

翼竜型羽ばたき機の開発の歴史

Development history of the pterosaur-type ornithopter

05/07/2023 角田和彦

YouTube 動画 <https://www.youtube.com/watch?v=97Uzr5BcS1I>

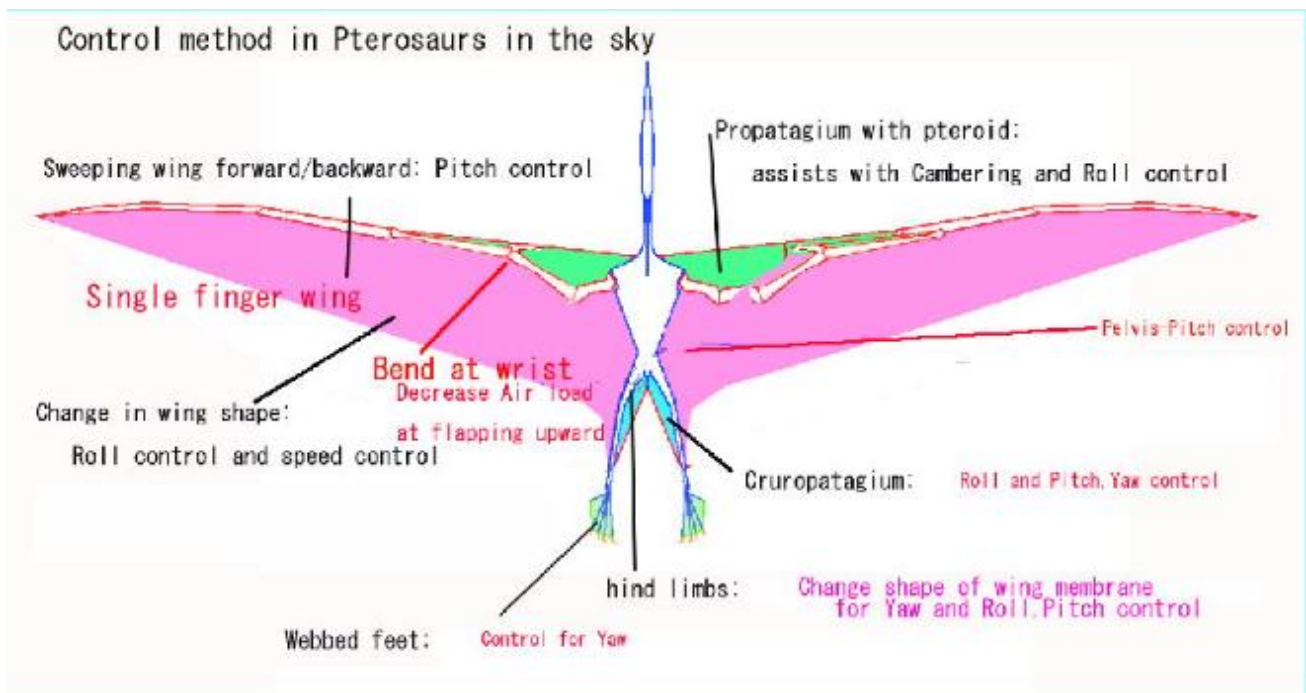
PDF File(English&Japanes) <http://kakutaclinic.life.coocan.jp/DvlpHPtO.pdf>

今まで多くの羽ばたき機を製作してきた。その経過を記します。

2007年、最初思い描いていた翼竜の形。これに従って、2017年までは翼竜型羽ばたき機を製作してきた。現在は、この形が間違っていたと考えている。

I have made many Ornithopters until now. I will describe the process.

In 2007, the shape of a pterosaur that I had envisioned at first. Following this, I have built a pterosaur-type ornithopter until 2017. I now believe that this was the wrong form.



2007年 — Foot membrane Control

最初から10年間は1機を除いて、次のような方法で製作し飛行を制御した。

Protopatagiumの傾きを変化させる方法は失敗した。

頭部のとさか(crest)を動かして制御する方法は着陸時の安易に損傷するため実現しなかった。

モーター+Gear+Servoを使った駆動方式では足の指の間の膜を使う方法しか実現できなかった。

翼の膜は足首にまで伸びて付着。

操縦は足の指の間に張った膜で行う。

つまり、本物の翼竜の飛行制御方法とは全く異なる。

羽ばたきが十分にできるため、推力は良好。

翼の膜が足首まで伸びるため、アスペクト比が少なく、滑空性能は悪い。

滑空はNewGLDABを搭載して行う。<http://kakutaclinic.life.coocan.jp/GLDABE.htm>

For the first 10 years, all but one aircraft were manufactured and controlled in the following manner.

The method of changing the slope of Protopatagium was unsuccessful.

