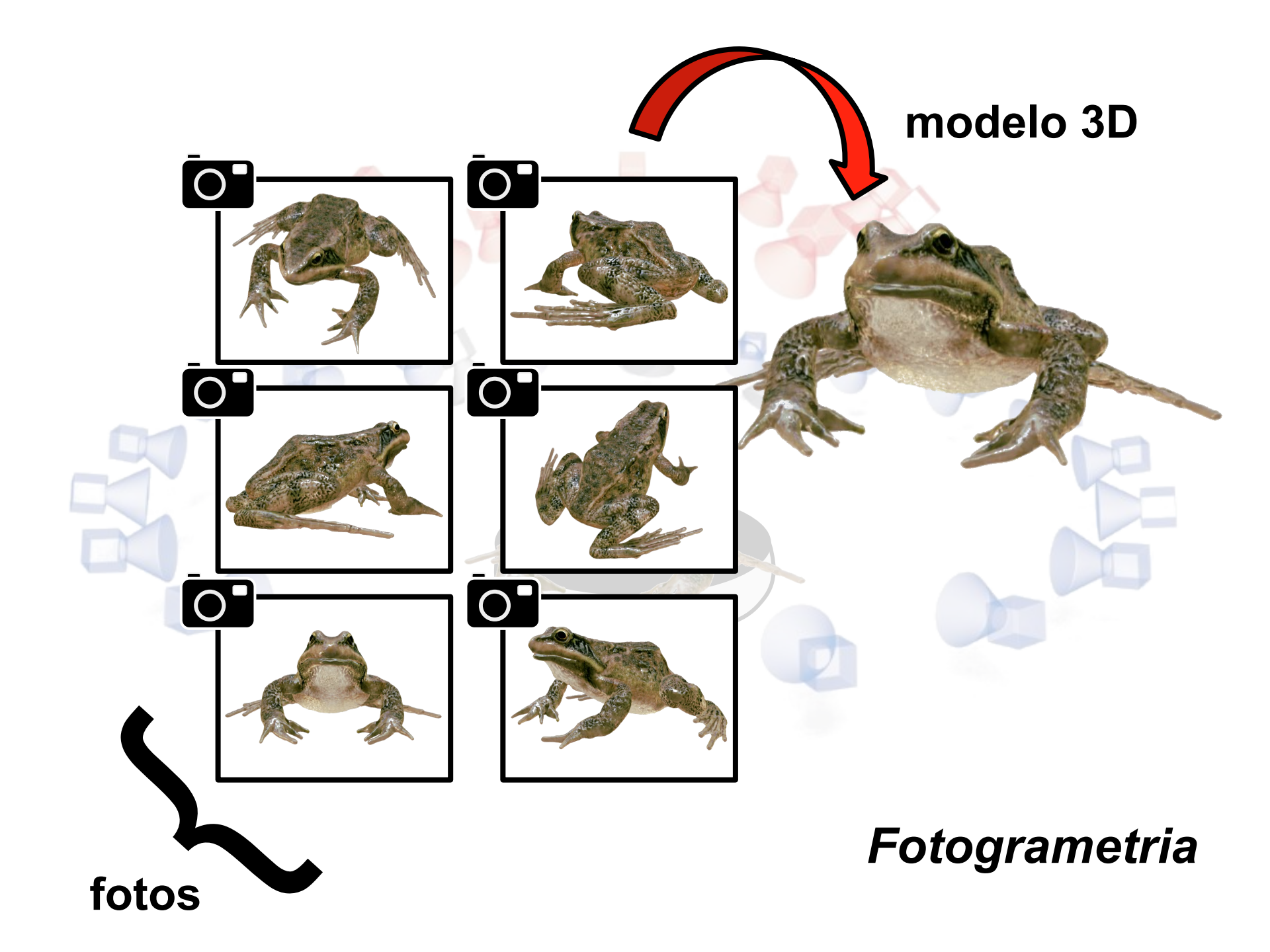
Tomografia



Tomografia

Fotogrametria



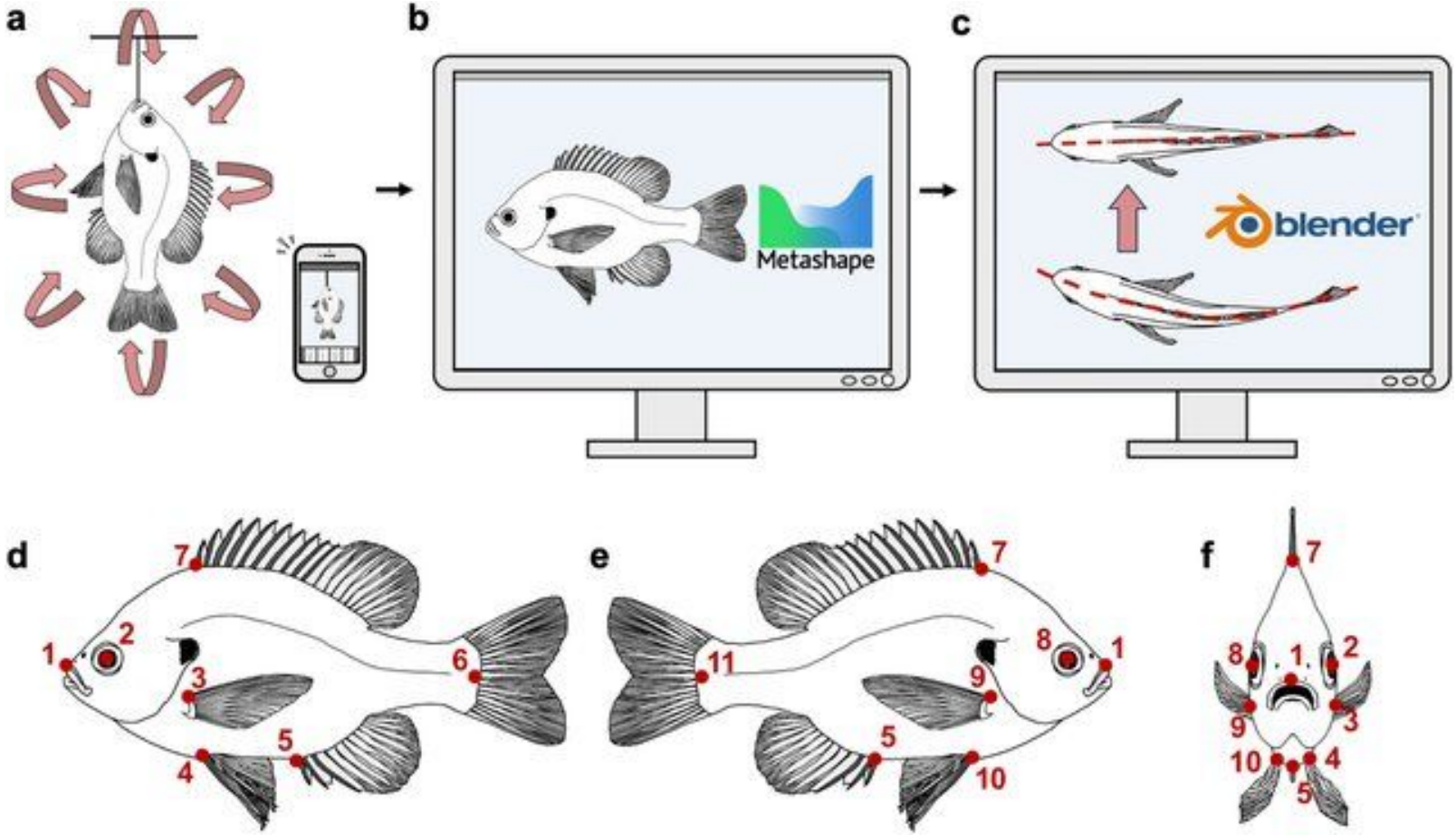

modelo 3D
fotos
Fotogrametria

scientific reports

OPEN

Water constraints drive allometric patterns in the body shape of tree frogs

Kathleen M. S. A. Castro[1,6]✉, Talita F. Amado[2,6], Miguel Á. Olalla-Tárraga[2], Sidney F. Gouveia[4,6], Carlos A. Navas[3] & Pablo A. Martinez[5,6]



scientific reports

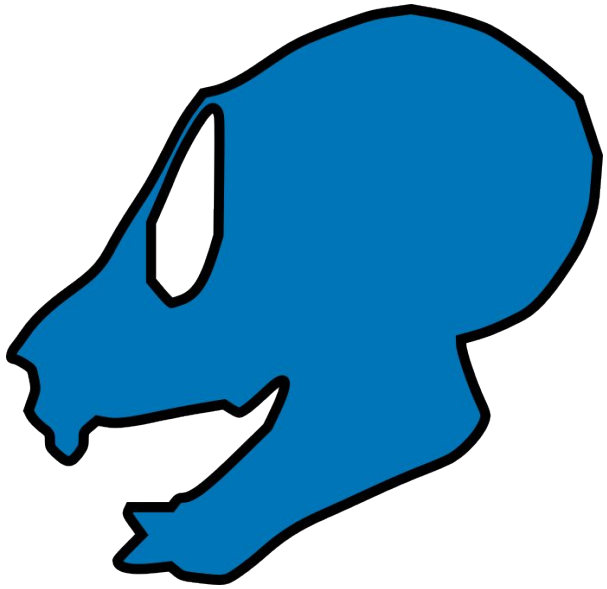
Check for updates

OPEN

Phylogenetic structure of body shape in a diverse inland ichthyofauna

Kevin T. Torgersen[1]✉, Bradley J. Bouton[1], Alyx R. Hebert[1], Noah J. Kleyla[1], Xavier Plasencia II[1], Garrett L. Rolfe[1], Victor A. Tagliacollo[2] & James S. Albert[1]

Fontes de dados online:



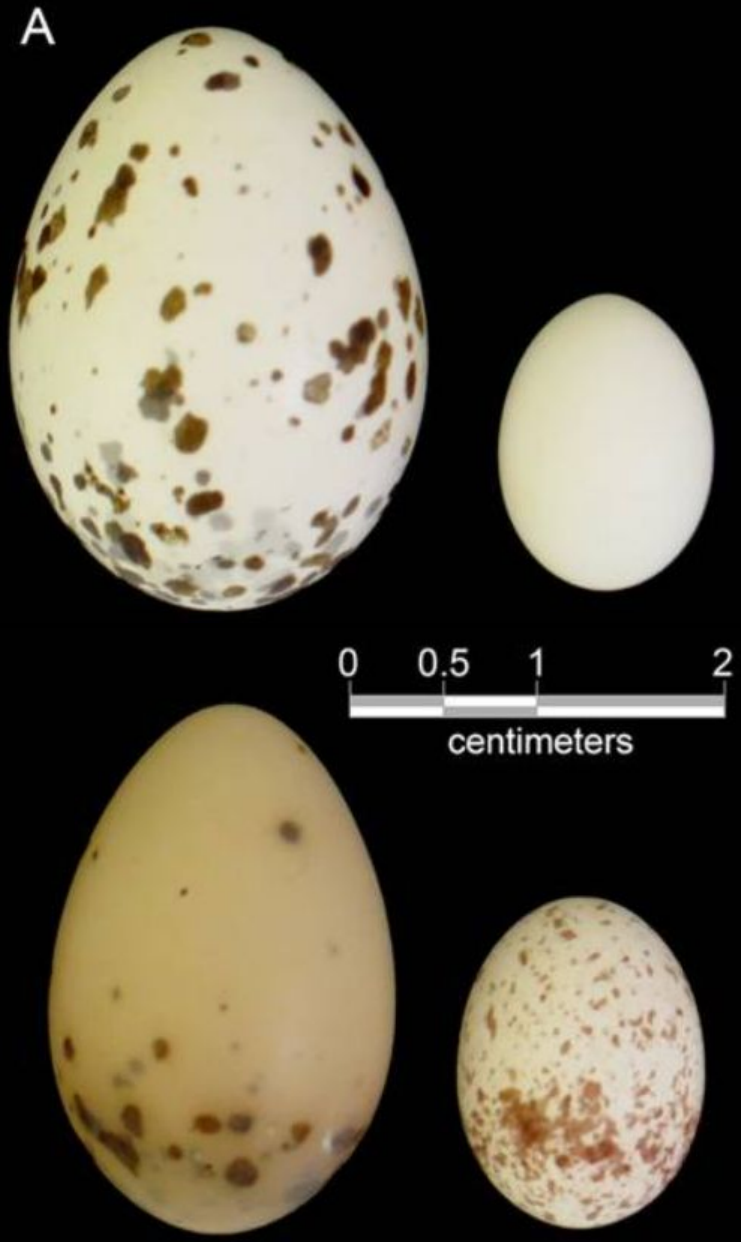
MorphoSource

https://www.morphosource.org/

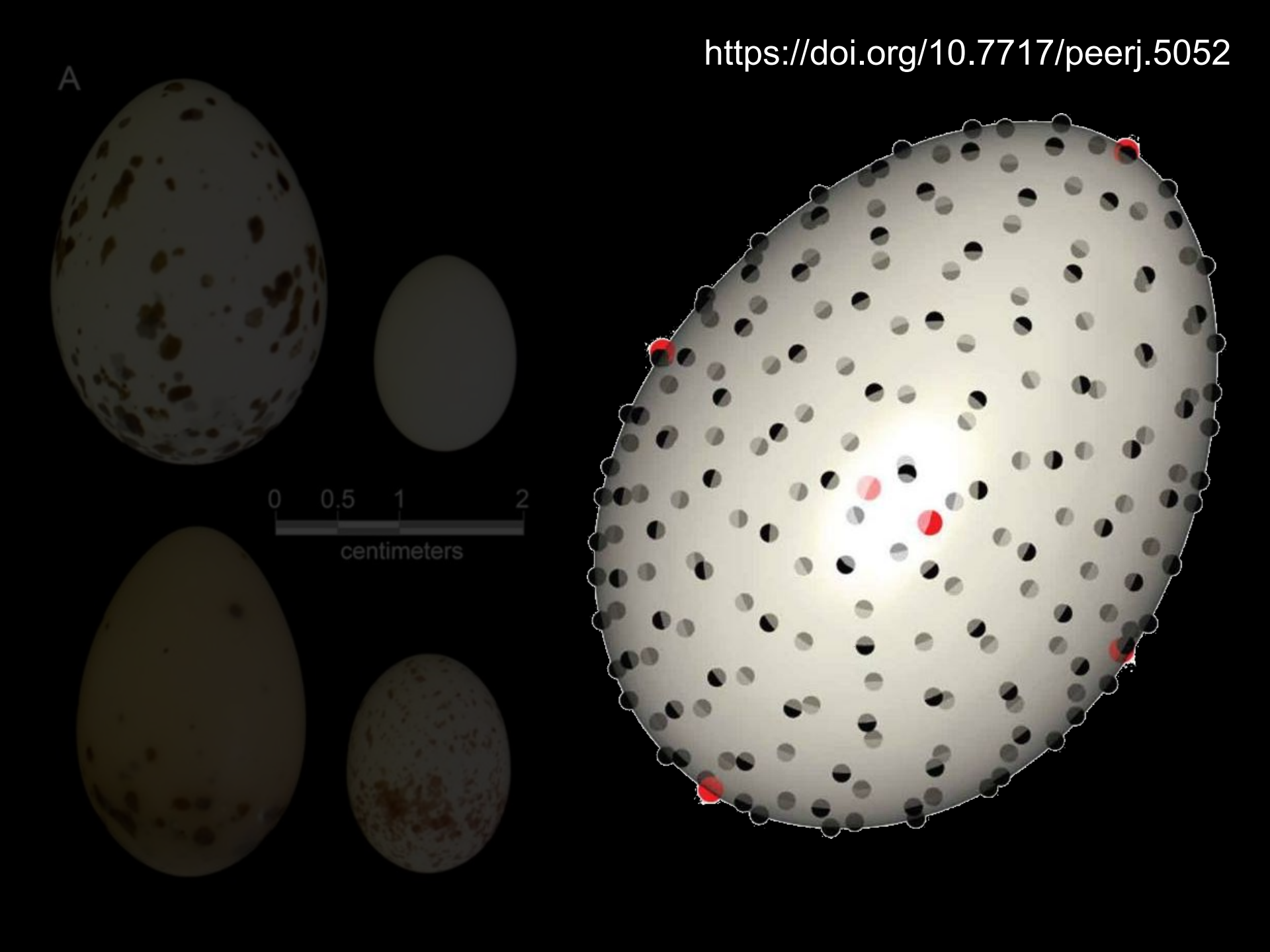
Sketchfab

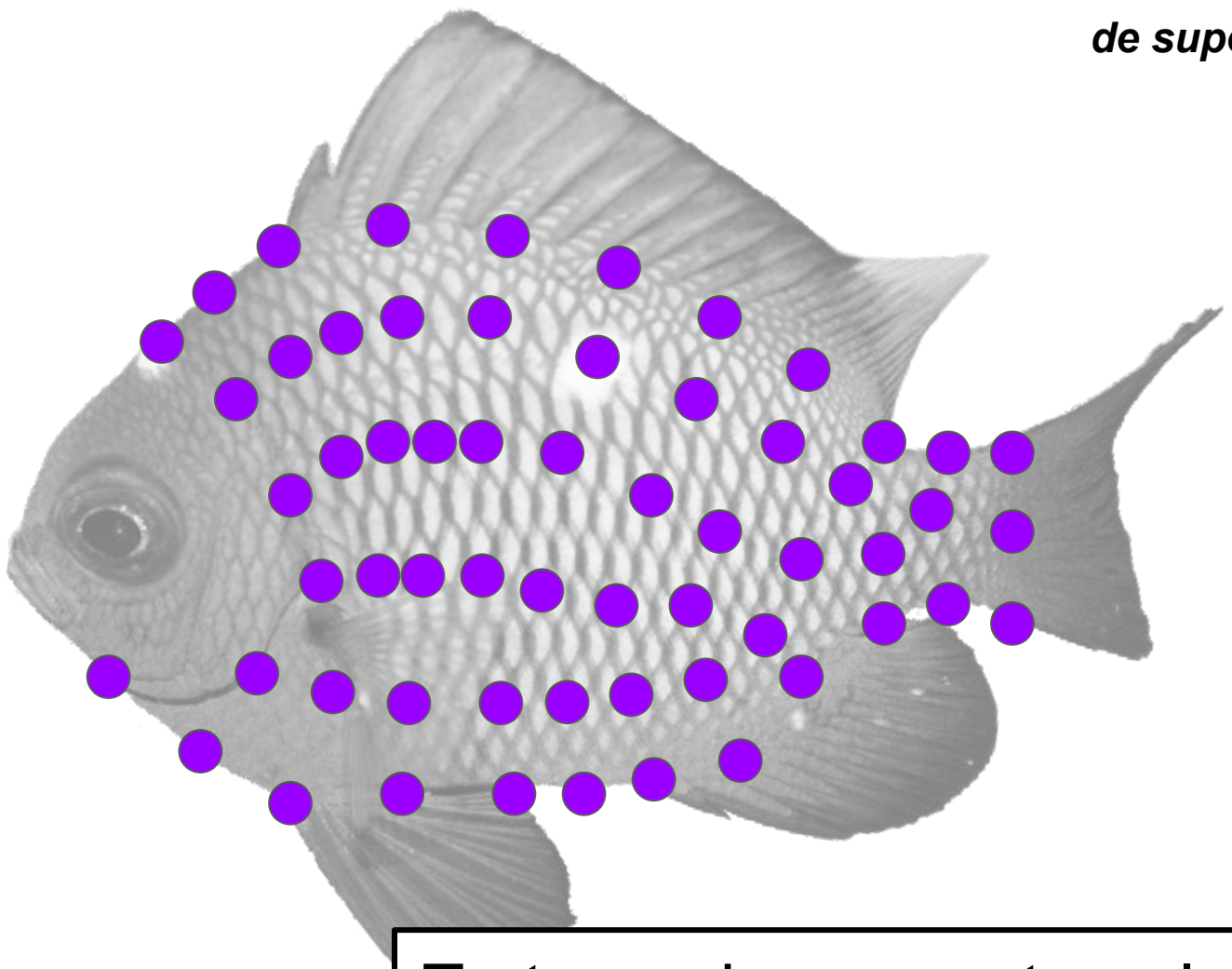
https://sketchfab.com/

https://doi.org/10.7717/peerj.5052



https://doi.org/10.7717/peerj.5052