The method of controlling by moving the crest on the head was not realized because it is easily damaged during landing.

In the drive system using Motor + Gear + Servo, only the method using the membrane between the toes could be realized.

The wing membrane extends to the ankle and adheres.

Maneuvering is done with a membrane stretched between the toes.

In other words, it is completely different from the flight control method of a real pterosaur.

Thrust is good because it can flap its wings sufficiently.

Since the wing membrane extends to the ankle, the aspect ratio is small and the glide performance is poor.

Gliding is carried out with NewGLDAB. <http://kakutaclinic.life.coocan.jp/GLDABE.htm>

1) Pteranodon2

<http://kakutaclinic.life.cocan.jp/Pteran2E.htm>

WingSpan 66cm Weight 25g

この羽ばたき機は 10 数秒の飛行ができた。

This ornithopter was able to fly for ten seconds.

<https://www.youtube.com/watch?v=XwueN8Xz95c>



2) Pteranodon3

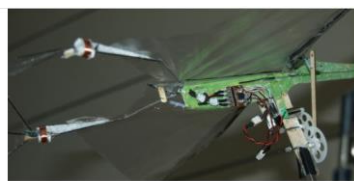
<http://kakutaclinic.life.cocan.jp/Pterano3E.htm>

WingSpan 46cm Weight 11.5g

この羽ばたき機は 10 数秒の飛行ができたが、操縦ができない。

This ornithopter was able to fly for 10-odd seconds, but could not be steered.

<https://www.youtube.com/watch?v=B6O9wHamKLs>



3) Pteranodon5

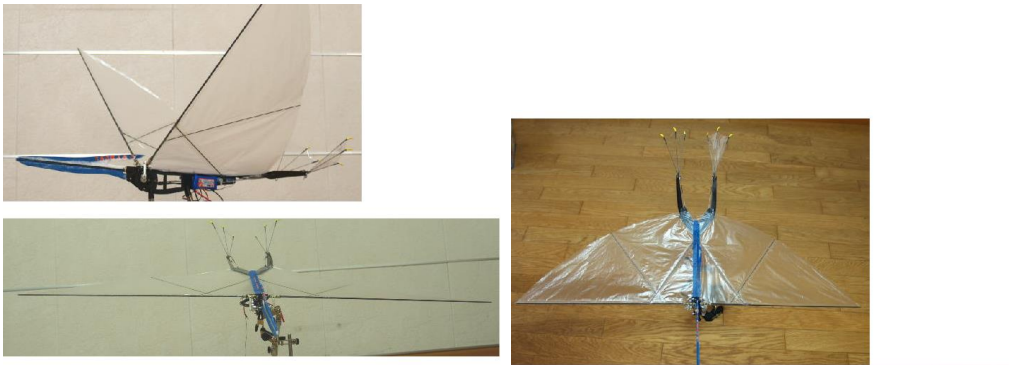
<http://kakutaclinic.life.coocan.jp/Ptera55E.htm>

WingSpan 99cm Weight 80g

この羽ばたき機は長時間の飛行が可能。YouTube に動画を公開した最初の機体。

This ornithopter can fly for a long time. The first aircraft to publish a video on YouTube.