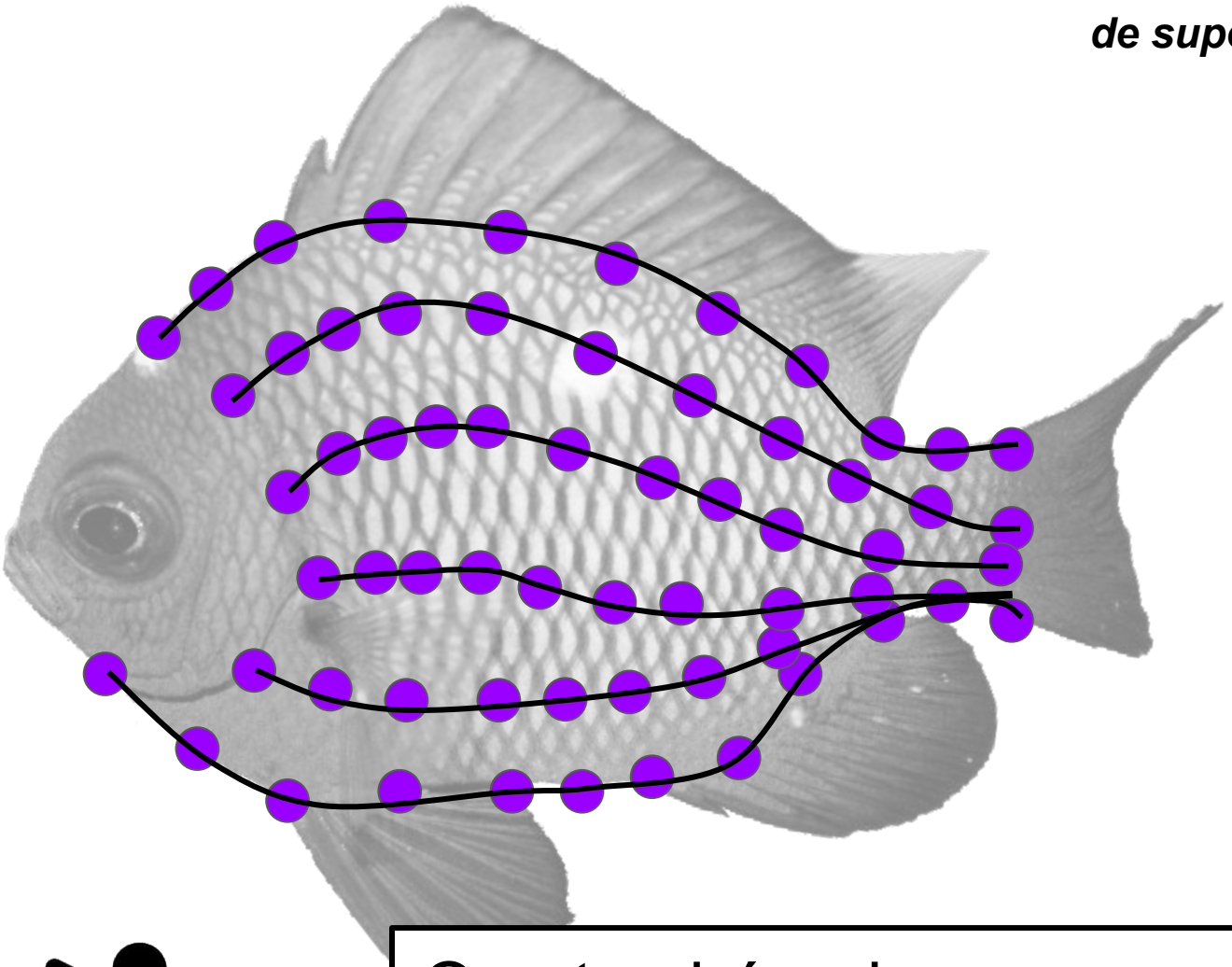




Trata-se de uma extrapolação das curvas habituais

Semilandmarks

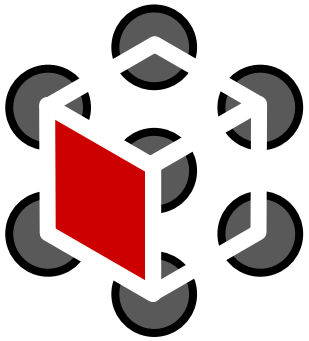
de superfície



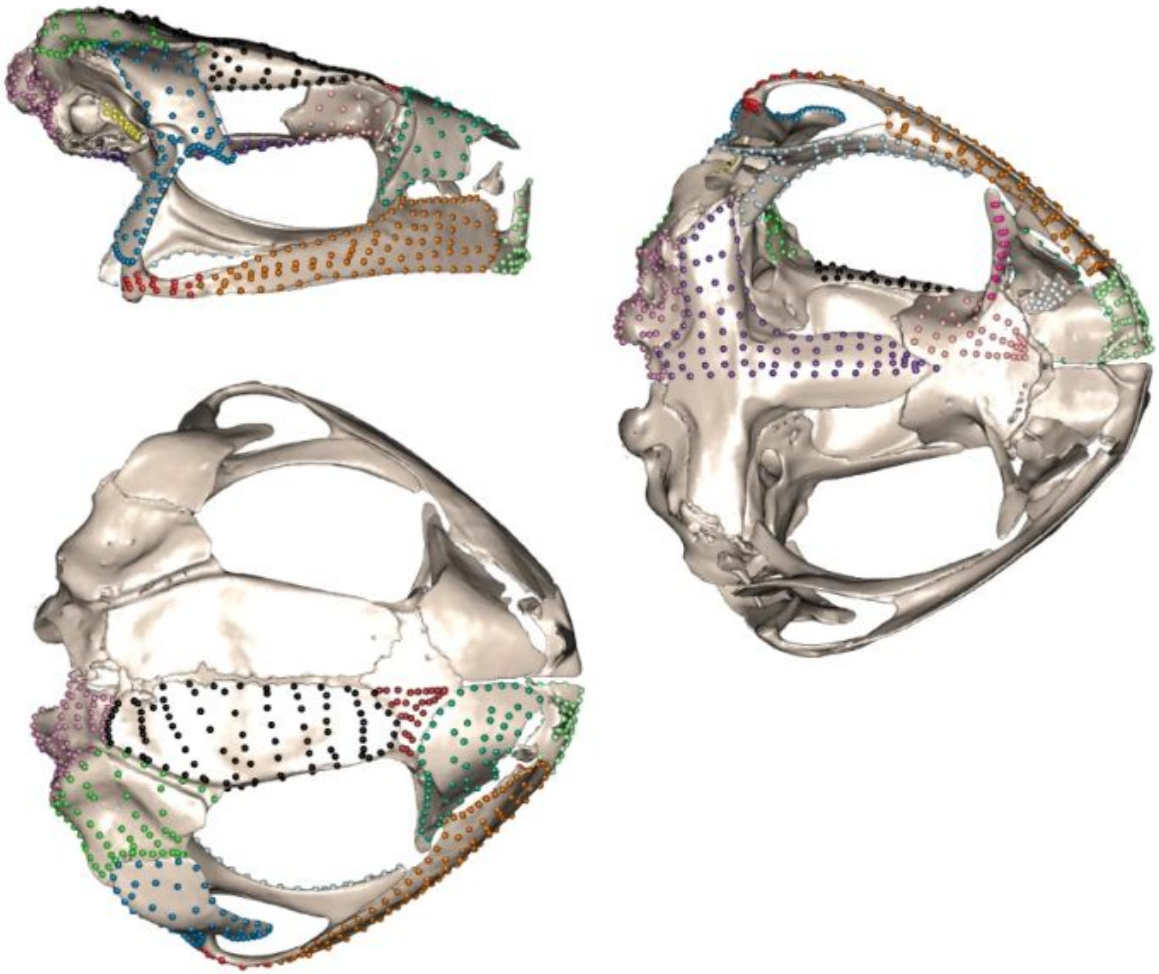
Que também deve passar por deslizamento (*sliding*)

O método tem aplicações importantes para diversas perguntas

Vide “Aula 6 - Tutorial” para um exemplo de posicionamento dos landmarks

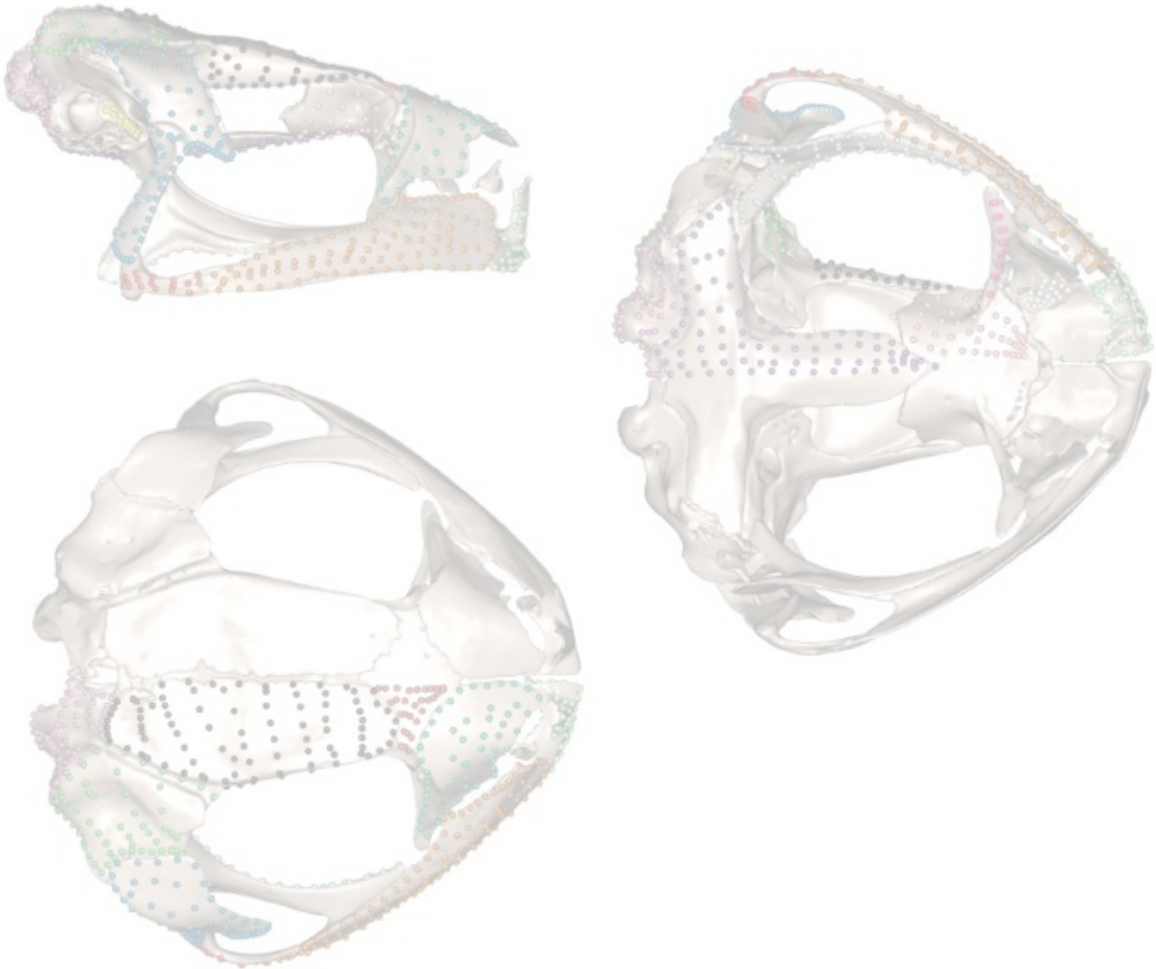


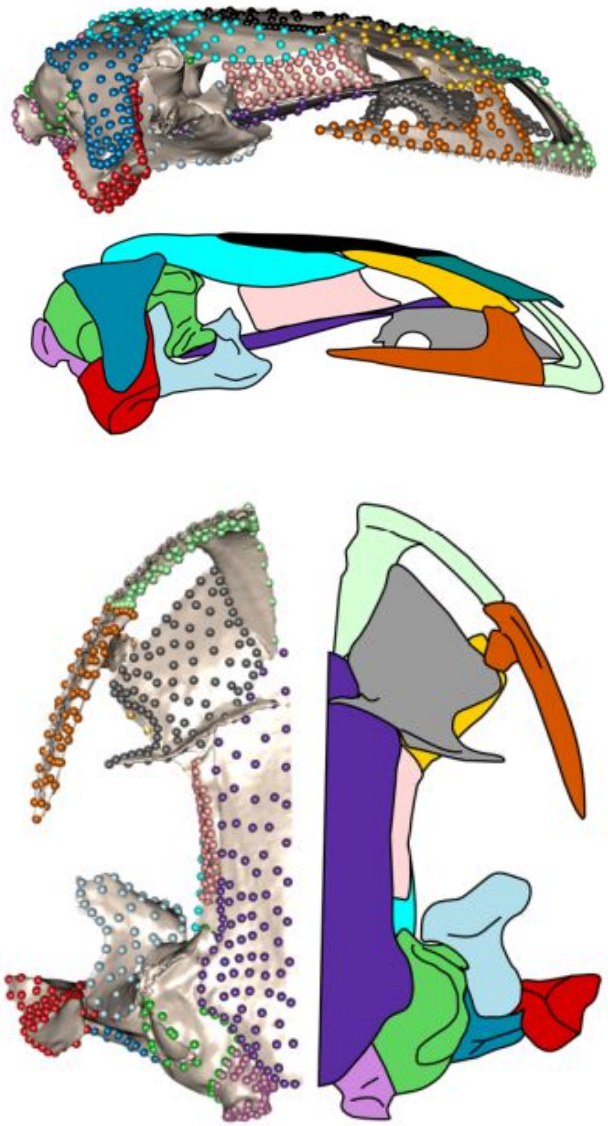
https://doi.org/10.1038/s41467-021-22792-y