<https://www.youtube.com/watch?v=D1TPIm94SIM>

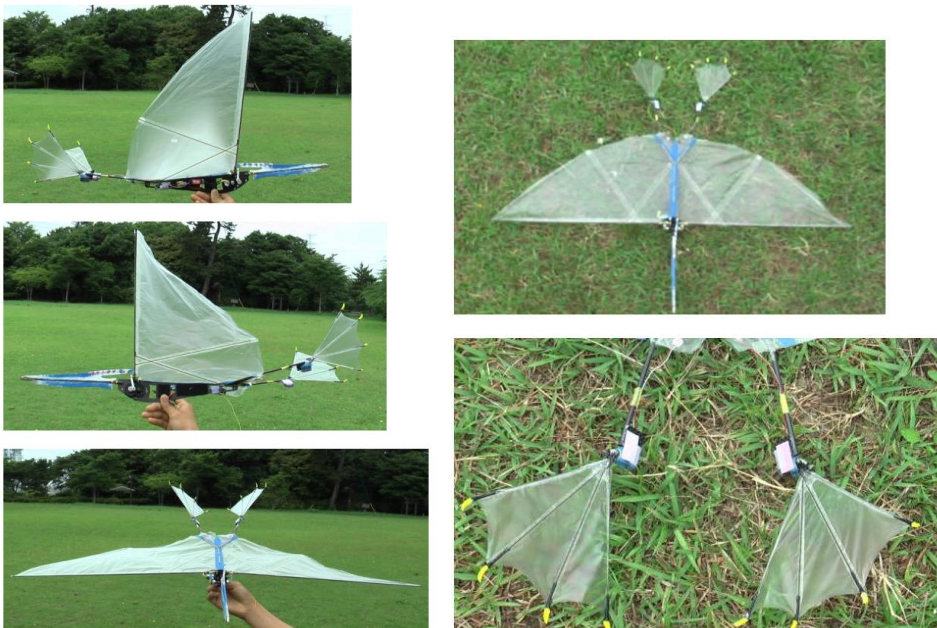


3-2) Pteranodon5-5 Vtail

<http://kakutaclinic.life.coocan.jp/Pter55VE.htm>

WingSpan 99cm Weight 80g 飛行は良好。Good flight.

https://www.youtube.com/watch?v=n_u2cHIL0mM



Tupuxuara 7-5

脚の間の膜を回転させることで左右への旋回を制御した。

Left and right turning was controlled by rotating the membrane between the legs.

<http://kakutaclinic.life.coocan.jp/TupuX75E.htm>

WingSpan 111cm Weight 115g <https://www.youtube.com/watch?v=ycH0RS9azlE>

回転する脚 rotating legs <https://www.youtube.com/watch?v=4vUin0H60Fk>



5) Tapejara8-7

<http://kakutaclinic.life.coocan.jp/Tapej87E.htm>

WingSpan 142cm Weight 200g

<https://www.youtube.com/watch?v=VijjvOOD3y4>

大きな頭の固定されたときか（crest）で直進性はいいが、左右に曲がるのが困難。

これ以後、翼竜型羽ばたき機の頭部は小さく作るようにした。

Due to the fixed crest on its large head, it can go straight, but it is difficult to turn left or right.

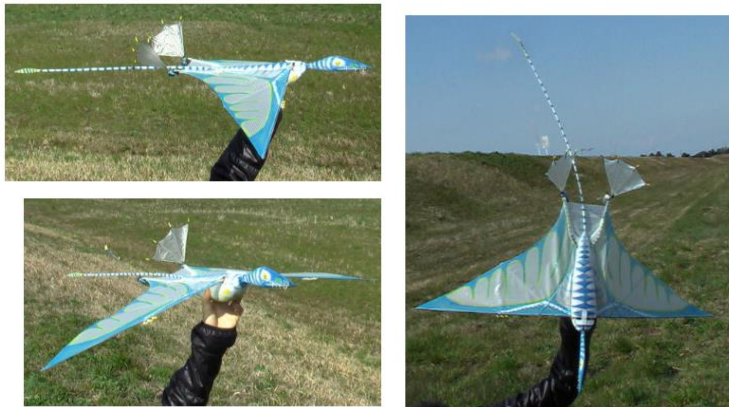
After that, I tried to make the head of the pterosaur-type ornithopter smaller.