Variação da forma, alometria

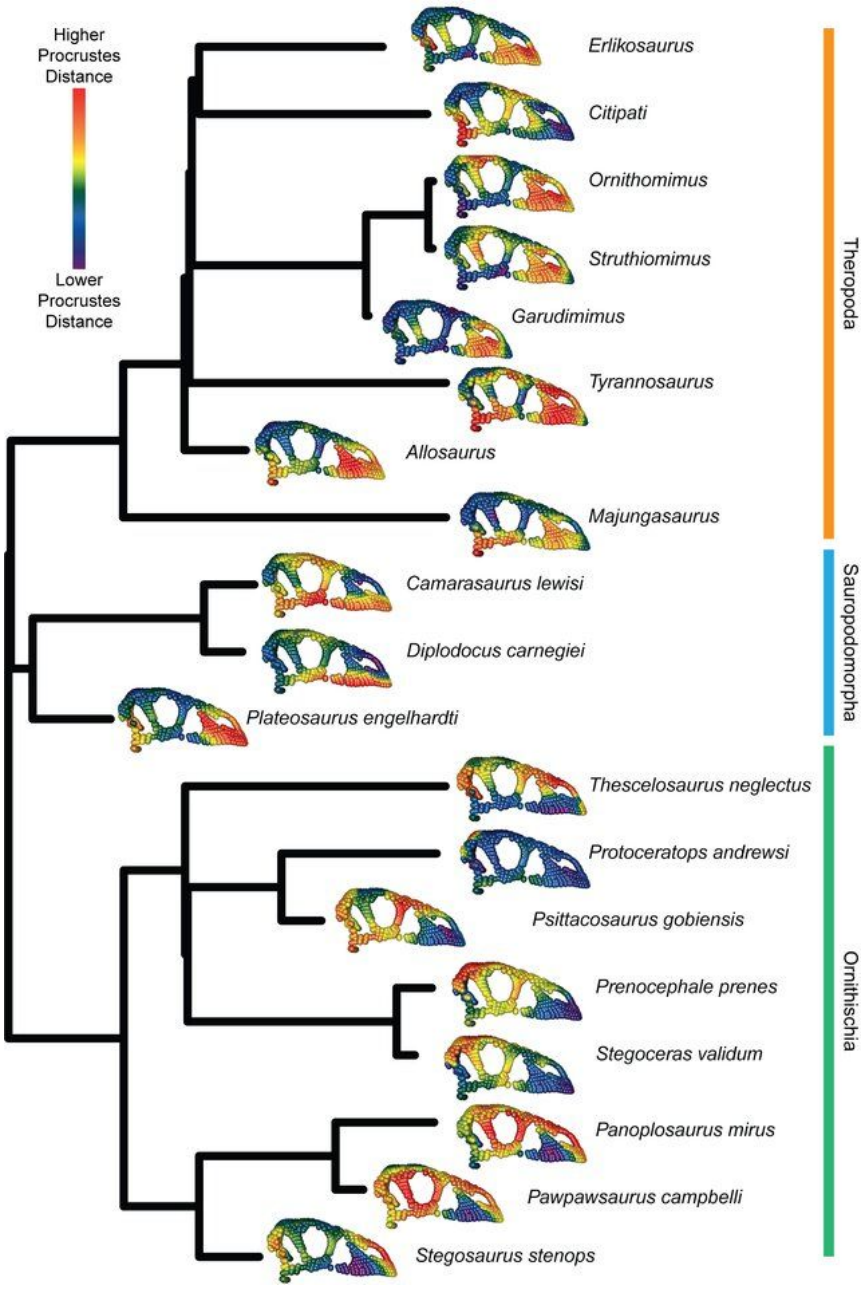
Modularidade





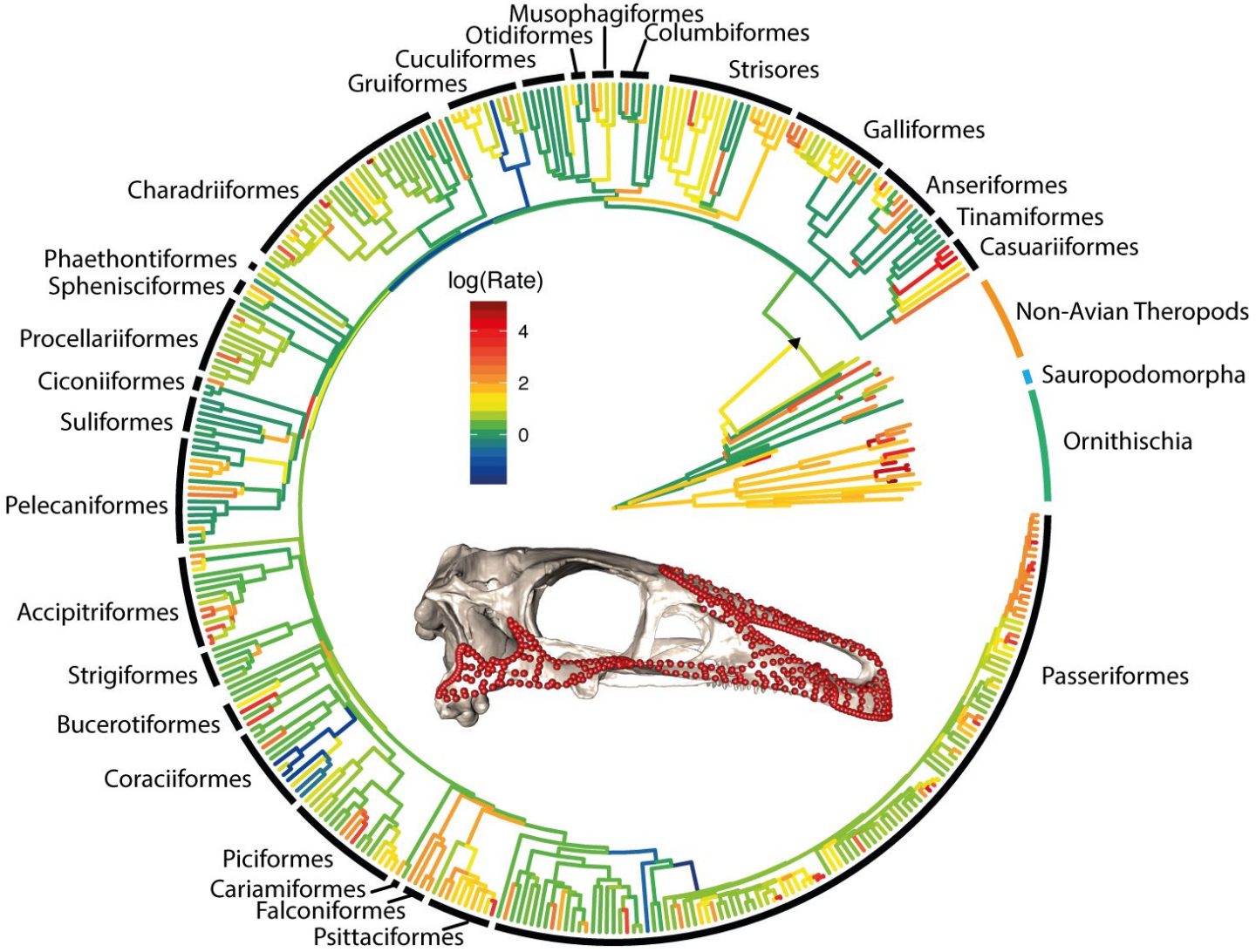
https://doi.org/10.1038/s41559-020-1225-3