6) Sordes5

Wing Span 95cm Weight 102g

飛行性能は良好。 Good flight performance. <https://www.youtube.com/watch?v=1JdsE89-G8I>

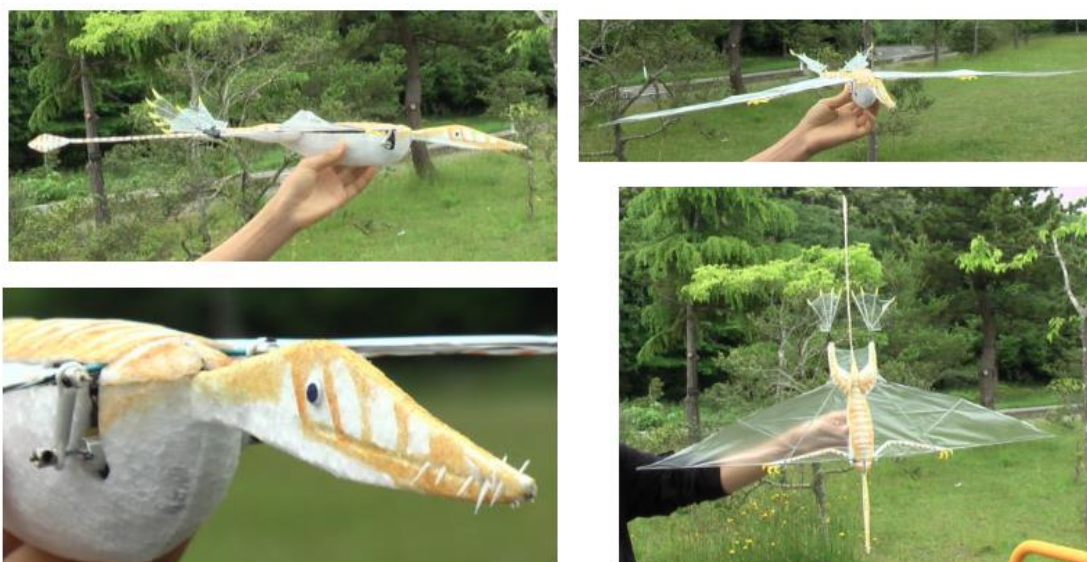


7) Rhamphorhynchus 10

<http://kakutaclinic.life.coocan.jp/Rhamp10E.html>

WingSpan 82cm Weight 43g

飛行は良好 Good flight performance. https://www.youtube.com/watch?v=waXz_0r-ODk



8) Pteranodon 9

<http://kakutaclinic.life.coocan.jp/Pter97E.html>

WingSpan 165-222cm Weight 604-610g

多くの改修が加えられた。Many improvements have been added.

最新飛行 latest flight <https://www.youtube.com/watch?v=hApijQ1aKaA>



9) Tupuxara 7-9

WingSpan 124cm Weight 136g

飛行は良好 Good flight performance.

<https://www.youtube.com/watch?v=jTF7FPaiHos>



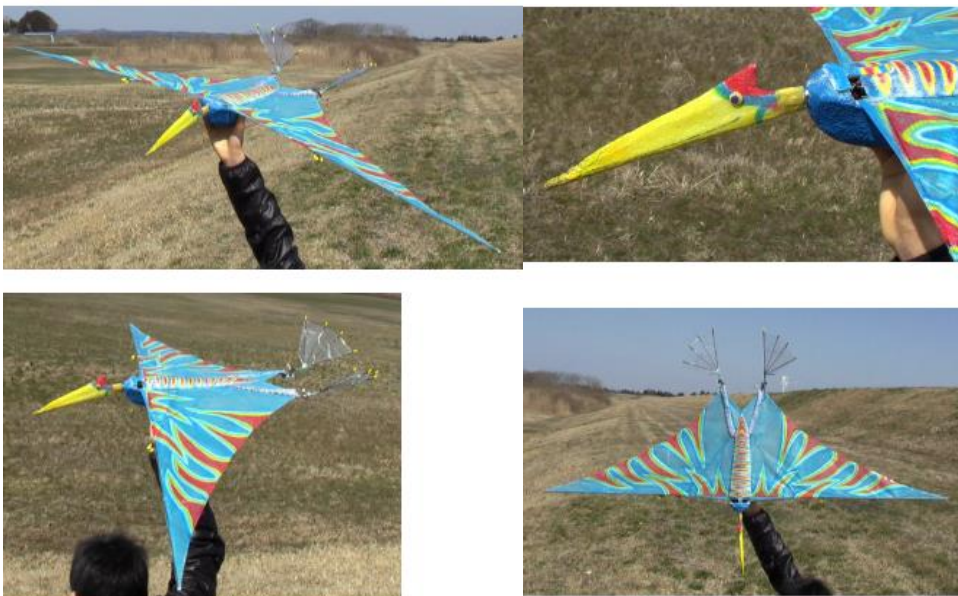
10) Chaoyangopterus8-9

<http://kakutaclinic.life.coocan.jp/ChaoyE88.html>

WingSpan 142cm Weight 200g

飛行は良好 Good flight performance.

<https://www.youtube.com/watch?v=vob9c9aWIUw>



11) Pteranodon 5-6V

<http://kakutaclinic.life.coocan.jp/Pter56VE.htm>

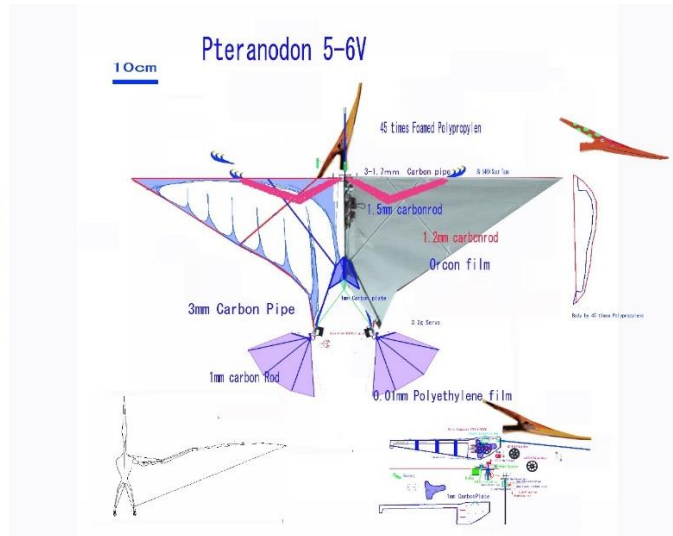
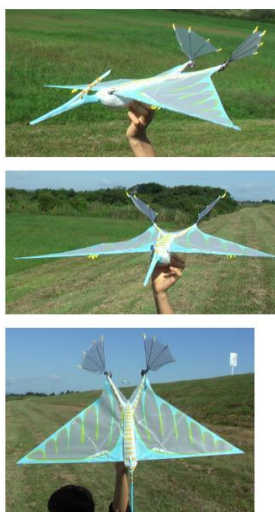
WingSpan 70cm Weight 102g

飛行は良好 Good flight performance.

<https://www.youtube.com/watch?v=SWf-rBL3OxA>

Making

<https://studio.youtube.com/playlist/PLErvdRrwWuPpyCPwoTYp5dV2yV9A4z4tc/edit>



12) Pteranodon32iV

WingSpan124cm Weight151g

飛行は良好 Good flight performance.

ダイナミックな飛行ができる dynamic flight

https://www.youtube.com/watch?v=_YlXVnMTK6I

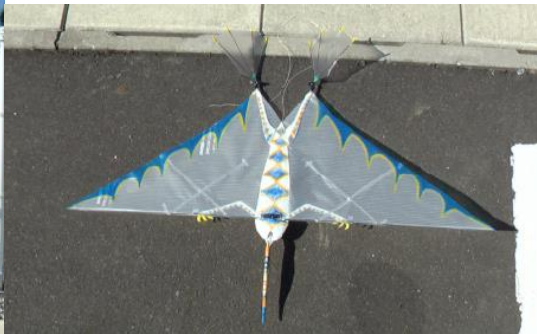


13) Dsungaripterus5-9

WingSpan127cm Weight130g

飛行は良好 Good flight performance. <https://www.youtube.com/watch?v=sgGfEcH9q4k>

ウミネコと飛ぶ fly with black-tailed gulls <https://www.youtube.com/watch?v=NOI5Bm9LbF8>



2017 年— Swing Leg Control

より翼竜の飛行に近づくために開発。

翼の膜は膝まで付着。

左右への飛行の制御はサーボで片方の脚を上げることで膝に付着した膜を上げることで行う。

ピッチ軸は腰の部分を可動にして、上下に動かすことで行う。

羽ばたき時に膜が引っ張られるために、操縦が難しい。

翼の膜が膝に付着するため、翼のアスペクト比が低く、滑空性能はよくない。

翼の膜を上上げるために、片方の脚を上上げるための骨格の構造と筋肉があったかどうかは不明。

Developed to more closely resemble the flight of a pterosaur.

The wing membrane is attached to the knee.

Controlling flight to the left and right is done by raising the membrane attached to the knee by raising one leg with a servo.

The pitch axis is made by moving the waist part and moving it up and down.

Maneuvering is difficult because the membrane is pulled when flapping.

Since the wing membrane adheres to the knee, the aspect ratio of the wing is low and the gliding performance is poor.

It is unknown whether there was skeletal structure and muscles to raise one leg to raise the wing membrane.

Structure of proximal wing

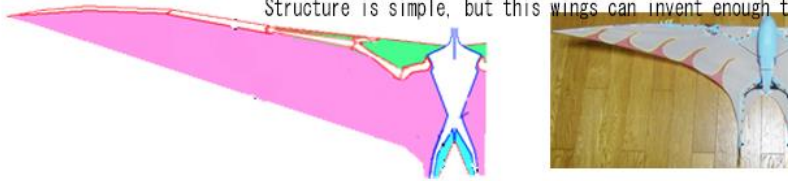


Structure of rear legs

Legs move up or down by servo--Control of Roll and Yaw

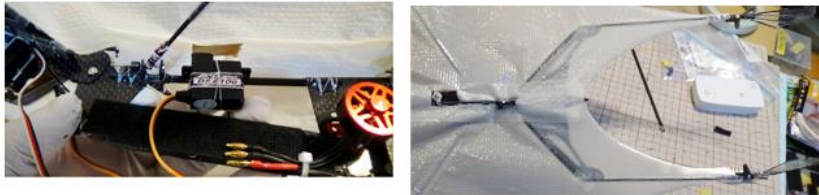


Structure of Wings The wing which consisted of only a membrane and the fourth finger
 Structure is simple, but this wings can invent enough thrust



Structure of a waist

Move a pelvis part up and down and do Pitch axial control



14) Sinopterus67 Leg Control

WingSpan161cm Weight188g

飛行は可能だが、羽ばたきの推力が小さく、操縦が難しい。

It can fly, but the flapping thrust is small, making it difficult to maneuver.

<https://www.youtube.com/watch?v=X2SIP0OVu2s>

Sinopterus67LegControl : Second Flight Test





15) Sordes66LegControl

WingSpan135cm Weight135g

飛行はできるが操縦が難しい。Can fly, but difficult to control.