https://doi.org/10.1371/journal.pbio.3000801



Reconstrução

https://doi.org/10.1371/journal.pbio.3000801



Taxas evolutivas

https://doi.org/10.1371/journal.pbio.3000801

Ponto importante: a relação de simetria entre pontos que formam um patch

Especialmente nos fósseis

Retrodeformação

Processo de correção da forma a partir da presumida simetria bilateral

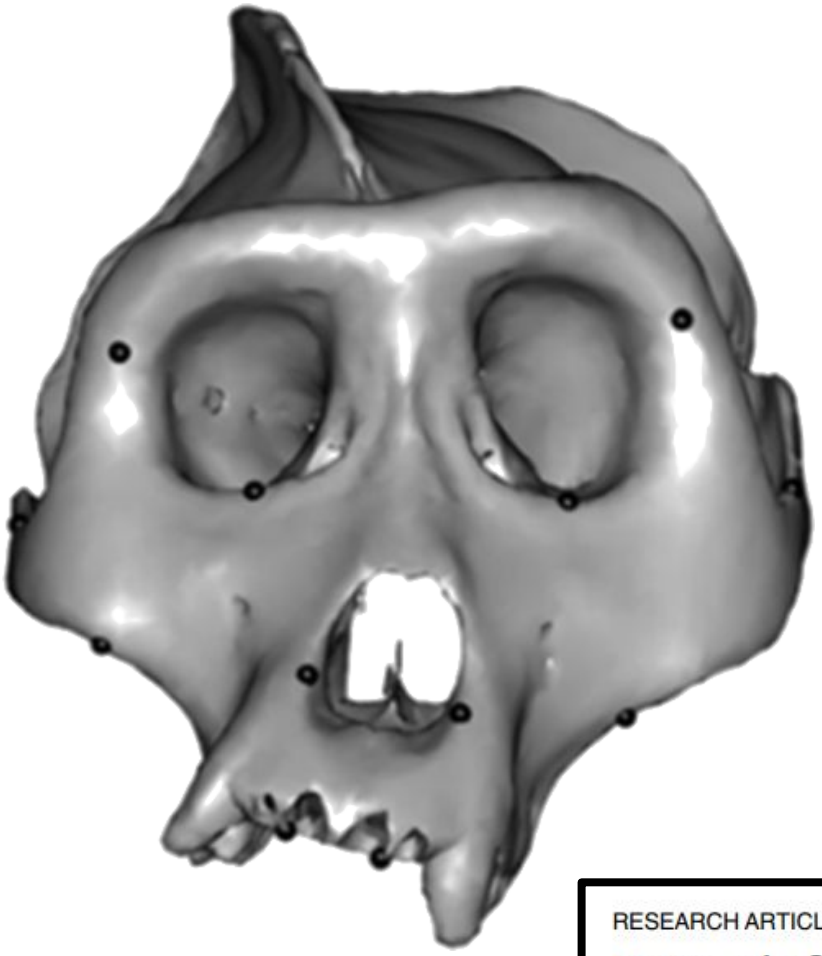
Especialmente nos fósseis

Retrodeformação

Processo de correção da forma a partir da presumida simetria bilateral

É gerada uma interpolação da forma através do espelhamento dos landmarks e cálculo da média entre a posição dos pontos espelhados e os originais

https://doi.org/10.1371/journal.pone.0194073



RESEARCH ARTICLE

Retrodeformation of fossil specimens based on 3D bilateral semi-landmarks: Implementation in the R package "Morpho"

Stefan Schlager[1]*, Antonio Profico[2], Fabio Di Vincenzo[2], Giorgio Manzi[2]

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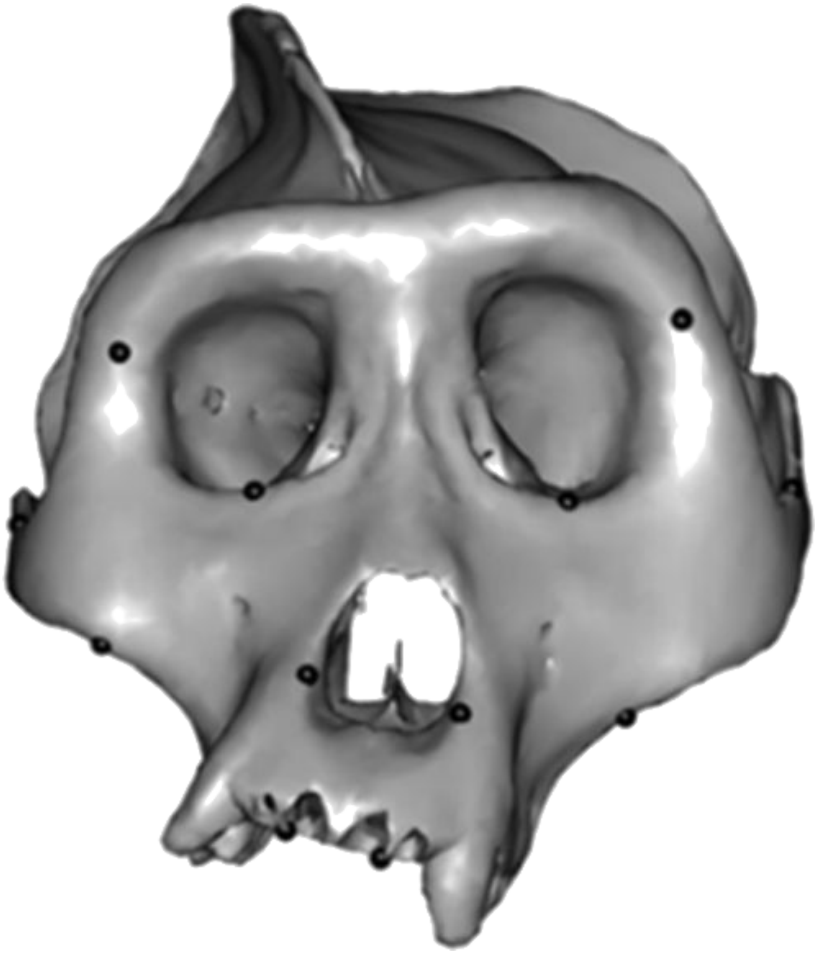

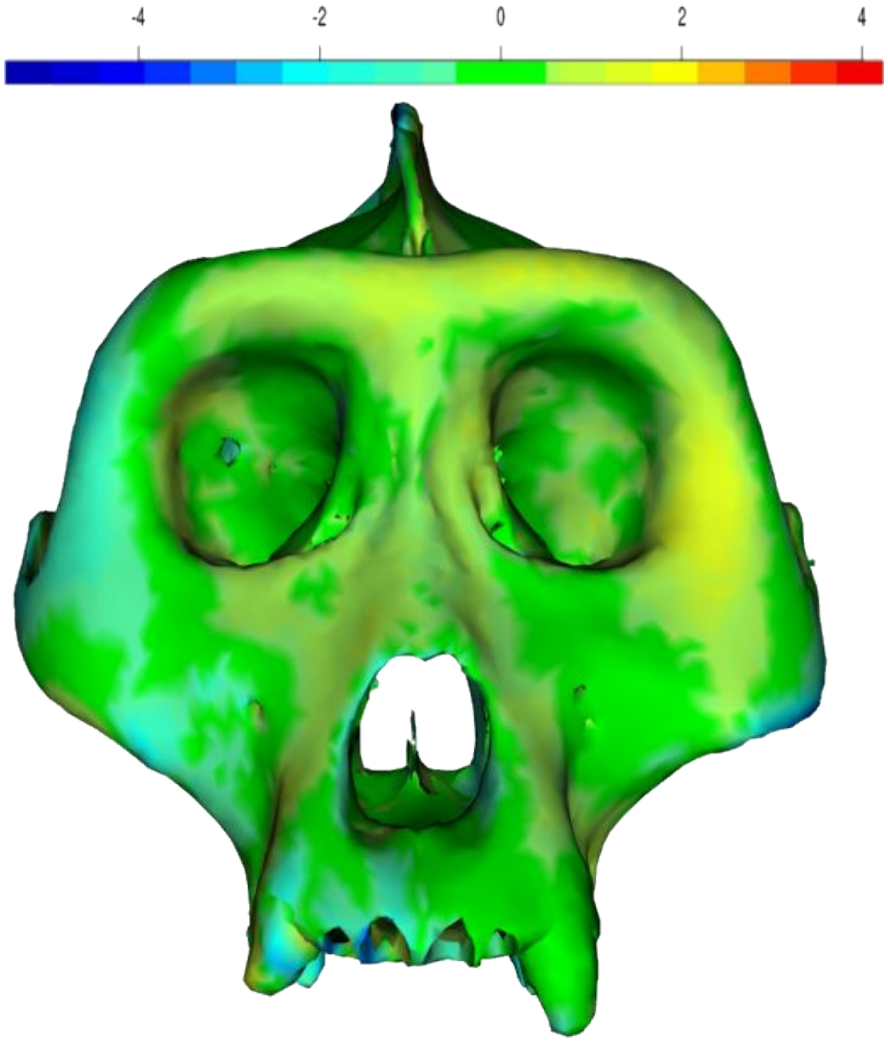

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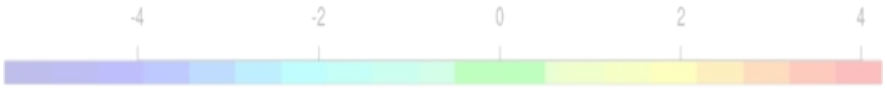

Ainda a respeito de fósseis, e se falta algum landmark na nossa amostra?