<https://www.youtube.com/watch?v=Cp1vs97uCpw>

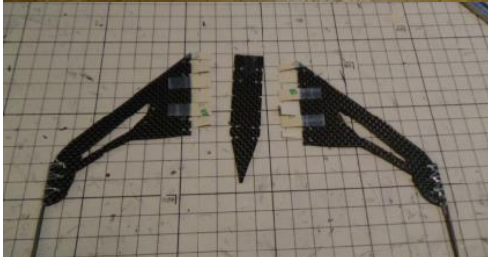


16) Pteranodon64LegControl

WingSpan169cm Weight193g

飛行はできるが操縦が難しい。Can fly, but difficult to control.

<https://www.youtube.com/watch?v=OJvlq6IB3Zk>



17) Anurognatus81

WingSpan 71.5cm Weight 101.5g

飛行はできるが操縦が難しい。Can fly, but difficult to control.

<https://www.youtube.com/watch?v=khoafPVN83o>



18) Tapejara65LC

WingSpan 127cm Weight 153g

飛行はできるが操縦が難しい。Can fly, but difficult to control.

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



2021/6— Servo Drive System ServoFlapOrnithopter (SFO)

左右の翼を1個ずつのサーボで動かすことで羽ばたきを行う Servo Drive の羽ばたき機を開発。飛行の制御は ArduinoBoard (Pro mini) に書き込んだプログラムによってサーボを動かし、左右の翼の羽ばたき振幅に差をつけること、翼を上下させ、または、傾かせることで行う。

このシステムでは、羽ばたきを停止することで、翼は滑空位置に固定されるため、簡単に滑空ができる。

Developed a Servo Drive Ornithopter that flaps its wings by moving the left and right wings one by one with a servo.

Flight control is performed by moving the servos by a program written in the ArduinoBoard (Pro mini), creating a difference in the flapping amplitude of the left and right wings, raising and lowering the wings, and tilting them.

With this system, the wing is fixed in the gliding position by stopping the flapping, so it can easily glide.

Arduino CODE for ServoFlapOrnithopter 2 servo new CODE Version2

<http://kakutaclinic.life.coocan.jp/SFOsys2S.html>

Servo Flap system



ch3 throttle Up --Flapping amplitude large thrust large
Down-Flapping amplitude small thrust small

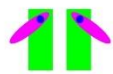
ch5 cycle time --large --Flapping cycle time long -- Flapping amplitude large
small--Flapping cycle time short--Flapping amplitude small



ch1 Aileron stick right --Left servo horn down Right servo horn up--the Tail vend to right turn to right
stick left --Left servo horn up Right servo horn down--the Tail vend to left turn to left



ch2 Elevator stick up --Left and Right servo horn up - ---Elevator Down
stick down Left and Right servo horn down ----Elevator Up



ch4 Rudder stick right --Left servo flapping angle large /Right servo flapping amplitude small ---turn to right
stick left --Left servo flapping angle small /Right servo flapping amplitude large ---turn to left



初期は翼の膜を膝まで付着させていたため、翼の膜が脚によって引っ張られ羽ばたきが十分できないため推力が出ず、羽ばたきによって脚が引っ張られてしまうため左右への飛行の制御もうまくできなかった。

In the early days, the wing membrane was attached to the knee, so the wing membrane was pulled by the legs and could not flap sufficiently, resulting in no thrust.