= *missing data*

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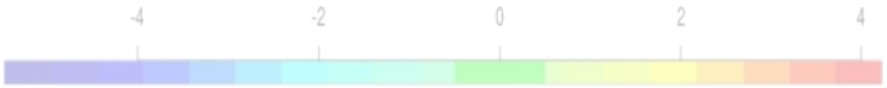

Ainda a respeito de fósseis, e se falta algum landmark na nossa amostra?

= *missing data*

**não é um problema exclusivo da paleontologia*

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Stefan Schlager[1]*, Antonio Profico[2], Fabio Di Vincenzo[2], Giorgio Manzi[2]

```
Electrorana_limoae

  -5.0621209e+000  -3.8099505e-003  -3.9463415e+000
  -5.0898237e+000  -1.9331388e-001  -3.9927847e+000
  -4.7747393e+000   1.7115210e+000  -3.5873501e+000
  -4.8440871e+000  -1.7103398e+000  -4.0063615e+000
  -5.4061427e+000   5.8428979e-001  -2.2647359e+000
  -5.3439765e+000  -1.2857398e+000  -2.4291258e+000
  9999  9999  9999
  -4.8955784e+000  -1.6598980e+000  -3.7135680e+000
  9999  9999  9999
  -3.2296526e+000  -1.4744456e+000  -1.1801982e+000
  -2.8094277e+000   2.4354935e+000  -1.7785830e+000
  -2.9339211e+000  -2.5582156e+000  -2.1103020e+000
  -4.4382401e+000   2.3665370e-001  -1.3000946e+000
  -4.6391826e+000  -7.8523791e-001  -1.5487530e+000
  -1.7757404e+000   4.0609388e+000  -2.2161775e+000
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   1.5491557e+000   2.8890617e+000  -8.8229084e-001
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   1.4104303e+000   5.0453706e+000  -2.4375682e+000
   1.8109424e+000  -4.1751618e+000  -3.4826241e+000
  -3.1773655e+000  -1.5936130e-001  -1.2884459e+000
   1.1637151e+000   5.0049825e+000  -2.4350321e+000
```

```
Electrorana_limoae

  -5.0621209e+000  -3.8099505e-003  -3.9463415e+000
  -5.0898237e+000  -1.9331388e-001  -3.9927847e+000
  -4.7747393e+000   1.7115210e+000  -3.5873501e+000
  -4.8440871e+000  -1.7103398e+000  -4.0063615e+000
  -5.4061427e+000   5.8428979e-001  -2.2647359e+000
  -5.3439765e+000  -1.2857398e+000  -2.4291258e+000
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  -2.9339211e+000  -2.
  -4.4382401e+000   2.
  -4.6391826e+000  -7.
  -1.7757404e+000   4.
  -1.5853300e+000  -4.
   1.5491557e+000   2.
   9999   9999   9999
   1.4104303e+000   5.0453706e+000  -2.4375682e+000
   1.8109424e+000  -4.1751618e+000  -3.4826241e+000
  -3.1773655e+000  -1.5936130e-001  -1.2884459e+000
   1.1637151e+000   5.0049825e+000  -2.4350321e+000
```

Cada landmark faltante deve ser indicado com NA (ou 9999, a depender do formato do arquivo)

Estimando landmarks

Existem métodos diversos:

- *Simetria*
- *Substituição média*
- *Interpolação através do TPS*
- *Interpolação por regressão*

Métodos de interpolação analisam toda a sua amostra

Estimando landmarks

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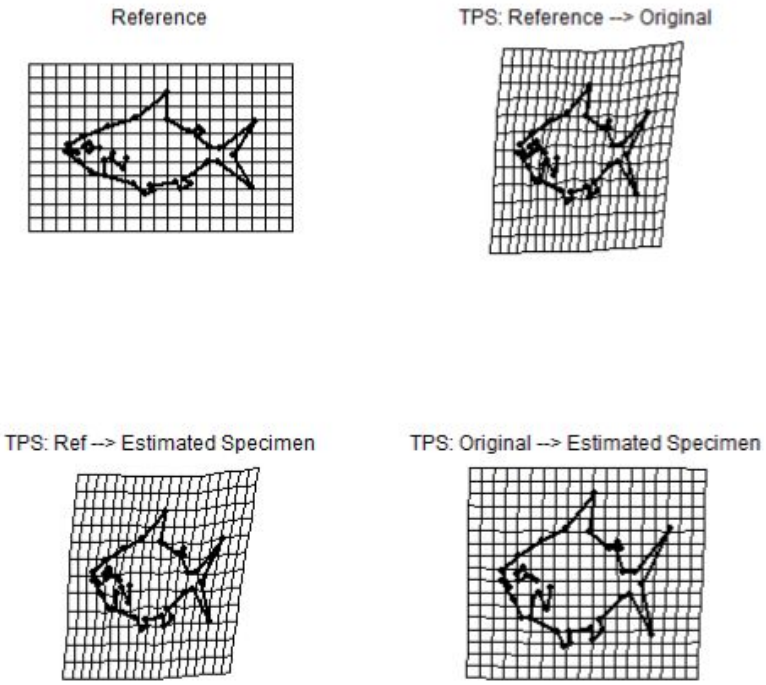
- *Interpolação através do TPS*
- *Interpolação por regressão*

Métodos de interpolação analisam toda a sua amostra

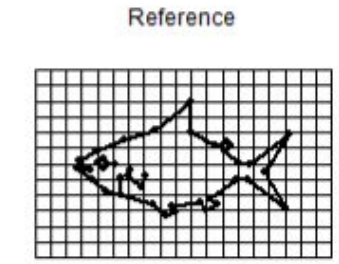
Estimando landmarks

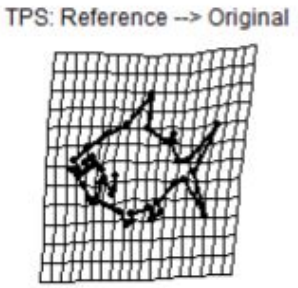
Interpolação a partir da grade para os landmarks completos, estimando o landmark ausente através da menor distorção possível

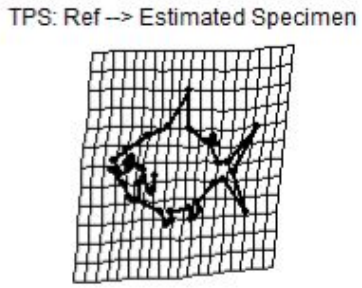


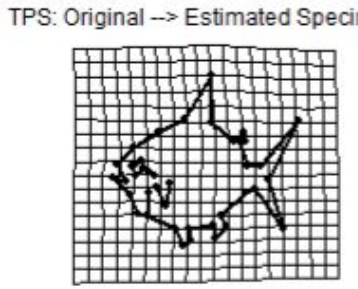
`method="TPS"`

Estimando landmarks









Prevê a posição dos landmarks ausentes usando um modelo de regressão baseado nos espécimes que possuem todos os landmarks

`method="Reg"`

Exemplo

Conhecendo o Morpho, outro dos pacotes do R para morfometria geométrica

Agora, vamos pro