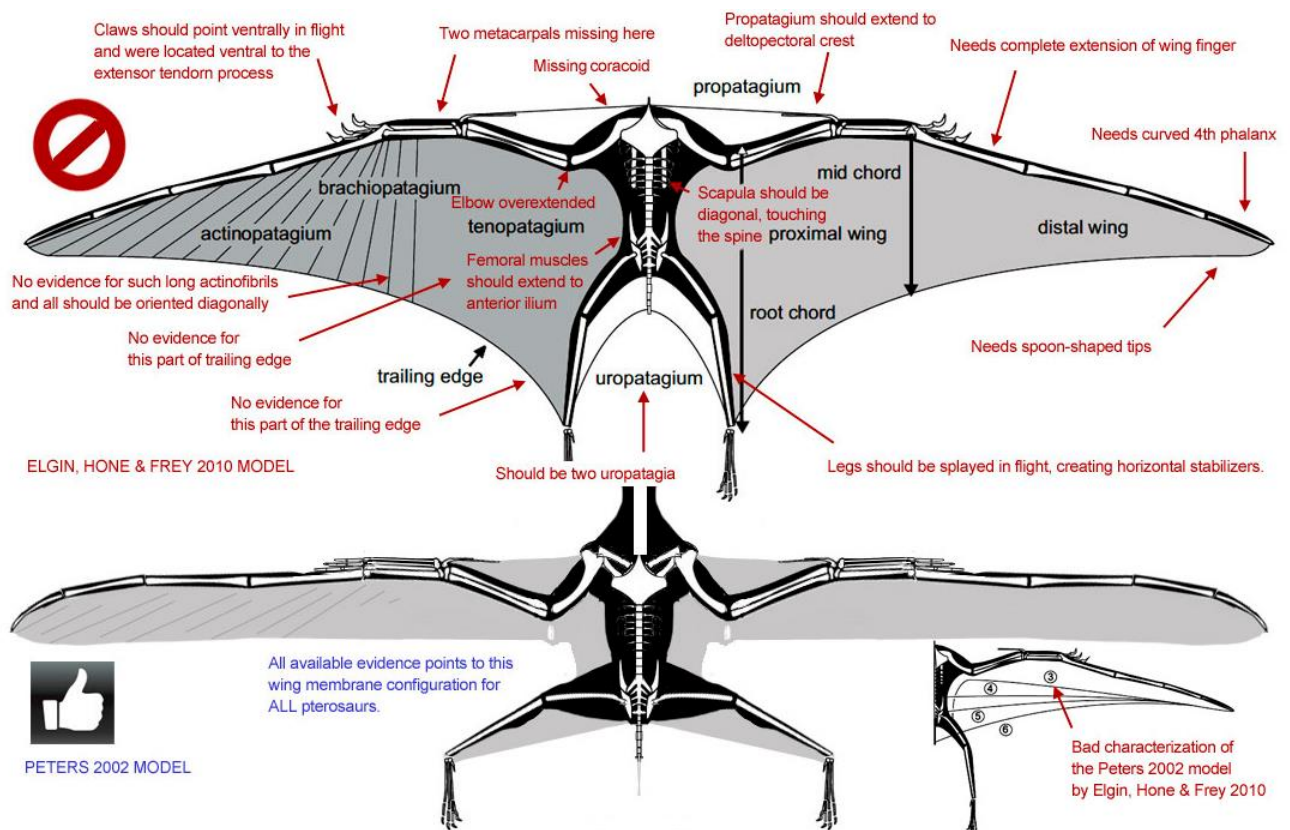
Since the flapping of the wings pulled the legs, it was not possible to control the flight to the left and right.

その後、David Peters 氏の助言があり、よりスリムな翼で、翼の膜が腰に付着する形の翼竜模型を作ってみた。

After that, with the advice of Mr. David Peters, I tried to make a pterosaur model with slimmer wings and a shape in which the wing membrane is attached to the waist.

<http://reptileevolution.com/pterosaur-wings.htm>





最初はこんな細い翼で羽ばたいて飛べるのかと不安があったが、製作して飛ばしてみると、その飛行性能に驚いた。

At first, I was worried that it would be able to fly with such thin wings, but when I built it and flew it, I was surprised at its flight performance.

翼をスリムにし、翼の膜の後縁の付着部位を腰の近位にし、翼の膜の影響が脚に及ばないようにすることで、卓越した飛行性能を発揮でき、卓越した飛行制御ができるようになった。

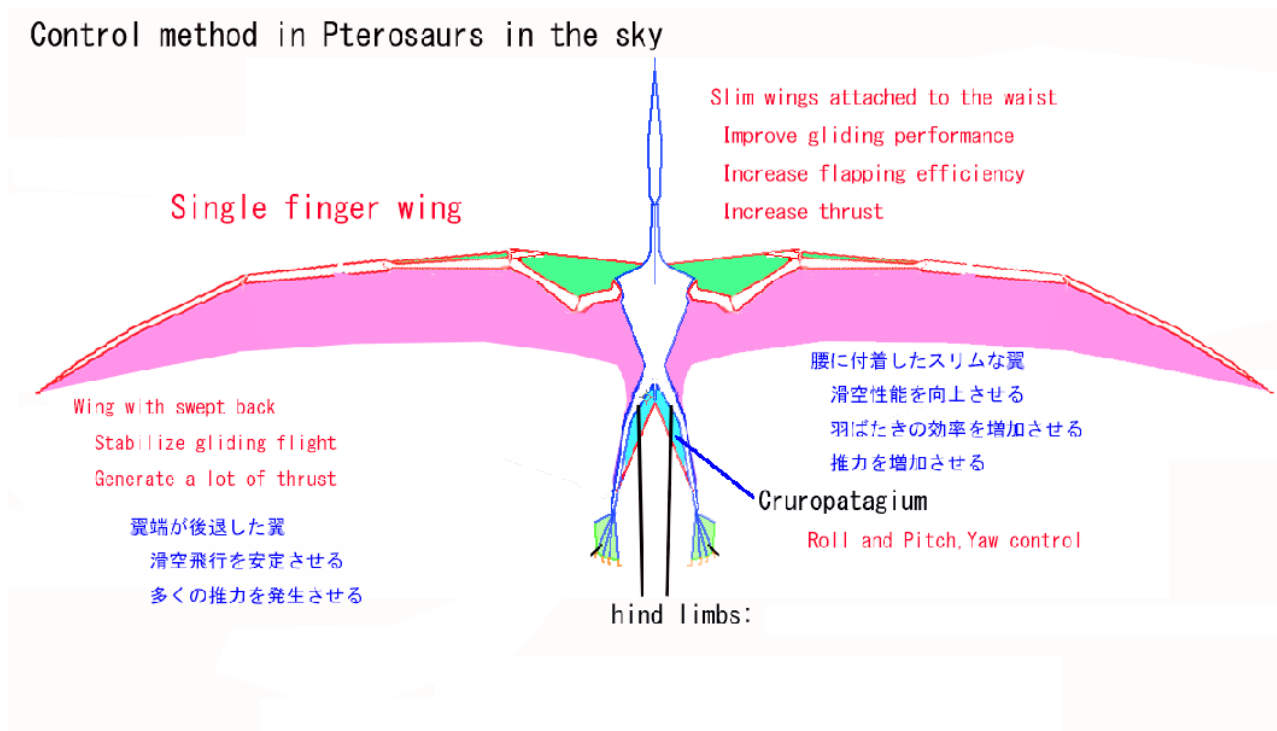
アスペクト比が高い翼は滑空性能が良い。大きく羽ばたくことができるようになり推力が効率よく生み出せる。左右の翼を大きく別々に動かすことができるので、操縦性が改善した。

By making the wing slim and attaching the trailing edge of the wing membrane closer to the hips so that the wing membrane does not affect the legs, it is possible to demonstrate excellent flight performance and excellent flight control.

Wings with a high aspect ratio have good gliding performance. It can flap its wings greatly, and thrust can be generated efficiently. Maneuverability was improved because the left and right wings could be moved independently.

その経験から、現在は以下の図のような方法で翼竜型羽ばたき機を製作している。

Based on that experience, I am currently manufacturing a pterosaur-type ornithopter using the method shown in the figure below.



19) SFORhamphorhynchus93-2

WingSpan110cm Weight28g

この機体は翼の膜が膝に付着しているため、羽ばたきの振幅は小さく推力も小さい。飛行の制御も難しい。滑空性能は良好。

Since the wing membrane is attached to the knee, the amplitude of flapping is small and the thrust is also small. Difficult to control flight. Good glide performance.

<https://www.youtube.com/watch?v=enmHpw95yZg>



20) SFORhamphorhynchus93-3

WingSpan109.5cm Weight30g

翼の膜の動きが脚に伝わらないため、飛行制御が十分にできる。また、脚によって膜の動きが妨げられないため、羽ばたきが十分にでき、推力もあり、飛行制御も効果大きい。

スリムな翼でアスペクト比が大きく滑空性能も良好。

Since the movement of the wing membrane is not transmitted to the legs, it is possible to fully control the flight. In addition, since the movement of the membrane is not hindered by the legs, it can flap its wings sufficiently, has thrust, and is highly effective in flight control.

It has a slim wing with a large aspect ratio and good gliding performance.

<https://www.youtube.com/watch?v=Z17xJvPdrI0>



21) SFOPterodactyl95-2

WingSpan 107cm Weight 30g

翼の後退が少ないため、推力が小さく、滑空性能が悪い。改修を予定している。

Since the wing has little receding, the thrust is small and the glide performance is poor. I am planning a renovation.

https://www.youtube.com/watch?v=08U_p7SzaDk



22) SFOPteranodon97

WingSpan 304cm Weight 384g

多くの改修を経てやっと飛ぶようになってきた。

大きな翼竜も飛ぶことができるという証明への第一歩。

After many repairs, it is finally flying.

A first step toward proving that even large pterosaurs can fly.

<https://www.youtube.com/watch?v=qs21GsuS4J4>

<https://www.youtube.com/watch?v=atsL23HpqeU>



23) SFO118Rhamphorhynchus118

WingSpan 136cm Weight 43g

私が製作した翼竜型羽ばたき機の中で最高の滑空性能がある羽ばたき機。

膜の形も最適と思われる。

The ornithopter with the best gliding performance among the pterosaur-type ornithopters I have built.

The shape of the membrane also appears to be optimal.

<https://www.youtube.com/watch?v=7Xfhj0IRC18>

